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CCB 2005: Towards developing a monitoring framework for Multiple Species Habitat Conservation Plans. Part I.

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EXECUTIVE SUMMARY

As the largest habitat conservation plan in southern California, the Western Riverside County Multiple Species Habitat Conservation Plan (WRC MSHCP) seeks to protect approximately 500,000 acres of natural habitats before their disappearance in an effort to conserve 146 rare plant and animal species. A requirement of the implementing agreement for the WRC MSHCP is that monitoring and management plans be developed to ensure successful conservation of these species in the long-term. A fundamental recommendation made by the Scientific Review Panel (2003) and National Center for Ecological Analysis and Synthesis (NCEAS 1999) was the need for scientific input into the development of monitoring approaches.

Development of the Riverside County Monitoring Program

In November 2002, the Center for Conservation Biology (CCB) at UC Riverside with the Southern California Resource Assessment Program (RAP) of the California Department of Fish and Game initiated the Multiples Species Habitat Conservation Plan monitoring program for Riverside County. This proposed Resource Assessment Project integrated the monitoring goals of species as identified by resource agencies and the goals of communities as defined under the Natural Communities Conservation Plan (NCCP) guidelines. The monitoring framework (Chapter 1) was designed as an iterative process, with species-habitat relationship models guiding monitoring efforts, which in turn would provide additional information for evaluating and refining distribution models. This was to be done in conjunction with the refinement and testing of monitoring strategies and protocols.

The proposed CDFG – CCB project duration was expected to be five years, and determined to be developed in three phases (Table 1): Initial Phase - Inventories, Middle Phase – Ecological Relationships, and Final Phase – Long-term Monitoring Methodologies. The CCB completed the Steps 1, 2, 3, and 5 of the Initial phase (Chapters 3, 4, 5, 6, 12, 13, 14 and 15), and in 2003-2004, began work on Initial Phase Step 6 (Chapter 6) and Middle Phase Step 1 (Chapters 7, 9 , 10 and 11). It is important to note that Step 4 of the Initial Phase, the creation/update/interpretation of the vegetation map for the planning area of Western Riverside County to be developed by CDFG, originally was to be available in 2004; it now has an expected release date of June 2005. The use of the 1994 vegetation map hampered the accuracy of the completed project models, but not the development of the procedure.

In developing the monitoring framework for the Western Riverside County Multiple Species Habitat Conservation Plan (WRC MSHCP), the CCB initiated several avenues of research with the objectives of understanding Covered Species habitat relationships and identifying environmental processes (natural and anthropogenic) affecting the occurrence of these species (Landres et al. 1999; Salafsky and Margoluis 1999; Barrows et al. 2005). This research included constructing niche models that identify suitable habitat for Covered Species

(Chapters 3, 5 and 6) and developing conceptual models hypothesizing how environmental processes affect multiple Covered Species within a community (Chapter 11).

Table 1 Development of the monitoring program (Source: CDFG-UC Collaboration, 2003)

Initial phase (2003-2005) - Species inventories and linking species to environmental variables:

1. Gathering existing data records from museums, literature, and field notes for species within the planning area.
2. Conduct field surveys to verity existing species records, particularly those for plants.
3. Gather existing environmental GIS layers for the MSHCP area.
4. Create/update/interpret vegetation map for planning area.
5. Create niche models for species using verified species records and existing GIS layers.
6. Survey predicted species locations based on niche models to find new populations.

Middle phase (2004-2007) - Understanding ecological relationships and developing a community approach:

1. Transects collecting multiple species information, community information
2. Trends – changing/magnitudes of change – response of species
3. Determine what to measure in monitoring

Final Phase (2008-2009) - Establish efficient methods for monitoring:

1. Take what learned from Phases I and II and implement across conservation area
2. Community transects and trend detection for management.

A third aspect of this research was to develop a community monitoring strategy that incorporated the niche and conceptual models as tools to guiding inventory and monitoring efforts (Chapters 9 and 10). Data collected from the initial community monitoring in 2004 and focused surveys for target taxa (Chapters 6, 13, 14 and 15) were used to construct preliminary niche models for a number of Covered Species and to identify taxa and environmental processes affecting the occurrence of Covered Species populations in developing the conceptual models (Chapters 5, 6, 9, 10 and 11).

In addition to the monitoring protocol development, CCB was charged with determining whether the criteria outlined in section 5.0 for each of the sixteen demonstrate conservation species (13 plants, 2 birds, and 1 mammal) are met on public and quasi-public lands already protected. CCB biologists conducted two full years (2003, 2004) of surveys for the rare plant species with a third year (2005) of surveys that is ongoing. The results show that only one plant species beautiful hulsea (*Hulsea vestita callicarpha*) meets the criteria for full coverage as outlined in the WRC MSHCP. Surveys for the San Bernardino flying squirrel were initiated by the U.S. Forest Service and are ongoing. So far no individuals have been observed. The

CCB conducted surveys for the Grasshopper Sparrow, however the surveys were not thorough enough to determine the level of coverage afforded to the sparrow. No surveys for the Lincoln's Sparrow were conducted due to manpower constraints.

In order for the County to undertake a monitoring program, one step is the determination of the actual *time and effort* required (Chapter 2). Realistic cost estimates for surveys, data reduction and analysis, administration, and report preparation need to be made. As actual costs for personnel vary by source (for example, oversight was largely from CCB faculty, and many students added time for theses to the project without cost), we only present the time allocation by CCB personnel. The responsible entities can generate accurate budgets for future community monitoring, based on these time requirements. Considerable effort was allotted to initial development of the monitoring framework; these efforts were divided among data collection, data entry and analyses, modeling, and management activities for the three year period for Western Riverside County alone.

- Fieldwork
  - Community surveys: 1906 hrs for CSS; 2120 hrs for Riparian
  - Rare plants surveys: 2912 hrs
  - Burrowing Owls: 360 hrs
  - Lizards: 610 hrs
  - Raptors: 450 hrs
- Field data entry
  - Community survey data entry: 2,212 hrs for both CSS and Riparian
  - Rare plants data entry: 600 hrs
  - Burrowing Owls: 180 hrs
  - Lizards: 77 hrs
  - Raptors: 93 hrs
  - Arthropod processing and identification: 546 hrs
- Database, GIS, and Modeling: 3,228 hrs
- Data Analyses & Report Preparation: 3,400 hrs
- Task Management (e.g., protocol development, sampling design, project supervision, field crew scheduling, permits): 3,631 hrs
- Faculty contribution: 1,500 hrs
- Administrative support: 3,540 hrs

Synopsis of CCB activities in WRC, 2003-2005:

- Database with 22,423 species location records gathered from historical databases and CCB Surveys
  - 40 organizations queried; 2,558 historical species records
  - CCB Surveys; 19,865 new species records
- 27 covered rare plant species surveys (604 surveyed locations in 2003 & 2004)
- 5 covered reptile species surveys (19 sites surveyed in 2003 & 2004)
- 4 raptor species surveys (250 point locations in 2003 & 2004)
- Burrowing owl surveys (7 sites surveyed in 2003 & 2004)

- Grasshopper Sparrow surveys (conducted as part of community sampling at 8 sites and in conjunction with Burrowing Owl monitoring at 3 sites in 2004)
- Coastal sage scrub community surveys (In 2004 surveyed 205 bird points; subsampled 128 points with 100m transects [i.e. 7.9 miles] for communities [vegetation, arthropods, reptiles, mammal signs, anthropogenic disturbances])
- Riparian community surveys (In 2004 surveyed 290 bird points; subsampled 281 points along 35 mi of riparian habitat [vegetation, arthropods, mammal signs, anthropogenic disturbances])
- 15 protocols developed for surveyed species
- 167 unique GIS layers, derived from 10 sources GIS layers
- 16 niche models for covered species
- 14 niche models for other shrubland bird species to use in community modeling
- 4 CSS community niche models for birds and reptiles
- Conceptual models for covered CSS birds/reptiles, and one for riparian birds
- Data for threats analyses (birds, plants) which will be analyzed over the course of the next year

CCB activities, for the development of a monitoring framework in Coachella Valley (Barrows et al 2005; CVAG 2003, 2004, 2005), contributed substantially to the planning and methods used in the WRC MSHCP monitoring framework. These related activities are listed below.

Synopsis of CCB activities in CV, 2002-2005:

- Riparian bird community surveys (2002, 2003, and 2004) including 5 covered species and 11 sites. Monitoring included point counts for the birds, pitfall trapping for arthropods, vegetation characteristics, and potential threats identification
- Sand dune community surveys (2002, 2003, 2004, and 2005). Includes 25 sampling stations with 5-8, 10 x 100 m belt transects established at each station. Data collection included surveys for Coachella Valley milkvetch, Coachella Valley giant sand-treader crickets, Coachella Valley round-tailed ground squirrels, Coachella Valley fringe-toed lizards, and flat-tailed horned lizards, as well as general reptile, arthropod, and small mammal surveys. Includes surveys in the spring-summer as well as in the fall to track reproductive success for focal species. Vegetation and sand compaction data were collected for each transect each year
- Population dynamics models for flat-tail and fringe-toed lizards to generate spatial and temporal dynamic basis of ecosystem
- Le Conte's thrasher surveys (2002, 2003, 2004, and 2005) development of survey protocol and monitoring on 11 transects
- Rare plant inventories for 5 covered species (2002, 2003, 2004 and 2005)
- Desert tortoise surveys (2004)
- Niche models developed for 4 species
- Framework for monitoring multiple species conservation programs manuscript accepted for publication in the October 2005 Journal for Wildlife Management

Results and Recommendations to date in the design of protocols and monitoring strategies:

- Monitoring should be multi-year to encompass the variation in environmental conditions: Climate impact on survey results (e.g., 1999-2003 Drought conditions affected survey and monitoring efforts, particularly for plants and reptiles)
- A regular schedule for a monitoring protocol is unreasonable given the annual variation. All surveys and monitoring must be flexible enough to respond to appropriate conditions. For example, 2002 was the driest year on record and there was almost no annual plant or small animal activity. We recommend that optimal climatological years be the focus of survey efforts.
- For the most effective niche models, important to use an accurate and reliable vegetation map.
- Multiple seasons are required to develop, test, compare, and refine protocols and monitoring/sampling strategies.
- Niche and conceptual models require testing and refinement with independent datasets.
- There is a need to develop more efficient CSS protocols for vegetation and reptile sampling.
- Community-level and threats sampling techniques need further development.
- Pending the results of the 2005 rare plant surveys, serious consideration should be given to expanding the surveys beyond public and quasi-public land to include private land. Acquiring land currently under private ownership may be the only mean to insure that all the rare plant species on the Demonstrate Conservation Species List meet the coverage requirements.
- Time and effort for data entry and management is extensive and needs to be a large fraction of any budget preparation. We also recommend using alternative data collection tools, such as PDA hand-held computers for field data entry. However, these need careful and immediate verification upon return to the office. Hard copies should be generated and stored immediately as back up.

CHAPTER 1
THEORETICAL FRAMEWORK AND METHODOLOGY

BACKGROUND

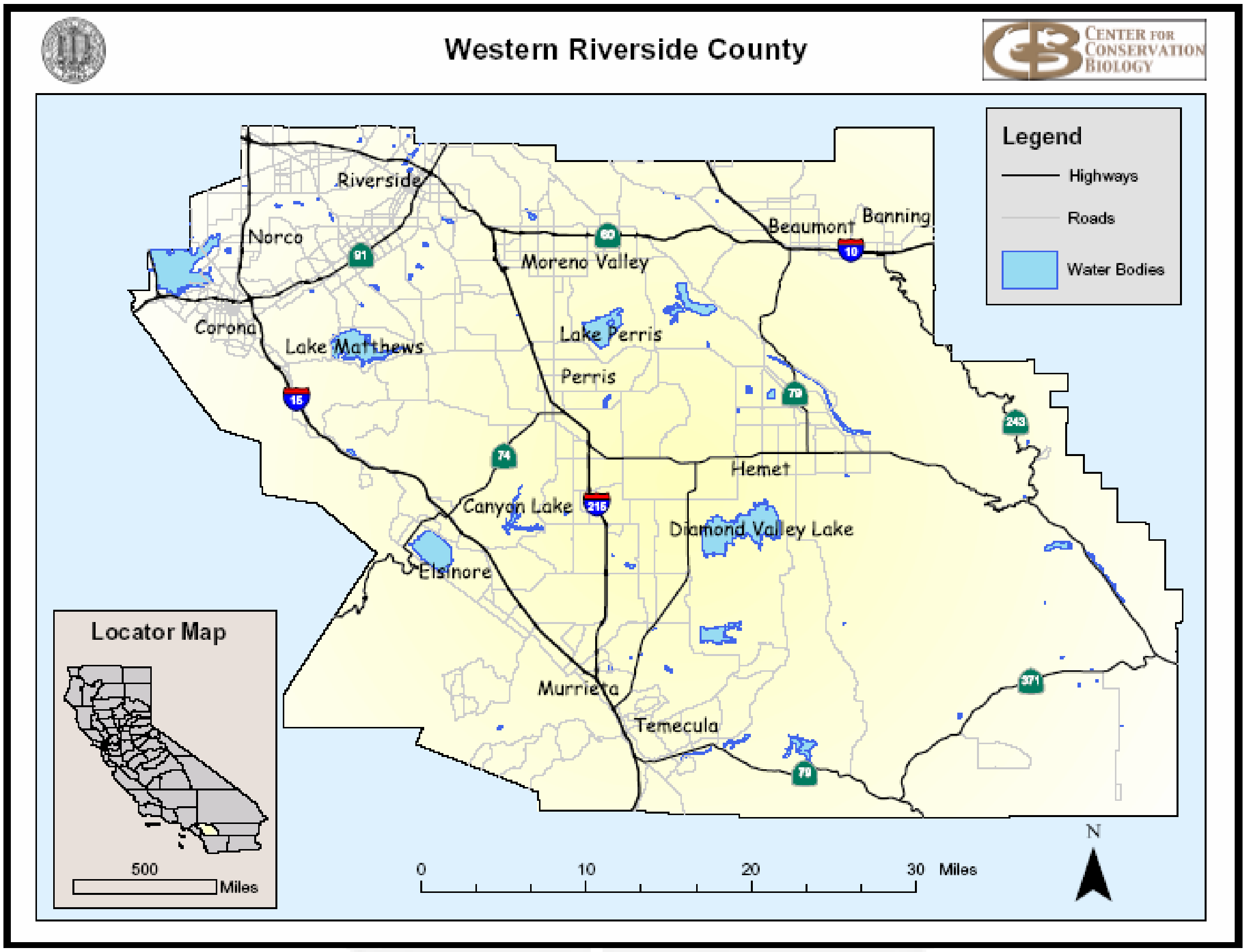
As the largest habitat conservation plan in southern California, the Western Riverside County Multiple Species Habitat Conservation Plan (WRC MSHCP) seeks to protect approximately 500,000 acres of natural habitats (Dudek and Associates 2003), before their disappearance, in an effort to conserve 146 rare plant and animal species (Appendix 1). The Plan Area (Figure 1.1) includes all unincorporated Riverside County land west of the crest of the San Jacinto Mountains to the Orange County line and the jurisdictional areas of the cities of Banning, Beaumont, Calimesa, Hemet, San Jacinto, Perris, Canyon Lake, Murrieta, Temecula, Lake Elsinore, Corona, Norco, Moreno Valley, and Riverside.

> *"The overriding management goal of the WRC MSHCP is to establish and maintain a self-sustaining WRC MSHCP Conservation Area, that focuses on conserving habitats and species and is consistent with the conservation objectives for the Covered Species. Ecosystems are dynamic environments of interacting processes and biotic and abiotic components; they may exhibit multiple equilibria, and destabilizing forces. Furthermore, ecological processes are not linear; they may function at different spatial and temporal scales simultaneously. Consequently, Adaptive Management of ecosystems, landscapes, and associated species and Habitats requires a flexible, inductive approach where ecological theory and field experimentation are combined to monitor the status of the system and respond to the unexpected. The Adaptive Management Plan for the WRC MSHCP encourages such an informed "learning by doing" approach."* (Dudek & Associates 2003)

To assure the persistence of the species under a Section 10(a) permit (US Endangered Species Act), the Plan requires a means to monitor numerous species across a vast area. This task is large and complex, given the idiosyncrasies of Covered Species and the complexity of their habitats. At present, no tested methods exist to aggregate these species in a manner that increases monitoring efficiency, nor do sufficient data exist on the occurrence, much less the abundance, for most species to be covered under the Plan. Further, all proposed study areas have highly variable climates (Figure 1.2), large fluctuations in plant productivity, and subsequently large fluctuations in species populations.

One requirement of the implementing agreement for the WRC MSHCP is that monitoring and management plans be developed to ensure successful conservation of these species in the long-term. A fundamental recommendation made by the Scientific Review Panel (2003) and National Center for Ecological Analysis and Synthesis (1999) was the need for scientific input into the development of planned monitoring approaches.

Figure 1.1 Western Riverside County Multiple Species Habitat Conservation Plan Area.



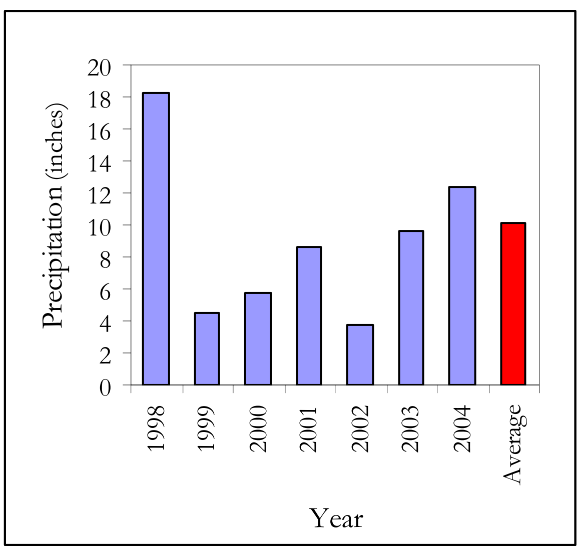


Figure 1.2. Annual precipitation from 1998 to 2004, compared with 49 year mean (Western Regional Climate Center, www.wrcc.dri.edu)

As such, in November 2002, the Center for Conservation Biology (CCB) at UC Riverside with the Southern California Resource Assessment Program (RAP) of the California Department of Fish and Game (CDF) initiated the *Inland Ecosystems of California: Resource Assessment Project*. This proposed Resource Assessment Project (RAP) integrated the monitoring goals of species as identified by resource agencies and the goals of communities as defined under the Natural Communities Conservation Plan (NCCP) guidelines (see Yoccoz et al. 2001; Trexler and Busch 2003). In addition, CCB activities with the Coachella Valley Association of Governments (CVAG) as pertaining to the Coachella Valley Multiple Species Habitat Conservation Plan (CV MSHCP) also contributed to the design of the monitoring framework. Conceived as an iterative process, the monitoring framework, with species-habitat relationship models would guide monitoring efforts, which in turn would provide additional information for evaluating and refining distribution models. This was to be undertaken in conjunction with the refinement and testing of monitoring strategies and protocols.

Table 1.1 Development of the monitoring program (Source: CDFG-UC Collaboration, 2003; Appendix 2)

Initial phase (2003-2005) Species inventories and linking species to environmental variables:

1. Gathering existing data records from museums, literature, and field notes for species within the planning area.
2. Conduct field surveys to verity existing species recores, particularly those for plants.
3. Gather existing environmental GIS layers for the MSHCP area.
4. Create/update/interpret vegetation map for planning area.
5. Create niche models for species using verified species records and existing GIS layers.
6. Survey predicted species locations based on niche model to find new populations.

Middle phase (2004-2007) Understanding ecological relationships and developing a community approach:

1. Transects collecting multiple species information, community information
2. Trends – changing/magnitudes of change – response of species
3. Determine what to measure in monitoring

Final Phase (2008-2009) Establish efficient methods for monitoring:

1. Take what learned from Phases I and II and implement across conservation area
2. Community transects and trend detection for management.

The proposed CCB-CDFG RAP project duration was projected to be five years, and was organized into three phases (Table 1.1): Initial Phase - Inventories, Middle Phase – Ecological Relationships, and Final Phase – Long-term Monitoring Methodologies. The CCB successfully completed Steps 1, 2, 3, and 5, and began step 6 of the Initial phase (Chapters 3, 4, 5, 6, 13, 14 and 15). These tasks included surveying for rare plants, lizards, Burrowing Owls (*Athene cunicularia*), and raptors in 2003 and 2004, as well as Grasshopper Sparrows (*Ammodramus savannarum*) in 2004. Upon acquiring sufficient location data, from historical databases and CCB surveys, niche models were constructed for 16 Covered Species (Chapters 5 and 6). Niche models constructed for lizards in 2003 were used to identify 2004 survey locations and the data were used to evaluate the models (Chapter 6). It is important to note that Step 4 of the Initial Phase, to be developed by CDFG, was to be made available in 2004; it now has an expected release date of June 2005. This required the CCB to use the 1994 vegetation map used in developing the WRC MSHCP (Dudek and Associates 2003), and hampered the accuracy of the resulting models.

The CCB has initiated Steps 1 and 2 in the Middle Phase. In 2004, CCB began initial coastal sage scrub (CSS) and riparian community monitoring (Chapters 9 and 10). For covered riparian bird species, logistic regression models were constructed to predict species occurrence using habitat quality and anthropogenic threat variables (Chapter 10). This data was used to create conceptual models predicting species responses to environmental processes and identifying potential anthropogenic threats (Chapter 11). To predict co-occurrences of multiple species, CCB created an additional 14 CSS bird niche models in order to construct CSS community niche models (Chapter 7). An analysis of the distribution of sensitive species locations in the Plan Area identified those areas with the greatest aggregations of sensitive species (Chapter 8).

When placing CCB activities in the context of the projected timeline (Table 1.1), steps 1, 2, 3, and 5 were completed for the initial phase. Expected completion of step 6 was Fall 2005; plant surveys are being completed, and CSS and riparian bird surveys are being undertaken using co-funding by the CDFG RAP program and CCB funds (El Sobrante). Assessing middle phase steps 1-3 and the final phase will be re-evaluated depending on funding availability.

COMMUNITY-BASED MONITORING APPROACH

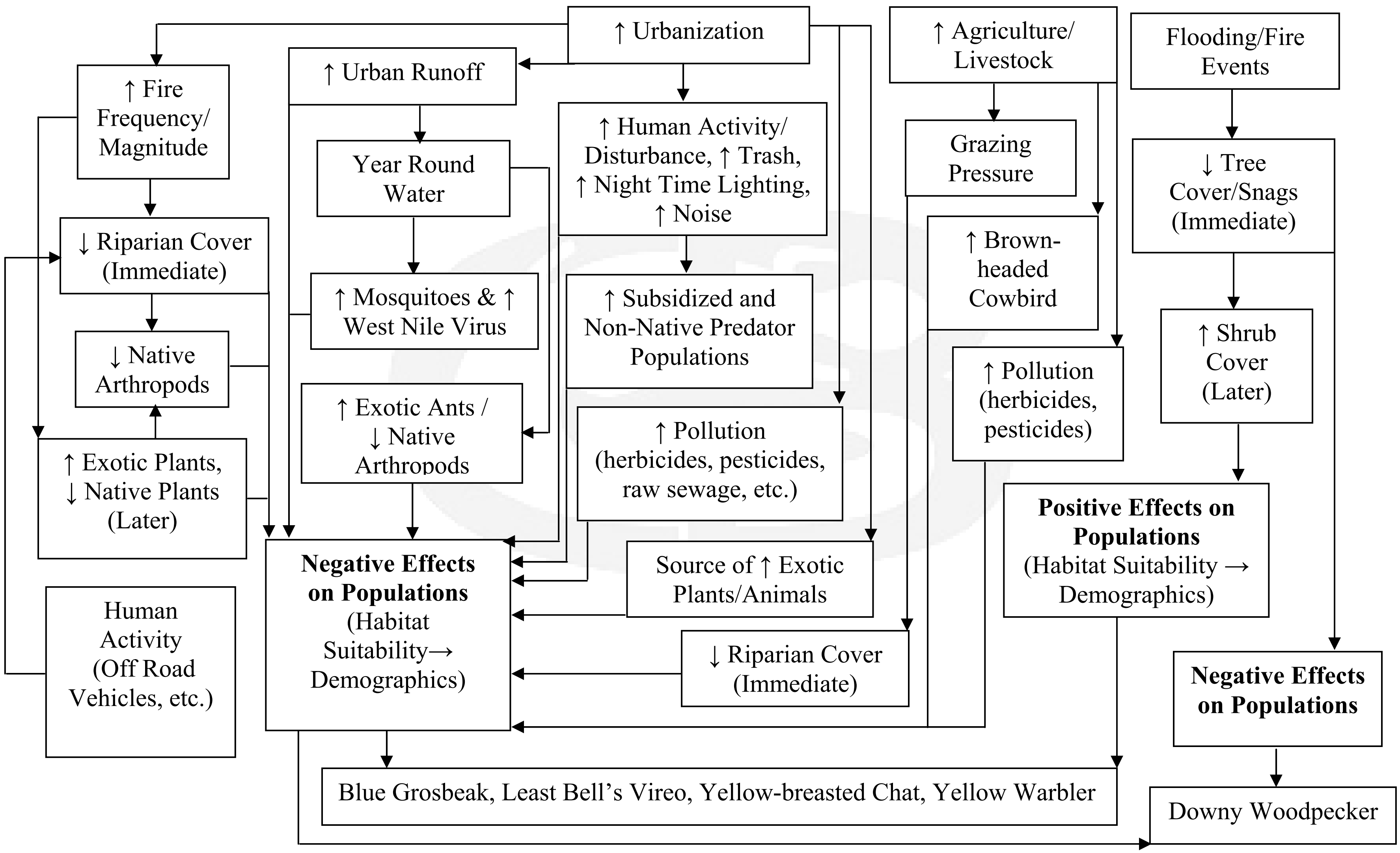
Whitaker (1975) defined an ecological community as "a system of organisms living together and linked together by their effects on one another and their responses to the environment they share." Species do not exist as isolated entities, but interact with both the biotic and abiotic components of the environment in time and space (Chapin et al. 1997). Our monitoring combines single species and ecosystem monitoring into a single community monitoring framework (Barrows et al, 2005). The basis for this framework focuses on the interconnections within the ecosystem that impinge upon the organism under scrutiny. When placed in an organism-centered context, we characterize the community and ecosystem attributes that influence the persistence and fitness of each of the Covered Species (MacMahon et al. 1981).

For example, a conceptual model, such as the "envirogram" developed for the riparian bird community in the Plan Area (Figure 1.3), depicts these interconnections. The illustrated relationships, both known and hypothesized, describe population responses to ecosystem processes. By monitoring Covered Species along with other "members" of the local biological community, the CCB sought to develop a program that could detect potential threats to these species (i.e., a breakdown in community integrity). Landscape-scale abiotic drivers, located on the uppermost tier of the envirogram, influence community processes via a cascade-effect and ultimately affect individual species' populations. Variation in any variable at any level within the envirogram, whether natural or anthropogenic in nature will affect the birth rates, death rates, and rates of immigration and emigration of the Covered Species and influence their population dynamics. The key is to separate natural variation from that which is anthropogenic and may be amenable to management actions. By sampling the populations of Covered Species, as well as species and functions at other levels in the system, relationships can be hypothesized among the different compartments in the diagram, which can be tested to better understand the system as a whole. Once established, the relationships can be monitored through time and space for abnormalities that do not represent normal fluctuations and that may arise from anthropogenic causes. Identifying and detecting threats early, allows effective management of these threats before they can significantly affect Covered Species (Barrows et al. 2005). Conceptual models can be constructed in a similar manner for other natural communities within Western Riverside County (See Chapter 11).

Implementing a monitoring program hinges on developing quantitative protocols and techniques that thoroughly characterize the spatial and temporal variability within and between the tiers described above. The spatial aspect is important because biologists must grasp the existing variation already present in community parameters across the length and breadth of the Plan Area in order to establish baseline conditions. Also, the monitoring framework must be able to detect and localize the scale at which variation of natural or anthropogenic factors are influencing the system. Therefore, the framework must be designed to adequately detect variation from local scale to regional variation. The temporal aspect is equally important because normal year-to-year variation must be filtered from the year-to-year variation that could signal a potential decline in community health. Because the Plan Area is so vast, monitoring may not be feasible in all locations. The information gathered in the first few years will allow managers to focus monitoring on locales that are likely to be "trouble spots" and will be more amenable to spatial and temporal monitoring. Management decisions can be based upon evaluation of temporal trends in the community data.

A community-based approach to species monitoring is practical for several reasons. First, conducting Population Viability Analyses (PVA) on individual species requires detailed life-history information. For many of the Covered Species, especially the plants, little autecological information exists including basic life history, pollinators and other symbioses, competitors, and soils associations. In many cases, even general distributional patterns and habitat associations are suspect. Individuals often persist in areas that are no longer suitable

Figure 1.3 Envirogram showing the interactions of biotic and abiotic variables within the riparian ecosystem and how they may impinge upon the bird community in the lowest tier.



habitat for reproduction and maintenance of populations, the "ghosts of habitats past" (Knick and Rotenberry 2000). Second, even if detailed life history information was available, policy makers may consider the expense associated with monitoring of multiple species at a vast scale to be prohibitive. Third, management actions taken to benefit one or more Covered Species' populations without knowing their relationship with other species in the same community may be detrimental to other target and/or non-Covered Species, or undermine community resilience. For example, creating habitat for Stephen's kangaroo rats will eliminate habitat for California Gnatcatchers, and these two species must co-exist across most of their respective ranges. Management actions toward Covered Species make ecological sense only within the context of the community. Finally, and most importantly, emphasizing the community provides a better understanding of how anthropogenic influences affect complex community dynamics.

PROJECT DESIGN AND IMPLEMENTATION

The framework of the proposed WRC MSHCP monitoring program comprises a three-phase process, modified from Barrows et al. (2005). The process begins with modeling the distributions of single species then builds upon the individual models up to the community level. The three phases are:

<u>Phase 1: Framework Construction</u>:

- Acquire historical and current species locations
- Acquire, compile, and configure environmental variables from GIS layers to use in niche modeling
- Prepare preliminary niche models for Covered Species to establish the environmental correlates of distribution
- Construct conceptual models postulating Covered Species population responses to environmental processes
- Establish sampling strategy and protocols to characterize natural communities

<u>Phase 2: Framework Evaluation</u>:

- Collect monitoring data to evaluate models
- Evaluate and refine niche models
- Evaluate and refine conceptual models
- Develop monitoring strategies using niche and conceptual models
- Test protocols in the field, then evaluate and refine protocols as needed

<u>Phase 3: Monitoring Implementation</u>:

- Initiate monitoring program that tracks Covered Species and community integrity

Framework Construction

In 2002, as part of a prior CDFG-funded project, the CCB initiated the acquisition of information on the distribution of Covered Species within the Plan Area. It involved querying 40 referenced institutions, and resulted in the obtainment of 2,558 historical species location records. In 2003 and 2004, these records were geo-referenced and compiled into CCB's species locations database (Table 1.2). Also during this period, CCB conducted field surveys to collect location information on a variety of species.

Table 1.2 CCB compiled species location records per taxonomic group for the Plan Area.

TAXONOMIC GROUP	Records
Plants	1,317
Birds	19,705
Mammals	42
Reptiles	1,234
Amphibians	124
Invertebrates	1
TOTAL	**22,423**

Once location data were collected, the CCB derived 167 unique GIS layers from ten source GIS layers, and incorporated these into the CCB database for constructing habitat suitability models (niche models) for Covered Species. A description of the species locations records acquisition and the development of the GIS layers may be found in Chapter 4.

CCB developed spatially explicit habitat suitability models to provide a powerful tool to guide monitoring and management of Covered Species in the Plan Area. These GIS-based niche models identify environmental variables associated with species distributions and predict habitat suitability over a large geographic area. Niche models were developed for 16 Covered Species that had adequate location data (see Chapters 3, 5 and 6).

As described earlier in this chapter, conceptual models serve to provide hypotheses about how species populations respond to multiple environmental processes. CCB developed initial conceptual models for CSS birds and reptiles, and riparian birds (Chapter 11). These models provide testable hypotheses to guide future monitoring objectives and the development of adaptive management plans.

CCB selected two communities (CSS and riparian) supporting large numbers of Covered Species and subject to a host of anthropogenic influences to begin development of community monitoring methodologies. Specific taxa were sampled as they were postulated to be potentially important indicators of the relative integrity of community processes. Protocols were established to monitor these taxa and assess environmental conditions within each community. Chapters 9 and 10 explain the community monitoring approach, and provide the results of the first year of monitoring in 2004. Appendix 3 presents the initial protocols used in monitoring.

Below is a description of the next steps to be undertaken in the development of the monitoring framework. As the CCB initiated the middle phase in 2004, we were only able to begin testing covered lizard species niche models. The following described activities need to be undertaken before the implementation of Monitoring Phase 3.

Framework Evaluation

Framework evaluation is an iterative process between modeling and monitoring activities. Models predict where species and communities should be sampled, and identify assessable variables. Data collected in monitoring not only provides information on the status of Covered Species but also is usable for model evaluation and refinement. This iterative process improves our understanding of species-habitat relationships and threats to species persistence, which then contributes to the development of adaptive management plans.

Habitat suitability maps, produced by the niche models, provide guidance on where Covered Species and communities should be monitored in the next field season. These niche models provide hypotheses about species habitat relationships, whereas conceptual models postulate potential responses of species populations to natural and anthropogenic processes. To be effective in managing Covered Species populations, these models require testing and evaluation. As such, it is necessary to collect independent species location datasets with which to evaluate and refine the models. These models should be periodically re-evaluated with monitoring data collected under a range of environmental conditions, such as the dramatic fluctuations in precipitation that characterize the region.

In combination with testing and evaluating models, different field techniques and sampling strategies should be tested for their effectiveness when collecting community monitoring data. The intention is to create reliable protocols that fit into an efficient sampling regime, which collects the necessary information allowing managers to assess the status and identify potential threats to Covered Species populations.

Monitoring Implementation

Once protocols have been tested and refined, and baseline conditions established, scientists and land managers decide on where to set-up the monitoring program for maximum effectiveness.

As previously mentioned, these are the initial steps taken by the CCB in developing a monitoring framework for the WRC MSHCP, as part of the CDFG-funded *Inland Ecosystems of California: Resource Assessment Project (2003-2005).* The following chapters describe the undertaken steps in detail, present results to date, and recommend future actions to complete the development of this proposed monitoring framework.

OCCUPANCY APPROACH

The community approach outlined above focuses on known species assemblages, however, not all covered species will conveniently fall into one or more community types. These species must be targeted individually. For some species, plants for example, only a few locations will ever exist where a given species is extant and these areas can be checked repeatedly from year to year or as climatic conditions favor their germination. Once these populations go extinct, the species is lost within the Plan area.

For other species that are more widespread a potential means for monitoring their persistence in the Plan Area may be through the occupancy approach. Based on a population viability analysis (PVA) using a metapopulation model first developed by Levins (1969) and later refined by Hanski (1997, 2002) for populations in a highly fragmented landscape, the occupancy approach may be applicable if a species exhibits metapopulation behavior. Due to their fragmented arrangement and their ability to colonize and re-colonize available habitat, metapopulation species occupy small habitat units that may constantly wink in and out of existence (local extinction), but are sustained by occupying some habitats all the time, and emigrating and re-occupying lost habitats during favorable conditions. The dynamics of the metapopulation can be modeled by a variety of mathematical models, provided the necessary information is available to parameterize the model (Hanski and Simberloff 1997). Before the approach can be applied, it will be necessary to determine if the subject species exhibit metapopulation behavior.

A key assumption of the metapopulation models used to develop the occupancy approach is that environmental conditions do not change over the time period for which the model is relevant. This may not be the case in the Plan Area since in the long term, local environmental conditions may experience modification through changes in land use. Therefore, the use of the occupancy approach may be restricted to shorter time frames (Hanski 2002). The model does allow for a minimum of information using presence/absence data and assessment of habitat quality. CCB did not pursue the possible implementation of the occupancy approach due to the short duration of the funding cycle, however data may be available in the future to test the applicability of the metapopulation models on covered species in the Plan Area.

DEMONSTRATE CONSERVATION SPECIES

Section 5.0 of the WRC MSHCP (Dudek and Associates 2003) document lists sixteen species (13 plants, 2 birds, and 1 mammal) as demonstrate conservation species (Appendix Table 1.2). While covered by the Plan, these species require additional information regarding their extent (number of extant populations) and status with the Plan area. The County of

Riverside charged CCB with determining whether the criteria outlined in section 5.0 for each species are met on lands already protected. If not, then additional requirements may be imposed to insure the species needs are met. Efforts for surveying for the vertebrate species are outlined below (Chapters 12 and 14). The results of surveys for the rare plants found on the list are discussed in the rare plant section (Chapter 13).

CHAPTER 2
TIME AND EFFORT

An important research initiative of the Center for Conservation Biology (CCB) is to foster the conservation of sensitive species through planning, management and restoration of habitats that support these species in Riverside County. Through multiple collaborations with UCR faculty and researchers, the CCB has contributed to a large array of projects that directly provide information and new research on local problems. The research projects include participation from graduate and undergraduate students, which enhances their training and understanding of local issues. Specific results of some of these other CCB research projects are presented elsewhere (e.g., http://www.cvmshcp.org/biomon). To provide a context to evaluate the extensive time and effort that were employed in conceptual development and initial evaluation of this framework, CCB has compiled the time and effort expended to date on developing a monitoring program for multiple species conservation plans.

CCB spent considerable time and effort in initial development of the monitoring framework for WRC MSHCP in fiscal years 2002-2003, 2003-2004, and 2004-2005 (Table 2.1). The hours presented here not only include work done in Western Riverside County proper, but also overlaps with work on the conceptual framework and testing conducted on the Coachella Valley MSHCP. The development of the monitoring program began within the sand and riparian communities in the Coachella Valley, which served as a basis for the conceptual development and testing of the community-based monitoring framework described in Chapter 1 (e.g., Barrows et al. 2005). Collected data for the Coachella Valley included multiple years of population data for a few Covered Species under variable environmental conditions, these long-term datasets facilitated the development and evaluation of the conceptual basis of the monitoring framework. Niche models and conceptual models were first developed and evaluated for Coachella Valley Covered Species with the techniques later applied by CCB biologists to species in Western Riverside County. Many of the sampling methods employed in Western Riverside County were first tested in the Coachella Valley. For example, the riparian community monitoring surveys conducted in Western Riverside County during the spring and summer of 2004 were modified from similar surveys in the Coachella Valley.

The bulk of the hours spent on developing a monitoring framework in all three fiscal years were allotted to fieldwork (42%, 42%, and 36 %) and to project development and management (24%, 22%, and 18%). Data entry used up 10%, 12%, and 17% of the time over the three years and compilation of the species database, Geographic Information Systems (GIS) tasks, and constructing and evaluating niche models accounting for 17%, 14%, and 16% of the time. Approximately 8%, 10%, and 13% of time in the three years were allocated to analyses and report preparation.

To accomplish some of the tasks outlined in Table 1.1., CCB conducted focused surveys for rare plants, covered lizard species, Burrowing Owls and raptors in 2003 and 2004 that accounted for approximately 24% of the total fieldwork. Western Riverside County coastal sage scrub and riparian community sampling and Coachella Valley sand community monitoring and riparian surveys accounted for the 72% of the fieldwork. CCB also helped CDFG map vegetation for Western Riverside County, which accounted for 4% of the fieldwork time.

Tables 2.2 and 2.3 list the number of sampling points and the hours spent in the various community monitoring tasks in the Western Riverside County Plan Area during 2004. CCB sampled over 127,000 meters of transects (~8 miles) measuring coastal sage scrub communities and assessed 58,000 meters (~36 miles) of riparian drainages. The total amount of time spent in fieldwork is greater in Table 2.1, as Tables 2.2 and 2.3 only list the time actually spent gathering data in these communities that was later used in analyses. These tables do not account for time spent training crews to conduct surveys, time spent developing and revising the coastal sage vegetation sampling protocol, and days when crews traveled to field sites but were unable to gain access for various reasons. Field crews also spent time identifying plants in the herbarium and processing arthropods that is not accounted for in Tables 2.2 and 2.3. While the total number of hours spent surveying riparian and coastal sage scrub taxa were similar, there were over twice as many community monitoring points measured in riparian compared with coastal sage scrub habitats. Surveys took longer in coastal sage scrub because vegetation sampling at each point required about twice as much time as vegetation sampling in riparian habitats. This is attributed to different sampling methods used in the two communities (Chapters 9 and 10). The sampling goals for vegetation characterization were different and more detailed measurements were required in coastal sage scrub to characterize the transition between coastal sage scrub and non-native grassland habitats. Arthropod pitfall-trap setup and surveys for mammal sign and other species were included in the vegetation sampling hours as these activities were carried out concurrently. Considerably more time was spent surveying birds in riparian habitats as repeated visits (2 to 3) were made to many of the points and in coastal sage scrub bird points were only surveyed once. Since coastal sage scrub vegetation sampling proved time consuming, only a subset of the bird survey points were measured for vegetation and other taxa. The reptile surveys conducted along 100-meter community transects were the least time consuming task.

Among the focused surveys, rare plant surveys required the most effort (Table 2.1) because of the large number of survey sites distributed throughout the Plan Area (Chapter 13). Many sites were remote and required a considerable amount of travel time. Lizard niche model survey protocols also required observers to spend considerable time hiking through rugged terrain, particularly compared with the more accessible locations for raptors and Burrowing Owls (Chapters 6, 14, 15, and Appendix 3).

There was extensive participation and oversight by faculty representing biology, entomology, botany, environmental sciences, and earth sciences in overseeing the project (Table 2.1). Faculty members provided scientific expertise in designing the project, developing niche models, and analyzing and interpreting results. The project coordinator and project manager were responsible for developing protocols and sampling strategies, scheduling field surveys, and supervising and training personnel to collect data. A large amount of time was spent coordinating surveys in 2004 when 17 undergraduate and graduate students, post-doctoral research fellows, staff, and volunteers worked in the field on the riparian and coastal sage scrub community sampling tasks alone. Obtaining permits proved time consuming since reserves within the Plan Area are owned and managed by several different government agencies that have varying requirements and levels of difficulty for obtaining permission to conduct surveys on their lands. During the project, coordinating and reviewing data entry, data analysis and report preparation were the main components of management time. Administrative support for purchasing, travel, contracts, budgeting, report preparation, and other support services are also included within the management category.

Over 64,000 records were entered into 21 riparian and coastal sage scrub community monitoring databases in 2004. These records represent detailed information about detections of birds, reptiles, and mammals, types of arthropods captured during pitfall trapping, records of mammal sign, vegetation measurements, and anthropogenic evaluations of sampling points. The focused surveys also resulted in substantial data entry efforts in 2003 and 2004, particularly for rare plants. Data entry and checking continued into 2005 as datasets were finalized for transfer to CDFG.

Obtaining and compiling the species location database, preparing GIS layers for niche modeling and running the niche models took considerable time, particularly in 2005 (Table 2.1). Table 2.4 breaks down the hours spent in various database and GIS related tasks. The greatest amount of time was spent in acquiring and compiling the species location database and preparing GIS layers for niche modeling. Running individual niche models and evaluating the results was also time intensive. Analyzing data and preparing reports took up 11% of the overall time devoted to developing the monitoring framework.

The information provided in this chapter is to offer realistic planning and budget guidance for the development of future monitoring efforts. As additional testing and refining improve the performance of niche models and survey methodologies, we expect that costs may decrease in some areas. However, this will be counter-balanced by the need to survey a larger number of sites over time.

Table 2.1 Hours spent in different tasks for the *Inland Ecosystems of California: Resource Assessment Project.*

Task	Fiscal Year			
	1/Nov/02 30/Jun/03	1/Jul/03 30/Jun/04	1/Jul/04 15/May/05	Total
Project Development and Management				
Faculty Oversight/Review	952	1,363	1,290	3,605
Task Management	1,706	4,035	3,238	8,979
Administrative Support	875	3,813	2,298	6,986
Development/Management Subtotal	***3,533***	***9,211***	***6,826***	***19,570***
Fieldwork				
Coastal Sage Scrub Community Monitoring		548	2,310	2,858
Riparian Community Monitoring		730	2,479	3,209
Rare Plant Surveys	618	2,813	2,348	5,779
Lizard Surveys for Niche Modeling		1,536	480	2,016
Burrowing Owl Surveys	125	126	252	503
Raptor Surveys		227	229	456
Coachella Valley Sand Dune and Riparian Community Monitoring	4,136	11,629	5,644	21,409
WRC Vegetation Mapping	1,344	336		1,680
Fieldwork Subtotal	***6,223***	***17,945***	***13,742***	***37,910***
Data Entry/Management				
Community Monitoring Data		375	2,103	2,478
Rare Plant Data		403	598	1,001
Lizard Niche Model Data		220	194	414
Burrowing Owl Data	25	63	50	138
Raptor Data		25	35	60
Arthropod Identification and Data Entry		1,258	1,825	3,083
Coachella Valley Sand Dune and Riparian Community Data Entry	1,109	1,694	1,309	4,112
Archival Data Entry – Plants and Insects	280	891	346	1,517
Data Entry/Management Subtotal	***1,414***	***4,929***	***6,460***	***12,803***
Species Database, GIS, and Niche Modeling				
Faculty Oversight	212	280	167	659
Task Completion	2,313	5,872	5,893	14,078
Species Database/Niche Modeling Subtotal	***2,525***	***6,152***	***6,060***	***14,737***
Data Analysis/Report Preparation				
Faculty Oversight	326	412	565	1,303
Task Completion	809	3,779	4,369	8,957
Data Analysis/Report Preparation Subtotal	***1,135***	***4,191***	***4,934***	***10,260***
Project Total	**14,830**	**42,428**	**38,022**	**95,280**

Table 2.2 Coastal sage scrub community monitoring survey effort by task in 2004 for the Western Riverside County Plan Area. Survey effort includes time spent traveling to and from each site on multiple survey days and the time traveling between survey points.

Site	# of Bird Points	# of Person Hrs/ Birds	# of Reptile Points	# of Person Hrs/ Reptiles	# of Vegetation Survey Points	# of Arthropod Survey Points	# of Person Hrs/ Vegetation & Arthropods	Total # of Person Hrs
Crown Valley	8	16	12	16	12	12	110	142
Lopez Canyon	21	40	13	22	13	13	150	212
Motte Reserve	36	64	23	44	23	23	350	458
Shipley Skinner Headquarters	18	40	11	16	11	11	170	226
East North Hills	15	32	8	19	8	8	100	151
West North Hills	69	120	39	50	39	39	480	650
West Potrero Canyon	18	40	10	19	10	10	190	249
Mid Potrero Canyon	20	40	12	20	12	12	170	230
Totals	**205**	**392**	**128**	**206**	**128**	**128**	**1,720**	**2,318**

Table 2.3 Riparian community monitoring survey effort by task in 2004 for the Western Riverside County Plan Area. Survey efforts include time spent traveling to and from each site on multiple survey days, and time traveling between survey points at each site. Note that the number of bird surveys conducted per point ranged from 1 to 3.

Site	Survey 1 # of Bird Points	Survey 1 # of Person Hrs	Survey 2 # of Bird Points	Survey 2 # of Person Hrs	Survey 3 # of Bird Points	Survey 3 # of Person Hrs	Total # of Person Hrs/ Bird Surveys	# of Riparian Vegetation Survey Points	# of Arthropod Survey Points	# of Other Species Survey Points	# of Person Hrs/ Vegetation & Arthropods	Total # of Person Hrs
Bautista Creek	38	60	38	60	0	0	120	38	38	38	200	320
Box Springs	3	4	3	4	0	0	8	3	3	3	10	18
Estelle Mountain	3	16	0	0	0	0	16	0	0	0	0	16
Santa Gertrudis Creek	14	20	14	20	0	0	40	14	14	14	50	90
Mockingbird Canyon	16	20	16	20	12	16	56	16	16	16	60	116
Motte Reserve	4	8	4	8	0	0	16	4	4	4	10	26
Potrero Canyon	37	60	37	60	13	24	144	37	37	37	180	324
Santa Ana River (4 sites)	77	104	55	80	21	40	224	77	77	77	440	664
Shipley Skinner Reserve	17	40	17	40	0	0	80	17	17	17	150	230
San Timoteo Canyon	28	40	28	40	14	20	100	28	28	28	150	250
San Jacinto River	2	4	0	0	0	0	4	2	2	2	10	14
Sycamore Canyon	22	40	22	40	0	0	80	22	22	22	120	200
University	2	2	0	0	0	0	2	2	2	2	5	7
Warm Springs Creek	21	36	21	36	0	0	72	21	21	21	180	252
Wilson Creek	6	20	0	0	0	0	20	0	0	0	0	20
TOTAL	**290**	**474**	**255**	**408**	**60**	**100**	**982**	**281**	**281**	**281**	**1,565**	**2,547**

TABLE 2.4 TIME & EFFORT for SPECIES OCCURRENCE DATABASE, NICHE MODELING & OTHER GIS RELATED TASKS - CDFG PROJECT AND FINAL REPORT

	Fiscal Year			
	2002/2003	**2003/2004**	**2004/2005**	**Total Hrs**
TASKS				
SPECIES OCCURRENCE DATABASE	1,553	2,716	844	**5,113**
• MUSEUM QUERIES	248	0	47	**295**
• GEOREFERENCE SPECIES RECORDS and INTEGRATE per SPECIES GROUP	1,033	1,002	40	**2,075**
• SPECIES OCCURRENCE DATABASE DESIGN	272	1,267	52	**1,591**
• ACCESSION SPECIES RECORDS		149	235	**384**
• TEMPORARY VERSION of SPECIES DATABASE for PARTITIONED NICHE MODELING		100	62	**162**
• FINAL VERSION of SPECIES DATABASE for CDFG			210	**210**
• METADATA and DATA DICTIONARY		198	80	**278**
• DATABASE TESTING and TROUBLESHOOTING			118	**118**
GIS RELATED TASKS and NICHE MODELING	972	3,436	5,217	**9,625**
• COMPILE GIS LAYERS from DIFFERENT SOURCES	130	174		**304**
• GIS METHODOLOGIES & STANDARDS	75	232		**307**
• MAPS for FIELD SURVEYS	125	273		**398**
• NON-PARTITIONED NICHE MODEL DEVELOPMENT & TESTING	415	100		**515**
• SPECIES-SPECIFIC NICHE MODELS - PARTITIONED MAHALANOBIS D^2	227	2,657	4,573	**7,457**
Conceptual Development & Testing (Preliminary Runs), GIS Layer Creation & Preparation, Calibration & Map datasets Creation, Model Runs per WRC MSHCP Covered Species, Model Refinement, Error Checking, Re-Runs, Model Completion and Map Creation				
• COMMUNITY-BASED NICHE MODELING			231	**231**
Develop Methodology and Species to Include, Run Individual Species Models, Run Community Model, Model Refinement, Produce Final Map				
• MENU of GIS LAYERS with METADATA and DATA DICTIONARY			368	**368**
• ADDITIONAL MAPS for FINAL REPORT			45	**45**
Community Survey Point Maps, Over All Site Map, Locator Map of Study Areas, Species Richness per Community Chart, Burrowing Owl Historical and New Locations Map, Build-Out Map for California Gnatcatcher				
TOTAL PERSON HOURS:	**2,525**	**6,152**	**6,061**	**14,738**

CHAPTER 3
DEVELOPING NICHE MODELS WITH PARTITIONED MAHALANOBIS D^2

Draft White Paper

John T. Rotenberry

Spatially explicit habitat suitability models provide potentially powerful tools for ecologists and conservation biologists. Coupled with the advent of improved Geographical Information Systems (GIS) software and digital environmental layers, the development of new modeling techniques allows us to create multivariate species' niche models encompassing large geographic areas. These "regional" niche models incorporate hypotheses about a species occurrence relative to various synoptic environmental variables that are available as GIS spatial layers. Digital environmental layers such as elevation, slope aspect, precipitation, temperature, soil type, land use, and vegetation type (often used as a surrogate for "habitat type") may be incorporated into regional niche models.

Such models can have direct relevance to the ecology and conservation of targeted species. For one, most modeling techniques permit the identification of the relative "importance" of individual variables (or their combinations) in influencing the distribution of a species. Although these "importances" are often more statistical than biological, they nonetheless serve as working hypotheses that can guide further, perhaps more experimental, investigation, as well as assist in implementing adaptive management decisions. For another, they provide a spatially explicit assessment of habitat suitability. It is one thing to know what variables are important; knowing where the appropriate combination of variables occurs can be equally valuable. Moreover, if the model is robust, predictions about habitat suitability can be extended into areas where there is currently no information about the occurrence of a particular species, where such predictions may help focus additional survey effort or guide the design of more efficient species' preserves.

Model builders are faced with several challenges in producing potentially useful predictive models. For example, habitat suitability models typically are created using abundance, density, or presence-absence data collected during surveys for the species of interest (Guisan and Zimmerman 2000, Brotons et al. 2004). However, creation of regional models encompassing large geographic areas (such as a county, state, or even larger area) generally requires using multiple sources of data collected with different survey methodologies. Whereas large-scale databases for sensitive plant and animal species are available (e.g., USFWS endangered species database, various state-based natural diversity databases, and museum collections' databases), these typically provide information on the presence of a target species at a point, but rarely report the absence of a species from a surveyed area. To further complicate matters, even with directed surveys obtaining "true absence" data can be problematic, especially for species that are rare and/or difficult to detect (Knick and Rotenberry 1998, Dunn and Duncan 2000, Rotenberry et al. 2002, Hirzel et al. 2002). Another challenge facing niche modeling is predicting a species' occurrence outside of the original study area or in a situation where the environment is undergoing change; in such cases, the particular combination of habitat characteristics present where the original data were collected may not exist (Knick and Rotenberry 1998, Rotenberry et al. 2002). To meet these challenges, new modeling techniques have been developed to create regional niche models predicting habitat suitability based solely on locations where a species is present, and which are relatively robust to the inadvertent inclusion of non-relevant environmental variation (Clark et al. 1993, Knick and Rotenberry 1998, Dettmers and Bart 1999, Dunn and Duncan 2000, Hirzel et al. 2002, Rotenberry et al. 2002). Our objective is to make one of these techniques widely available and easily implemented.

Mahalanobis D^2

We begin with Mahalanobis D^2 (Clark et al. 1993, Dunn and Duncan 2000, Rotenberry et al. 2002, Browning et al. 2005). Concisely, Mahalanobis D^2 is simply the standardized difference between the values of a set of environmental variables for any point (or rasterized cell or pixel in a GIS layer) and the mean values for those same variables calculated from all points at which a species was detected. Thus, the more similar in environmental conditions a point is to the species' mean, the smaller the D^2 and the more "suitable" the habitat at that point.

Eqn. 1: Mahalanobis distance D^2:

$$D^2(\mathbf{y}) = (\mathbf{y} - \boldsymbol{\mu})' \, \boldsymbol{\Sigma}^{-1} \, (\mathbf{y} - \boldsymbol{\mu})$$

Where $\boldsymbol{\mu}$ = vector of means based on $\mathbf{H}$ (p x 1) (i.e., the centroid),

$\mathbf{H}$ = "occupied habitat," an n x p matrix of p variables measured at n points where a species was detected,

$\mathbf{y}$ = vector of measurements on any point (p x 1; may or may not be taken from $\mathbf{H}$); thus $\mathbf{y} - \boldsymbol{\mu}$ is a vector of deviations of a point from a species' mean vector,

$\boldsymbol{\Sigma}$ = variance-covariance matrix based on $\mathbf{H}$ (p x p), and

D^2 is a squared scalar distance, standardized in the $\boldsymbol{\Sigma}$ metric.

Because D^2 follows a Chi-squared distribution, it can be rescaled to range from 0 to 1 (called "p-values," although they lack statistical implications), with 1 representing environmental conditions identical to the species' mean (Clark et al. 1993).

Use of D^2 to characterize a species' habitat relationship assumes that the original sample reflects the optimal habitat distribution of the animals in the sampled landscape. As a corollary, it assumes that the selection response has been fully characterized (at least in the vicinity of the mean), or in other words, that $\boldsymbol{\mu}$ and $\boldsymbol{\Sigma}$ fully characterize the species response to habitat. This implies two additional features: the sampled area contains the full range of habitat variation to which the species responds, and we have identified and measured the appropriate variables (i.e., we have not left out any that are important, and we have not included any that are irrelevant). These assumptions are not always justified. Although D^2 performs quite well in many circumstances (e.g., Knick and Dyer 1997), it may perform poorly when applied to areas not included in the original sample or if applied to dynamic landscapes, such as those that are disturbance prone (whether natural or anthropogenic) or undergoing restoration or succession (Knick and Rotenberry 1998, Rotenberry et al. 2002).

Partitioning Mahalanobis D^2

Modeling techniques based on dissimilarity to an *optimum* configuration may not be ideal for predicting animal occurrence because of the uncertainty associated with defining a biological optimum from distributional data. We propose, instead, that identifying a *minimum* set of basic habitat requirements for a species is more appropriate for predicting potential animal use in changing environments.

The performance of D^2 is improved by "partitioning" it into separate components, each representing independent relationships between a species' distribution and environmental variables (Dunn and Duncan 2000, Rotenberry et al. 2002).

Eqn. 2a: Partitioned D^2 for any point $\mathbf{y}$:

$$D^2(\mathbf{y}) = \sum_{j=1}^{p} d_j^2/\lambda_j$$

Where $\lambda_1 \geq \ldots \lambda_k \ldots \geq \lambda_p$ are the eigenvalues of $\boldsymbol{\Sigma}$, and

$$d_j = (\mathbf{y} - \boldsymbol{\mu})' \boldsymbol{\alpha}_j$$

where $\mathbf{y}$ and $\boldsymbol{\mu}$ are as above, and $\boldsymbol{\alpha}_j$ is the eigenvector associated with λ_j.

Eqn. 2b: Alternatively,

$$D^2(\mathbf{y}) = d_1^2/\lambda_1 + \ldots + d_k^2/\lambda_k + \ldots + d_p^2/\lambda_p$$

These distance partitions are additive, and each is associated with an eigenvalue and eigenvector arising from a principal components analysis (PCA) of the dataset $\mathbf{H}$ containing the values of the environmental variables from the points at which the species occurred. Unlike regular PCA, however, biological significance is attached to those components with the *smallest*, rather than the largest, eigenvalues (which in PCA are measures of variance). This is based on the notion (consistent with the idea of the species' niche; Hutchinson 1957, Pulliam 2000) that we want to identify the *constant relationships* in a species' distribution (i.e., which variables maintain a *consistent* *value* where the species occurs), which are those most likely to be associated with limiting factors. Any environmental variables that take on a wide range of values, where a species occurs (and which will therefore be associated with components with larger eigenvalues), are less likely to be informative since they are not restrictive of a species' distribution, at least over the range of variation sampled. Collins (1983) and Knopf et al. (1990) have also presented this concept, although in substantially different forms. Dunn and Duncan (2000) and Rotenberry et al. (2002) show the relationship between the partition with the lowest eigenvalue and Pearson's "plane of closest fit" (Pearson 1901), that plane for which the sums of squares of the perpendiculars from a set of points to the plane is a minimum. The variance of these projections of points on a vector normal to such a plane will be a minimum, the same as the variance of points projected onto an axis defined by the eigenvector associated with the smallest eigenvalue. Axes, or partitions of D^2, associated with increasingly larger eigenvalues represent combinations of variables that are increasingly less consistent where a species occurs.

Not all of the p components of $D^2(y)$ as partitioned above define limiting combinations of habitat variables. Some $p - k$ of these do not define habitat suitability, but rather are included in $D^2(y)$ simply because the investigator decided a priori to measure p habitat variables. Certainly the first principal component cannot be considered a limitation since its variance is λ_1, the maximum possible. Thus, habitat suitability for a p-dimensional y is

Eqn. 3:

$$D^2(\mathbf{y};k) = d_k^2/\lambda_k + \ldots + d_p^2/\lambda_p$$

for some $1 \leq k \leq p$. Thus, suitability of a particular habitat location **y** for a species would be measured in terms of deviations from k basic requirements for that species, to the extent that we are able to know k.

The partitioned D^2's can be considered sequentially, beginning with that associated with the single smallest eigenvalue, then the two smallest, the three smallest, etc. If we add all the partitions together, we have the original D^2 model.

The choice of k (or rank of the model) is likely to be somewhat qualitative. Dunn and Duncan (2000) suggest that one examine the magnitude and relative spacings among the eigenvalues, the interpretability of the partitions (see below), and the credibility of predicted use areas that result from particular choices of k. In this respect, use of partitioned D^2 does not differ from other principal components applications where interpretability often dictates the choice of the number of "ecologically significant" dimensions. Alternatively, if one has validation data one can examine the predictive value obtained by successive increases in k. An additional consideration is that increasing the number of k partitions used results in an increasingly restrictive model, analogous to increasing the fit (and potentially reducing the generality) of a multiple regression model by adding variables. In the end this yields the original D^2 model that Knick and Rotenberry (1998) criticized as overly restrictive.

Assessing which environmental variables are associated with likelihood of occurrence is based on examination of the PCA's eigenvector values associated with each partition of D^2; variables with larger absolute eigenvector values are considered more "important" (Dunn and Duncan 2000). For this interpretation to be valid, environmental variables should be in identical units; this is effectively achieved by performing the PCA on a correlation matrix (i.e., a variance-covariance matrix of standardized variables). A major advantage of partitioning is that less distributionally relevant variables (assuming some are unknowingly included in the original variable set) are shifted to components with larger eigenvalues, and thus may not contribute to the final, reduced-rank model (Rotenberry et al. 2002). As with selecting k, there is no numerical or statistical criterion for distinguishing "important" from "unimportant" eigenvector values. However, in practice there often appears to be a sharp demarcation between near-zero and higher values (Dunn and Duncan 2000).

Once a satisfactory model is obtained for a species, it may be used to calculate a p-value (representing habitat suitability on an increasing 0-1 scale) for any point for which one has values for the environmental variables:

Eqn. 4:

$$\text{p-value for } D^2(\mathbf{y};k) = 1 - \text{prob}(\chi^2, \text{df} = k)$$

where k may range from 1 to p, the latter representing a full-rank model, or simply D^2 (Clark et al. 1993). In most cases, p-values will be calculated and mapped for all points in a landscape of interest, and/or for a set of independently derived validation points (i.e., points where the target species was detected, but that were not included in creating the model; Guisan and Zimmermann 2000).

Calculations for D^2, $D^2(\mathbf{y};k)$, and their p-values are all easily calculated in SAS (SAS Institute 2001, Duncan and Dunn 2001).

We show two niche models for California Gnatcatchers (*Polioptila californica*) calculated for a roughly 480,000 ha area of western Riverside County, California (Figs. 1 and 2). Both are based on an analysis of 21 environmental variables (several climatic and topographic variables, distances to certain landscape elements, plus proportion coverages of major vegetation types within a 250-m radius) assessed at 566 points (80%) that were randomly selected from the original 706 locations where gnatcatchers had been detected. One is a full-rank model based on p-values from the total D^2 (Fig. 3.1); the other is a reduced-rank model using the smallest partitioned D^2, $D^2(\mathbf{y};1)$ (Fig. 3.2). Examining the distribution of eigenvalues suggests that, at least as a preliminary cut, retaining only the last eigenvector may produce a satisifactory reduced-rank model (Table 3.1). Other potential "breaks" in the distribution appear with eigenvalues associated with the 20th ($D^2(\mathbf{y};2)$) and the 14th ($D^2(\mathbf{y};7)$) components. Environmental variables with relatively high absolute eigenvector values on the 21st component are CL4GS, CL5GS, and CL6GS (Table 3.2); we interpret these variables as defining the most "suitable" habitat for gnatcatchers in this region. Note that these variables appear "important" because they have relatively consistent values where gnatcatchers occur; other variables have considerably higher variance when measured across gnatcatcher-occupied points, and thus are considered to be less restrictive of gnatcatcher distributions. Mean values of these variables, and their variances, is given in Table 3.3. Note also that the increased precision (reduced generality) of the full-rank model is manifest in the identification of less area as potentially "suitable."

The reduced-rank model using only the 21st component (i.e., $D^2(\mathbf{y},1)$) scored the validation dataset quite well, yielding a median p-value of 0.828 for 140 points. Other suggested reduced-rank models did not perform as well, with a median of 0.734 for the validation dataset.

Field Surveys to Collect an Independent Dataset for Niche Model Evaluation

The "gold standard" for evaluating habitat models is to use a data set generated independently from the observations used to construct the model in the first place (Guisan and Zimmermann 2000). Ideally, an independent data set of bird locations from across the study area is used to evaluate model performance for the set of candidate models predicting a species' occurrence. This allows identification of the model that best describes a species distribution and that provides information on those environmental predictors that can be most effectively monitored to provide information on the status of the species of interest.

Receiver operating characteristic (ROC) plots applied to validation datasets can be used to assess the accuracy of each model (Fielding and Bell 1997). These ROC plots have the advantage of being threshold-independent; that is, they do not require an *a priori* specification of a cut-point (e.g., a p-value > 0.5) to determine whether a model does or does not predict the presence of a species. However, analysis of an ROC plot does permit the estimation of the most efficient threshold for predicting presence or absence from model output.

For species with sufficient observations, a classical cross-validation approach can be employed as well. A randomly selected subset of data points (e.g., 20%) can be withheld while the ecological niche model can be created with the remaining points (e.g., 80%). Accuracy can be assessed using ROC plots. To ensure enough points in each set to provide meaningful results, a minimum of 40 independent points can be set to employ this approach. While this type of evaluation falls somewhat short of the "gold standard," the results can be compared to that of the standard to evaluate this validation technique. For those species for whom obtaining a sufficiently large independent data set to use in validation may be difficult, this exercise indicates the degree of confidence that can be placed in this alternative technique. The proximate significance of these models is that they contribute to conservation planning, monitoring, and management of sensitive species by increasing knowledge of species habitat requirements at the regional scale. Comparisons can be made among species to determine which environmental drivers appear most important in predicting a particular species distribution, and to assess the extent to which multiple species share common responses. A greater understanding of habitat relationships manifest at the regional scale has two additional direct benefits. First, it facilitates designing and refining future monitoring and sampling strategies both to further test habitat relationships and to see how populations respond to changing environmental conditions (natural and anthropogenic). Secondly, it permits identification of those lands with potentially high conservation value for a target species, which can then be prioritized for conservation acquisition. Overall, these models are tools that can be used to guide adaptive management strategies and recommendations at the regional level and at the level of individual preserves.

Although there are a plethora of analytical tools developed by ecologists to assess habitat relationships (Scott et al. 2002), few have been subjected to rigorous, independent testing (Guisan and Zimmerman 2000). Validation of this modeling approach will facilitate its use as a tool well into the future. It will allow use of the considerable amount of existing information on species distributions, information not dependent upon the existence or creation of multiple species-specific surveys. As such, it can be more easily extended to conservation efforts in different regions.

Figure 3.1. Full-rank ecological niche model for California Gnatcatchers based on 21 environmental variables. Habitat suitability increases as color changes from yellow to blue.

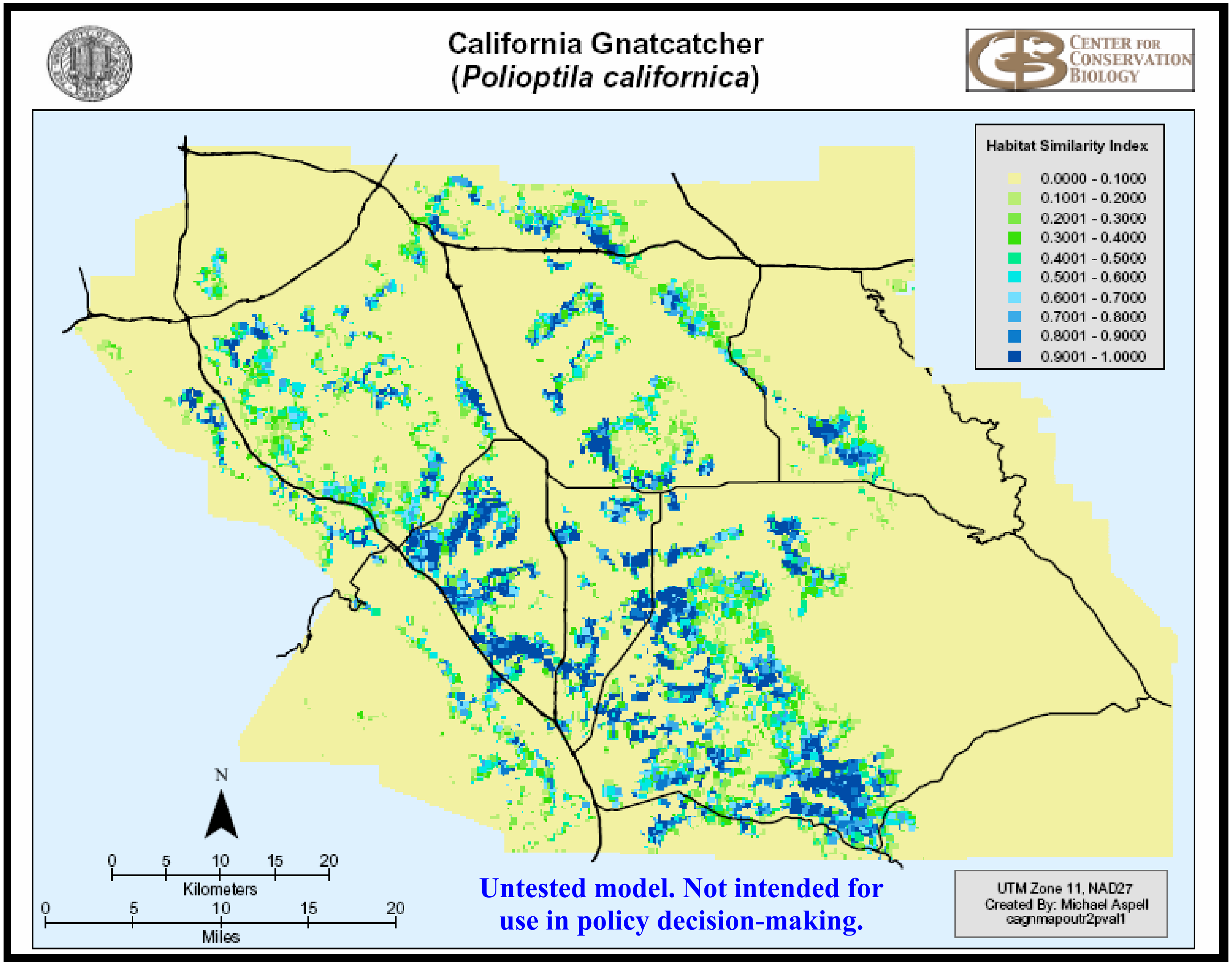


Figure 3.2. Reduced-rank ecological niche model for California Gnatcatchers using same variables as in Fig. 3.1, but using the smallest partitioned D^2. Habitat suitability increases as color changes from yellow to blue.

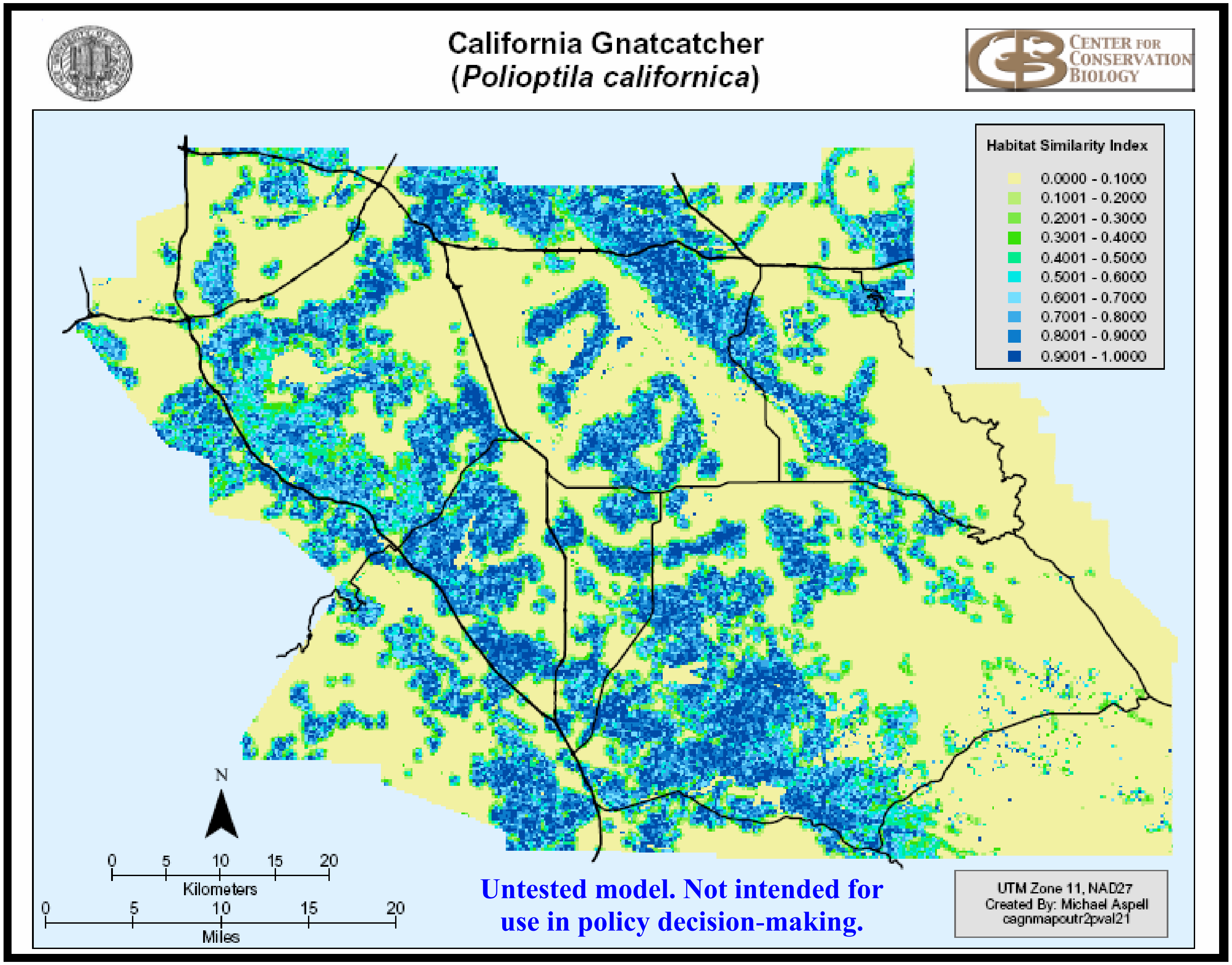


Table 3.1. Results of principal components analysis performed on a correlation matrix of 21 environmental variables assessed at 566 points where California Gnatcatchers were detected in western Riverside County, California.

Principal Component	***k***	Eigenvalue	Proportion	Cumulative Proportion
1	21	4.307632	0.2051	0.2051
2	20	2.191995	0.1044	0.3095
3	19	1.775825	0.0846	0.3941
4	18	1.498409	0.0714	0.4654
5	17	1.299697	0.0619	0.5273
6	16	1.268958	0.0604	0.5877
7	15	1.172015	0.0558	0.6435
8	14	1.06354	0.0506	0.6942
9	13	0.946606	0.0451	0.7393
10	12	0.860575	0.0410	0.7803
11	11	0.783401	0.0373	0.8176
12	10	0.773595	0.0368	0.8544
13	9	0.722581	0.0344	0.8888
14	8	0.487229	0.0232	0.9120
15	7	0.445378	0.0212	0.9332
16	6	0.417711	0.0199	0.9531
17	5	0.347218	0.0165	0.9696
18	4	0.295632	0.0141	0.9837
19	3	0.212982	0.0101	0.9939
20	2	0.110757	0.0053	0.9991
21	1	0.018262	0.0009	1.0000

Table 3.2. Eigenvector values associated with the 21st component resulting from principal components analysis performed on a correlation matrix of 21 environmental variables assessed at 566 points where California Gnatcatchers were detected in Western Riverside County, California.

Environmental Variable	Environmental Variable Description	Eigenvector 21
ELEV	Median elevation for an 8 pixel x 8 pixel (240m x 240m) neighborhood at the point	0.028
EAST_0	Eastness = median sin(aspect) for an 8 pixel x 8 pixel (240m x 240m) neighborhood at the point	0.010
NORTH_0	Northness = median cos(aspect) for an 8 pixel x 8 pixel (240m x 240m) neighborhood at the point	-0.002
SLOPE	Median slope (percent) for an 8 pixel x 8 pixel (240m x 240m) neighborhood at the point	-0.017
PRECIP	Median annual precipitation at the point (mm)	-0.012
MINTJAN	Minimum mean annual temperature (°F) at the point	0.015
MAXTJUL	Maximum mean annual temperature (°F) at the point	-0.004
CSS_AREA	Size (meter^2) of the coastal sage scrub patch closest toor at the point	0.028
FIN_DCSS	Distance (m) from the point to the closest patch of coastal sage scrub (the value is zero when point is within a coastal sage scrub patch)	0.057
DIST2_WAT	Distance squared (meters) from the point to the nearest body of open water	-0.001
CL1GS	Sum of pixels classified as "Agriculture" within an 8 pixel x 8 pixel (=240m x 240m) neighborhood at the point	0.226
CL2GS	Sum of pixels classified as "Developed" within an 8 pixel x 8 pixel (240m x 240m) neighborhood at the point	0.178
CL3GS	Sum of pixels classified as "Riparian" within an 8 pixel x 8 pixel (240m x 240m) neighborhood at the point	0.104
CL4GS	Sum of pixels classified as "Coastal Sage Scrub" within an 8 pixel x 8 pixel (240m x 240m) neighborhood at the point	0.662
CL5GS	Sum of pixels classified as "Chaparral" within an 8 pixel x 8 pixel (240m x 240m) neighborhood at the point	0.459
CL6GS	Sum of pixels classified as "Non-Native Grassland" within an 8 pixel x 8 pixel (240m x 240m) neighborhood at the point	0.497
CL7GS	Sum of pixels classified as "Woodlands" within an 8 pixel x 8 pixel (240m x 240m) neighborhood at the point	0.054
EDGE	The amount of edge (m) between developed and natural habitats within a 2,250m x 2,250m neighborhood at the point	-0.013
PERGRA	Percent of pixels classified as "Non-Native Grassland" within a 75 pixel x 75 pixel (2,250m x 2,250m) neighborhood at the point	-0.016
PERCSS	Percent of pixels classified as "Coastal Sage Scrub" within a 75 pixel x 75 pixel (2,250m x 2,250m) neighborhood at the point	-0.031
PERDEV	Percent of pixels classified as "Developed" within a 75 pixel x 75 pixel (2,250m x 2,250m) neighborhood at the point	0.000

Table 3.3. Mean (± Standard Deviation) values for environmental variables at occupied California Gnatcatcher points.

Environmental Variable	**Mean ± Standard Deviation**
ELEV (Elevation)	480.2 ± 98.5
EAST_0 (Eastness)	-0.003 ± 0.198
NORTH_0 (Northness)	0.049 ± 0.201
SLOPE (Percent Slope)	10.8 ± 5.7
PRECIP (Precipitation)	280.5 ± 22.2
MINTJAN (Average Minimum January Temperature)	2.9 ± 0.8
MAXTJUL (Average Maximum July Temperature)	33.0 ± 1.5
CSS_AREA (Area of Closest Coastal Sage Scrub (CSS) Patch)	8,940,934.6 ± 18,450,487.0
FIN_DCSS (Distance to Closest CSS Patch)	54.7 ± 130.8
DIST2_WAT (Distance to Water Squared)	11,971,331.5 ± 15,824,782.1
CL1GS (Agriculture – local scale)	2.6 ± 8.5
CL2GS (Development – local scale)	2.5 ± 6.7
CL3GS (Riparian – local scale)	1.0 ± 4.0
CL4GS (CSS – local scale)	36.3 ± 23.7
CL5GS (Chaparral – local scale)	10.2 ± 17.8
CL6GS (Non-Native Grassland (NNG)– local scale)	10.4 ± 18.3
CL7GS (Woodland – local scale)	0.3 ± 2.0
EDGE (Developed versus Natural Edge)	1403.2 ± 977.4
PERGRA (Percent NNG – Landscape Scale)	17.6 ± 14.2
PERCSS (Percent CSS – Landscape Scale)	34.8 ± 18.7
PERDEV (Percent Development – Landscape Scale)	14.5 ± 14.4

CHAPTER 4
SPECIES OCCURRENCE DATABASE AND GIS METHODOLOGIES

OVERVIEW

Elements used to run ecological niche models as described in this report include:

- A set of known species locations (presence data), with relatively high spatial precision.
- A randomly placed grid of points distributed throughout the spatial domain of the region to be modeled (e.g., western Riverside County).
- GIS Layers - Complete coverage of digital environmental variables which span the spatial domain of the region to be modeled.
- ArcGIS 8.3 software, with ArcInfo capabilities, and Spatial Analyst.
- SAS 8.2 statistical software.
- Microsoft Excel.
- Equations for calculating Mahalanobis D^2 and partitions (Chapter 3).

CCB SPECIES OCCURRENCE DATABASE

The CCB assembled approximately 45,000 known species locations (species observation records) from numerous sources (~40)(Table 4.1), including fellow UCR researchers (3), museums and herbaria (~23), the California Natural Diversity Database (CNDDB), the U.S. Fish & Wildlife (Carlsbad office), several online resources (4), and 2003-2004 CCB surveys. The bulk of these resources were queried in November 2002, for inclusion in our species database, however, species records from CCB surveys, UCR researchers, and the U.S. Fish & Wildlife were added more recently (2005). Currently, the database housed at the CCB includes both covered and non-covered species of birds, herptiles, and plants, and to a lesser extent species of invertebrates, fish, and mammals, occurring in southern California.

Many of the records compiled initially were *not* retained in the final version of the Species Occurrence Database prepared for the CDFG, as many of the records were restricted from distribution (such as the species point data received from U.S. Fish & Wildlife, Carlsbad office). All records acquired, however, were used in the development of the species niche models. Table 4.2 gives a breakdown of the number of records per taxonomic group and source type in the version of the CCB Species Occurrence Database prepared for CDFG.

Table 4.1 Organizations queried for species records and corresponding source code (SOURCCODE) for records in CCB Species Occurrence Database (If no source code is listed, no records from this source were integrated into the CCB Database.)

Organization:	**SOURCCODE in Database**
Academy of Natural Sciences	ANS
American Museum of Natural History	AMNH
Brigham Young University	BYU
CalFlora	CALFL
California Natural Diversity Database (CDFG)	CNDDB
Carnegie Museum	CARM
California Academy of Sciences	CAS
Center for Natural Lands Management, Cameron Barrows	CAMBA
Center for Natural Lands Management, Wilson Valley	CNLMW
Coachella Valley Association of Governments	CVAG
Coachella Valley Wild Bird Center	
Harvard Online Herbarium	HARVA
Harvard University, Museum of Comparative Zoology	HARVA
Los Angeles County Museum (Natural History Museum of Los Angeles County)	LACM
Louisiana State University, Herbarium	
Metropolitan Water District, Bill Wagner	WAGNR
Lester G. Milroy, Research Consultant	MIL
Oklahoma Museum of Natural History, Herptiles	OMNH
Oklahoma Museum of Natural History, Mammals	OMNH
Princeton University, Museum of Natural History	
Rancho Santa Ana Botanic Garden	RSABG
Riverside Municipal Museum	RMM
University of California Santa Barbara	SANTAB
San Jose State University	SJSTU
The Living Desert Museum	
United States National Herbarium Type Specimen Register	USNHB
United States Fish & Wildlife, Carlsbad Office	CFWO
University of Arizona	UARIZ
University of California Riverside, Dr. Tom Scott (ecoregions database)	SCOTT
University of California Riverside, Dr. Tom Scott (San Jacinto Watershed bird records)	SJWS
University of California Riverside, Herbarium	UCRHB
University of California Riverside, Dr. John Rotenberry	JROTE
University of California Riverside, Pey-Yi Lee	PEYYI
University of California Los Angeles (Dickey Collection)	UCLA

Table 4.1 (cont.)

Organization:	**SOURCCODE in Database**
University of California Los Angeles (specimens of herps and plants)	UCLA
University of Michigan, Museum of Zoology	
University of Washington, Burke Museum	
University of Wisconsin Zoological Museum	
Yale Peabody Museum	YPM
Western Foundation of Vertebrate Zoology	

Table 4.2. Number of species records per taxonomic group and source type in the CCB Species Occurrence Database prepared for CDFG.

	Source Type					
Taxonomic Group	**CCB Surveys**	**UCR Researchers**	**CNDDB**	**Museums & Herbaria**	**Online**	**Grand Total:**
PLANTS	392	0	295	537	93	1,317
BIRDS	18,662	359	330	354	0	19,705
REPTILES	763	0	316	58	97	1,234
MAMMALS	42	0	0	0	0	42
AMPHIBIANS	5	0	50	4	65	124
INVERTEBRATES	1	0	0	0	0	1
Grand Total	19,865	359	991	953	255	22,423

Species records were organized into a single, standardized format, so that species records could be queried on fields important to mapping species records for survey purposes, and generating niche models. The structure and content of the database (data dictionary) are given in Appendix 4. As is often the case with historical species records, locality information is received as text. Thus, it was necessary to georeference thousands of records before they could be incorporated into the database. Georeferencing is the process of assigning real-world map coordinates to an observation or object. Georeferencing was accomplished by CCB staff using the text description of the locations as received in the original species record. Online mapping tools such as MapQuest, Topozone, and MaNIS, aided in the placement of points for species locations. After placement, each point was assigned a precision code (Table 4.3) to approximate its spatial accuracy as judged by the georeferencer.

Once georeferenced, all species records from all sources were converted to a common coordinate system, UTM NAD27 zone 11, CONUS – the coordinate system adopted for our species database. Coordinate transformations were most often performed in ArcGIS 8.3, via ArcToolbox.

Of special note, the CCB Species Occurrence Database contains all records of species observations acquired by the CCB, regardless of their proximity in time or space. That is, the database may contain duplicate records for the same observation, (because it was received from more than one source databases), or it may contain multiple records for the same population recorded during any one visit. This explains why the total number of plant species records reported in the Rare Plant section (Chapter 13) of this report is different than the total number of plant species records found in the Species Occurrence database. However, duplicate and/or spatially identical records were deleted from data files used in niche modeling as described below in section, "Creation of Calibration Point Datasets".

Table 4.3 CCB Species Occurrence Database Location Precision Codes.

0.0 = within 50x50m area;
0.1 = within 100x100m area;
0.2 = within 200x200m area;
0.3 = within 300x300m area;
0.4 = within 400x400m area;
1.0 = within 500x500m area; Location has X, Y coordinates or equivalent, e.g., 5 miles west of Hemet on Hwy 74; or location is a relatively small area, e.g. UCR campus Botanic Garden, the head of Avery Canyon, etc.
2.0 = within 2500x2500m (1.6x1.6mi) area; Location has one X or one Y coordinate or equivalent, e.g. 2 miles west of Hemet; or location is moderate in size, e.g. Avery Canyon, small town, Three Sisters, Strawberry Flat, Tahquitz Valley, Skunk Cabbage Meadow, etc.
3.0 = within 9500x9500m (6x6mi) area; Location has no X or Y coordinate or equivalent; May include large areas such as large mountains, e.g. Black Mountain, or vicinity of larger city, e.g. Riverside, Corona, and Colton.
4.0 = within a region >9500x9500m (>6x6mi); Associated with a large named geographic feature or biome, e.g., San Jacinto Mountains, San Jacinto River, San Gorgonio Pass, Joshua Tree National Park.
5.0 = region >90x90mi, including county and state-level precision.

NICHE MODEL VARIABLES – PREPARATION OF GIS LAYERS

Model variables were derived from readily available GIS layers. CDFG provided several layers (vegetation, soil type) upon which many model variables were derived. Other variables were summarizations of GIS layers obtained from university colleagues (climate), or free from the internet (Digital Elevation Model, Hydrography). A few source layers were created by CCB staff (Rock Outcrop and Temperature). A list of original GIS source layers is given in Table 4.4 and Appendix 5. Detailed descriptions of how each source layer was further summarized to derive the model variables are given in Appendices 5, 6 and 7. A list of model variables created and available for use in niche modeling is given in Appendix 8.

Table 4.4 Original GIS source layers used to derive niche model GIS layers and variables

Source Layer	**Description**	**Source**
hydrarca	California, Statewide coverage of Hydrolines and Polygons, 1992	CaSIL <http://gis.ca.gov/index.epl>
rock_outcrop	Rock outcrops in Western Riverside County	CCB Staff, Adam Malish & Michael Aspell
mnmeanjann (raster)	Mean Minimum January Temperature	Joel Michaelsen, (U.C. Santa Barbara) via CDFG Todd Keeler-Wolfe
mxmeanjul (raster)	Mean Maximum July Temperature	Joel Michaelsen, (U.C. Santa Barbara) via CDFG Todd Keeler-Wolfe
vegu27	1994 Vegetation of Western Riverside County	As received from CDFG
wrrc_lu107	Western Riverside County Existing Land use Map	LSA Associates, Inc.
wrcc_tmin__jan_jun.txt	Western Riverside County, daily minimum temperature between January and June.	CCB GIS Specialist, Michael Aspell, using data compiled from the Western Regional Climate Center Long Term Temperature Data (text files)
wrcc_tmin_jul_dec.txt	Western Riverside County, daily minimum temperature between July and December.	CCB GIS Specialist, Michael Aspell, using data compiled from the Western Regional Climate Center Long Term Temperature Data (text files)
wrcfinal (raster)	Mosaic of 7.5' 30m Digital Elevation Model	GIS Data Depot <http://data.geocomm.com/>
wrcsoilsurvey	Soil Survey of Western Riverside County	As received from CDFG

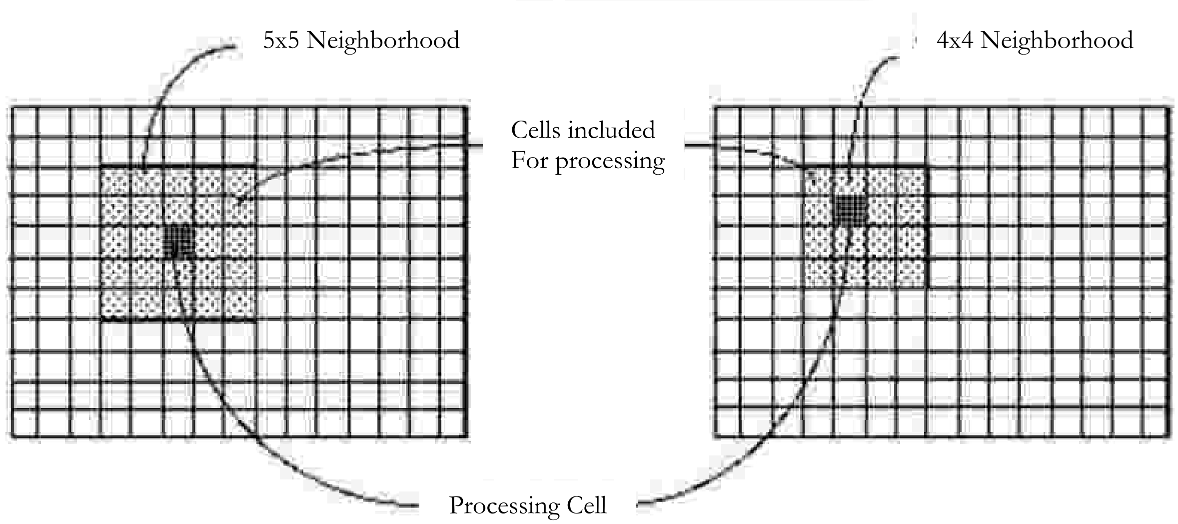
Model variables were of different types (area-based, distance-based, and point-based), and of different scales (local and landscape). "Area-based" variables summarized the habitat within a buffer around the point (such as the proportion of different vegetation types within a 240m x 240m buffer). "Distance-based" variables were a measure of the proximity (straight line distance) of a point to other features, such as the distance to the nearest patch of coastal sage scrub, or urbanized area, etc., (spatial join in ArcMap). "Point-based" variables indicated the value of the GIS layer at the point, such as the value of the rainfall grid at the point. Local-scale variables summarized the environment within a relatively small buffer around the point (240m x 240m, for example), and landscape variables summarized the environment within a much larger buffer around the point (2,250m x 2,250m, for example).

Area-Based Variables: Calculation of Focal Sum/Focal Median/Focal Mean:

Area-based variables were calculated by summarizing the grid layers via "Neighborhood" statistics in ArcInfo (FocalSum, FocalMedian, and FocalMean procedures).

- ArcInfo will perform a calculation on the values of a neighborhood to produce a new grid with values that are a product of the calculation made in that neighborhood.
- Calculations that can be done include Mean, Maximum, and Minimum, among others.
- The possible neighborhood shapes are the rectangle, circle, annulus, wedge, irregular, and weighted irregular
- The calculated value is allocated in the central pixel of a rectangle neighborhood with an odd number of pixels, or in the upper left center pixel in the rectangle neighborhood of an even number of pixels (Figure 4.1).

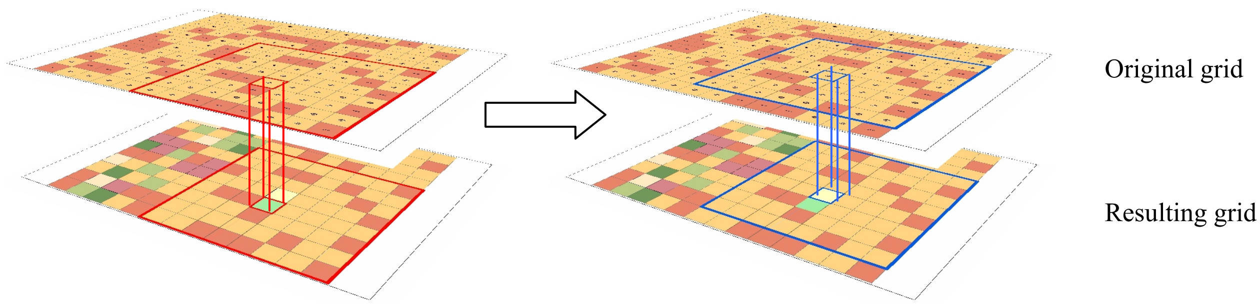
Figure 4.1 Location of processing cell within a 5x5 and 4x4 pixel neighborhood (ESRI).



- After the value of that pixel is calculated based on the neighborhood around it, calculations for the next pixel will be performed, then again until all values for all pixels in the raster are determined, resulting in a new surface grid of "neighborhood" calculated values.

Figure 4.2 New grid created during neighborhood calculations. Calculations are made each time the neighborhood shifts one pixel.

1st neighborhood calculation 2nd neighborhood calculation



- The resulting grid may have values of -9999 in the areas in which a complete neighborhood calculation could not be made because of missing values within the neighborhood. This occurs primarily at the edges of the grid. Thus, areas in the resulting grid which contained values of –9999 were eliminated from the modeled area prior to analysis (i.e., niche modeling maps were not generated for these areas).
- Several different-sized neighborhoods were used to generate habitat variables. “Local” scale habitat variables were calculated within a 6x6, 8x8 and 16x16 pixel neighborhood, and “Landscape” habitat variables were calculated within 75x75 pixel neighborhood.

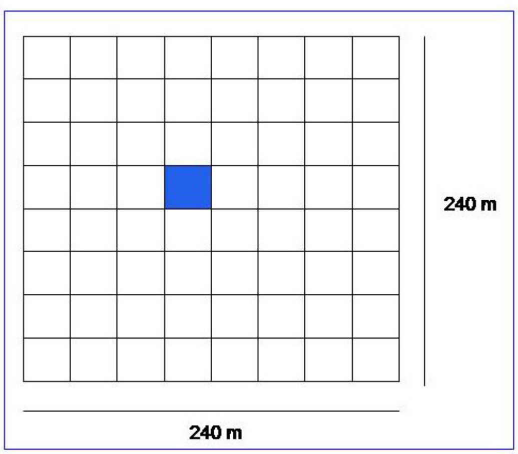


Figure 4.3 An example of a single 8x8 pixel neighborhood in which each pixel is 30m. The blue pixel stores the resulting value of the neighborhood calculation.

Distance-based Variables:

"Distance" variables indicated the proximity (straight line distance) of a point to other features, such as the distance to the nearest patch of coastal sage scrub, or urbanized area. Distance variables were calculated in ArcMap (8.3) by adding point files (calibration and map point shapefiles), and shapefiles of each environmental variable (vegetation class and land-use class, for example) to an ArcMap document, then running a spatial join to add a field for "distance" from each point to each desired environmental feature.

Point-based Variables:

In some cases, a neighborhood (area) or distance calculation was not performed, and the value of the original grid at the point was used. This was the case for the climate variables (precipitation, and temperature), which had a spatial resolution of ~1 km. Point variables were extracted from GIS layers using Lattice spot command in ArcInfo (8.3).

CREATION OF CALIBRATION POINT DATASETS

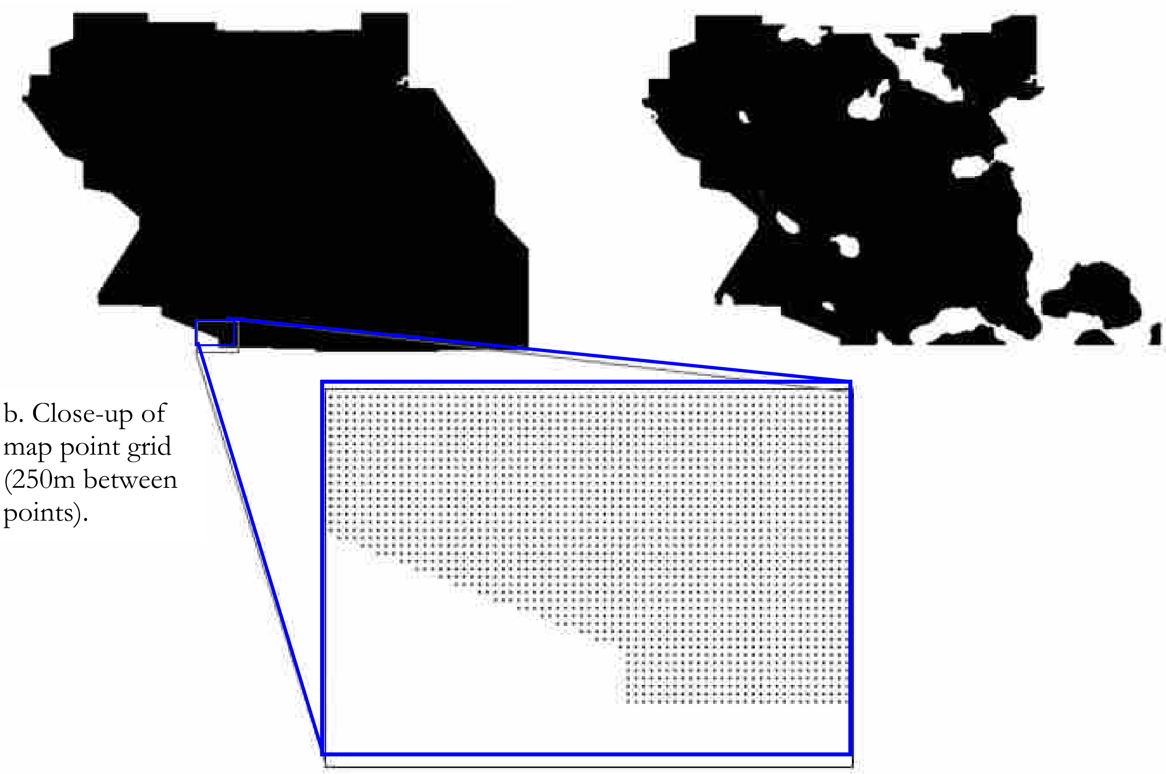
Species records of occupied habitat locations were used as the basis of the model, i.e., were used to "calibrate" the model. Before analysis, however, calibration points were filtered to exclude those having a spatial precision greater than 0.2 (200m x 200m area), and an observation year of less than 1994 (age of the vegetation map used in the analysis). In addition, calibration points were filtered to exclude spatially redundant records. This was accomplished by randomly placing a 240m x 240m network of cells (polygons) over all calibration points, and excluding all but one point within each cell. A cell size of 240m was chosen because this was approximately the distance between sampling points for the CSS surveys. Species points within a common cell were chosen, in order of preference, based on their spatial precision, recentness of year, or at random (all else being equal). This task was performed using Microsoft Excel, by sorting the dataset first by "grid ID", then by "precision", "Observation Year", and "random number". After filtering, models were attempted on species for which sufficient numbers of records (~40) were retained after filtering.

In some instances (plant species and several reptile species), records with a spatial precision of 0.2 or less were minimal or lacking, therefore the CCB used species locations with a precision of "1" (within an area 500m x 500m) as part of the calibration dataset for these species. These records were similarly filtered to exclude those with an observation year of less than 1994, but were filtered for spatial redundancy using a 500m x 500m grid rather than a 240m x 240m grid.

CREATION OF MAP POINT DATASET

In addition to building a calibration dataset of known species locations, the model required a second set of points, so-called "map points," of unknown species occupancy, to generate the model. Map points were generated by randomly placing a network of regularly spaced points every 250m (Fishnet procedure, ArcInfo), across the western Riverside County region, i.e., the domain of the area to be modeled (Figure 4.4a. and 4.4b.). For some plant species, the domain was reduced (Figure 4.4c.), because some of the GIS variables used in the model did not have complete coverage throughout the domain of analysis, and therefore could not be modeled.

Figure 4.4 Domain of niche model analysis, and distribution of random map points.



a. Domain of niche model analysis with randomly placed grid of map points distributed throughout.

c. Reduced domain of niche model analysis for *Atriplex coronata* with randomly placed grid of map points distributed throughout.

b. Close-up of map point grid (250m between points).

EXTRACTION OF GIS ENVIRONMENTAL VARIABLES TO CALIBRATION AND MAP POINT DATASETS

For Area-based and Point-based variables, a Latticespot procedure (ArcInfo) was used to extract the value of the raster for all calibration and map point locations. The results of these extractions were stored as a field in the attribute table of the calibration and map point data files.

MODEL RUNS

Please refer closely to the sections on niche modeling that appear in this report (Chapter 3), for details about the modeling formulas and theory. Formulas for the calculation of Mahalanobis D^2 and its partitioning were scripted and run in SAS statistical software (8.2) for individual models.

As depicted in Figure "Flow" below, the attribute table of the Calibration dataset was used to "calibrate" the model, and the attribute table of the Map dataset was used to calculate the habitat similarity index (HSI) of each map point to known habitats of the species, receiving a score between "0" and "1.0", with "1.0" indicating very high similarity, and "0" indicating very low similarity.

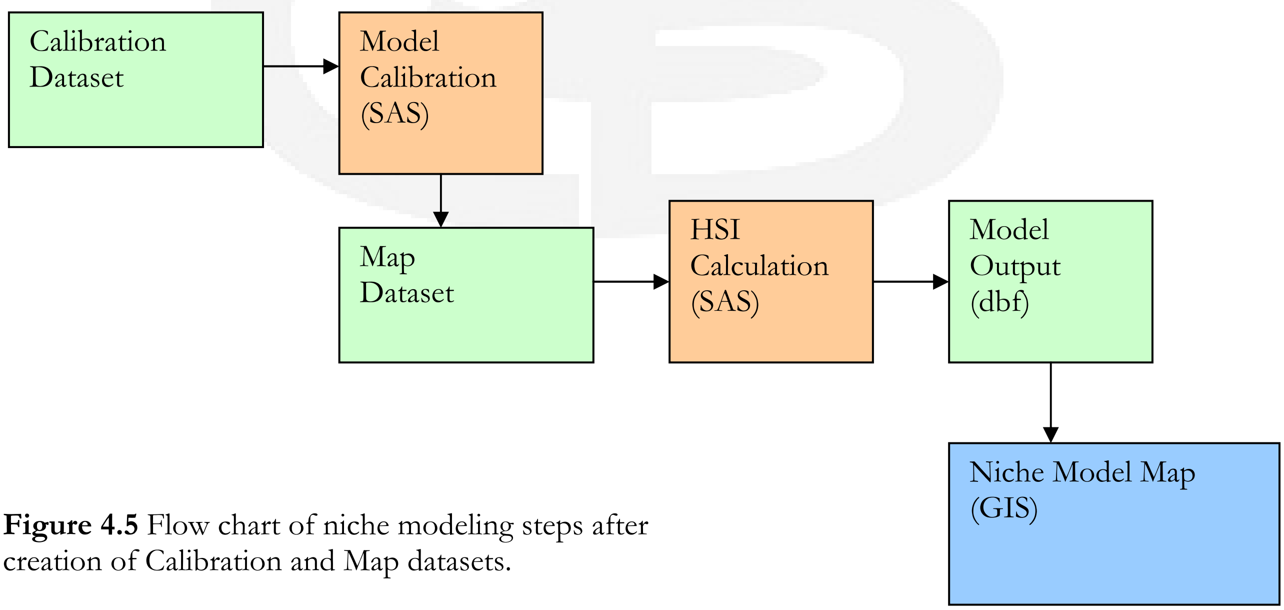


Figure 4.5 Flow chart of niche modeling steps after creation of Calibration and Map datasets.

The output of the modeling procedure is a dbf file which contains the following fields:

- WRC250_ID (Unique Map point identifier)
- UTM27E, UTM27N (Map point coordinates, UTM NAD27)
- Prin1 - Prin*p* (ordinary factor scores for each point for p original environmental variables)
- D2_1 - D2_*p* (for each point, cumulative $d^2(k)$, where D2_1 is for k=1+2+…+*p*,D2_2 is for k=2+3+…+*p*, D2_3 is for k=3+4+…+*p*, and D2_*p* is for k=*p*)
- D2C_1 - D2C_*p* (for each point, $d^2(k)$)
- PVALUE1 PVALUE*p* for each point, 1-(Chi-squared p-value) for cumulative $d^2(k)$
- DF1 - DF*p* (df's [number of components combined] for cumulative $d^2(k)$ used in calculating p-values).

The PVALUEs (HSIs) are plotted in ArcGIS to create a map of the model output. PVALUE1 is the most restrictive model, and PVALUEp is the least restrictive. As we have stated many times in this report, these models are hypotheses about the potential distribution of species and their habitat, and are subject to testing (ground-truthing, etc.) and reiteration (refinement). There is no method of selecting the "best" model to map (i.e., the "best" PVALUE to map). Knowledge of the species being modeled, and its environmental requirements can help interpret which map may be most appropriate; however, an examination of the eigenvalues and eigenvectors from the principal components analysis (PCA) should be made, to (1) determine an appropriate PVALUE partition *(k)*, to map, and (2) to interpret which variables contribute to which eigenvectors. Unlike regular PCA, biological significance is attached to those components with the smallest, rather than the largest, eigenvalues, because we are looking for those variables showing the least amount of variation (that are most consistent) at known locations of the species (Chapter 3). In turn, high eigenvector values (whether negative or positive) in any component indicate which environmental variables weigh most heavily in each component. As an example, results of the PCA performed on calibration points for the Burrowing Owl niche model are given in Figure 4.6. Here, principal components 4 and 5 in the Eigenvalues of the Correlation Matrix table have the smallest eigenvalues (0.93180868 and 0.22913510 respectively). If we were to choose principal component 5 (PVALUE5) as our model, the analysis results in the Eigenvectors table tells us that variable V1 weighs most heavily in this component, followed by variables V9 and V15, and we would conclude that these variables may be important factors in defining the minimal distribution of the species.

Figure 4.6 Sample of niche model Principal Component Analysis results for a Calibration Dataset

The SAS System
The PRINCOMP Procedure

Observations	89
Variables	5

Simple Statistics					
	V9	V6	V1	V15	V3P
Mean	50.33238944	23.60447878	81.17878049	36.30797865	84.7090775
StD	70.67166995	51.49363089	97.74737022	77.67349013	299.0172508

Correlation Matrix						
		V9	V6	V1	V15	V3P
V9	V9	1.0000	-.0209	-.4775	-.2305	-.0373
V6	V6	-.0209	1.0000	-.2604	-.1970	-.0831
V1	V1	-.4775	-.2604	1.0000	-.2786	-.0396
V15	V15	-.2305	-.1970	-.2786	1.0000	0.1003
V3P	V3P	-.0373	-.0831	-.0396	0.1003	1.0000

Eigenvalues of the Correlation Matrix				
	Eigenvalue	Difference	Proportion	Cumulative
1	1.53678208	0.24633513	0.3074	0.3074
2	1.29044695	0.27861975	0.2581	0.5654
3	1.01182720	0.08001852	0.2024	0.7678
4	0.93180868	0.70267358	0.1864	0.9542
5	0.22913510		0.0458	1.0000

Eigenvectors						
		Prin1	Prin2	Prin3	Prin4	Prin5
V9	V9	0.628744	-.098033	-.552882	-.079797	0.531999
V6	V6	0.337200	-.338985	0.724298	0.357126	0.345310
V1	V1	-.697518	-.329367	-.149575	0.053468	0.616242
V15	V15	-.041478	0.768595	0.309128	-.308475	0.465645
V3P	V3P	-.052203	0.419831	-.227554	0.876400	0.034029

CHAPTER 5

PREDICTING SPECIES DISTRIBUTIONS: NICHE MODELS FOR COVERED PLANT AND BIRD SPECIES

Introduction

To effectively conserve and manage Covered Species in the Plan Area requires an understanding of their habitat affinities and distribution patterns. The WRC MSHCP stipulates that 146 Covered Species are to be monitored on over 490,800 ha (1.2 million acres) of land (Dudek and Associates 2003). To achieve this goal requires developing new tools and methodologies to identify suitable habitat for multiple species over a large geographic area. Spatially explicit habitat suitability models provide one such tool for reserve managers, agency personnel, and researchers to use in monitoring and managing Covered Species. When coupled with GIS and digital environmental data these models not only identify variables that may be important in influencing a species' distribution, they also show where these variables come together in a combination most conducive to a species' occurrence (Hirzel et al. 2002; Rotenberry et al. 2002). There are a number of modeling techniques that take advantage of GIS to create models predicting suitable habitat for a species across large geographical areas (Guisan and Zimmerman 2000). A niche-based modeling approach emphasizes those variables that appear associated with the *limits* to a species' distribution; that is, those variables that maintain a consistent value where the species occurs (Rotenberry et al. 2002). Particularly useful are modeling approaches that do not require *a priori* estimates of abundance or presence/absence, but use presence-only data (Hirzel et al. 2002; Rotenberry et al. 2002), allowing researchers to use large-scale presence-only databases (e.g., California Natural Diversity Database (CNDDB), museum records).

Niche models provide a spatially explicit assessment of habitat suitability and identify those environmental variables that are important in determining a species occurrence. This information is critical to designing, monitoring, and managing a reserve system. The results of niche modeling can be used to formulate working hypotheses to guide research used to develop and implement adaptive management plans. Niche model predictions can be extended into areas where there is no information about the occurrence of a particular species, which helps focus future monitoring efforts. They can be used to manage lands to conserve endangered species and biodiversity, to evaluate restoration sites and areas vulnerable to exotic species expansion, and to predict the responses of species and communities to environmental change (Peterson and Vieglais 2001; Hirzel et al. 2002; Rotenberry et al. 2002; Hannah et al. 2005). For example, changes in the pattern of distribution of regional environmental stressors (e.g., nitrogen deposition and the spread of non-native grasslands) can be used to make spatially explicit predictions about how Covered Species' habitat suitability and community biodiversity are expected to change. Niche models can also be used to make predictions about the persistence of Covered Species after the conservation plan is implemented and the region is built out.

The Partitioned Mahalanobis D^2 Model

CCB biologists used the *partitioned* Mahalanobis D^2 modeling technique (Clark et al. 1993; Dunn and Duncan 2000; Rotenberry et al. 2002) to create regional scale niche models for Covered Species with sufficient location data. This technique is explained in detail in Chapter 3 and only the more important points will be touched upon in this chapter.

Mahalanobis D^2 is the standardized difference between the values of a set of environmental variables for any point in the region (e.g., the Plan Area) and the *mean* values for those same variables calculated from all points in the region at which a species was detected. The more similar in environmental conditions a regional point is to the species' mean, the smaller the D^2 and the more "suitable" the habitat at that point. Because D^2 follows a Chi-squared distribution, it can be rescaled into habitat similarity values (also referred to as p-values) that range from 0 to 1, with 1 representing environmental conditions identical to the species' mean (Clark et al. 1993). Although D^2 performs quite well in many circumstances (e.g., Knick and Dyer 1997), it may perform poorly when applied to areas not included in the original sample or if applied to dynamic landscapes, such as those that are disturbance prone (whether natural or anthropogenic) or undergoing restoration or succession (Knick and Rotenberry 1998). Moreover, it assumes that one has correctly identified and measured the appropriate environmental variables influencing a species' distribution.

The performance of D^2 is improved by "*partitioning*" it into separate components, each representing independent relationships between a species distribution and environmental variables (Dunn and Duncan 2000, Rotenberry et al. 2002). These distance partitions are additive, and each is associated with an eigenvalue arising from a principal components analysis (PCA) of the dataset containing the values of the environmental variables from the points at which the species occurred. PCA is a technique that allows researchers to find subsets of variables that are correlated with one another but independent of other such subsets of variables (Tabachnik and Fidell 1996). These independent subsets are combined into factors, which are related to underlying processes that create the correlations among variables. As such, PCA is well suited for handling multiple correlated variables. This technique allows researchers to address the question of how much variance in a dataset is explained by each factor. Unlike regular PCA, however, biological significance is attached to those components with the *smallest*, rather than the largest, eigenvalues (which in PCA are measures of variance). We want to identify the *constant relationships* in a species' distribution (i.e., which variables maintain a *consistent value* where the species occurs), and that are most likely to be associated with limiting factors. Any environmental variables that take on a wide range of values where a species occurs, and which will therefore be associated with components with larger eigenvalues, are less likely to be informative since they are not restrictive of a species' distribution, at least over the range of variation sampled. The partitioned D^2's can be considered sequentially, beginning with that associated with the single smallest, then the two smallest, the three smallest, etc. If we add all the partitions together, we have the original D^2 model. In evaluating how many principal components to retain for a niche model, CCB biologists carefully evaluated eigenvalue differences, beginning with the eigenvalue for the last principal component and working up toward the eigenvalue for the first principal component. The first large difference in eigenvalues relative to preceding differences was chosen as the cutoff point. Once this cutoff point was selected, the principal component preceding it was designated as the model rank (see Chapter 3 for more details).

Assessing which environmental variables are associated with likelihood of a species occurrence is based on examination of the PCA's eigenvector values associated with each component (i.e., each partition of D^2); variables with larger absolute eigenvector values are considered more "important." The number of components retained (the rank of the model) is generally based on the number of eigenvectors with variables deemed important, although this can be somewhat subjective (Dunn and Duncan 2000). A major advantage of partitioning is that less distributionally relevant variables (assuming some are unknowingly included in the original variable set) are shifted to components with larger eigenvalues, and thus may not contribute to the final, reduced-rank model (Rotenberry et al. 2002). Increasing the number of partitions that are retained increases the precision of the model, but reduces its generality.

Once a satisfactory model is obtained for a species, it may be used to calculate the habitat similarity index value (the p-value representing habitat suitability on an increasing 0-1 scale) for every point in a given landscape for which one has values for the environmental variables. It is important to emphasize that these niche models do not correlate the values of variables at occupied points with values of these variables at map points. Rather, Mahalanobis D^2 reflects the distance of each map point from the mean value of occupied habitat for the species that is being modeled. The correlations in this modeling approach are between variables at occupied points and are reflected in how these variables "load" onto the principal components.

Incorporating Niche Models into Monitoring Covered Species
CCB has initiated development of a framework for monitoring multiple species conservation plans (Barrows et al. 2005). The monitoring framework unites traditional single species monitoring to broader ecosystem approaches in a "hybrid" strategy that iteratively incorporates conceptual models and spatial data to create niche models linking sensitive species to their natural communities. These niche models focus on natural and anthropogenic environmental drivers hypothesized to affect a species distribution. These processes can be monitored and, where feasible, adaptively managed to retain or improve habitat suitability for species of conservation concern. The crucial aspect of this process is that it is iterative. Developing and testing niche models and monitoring Covered Species distributions and abundance are interdependent processes with the ultimate goal of

understanding habitat affinities and the mechanisms underlying them. Data acquired from monitoring is used to test and refine niche models, which in turn are used to guide the design of successive monitoring and research efforts. Initially there is a period of model construction, evaluation, and modification and then the "best" niche model is adopted for a species. This model is tested periodically with new datasets and continually refined to reflect changes in our understanding of species habitat relationships.

CCB has begun this process by developing *preliminary* niche models for Covered Species for which there are sufficient location data. It is important to note that these models have been constructed using the vegetation map currently available to CCB. This vegetation map was created in 1994 and is the basis for the WRC MSCHP (Dudek and Associates 2003). There has been substantial change to natural habitats in western Riverside County since 1994. CCB's preliminary niche models are based on the vegetation conditions mapped in 1994 and as such do not reflect current levels of development or changes in habitat types from other processes. ***These preliminary niche models are intended to guide the next round of monitoring and to be tested with data collected during these surveys*. *Without the necessary testing, we cannot be sure whether the hypothesized relationships inherent to these models are consistent with suitable habitat for a species.***

Previous chapters cover the details of developing a monitoring framework (Chapter 1), the theoretical basis for niche models (Chapter 3), and a description of how GIS environmental layers are incorporated into niche modeling (Chapter 4). This chapter presents the results of preliminary niche modeling for covered birds and rare plants in the Plan Area. Chapter 6 presents the niche model results for covered reptile species.

Methods

Constructing Niche Models for Covered Species
In 2005, CCB developed preliminary niche models to predict habitat suitability across the 490,844 ha Plan Area for 11 sensitive plant and bird species covered by the WRC MSHCP. These models were created using sets of predictor variables hypothesized *a priori* to be important in determining the distribution of each particular species. These hypotheses were formulated based upon knowledge of the natural history of each species. Chapter 4 explains in greater detail the GIS procedures, environmental variables, and the species database used to construct these niche models. This chapter highlights the more important elements of the modeling process.

Presence-only data for each species were taken from several sources, including museum records, published and unpublished species accounts, environmental impact reports, field notes of local naturalists, and CCB's surveys. Any spatially redundant records for a species were deleted from the data set. For species with a sufficient number of records with a precision code of less than 0.2 (point located within a 200 m x 200 m area), the models were constructed based on a 240 m x 240 m grid centered on the species location. Any locations occurring within the same grid cell were considered spatially redundant and one of the records was chosen at random and deleted from the modeling dataset. For the plant species, several reptile species, and the Burrowing Owl (*Athene cunicularia*), there were insufficient locations with a precision of 0.2 or less, therefore CCB used species locations with a precision of 1 (500 m x 500 m grid) or less for these models. After screening datasets for spatially redundant points, niche models were constructed for each species using datasets ranging from 40 records for some of the plant species up to 700 records for California Gnatcatchers. CCB biologists did not attempt models for species with fewer than 40 independent locations. For species with more than 135 independent locations, approximately 80% of locations were randomly chosen to construct the model while the remaining 20% were used to cross validate model performance. Model performance was cross-validated using the median habitat similarity index value for the validation dataset.

Using biological expertise and information obtained from literature reviews, CCB biologists selected from among the GIS variables those that were hypothesized to be relevant to a particular species distribution and calculated their values at every point on the map. The California Gnatcatcher (*Polioptila californica californica*) provides an example of how environmental variables were chosen in constructing a niche model. California Gnatcatchers are generally documented as occurring at elevations below 800 m (Atwood and Bontrager 2001), so elevation was included as a variable in the model. Similarly, given their small body size (e.g., ~6 grams), temperature extremes and annual rainfall may limit their distribution, so mean annual precipitation, average minimum January temperature, and average maximum July temperatures were included in the model. Coastal sage scrub is the primary habitat of this species and it has been hypothesized that California Gnatcatchers are more prevalent at the coastal sage scrub-grassland transition than the interface between coastal sage scrub and chaparral (Atwood and Bontrager 2001). As a result, the local-scale and landscape levels of these three habitat types were included as variables. Percent slope and aspect influences the composition of vegetation communities and gnatcatchers vary in abundance with different subassociations of coastal sage scrub. For this reason, slope (percent) and aspect (northness and eastness) were also included in the model. The gnatcatcher model included other variables for a total of 21 (Table 5.1), each of which was postulated to potentially influence habitat suitability for this species. Variables were chosen in a similar fashion to construct niche models for other plant and bird species.

Chapter 4 describes the different environmental variables available for constructing niche models, explains how these layers were compiled, and provides details of the GIS niche modeling process. The Plan Area map is divided into 78,021 "cells" for both the 250 m x 250 m and 500 m x 500 m grids. CCB used GIS layers converted to a raster format for these analyses. The variables used to construct the models included the focal sum of 30 m x 30 m cells containing each major vegetation and land use type (residential versus commercial) within a 240m x 240m grid around a point ("local scale") for the 250 m scale models. For the 500 m scale models, vegetation and land use types were summed over a 480 m x 480 m grid around each point. Other variables included the closest distance from a point to each major vegetation type and to each land use type; the proportion of each major vegetation type and land use type within a 2,250 m x 2,250 m grid around a point ("landscape scale"); and the amount of developed edge adjacent to natural habitat within this latter grid size. Abiotic environmental variables include minimum average January temperature, maximum average July temperature, elevation, annual precipitation, and slope (eastness, northness and percent). In the current round of niche modeling, CCB used a 1994 land cover-land use map provided by Riverside County and which was used in the original development of the WRC MSHCP. This map reflects habitat conditions in 1994 and no longer accurately depicts the distribution of habitats across the Plan Area, especially given the large amount of development that has occurred in the region over the last ten years.

"Calibration" datasets were created for each species. These datasets included the value of all environmental variable extracted from the GIS environmental variable layers at locations where a species occurred. A second dataset, the "map points" dataset contained values for each variable for all points in a 250 m x 250 m or 500 m x 500 m grid of the Plan Area. Variables were chosen from these datasets to include in each model and then the calibration dataset was run through a SAS software program (Duncan and Dunn 2001) to calibrate the model. In this process a multivariate mean was calculated for occupied points. Next, the map point dataset was run through the SAS code to assign habitat similarity values to each map point. Each habitat similarity value represents the distance between the multivariate means of occupied habitat (calibration dataset) and a map point. Based on the output produced by the calibration run, a model rank was chosen and the important variables were identified. Validation datasets were also ran through the SAS code to calculate the difference from the species mean to each validation point.

Results

Niche models were prepared for eleven covered plant and bird species that had sufficient location data to construct a niche model. The environmental variables, model scale, and number of locations used to calibrate niche models for each species are listed in Table 5.1. Asterisks highlighted in bold indicate those environmental variables that were identified as important to the eigenvectors of those principal components used to construct the niche model. These parameters were least variable among occupied locations and are considered important in determining habitat suitability for the particular species in question. Five sensitive plant species had sufficient location data to construct niche models (Table 5.1; Figures 5.1-5.5). None of the species had enough locations for a model validation dataset. These species occur in different vegetation communities, which is apparent from their niche models.

Two rare plants, San Jacinto Valley crownscale (*Atriplex coronata notatior*; Figure 5.1) and Coulter's goldfields (*Lasthenia glabrata coulteri*; Figure 5.4), are frequently found in floodplains supporting alkali scrub, vernal pools, alkali playas, and alkali grasslands. Elevation, temperature, and percent silt were identified as important variables for each of these species

(Table 5.1). Vernal pool and alkali habitats also showed up as an important variable in the Coulter's goldfield model. Figure 5.6 shows the mean and standard error values for important environmental variables at occupied points and at map points across the Plan Area. Occupied points for both species were typically at elevations below 500 m where the average minimum January temperature was 38 °F, and the percent silt in the soil was 14-18% (Figures 5.6 a, b, and d). At the local scale (a 16 x 16 grid neighborhood of 256, 30 m x 30 m cells), Coulter's goldfields points were characterized by an average of nearly 140 cells (55%) classified as vernal pool/alkali habitats (Figure 5.6 e).

Beautiful hulsea (*Hulsea vestita callicarpha*; Figure 5.3) is typically associated with rocky soils in chaparral and lower montane forests. The niche model shows suitable habitat for beautiful hulsea along the eastern edge of the plan area. Some potentially suitable habitat is also identified for the Hemet area with this particular model. The more restrictive niche models for beautiful hulsea do not identify suitable habitat in the Hemet area and if tested with an independent dataset may turn out to be better models for predicting the occurrence of this species. Annual precipitation, average minimum January temperature, and elevation were identified as important variables in the distribution of this species (Table 5.1). Beautiful hulsea occurred at higher elevations where there were low minimum January temperatures and greater levels of precipitation compared to the overall Plan Area (Figure 5.6 a-c).

Table 5.1 Variables used to construct niche models for Covered plant and bird species in the Plan Area. An "*" indicates the variable is an "important" component of the niche model map, whereas an "x" indicates it was included in the model but not considered "important".

Scientific Name	*Atriplex coronata notatior*	*Centromadia pungens laevis*	*Hulsea vestita callicarpha*	*Lasthenia glabrata coulteri*	*Romneya coulteri*
Common Name	San Jacinto Valley Crownscale	Smooth Tarplant	Beautiful Hulsea	Coulter's Goldfields	Coulter's Matilija Poppy
Model Scale	500 m	500 m	500 m	500 m	500 m
Number of Species Locations	44	61	43	46	38
Number of Variables	4	5	4	4	5
Variable Name:					
Annual Precipitation		*	*		*
East					*
Elevation	*	*	*	*	*
Mean Maximum July Temperature			x		
Mean Minimum January Temperature	*	*	*	*	
North					*
Percent Slope					*
Vegetation/Substrate Categories:					
Local Scale (500m x 500m):					
Agriculture (field crops, livestock)					
Chaparral					
Coastal Sage Scrub					
Developed (residential, commercial,					
Non-Native Grassland					
Oak Woodlands/Coniferous Forest					
Riparian (scrub and forest)		*			
Vernal Pool/Alkali Playa	x	x		*	
Distance to Closest Coastal Sage Scrub					
Percent Clay					
Percent Silt	*			*	
Rock Outcrop					
Landscape Scale (2,250m x 2,250m):					
Percent Agriculture (field crops, livestock)					
Percent Chaparral					
Percent Coastal Sage Scrub					
Percent Developed					
Percent Non-Native Grassland					
Percent Oak/Coniferous Woodland					
Percent Open Water					
Amount of Developed – Natural Edge					

Table 5.1 (Cont.) Variables used to construct niche models for Covered plant and bird species in the Plan Area.

Scientific Name	*Accipiter cooperii*	*Aimophila ruficeps canescens*	*Amphispiza belli belli*	*Athene cunicularia hypugaea*	*Lanius ludovicianus*
Common Name	Cooper's Hawk	So Cal Rufous-crowned Sparrow	Bell's Sage Sparrow	Western Burrowing Owl	Loggerhead Shrike
Model Scale	250 m	250 m	250 m	500 m	250 m
Number of Locations	57	160	107	89	140
Number of Variables	6	17	10	5	10
Variable Name:					
Annual Precipitation		*	x		*
East		x			
Elevation		*	*		*
Mean Maximum July Temperature		x	*		*
Mean Minimum January Temperature		*	*		*
North		x			
Percent Slope		x	x		*
Vegetation/Substrate Categories:					
Local Scale (250m x 250m or 500m x					
Agriculture (field crops, livestock)				*	
Chaparral		*	x		*
Coastal Sage Scrub	*	*	*	x	*
Developed (residential, commercial,	*	x			*
Non-Native Grassland		*	*	*	x
Oak Woodlands/Coniferous Forest	*				
Riparian (scrub and forest)	*				
Vernal Pool/Alkali Playa				*	
Distance to Closest Coastal Sage Scrub					
Percent Clay					
Percent Silt					
Rock Outcrop		x			
Landscape Scale (2,250m x 2,250m):					
Percent Agriculture (field crops, livestock)		x			
Percent Chaparral					
Percent Coastal Sage Scrub		*	x		
Percent Developed	*	*	x		*
Percent Non-Native Grassland		x			
Percent Oak/Coniferous Woodland	*				
Percent Open Water				*	
Amount of Developed – Natural Edge		*			

Table 5.1 (Cont.) Variables used to construct niche models for Covered plant and bird species in the Plan Area.

Scientific Name	*Polioptila californica californica*
Common Name	California Gnatcatcher
Model Scale	250 m
Number of Locations	554
Number of Variables	21
Variable Name:	
Annual Precipitation	x
East	x
Elevation	*
Mean Maximum July Temperature	*
Mean Minimum January Temperature	*
North	x
Percent Slope	x
Vegetation/Substrate Categories:	
Local Scale (250m x 250m):	
Agriculture (field crops, livestock)	x
Chaparral	*
Coastal Sage Scrub	*
Developed (residential, commercial,	x
Non-Native Grassland	*
Oak Woodlands/Coniferous Forest	
Riparian (scrub and forest)	
Vernal Pool/Alkali Playa	
Distance to Closest Coastal Sage Scrub	x
Percent Clay	
Percent Silt	
Rock Outcrop	
Landscape Scale (2,250m x 2,250m)	
Percent Agriculture (field crops, livestock)	*
Percent Chaparral	x
Percent Coastal Sage Scrub	*
Percent Developed	x
Percent Non-Native Grassland	x
Percent Oak/Coniferous Woodland	x
Percent Open Water	x
Amount of Developed – Natural Edge	x

Figure 5.1 "HSIs" of habitat similarity for *Atriplex coronata notatior* across the Plan Area: The higher the HSI, the greater the similarity between occupied habitat and other areas. Some portions of the Plan Area were not modeled as the soil layer was missing.

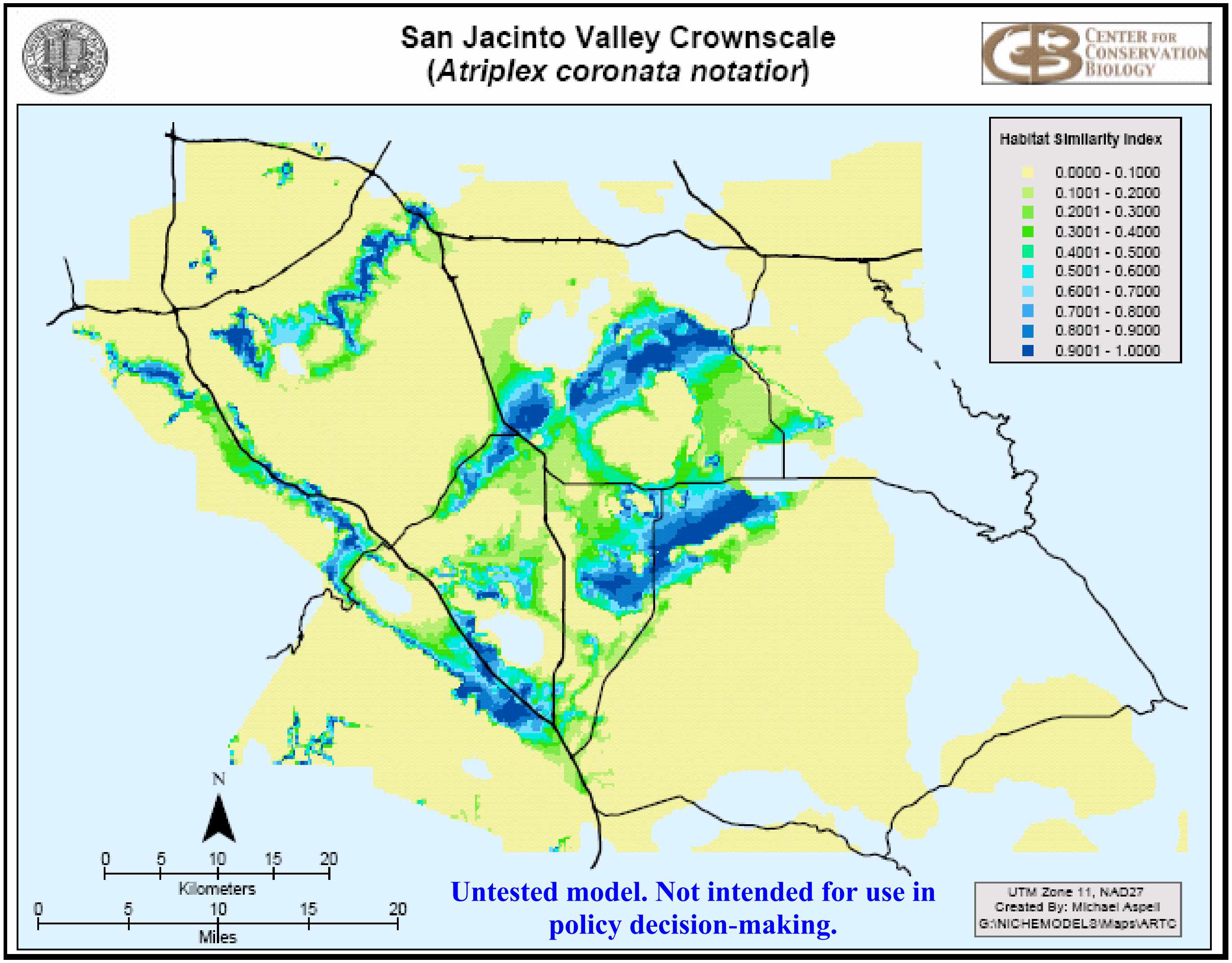


Figure 5.2 "HSIs" of habitat similarity for *Centromadia pungens laevis* across the Plan Area: The higher the HSI, the greater the similarity between occupied habitat and other areas.

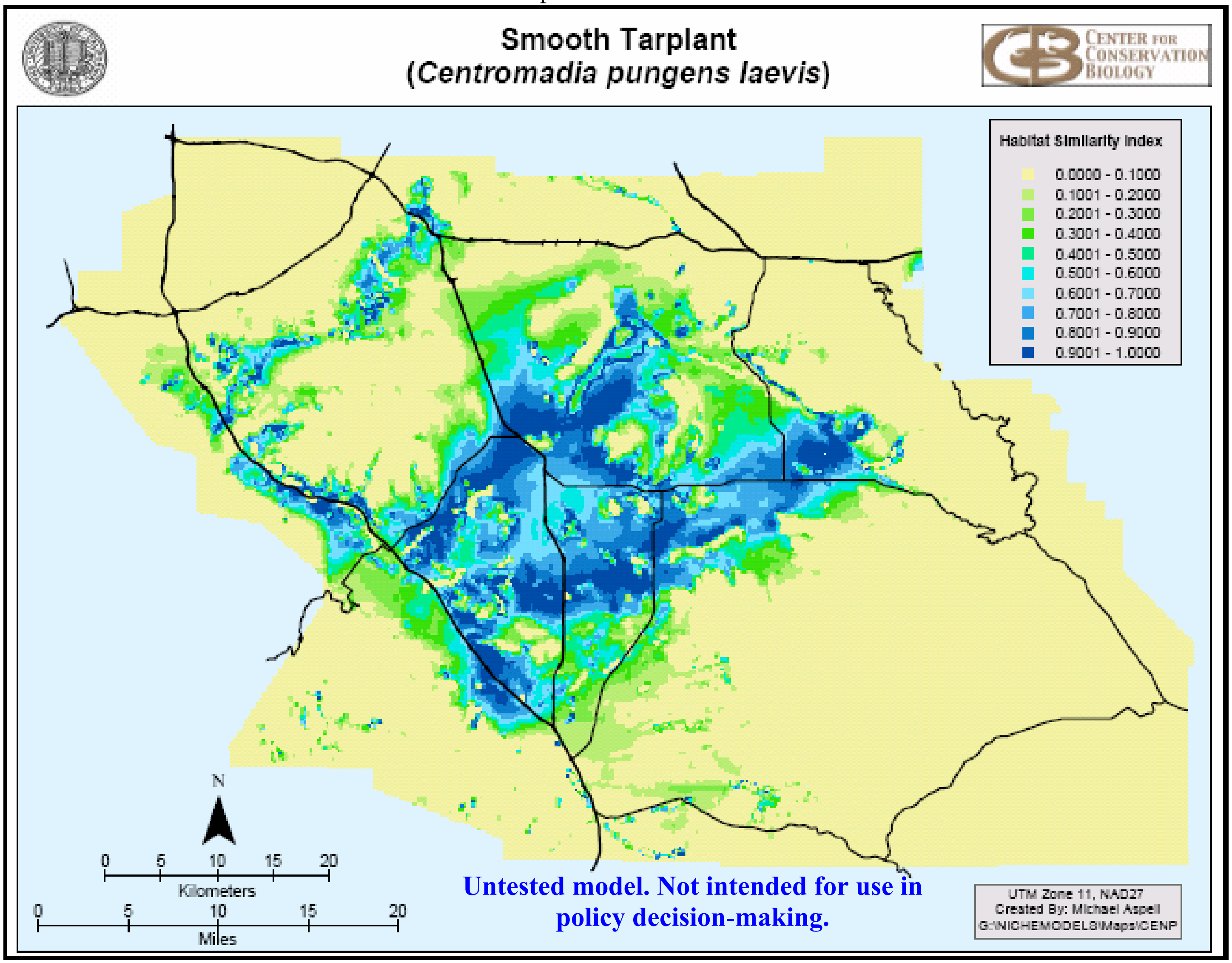


Figure 5.3 "HSIs" of habitat similarity for *Hulsea vestita callicarpha* across the Plan Area: The higher the HSI, the greater the similarity between occupied habitat and other areas.

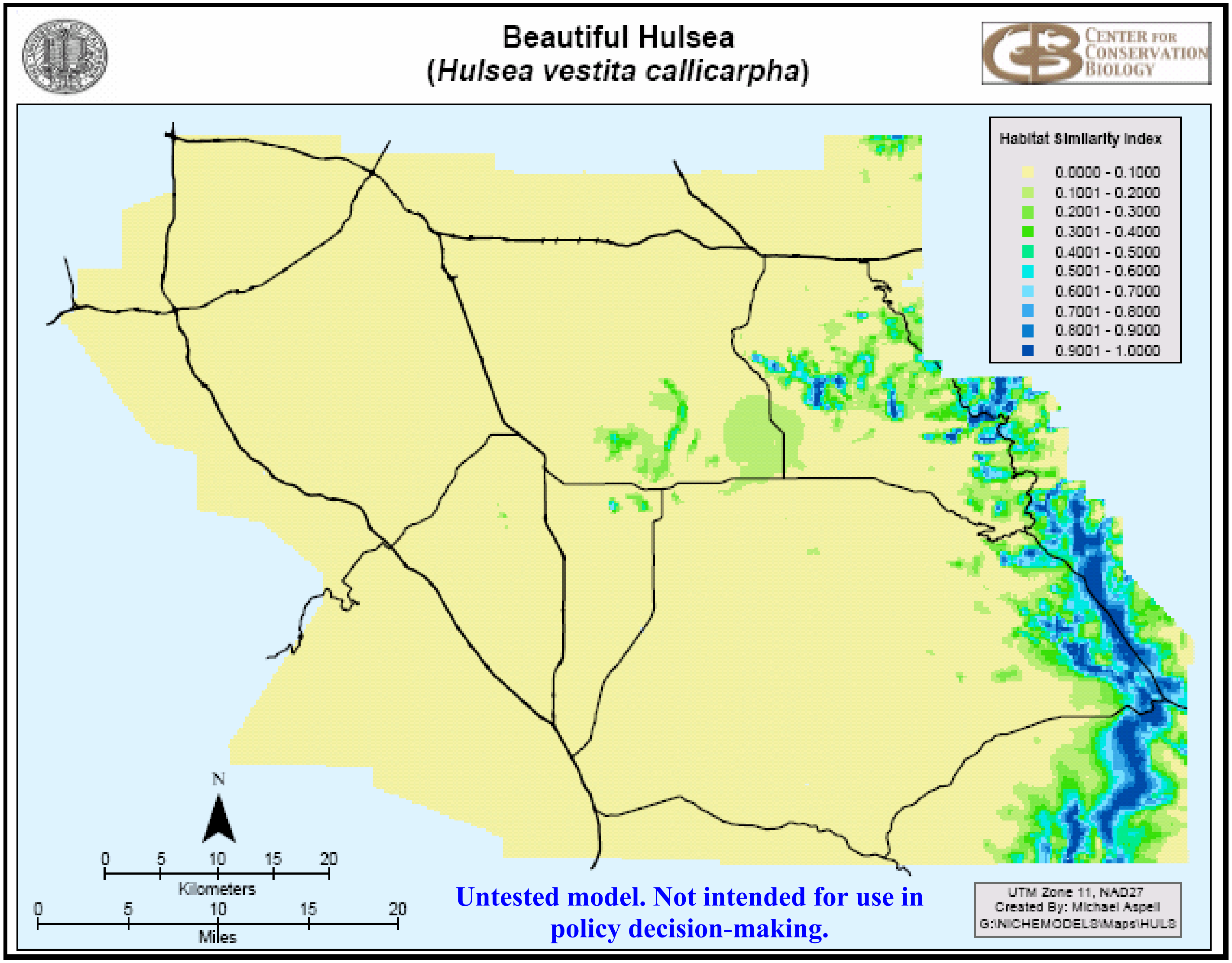


Figure 5.4 "HSIs" of habitat similarity for *Lasthenia glabrata coulteri* across the Plan Area: The higher the HSI, the greater the similarity between occupied habitat and other areas. Some portions of the Plan Area were not modeled as the soil layer was missing.

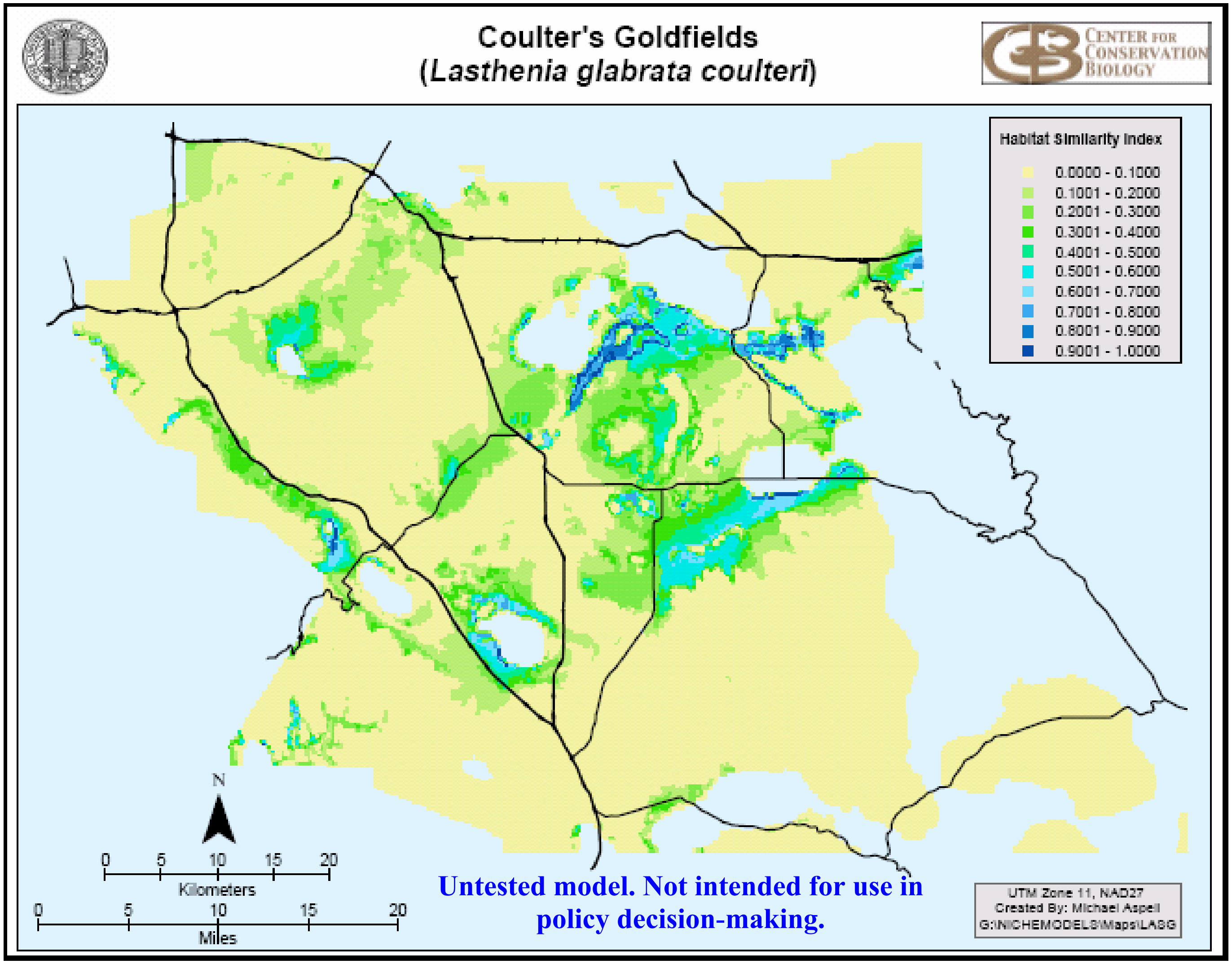


Figure 5.5 "HSIs" of habitat similarity for *Romneya coulteri* across the Plan Area: The higher the HSI, the greater the similarity between occupied habitat and other areas.

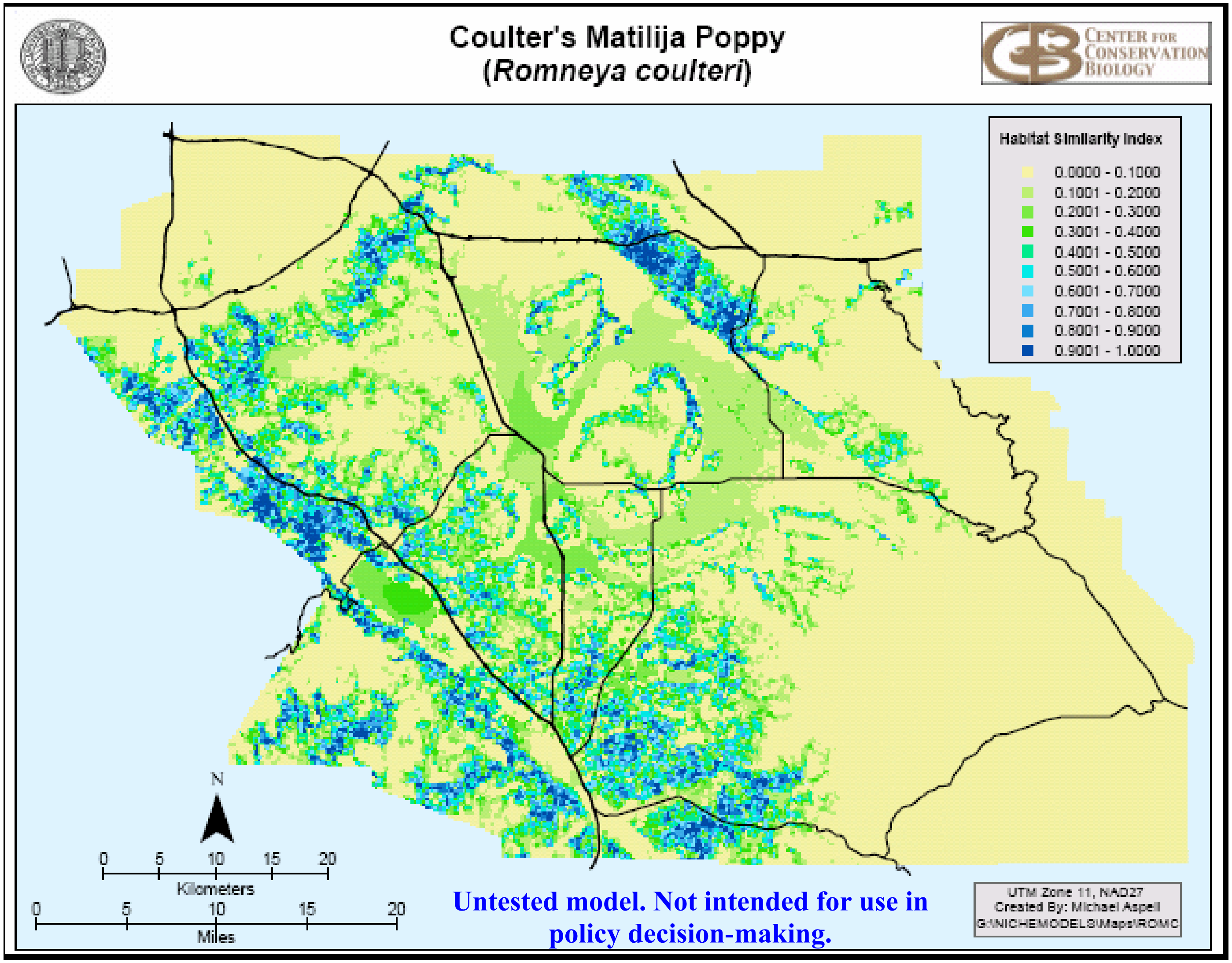


Figure 5.6 Covered plant species mean (± SE) values for important environmental variables at occupied points versus map points across the Study Area. ARTCOR = *Atriplex coronata notatior*, CENPUN = *Centromadia pungens laevis*, HULVES = *Hulsea vestita callicarpha*, LASGLA = *Lasthenia glabrata coulteri*, ROMCOU = *Romneya coulteri*.

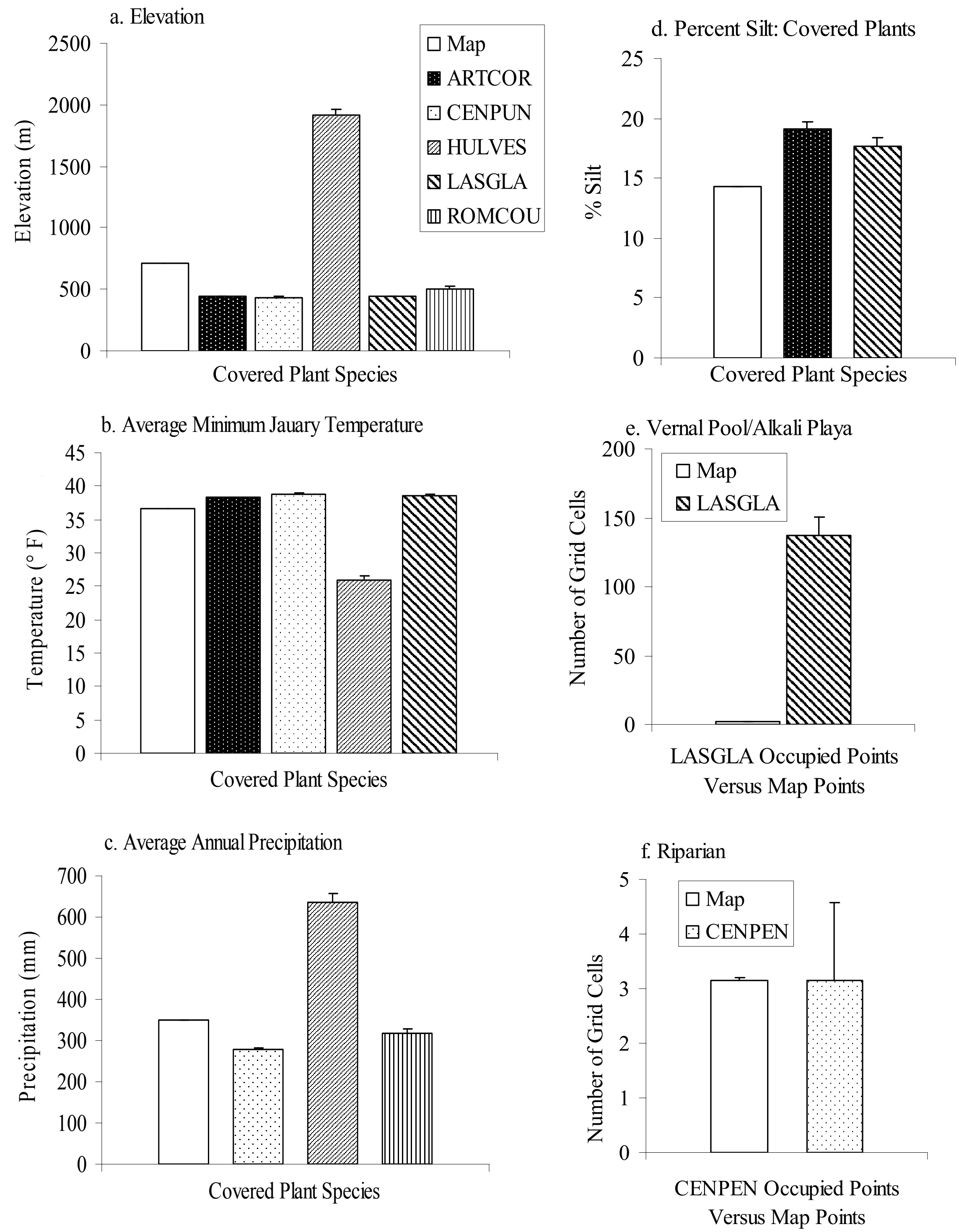
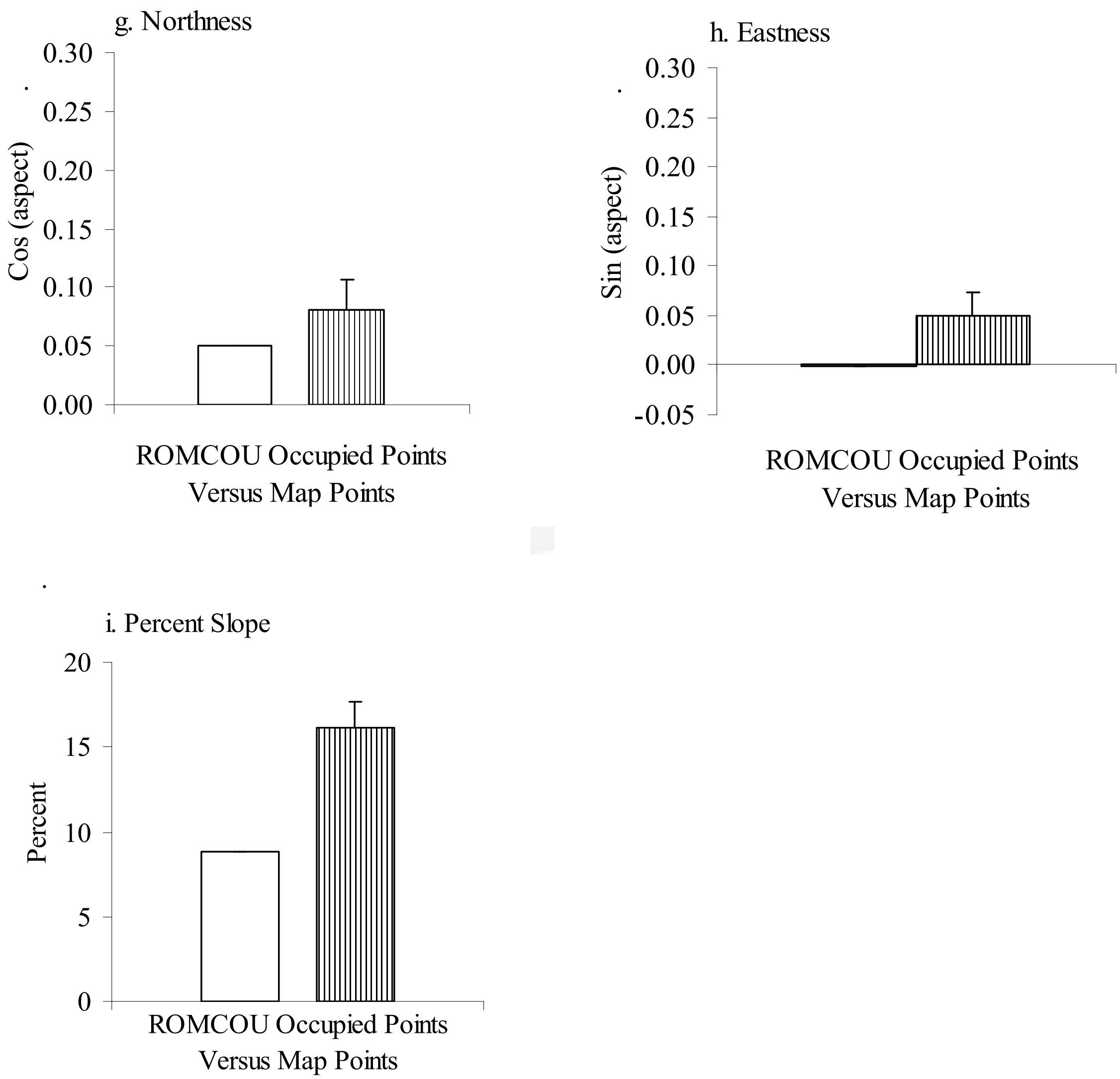


Figure 5.6 (Cont.) Covered plant species mean (± SE) values for important environmental variables at occupied points versus map points across the Study Area.



The niche models for smooth tarplant (*Centromadia pungens laevis*; Figure 5.2) and Coulter's matilija poppy (*Romneya coulteri*; Figure 5.5) show larger areas of potentially suitable habitat, which is consistent with the broader range of habitats with which they are typically associated. Important variables in the smooth tarplant model were elevation, mean average January temperature, annual precipitation, and the presence of riparian habitat within 250 meters of the point (Table 5.1). Smooth tarplant was typically found at low elevations (<500m), with minimum average temperatures of about 39°F, low annual precipitation, and small amounts of riparian habitat in the local neighborhood (Figures 5.6 a-c, e). The Coulter's matilija poppy niche model identifies percent slope and aspect (northness and eastness) as important determinants of suitable habitat, as well as elevation and annual precipitation (Table 5.1). Occupied points for this species were characterized as occurring at elevations below 500m with relatively low annual rainfall (Figures 5.6 a, c). There was no consistent tendency for poppies to occur on a particular slope aspect (Figures 5.6 g, h). Northness, equaling cos(aspect), was close to zero, as was eastness, which is equal to sin(aspect). The poppy occupied steeper slopes than was typical for the entire Plan Area (Figure 5.6 i).

Six covered bird species associated with coastal sage scrub and non-native grassland habitats were modeled (Table 5.1; Figures 5.7-5.12). The Coastal California Gnatcatcher (*Polioptila californica californica*) is the most restricted of these species to coastal sage scrub habitats. The niche model was constructed with 21 variables (Table 5.1) and identifies most coastal sage scrub vegetation as suitable. The selected gnatcatcher niche model indicates that coastal sage scrub, chaparral and non-native grassland habitats within 125 m of the occupied point (local scale), average minimum January and maximum July temperatures, and elevation are important components of suitable gnatcatcher habitat. Also important is the percentage of land in coastal sage scrub and agriculture within 1,125 m of the point (landscape scale). Two other species closely tied to coastal sage scrub in the Plan Area are the Bell's Sage Sparrow (*Aimophila ruficeps canescens*) and Southern California Rufous-crowned Sparrow (*Amphispiza belli belli*). The Bell's Sage Sparrow niche model (Figure 5.7) is similar to that of the California Gnatcatcher, although it includes more suitable habitat in the eastern portion of the Plan Area. Important variables associated with suitable Bell's Sage Sparrow habitat include the local scale distribution of coastal sage scrub and non-native grassland, average minimum January and maximum July temperatures, and elevation (Table 5.1). In contrast to the other two species, the Southern California Rufous-crowned Sparrow model is much more restrictive (Figure 5.12). For this species, the important environmental variables are local scale amounts of coastal sage scrub, chaparral, and non-native grassland, average minimum January temperature, elevation, annual precipitation, percent of developed land and coastal sage scrub at the landscape level, and the amount of developed edge adjacent to natural lands at the landscape scale (Table5.1).

Figures 5.13-5.15 show mean (± SE) values for the important habitat variables for California Gnatcatchers, Bell’s Sage Sparrows, and Southern California Rufous-crowned Sparrows at occupied points and at map points across the Plan Area. The three species occurred at mean elevations of 475-550 m, which were lower than the average 715 m for the entire Plan Area (Figure 5.13 a). All three species, particularly the gnatcatcher, occurred at relatively warm minimum January temperatures (Figure 5.13 b). Both the gnatcatcher and sage sparrow also occurred at points where the average maximum July temperatures was greater than the mean temperature for the Plan Area (Figure 5.13 c). Occupied rufous-crowned sparrow points were characterized by relatively low annual precipitation (Figure 5.13 d). The local scale distribution of vegetation was measured as the total number of grid cells (each cell equaling 30 m x 30 m) in a 240 m x 240 m neighborhood surrounding each point, with a total of 64 cells. Occupied points for all three species typically supported coastal sage scrub at approximately 35 cells (55% of the local neighborhood), which was substantially greater than the map points mean (Figure 5.14 a). Occupied gnatcatcher points supported slightly less chaparral habitat than rufous-crowned sparrows (9 versus 11 cells) and considerably less than the average (22 cells) for the Plan Area (Figure 5.14 b). The two sparrow species had slightly more non-native grassland habitat (14 cells) in the vicinity of occupied points than gnatcatchers (11 cells; Figure 5.14 c). At the landscape scale (2,250 m x 2,250 m neighborhood), suitable habitat for California Gnatcatchers and Southern California Rufous-crowned Sparrows was associated with close to 35% cover of coastal sage scrub, considerably greater than the Plan Area mean of 13% (Figure 5.15 a). Rufous-crowned sparrows were associated with points where only 11% of the landscape was developed and where developed edges with natural habitats averaged 550 m (Figures 5.15 b, d). Gnatcatcher points averaged 13% of the landscape converted to agricultural crops (Figure 5.15 c).

Two other covered bird species, Cooper's Hawk and Loggerhead Shrike are associated with coastal sage scrub to varying degrees. Loggerhead Shrikes are often associated with open shrubland that provide perches for hunting and sparsely distributed large shrubs for nesting. The Loggerhead Shrike niche model indicated a number of abiotic environmental variables were associated with suitable habitat (Table 5.1) and that this habitat was concentrated in the San Jacinto Valley and north of Temecula (Figure 5.11). Occupied shrike points were characterized by flat land at low elevations, with relatively warm temperatures, and low annual precipitation (Figures 5.13 a-e). At the local scale, shrike points contained a variety

Figure 5.7 "HSIs" of habitat similarity for Bell's Sage Sparrow across the Plan Area: The higher the HSI, the greater the similarity between occupied habitat and other areas.

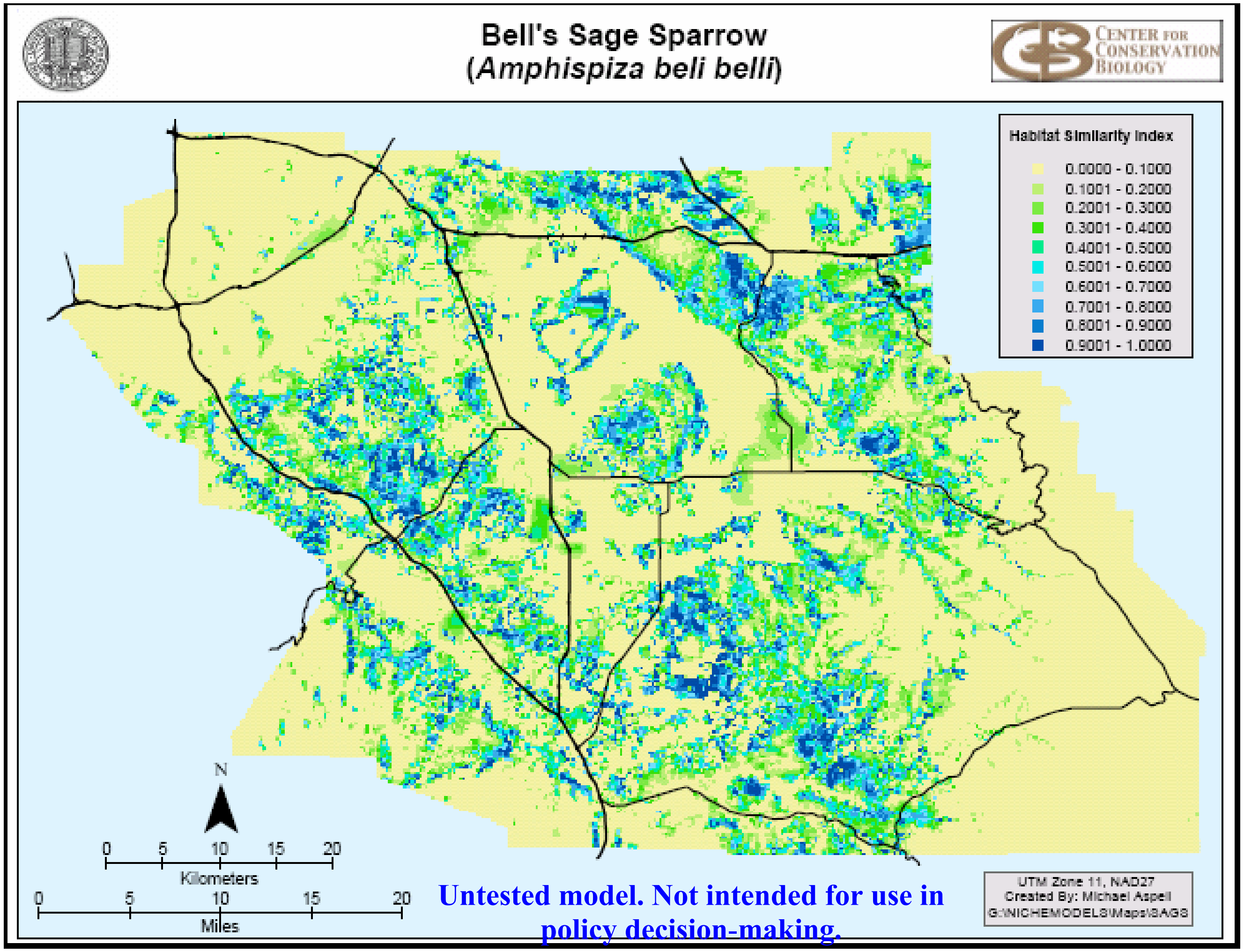


Figure 5.8 "HSIs" of habitat similarity for Burrowing Owl across the Plan Area: The higher the HSI, the greater the similarity between occupied habitat and other areas

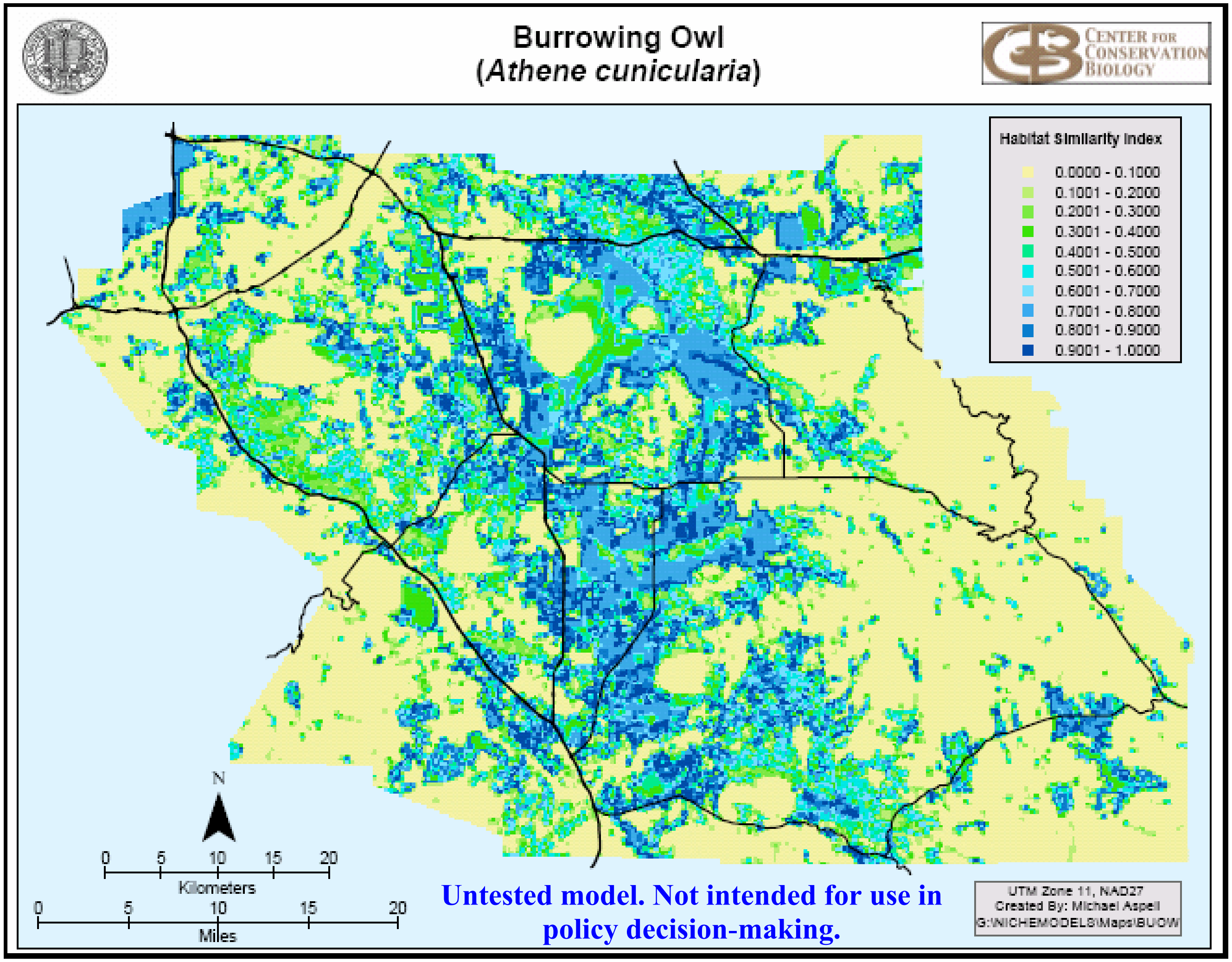


Figure 5.9 "HSIs" of habitat similarity for California Gnatcatcher across the Plan Area: The higher the HSI, the greater the similarity between occupied habitat and other areas

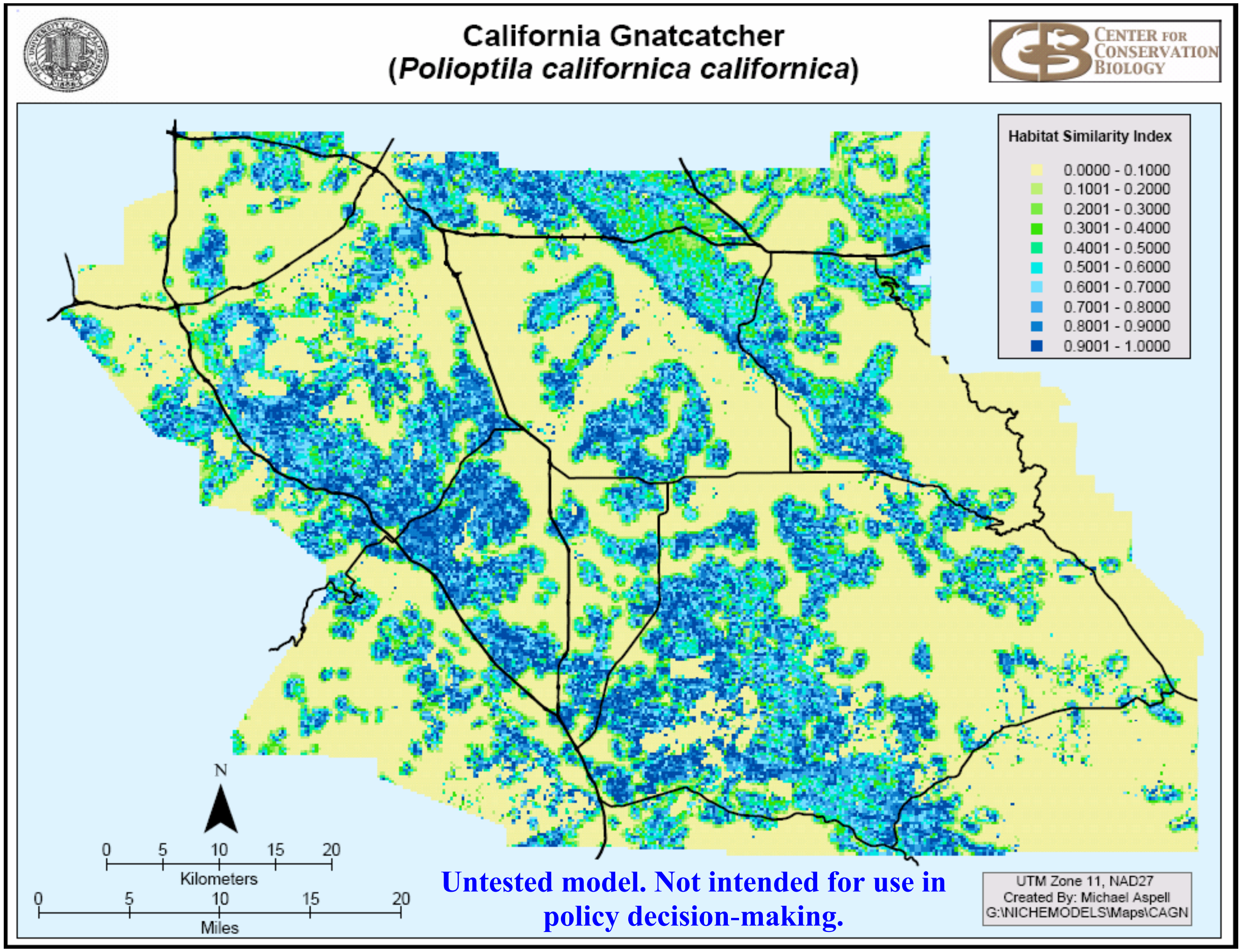


Figure 5.10 "HSIs" of habitat similarity for Cooper's Hawk across the Plan Area: The higher the HSI, the greater the similarity between occupied habitat and other areas.

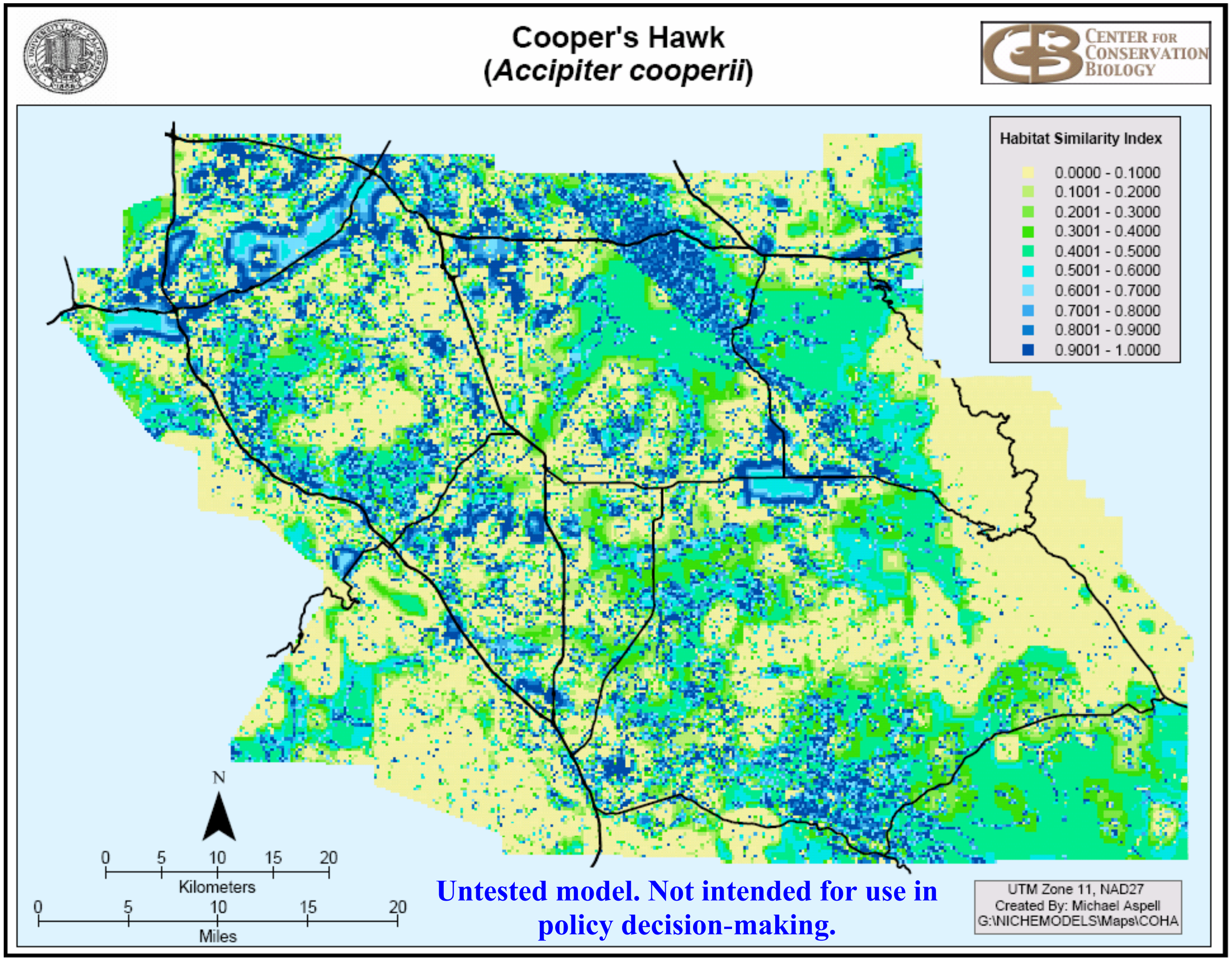


Figure 5.11 "HSIs" of habitat similarity for Loggerhead Shrike across the Plan Area: The higher the HSI, the greater the similarity between occupied habitat and other areas

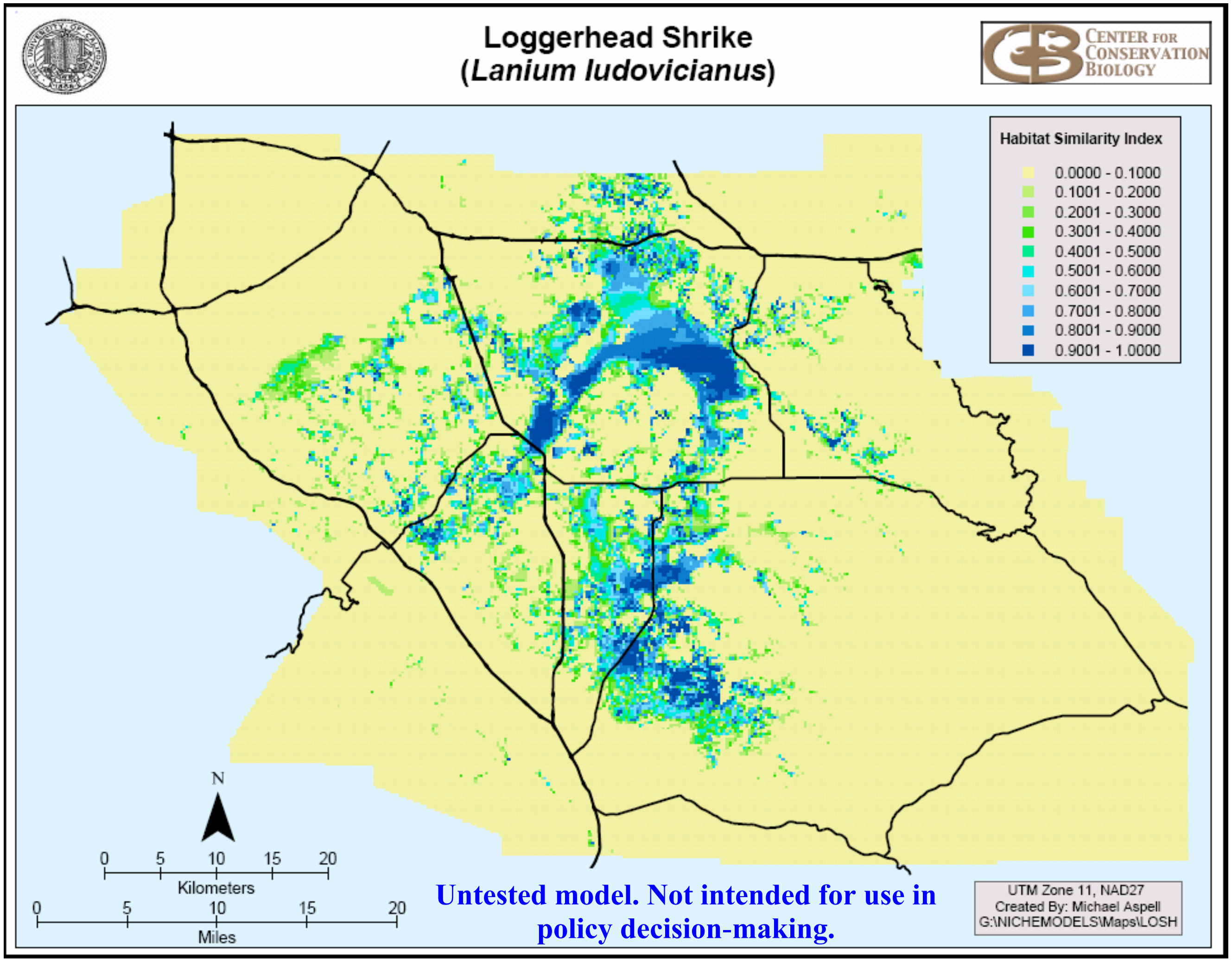


Figure 5.12 "HSIs" of habitat similarity for Southern California Rufous-crowned Sparrow across the Plan Area: The higher the HSI, the greater the similarity between occupied habitat and other areas

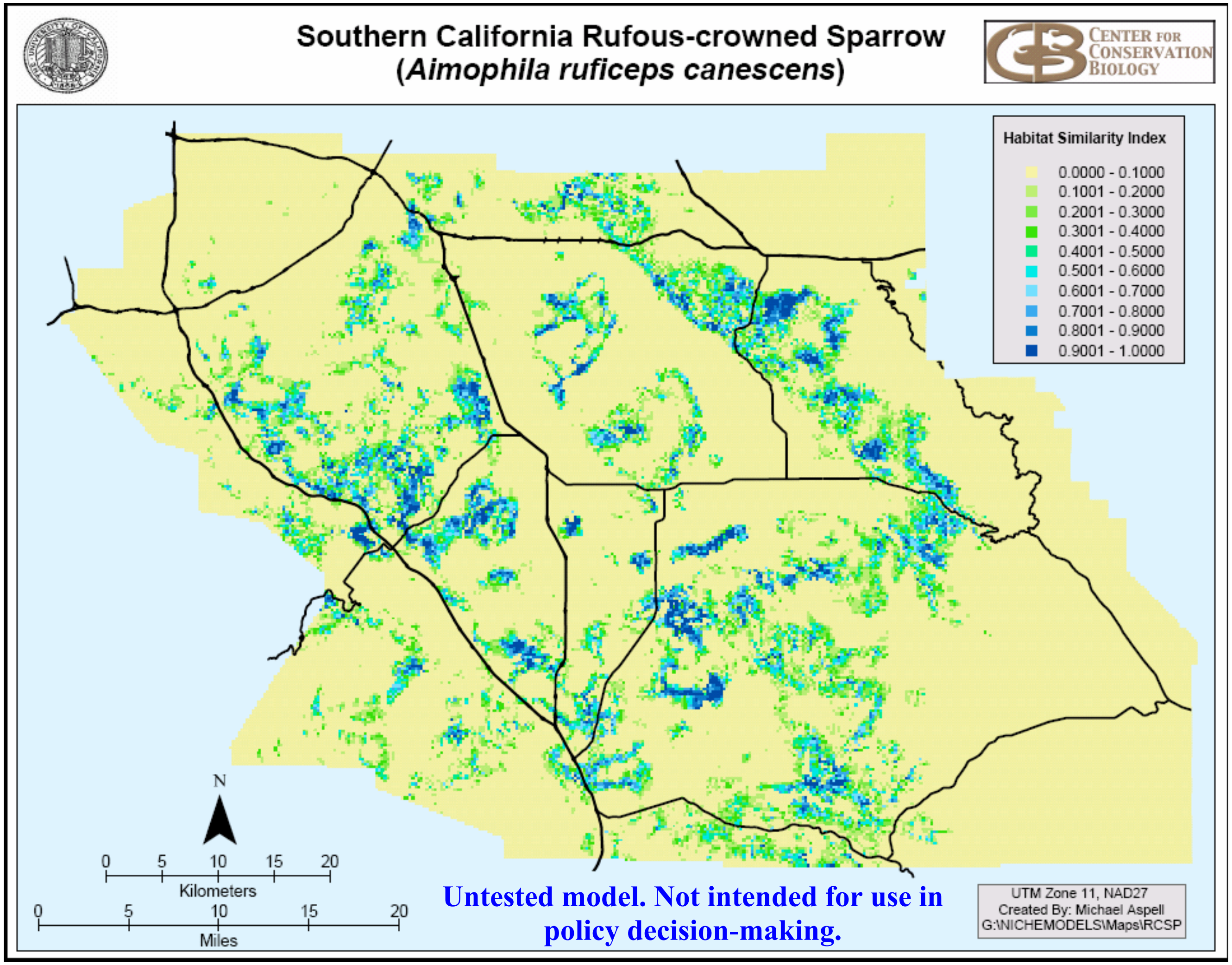


Figure 5.13 Covered bird species mean (± SE) values for important environmental variables at occupied points versus map points across the Study Area. CAGN = California Gnatcatcher, LOSH = Loggerhead Shrike, RCSP = Southern California Rufous-crowned Sparrow, and SAGS = Bell's Sage Sparrow.

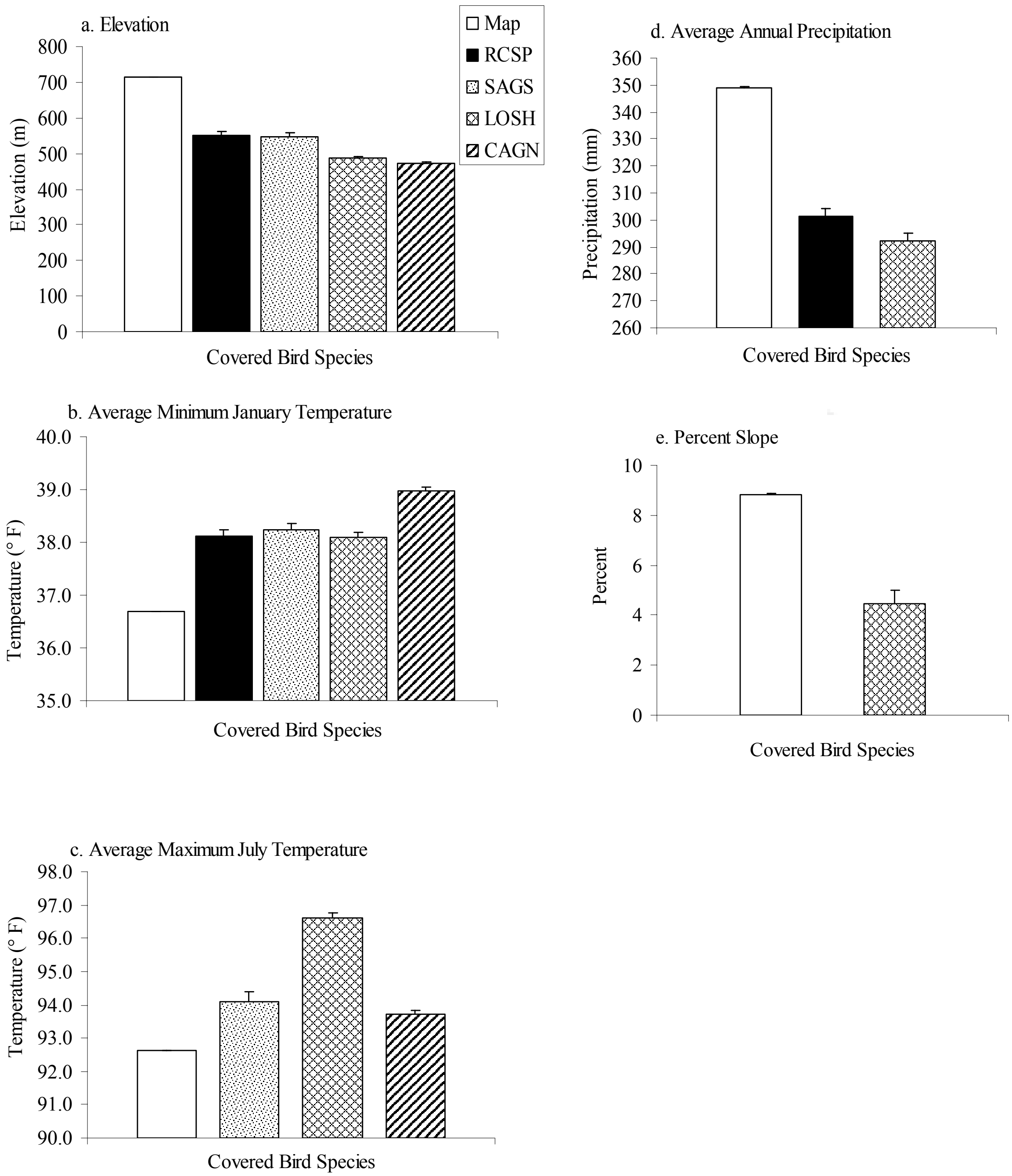
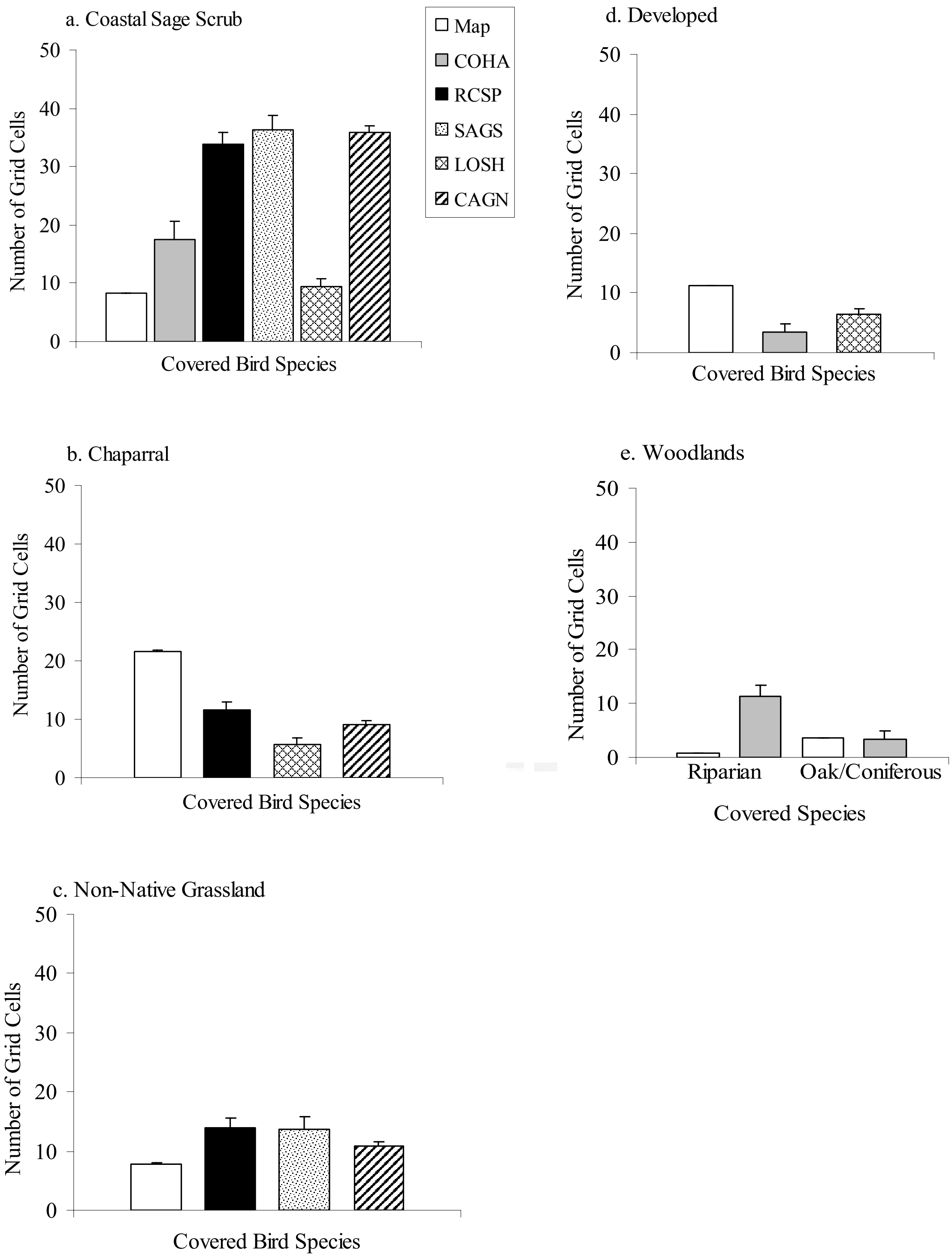


Figure 5.14 Covered bird species mean (± SE) values for important local scale vegetation variables at occupied points versus map points across the Study Area. CAGN = California Gnatcatcher, COHA = Cooper's Hawk, LOSH = Loggerhead Shrike, RCSP = Southern California Rufous-crowned Sparrow, and SAGS = Bell's Sage Sparrow.



of habitats, all present at relatively low levels. These habitats included coastal sage scrub, chaparral, non-native grassland, and development (Figures 5.14 a-c). Shrikes also used agricultural lands (average of 22 cells), although this use was variable and was not identified as a consistent component of shrike habitat in the preliminary niche model. At the landscape scale, shrikes were typically found in areas with less than 5% development (Figure 5.15 b).

Cooper's Hawks are often associated with coast live oak woodlands where they typically nest. They also nest in riparian and urban areas. They forage for bird and mammal prey in a variety of habitats, including coastal sage scrub and chaparral. Reflecting their broad habitat use the Cooper's Hawk niche model shows the largest area of suitable habitat for any of the modeled species (Figure 5.5.10). Only vegetation variables were used in this species niche model and they all showed up as important components of suitable habitat (Table 5.1). At the local scale, occupied Cooper's Hawk points were associated with coastal sage scrub, riparian, and oak/coniferous woodlands (Figures 5.14 a, d). On average, less than 4% of their local neighborhood was developed (Figure 5.14 d). At the landscape scale, approximately 10% of the surrounding habitat at occupied points was developed (Figure 5.15 b).

Burrowing Owls are primarily found in non-native grassland habitats and agricultural areas. Potentially suitable habitats for Burrowing Owls were widely distributed throughout the Plan Area (Figure 5.8). The variables most closely associated with suitable owl habitat include the amount of non-native grassland, agricultural fields and alkali playas/vernal pools at the local scale and the amount of open water at the landscape scale (Table 5.1). Burrowing Owls were modeled at the 500 m x 500 m scale. Their local neighborhood consisted of 256 30 m x 30 m cells (16 x 16 grid). The landscape scale was similar to the local models with a neighborhood of 2,250 m x 2,250 m (75 x 75 cell grid). At the local scale, approximately 35% of the 256 cells surrounding occupied points were non-native grassland (49 cells) and vernal pool/alkali habitats (40 cells; Figure 5.16 a). Agricultural lands comprised only a small proportion of the neighborhood around Burrowing Owl points. At the landscape scale, an average of nearly 2 cells was associated with open water at occupied owl locations (Figure 5.16 b). Except for the California Gnatcatcher, there were insufficient location data to adequately compare validation datasets with predicted habitat suitability values for all bird niche models. Validation of gnatcatcher modeling was discussed previously in Chapter 3.

Discussion

Preliminary niche models constructed for rare plants and birds identify a number of abiotic environmental variables and vegetation types that are associated with suitable habitat for covered species. As would be expected, occupied habitat for co-occurring species share similar characteristics. However, there are subtle differences in the importance of different environmental variables to each species and this leads to substantial differences in habitat suitability maps.

For example, California Gnatcatchers, Southern California Rufous-crowned Sparrows, and Bell's Sage Sparrows occur at the same elevations with similar levels of coastal sage scrub and non-native grassland habitats in their local neighborhoods. However, there are differences among the three species in terms of which environmental variables are important and how occupied habitat is characterized by a particular variable. For example, occupied points for the small California Gnatcatcher have slightly warmer average minimum January temperatures than points occupied by the two sparrow species. This may reflect a limitation to the distribution of small 6 gram insectivorous gnatcatchers relative to larger, seed eating sparrows that also occur in coastal sage scrub. On the other hand, the amount of development and edge habitat at the landscape scale is identified as an important variable influencing suitable habitat for the rufous-crowned sparrow but is not identified by the models for the other two species. This subtle difference in responses between species to environmental variables leads to substantially different habitat suitability maps for these three co-occurring species. The least restrictive map is that of Bell's Sage Sparrow, while the most restrictive is that for the Southern California Rufous-crowned Sparrow.

Similarly, for co-occurring plants, the niche models for San Jacinto Valley crownscale and Coulter's goldfields were constructed of the same four variables. The maps are very similar, although subtle differences exist. The Coulter's goldfield model shows suitable habitat in the northeast corner of the Plan Area, which is not identified as suitable for San Jacinto Valley crownscale. In support of this niche model, there are records for Coulter's goldfield populations east of the Plan Area, whereas this is not the case for the crownscale. The partitioned Mahalanobis D^2 models allow us to potentially identify factors causing differences in the distribution of suitable habitat for species. This tool can be used as a beginning point for further studies of habitat relationships, to guide monitoring, and to prepare adaptive management strategies.

It should be noted that the mean values for important habitat variables are expected to remain relatively constant for a species as they define the minimum habitat requirements for that species. In contrast, the mean values of map points may differ depending on what region is modeled. For example, CCB created niche models encompassing the entire Plan Area, whereas if only lower elevations had been modeled mean values for map points would differ. The map of suitable habitat would not be expected to change substantially as it is dependent on the characteristics of the calibration dataset, which remain the same. The landscape or region within which a species is modeled may also change, which would also alter the distance between the mean values of occupied points and map points. This is why the partitioned Mahalanobis D^2 technique is suited for predicting species responses to future changing environmental conditions (Martinez-Meyer et al. 2004; Hannah et al. 2005). Niche models can also be used to map the invasion of exotic species (Townsend Peterson and Vieglais 2001) and these invasive species responses to future changing environmental conditions (Martinez-Meyer et al. 2004; Hannah et al. 2005). Niche models can also be used to map the invasion of exotic species (Townsend Peterson and Vieglais 2001) and these invasive species habitat suitability maps could be used to predict habitat suitability changes for covered species.

Figure 5.15 Covered bird species mean (± SE) values for important landscape scale variables at occupied points versus map points across the Study Area. CAGN = California Gnatcatcher, COHA = Cooper's Hawk, LOSH = Loggerhead Shrike, and RCSP = Southern California Rufous-crowned Sparrow.

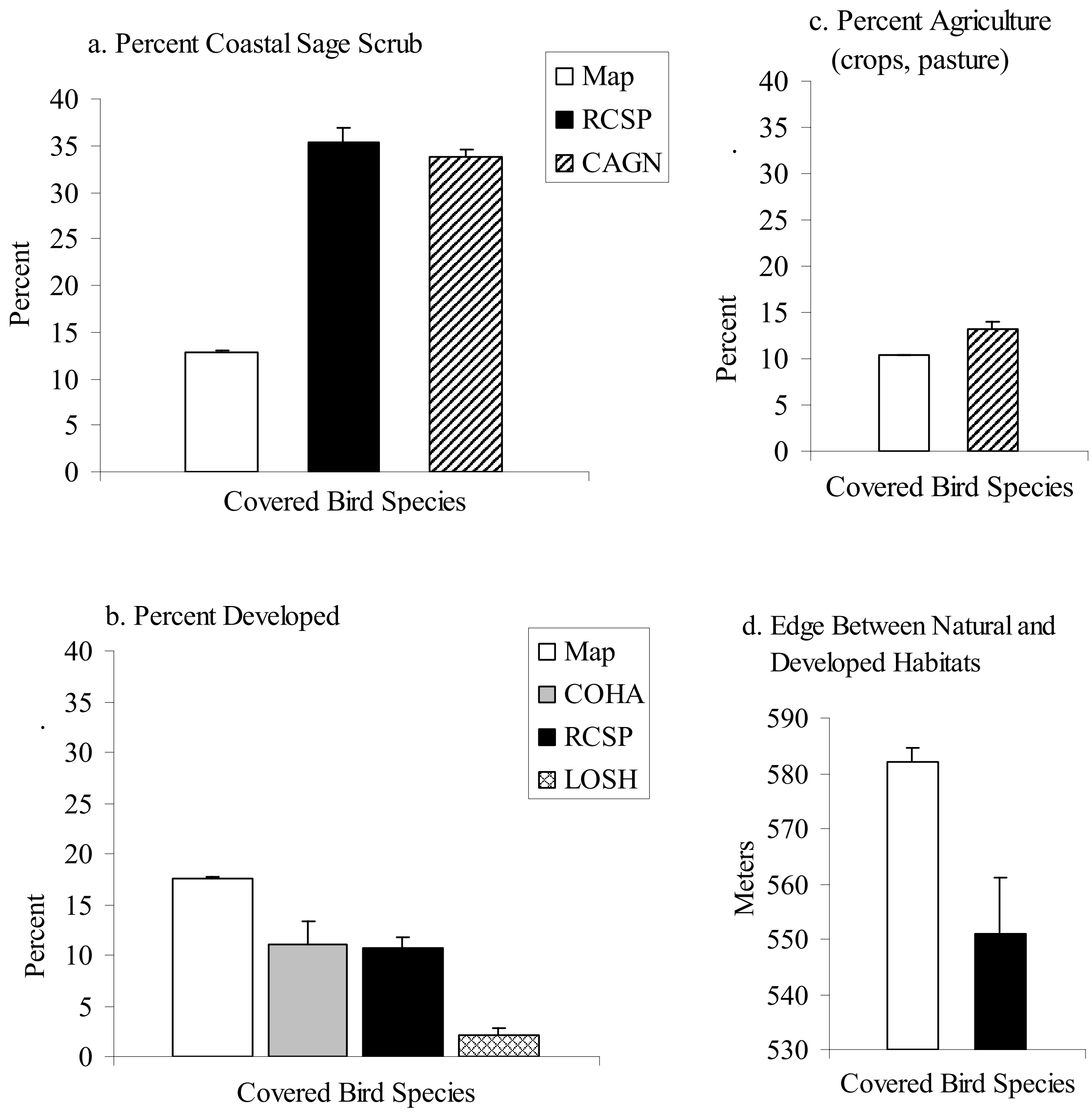
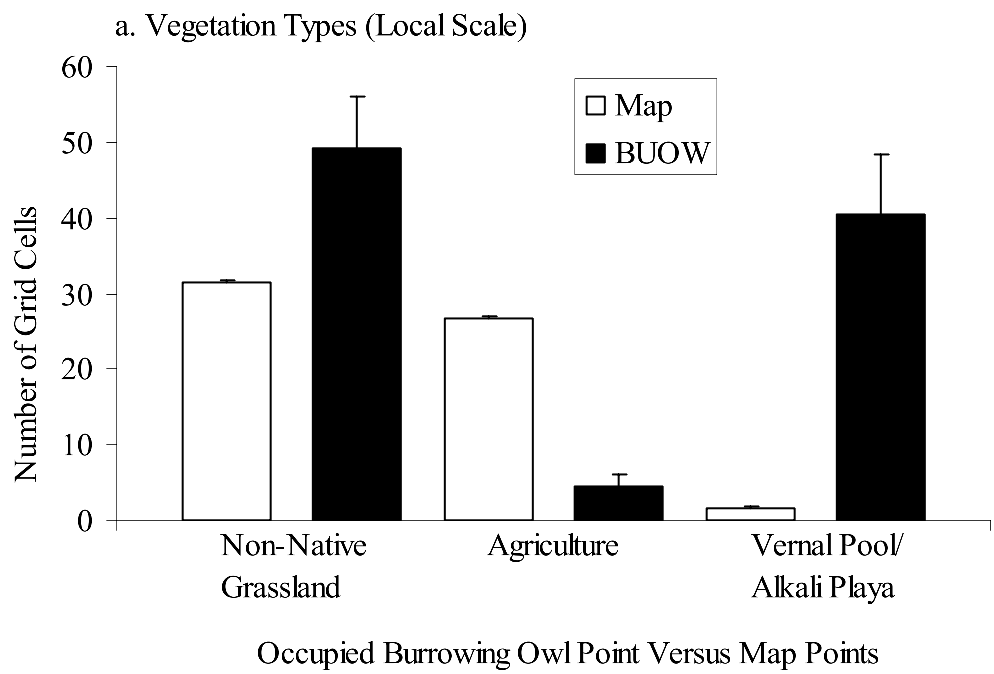
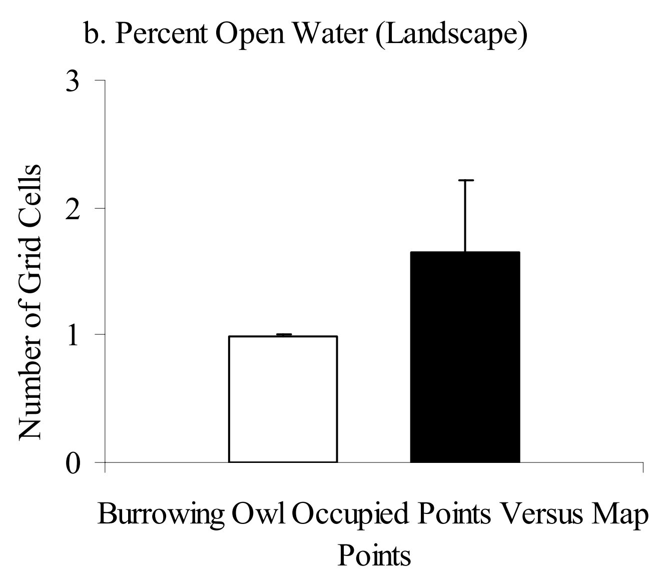


Figure 5.16 Burrowing Owl mean (± SE) values for important environmental variables at occupied points versus map points across the Study Area. BUOW = Burrowing Owl.





Each niche map in this report represents a hypothesis about a species potential distribution or more conservatively about where habitat is similar to habitat at the species known locations. Each of these habitat suitability maps should be treated as preliminary, remaining to be tested with an independently collected dataset. Independent location data will allow testing of the models to determine how well the model and the chosen principal components categorize suitable habitat. It is anticipated that the models and corresponding maps of habitat suitability may be improved as new species location data and relevant GIS layers (e.g., the revised vegetation map) become available. Testing and refining niche models is an integral part of the monitoring framework that CCB has developed (Barrows et al. 2005). At this point, the preliminary phase of constructing niche models for species with sufficient location data has been achieved. It remains to test, refine, and improve these models so that they can be most effective in identifying and managing suitable habitat for sensitive species.

CHAPTER 6
REPTILE NICHE MODELS

Introduction

The first phase of the monitoring framework development involves establishing the correlates to distribution for as many of the covered species as possible. Niche models can be used to identify potentially suitable habitat for covered species and to identify community groupings. These spatially explicit habitat suitability models have the potential to be valuable tools for reserve managers, agency personnel, and researchers to use in monitoring and managing covered species. When coupled with GIS and digital environmental data these models not only identify variables that may be important in influencing a species' distribution, they also show where these variables occur together in a combination most conducive to a species' occurrence (Hirzel et al. 2002; Rotenberry et al. 2002).

The niche models used to model covered reptile species employ the partitioned Mahalanobis D^2 procedure (Rotenberry et al. 2002), as described previously in this document (Chapters 3,4, and 5). In this section, the results of the models are presented along with their interpretation.

The discussions of reptile niche models in this chapter derive from two sources. First, CCB developed a series of niche models for five of the eleven reptile species covered by the WRC MSHCP. These five species were chosen because they have habitat requirements that are relatively well understood, they are potentially detectable during standardized visual encounter surveys, and they were believed to have an adequate number of historic observation records. The models were developed utilizing historic records and field data collected in 2003 and 2004. The target reptile species for the CCB niche models are: coast horned lizard (*Phrynosoma coronatum*), granite spiny lizard (*Sceloporus orcutti*), orange-throated whiptail (*Cnemidophorus hyperythrus*), coastal western whiptail (*C. tigris stejnegeri*), and red diamond rattlesnake (*Crotalus ruber*) (Stebbins 2003).

Second, in addition to the CCB models, CCB biologist Adam Malisch constructed niche models for the four lizard species listed above and the southern sagebrush lizard (*S. graciosus vandenburgianus*) using only data collected in 2003 and historic data. These models were tested utilizing independently collected validation data from the spring and summer of 2004. The results of the field surveys Adam conducted appear in Tables 6.1 and 6.2. The primary goal of this two-year study was to construct niche models for the five lizard species during the first year and then attempt to validate the models in the second year by generating an independent data set to compare against model predictions. The summaries presented below are summarized from the niche models developed by CCB. The full details and results of the lizard niche model validation study can be found in Malisch (2005). A brief discussion of this work will also be presented following the discussion of the CCB reptile niche modeling results. The lizard niche model validation study also involved collaboration with biologists to develop a surveying protocol utilizing handheld devices to delineate survey areas and digitally record data. This technology allows easy downloading of data into a computer database without the need for time-consuming data entry "by hand". Not only does this speed up data downloading, but also reduces the possibility of additional errors during data transcription from one format to another. The goal is to apply this technology to all types of field data collection in the future. The field protocols can be found in Appendix 3.

Methods

Utilizing the historic records amassed within the CCB database and the records accumulated in the surveys described above, CCB developed preliminary niche models to predict habitat suitability across the 490,844 ha WRC MSHCP area for five covered reptile species. The modeled species include: the granite spiny lizard (*Sceloporus orcutti*), orange-throated whiptail (*Cnemidophorus hyperythrus*), western whiptail (*C. tigris stejnegeri*), coast horned lizard (*Phrynosoma coronatum*), and red diamond rattlesnake (*Crotalus ruber*). A niche model was not constructed for the sagebrush lizard (*Sceloporus graciosus*) due to a lack of a sufficient number of records for model calibration.

The models were created using sets of predictor variables hypothesized *a priori* to be important in determining the distribution of each particular species. These hypotheses were formulated based upon knowledge of the natural history of each species. Presence data for each species were taken from several sources, including museum records, published and unpublished species accounts, environmental impact reports, field notes of local naturalists, and CCB surveys.

Each reptile niche map in this report represents a hypothesis about a species' potential distribution or more conservatively about where habitat is similar to habitat at the species known locations. Four of the six reptile models were tested using 2004 survey data (the sagebrush lizard model was deemed unacceptable due a lack of model calibration data, and red diamond rattlesnakes were not included in 2004 target species). In their current form, the models and associated maps should not be accepted as final, but remain to be modified and tested further. It is anticipated that the models and corresponding maps of habitat suitability may be improved as new species location data and relevant GIS layers become available. Testing and refining niche models is an integral part of the monitoring framework that CCB has developed (Barrows et al. 2005). At this point, the preliminary phase of constructing niche models for species with sufficient location data has been achieved. It remains to test refine and improve these models so that they can be effective tools in identifying and managing suitable habitat for sensitive species. The niche modeling process developed by CCB is designed to be an iterative process, with validation survey data fed back into future models. While the precision and accuracy of model predictions should improve with each iteration, models remain hypotheses about species' distributions.

Table 6.1 WRC MSHCP reptile survey results for the 2003 field season.

Site:	General Habitat:	Distance Surveyed (km):	Target Species:				
			Cn Hy	Cn Ti	PhCo	Sc Gr	Sc Or
Box Springs, Two Trees Trail	CSS/Exotic grassland with trail, rocky	6.0	4	10	_	_	20
Box Springs, Big Springs parking lot trails	Disturbed exotic grassland with trail	5.8	1	4	_	_	10
Lake Perris	CSS/Exotic grassland with trail, rocky	4.3	_	3	_	_	5
Motte Rimrock Reserve	CSS/Exotic grassland with trail, rocky	21.0	2	9	4	_	43
Mt Rubidoux	CSS/Exotic grassland with trail, rocky	6.1	1	_	_	_	20
San Jacinto Mnts, Black Mountain Trail	Chaparral/Pine with trail	7.0	_	3	_	4	2
San Jacinto Mnts, Deer Springs Trail	Pine forest with trail	_	_	_	_	12	_
San Mateo Canyon, Morgan Trail	Oak woodland with trail	3.5	_	1	_	_	_
Santa Rosa Plateau, Torino Trail and Coyote Trail	CSS/Chaparral/Oak/Exotic grassland with trail	4.6	_	_	_	_	3
Shipley-Skinner, Lake Skinner	CSS/Exotic grassland with trail	12.4	_	4	10	_	_
Shipley-Skinner, Lopez Canyon	CSS/Exotic grassland, no trail	13.9	_	8	3	_	1
Summit of Ortega Hwy	Chaparral with trail	3.5	_	1	_	_	_
Sycamore Canyon, Riverside	Disturbed exotic grassland with trail	4.8	3	_	_	_	14
UCRiverside, Botanic Gardens	CSS with trail	6.0	_	_	_	_	5
Totals		98.9	11	43	17	16	123
		Ratio of occupied sites to total sites:	5/14	9/14	3/14	2/14	10/14

Abbreviations:
CSS = Coastal sage scrub
Cn Hy = Orange-throated whiptail (*Cnemidophorus hyperythrus*)
Cn Ti = Coastal whiptail (*Cnemidophorus tigris stejnegeri*)
Ph Co = Coast horned lizard (*Phrynosoma coronatum*)
Sc Gr = Southern sagebrush lizard (*Sceloporus graciosus vandenburgianus*)
Sc Or = Granite spiny lizard (*Sceloporus orcutti*)

Table 6.2 WRC MSHCP reptile survey results for the 2004 field season.

Site:	General Habitat:	Area Surveyed (m2):	Number of Individuals Observed:								
			Target Species:					Other Herps Observed:			
			Cn Hy	Cn Ti	Ph Co	Sc Gr	Sc Or	Ut St	Sc Oc	Cr Ru	Ma Fl
Sycamore Canyon	Disturbed CSS/Exotic Grass	432,000	3	0	0	0	10	33	4	1	0
Potrero Canyon	Chaparral/Exotic Grass/Riparian Zone	432,000	1	4	0	0	3	19	3	0	1
Box Springs	Disturbed CSS/Exotic Grass	216,000	0	0	0	0	7	21	0	0	0
Lake Perris	Disturbed CSS/Exotic Grass	432,000	4	9	0	0	2	24	0	0	0
Highway 74, near South Fork Trail	Chaparral	432,000	0	2	1	11	0	14	0	0	0
		Ratio of occupied sites to total sites:	3/5	3/5	1/5	1/5	4/5	5/5	2/5	1/5	1/5

Abbreviations:
CSS = Coastal sage scrub
Cn Hy = Orange-throated whiptail (*Cnemidophorus hyperythrus*)
Cn Ti = Coastal whiptail (*Cnemidophorus tigris stejnegeri*)
Ph Co = Coast horned lizard (*Phrynosoma coronatum*)
Sc Gr = Southern sagebrush lizard (*Sceloporus graciosus vandenburgianus*)
Sc Or = Granite spiny lizard (*Sceloporus orcutti*)
Ut St = Side-blotched lizard (*Uta stansburiana*)
Sc Oc = Western fence lizard (*Sceloporus occidentalis*)
Cr Ru = Red diamond rattlesnake (*Crotalus ruber*)
Ma Fl = Coachwhip (*Masticophis flagellum*)

Results

To interpret the results of the niche models developed by CCB, the mean for each of the landscape variables quantified at each of the point locations contained within the calibration data set (i.e., the data set used to construct the model) was compared against the mean for each variable averaged across the entire Plan area. This comparison provides a characterization of suitable habitat for each species. See Table 6.3 for details. The descriptions of suitable habitat presented refer to those habitat variables that display the least amount of variation among the sites where the species was observed in the past. Other variables not described may show considerable variation among occupied sites. As stated previously, the models are preliminary in nature and have not been adequately validated.

Granite Spiny Lizard (SCOR): The preliminary niche model for the granite spiny lizard hypothesizes that this species is associated with higher than average minimum temperature, lower elevations, lower than average precipitation, and greater than average amounts of coastal sage scrub (Table 6.3). Surprisingly, the presence of rock outcrops did not show up as a variable characteristic of suitable habitat even though it is well known that the granite spiny lizard is a rock specialist (Stebbins 2003). The fact that the model does not reveal rock as a key variable demonstrates why preliminary models must be used with caution. The problem may lie with the rock outcrop layer. This GIS layer was derived from a combination of digital aerial photographs and a soils map of the Plan area. Soils maps vary in the level of detail they ascribe to specific areas (Robert Graham, personal communication). Often areas suitable for agriculture contain substantial detail in soils relative to non-agricultural areas. Because non-agricultural areas contain less detail, they may under represent the extent of rock outcrops. To attempt to remedy this problem, aerial photos were used to digitize rock outcrops in areas of the County not covered by the soils map and areas with poor coverage.

Coast Horned Lizard (PHCO): The preliminary niche model for the coast horned lizard hypothesizes that suitable habitat for this species is characterized by higher than average minimum temperature, lower elevations, lower than average precipitation, and greater than average amounts of coastal sage scrub and grassland, and smaller than average amounts of chaparral (Table 6.3). Compared to the granite spiny lizard, the horned lizard appears more catholic regarding suitable habitat. Since this species has a very specialized diet consisting of native ants, the ability of the species to exist in a given habitat may be a function of the presence or absence of native ant species. A study conducted by Suarez et al. (2000) demonstrated that horned lizards avoid eating non-native ant species when present, which may in turn affect the distribution and abundance of the lizard at local scales. Management for this species may rely upon exotic ant species control in addition to preserving suitable habitat.

Orange-throated Whiptail (CNHY): The preliminary niche model for the orange-throated whiptail hypothesizes that suitable habitat is characterized by higher than average minimum temperature, low elevations, lower than average precipitation, and greater than average amounts of coastal sage scrub and grassland (Table 6.3). Of the four lizard species modeled, this species shows the most restricted habitat requirements. Suitable habitat consists predominantly of low elevation coastal sage scrub. In an extensive survey spanning the entire range of this species in southern California, Brattstrom (2001) demonstrated that *Cnemidophorus hyperythrus* utilizes areas of sage scrub that are an even mixture of open ground and vegetative cover to a greater extent than areas with dense vegetation. This lizard will also utilize chaparral and grassland, but only if ample bare ground among shrubs or within the grass is present. Ground litter is also required, as this provides the substrate for termites, which are a major component of the whiptail's diet. The invasion of non-native grass into coastal sage scrub habitat could reduce this species' ability to utilize coastal sage habitat by reducing the amount of bare ground available for this species to forage.

<u>Western Whiptail</u> (CNTI): The preliminary niche model for the western whiptail hypothesizes that suitable habitat is characterized by lower than average minimum temperature, mid elevations, slightly less than average precipitation, and lower than average amounts of coastal sage scrub and grassland (Table 6.3). The western whiptail showed the highest mean elevation and lowest minimum average temperature relative to the other species modeled. This is surprising since, in general, *Cnemidophorus* species display a higher average optimal body temperature than other North American lizard species (Brattstrom 1965). However, this species also exhibits the widest geographical range of the five species modeled. The range extends as far north as southern Idaho and as far south as the tip of the Baja Peninsula. At higher elevations and latitudes, the thermal window of opportunity for optimal thermoregulation may be greatly reduced, thereby reducing the length of the daily activity period (Avery 1982). Because this species is capable of living in a wide range of environments, and the Plan area includes large expanses of higher elevation areas (e.g., San Jacinto mountains) this may help explain why this species showed the lowest minimum average temperature among modeled species even though we know that it prefers higher temperatures. While western whiptails may prefer the higher temperatures more typically found at lower elevations, they are apparently able to tolerate a wider range of elevations and temperatures than other target species.

<u>Red Diamond Rattlesnake</u> (CRRU): The preliminary niche model for the red diamond rattlesnake hypothesizes that suitable habitat is characterized by high minimum temperature, low elevation, low precipitation, and higher than average amounts of coastal sage scrub (Table 6.3). This species displays a mean coverage of coastal sage scrub value that is higher than *C. hyperythrus*. Like the granite spiny lizard, anecdotal information for red diamond rattlesnakes usually associates its occurrence with the presence of rock outcrops (Stebbins 2003), yet rock does not appear as a problem with the rock outcrop layer than biological reality. Models for both species would benefit greatly from the detailed vegetation map currently under development by CDFG.

Table 6.3. Interpretation of preliminary niche models. The mean for each variable averaged across all 480 x 480 m^2 neighborhoods surrounding each animal point location is compared to the mean for each 480 x 480 m^2 neighborhood surrounding each of the 78,021 pixels that comprise the Plan area. The mean value for the vegetation classes represents the numbers of pixels in the 480 x 480 m^2 area consisting of that vegetation class.

Variable	**Mean Value for Planning Area**	**Species** (see text for acronym meaning)				
		SCOR	PHCO	CNHY	CNTI	CRRU
Min. Temp (°C)	**36.68**	37.74	37.89	38.48	36.76	38.32
Max. Temp (°C)	**92.62**	93.39	92.88	93.7	92.69	98.67
Precipitation (mm)	**348.89**	315.53	321.09	295.86	345.79	299.94
Elevation (m)	**714.59**	593.11	613.67	520.14	711.26	529.39
Agriculture (# of Pixels)	**26.59**	35.71	15.68	11.57	1.95	N/A
Sage Scrub(# of Pixels)	**33.01**	25.73	72.48	109.91	15.85	126.09
Chaparral (# of Pixels)	**86.58**	15.61	72.74	N/A	22.37	48.23
Grassland (# of Pixels)	**31.58**	10.58	51.3	48.55	14.63	30.23

Figure 6.1. Map depicting the distribution of habitat similarity index (HSI) values for *Sceloporus orcutti* across the Plan Area: The higher the HSI, the greater the similarity between occupied habitat and other areas.

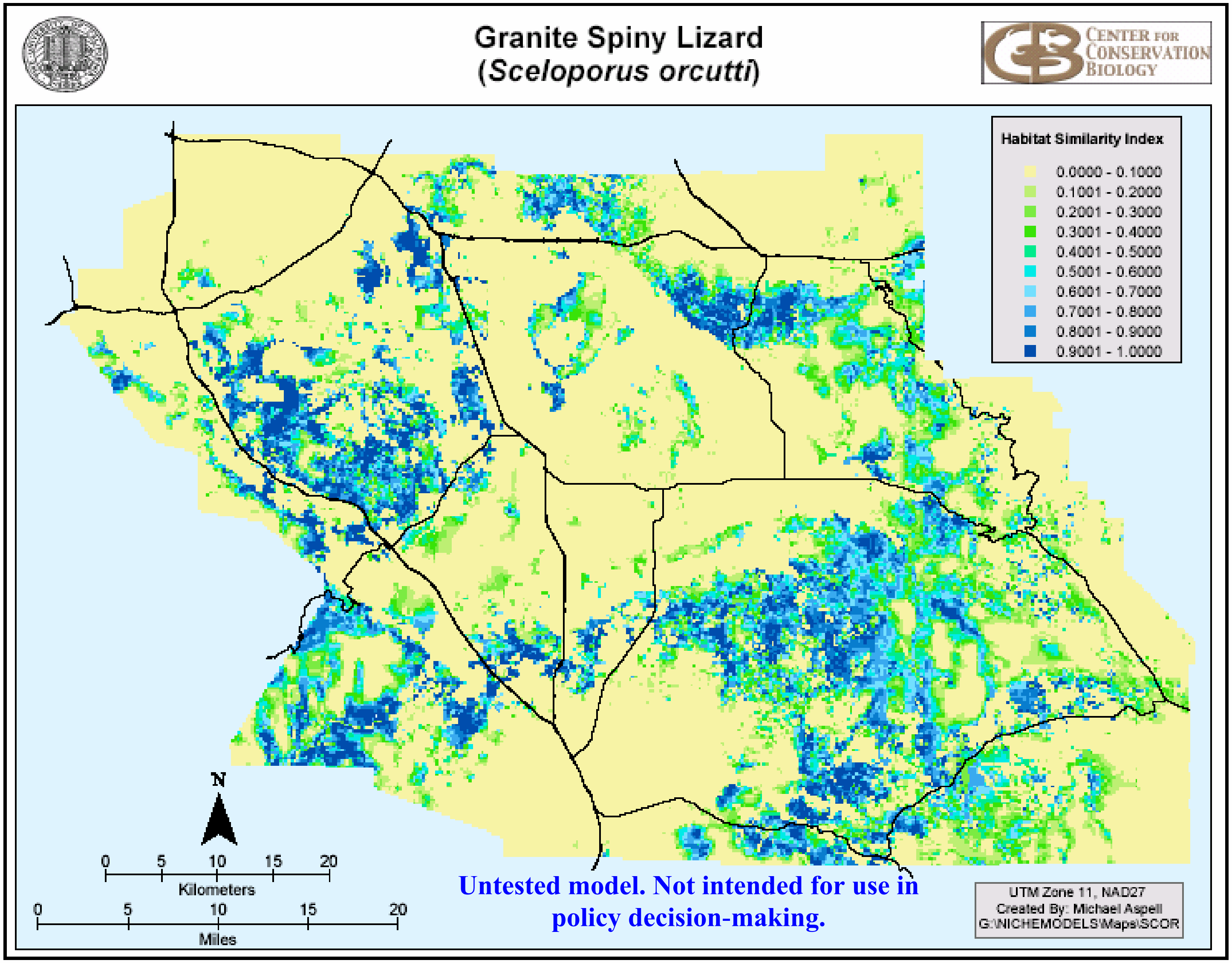


Figure 6.2 Map depicting the distribution of habitat similarity index (HSI) values for *Phrynosoma coronatum blainvillei* across the Plan Area: The higher the HSI, the greater the similarity between occupied habitat and other areas.

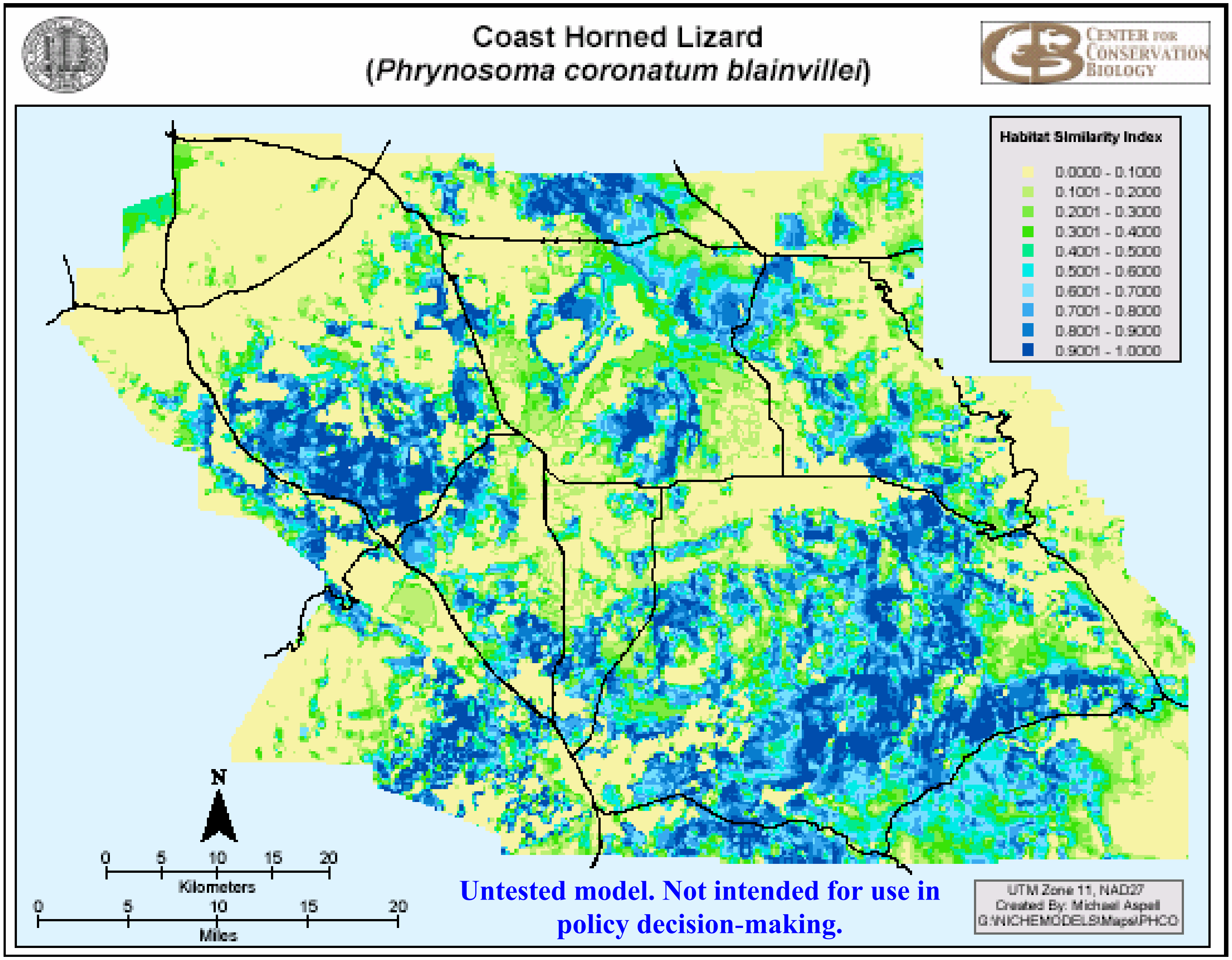


Figure 6.3 Map depicting the distribution of habitat similarity index (HSI) values for *Cnemidophorus hyperythrus beldingi* across the Plan Area: The higher the HSI, the greater the similarity between occupied habitat and other areas.

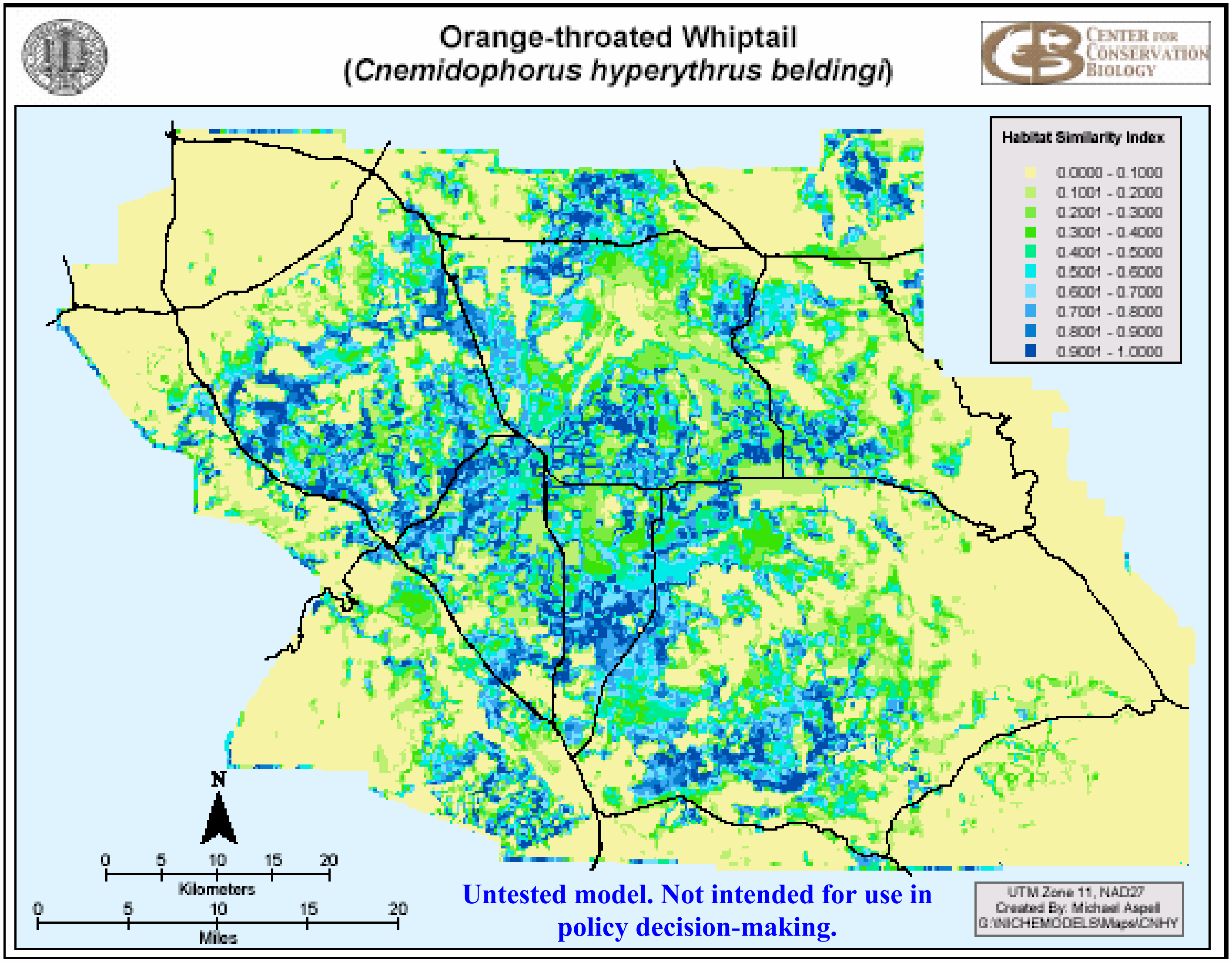


Figure 6.4 Map depicting the distribution of habitat similarity index (HSI) values for *Cnemidophorus tigris* across the Plan Area: The higher the HSI, the greater the similarity between occupied habitat and other areas

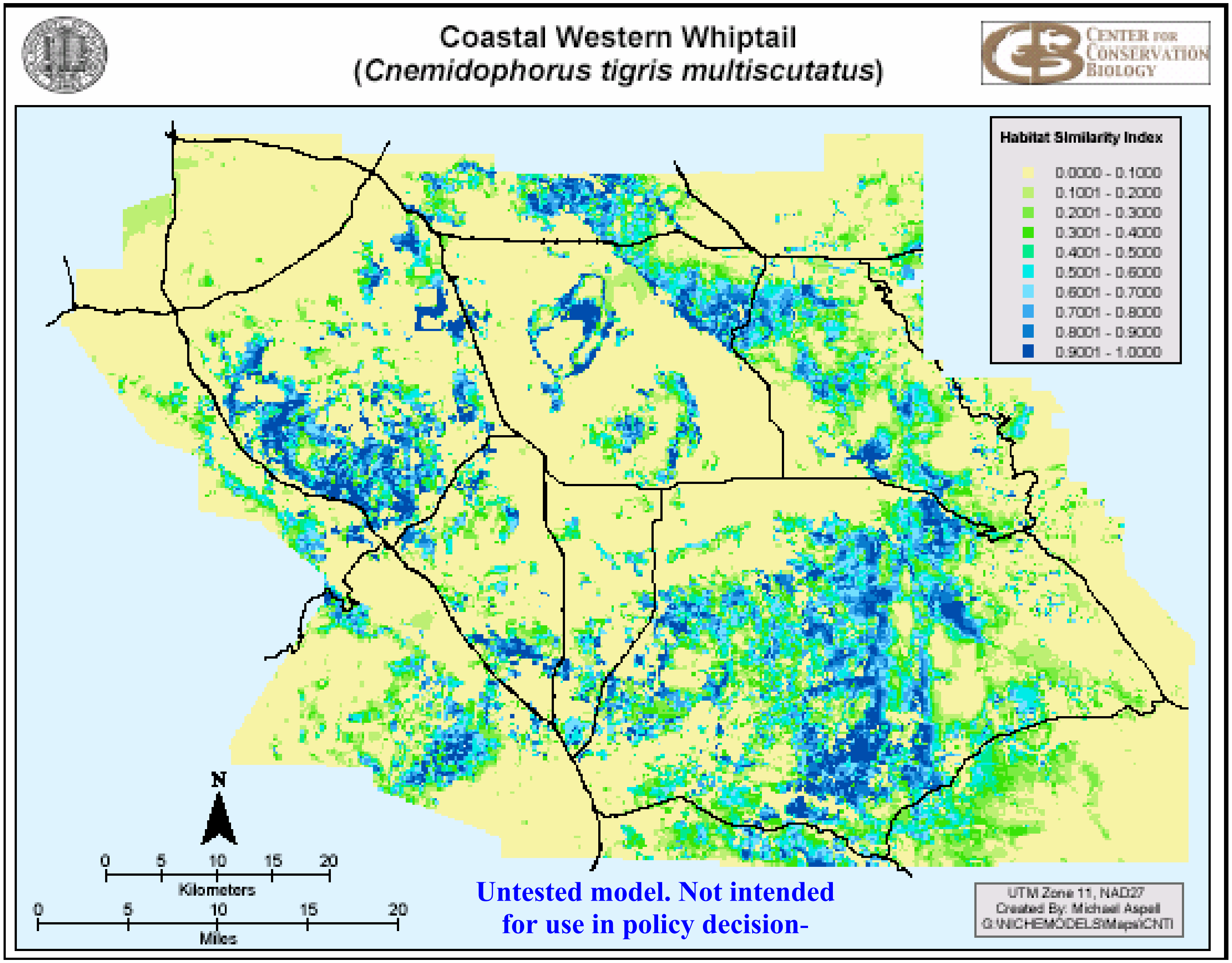


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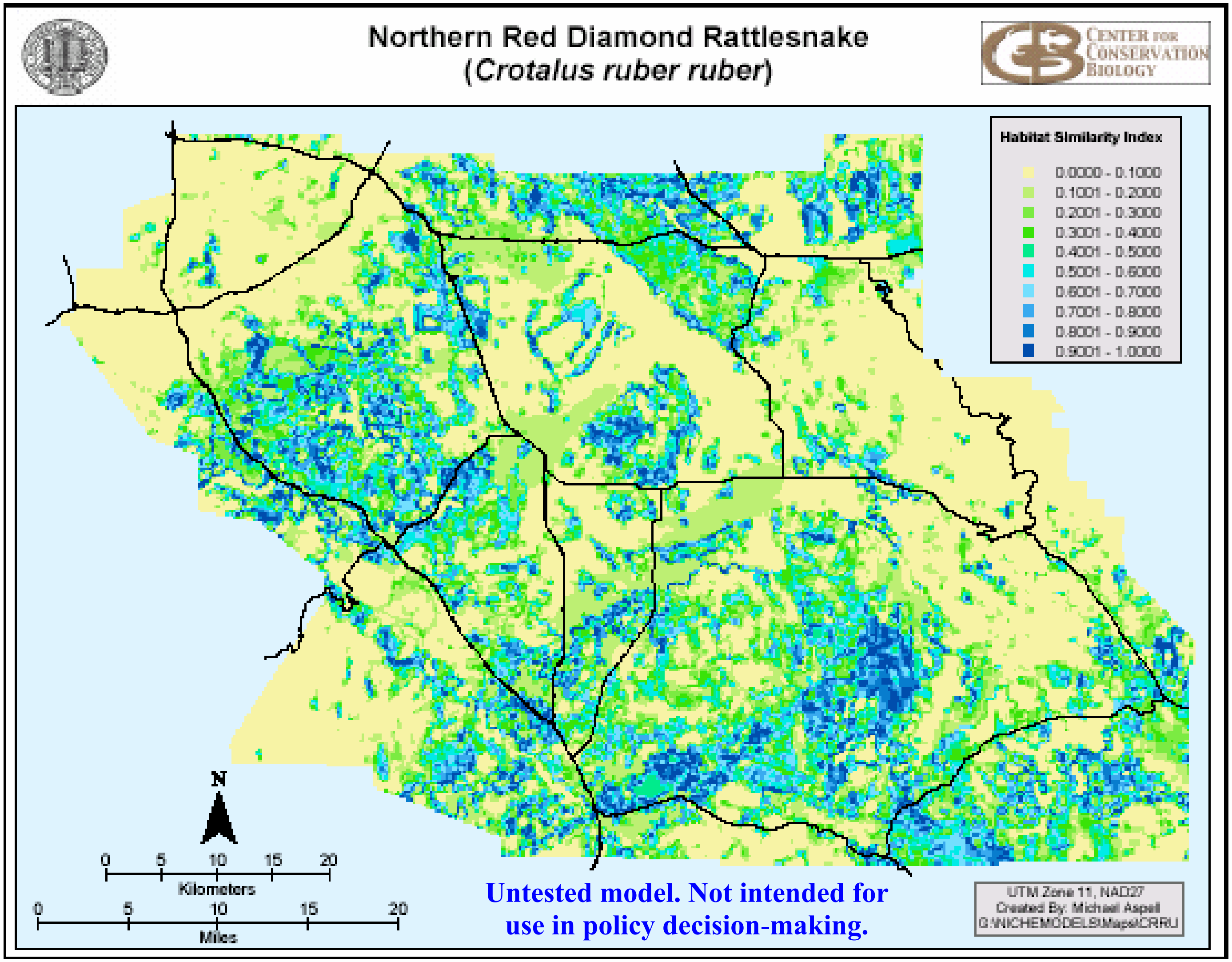
Figure 6.5. Map depicting the distribution of habitat suitability index (HSI) values for *Crotalus ruber* across the Plan Area: The higher the HSI, the greater the similarity between occupied habitat and other areas.



Discussion

The characterizations of suitable habitat for the five reptile species modeled tend to match anecdotal descriptions for each species' specific habitat affinities with two notable exceptions: the granite spiny lizard and the red diamond rattlesnake. Both species are often associated with rocky hillsides and rock outcrops, yet in both cases rock does not fall out as an important variable describing their distribution. This discrepancy may reflect problems with the model; more specifically with the utility of the rock outcrop GIS layer used to construct the models. This inconsistency exemplifies why the models remain preliminary and unvalidated in their current state, and should not be used for management purposes until they are revised and more. thoroughly tested.

The models developed by Malisch (2005) are structurally similar to the reptile niche models developed here, but with fewer point locations and some modification to the methods of extracting the landscape variables in GIS. Both suites of models provide the same results. The major difference is that Malisch (2005) attempts to validate the reptile models developed in 2003 with independently collected field data from 2004. For four of the five lizard species, (*S. graciosus* was not included because too few point locations were collected to produce an adequate niche model), Malisch selected sites on public and quasi-public land displaying high HSI values and sites with low HSI values. These sites were located using GIS and then surveyed for individuals of the four lizard speciesThe validation study demonstrated that models for *S. orcutti*, *C. hyperythrus*, and *C. tigris* show a significant ability to discriminate between suitable and unsuitable habitat. This result was determined when the mean HSI value of locations where target species were detected was significantly higher than the mean HSI value of locations where target species were not detected ($p<0.05$). Thus, models for these three species appear to adequately predict the distribution of the target species. The *P. coronatum* model did not significantly discriminate between suitable and unsuitable habitat, although analyses were limited by a small sample size of validation detections. This species may require a greater sample size of individuals to obtain enough statistical power to validate the model. A full discussion of these models can be found in Malisch (2005).

Even though the niche models developed thus far remain preliminary, they signify a major departure from other studies of wildlife habitat selection, because they present testable hypotheses that can be addressed using the scientific method (Romesburg 1981). The next logical step in the niche modeling process necessitates field-testing models that have not been tested and feeding future validation survey data back into subsequent models. The testing procedure involves generating an independent data set of locations for each modeled species by systematically searching areas categorized within all levels of similarity for the presence of populations. If the predictions hold, then each species should have a greater probability of occupying high similarity habitat than lower similarity habitat. If this result is not achieved, then a better model is needed. The interactive aspect of the modeling process involves entering the additional locations gathered during model testing into the original model algorithm for each species along with the original data sets. The expanded calibration data sets generate a modified set of predictions that incorporates the information embodied in the additional location data. The new hypotheses should then be evaluated. At each step, the addition of new information helps to fine tune the model and improve its ability to map suitable habitat.

CHAPTER 7
COASTAL SAGE SCRUB COMMUNITY NICHE MODELS

Introduction

The WRC MSHCP represents a paradigm shift from traditional single species based conservation to conservation of multiple species and the natural communities in which they occur. This approach has become necessary in southern California where large numbers of sensitive species are threatened by the loss and degradation of natural habitats due to rapid urbanization and agricultural expansion (Pulliam and Babbitt 1997). Southern California is considered one of 25 global diversity hotspots (Myer et al. 2000), and in the United States, along with Florida and Hawaii, supports the greatest number of federally endangered species (Dobson et al. 1997). The concentration of endangered species in southern California is attributed to a high number of endemic species resulting from the unique Mediterranean climate in coastal areas and to unusual habitat features (Pulliam and Babbitt 1997). Southern California also encompasses the northern range limits of several species endemic to Baja California and supports a diverse array of habitat types extending from the coast east to the foothills and mountains and into the deserts, all of which contributes to the high biodiversity of this region.

Single species, particularly rare species, are not always adequate indicators of biodiversity (Chase et al. 2000; Roberge and Angelstam 2004) and conservation planning focused one or a few species does not necessarily protect ecological processes or resources required by other species (Landres et al. 1988; Lindenmayer et al. 2002). Conservation strategies are increasingly focusing on preserving biotic communities, although there is a challenge to identifying representative communities (Su et al. 2004). In southern California, the federally threatened California Gnatcatcher (*Polioptila californica californica*) has been the focus of conservation planning for coastal sage scrub communities. Although, it has large area requirements and is restricted to coastal sage scrub habitats, it has not proven to be a reliable indicator of bird or mammal community composition or richness (Chase et al. 2000). Some coastal sage scrub species were found to be indicators of community composition, perhaps a more relevant measure for use in conservation planning than species richness. For example, species richness does not provide information on community composition and areas with high numbers of species may not include species of conservation concern (Olden 2003). It was recommended based on this extensive sampling of bird and mammal communities that conservation of coastal sage scrub communities should focus on a variety of species representing the range of variability within this habitat type (Chase et al. 2000).

In designing and managing reserves, it is important to have an idea of where biodiversity is greatest and to understand where habitat requirements of multiple species coincide. Conservation goals can be achieved if areas are preserved that support high biodiversity as well as the species of conservation concern. Tools are needed to identify these biodiversity "hotspots" over large geographical regions where spatially explicit information on community composition and richness is typically lacking. Niche modeling is an effective tool for predicting the spatial distribution of individual species and for identifying environmental variables associated with suitable habitat (see Chapters 3, 5, and 6). In this chapter, we extend the use of individual species niche models to map habitat suitability for a suite of species within coastal sage scrub communities. These models predicts "community" habitat suitability over a large geographic area and are based on the intersection of habitat suitability values for multiple, individual species at each point within the Plan Area.

Chapters 5 and 6 report niche modeling results for reptile and bird species that inhabit coastal sage scrub habitats and are covered by the WRC MSHCP. In this chapter, we present coastal sage scrub "community" niche models that identify habitat suitability for a suite of reptile and bird species. In this context, "community" does not include all components of the coastal sage scrub community, such as individual plant species, arthropods, amphibians, or mammals. These models are constructed from individual niche models for the covered reptile and bird species, as well as niche models constructed for 14 additional bird species that typically inhabit coastal sage scrub. This modeling effort is an attempt to identify areas predicted to support a diverse array of coastal sage scrub bird and reptile species. The premise is that identifying suitable habitat for each species (based on the mean values of environmental variables for occupied habitat) will capture the minimal habitat requirements of each particular species. By overlaying these minimal habitat requirements for individual species, habitat similarity scores for each cell in the Plan Area can be summed. This cumulative score is mapped showing predicted habitat suitability for that particular suite of species over the Plan Area. If the niche models accurately predict the spatial occurrence of individual species, then overlaying models of different species should identify how well different areas provide suitable habitat for that suite of species.

Individual species niche models have not been evaluated with independent datasets. Preliminary community models presented in this chapter are based on untested hypotheses about where suitable habitats for multiple species converge. Areas predicted to provide suitable habitat for many species are identified as coastal sage scrub "hotspots" whereas areas that provide suitable habitat for only a few species are ranked lower on the community niche model map. In order to ensure that areas important to covered species are identified, CCB biologists also created three other community models. These include a community niche model for the five covered reptile species, a community niche model for four of the covered bird species, and a third community niche model that includes both covered reptiles and birds. The four model types can be compared to see how predictions of community habitat suitability vary.

Methods

Table 7.1 presents the reptile and bird species used to construct the four coastal sage scrub community niche models. For each of these species, an individual niche model was constructed following the procedures outlined in Chapters 3 through 6. The GIS environmental variables, model scale, and number of species locations used to construct each species' model are listed for reptiles in Table 7.2 and for birds in Table 7.3. Four community niche models were constructed. The first model included the five reptile species (Table 7.2) and the 18 bird species (Table 7.3). The second model only included the five covered reptile species (Table 7.2). The third model was constructed with four covered bird species. These species were Bell's Sage Sparrow, California Gnatcatcher, Loggerhead Shrike, and Southern California Rufous-crowned Sparrow (Table 7.3). The fourth model combined the covered reptile and bird species into one community niche model.

For community modeling, the most restrictive niche model (full rank Mahalanobis D^2) was selected for each species. This ensured the most conservative approach was employed in predicting suitable habitat for a particular suite of species within the coastal sage scrub community. Each species niche model assigned a habitat similarity index value to every grid point on the map of the Plan Area. As explained in previous chapters, this value ranged from 0 to 1. A value of zero indicates that the location was predicted to be unsuitable for a particular species. A value of 1 means the location was most similar to the mean values of occupied habitat for that particular species. By overlaying individual species niche model maps, a cumulative habitat similarity index value was calculated for each grid point in the Plan Area. The upper range of the cumulative habitat similarity index was equal to the maximum number of species included in the particular community model. For example, the reptile community model included five reptile species and this cumulative score ranged from 0 to 5 at each grid point. A cumulative habitat suitability value of 0 meant that a particular grid location was predicted to be unsuitable habitat for all five of the reptile species. In this case, each species niche model would have predicted a habitat similarity value of 0 at this point. A score of 5 indicates that the location was predicted to be highly suitable for all five of the reptile species. In this latter case, the habitat similarity value for each species map would be equal to one. This overlay process was repeated for each of the community niche models. For the covered bird community model the maximum habitat suitability value is four, for the covered reptile and bird species combined it was equal to nine, and for all coastal sage scrub birds (18 species) combined with the five covered reptile species it is 23.

Table 7.1 Scientific names, common names, and species codes for reptile and bird species included in the coastal sage scrub community models.

Scientific Name	Common Name	Species Code
Reptile Species:		
Cnemidophorus hyperythrus	Orange-throated Whiptail	CNHY
Cnemidophorus tigris	Coastal Western Whiptail	CNTI
Crotalus ruber ruber	Northern Red Diamond Rattlesnake	CRRU
Phrynosoma coronatum	Coast Horned Lizard	PHCO
Sceloporus orcutte orcutti	Granite Spiny Lizard	SCOR
Bird Species:		
Callipepla californica	California Quail	CAQU
Calypte costae	Costa's Hummingbird	COHU
Calypte anna	Anna's Hummingbird	ANHU
Myiarchus cinerascens	Ash-throated Flycatcher	ATFL
Lanius ludovicianus	Loggerhead Shrike	LOSH
Aphelocoma californica	Western Scrub-Jay	WESJ
Chamaea fasciata	Wrentit	WREN
Psaltriparus minimus	Bushtit	BUSH
Thryomanes bewickii	Bewick's Wren	BEWR
Salpinctes obsoletus	Rock Wren	ROWR
Polioptila californica	California Gnatcatcher	CAGN
Toxostoma redivivum	California Thrasher	CATH
Pipilo crissalis	California Towhee	CALT
Pipilo maculatus	Spotted Towhee	SPTO
Aimophila ruficeps canescens	Southern California Rufous-crowned Sparrow	RCSP
Chondestes grammacus	Lark Sparrow	LASP
Amphispiza belli belli	Bell's Sage Sparrow	SAGS
Carduelis psaltria	Lesser Goldfinch	LEGO

Table 7.2 Variables, modeling scale, and number of location points used to construct individual niche models for WRCMSHCP covered reptile species in the Plan Area.

Scientific Name	*Cnemidophorus hyperythrus beldingi*	*Cnemidophorus tigris multiscutatus*	*Crotalus ruber ruber*	*Phrynosoma coronatum blainvillei*	*Sceloporus orcutti orcutti*
Common Name	Orange-throated Whiptail	Coastal Western Whiptail	Northern Red Diamond Rattlesnake	Coast Horned Lizard	Granite Spiny Lizard
Model Scale	500 m	250 m	500 m	500 m	250 m
Number of Locations	117	120	69	107	169
Number of Variables	10	10	8	11	10
Variable Name:					
Percent Slope	X				X
Elevation	X	X	X	X	X
Mean Minimum January Temperature	X	X	X	X	X
Mean Maximum July Temperature	X	X	X	X	X
Annual Precipitation	X	X	X	X	X
Vegetation/Substrate Categories:					
Local Scale (250 m x 250 m or 500m x 500m):					
Agriculture (field crops, livestock)	X			X	
Agriculture (Groves/Orchards)	X	X		X	
Coastal Sage Scrub (CSS)	X	X	X	X	X
Chaparral		X	X	X	X
Other Shrublands	X	X		X	
Non-Native Grassland	X	X	X	X	X
Oak Woodlands		X		X	X
Rock Outcrop			X		X

Table 7.3 Variables, modeling scale, and number of location points used to construct individual niche models for 18 bird species in the Plan Area. Species codes are defined in Table 1. Species sharing the same modeling variables are listed together.

Species Code (number of locations):	ANHU (229), BEWR (319), BUSH (234), CAGN (554), CALT (447), LEGO (290), SPTO (310)	RCSP (196)	WESJ (197)	ATFL (182) WREN (182)	LOSH (183)	CAQU (164)
Model Scale	250 m	250 m	250 m	250 m	250 m	250 m
Number of Variables	21	20	20	18	18	16
Variable Name:						
Annual Precipitation	X	X	X	X	X	X
East	X	X	X	X	X	X
Elevation	X	X	X	X	X	X
Mean Maximum July Temperature	X	X	X	X	X	X
Mean Minimum January Temperature	X	X	X	X	X	X
North	X	X	X	X	X	X
Percent Slope	X	X	X	X	X	X
Vegetation/Substrate Categories:						
Local Scale (250m x 25m):						
Agriculture (field crops, livestock)	X		X			
Chaparral	X	X	X	X	X	X
Coastal Sage Scrub	X	X	X	X	X	X
Developed (residential, commercial, industrial)	X					
Non-Native Grassland	X	X	X	X	X	X
Oak Woodlands/Coniferous Forest	X	X	X	X		
Distance to Closest Coastal Sage Scrub Patch	X	X	X	X	X	X
Rock Outcrop		X				
Landscape Scale (2,250m x 2,250m):						
Percent Agriculture (field crops, livestock)	X	X	X		X	
Percent Chaparral	X	X	X	X	X	X
Percent Coastal Sage Scrub	X	X	X	X	X	X
Percent Developed	X	X	X	X	X	X
Percent Non-Native Grassland	X	X	X	X	X	X
Percent Open Water	X	X	X	X	X	
Amount of Developed – Natural Edge	X	X	X	X	X	X

Table 7.3 (Cont.) Variables, modeling scale, and number of location points used to construct individual niche models for 18 bird species in the Plan Area.

Species Code (number of locations):	COHU (140)	SAGS (107)	CATH (89)	LASP (82)	ROWR (65)
Model Scale	250 m	250 m	250 m	250 m	250 m
Number of Variables	14	11	9	8	7
Variable Name:					
Annual Precipitation	X	X	X	X	
East	X				
Elevation	X	X	X	X	X
Mean Maximum July Temperature	X	X	X	X	X
Mean Minimum January Temperature	X	X	X	X	X
North	X				
Percent Slope	X				
Vegetation/Substrate Categories:					
Local Scale (250m x 25m):					
Agriculture (field crops, livestock)					
Chaparral	X	X	X	X	X
Coastal Sage Scrub	X	X	X	X	X
Developed (residential, commercial, industrial)					
Non-Native Grassland	X	X	X	X	X
Oak Woodlands/Coniferous Forest					
Distance to Closest Coastal Sage Scrub Patch					
Rock Outcrop					
Landscape Scale (2,250m x 2,250m):					
Percent Agriculture (field crops, livestock)					
Percent Chaparral					
Percent Coastal Sage Scrub	X	X	X	X	
Percent Developed	X	X	X		
Percent Non-Native Grassland	X	X			
Percent Open Water					
Amount of Developed – Natural Edge	X	X			

Results

Figure 7.1 presents the community niche model for five reptile species and 18 bird species in the Plan Area. Community habitat suitability values are relatively high in coastal sage scrub and chaparral habitats along the I-15 corridor between Corona and Temecula, north and east of Lake Skinner, and along the foothills of the San Jacinto Mountains and in the badlands east of Moreno Valley. Predicted hotspots for coastal sage scrub species are in the hills northwest of Canyon Lake, at the Shipley Skinner Reserve, in foothills northwest of Hemet, and in the badland foothills northwest of Highway 79. This model is more restrictive than the three other community models for the covered WRC MSHCP species. The community model for the combined covered bird and reptile species shows more suitable habitat (Figure 7.2) than the first model. However, the distribution pattern of highest cumulative habitat suitability values is similar for the two models. The least restrictive model is the one for the five covered reptile species (Figure 7.3). The model for the four covered bird species shows the most limited distribution of highest suitability habitat (Figure 7.4). The patterns for highest suitability habitat are most similar between the WRC MSHCP covered bird species model and the combined model for reptiles and 18 bird species.

CCB biologists overlaid coastal sage scrub and chaparral vegetation polygons from the 1994 WRC MSHCP vegetation map over the community map produced for the 23 bird and reptile species. Nearly all areas identified as suitable habitat in the Plan Area fall within these two habitat types. Coastal sage scrub encompasses nearly all those map points categorized as having the highest habitat suitability values. However, not all coastal sage scrub vegetation is identified as suitable to support a high number of species. Some of the high suitability areas, particularly in the middle east, southeast, and middle west portions of the Plan Area, fall within chaparral habitats. It is important to note that these models are only attempting to predict community diversity within coastal sage scrub and to a lesser degree in chaparral. A similar evaluation was not made of other habitat types in the plan area, such as riparian, oak woodland or coniferous forest.

Discussion

The covered bird species map (Figure 7.4) shows less suitable habitat than the reptile map (Figure 7.2). This likely reflects differences in habitat breadth between the bird and reptile species. Three of the four bird species (Bell's Sage Sparrow, California Gnatcatcher and Southern California Rufous-crowned Sparrow) are primarily associated with coastal sage scrub habitats in the Plan Area. Their niche maps are relatively restrictive compared to the reptile niche maps (Chapters 5 and 6). In contrast, all five of the covered reptile species inhabit coastal sage scrub as well as other vegetation types such as chaparral within the Plan Area. Many of the areas identified as highly suitable for the four bird species are also highly suitable for the five reptile species. Interestingly, the second most restrictive map is the one that includes the 18 additional bird species that occur in coastal sage scrub habitats.

Figure 7.1 Cumulative habitat similarity index (HSI) values for 23 coastal sage scrub reptile and bird species across the Plan Area. The higher the cumulative HSI, the greater the predicted habitat suitability for multiple bird and lizard species at that location.

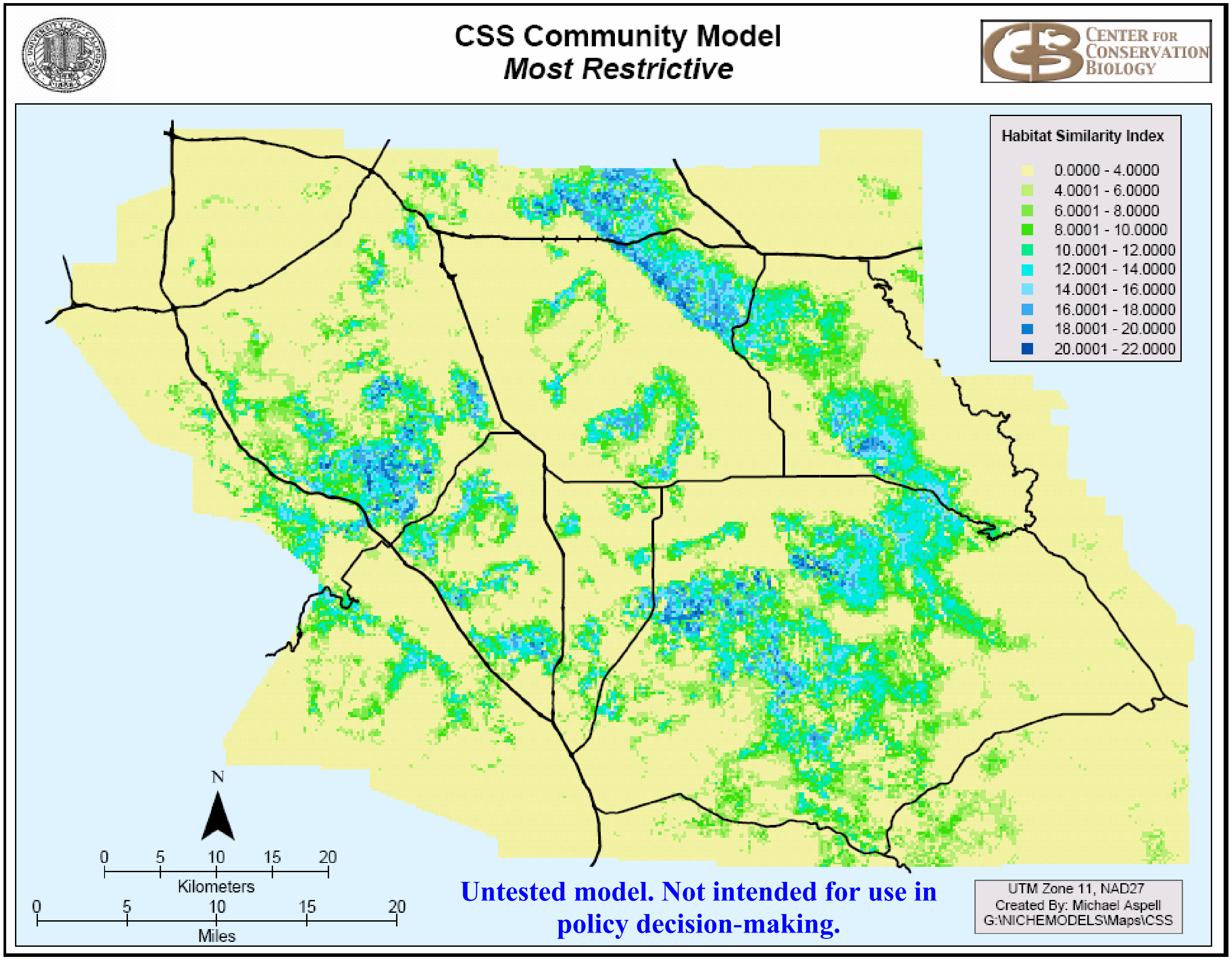


Figure 7.2 Cumulative habitat similarity index (HSI) values for ten covered coastal sage scrub reptile and bird species across the Plan Area. The higher the cumulative HSI, the greater the predicted habitat suitability for multiple bird and lizard species at that location.

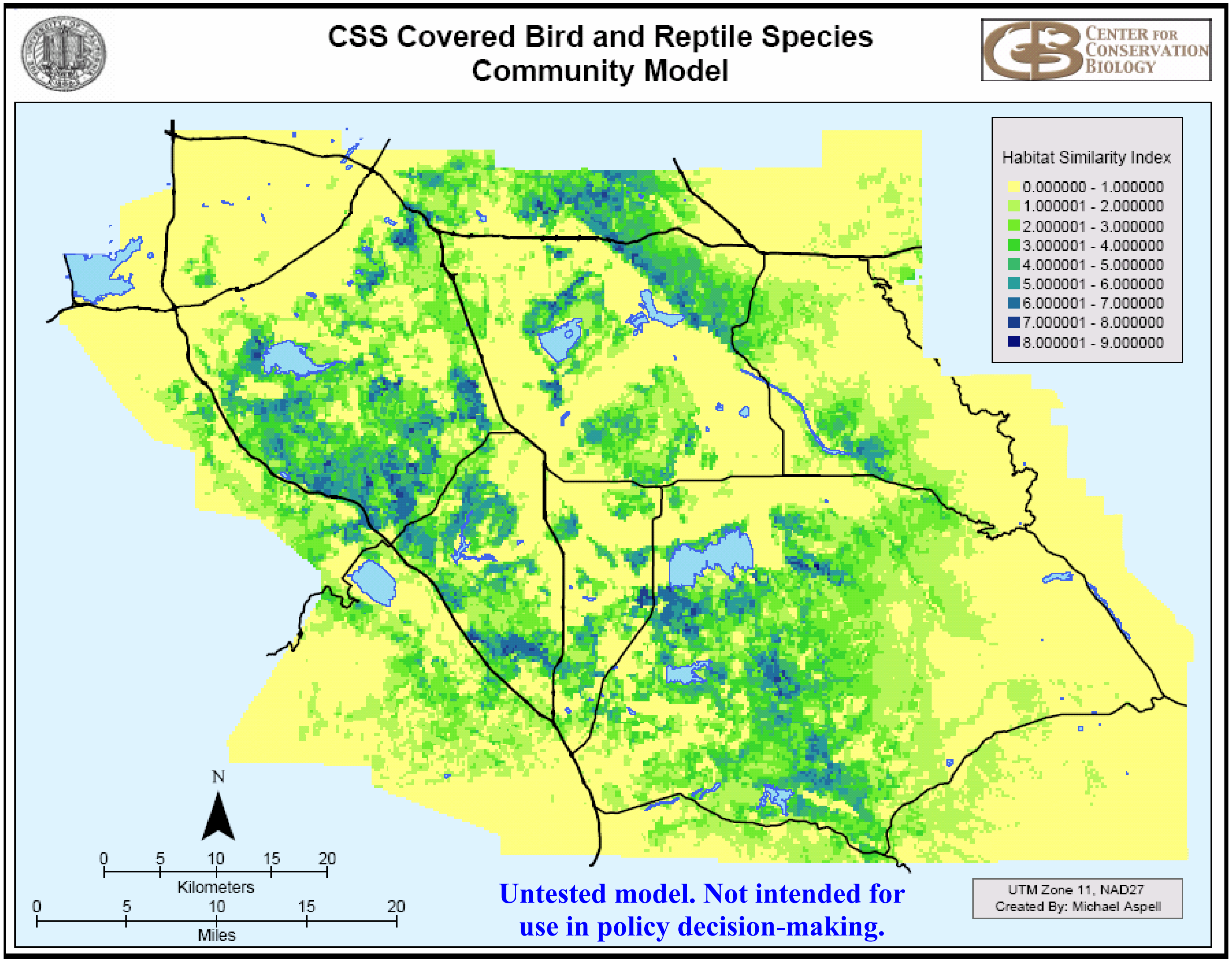


Figure 7.3 Cumulative habitat similarity index (HSI) values for five covered coastal sage scrub reptile species across the Plan Area. The higher the cumulative HSI, the greater the predicted habitat suitability for multiple lizard species at that location.

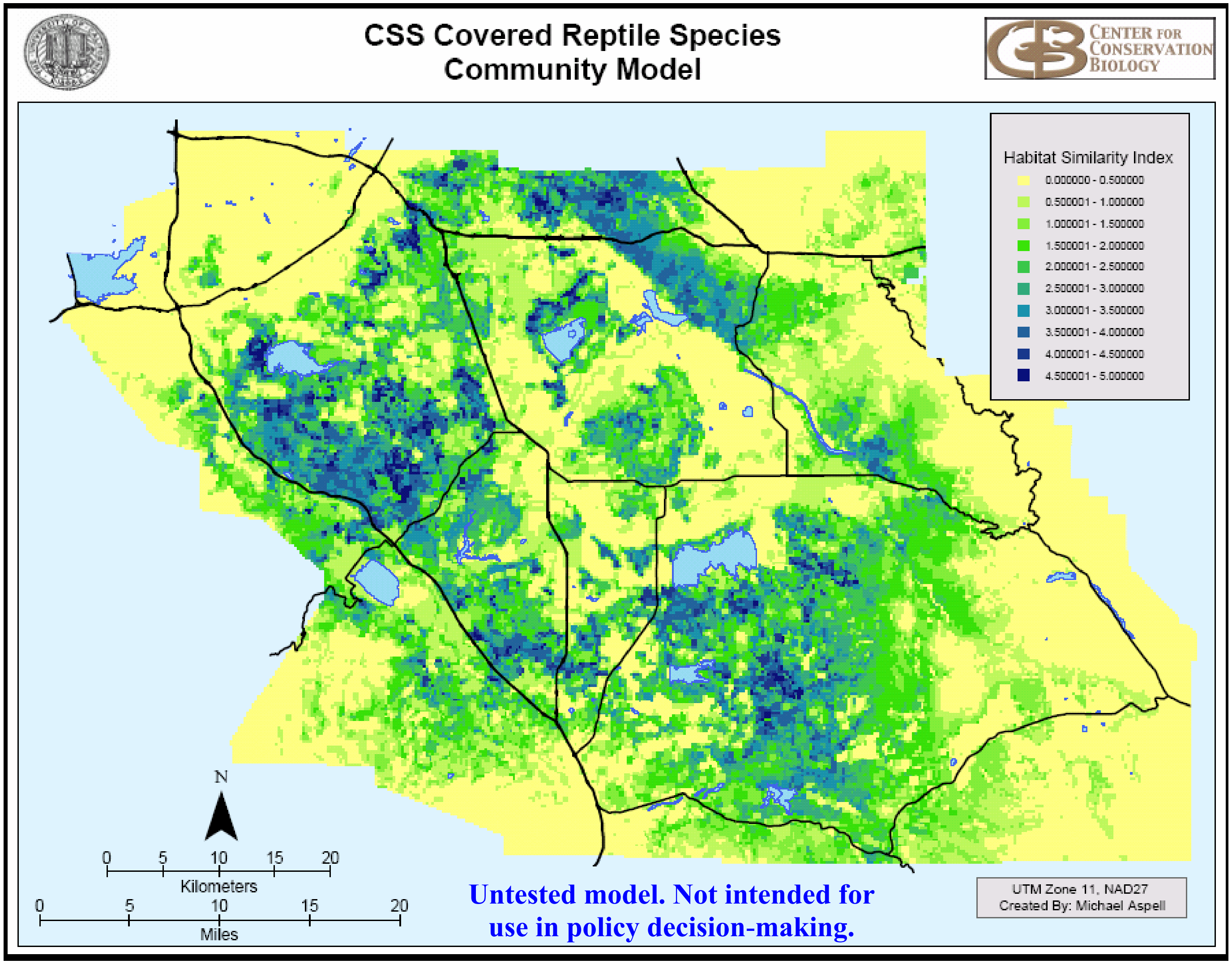
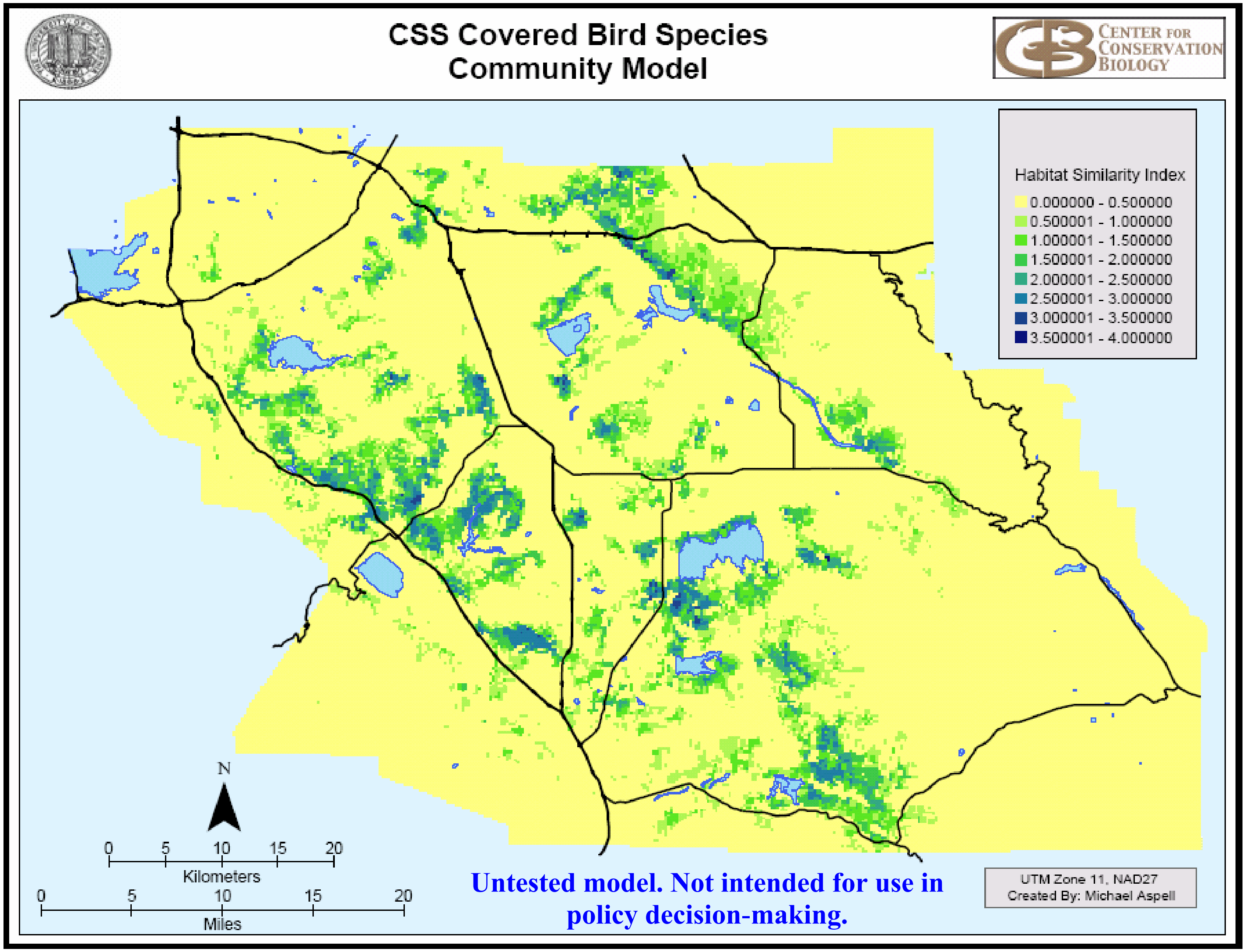


Figure 7.4 Cumulative habitat similarity index (HSI) values for four covered coastal sage scrub bird species across the Plan Area. The higher the cumulative HSI, the greater the predicted habitat suitability for multiple bird species at that location.



Some of these species are widely distributed (e.g., Anna's Hummingbird and California Towhee) and are frequently found in habitats besides coastal sage scrub. However, when a number of species are considered together, the importance of any one species is minimized, particularly as the number of species included in the model increases. The community map constructed with the greatest number of species identifies the same areas of highest habitat suitability that are predicted by the WRC MSHCP covered reptile and bird species models. However, the first model (Figure 7.1) re-categorizes moderate habitat throughout much of the Plan Area to a lower suitability category compared with the covered species community models.

Chapter 8 presents a paper by Chen et al. (2005) that models biological diversity for the Plan Area. All sensitive plant, reptile, bird and mammal species locations were included in modeling the spatial distribution and aggregation of multiple species in different vegetation types within western Riverside County. They found that the Santa Rosa Plateau and San Jacinto Mountains were areas with high aggregations of sensitive species. Rare plant species, which were not incorporated in CCB's community niche models, were especially well represented at the Santa Rosa Plateau and in the Santa Ana Mountains, contributing to the high overall biodiversity of these two areas. Areas of high diversity of non-riparian birds included Temecula, Lake Mathews, Lake Perris, Lake Skinner, and Lake Elsinore. Many of these areas show up in the community niche models as being suitable for supporting a high number of bird species. Consistent with some of the predictions of our community models, reptile species were aggregated in the Temecula area, near Lake Skinner and Lake Mathews. Our community models differ from the aggregation model, as they do not predict high diversity for the Santa Rosa Plateau or Santa Ana Mountains. This difference could be because our models focus on predicting multiple species co-occurrence in coastal sage scrub habitats, which are not well represented in either the Santa Rosa Plateau or Santa Ana Mountains. Chen et al. did find that coastal sage scrub and chaparral comprised 70-80% of all locations of sensitive species, with chaparral supporting even more species than coastal sage scrub. The niche models presented in this chapter also find that many high suitability points occur in chaparral. However, coastal sage scrub encompassed most of the highest cumulative habitat similarity values in both the WRC MSHCP covered bird community niche model and in the model with the full complement of birds and reptiles.

An advantage of community niche modeling is that different suites of species can be modeled easily, depending on conservation goals and management needs. As with the individual species models, community niche models have the potential to identify areas vulnerable to environmental change resulting from anthropogenic processes (Townsend Peterson and Vieglais 2001; Martinez-Meyer et al. 2004; Hannah et al. 2005). For example, a model could be constructed to predict the future distribution of non-native grasslands using a GIS layer with nitrogen deposition patterns and other environmental variables (e.g., soil types, precipitation, distance to closest patch of non-native grassland, slope aspect, minimum and maximum temperatures, elevation, etc). The niche model predicting the invasion potential of non-native grasslands could be overlaid on a community niche model to identify areas of coastal sage scrub with high biodiversity that are most at risk of converting to grassland. Management plans could be developed and implemented to reduce the threat of coastal sage scrub conversion in areas with high biodiversity. The contribution of individual species to community models can also be evaluated using a combination of individual species niche models and community niche models. Differing habitat relationships among species could be identified and areas of potential conflict between co-occurring species could be delineated. This information could be incorporated into conceptual models and be used to determine where management conflicts might arise and where actions taken to benefit one covered species might have adverse effects on another covered species.

It remains to test these community models with an independent dataset to analyze how well they predict levels of biodiversity in coastal sage scrub within the Plan Area. These community models are untested since each individual species model incorporated into them is untested. They are based on hypothesized relationships between environmental variables and a particular species occurrence. They are constructed with the 1994 WRC MSHCP vegetation map so they do not accurately represent current conditions, as natural habitats have been lost to development and agricultural expansion over the last 10 years. The community models should be re-run when a new vegetation map becomes available in order to reflect current environmental conditions. The community models also do not account for arthropod, plant, or mammal taxa, which are important components of coastal sage scrub communities. In the future, when niche models are available for these other groups, more complete community models can be constructed. It should be stressed that the maps produced by these models do not reflect community diversity for all habitat types within the Plan Area. Instead, these models focus on identifying where multiple coastal sage scrub and chaparral species are likely to occur. The preliminary community models do provide guidance for designing monitoring strategies and for identifying areas where research is needed. During community monitoring, data should be collected on reptile and avian biodiversity in order to test these models. It is anticipated that with future testing and revision, community niche modeling will serve as effective monitoring and management tool.

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SPATIAL STRUCTURE OF MULTISPECIES DISTRIBUTIONS IN SOUTHERN CALIFORNIA, USA

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Abstract

Analysis of the spatial distribution of all species of conservation importance within a region is necessary to augment reserve selection strategies and habitat management in biodiversity conservation. In this study, we analyzed the spatial aggregation, spatial association, and vegetation types of point occurrence data collected from museum and herbaria records for rare, special concern, threatened, and endangered species of plants, reptiles, mammals, and birds in western Riverside County in southern California, USA. All taxa showed clumped distributions, with aggregation evident below 14 km for plants, 12 km for reptiles, 2 km for mammals, and 10 km for birds. In addition, all combinations of the different species groups showed high positive spatial association. The Santa Rosa Plateau exhibited the highest number of rare, special concern, threatened, and endangered species, and shrubland (coastal sage and chaparral) was the vegetation type inhabited by the most species. Local land use planning, zoning and reserve design should consider the spatial aggregation within and between species to determine the appropriate scale for conservation planning. The higher spatial association between species groups in this study may indicate interdependence between different species groups or shared habitat requirements. It is important to maintain diverse communities due to potential interdependence. The results of the study indicate that concentrating preservation efforts on areas with the highest number of species of concern and the restoration of native shrublands are the most appropriate actions for multiple species habitat conservation in this area.

CHAPTER 9
COASTAL SAGE SCRUB COMMUNITY MONITORING RESULTS

Introduction

In developing the monitoring framework for WRC MSHCP, CCB initiated several avenues of research with the objectives of understanding Covered Species habitat relationships and identifying natural and anthropogenic environmental processes affecting the occurrence of these species (Barrows et al. 2005). This research included constructing niche models identifying environmental variables associated with Covered Species occupied habitat and producing maps predicting habitat suitability (Chapters 3, 4, 5, and 6). Conceptual models were also developed that hypothesized population responses to various environmental processes (Chapter 11). A third aspect of this research was to develop a community monitoring strategy that incorporated niche and conceptual models as tools to guide monitoring efforts (Chapters 7 and 11). In conjunction with community monitoring, focused surveys were also conducted for various taxa (Chapters 12, 13, 14, and 15). Data collected from 2004 community monitoring and 2003-2004 focused surveys were used to construct preliminary niche and conceptual models. The monitoring framework was designed as an iterative process, with niche and conceptual models guiding monitoring efforts, which, in turn would provide additional data for evaluating and refining the models. Five years were originally scheduled to construct, evaluate, and refine models in order to identify drivers of species distributions and better understand species habitat relationships. This was to be done in conjunction with the evolution and testing of monitoring strategies and protocols.

The monitoring component combines single species and ecosystem monitoring into a single community monitoring approach (Barrows et al. 2005). Under this approach, Covered Species are surveyed within the context of the larger community in which they occur. Other taxa and environmental processes that might affect the distribution and abundance of Covered Species are identified and also monitored. In particular, threats to populations are identified and monitored so that management actions can be undertaken to reduce the threats. For example, introduced Argentine ants (*Linepithema humile*) displace native ant species in southern California (Suarez et al. 1998) and have been found to be negatively associated with a number of native arthropod species (Bolger et al. 2000; Kirshtner and Redak, unpubl. data). A reduction in native arthropods could have an adverse effect on species that forage on native insects (e.g., several covered reptile and bird species). Monitoring the distribution and abundance of Argentine ants could give an indication of where habitat quality is threatened for Covered Species and facilitate the development of a management plan to control Argentine ant populations in these habitats. Similarly, it is important to monitor large-scale environmental change that affects Covered Species' habitats. An example is the conversion of coastal sage scrub to non-native grassland (Minnich and Dezzani 1998), which adversely affects a number of coastal sage scrub Covered Species. Individual responses to changing environmental conditions may include reductions in reproduction and/or survival rates, which in turn can adversely affect the eventual distribution and abundance of a population. Individuals may also respond behaviorally via habitat selection responses, such that previously suitable habitat may become unoccupied. It is important to identify and monitor population responses to environmental processes in order to develop and implement effective adaptive management measures. Coastal sage scrub was selected for initial community monitoring because of the large number of Covered Species and high level of anthropogenic impacts present in this habitat type.

Coastal Sage Scrub Community Monitoring

Coastal sage scrub supports shrubs and subshrubs typically less than a meter tall that are facultatively drought deciduous (Westman 1983). This community is distributed at lower elevations in the Mediterranean climate coastal zone from San Fransisco to northern Baja California. Coastal sage scrub varies in species composition along latitudinal and coastal to interior gradients throughout its' range (Atwood and Bontrager 2001). Slope aspect and other local site conditions also affect the composition of coastal sage scrub communities. Riversidean coastal sage scrub is the most prevalent type of coastal sage scrub in the Plan Area. There has been an extensive loss and fragmentation of coastal sage scrub in southern California due to large-scale urbanization and agricultural development, particularly since the 1980's (Atwood 1992; Bolger 2002). Riversidean coastal sage scrub supports several sensitive species including the federally endangered Munz's onion (*Allium munzii*), the federally threatened California Gnatcatcher, and species of concern including the coast horned lizard, orange-throated whiptail lizard, northern red diamond rattlesnake, Bell's Sage Sparrow and the Southern California Rufous-crowned Sparrow.

Coastal sage scrub habitats within the Plan Area are subject to several large-scale, interacting, anthropogenic processes that combine to disrupt normal ecological processes within the community. Increasing urbanization in the Plan Area has led to unprecedented increases in soil nitrogen, which is largely deposited from air pollution (Fenn et al. 2003a). Higher soil nitrogen facilitates the invasion of exotic grasses and forbs into originally nitrogen poor plant communities (Allen et al. 1998; Fenn et al. 2003b). Fires have increased in frequency and magnitude with human population growth, and are enhanced by these nitrogen-induced increases in non-native grass cover and by fire suppression policies (Minnich 2001). Combined, nitrogen deposition and fire events are causing the conversion of coastal sage scrub to non-native grassland in much of the Plan Area (Minnich and Dezzani 1998). This habitat conversion adversely impacts Covered Species that are already subject to high rates of habitat loss from development. Effective monitoring of this community requires characterizing changes in coastal sage scrub habitats, predicting areas susceptible to conversion, and determining how these altered environmental conditions are affecting Covered Species.

The primary goal for coastal sage scrub community monitoring in 2004 was to begin characterizing plant and animal communities in coastal sage scrub and transition zones between coastal sage scrub and non-native grassland habitats at different sites across the Plan Area. A second objective was to begin identifying taxa and processes that could be efficiently monitored to indicate the quality of habitat at a particular location or that were associated with the occurrence of Covered Species. Other objectives were to develop initial community sampling protocols and to gather location data for Covered Species with which to develop niche models. Originally, it was planned that expanded monitoring over a larger portion of the Plan Area in 2005 would result in sufficient datasets to characterize transition zones between coastal sage scrub and non-native grassland habitats and to use in evaluating niche and conceptual models relating species occurrence to natural and anthropogenic processes.

Methods

Eight sites located on public or quasi-public lands and supporting Riversidean coastal sage scrub/non-native grassland habitats were chosen for monitoring in 2004 (Figure 9.1). These included two sites north of Hemet at Potrero Canyon, the Motte Reserve west of Perris, two sites in the North Hills adjacent to Diamond Valley Lake, and three sites (Crown Valley, Lopez Canyon, Shipley-Skinner Headquarters) in the Shipley-Skinner Multi-Species Reserve northeast of Temecula. The sites were chosen to encompass variation in: coastal sage scrub community composition and structure, geographic location and topography, extent of invasion by non-native grasses, and level of anthropogenic disturbance. Sites varied in the type and intensity of anthropogenic influences such as the level of surrounding development, relative location within the regional air pollution/nitrogen deposition gradient, and fire history. Two sites had recently been exposed to off-road vehicle activity and cattle grazing. At each site, CCB biologists established a grid of survey points spanning the transition zone from coastal sage scrub to non-native grassland (see Appendix 10 for site figures). This grid was randomly laid over the site with points spaced 250 meters apart. The number of points and area sampled varied from site to site (Table 9.1). Two of the sites were fairly large (West North Hills and the Motte) in order to allow data collection across a large coastal sage scrub and non-native grassland transition and to include both north and south facing slopes supporting coastal sage scrub communities with different plant composition and structure. The remaining six sites were similar in size to one another but varied in the characteristics described above.

At each site, CCB surveyed different taxa that are important components of coastal sage scrub communities, for which data could be fairly easily collected, and that would potentially provide information on habitat quality or Covered Species occurrence. Vegetation was measured to describe the condition of coastal sage scrub at different sites in the Plan Area. The aim was to characterize the distribution and abundance of native coastal sage scrub shrubs and herbaceous plants in comparison to the distribution of invasive, non-native grasses and herbs. Soil arthropods were sampled, since arthropods are a diverse group, can be early indicators of ecological change, and are important food resources for other animal taxa (Kremen et al. 1993, Bolger et al. 2000). Reptiles were surveyed since five Covered reptile species occur in coastal sage scrub habitats. The assemblage of coastal sage scrub birds is fairly diverse, relatively easily sampled and includes several Covered Species making it an important monitoring component. In order to characterize the relative activity of mammals at each site, CCB collected data on rodent burrows and mammal sign. Each site was also evaluated as to the extent of anthropogenic disturbance. Human activity and presence, off-road vehicle activity, littering, dumping of yard waste and appliances, cattle grazing, fire, and other disturbances were scored at each sampling point. These scores were summed to provide an index of relative anthropogenic disturbance. Anthropogenic disturbances were also summed for those relating to human activity and those related to larger scale destruction of habitat (e.g., fires and livestock grazing).

A total of 128 points were sampled for multiple taxa (plants, arthropods, reptiles, birds, mammal activity, and anthropogenic disturbance) while 77 additional points were surveyed only for birds. There is no clear definition of non-native grassland versus coastal sage scrub habitats. One of the goals of monitoring coastal sage scrub communities is to gather sufficient data to characterize the continuum between undisturbed coastal sage scrub and areas that are completely converted to non-native grassland habitat. In order to roughly characterize the types of habitat that were sampled at each site, relatively intact coastal sage scrub was considered to have 50% or greater shrub cover, mixed coastal sage scrub points in the transition zone between scrub and non-native grassland had between 10 and 50% shrub cover, and non-native grassland points had < 10% shrub cover. Table 9.1 describes the size of each site, the number of coastal sage scrub, non-native grassland, and mixed habitat sampling points, and the period over which different taxa were surveyed. Table 9.2 lists CCB personnel, graduate and undergraduate students, post-graduate research fellows, and volunteers participating in the various coastal sage scrub community monitoring tasks.

The sampling strategy at each site was to randomly choose a starting point to lay down the grid of points spaced 250 m apart. Each of these points was the center point of a randomly oriented 100 m grid along which taxa were sampled. Appendix 3 contains the community monitoring protocols for the different groups that were sampled in 2004. The center point served as the location for 8-minute bird count surveys and arthropod pitfall traps while all other taxa were sampled along the 100 m transect running through the point. A point drop and point quarter sampling methodology was originally used to measure vegetation. However, this method proved to be very time intensive so a line intercept method was employed instead. Shrub cover, height, vigor, and phenology were measured along the 100 meter line transect. The number of shrubs and shrub seedlings were counted within one meter on each side of the 100 meter transect. Each interval along a transect that was without shrub cover was considered an "interspace" and the length of this interval was recorded. Herbaceous vegetation was identified to species level and along with rock, bare ground and leaf litter were categorized into percent cover categories for each interspace along the

Figure 9.1 Locations of coastal sage scrub/grassland sites sampled during community monitoring surveys conducted by CCB in 2004.

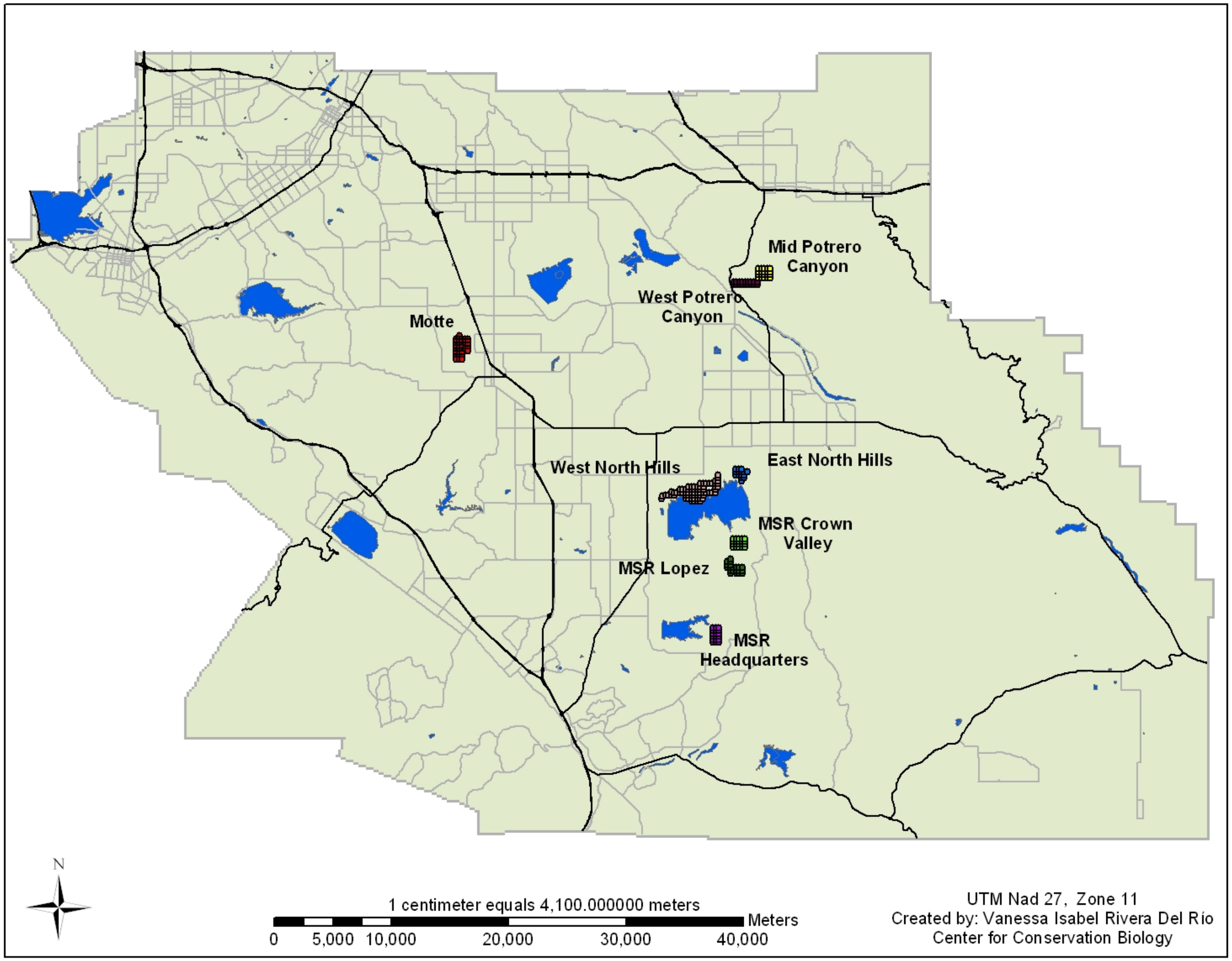


Table 9.1 General characteristics of eight coastal sage scrub sites in the Plan Area and survey periods for the various taxa sampled in community monitoring. "Bird points" refer to points sampled only for birds, whereas "community points" refers to points sampled for multiple taxa. "Community sampling transect length" is the number of meters sampled for vegetation, reptiles and mammal sign at each site. "Survey area" is the number of hectares at each site. This includes land surveyed for multiple taxa with point counts, line transects, and incidental sightings when traveling between points. "Coastal sage scrub" points have > 50% shrub cover along the 100 meter line intercept, "non-native grassland" points have less than 10% shrub cover, and "mixed CSS/NNG points" support 10 to 50% shrub cover.

Site	# Bird Points	# Community Points	Community Sampling: Transect Length (m)	Survey Area (ha)	# Coastal Sage Scrub Community Sampling Points	# Mixed CSS/NNG Community Sampling Points	# Non-Native Grassland Community Sampling Points	Vegetation Sampling Period	Arthropod Sampling Period	Reptile Sampling Period	Bird Sampling Period	Mammal Sign Sampling Period
Crown Valley	8	12	1,200	75	1	4	7	6/14 – 8/11/04	8/9 – 8/11/04	7/1 – 7/5/04	6/3/04	6/14 – 8/11/04
Lopez Canyon	21	13	1,300	81	1	10	2	6/16 – 8/11/04	8/9 – 8/11/04	6/4 – 7/5/04	4/29 – 7/14/04	6/16 – 8/9/04
Motte Reserve	36	23	2,250*	144	7	11	5	5/24 – 8/13/04	8/11 – 8/13/04	5/11 – 7/7/04	4/12 – 6/10/04	5/24 – 8/13/04
Shipley Skinner Headquarters	18	11	1,100	69	7	4	0	6/1 – 7/29/04	7/26 – 7/29/04	6/9 – 6/10/04	5/20 – 7/12/04	6/1 – 7/29/04
East North Hills	15	8	750*	50	3	4	1	7/8 – 8/6/04	8/3 – 8/6/04	6/24 – 7/22/04	6/9 – 7/8/04	7/8 – 8/6/04
West North Hills	69	39	3,900	313	12	18	9	5/18 – 8/4/04	8/3 – 8/6/04	5/6 – 7/22/04	4/27 – 7/8/04	5/18 – 8/4/04
West Potrero Canyon	18	10	1,000	63	0	9	3	6/24 – 8/5/04	8/2 – 8/5/04	5/14 – 7/2/04	4/15 – 6/24/04	6/24 – 8/5/04
Mid Potrero Canyon	20	12	1,200	75	1	5	4	5/25 – 8/12/04	8/2 – 8/5/04	6/9 – 7/9/04	5/25 – 6/8/04	5/25 – 8/12
Total for All Sites	**205**	**128**	**12,700**	**870**	**32**	**65**	**31**	**5/18 – 8/13/04**	**7/26 – 8/13/04**	**5/6 – 7/22/04**	**4/15 – 7/14/04**	**5/18 – 8/13/04**

* Due to either site or weather conditions, one transect at each of these sites was only surveyed for 50 meters rather than the typical length of 100 meters

Table 9.2 Coastal sage scrub community monitoring tasks and CCB personnel conducting each task during 2004.

Name	Initials	Tasks
Alex Yun	AY	Vegetation/Arthopod Sampling, Other species
Antonio Celis	AC	Vegetation/Arthopod Sampling, Birds, Other species
Brandon Mutrux	BM	Vegetation/Arthopod Sampling, Reptiles, Other species
Chris True	CT	Vegetation/Arthropod Sampling
Eliza Maher	EMA	Vegetation/Arthopod Sampling, Other species
Emma Middlemess	EM	Vegetation/Arthopod Sampling, Other species
Greg Smith	GS	Vegetation/Arthopod Sampling, Birds, Other species
Jason Hlebakos	JH	Vegetation/Arthopod Sampling, Other species
Jill Deppe	JD	Vegetation/Arthopod Sampling, Birds, Other species
Ken Halama	KH	Vegetation/Arthropod Sampling, Reptiles
Kim Oldehoeft	KO	Vegetation/Arthopod Sampling, Other species
Kris Preston	KLP	Vegetation/Arthopod Sampling, Birds, Other species
Melissa Preston	MKP	Vegetation/Arthopod Sampling, Birds, Other species
Myung Bok Li	MBL	Vegetation/Arthopod Sampling, Other species
Robert Steers	RS	Vegetation/Arthopod Sampling, Other species
Sheila Kee	SK	Birds
Tracy Tennant	TT	Vegetation/Arthropod Sampling, Birds, Other Species

transect. Plant names follow Roberts et al. (2004). Surveys were conducted for mammal sign, game trails, rodent and insect burrows within 1 meter on either side of the 100-meter transect. The level of disturbance was scored for different anthropogenic disturbance categories within 50 m of the center point and greater than 50 meters from the point. Analysis for this report includes descriptive statistics, (site means and standard deviations) that were calculated for the various parameters measured for each taxonomic group.

Results

Characteristics of coastal sage scrub habitats varied considerably between the eight sites (Tables 9.3 and 9.4). The Shipley-Skinner Headquarters site had the greatest average shrub cover (54%) whereas the Mid Potrero Canyon site had the lowest average shrub cover (15%; Table 9.3). For individual species, flat-topped buckwheat (*Eriogonum fasciculatum*) had the highest proportion of shrub cover at all but the East North Hills and Mid Potrero Canyon sites where brittlebush (*Encelia farinosa*) was the dominant shrub. California sagebrush (*Artemisia californica*) was present in low amounts at every site and was most abundant at the West North Hills site. Black sage (*Salvia mellifera*) only occurred as a minor component of the coastal sage scrub community at the Motte Reserve, Shipley-Skinner Headquarters, and West Potrero Canyon. The Plan Area has received below average rainfall since 1999 and recorded unusually low levels of precipitation in 2002. During the vegetation sampling, the proportion of the transect covered by completely dead shrubs and dead portions of living shrubs was quite high for some sites (Table 9.3). Dead shrub cover was over 25% for Shipley-Skinner Headquarters and the East North Hills sites and 18% for the West North Hills site. At other sites such as Crown Valley and West Potrero Canyon, there was only 2% dead shrub cover per transect. Average shrub height did not vary substantially between sites and ranged from 0.7 to 1.0 meters.

Interspaces (intervals of the transect with no shrub cover) contained a variety of substrates and herbaceous vegetation (Table 9.4). The presence of a substrate or non-shrub plant species was noted for each interval and the length of the interval was recorded. The substrate or plant often occurred within only a portion of the interval and not the entire extent. The following measures give the total interval length in which the substrate/plant was detected and do not incorporate a measure of how much of that interspace interval was covered by that substrate/plant. Leaf litter occurred on average in 48 – 83 meters of interspaces/transect, with leaf litter cover the highest at Mid Potrero Canyon and lowest at the Shipley-Skinner Headquarters site. It is important to note that leaf litter under shrubs is not included in this measure, only the leaf litter in the interspaces without shrubs. Bare ground was detected on average in intervals encompassing 38 to 76 meters of the 100m transect. Bare ground was most prevalent at Lopez Canyon where most of the site had burned in wildfires in 2003. Rock cover does not distinguish between small rocks and boulders and was greatest at West North Hills, Mid Potrero Canyon, an Lopez Canyon. Herbaceous plant species were present in nearly all interspace intervals with non-native grasses and forbs dominating all native annuals. Common fiddleneck (*Amsinckia menziesii*) was the only native herb detected on more than 10 meters of interspace at any of the sites. Foxtail (*Bromus madritensis rubens*) ranked as the most abundant herbaceous herb species at all sites except Potrero Canyon. At West Potrero Canyon, Mediterranean schismus (*Schismus barbatus*) was the dominant herb whereas in Mid Potrero Canyon it was short-fruited filaree (*Erodium brachycarpum*). Other grasses in the *Bromus* genus were common at all sites.

Appendix Table 9 lists all vertebrate species detected at the sites during community monitoring surveys in 2004. Data are combined for the two Potrero Canyon sites, the three Shipley-Skinner Reserve sites, and the two North Hills sites. Common and scientific names are listed for each species and are not repeated in tables and text in this chapter. Vertebrate species were detected during focused surveys for specific taxa and while traveling between sampling points or surveying for other taxa.

Of the arthropods where it could be determined if they were native or non-native, only six individuals were non-native. Four of these individuals were trapped at the Motte Reserve (2 Hymenoptera, 1 Microcoryphia, and 1 Orthoptera), and one individual each at East North Hills (Hymenoptera) and West North Hills (Araneae). West North Hills and Shipley-Skinner Headquarters sites had the fewest orders per transect (adjusted for trapping effort) whereas the number of orders was similar for the remaining sites (Table 9.5). The number of arthropod families and genera adjusted for trapping effort were greatest at West Potrero Canyon and the Motte Reserve.

Transect surveys for reptiles were conducted between May 15, and July 16 at the eight CSS/grassland study locations. During this period, only one survey was conducted per transect due to manpower constraints. The results from the 2004 surveys show wide variation among the sites in terms of the numbers of individuals observed. The Motte Rimrock Reserve had the highest number of animals per transect, while Crown valley had the lowest (Table 9.6).

Table 9.7 gives the number of sensitive bird species locations documented at each site during focused surveys as well as observed incidentally while surveying other taxa or traveling between survey points. These numbers are unadjusted for effort and may represent multiple observations of the same individuals on different survey dates. These are not estimates of abundance of these species at each site. The most commonly detected species was the California Gnatcatcher followed by the Southern California Rufous-crowned Sparrow. Table 9.8 lists the mammal species visually detected during focused surveys and incidentally during other monitoring activities. Sign (tracks, scat) for coyotes, mountain lion and bobcats were detected at all sites during surveys for mammal sign.

Levels of anthropogenic disturbance varied between sites and were highest at Lopez Canyon, which burned in fall of 2003, Middle Potrero Canyon, and East North Hills (Table 9.9).

Table 9.3 Mean (± standard deviation) shrub cover and shrub height at eight sites in the Plan Area. Sample size (n) refers to the number of transects sampled during coastal sage scrub community monitoring in 2004.

Site (n)	% Total Shrub Cover	% *Encelia farinose* Cover	% *Eriogonum Fasciculatum* Cover	% *Artemisia Californica* Cover	% *Salvia Mellifera* Cover	% Dead Shrub Cover	Shrub Height (m)
Crown Valley (12)	21.0 ± 25.4	0.0 ± 0.2	15.4 ± 18.4	2.7 ± 7.2	0.0 ± 2.5	1.4 ± 2.5	1.0 ± 0.4
Lopez Canyon (8)	22.1 ± 15.9	0.3 ± 1.2	6.6 ± 6.2	0.4 ± 0.8	0.0 ± 0.0	9.0 ± 7.9	0.8 ± 0.5
Motte Reserve (23)	35.3 ± 22.1	1.2 ± 3.3	14.7 ± 17.9	1.7 ± 2.9	5.7 ± 9.2	12.1 ± 11.9	0.9 ± 0.4
Shipley Skinner Headquarters (11)	53.7 ± 19.5	0.1 ± 0.2	24.4 ± 12.2	2.3 ± 2.8	3.8 ± 5.7	25.6 ± 19.1	0.9 ± 0.4
East North Hills East (8)	40.4 ± 28.6	7.7 ± 8.3	5.2 ± 5.5	1.9 ± 2.3	0.0 ± 0.1	27.6 ± 23.9	0.7 ± 0.4
West North Hills (39)	35.7 ± 24.0	2.9 ± 5.2	7.1 ± 7.6	6.5 ± 8.9	0.0 ± 0.1	18.0 ± 17.6	0.8 ± 0.4
West Potrero Canyon (10)	22.4 ± 19.1	2.3 ± 4.9	2.3 ± 2.9	0.6 ± 1.1	1.5 ± 2.2	1.9 ± 2.5	0.7 ± 0.3
Mid Potrero Canyon (12)	14.6 ± 9.5	11.7 ± 17.1	1.9 ± 4.1	0.4 ± 0.8	0.0 ± 0.0	4.2 ± 8.8	0.7 ± 0.3

Table 9.4 Mean total interspace cover per 100 m transects at eight sites in the Plan Area. Interspaces are those intervals along the 100 meter line transect without shrub cover. Different types of substrates and herbaceous cover were recorded within the same interval, and often co-occurred (e.g., leaf litter under herbaceous plants). Herbaceous plant species were found in most interspaces and are ranked in order of the average total length of interspace/100 m transect they were observed in at each site. Herbaceous species detected in less than 10 meters of interspace/transect are not included in the table. Sample size (n) refers to the number of transects sampled during coastal sage scrub community monitoring in 2004.

Site (n)	Meters of Interspace/ Transect (m)	Meters of Interspace with Litter/ Transect (m)	Meters of Interspace with Bare Ground / Transect (m)	Herbaceous Plant Species* Ranked in Order of Average Total Interspace Length/Transect (n) = native, (e) = exotic
Crown Valley (12)	**79**	79	53	BROMAD (E), EROBRA (E), BRODIA (E), BROHOR (E), AMSMEN (N)
Lopez Canyon (8)	**78**	79	76	BROMAD (E), EROBRA (E), BROHOR (E), AMSMEN (N), EROCIC (E), FILGAL (E)
Motte Reserve (23)	**65**	61	44	BROMAD (E), AMSMEN (N), Brassica Sp. (E)
Shipley Skinner Headquarters (11)	**47**	48	38	BROMAD (E), AMSMEN (N), EROBRA (E)
East North Hills East (8)	**60**	55	40	BROMAD (E), AMSMEN (N), SCHBAR (E)
West North Hills (39)	**64**	62	42	BROMAD (E), AMSMEN (N), *Brassica* Sp.(E), BRODIA (E)
West Potrero Canyon (10)	**78**	75	57	SCHBAR (E), EROBRA (E), BROMAD (E), *Brassica* Sp. (E), AMSMEN (N), BRODIA (E)
Mid Potrero Canyon (12)	**85**	83	63	EROBRA (E), BROMAD (E), *Brassica* Sp. (E), FILGAL (E), AMSMEN (N), SCHBAR (E), BRODIA (E), LAMAUR (E)

* AMSMEN = *Amsinckia menziesii*, BRODIA = *Bromus diandrus*, BROHOR = *Bromus hordeaceus*, BROMAD = *Bromus madritensis*, EROBRA = *Erodium brachycarpum*, EROCIC = *Erodium cicutarium*, FILGAL = *Filago gallica*, LAMAUR = *Lamarchia auria*, SCHBAR = *Schismus barbata*

Figure 9.5 Site averages for numbers of arthropods by taxonomic grouping and for number of individuals/taxonomic group captured in pitfall traps in 2004. All individuals were identified to order, but not all were able to be identified to genus or species level.

Site	# Orders	# Families	# Genera	# Species	# Individuals	# Traps	# Orders/Trap	# Families/ Trap	# genera/ Trap	# Species/ Trap	# Individuals/ Trap
Crown Valley	14	13	13	12	1320	12	1.17	1.08	1.08	1.00	110.00
Lopez Canyon	13	18	21	18	381	11	1.18	1.64	1.91	1.64	34.64
Motte Reserve	14	32	44	29	1590	16	0.88	2.00	2.75	1.81	99.38
Shipley-Skinner Headquarters	12	15	22	17	294	10	1.20	1.50	2.20	1.70	29.40
East North Hills	11	15	17	15	2495	8	1.38	1.88	2.13	1.88	311.88
West North Hills	20	37	45	35	5472	36	0.56	1.03	1.25	0.97	152.00
Mid Potrero Canyon	13	21	23	18	1056	11	1.18	1.91	2.09	1.64	96.00
West Potrero Canyon	9	18	24	16	1528	9	1.00	2.00	2.67	1.78	169.78

Table 9.6 Results of the 2004 reptile transect surveys at eight CSS-grassland sites within the Plan Area. The numbers in parentheses are the number of transects where a species was detected while the number preceding the parentheses is the total number of individuals detected at that site.

Species	Motte Reserve	Potrero East	Potrero West	North Hills East	North Hills West	Shipley HQ	Crown Valley	Lopez Canyon
Cnemidophorus hyperythrus	4(4)	3(2)	4(3)	1(1)	9(8)	2(2)	0	1(1)
Cnemidophorus tigris	11(7)	6(5)	4(2)	0	5(5)	1(1)	0	0
Crotalus ruber	0	0	0	0	1(1)	0	0	0
Masticophis flagellum	1(1)	0	0	0	0	0	0	0
Masticophis lateralis	0	0	0	0	1(1)	0	0	0
Phrynosoma coronatum	0	0	0	0	0	0	0	0
Sceloporus occidentalis	24(12)	3(3)	0	0	10(6)	2(2)	0	5(3)
Sceloporus orcutti	33(21)	2(1)	0	0	3(2)	1(1)	0	0
Uta stansburiana	28(16)	16(7)	11(10)	4(3)	44(26)	2(2)	4(1)	11(7)
Transects with no Observations	6	6	6	5	18	5	11	4
Total Animals Observed	**101**	**30**	**19**	**5**	**73**	**8**	**4**	**17**
Number of Transects at Site	**36**	**16**	**11**	**8**	**53**	**12**	**12**	**13**
Number of Animals/Transect	**2.81**	**1.88**	**1.73**	**0.63**	**1.38**	**0.67**	**0.33**	**1.31**

Table 9.7 Covered bird species detected during 2004 coastal sage scrub community monitoring. The number of points sampled is indicated in parentheses.

Species	Crown Valley/ Lopez Canyon (29)	Motte Reserve (36)	Shipley-Skinner Headquarters (18)	North Hills (84)	Potrero Canyon (38)	Species Totals (205)
Black-crowned Night Heron	0	0	0	1	0	1
Burrowing Owl	0	0	0	1	0	1
California Gnatcatcher	10	17	42	153	0	222
Cooper's Hawk	1	4	0	1	1	7
Great Blue Heron	0	0	1	0	0	1
Golden eagle	0	0	0	6	2	8
Grasshopper Sparrow	5	0	0	0	2	7
Least Bell's Vireo	0	0	0	0	0	0
Loggerhead Shrike	1	0	0	31	10	42
Prairie Falcon	0	0	0	0	1	1
Southern California Rufous-Crowned Sparrow	24	31	21	75	24	175
Bell's Sage Sparrow	3	22	1	16	4	46
Turkey Vulture	1	4	2	6	0	13
White-faced Ibis	0	0	0	1	0	1
Wilson's Warbler	0	2	0	0	0	2
White-tailed Kite	0	1	4	0	0	5
Site Total:	**45**	**81**	**71**	**291**	**44**	**532**

Table 9.8 Covered mammal species detected visually during 2004 coastal sage scrub community monitoring. The number of points sampled is indicated in parentheses.

Species	Crown Valley/ Lopez Canyon (29)	Motte Reserve (36)	Shipley-Skinner Headquarters (18)	North Hills (84)	Potrero Canyon (38)	Species Totals (205)
Black-tailed Jackrabbit	1	3	0	4	0	8
Bobcat	0	0	0	4	0	4
Coyote	2	1	0	0	1	4
Mountain Lion	0	0	0	1	0	1
Species Total	**3**	**4**	**0**	**9**	**1**	**17**

Table 9.9 Mean (± standard deviation) index value for levels of anthropogenic disturbance at coastal sage scrub sites sampled during community monitoring in 2004.

Sites		Roads	Off Road Vehicles	Human Activity	Dumping	Grading	Cattle Grazing (past)	Fire	Total Anthropogenic Disturbance	Average Human Disturbance	Average Vegetation Disturbance
Crown Valley	Mean	0.50	0.00	0.00	0.00	0.00	0.00	0.75	1.50	0.75	0.75
	St. Dev.	0.80	0.00	0.00	0.00	0.00	0.00	1.14	1.88	1.22	1.14
Lopez Canyon	Mean	0.15	0.00	0.00	0.15	0.00	0.00	3.46	3.77	0.31	3.46
	St. Dev.	0.55	0.00	0.00	0.38	0.00	0.00	1.33	1.42	0.63	1.33
Motte Reserve	Mean	0.91	0.09	0.04	0.65	0.00	0.00	0.13	2.00	1.87	0.13
	St. Dev.	1.12	0.42	0.21	1.40	0.00	0.00	0.34	2.68	2.55	0.34
Shipley-Skinner Headquarters	Mean	0.45	0.00	0.00	0.09	0.00	0.09	0.64	1.27	0.55	0.73
	St. Dev.	0.82	0.00	0.00	0.30	0.00	0.30	1.21	1.56	0.82	1.19
North Hills East	Mean	2.25	0.00	0.00	0.75	0.88	0.00	0.00	4.50	4.50	0.00
	St. Dev.	2.19	0.00	0.00	0.89	1.64	0.00	0.00	3.89	3.89	0.00
North Hills West	Mean	0.51	0.05	0.08	0.38	0.08	0.00	0.23	1.90	1.67	0.23
	St. Dev.	0.94	0.32	0.27	0.59	0.35	0.00	0.71	2.19	2.18	0.71
Mid Potrero Canyon	Mean	0.09	0.00	0.00	0.09	0.00	1.73	1.73	3.82	0.36	3.45
	St. Dev.	0.30	0.00	0.00	0.30	0.00	1.42	1.42	2.48	0.50	2.46
West Potrero Canyon	Mean	0.30	0.00	0.10	0.20	0.00	1.40	0.80	2.90	0.70	2.20
	St. Dev.	0.67	0.00	0.32	0.42	0.00	1.35	1.32	2.77	0.82	2.53

Discussion

All community monitoring sites showed evidence of extensive invasion by non-native grasses (Tables 9.3 and 9.4). In order to manage reserves to preserve coastal sage scrub and reduce the invasion of exotic annual grasses and forbs, it is necessary to understand how the system responds under different environmental conditions. Future coastal sage scrub community monitoring should be conducted over a wide range of environmental conditions to determine responses of plant and animal populations (Landres et al. 1999; Barrows et al. 2005). The 2004 surveys were conducted in a year of near average rainfall and following five years of drought, including an especially low amount of annual precipitation in 2002. The drought may have contributed to substantial die-off of shrubs at some sites as evidenced by the high proportion of dead shrub cover along transects. Repeating surveys at the same points in 2005 (an unusually wet year) would provide information on plant responses in wet versus dry years. A more in-depth understanding of how the coastal sage scrub community responds to changing environmental conditions, and in particular variable precipitations, could improve management of these lands. Since the Plan Area has an arid climate, it is important to gather data on how different components of the coastal sage scrub community respond to variable rainfall levels. In particular, changes in the composition and cover of non-native herbaceous plants should be characterized and the recovery of shrub stands where there were significant die-offs.

Long-term studies of these survey areas could address whether responses of shrubs and grasses persist over time or are transitory. For example, research could address whether shrubs with significant dead growth in 2004 were able to recover with increased rainfall in 2005 and whether there were any consequences of the drought to their long-term survival. Other important measures would be seedling establishment and recovery of native forbs versus the spread of non-native annuals. The response of plants to variable rainfall has implications for animal populations. Plants provide the primary productivity upon which arthropods and many vertebrate species are dependent. Shrub die-offs may adversely affect insect populations, which in turn can affect the productivity and survivorship of insectivorous bird species such as the California Gnatcatcher.

In addition to monitoring natural environmental processes, it is important that a long-term monitoring program also evaluate levels of anthropogenic disturbances (e.g., the invasion of exotic species such as annual grasses and Argentine ants into natural communities). The monitoring program should measure the range of variation in environmental conditions and community responses so that a greater understanding of what constitutes a normal fluctuation in population distribution and abundance versus when populations are vulnerable to environmental threats. This is best accomplished by establishing long-term monitoring sites at reserves throughout the Plan Area that encompass a range in habitat quality, invasion by exotic species, patch size and connectivity, and levels of anthropogenic disturbance. Data gathered periodically at these reference sites combined with focused research could inform conceptual models (Chapter 11) and guide the development of adaptive management plans.

To monitor effectively coastal sage scrub vegetation will require more efficient sampling techniques as an extensive amount of effort went into characterizing coastal sage scrub transects in 2004 (see Chapter 2). Critical components for characterizing and evaluate the status of coastal sage scrub habitats at a site include measuring shrub composition and cover, the amount of dead shrub cover, the composition and cover of herbaceous species, and recruitment of seedlings. Originally, it was planned that baseline measurements of the coastal sage scrub sites would be established in 2004 and that these sites would be revisited in 2005 to record changes in vegetation characteristics under different environmental conditions and to compare the efficiency and accuracy of alternative sampling methods. In addition, a useful tool would be developing a remote sensing technique to evaluate the composition and status (e.g., die-offs) of coastal sage scrub over the entire Plan Area. Such a method could potentially be developed using satellite imagery and would be helpful to land managers in evaluating overall conditions of shrublands on a regular basis and identifying areas undergoing substantial change where management actions might be warranted.

Although data collection was conducted on the reptile transects during the 2004 field season, the focus was to test the transect sampling field protocol and to suggest ways for its improvement. Transect sampling's main advantage over the other widely used sampling technique, pitfall trapping, is that transects are non-invasive, can be run on steep or uneven terrain, and require little set up time. The main drawbacks are that sampling only occurs over a short time span and detection of reptiles is dependent upon the ability of the observer to spot individuals under varying environmental conditions. Alternatively, pitfall traps passively sample the vicinity for the entire time they are open. The high number of reptiles at the Motte Reserve may be explained by a mature stand of coastal sage scrub in portions of the site that has been undisturbed since at least the mid 1980's (Mayhew and Carlson 1990). The remaining sites have been subjected to various disturbances over the years. For example, the Potrero site was subjected to grazing and off road vehicular traffic while Lopez Canyon burned in fall 2003. Further complicating the results were the very dry year of 2002 and below normal rainfall of 2003. Reduced precipitation negatively affects primary productivity which contributes to low arthropods abundance and hence to low population densities in lizards (Dunham 1981).

The variation in species numbers may also result from problem in the sampling design as well as with behavioral differences among species. The north facing slopes of the North Hills sites supported dense costal sage scrub vegetation, which may serve to obscure some of the ground dwelling species like *Cnemidophorus* and *Phrynosoma* during surveys. Only one *Phrynosoma coronatum* was observed during the entire survey period. Horned lizards are notoriously cryptic. They remain stationary when startled, stay close to the base of vegetation, and their coloration matches background (Sherbrooke 2003). Rowland and Brattstrom (2001) showed that *Cnemidophorus hyperythrus* utilizes largely areas of open vegetation rather than areas with dense vegetation. Species that utilize rock outcrops, such as *Sceloporus* and *Uta* may be more apparent and over represented in the data.

To remedy problems with detection it is suggested that transects be sampled at least twice during between early spring and mid-summer to estimate the relative population sizes among sites. These surveys may be supplemented with mid to late summer surveys, a time when the young of the year are emerging, to serve as an index of reproductive activity among sites. Calculating estimates of true population sizes is feasible employing the distance method when sufficient sample data is available. However, for 2004 survey season the number of individuals observed per transect is too few to utilize the distance formula calculations, therefore only relative density estimates (i.e. number of individuals per transect) are feasible (Buckland, et al. 2001).

Location data collected for coastal sage scrub birds were included in niche modeling. The next step in developing the monitoring framework is to test and refine the preliminary niche models using data collected during community monitoring. Future monitoring efforts should focus on surveying for Covered Species in areas with a lack of location data to see how well the niche models identify suitable habitat and predict species occurrence. Evaluating and refining these preliminary niche models is important to improving their utility as a tool for guiding future monitoring and management strategies. In the same way, hypothesized relationships between environmental drivers and Covered Species populations require testing and evaluation in future monitoring research. Understanding the roles environmental processes play in defining suitable habitat for Conserved Species is essential to refining conceptual models that guide monitoring and management strategies. These niche and conceptual models should be incorporated into designing a monitoring strategy to provide information on where to sample Covered Species, what taxa and processes should be sampled, and where environmental conditions may be predicted to deteriorate and thus should be sampled. Under this monitoring framework, the modeling and monitoring components are interdependent and meant to be iteratively tested and improved.

CHAPTER 10
RIPARIAN COMMUNITY MONITORING AND MODELING

Introduction

Riparian habitats in the Plan Area support a diverse assemblage of covered bird species. These species included the federally-listed Least Bell's Vireo (*Vireo bellii pusillus*) and Southwestern Willow Flycatcher (*Empidonax traillii extimus*), as well as many other species of conservation concern to federal, state, and local governments. These species include Downy Woodpecker (*Picoides pubescens*), Wilson's Warbler (*Wilsonia pusilla*), Yellow-breasted Chat (*Icteria virens*), and Yellow Warbler (*Dendroica petechia brewsteri*). Riparian communities are becoming increasingly fragmented and isolated as surrounding areas are developed or converted to agricultural uses. There are a host of processes related to urbanization that potentially threaten these communities. Human activity, subsidized predators, and invasions of Argentine ants (*Linepithema humile*) may adversely affect species in riparian communities (RHJV 2004, Holway 2005). Dams, channels, levees and urban runoff have altered natural hydrological regimes in riparian systems, leading to changes in plant communities (RHJV 2004). Year-round water from urban runoff has contributed substantially to problems with non-native plants invading and crowding out native species. Especially difficult to control, have been invasive plants such as *Arundo donax*, which create large impenetrable thickets crowding out native plants and further altering the hydrology of the system (Holt 1999). Brood parasitic Brown-headed Cowbirds (*Molothrus ate*r), are prevalent in southern California riparian systems and can cause substantial reductions in the reproductive success of covered riparian bird species (Kus 1999). Birds are also hosts to the West Nile Virus. In riparian areas mosquitoes, carriers of the virus, are especially abundant.

CCB began developing a monitoring program for riparian communities because of the concentration of sensitive bird species and potential anthropogenic threats to species within this community. In 2004, surveys were conducted of vegetation, arthropods, and birds in riparian habitats. In addition, data were collected on mammal sign and other species of interest. Riparian sites were also assessed for levels of anthropogenic disturbance. Chapters 1 and 9 describe in detail the concepts and goals behind community monitoring, and how these fit into the larger monitoring framework (Barrows et al. 2005).

CCB was unable to construct niche models for covered riparian bird species as the available 1994 vegetation map inaccurately depicted riparian vegetation within the Plan Area. Instead, CCB biologists constructed logistic regression models predicting each species occurrence at points sampled during riparian community monitoring in 2004. These models were constructed to identify those variables describing habitat quality and levels of anthropogenic disturbance that were important in predicting a species occurrence. Modeling was performed at three different spatial scales. At the "regional" scale, models predicted the occurrence of each covered species across 13 drainages within the Plan Area. At the "watershed" scale, models were constructed for six drainages within the Santa Ana River watershed and at the "river" scale, models were constructed for only the Santa Ana River. The intent were for the models to provide information for constructing the conceptual models (Chapter 11) and to guide future riparian community monitoring recommendations (Chapter 17).

Methods

Fifteen riparian corridors located on public or quasi-public lands served as the initial testing sites for the riparian survey protocols (Figure 10.1). Survey efforts were restricted to communities consisting of cottonwood-willow riparian forest and southern willow scrub vegetation. Monitoring sites were selected to encompass a wide geographic distribution within the Plan Area. Sites were chosen to include a range of variation in the size of the drainage, the amount of riparian habitat, and the extent of surrounding development. Within each riparian corridor, CCB biologists established survey stations spaced at 200 m intervals. The length of the riparian corridor surveyed determined the number of survey points established with a total number of 290 survey points across all sites. Aerial photographs showing the study sites and the arrangement of the survey points can be found on in Appendix 11.

CCB focused surveys on three groups within the riparian corridors: vegetation composition and structure, birds, and soil arthropods. All three taxa were surveyed at each sampling point at each site. Birds were sampled using 10-minute point counts in the early morning hours between dawn and 10:30 am. To evaluate how well observers detected and correctly identified different bird species and as a potential method for monitoring bird communities, bird vocalizations were recorded at a subset of point counts. Details of the methodology and equipment used are presented in Chapter16. As another means to calculating detectability of the different bird species during point counts, observers collected distance sampling data (Rosenstock et al. 2002), categorized each observation by the time interval that the bird was detected, and conducted repeated surveys for many of the points. Vegetation was sampled using 50 m relevé plots and methods developed by Point Reyes Bird Observatory. Arthropods were sampled with pitfall traps. CCB biologists also conducted qualitative wildlife surveys while traveling through the riparian corridors between sampling points. Any amphibians, reptiles, mammals or their sign (scat, tracks, burrows, shed skin, etc.) were recorded. Harvester ant mounds and any unusual species were also recorded. The survey included an assessment of the level of disturbance, human and otherwise at each survey point within each corridor. The amount of trash, presence/absence of vehicle traffic, and level of invasive plant intrusion were among the variables quantified. The monitoring protocols for conducting vegetation sampling, bird point counts, soil arthropod pitfall trapping, assessing anthropogenic disturbance, and conducting surveys of mammal sign and other species are in Appendix 3. These protocols provide details about sampling methods for each survey type. The number of points surveyed, the size of the survey area and survey periods for the different groups that were monitored are presented for each site in Table 10.1. Table 10.2 lists the field personnel involved in riparian community-monitoring tasks.

Figure 10.1 Map showing the distribution of riparian corridor study sites across the Plan Area.

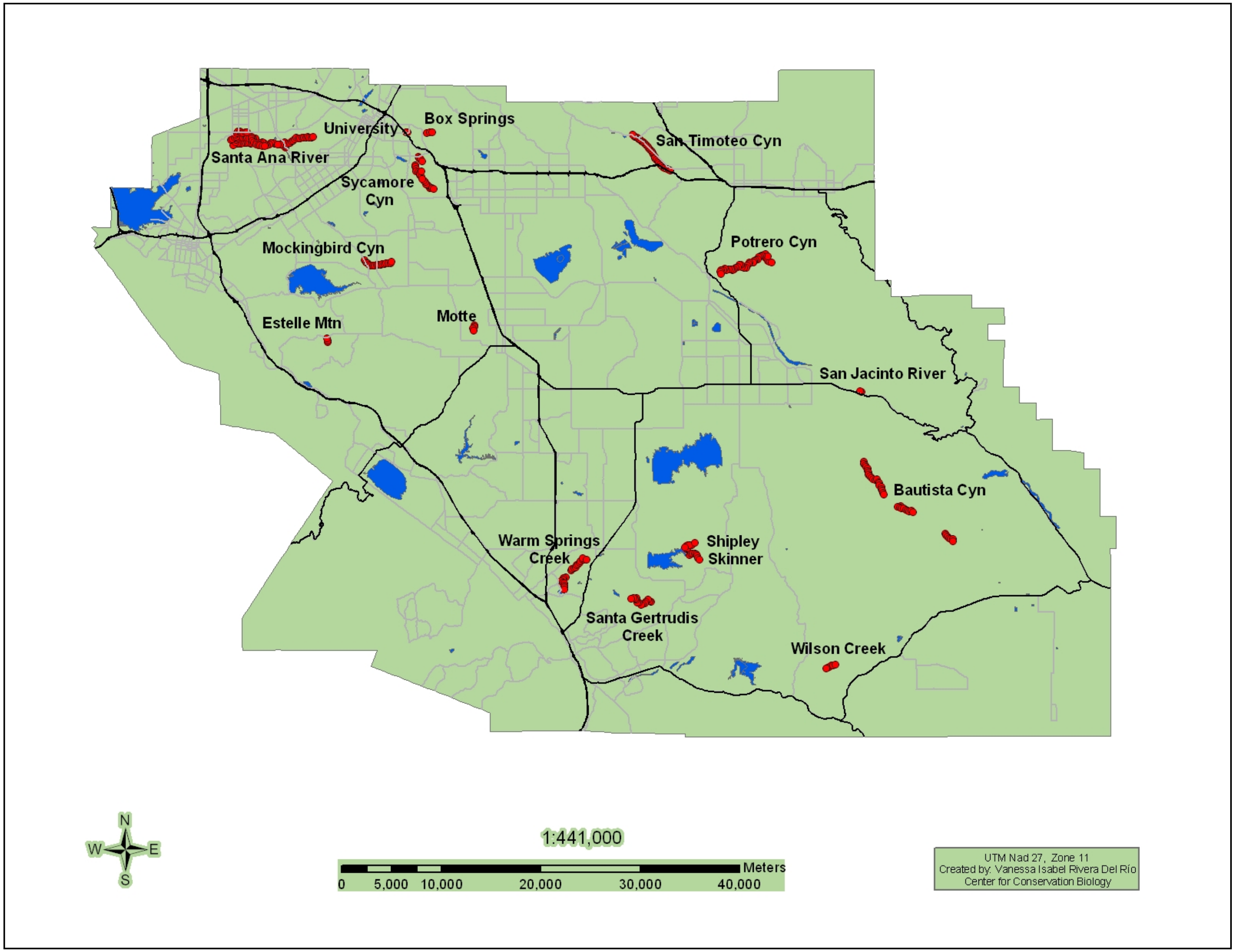


Table 10.1 Sample sizes, survey area, and survey periods for riparian community monitoring sites. "Bird points" refer to points sampled only for birds, whereas "community points" refers to points sampled for multiple groups, including birds.

Site	# Bird Points Sur. 1	# Bird Points Sur. 2	# Bird Points Sur. 3	# Community Points	Survey Area (ha)	Vegetation Sampling Period	Arthropod Sampling Period	Bird Sampling Period	Mammal Sign Sampling Period
Bautista Creek	38	38	0	38	119.3	8/24 - 8/25/04 11/2 – 11/4/04	8/24 – 8/27/04	5/5 – 7/28/04	8/24 – 8/27/04
Box Springs	3	3	0	3	9.4	10/8/04	10/5 – 10/8/04	4/13 – 6/16/04	10/8/04
Estelle Mountain	3	0	0	0	9.4			6/7/04	
Mockingbird Canyon	16	16	12	16	50.2	9/13 – 9/16/04	9/13 – 9/16/04	4/19 – 7/23/04	9/13 – 9/16/04
Motte Reserve	4	4	0	4	12.6	8/10/04	8/10 – 8/13/04	4/7 – 6/10/04	8/13/04
Potrero Canyon	37	37	14	37	116.2	9/8 – 9/17/04	9/14 – 9/17/04	4/21 – 8/2/04	9/8 – 9/17/04
San Jacinto River	2	0	0	2	6.3	11/2/04	11/2 – 11/5/04	4/9/04	11/5/04
San Timoteo Canyon	28	28	14	28	87.9	8/23 – 8/26/04 11/8 – 11/9/04	8/23 – 8/26/04	4/5 – 7/12/04	8/26/04
Santa Ana River	77	55	21	77	241.8	8/18 – 11/05/04	8/31 – 9/03/04 9/7 – 9/10/04 9/20 – 9/23/04 10/11 – 10/14/04	4/1 – 7/30/04	8/18 – 10/19/04
Santa Gertrudis Creek	14	14	0	14	44.0	10/12 – 10/15/04	10/12 – 10/15/04	4/28 – 6/30/04	10/12/04
Shipley Skinner Multi-Species Reserve	17	17	0	17	53.4	8/17 – 9/15/04	8/17 – 8/20/04	5/13 – 7/21/04	8/17 – 9/9/04
Sycamore Canyon	22	22	0	22	69.1	8/30 – 9/3/04	8/30 – 9/2/04	4/8 – 8/1/04	8/30 – 9/2/04
University Avenue	2	2	0	2	6.3	10/8/04	10/6 – 10/8/04	6/5 – 6/16/04	10/8/04
Warm Springs Creek	21	21	0	21	65.9	8/16 – 8/19/04 11/17/04	8/16 – 8/19/04	4/26 – 7/22/04	8/16 – 8/19/04
Wilson Creek	6	0	0	0	18.8			4/20/04	
Totals	290	257	61	281	910.6	8/10 - 11/17/04	8/10 - 10/8/04	4/1 - 8/2/04	8/13 – 11/5/04

Table 10.2 Riparian community monitoring tasks and CCB personnel conducting each task during 2004.

Name	Initials	Tasks
Alex Yun	AY	Vegetation/Arthopod Sampling, Other species
Antonio Celis	AC	Vegetation/Arthopod Sampling, Birds, Other species
Brandon Mutrux	BM	Vegetation/Arthopod Sampling, Other species
Chris True	CT	Vegetation/Arthropod Sampling
Eliza Maher	EMA	Vegetation/Arthopod Sampling, Other species
Jason Hlebakos	JH	Vegetation/Arthropod Sampling
Jill Deppe	JD	Vegetation/Arthopod Sampling, Birds, Other species
Ken Halama	KH	Vegetation/Arthropod Sampling, Other Species
Kim Oldehoeft	KO	Vegetation/Arthopod Sampling, Other species
Kris Preston	KLP	Vegetation/Arthopod Sampling, Birds, Other species
Melissa Preston	MKP	Birds, Other Species
Myung Bok Li	MBL	Vegetation/Arthopod Sampling, Other species
Tracy Tennant	TT	Vegetation/Arthropod Sampling
Susana Peluc	SP	Vegetation Sampling
Amber Holt	AH	Other Species

To construct niche models for coastal sage scrub species, CCB used the 1994 vegetation maps prepared for the WRCMSHCP. These maps were not accurate in depicting riparian vegetation at several of the drainages CCB surveyed in the spring and summer of 2004. This is likely due to the natural patchiness of riparian vegetation and the scale at which vegetation was mapped in 1994, as well as to subsequent changes in riparian habitats since the vegetation map was prepared. Riparian habitat often occurs in narrow, linear bands or small fragments that may be difficult to detect when using aerial photos to map over a large region such as the Plan Area. Typically, sites with fragmented or narrow bands of riparian vegetation were not mapped as riparian habitat on the 1994 vegetation map. There were no other digital riparian habitat layers available for the entire Plan Area. As a result, it was not possible to construct regional GIS niche maps for sensitive bird species. Instead, CCB biologists took an alternative approach to identifying factors important in predicting the distribution of covered riparian bird species in the Plan Area.

CCB biologists constructed logistic regression models to identify factors important in determining the occurrence of seven sensitive riparian bird species in the Plan Area. A hierarchial modeling approach was used to identify whether patterns of habitat use varied with spatial extent. In this context, CCB evaluated bird-habitat relationships at a regional level that encompassed much of the Plan Area including three major watersheds supporting numerous diverse drainages. Regional logistic regression models were constructed using data collected during 2004 riparian community surveys of 13 different drainages. At the next level, CCB biologists investigated whether the same or different environmental factors were associated with choice of occupied habitat within a watershed, in this case among six drainages within the Santa Ana River watershed. Finally, at a local level, bird habitat relationships were modeled for the Santa Ana River only. This comparison included four sites along a 5.5 mile segment of the Santa Ana River and covered riparian habitat on both the north and south sides of the river. Sampling locations extended from two miles east of Van Buren Bridge downstream to the western edge of Hidden Valley Ranch Park.

To investigate how human modified habitats might affect bird distributions at the three different spatial extents, three types of models were compared for each species. "Quality" models included only variables indicating the characteristics of the natural habitat, for instance the structure and composition of native vegetation, the abundance of native ground dwelling arthropods, and the presence of water. To quantify the effects of human activity and modification of natural habitats, "threats" models were constructed with variables related to the presence of introduced plant and animal species and to measures of anthropogenic disturbances, including distance from the sampling point to the closest developed and agricultural areas. Finally, at each spatial extent, a "full" model was constructed for each species consisting of both "quality" and "threat" variables. Table 3 describes the variables used in constructing the logistic regression models. Data for most of these variables were collected during the riparian community surveys in 2004. Several variables such as distance from the sampling point to a particular land use type (e.g., development, agriculture) were calculated using Geographical Information Systems. Table 4 describes the models constructed for sensitive riparian bird species at each of the three spatial scales.

Presence-absence data were used in the logistic regression models to identify factors important in determining species occurrence. The dependent variable for all models was the number of visits in which a particular species was detected at a survey point. Points were surveyed from one to three times so there were four categories of response (0-3). To control for differences in survey effort between points, every model included as one of the independent variables, the number of times each sampling point was surveyed. The models best predicting a species occurrence were determined by using Akaike's Information Criteria modified for small sample sizes (AIC_c; Burnham and Anderson 1998). We selected the model with the lowest AIC_c value and subtracted the AIC_c of that model from every other model to determine the difference in AIC_c value (Δ_i) for each model. This value was used to compare and rank models. Models with a Δ_i value of 4 or less were considered potential candidate models explaining nest success (Burnham and Anderson 1998). If the model with the lowest AIC_c was not significant for a particular species, then it was concluded that none of the three models were satisfactory at predicting that species occurrence at that spatial scale. We identified variables that were important in determining a species distribution as those that were significant at an alpha of < 0.05.

Results

Avian surveys were conducted throughout the spring and summer (Table 10.1) to capture temporal variation in the structure of the avian community as waves of migrant species arrive and depart. Over 85% of points were sampled a second time for birds. The third series of surveys were conducted at a reduced number of sites. Originally, 15 drainages were surveyed for birds; however, CCB was unable to gather other community level data at two sites. Access was problematic at Wilson Creek making it difficult to return to sample vegetation and arthropods. A fire burned the Estelle Mountain site in 2004 just prior to the first bird survey and damage to the riparian habitat was considerable so that it was not sampled further. The effort spent in each community monitoring task is provided in Chapter 2 (Table 2.3).

Appendix Table 9 lists all the vertebrate species detected by CCB biologists at riparian sites in 2004. These sightings were made during bird point count surveys, incidental sightings when traveling between points or conducting other work such as vegetation and arthropod sampling. Riparian cover at the sites varied from an average of 24 – 100% and varied for cover distributed between tree and shrub layers (Table 10.5). There was also considerable heterogeneity in species composition among the sites. The number of identified native arthropod species ranged from an average of two to over five species per pitfall trap, with the lowest number of native species at Mockingbird Canyon and the highest at Shipley-Skinner Reserve (Table 10.6). The average number of exotic species per pitfall trap ranged from around 0.15 at Potrero Canyon and Bautista Creek to 1.5 at Mockingbird Canyon.

Introduced Argentine ants were greatest in abundance at Mockingbird Canyon and absent from Bautista Creek, Box Springs, Potrero Canyon, and the Shipley-Skinner Reserve. The number of Covered Species recorded at each site is listed in Tables 10.7-10.9. These are the total number of sensitive species observed and do not reflect the abundance of these species at the site as there is no correction for survey effort or detectability. Sites varied in their level of anthropogenic disturbance (Table 10.10). San Timoteo Canyon, Santa Ana River, Mockingbird Canyon, and University Avenue showed the greatest levels of human disturbance (e.g., trash dumping, hiking, vehicles, etc.), whereas Santa Gertrudis Creek, Potrero Canyon and Shipley-Skinner showed the lowest levels.

Table 10.11 presents the models that best predict the occurrence of seven sensitive riparian bird species modeled at the three different spatial scales. For variables that were significant in the model, the regression coefficient indicates the magnitude and direction of the bird-habitat relationship. The occurrence of most species was best predicted by a combination of habitat quality and threats variables. No consistent patterns were found in which types of variables were associated with a species occurrence at the regional Santa Ana watershed, or Santa Ana River levels.

Habitat quality associations varied by species. Three species responded strongly to the presence of snags > 10 cm DBH. Least Bell's Vireos and Yellow-breasted Chats avoided areas with high numbers of snags whereas Downy Woodpeckers were positively associated with increasing number of snags. Least Bell's Vireos and Yellow-breasted Chats shared similar preferences for increased riparian cover and reduced tree cover. Yellow Warblers were most consistent in their habitat associations at all three spatial extents.

Species detectability was not estimated for the Covered Species. Based upon recommended sample sizes required to estimate species detectability for point count surveys (Rosenstock et al. 2002), it was determined samples sizes were inadequate for covered species. Instead, detectability was partially accounted for by repeated surveys and including this variable of survey effort in the model.

The following is a description of how each species responded to threat and habitat quality variables at the three spatial extents.

Table 10.3 Description of the variables used in logistic regression models predicting the probability of occurrence of sensitive riparian bird species in the Plan Area. Variables are classified as threats, if they are non-native features of the environment or related to human activities; Variables are classified as habitat quality, if they are natural features of the environment. Data source refers to whether the data were collected during CCB's 2004 riparian community sampling (Community) or derived from Geographical Information Systems (GIS) spatial data layers.

Type of Variable	Variable Name	Data Source	Description of Variable
	# Visits	Community	Each sampling point was visited from one to three times and this variable quantifies how many visits were made to each sampling location. This variable was included in every model to control for the effects of survey effort.
Threat	Dist. Dev.	GIS	Distance (m) from the sampling point to the closest development polygon. The development category includes residential, commercial, and industrial land uses.
Threat	Dist. Ag.	GIS	Distance (m) from the sampling point to the closest agriculture polygon. Agriculture includes row crops, agricultural fields, and dairy /livestock operations.
Threat	# Non-Native Ants	Community	Number of individuals of non-native ant species collected with a pit fall trap at each sampling point.
Threat	Human Disturbance	Community	Cumulative score of human activity within 50 m of each sampling point. Different types of human disturbance were scored from 0 (absent) to 3 (large amount of disturbance) within a 50 m radius circle around the point. Categories of human disturbance include trash/illegal dumping, vehicle tracks/presence, paved roads and trails, equestrian activity, and human presence/footprints. The scores for each of these categories were added to give a total score for human disturbance at that point.

Table 10.3 (Cont.) Description of variables used in logistic regression models predicting riparian species occurrence in the Plan Area.

Type of Variable	Variable Name	Data Source	Description of Variable
Threat	Vegetation Disturbance	Community	Cumulative score of disturbance to vegetation within 50 m of each sampling point. Different types of disturbance to the vegetation were scored from 0 (absent) to 3 (large amount of disturbance) within a 50 m radius circle around the point. Categories of vegetation disturbance included cattle/livestock grazing, offroad vehicle damage, and fire/flood damage. The scores for each of these categories were added to give a total score for vegetation damage at that point.
Threat	% Non-Native Herbs	Community	Percent of the riparian habitat within a 50 m radius circle around the sampling point that is composed of non-native herbaceous vegetation < 0.5 m tall.
Threat	% *Arundo donax*	Community	Percent of the riparian habitat within a 50 m radius circle around the sampling point that is composed of *Arundo donax* > 5 m tall.
Threat	% *Tamarix* spp.	Community	Percent of the riparian habitat within a 50 m radius circle around the sampling point that is composed of *Tamarix* species > 0.5 m tall.
Threat	# Brown-headed Cowbirds	Community	# of visits that Brown-headed Cowbirds were detected at the sampling point
Quality	Dist. Undev.	GIS	Distance (m) from the sampling point to the closest undeveloped natural habitat polygon. Habitat types include coastal sage scrub, chaparral, non-native grassland, and oak woodland.
Quality	# Native Arthropods	Community	Number of individuals of all known native arthropod species collected in a pit fall trap at the sampling point.
Quality	Snags > 10 cm DBH	Community	Number of standing dead tree trunks > 10 cm DBH within 50 m radius of sampling point.
Quality	% Riparian	Community	Percent of riparian habitat (riparian vegetation and water) within a 50 m radius around the sampling point.

Table 10.3 (Cont.) Description of variables used in logistic regression models predicting riparian species occurrence in the Plan Area.

Type of Variable	Variable Name	Data Source	Description of Variable
Quality	% Trees	Community	Percent of the riparian habitat within a 50 m radius circle around the sampling point that is composed of trees and tall shrubs > 5 m tall.
Quality	% Shrubs	Community	Percent of the riparian habitat within a 50 m radius circle around the sampling point that is composed of small trees and tall shrubs between 0.5 and 5 m tall.
Quality	% Herbs	Community	Percent of the riparian habitat within a 50 m radius circle around the sampling point that is composed of plants < 0.5 m tall.
Quality	% Water	Community	Percent of the riparian habitat within a 50 m radius circle around the sampling point that is covered by water.
Quality	% Bare Ground	Community	Percent of the riparian habitat within a 50 m radius circle around the sampling point that is covered by bare ground (sand, soil and rock).
Quality	% *Platanus racemosa*	Community	Percent of the riparian habitat within a 50 m radius circle around the sampling point that is covered by *Platanus racemosa* > 5 m tall.
Quality	% *Populus fremontii*	Community	Percent of the riparian habitat within a 50 m radius circle around the sampling point that is covered by *Populus fremontii* > 5 m tall.
Quality	% *Quercus* spp.	Community	Percent of the riparian habitat within a 50 m radius circle around the sampling point that is covered by *Quercus* spp. > 5 m tall.
Quality	% *Salix* spp.	Community	Percent of the riparian habitat within a 50 m radius circle around the sampling point that is covered by *Salix* species > 5 m tall. Excludes the uncommon shrubby species *Salix exigua*.
Quality	% *Baccharis* spp.	Community	Percent of the riparian habitat within a 50 m radius circle around the sampling point that is covered by *Baccharis* spp. > 0.5 m tall.

Table 10.4 Variables included in logistic regression models predicting the occurrence of sensitive riparian bird species at three different spatial scales within the Plan Area. Regional models predicted species occurrence across 13 riparian systems in the ~490,000 ha Plan Area and were constructed using the same variables for all species. Watershed models predicted species occurrence within five drainages in the Santa Ana watershed and were constructed using variables that significantly predicted species occurrence in the regional models. The same sets of variables were used for all species in the watershed models. The river models predicting species occurrence along the Santa Ana River were constructed using biologically relevant variables for each species. Each modeling scale included three types of models: *threat models* constructed using only threat variables; *habitat quality models* including only quality variables; and *full models* including both threat and quality variables. All models included the number of visits to account for survey effort at each sampling point.

Model	Species	# of Survey Points	# of Variables Full Model	Survey Effort	Variables in Model	
					Threat Variables	**Habitat Quality Variables**
Regional: Multiple Watersheds Across WRCMSHCP Area	All	281	24	# of Visits	Dist. Dev., Dist. Ag., # Non-Native Ants, Human Disturbance, Vegetation Disturbance, % Non-Native Herbs, % *Arundo donax,* % *Tamarix* spp., # Brown-headed Cowbirds	Dist. Undev., # Native Arthropods, # Snags >10 cm DBH, % Riparian, % Trees, % Shrubs, % Herbs, % Water, % Bare Ground, % *Salix* spp., % *Populus fremontii*, % *Quercus* spp., % *Platanus racemosa,* % *Baccharis* spp.
Watershed: Six Drainages within the Santa Ana River Watershed	All	148	15	# of Visits	Dist. Dev., Dist. Ag., , # Non-Native Ants, Human Disturbance, % Non-Native Herbs, % *Arundo donax*	Dist. Undev., # Native Arthropods, # Snags > 10 cm DBH, % Riparian, % Tree, % Shrub, % *Baccharis* spp., % *Salix* spp.
River: Santa Ana River Locations Only	Blue Grosbeak	79	8	# of Visits	Dist. Dev., Dist. Ag., % Non-Native Herbs, % *Arundo donax*	# Native Arthropods, % Tree, % Shrub
	Downy	79	8	# of Visits	Dist. Ag., Dist. Dev., % *Arundo donax*	Dist. Undev., % Bare Ground, # Snags > 10 cm DBH, # Native Arthropods

Table 10.4 (Cont.) Variables included in logistic regression models predicting species occurrence at three different spatial scales in the Plan Area.

Model	Species	# of Survey Points	# of Variables Full Model	Survey Effort	Variables in Model	
					Threat Variables	Habitat Quality Variables
River: Santa Ana River Locations Only	Least Bell's Vireo	79	8	# of Visits	Dist. Dev., # Non-Native Ants, % *Arundo donax*	Dist. Undev., # Native Arthropods, % *Salix* spp., , # Snags > 10 cm DBH
	Willow Flycatcher	79	8	# of Visits	Dist. Ag., Human Disturbance, % Non-Native Herb, % *Arundo donax*	Dist. Undev., % Water, % Bare Ground
	Wilson's Warbler	79	8	# of Visits	Dist. Dev., # Non-Native Ants, % *Arundo donax*	Dist. Undev., # Native Arthropods, % Shrub, % *Salix* spp.
	Yellow-breasted Chat	79	8	# of Visits	Dist. Dev., # Non-Native Ants, % Non-Native Herbs, % *Arundo donax*	Dist. Undev., % Tree, % Shrub
	Yellow Warbler	79	8	# of Visits	Dist. Dev., # Non-Native Ants	Dist. Undev., # Native Arthropods, % Shrub, % *Salix* spp., % *Baccharis* spp.

Table 10.5 Vegetation and site characteristics at 13 riparian drainages surveyed in 2004. The number of sampling points is listed in parentheses after the name of each riparian drainage.

Drainages		% Riparian Vegetation	% Tree Cover	% Shrub Cover	% Herb Cover	% Exotic Herb Cover	% Water Cover	% Bare Ground Cover	# Snags > 10cm DBH
Bautista Creek (n = 38)	Mean	49.61	19.32	21.60	28.41	23.05	0.15	10.83	1.42
	± STD	25.95	17.30	11.70	18.76	19.35	0.65	10.30	2.01
Box Springs (n = 3)	Mean	49.61	19.32	21.60	28.41	23.05	0.15	10.83	1.42
	± STD	17.42	4.55	3.67	3.79	0.94	0.32	2.77	0.25
Santa Gertrudis Creek (n = 14)	Mean	35.00	20.00	8.25	11.25	8.08	0.00	6.66	0.29
	± STD	15.93	15.91	4.69	6.66	5.55	0.00	4.86	0.73
Mockingbird Canyon (n = 16)	Mean	55.75	26.40	21.68	8.57	3.05	2.65	7.87	2.19
	± STD	9.22	15.71	7.96	7.10	3.05	2.20	4.54	2.97
Motte Reserve (n = 4)	Mean	40.00	7.96	21.44	17.25	14.24	0.00	3.31	5.50
	± STD	30.28	11.87	28.26	6.27	4.81	0.00	3.18	9.71
Potrero Canyon (n = 37)	Mean	60.27	15.62	18.83	29.01	23.11	0.46	17.44	2.51
	± STD	29.84	17.12	12.61	21.76	21.06	1.29	15.70	3.29
Santa Ana River (n = 77)	Mean	85.61	35.47	34.16	21.55	12.78	12.08	12.81	1.21
	± STD	20.63	28.04	18.13	16.67	14.24	14.45	10.84	3.08
San Jacinto River (n = 2)	Mean	100.00	50.00	60.00	27.50	22.75	25.00	20.00	0.50
	± STD	0.00	28.28	14.14	3.54	3.89	7.07	0.00	0.71
Shipley Skinner Reserve (n = 17)	Mean	76.47	31.24	36.78	14.49	7.15	2.01	14.81	7.94
	± STD	22.69	16.53	20.82	17.47	8.88	5.54	18.20	14.36
San Timoteo Canyon (n = 28)	Mean	51.86	31.95	16.80	14.09	2.89	3.52	10.54	4.36
	± STD	14.15	15.36	13.79	8.91	2.27	2.00	6.26	9.34
Sycamore Canyon (n = 22)	Mean	24.32	13.87	8.19	4.06	1.00	0.98	3.79	0.32
	± STD	11.78	10.27	3.92	3.72	0.97	1.04	3.23	0.72
University Avenue (n = 2)	Mean	55.00	49.50	7.00	8.00	3.42	0.88	2.56	1.50
	± STD	7.07	6.36	2.83	2.83	1.11	0.18	2.03	2.12
Warm Springs Creek (n = 21)	Mean	41.10	25.05	14.06	13.50	5.81	1.29	7.28	0.62
	± STD	16.45	18.61	8.87	8.14	7.15	1.74	3.35	0.97

Table 10.5 (Cont.) Vegetation characteristics at 13 drainages in the Plan Area.

Drainage		% *Arundo donax* Cover (Tree + Shrub)	% *Baccharis* Cover	% *Tamarix* Cover (Tree + Shrub)	% *Platanus racemosa* Cover	% *Populus fremontii* Cover	% *Quercus* spp. Cover	% All *Salix* spp. Cover
Bautista Creek (n = 38)	Mean	0.00	4.17	2.85	0.92	10.05	2.80	3.99
	± STD	0.00	4.26	5.97	2.20	11.61	4.87	6.97
Box Springs (n = 3)	Mean	77.00	77.00	77.00	77.00	77.00	77.00	77.00
	± STD	13.07	13.07	13.07	13.07	13.07	13.07	13.07
Santa Gertrudis Creek (n = 14)	Mean	0.00	4.33	0.41	0.00	0.64	0.25	18.14
	± STD	0.00	2.99	1.44	0.00	1.48	0.83	16.18
Mockingbird Canyon (n = 16)	Mean	0.00	4.60	0.00	0.00	0.63	0.00	23.88
	± STD	0.00	5.14	0.00	0.00	1.80	0.00	14.44
Motte Reserve (n = 4)	Mean	0.00	8.64	0.00	0.00	0.00	0.00	7.74
	± STD	0.00	13.37	0.00	0.00	0.00	0.00	12.06
Potrero Canyon (n = 37)	Mean	0.00	10.78	0.47	0.00	8.09	0.15	7.24
	± STD	0.00	8.87	0.99	0.00	9.68	0.61	9.75
Santa Ana River (n = 77)	Mean	18.73	6.10	1.49	0.28	3.62	0.00	15.08
	± STD	20.58	7.80	2.73	1.25	7.15	0.00	13.96
San Jacinto River (n = 2)	Mean	0.00	13.55	0.00	6.00	15.00	3.25	24.00
	± STD	0.00	8.56	0.00	6.36	8.49	0.35	10.61
Shipley Skinner Reserve (n = 17)	Mean	0.00	14.85	5.47	0.00	4.93	0.83	24.06
	± STD	0.00	14.04	12.74	0.00	9.08	3.20	18.67
San Timoteo Canyon (n = 28)	Mean	0.27	7.33	0.02	0.00	4.32	0.17	25.66
	± STD	1.06	8.07	0.11	0.00	5.29	0.61	12.32
Sycamore Canyon (n = 22)	Mean	0.02	1.55	0.06	4.30	1.65	0.00	7.08
	± STD	0.11	1.87	0.23	6.12	4.07	0.00	7.80
University Avenue (n = 2)	Mean	0.00	2.25	0.00	1.13	18.90	0.00	9.90
	± STD	0.00	3.18	0.00	1.59	7.64	0.00	1.27
Warm Springs Creek (n = 21)	Mean	0.00	3.01	0.26	0.00	1.89	7.77	14.54
	± STD	0.00	2.82	0.63	0.00	3.15	15.59	11.72

Table 10.6 Mean (± standard deviation) arthropod species and numbers of individuals sampled with pitfall traps at 13 drainages across the Plan Area. Sample size (n) is the number of undisturbed pitfall traps and not the number of pitfall traps set out, as some were disturbed.

Drainage	Descriptive Statistics	# Native Sp.	# Native Indiv.	# Exotic Sp.	# Exotic Indiv	# Unknown Sp.	# Unknown Indiv	# Exotic Ant Sp.	# Exotic Ant Indiv
Bautista Creek	Mean	5.27	57.49	0.16	1.49	2.51	4.27	0.00	0.00
	St. Dev.	2.49	73.84	0.37	8.20	1.52	3.27	0.00	0.00
	n	37	37	37	37	37	37	37	37
Box Springs	Mean	3.00	10.00	0.33	0.33	1.00	1.67	0.00	0.00
	St. Dev.	1.00	9.17	0.58	0.58	1.00	1.53	0.00	0.00
	n	3	3	3	3	3	3	3	3
Santa Gertrudis Creek	Mean	3.71	10.36	0.43	0.57	2.50	3.00	0.21	0.29
	St. Dev.	1.86	8.70	0.65	0.94	2.03	2.45	0.43	0.61
	n	14	14	14	14	14	14	14	14
Mockingbird Canyon	Mean	2.13	10.73	1.47	115.60	2.13	3.60	1.00	114.80
	St. Dev.	2.26	29.29	0.64	219.79	1.73	3.33	0.00	220.13
	n	15	15	15	15	15	15	15	15
Motte Reserve	Mean	4.75	8.50	1.25	23.00	2.00	6.00	0.50	21.75
	St. Dev.	2.36	5.80	1.50	37.83	1.15	1.41	0.58	37.13
	n	4	4	4	4	4	4	4	4
Potrero Canyon	Mean	5.14	115.91	0.14	0.14	2.00	4.54	0.00	0.00
	St. Dev.	2.38	157.89	0.36	0.36	2.00	7.18	0.00	0.00
	n	35	35	35	35	35	35	35	35
Santa Ana River	Mean	3.74	41.57	1.03	32.87	3.26	17.30	0.38	28.51
	St. Dev.	2.36	185.79	0.96	184.58	2.04	42.71	0.49	184.46
	n	68	68	68	68	68	68	68	68
San Jacinto River	Mean	2.50	43.50	0.50	10.50	3.50	29.00	0.50	10.50
	St. Dev.	0.71	57.28	0.71	14.85	0.71	9.90	0.71	14.85
	n	2	2	2	2	2	2	2	2

Table 10.6 (Cont.) Mean (± Standard Deviation) arthropod species and numbers of individuals sampled with pitfall traps at 13 drainages across the Plan Area.

Drainage	Descriptive Statistics	# Native Sp.	# Native Indiv.	# Exotic Sp.	# Exotic Indiv	# Unknown Sp.	# Unknown Indiv	# Exotic Ant Sp.	# Exotic Ant Indiv
Shipley-Skinner Reserve	Mean	5.41	109.00	0.35	0.53	2.53	6.06	0.00	0.00
	St. Dev.	2.09	138.34	0.61	0.94	1.59	6.68	0.00	0.00
	n	17	17	17	17	17	17	17	17
San Timoteo Canyon	Mean	4.12	116.84	1.52	62.12	3.40	14.72	0.76	16.84
	St. Dev.	1.99	168.65	1.23	165.33	2.35	18.79	0.83	39.45
	n	25	25	25	25	25	25	25	25
Sycamore Canyon	Mean	4.33	21.67	0.14	2.90	2.24	6.43	0.10	0.10
	St. Dev.	2.03	20.63	0.36	12.86	1.22	6.61	0.30	0.30
	n	21	21	21	21	21	21	21	21
University Avenue	Mean	2.00	8.00	1.00	1.00	4.00	6.00	0.00	0.00
	St. Dev.	.	.	.	.	.	.	.	.
	n	1	1	1	1	1	1	1	1
Warm Springs Creek	Mean	5.11	195.28	0.89	28.28	2.94	10.89	0.33	21.17
	St. Dev.	3.16	294.12	0.83	45.71	1.55	24.16	0.49	40.14
	n	18	18	18	18	18	18	18	18

Table 10.7 Covered reptile species detected at 13 riparian drainages in the Plan Area. The number of sampling points are in parentheses following the name of the drainage.

Species	Bautista Canyon (38)	Box Springs (3)	Mockingbird Canyon (16)	Motte Reserve (4)	Potrero Canyon (37)	San Jacinto River (2)	San Timoteo Canyon (28)	Santa Ana River (77)	Santa Gertrudis Creek (14)	Shipley-Skinner Reserve (17)	Sycamore Canyon (22)	University Ave. (2)	Warm Springs Creek (21)	Species Total (281)
Coastal Western Whiptail	7	0	0	0	1	0	2	0	0	2	0	0	0	**12**
Coast Horned Lizard	2	0	0	0	2	0	0	0	0	0	0	0	1	**5**
Granite Night Lizard	1	0	0	0	0	0	0	0	0	0	0	0	0	**1**
Granite Spiny Lizard	4	3	1	0	1	0	0	0	0	0	11	0	6	**26**
Orange-throated Whiptail	0	0	2	0	0	0	0	0	0	0	0	0	3	**5**
Northern Red Diamond Rattlesnake	0	1	0	0	2	0	0	0	1	0	0	0	0	**4**
Site Total:	**14**	**4**	**3**	**0**	**6**	**0**	**2**	**0**	**1**	**2**	**11**	**0**	**10**	**53**

Table 10.8 Covered bird species detected at 13 riparian drainages in the Plan Area. The number of sampling points are in parentheses following the name of the drainage.

Species	Bautista Canyon (38)	Box Springs (3)	Mocking-bird Canyon (16)	Motte Reserve (4)	Potrero Canyon (37)	San Jacinto River (2)	San Timoteo Canyon (28)	Santa Ana River (77)	Santa Gertrudis Creek (14)	Shipley-Skinner Reserve (17)	Sycamore Canyon (22)	University Ave. (2)	Warm Springs Creek (21)	Wilson Creek (6)	Species Total (285)
Black-crowned Night Heron	0	0	0	0	0	0	0	4	0	0	0	0	0	0	**4**
California Gnatcatcher	0	0	0	0	0	0	0	0	7	10	0	0	12	0	**29**
Coastal Cactus Wren	0	0	0	0	0	0	0	0	0	0	0	0	0	6	**6**
Cooper's Hawk	8	1	9	6	6	1	8	17	2	5	6	0	11	0	**80**
Double-crested Cormorant	0	0	0	0	0	0	0	13	0	0	0	0	0	0	**13**
Downy Woodpecker	0	0	5	0	2	0	13	29	0	3	1	0	1	0	**54**
Great Blue Heron	0	0	0	0	0	0	1	10	0	0	0	0	0	0	**11**
Golden Eagle	0	0	0	0	7	0	1	0	0	0	0	0	0	0	**8**
Grasshopper Sparrow	0	0	0	0	1	0	0	1	0	0	0	0	0	0	**2**
Least Bell's Vireo	0	0	17	0	0	0	8	184	0	13	16	0	0	0	**239**
Loggerhead Shrike	0	0	0	4	4	0	0	0	0	1	0	0	1	0	**10**
Mountain Quail	5	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
Nashville Warbler	0	0	0	0	0	0	0	4	0	0	0	0	0	0	**4**
Northern Harrier	0	0	0	0	0	0	0	0	1	1	0	0	0	0	**2**
Osprey	0	0	0	0	0	0	0	2	0	0	0	0	0	0	**2**
Southern California Rufous-crowned Sparrow	14	2	3	6	17	0	0	0	5	2	7	0	18	0	**74**
Bell's Sage Sparrow	0	0	0	0	0	0	0	0	0	0	0	0	4	4	**8**
Sharp-shinned Hawk	0	0	0	0	0	0	0	0	0	0	0	0	1	0	**1**
Turkey Vulture	0	0	1	0	0	0	1	19	4	4	1	0	3	0	**33**
White-facted Ibis	0	0	0	0	0	0	0	2	0	0	0	0	0	0	**2**
Willow Flycatcher	3	0	0	0	5	0	2	10	0	9	0	0	1	0	**30**
Wilson's Warbler	3	1	2	0	6	0	5	6	8	7	1	0	4	0	**43**
White-tailed Kite	0	0	1	0	0	0	0	0	37	22	0	0	13	0	**73**
Yellow-breasted Chat	0	0	2	0	0	0	0	161	0	0	1	0	0	0	**164**
Yellow Warbler	8	0	11	0	7	0	35	173	0	12	1	0	2	1	**250**
Total:	**42**	**4**	**51**	**16**	**55**	**1**	**74**	**635**	**64**	**89**	**34**	**0**	**71**	**11**	**1147**

Table 10.9 Covered mammal species detected visually at 13 riparian drainages in the Plan Area. The number of sampling points is in parentheses following the name of the drainage.

Species	**Bautista Canyon (38)**	**Box Springs (3)**	**Mockingbird Canyon (16)**	**Motte Reserve (4)**	**Potrero Canyon (37)**	**San Jacinto River (2)**	**San Timoteo Canyon (28)**	**Santa Ana River (77)**	**Santa Gertrudis Creek (14)**	**Shipley-Skinner Reserve (17)**	**Sycamore Canyon (22)**	**Warm Springs Creek (21)**	**Species Total (279)**
Black-tailed Jackrabbit	0	0	0	0	1	0	0	0	0	0	0	0	**1**
Coyote	4	0	0	0	0	1	0	0	0	0	1	0	**6**
Bobcat	0	0	2	0	0	0	0	0	0	0	0	0	**2**
Long-tailed Weasel	0	0	0	0	0	0	0	1	0	0	0	0	**1**
Site Total	**4**	**0**	**2**	**0**	**1**	**1**	**0**	**1**	**2**	**1**	**1**	**3**	**16**

Table 10.10 Mean (± standard deviation) anthropogenic disturbance index values within 50 meters of sampling points at 13 riparian drainages in the Plan Area sampled in 2004. The number of sampling points is in parentheses following the name of the drainage.

Site		Trash	Vehicle Activity	Roads	Human Activity	Other Human	Other Disturbance	Summary Human	Damaged Vegetation	Cattle	Flood	Fire	Summary Vegetation
Bautista Creek (38)	mean	0.68	0.32	0.95	0.35	0.05	0.00	2.32	0.13	0.00	0.58	0.00	0.71
	stdev	0.57	0.74	1.06	0.48	0.23	0.00	1.34	0.53	0.00	0.68	0.00	0.80
Box Springs (3)	mean	0.33	0.00	0.33	2.33	0.00	1.00	3.67	0.00	0.00	0.00	0.00	0.00
	stdev	0.58	0.00	0.58	1.15	0.00	0.00	0.58	0.00	0.00	0.00	0.00	0.00
Santa Gertrudis	mean	0.00	0.36	0.29	0.00	0.00	0.00	0.64	0.14	0.00	0.00	0.00	0.14
Creek (14)	stdev	0.00	0.63	0.83	0.00	0.00	0.00	0.93	0.36	0.00	0.00	0.00	0.36
Mockingbird	mean	1.00	0.60	1.13	1.53	0.00	1.00	4.40	0.53	1.13	0.07	0.07	1.81
Canyon (16)	stdev	0.85	0.99	1.06	0.83	0.0	1.41	3.07	0.64	1.06	0.26	0.26	1.05
Potrero Canyon (37)	mean	0.38	0.27	0.03	0.27	0.00	0.00	0.95	0.03	0.30	0.05	0.00	0.38
	stdev	0.49	0.45	0.16	0.45	0.00	0.00	0.70	0.16	0.57	0.23	0.00	0.59
San Jacinto River (2)	mean	0.50	0.00	0.00	0.50	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
	stdev	0.71	0.00	0.00	0.71	0.00	0.00	1.41	0.00	0.00	0.00	0.00	0.00
San Timoteo	mean	1.61	2.29	1.39	0.86	0.00	0.00	6.14	1.00	0.12	1.18	0.00	2.29
Canyon (28)	stdev	0.88	0.85	1.52	0.80	0.00	0.00	2.45	0.90	0.59	0.94	0.00	1.70
Santa Ana River Sites:	mean	0.71	0.24	0.00	1.24	1.33	0.00	2.57	0.29	0.48	0.10	0.38	1.24
Hidden Valley Park (19)	stdev	0.46	0.54	0.00	0.62	1.03	0.00	1.50	0.56	0.68	0.44	0.74	1.30
Limmonite Street (12)	mean	1.00	0.00	0.00	2.58	2.00	0.90	4.83	1.17	1.75	0.08	0.00	3.00
	stdev	0.85	0.00	0.00	0.51	1.73	1.45	1.27	0.72	1.54	0.29	0.00	1.48
Tyler Street (23)	mean	0.95	1.05	0.67	1.19	1.50	0.00	4.17	1.32	0.05	0.18	0.00	1.57
	stdev	1.00	0.65	0.73	0.98	0.84	0.00	2.81	1.17	0.21	0.50	0.00	1.24
Van Buren Blvd. (23)	mean	0.96	0.43	0.83	1.26	0.13	0.00	3.52	1.09	0.04	0.43	0.00	1.57
	stdev	0.77	0.59	1.15	0.96	0.35	0.00	1.38	1.20	0.21	1.04	0.00	1.75
Shipley-Skinner Reserve	mean	0.53	0.00	0.00	0.35	0.00	0.00	0.88	1.24	0.00	0.00	0.53	1.76
(17)	stdev	0.51	0.00	0.00	0.49	0.00	0.00	0.78	1.39	0.00	0.00	1.18	1.39
Sycamore Canyon (22)	mean	0.64	0.18	0.18	0.73	0.00	0.00	1.73	0.41	0.00	0.09	0.00	0.50
	stdev	0.49	0.50	0.39	0.63	0.00	0.00	1.32	0.73	0.00	0.29	0.00	0.86
University Avenue (2)	mean	1.50	1.50	2.00	2.50	0.00	1.00	8.50	1.50	0.00	0.00	0.00	1.50
	stdev	0.71	0.71	1.41	0.71	0.00	1.41	2.12	0.71	0.00	0.00	0.00	0.71
Warm Springs Creek (21)	mean	0.79	0.53	0.44	1.00	1.11	0.30	3.05	0.89	0.68	0.42	0.00	1.95
	stdev	0.54	0.94	1.03	1.00	1.27	0.48	3.00	1.02	0.82	0.61	0.00	1.59

Table 10.11 Comparison of threat and habitat quality logistic regression models predicting sensitive riparian bird species occurrence at three different spatial scales within the Plan Area. Regression coefficients for variables significantly related to the probability of a species occurrence indicate the magnitude and type of relationship. See Tables 10.3-10.4 for a description of variables included in each model.

Species	Scale	Model	K	AIC_c	Δ_i	Survey Effort	Coefficients of Significant Variables					
							Threats					
						# Visits	Dist. Dev.	Dist. Ag.	# Non-Native Ants	Human Disturbance	% Non-Native Herbs	% *Arundo donax*
Blue Grosbeak	Regional	Threats	13	392.49	0.00	1.4522		-0.0003				
		Quality*	18	394.62	2.13	1.2646						
	Watershed	Threats	10	237.72	0.00	2.2283					0.0420	
		Quality*	12	239.25	1.53	2.0491						
		Full	18	240.42	2.70	2.5069	0.0009	0.0009				0.0533
	River	Quality	7	106.96	0.00	3.3860						
		Threats*	8	109.33	3.66	3.0743						
Downy Woodpecker	Regional	Threats	12	207.76	0.00	1.0476						0.0275
	Watershed	Quality	11	160.24	0.00	1.7466						
	River	Threats*	6	91.937	0.00	2.1256						
		Full*	10	95.319	3.38	2.3669						
		Quality*	7	95.360	3.42	1.9028						
Least Bell's Vireo	Regional	Quality	17	363.19	0.00	0.7642						
	Watershed	Full	18	278.48	0.00	1.4446	-0.0019					
	River	Full	11	159.21	0.00	2.0611						-0.0356
Willow Flycatcher	Regional	Not Sig.										
	Watershed	Full	17	86.96	0.00	-2.6919		0.0024		0.7633		
	River	Not Sig.										
Yellow-Breasted Chat	Regional	Full	26	234.90	0.00	1.5427			-0.0350			0.0858
	Watershed	Full	18	213.83	0.00	1.8422					0.0423	0.0616
	River	Full	11	150.05	0.00	2.6505	0.0043					
		Threats	8	152.13	2.08	2.3950	0.0048					
Yellow Warbler	Regional	Quality	18	413.86	0.00	0.6610						
		Full	27	414.44	0.58	0.6132	0.0004					
	Watershed	Quality	12	286.95	0.00	0.6839						
	River	Quality	9	177.52	0.00	0.8894						
		Full	11	178.20	0.68	1.1476						

Table 10.11 (Cont.) Comparison of logistic regression models predicting occurrence of sensitive riparian bird species.

Species	Scale	Model	Coefficients of Significant Variables							
			Habitat Quality							
			Dist. Undev.	# Native Arthropods	# Snags >10cm	% Riparian	% Trees	% Shrubs	% *Salix* spp.	% *Baccharis* spp.
Blue Grosbeak	Regional	Threats								
		Quality*								
	Watershed	Threats								
		Quality*								
		Full					-0.0723			
	River	Quality					-0.0307			
		Threats*								
Downy Woodpecker	Regional	Threats								
	Watershed	Quality			0.1493					
	River	Threats*								
		Quality*								
		Full*								
Least Bell's Vireo	Regional	Quality				0.0290	-0.0251		0.0439	
	Watershed	Full			-0.4120				0.0603	
	River	Full			-0.9383					
		Quality			-0.8270					
Willow Flycatcher	Regional	Not Sig.								
	Watershed	Full								
	River	Not Sig.								
Yellow-Breasted Chat	Regional	Full	-0.0800		-0.7170		-0.0781			
	Watershed	Full			-0.6238	0.0306	-0.0615			
	River	Threats								
		Full	0.1227							
Yellow Warbler	Regional	Quality	-0.0365	0.0018				0.0302	0.0453	-0.0807
		Full	-0.0525			0.0270		0.0314		-0.0717
	Watershed	Quality	-0.0426	0.0043		0.0304	-0.0233		0.0523	-0.0638
	River	Quality		0.0179					0.0507	-0.0977
		Full		0.0192				0.0276	0.0515	-0.0980

* Indicates that the model is only significant because as the number of visits to a location increases the probability that a species will be detected also increases and there is no significant effect of threat or habitat quality variables on species occurrence.

Blue Grosbeak (*Passerina caerulea*):
This species was the third most frequently detected sensitive riparian bird species during point counts. Blue Grosbeaks were observed most often at Santa Gertrudis Creek and San Timoteo Canyon. They also occurred relatively often along the Santa Ana River and in Potrero Canyon. Blue Grosbeaks were infrequently observed in the drainage east of Lake Skinner, at Sycamore Canyon, at Mockingbird Canyon, and at Warm Springs Creek.

A threats model (Table 10.11) best explained the regional distribution of Blue Grosbeaks. The habitat quality model was significant at the regional level, although this was because survey effort (measured as the number of surveys of a point) was the only significant variable in the model. At the watershed level, all three models predicted Blue Grosbeak occurrence, although once again the habitat quality model was dependent only on the number of visits to a survey point. Within the Santa Ana River drainage, the quality model best described grosbeak occurrence and threats model was significant only because of the number of surveys. At the regional scale points in closer proximity to agriculture tended to support Blue Grosbeaks, while within the Santa Ana watershed grosbeaks avoided settling in close proximity to agricultural fields. Within the Santa Ana watershed where agricultural fields were located relatively close to most drainages, Blue Grosbeaks chose to select areas farther away from fields as well as farther from developed areas. Grosbeaks were also attracted to locations within the watershed supporting greater cover of *Arundo donax* and exotic herbs, and reduced tree cover. Within the Santa Ana River drainage, a habitat quality model in which there was a negative relationship with tree cover best explained Grosbeak occupancy.

Downy Woodpecker (*Picoides pubescens*):
Downy Woodpeckers were relatively uncommon in riparian habitats in the Plan Area. They were most often seen along the Santa Ana River and at San Timoteo Canyon (Table 10.8). They were infrequently detected at Potrero Canyon, Mockingbird Canyon, in the drainage east of Lake Skinner, at Sycamore Canyon, and at Warm Springs Creek.

The threats model best explained Downy Woodpecker occupancy at the regional scale while at the level of the watershed habitat quality traits were associated with woodpecker occurrence (Table 10.11). At the local level, none of the models effectively predicted Downy Woodpecker presence except as a function of survey effort. Downy Woodpeckers were positively associated with *A. donax* at the regional level. This may be explained by the fact that *A. donax* was found only along the Santa Ana River where most Downy Woodpeckers occurred. At the watershed scale, the woodpeckers were attracted to areas with snags > 10 cm DBH at the watershed scale.

Least Bell's Vireo (*Vireo bellii pusillus*):
This was the second most abundant sensitive riparian bird species, although they were only distributed among five drainages in the Plan Area (Table 10.8). Most vireos were observed along the Santa Ana River. Least Bell's Vireos were also detected at Mockingbird Canyon, San Timoteo Canyon, Sycamore Canyon, and in the drainage east of Lake Skinner.

Habitat quality variables were important predictors of Least Bell's Vireo occurrence at all three spatial extents (Table 10.11). Threat variables were also important at the watershed and local river levels. Across the Plan Area, vireos were positively associated with riparian vegetative cover and willow (*Salix* species) cover while their presence was negatively associated with tree cover. At both the watershed and Santa Ana River scale there was a strong avoidance of areas with high numbers of tree snags > 10 cm DBH. Within the Santa Ana River watershed, Least Bell's Vireos settled in areas close to development and along the Santa Ana River drainage they avoided areas with greater coverage of *A. donax*.

Willow Flycatcher (*Empidonax traillii*):
This species was infrequently observed in the Plan Area. Willow Flycatchers were detected during the spring migratory period (mid-May to mid-June) at several sites along the Santa Ana River, in Potrero Canyon, and San Timoteo Canyon (Table 10.8). A few males sang as they passed through and were identified as Southwestern Willow Flycatchers. However, in most cases it was not determined which subspecies the migrants belonged to. There were two pairs of potentially breeding Southwestern Willow Flycatchers observed on May 20 and August 17 in the drainage east of Skinner Lake at the Shipley Skinner Preserve. At the Santa Ana River there were two pairs and one individual observed in June and July that were potentially breeding summer residents. Based on the timing of sightings (August 24 and 25), it was also suspected that there was a resident pair at Bautista Creek and one lone individual observed July 22 at Warm Springs Creek. Modeling was done at the species level and there was no attempt to model migrants versus summer residents for this species.

The presence of Willow Flycatchers was not well explained by any models at the regional or river level (Table 10.11). Only within the Santa Ana River watershed were significant bird habitat relationships identified. Within the Santa Ana River watershed, Willow Flycatchers were found farther away from agricultural fields and were associated with greater levels of human disturbance. Human disturbance was characterized by the presence of roads, trails with equestrians and hikers, trash dumping, and transient camps.

Wilson's Warbler (*Wilsonia pusilla*):
This species migrates through WRCMSHCP area and was detected in relatively low numbers during the first round of surveys in all but the smallest drainages in the Plan area (Table 10.8). There were no models that satisfactorily predicted Wilson's Warbler occurrence at any of the three spatial levels, as such, this species was excluded from Table 10.11.

Yellow-breasted Chat (*Icteria virens*):
While chats were the third most frequently detected covered riparian bird species in the Plan Area, they were also the most restricted in distribution. They were found primarily along the Santa Ana River with two observed in Mockingbird Canyon and one individual detected at Sycamore Canyon during point count surveys (Table 8).

Full logistic regression models that included both threat and habitat quality variables were effective at predicting Yellow-breasted Chat occurrence at all three spatial extents (Table 10.11). The threat model also explained chat presence at the Santa Ana River scale. In terms of threat variables, at the regional level, chats avoided areas with non-native ants. Yellow-breasted Chats were attracted to areas in the Santa Ana River watershed with increased cover of non-native herbaceous species, although this relationship was not detected at the regional or Santa Ana River scale. At both the regional and watershed scale, chats were attracted to areas with higher coverage of *A. donax*.. Among survey points along the Santa Ana River, there was no significant relationship between chat occurrence and the amount of *A. donax* cover. Along the Santa Ana River, chats were more likely to occur at locations farther from developed areas. Important habitat quality variables predicting Yellow-breasted Chat occurrence at the regional and Santa Ana River watershed scale included a negative association with snags > 10 cm DBM and with higher levels of tree cover. Within the watershed, chats were attracted to areas with higher riparian cover.

<u>Yellow Warbler (*Dendroica petechia*)</u>:
Yellow Warbler was the most frequently detected covered riparian species during point count surveys in the Plan Area (Table 10.8). They were observed at almost all riparian drainages during migration except for Santa Gertrudis Creek and the three smallest drainages (Box Springs, University Avenue, and the Motte; Table 8). Yellow Warblers were common breeding residents along the Santa Ana River and San Timoteo Canyon and less frequent residents at Mockingbird Canyon and the drainage east of Lake Skinner.

Habitat quality, and to a lesser degree, threat variables, were important predictors of Yellow Warbler occurrence at all three spatial extents (Table 10.11). There was a fairly high consistency among the variables that were significant in predicting Yellow Warbler distribution at the different spatial scales. At regional, watershed, and Santa Ana River scales, Yellow Warblers were positively associated with increasing amounts of willow (*Salix* spp.) cover and with increased numbers of native arthropods. At the regional and Santa Ana River levels, they were positively associated with shrub cover. They were negatively associated with *Baccharis* spp cover at the three different spatial extents. Yellow Warblers were positively associated with riparian cover at the regional and watershed levels and avoided areas with greater tree cover within the Santa Ana River watershed. Yellow Warblers tended to settle in areas located away from developed areas and close to undeveloped habitats.

Discussion

These logistic regression models are preliminary, although they provide a valuable starting point for future monitoring and further analysis. The species habitat relationships indicated by these models were incorporated into conceptual models for the riparian bird community (Chapter 11) as hypotheses to be tested with the collection of monitoring data, focused research, and more in-depth analysis. Future riparian community monitoring studies should incorporate measurement of the same variables to see if detected occupancy patterns and habitat relationships are consistent between years, especially with changing environmental conditions.

The riparian bird models could be improved with the inclusion of landscape level variables, such as the extent of riparian habitat greater than 50 m from the point. Once a current vegetation map is available, these models can be re-run to calculate landscape measures of riparian cover. Landscape level habitat components have been found to be important in determining the distribution and abundance of other bird species and in particular, riparian bird species (Saab 1999). The hierarchial analysis indicates that there is spatial autocorrelation accounting for some of the patterns described below (e.g., the distribution of birds in relation to *A. donax*). Future analysis could incorporate measures of the spatial distribution of sampling sites to see if factors such as *A. donax* still show up as indicators of species occurrence in the regional scale models. There was also insufficient data for the covered species to develop reliable detectability estimates, which is not uncommon for rare species (Rosenstock et al. 2002). Future monitoring may allow collection of sufficient data to estimate detectability. Repeated sampling at all points, rather than a subset of points could increase the number of rare species recorded in order to calculate detectability estimates. However, some species such as Willow Flycatcher are so rare in the Plan Area, that developing detectability estimates may not be a realistic expectation.

In many cases, riparian birds did not seem to be avoiding anthropogenic threats as evidenced by primarily positive regression coefficients for all but the distance variables. For distance to development and to agriculture, a positive correlation indicates that a species was more likely to occur farther away from the land use type than closer to it. In most cases where there was a relationship between a species occurrence and distance to either development or agriculture, birds tended to be located farther away from these land use types than closer. The lack of avoidance of other types of anthropogenic threats at the regional and watershed scales may be explained by the fact that the greatest concentration of sensitive species occurred in the Santa Ana River watershed, where the level of threat variables was greatest. For example, a few species were positively associated with increased cover of *A. donax* at the regional and Santa Ana River watershed levels. For the drainages surveyed, *A. donax* occurred primarily in the Santa Ana River, which also supported the greatest number of sensitive bird locations. Within the Santa Ana River drainage, there were no cases of bird species being positively associated with *A. donax,* and the Least Bell's Vireo even avoided areas with high cover of this introduced species. *A. donax* is documented as substantially altering hydrology and native plant communities in riparian systems and represents a threat to riparian bird species (Holt 1999; RHJV 2004). It is important that future monitoring work continue vegetation sampling so that the distribution and abundance of *A. donax* is regularly assessed in riparian habitats in the Plan Area. This information is important for informing development and implementation of management plans to reduce this threat to covered riparian bird species. In addition, better methods of controlling invasive species, particularly *A. donax* should be researched and developed (RHJV 2004).

Exotic Argentine ants depend on moist environments in arid southern California and are often found in riparian corridors where they can adversely affect native ants (Holway 2005). Ants are an important component of breeding Yellow-Breasted Chat diets (Yard et al. 2004) and it has been documented that introduced Argentine ants (*Linepithema humile*) displace native ant species in southern California (Suarez et al. 1998). At the regional scale, there was a negative association between the number of exotic Argentine ants at a point and the probability of Yellow-breasted Chat occurrence. Argentine ants are also associated with a decline in diversity of other types of native arthropods in coastal sage scrub systems in southern California (e.g., Bolger et al. 2000, Kirshtner and Redak, unpubl. data). It is possible that they could have similar effects on riparian arthropod communities and be a threat to covered riparian birds dependent on native arthropods for food. For example, the number of native arthropod individuals at a point consistently predicted the occurrence of Yellow Warbler. These results suggest that Argentine ant populations may be a threat to covered riparian bird populations and this hypothesis should be further evaluated with additional arthropod data collection in future monitoring surveys. In addition, research into eradication and control measures is critical to developing methods to reduce the prevalence of this species in riparian systems.

CCB recommends that two different strategies be established to monitor riparian communities. Reference sites should be established within different drainages across the Plan Area and should be monitored over the long term. These sites should include high quality riparian habitat in large patches as well as lower quality habitats associated with smaller drainages. Different levels of anthropogenic disturbance should also be sampled at these reference sites. Long-term monitoring of the same sites will allow detection of trends in riparian bird populations, which could be evaluated in light of environmental conditions at these sites. This information would improve conceptual models and our understanding of bird habitat relationships and the role of anthropogenic processes in affecting bird populations. The information gained from focused research and long-term periodic monitoring of these sites could guide development of effective adaptive management plans. A second type of sampling should periodically be undertaken over a wider range of riparian habitats with similar types of community data collected. This would allow an assessment of the distribution and abundance of covered riparian birds across the Plan Area and allow detection of habitats vulnerable to anthropogenic impacts that might adversely affect covered bird populations. This information could be important for land managers to identify areas where management actions should be taken to reduce threats to Covered Species populations. Repeated years of community sampling under variable environmental conditions is necessary to determine the frequency with which each of these sampling strategies should be carried out.

Riparian protocols for surveying birds, sampling arthropods, measuring vegetation, and recording incidental sightings of Covered Species worked well in terms of the type and amount of data collected and the amount of time required. CCB's late season, third round point counts were effective at identifying family groups for various species. The

WRCMSHCP has a population monitoring component for covered riparian bird species that requires an assessment of reproductive output at numerous core sites. A method is required that efficiently measures reproduction in multiple Covered Species at many sites; traditional studies of breeding birds rely on nest searches to determine nest success and would be very costly. The ultimate goal of this required monitoring is to determine whether Covered Species are successfully reproducing at a site. A more easily measured metric could be to estimate annual reproductive success. Vickery et al. (1992) developed a method for calculating an index of reproductive activity for a population at a site. This method is based upon recording all signs of breeding behavior over repeated visits to a site. This method could be adopted to simultaneously sample species such as Least Bell's Vireo, Yellow-breasted Chat, and Yellow Warbler. Before relying upon such a method, it would be necessary to test it against nest monitoring results to ensure that it accurately portrays the reproductive status of species at different site.

CHAPTER 11
CONCEPTUAL MODELS AND THE MONITORING FRAMEWORK

Introduction

An important component of the monitoring framework is developing conceptual models connecting species population dynamics with environmental processes (Barrows et al. 2005). Conceptual models include documented and hypothesized relationships about natural and anthropogenic drivers of population change. Creating such a model provides a theoretical context in which to evaluate species responses. Particularly important is determining what constitutes normal population fluctuations for a species versus identifying when environmental processes, particularly anthropogenic stressors, threaten populations. These models can take the form of envirograms where various environmental factors are identified as promoting or limiting population growth. Envirograms for multiple species can be incorporated into a community wide model identifying responses of different species to a host of environmental processes. The way a species responds to an environmental trigger represents a hypothesis that can be tested. Species may respond in different ways to the same environmental factor and their responses may vary depending on environmental conditions.

Identifying how anthropogenic and natural drivers affect individual species and the impacts to the larger community provides information that is essential to guide monitoring and adaptive management programs (Barrows et al. 2005). Conceptual models can delineate where management activities that enhance populations of some species might have adverse effects on other species. This type of information is crucial to managing multiple species within a dynamic landscape. As with niche modeling, conceptual models rely on the periodic collection of monitoring data. This data is used to evaluate and where necessary to revise the conceptual models to reflect a greater understanding of species responses to dynamic environmental conditions. Focused research to test these hypotheses is also an integral part of the iterative process of refining conceptual models.

In this chapter, CCB presents conceptual models for coastal sage scrub and riparian communities showing potential responses of Covered Species populations to natural and anthropogenic environmental processes. The first step in this process consisted of gathering available information on how environmental processes might affect species in riparian and coastal sage scrub communities. This was done by reviewing the literature on how species are affected by anthropogenic processes and by analyzing initial data gathered during the 2004 monitoring fieldwork. A synopsis of information used in constructing the conceptual models is presented below. Envirograms were created to illustrate hypothesized relationships between environmental processes and population responses for Covered Species in both communities. Envirograms for individual species were compiled and synthesized to show potential effects of a multitude of environmental processes on Covered Species in the community. The coastal sage scrub conceptual model focuses on reptile and bird species whereas the riparian conceptual model includes only bird species.

Potential Drivers of Population Change for Coastal Sage Scrub Species

High levels of development and agricultural expansion in southern California have led to fragmented natural habitats imbedded within an urban matrix. Habitat fragmentation can negatively affect populations via increased isolation and extinction rates (Soule et al. 1988). Anthropogenic disturbances associated with development can also produce significant changes in ecosystem structure and function in adjacent natural lands (Lovejoy et al. 1986, Forman and Godron 1986). Development adjacent to natural lands can create an "edge effect" such that a species' population abundance increases as a function of distance from developed edge. A portion of the variation in animal species distribution near the urban edge may be explained by habitat changes where there are differences in vegetation structure and distribution (Kristan et al. 2003). However, much of the remaining variation may be a function of behavioral responses by animals to processes associated with the urban edge, such as artificial light and sound, and urban subsidized predators.

Edge-enhanced activities of both exotic and native predators have been well documented. Suburban housing is known to be a source of subsidized domestic predators, such as house cats, which can have major impacts on small birds, mammals, and reptiles adjacent to developed areas (Churcher and Lawton 1987). An increase in predator activity at edges has also been observed for wild native predators (Dijak and Thompson 2000, Kristan et al. unpubl. data). Natural vegetation can be altered adjacent to development. Irrigation seeps into adjacent fragments and may modify soil moisture levels, altering habitat for plants. Irrigation runoff may also create a conduit along which organisms successfully invade an environment that is otherwise too dry, both for plants and animals (e.g., Argentine ants, *Linepithema humile*; Holway 1998, Holway et al. 2002). Exotic plants used in landscaping may escape and then establish themselves in these areas. Residential lighting can affect foraging behavior in rodents (Bird et al. 2004), singing behavior in birds and frogs (Derrickson 1988, Bergen and Abs 1997), predation risk of moths by bats (Svensson and Rydell 1998), and habitat use patterns in mammalian predators (Beier 1995). Humans also cross into natural habitats creating short-term perturbations (e.g., noise) that may influence a few individual organisms, and more long-term disturbances (e.g., establishment of trails, creation of garbage dumps) with wider-scale effects.

Research on the effects of residential and agricultural development on adjacent bird communities in the Plan Area suggests that there is a subtle edge effect on bird abundance (Unfried 2003). Overall bird community composition varies significantly between edge and interior points in coastal sage scrub because of slight shifts in the presence and abundance of numerous bird species. Other studies in southern California have found that some bird and mammal species are more sensitive to fragmentation and edge effects than other species

(Bolger et al. 1997; Kristan et al. 2003). The mechanisms causing edge effect responses in birds and mammals are not clear. For some species, changes in vegetation associated with the edge may cause a pattern of decreased abundance near developed or agricultural edges (Kristan et al. 2003). However, for many species there does not appear to be a change in vegetation adjacent to edges that birds and mammals respond to.

Habitat fragmentation and urban edges have also been shown to affect arthropod communities in southern California. Kirshtner and Redak are conducting a study of arthropod communities in undisturbed coastal sage scrub and in coastal sage scrub adjacent to urban development in the Plan Area. Their preliminary results show that native arthropod species are significantly more abundant in undisturbed interior plots compared to urban edge plots (Kirshtner and Redak, unpubl. data). Exotic species such as Argentine ants (*Linepithema humile)* are found only in the urban edge plots. Bolger et al. (2000) studied arthropods in coastal sage scrub fragments imbedded within an urban matrix in San Diego County and found that arthropod diversity and abundance was positively associated with fragment size and negatively correlated with fragment age. There were also negative correlations between Argentine ant abundance and the richness and abundance of several arthropod orders.

Superimposed on local scale edge-related processes are large-scale influences on native community composition, both natural (e.g., precipitation and temperature) and anthropogenic (e.g., nitrogen deposition; Allen et al. 1998, Padgett et al. 1999). Southern California supports very high nitrogen deposition rates (Fenn et al. 2003a; Meixner et al. 2005). Anthropogenic nitrogen deposits from air pollution have led to a decrease in native shrublands and an increase in introduced Mediterranean annual grasses and forbs in southern California (Allen et al. 2005). The species richness of native forbs and shrubs declines with increasing nitrogen deposition, which is positively associated with increases in exotic grass and forb cover. In particular, exotic grasses, such as red brome (*Bromus madritensis*), take up nitrogen more rapidly than native shrubs such as California sagebrush (*Artemisia californica*), thereby increasing non-native grass biomass in native coastal sage scrub habitats. Coastal sage scrub forbs and shrubs are adapted to a system where nutrient cycling is low because of physical environmental constraints (Bowman 2005). The addition of nitrogen to these systems allows non-native grasses and forbs to gain a competitive foothold and to out compete the native species.

Fire plays an important role in the conversion of native shrublands to non-native grasslands. Sites with high nitrogen deposition have been shown to have more frequent fire events, which contributes to the conversion of coastal sage scrub to non-native grassland (Allen et al. 2005). Urbanization increases source points for fires and in combination with historic fire suppression practices and the presence of flammable non-native grasses has led to an increase in the frequency and magnitude of fires near urbanized areas of southern California (Minnich 2001; Fenn et al. 2003 a, b). While coastal sage scrub and chaparral habitats have evolved in response to wildfire, the increasing frequency and magnitude of fires can lead to large-scale destruction of native habitats. Depending on local conditions, particularly levels of nitrogen deposition, precipitation, and previous fire history, coastal sage scrub habitats may convert to non-native grasslands when fire frequencies increase (Minnich and Dezzani 1998; Minnich 2001; Fenn et al. 2003 b).

Potential Drivers of Population Change for Riparian Species

Riparian habitats are subject to many of the same anthropogenic stressors as coastal sage scrub habitats. As with the coastal sage scrub community, human activity, subsidized predators, and invasions of Argentine ants may adversely affect species in riparian communities. Dams, channels, levees and urban runoff have altered natural hydrological regimes in riparian systems, which can lead to large-scale changes in plant communities (RHJV 2004). Year-round water from urban runoff has contributed substantially to problems with non-native plants invading and crowding out native species. Especially difficult to control, have been invasive plants such as *Arundo donax* and *Tamarisk* species, which create large impenetrable thickets crowding out native plants and further altering the hydrology of the system. *A. donax* is a particular problem in Santa Ana River riparian habitats within the Plan Area. Urbanization and agriculture have reduced and fragmented riparian habitats so that small populations in isolated remnant patches are increasingly vulnerable to population extinction (RHJV 2004). Brood parasitic Brown-headed Cowbirds (*Molothrus ate*r), are prevalent in southern California riparian systems and if not trapped and removed can cause substantial reductions in the reproductive success of covered riparian bird species (Kus 1999). Birds are also hosts to the West Nile Virus. In riparian areas mosquitoes, carriers of the virus, are especially abundant. This virus caused substantial mortality in a number of bird species, particularly corvids and raptors, in the Plan Area during 2004 (T. Scott, unpubl. data). The effects of West Nile Virus on covered riparian bird species are currently unknown.

Riparian bird models presented in the preceding chapter (Chapter 11) provide preliminary information on anthropogenic disturbances that were shown to affect sensitive covered riparian species. These models also identify components of the natural habitat that are associated with the occurrence of individual species. The conceptual model suggests how habitat attributes may be altered through natural and anthropogenic environmental processes and the potential effects to riparian bird populations.

Methods

The first step in the process of constructing a conceptual model for a Covered Species in the Plan Area consisted of gathering available information on the effects of environmental processes on Covered Species in riparian and coastal sage scrub communities. This was done by reviewing the literature on species habitat relationships and by evaluating data gathered during the 2004 community monitoring surveys. Envirograms were created showing the direction of hypothesized relationships between environmental processes and population responses for Covered Species in the community (Barrows et al. 2005). Envirograms were not prepared for the Willow Flycather since breeding pairs of this species are rare within the Plan Area or for Wilson's Warbler which only migrates through. Envirograms for multiple species were compiled and synthesized into a single conceptual community model to show simultaneous effects of different environmental processes on multiple species. These analyses were restricted to reptile and bird species in coastal sage scrub and to birds in riparian habitats.

Results

Figures 11.1-11.5 present envirograms constructed for five of the covered riparian bird species. Hypothesized relationships between environmental processes and species populations are based on information available in the literature and from the preliminary riparian bird modeling results (Chapter 10). Based on multiple species' envirograms, a conceptual model was constructed for the riparian bird community (Figure 11.6). A similar conceptual model was created for the coastal sage scrub community (Figure 11.7).

Discussion

The conceptual models incorporate ecological processes that are well studied in combination with other environmental processes for which there is little information. For example, it is well documented that nitrogen deposition and an altered fire regime are contributing to the conversion of coastal sage scrub to non-native grassland in the Plan Area (e.g., Allen et al. 1998, 2005; Minnich and Dezzani 1998; Fenn et al. 2003a, b; Meixner et al. 2005). However, there are gaps in our knowledge about these processes. For example, is there a critical nitrogen deposition threshold where coastal sage scrub habitats will almost certainly convert to grassland? If so this would be important information to know in assessing vulnerability of coastal sage scrub to conversion. If the most vulnerable areas could be identified, then management efforts could be prioritized toward researching and implementing techniques to manage this threat. It is also generally accepted that the conversion of coastal sage scrub to non-native grassland will adversely affect populations of covered coastal sage scrub species, although this remains to be explicitly documented. The conceptual models provide a basis for prioritizing research and management dollars at individual reserves. For example, little is known about the effect of human activity, artificial lighting and noise on species in adjacent natural communities. Depending on proximity to urban development, this may be an important question to investigate. However, for other reserves situated in more rural areas, it may be more important to investigate the effects that fire has on Covered Species. By explicitly stating hypotheses about the direction of species responses to environmental processes, managers can evaluate these hypotheses to determine which might be the most important in affecting species in their reserves.

It is expected that species responses will differ under variable environmental conditions (e.g., a drought year versus a year of above average rainfall). These envirograms do not consider interactions between environmental processes, which could add considerable complexity to the models. These models do provide a starting point to identify where research is needed to improve management options. They identify anthropogenic processes that should be evaluated as part of the monitoring and adaptive management programs. Chapter 17 identifies initial research needs originating from the hypotheses presented in these conceptual models. Gathering more information on these processes and on species responses will be integral to developing and implementing an effective management program.

These models rely on hypothesis testing and evaluation to be effective tools. They must be revised as new information on habitat relationships and species responses to environmental drivers become available. The successful use of these models in informing monitoring and management activities depends on an iterative process of collecting data, testing hypotheses, and revising the models as new information becomes available.

Figure 11.1. Envirogram for the Blue Grosbeak in the Plan Area illustrating hypothesized relationships between environmental processes and population responses.

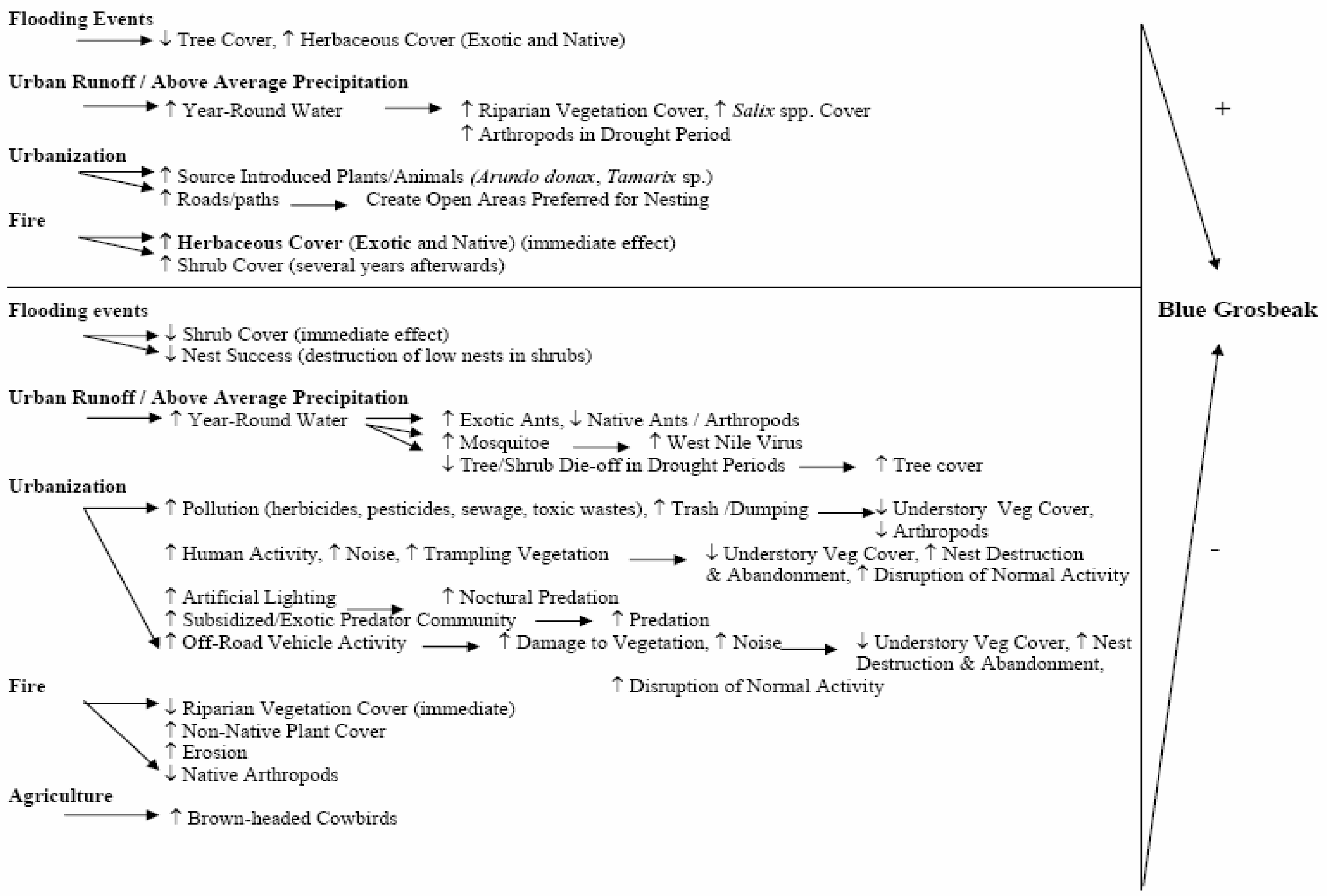


Figure 11.2 Envirogram for the Downy Woodpecker in the Plan Area illustrating hypothesized relationships between environmental processes and population responses.

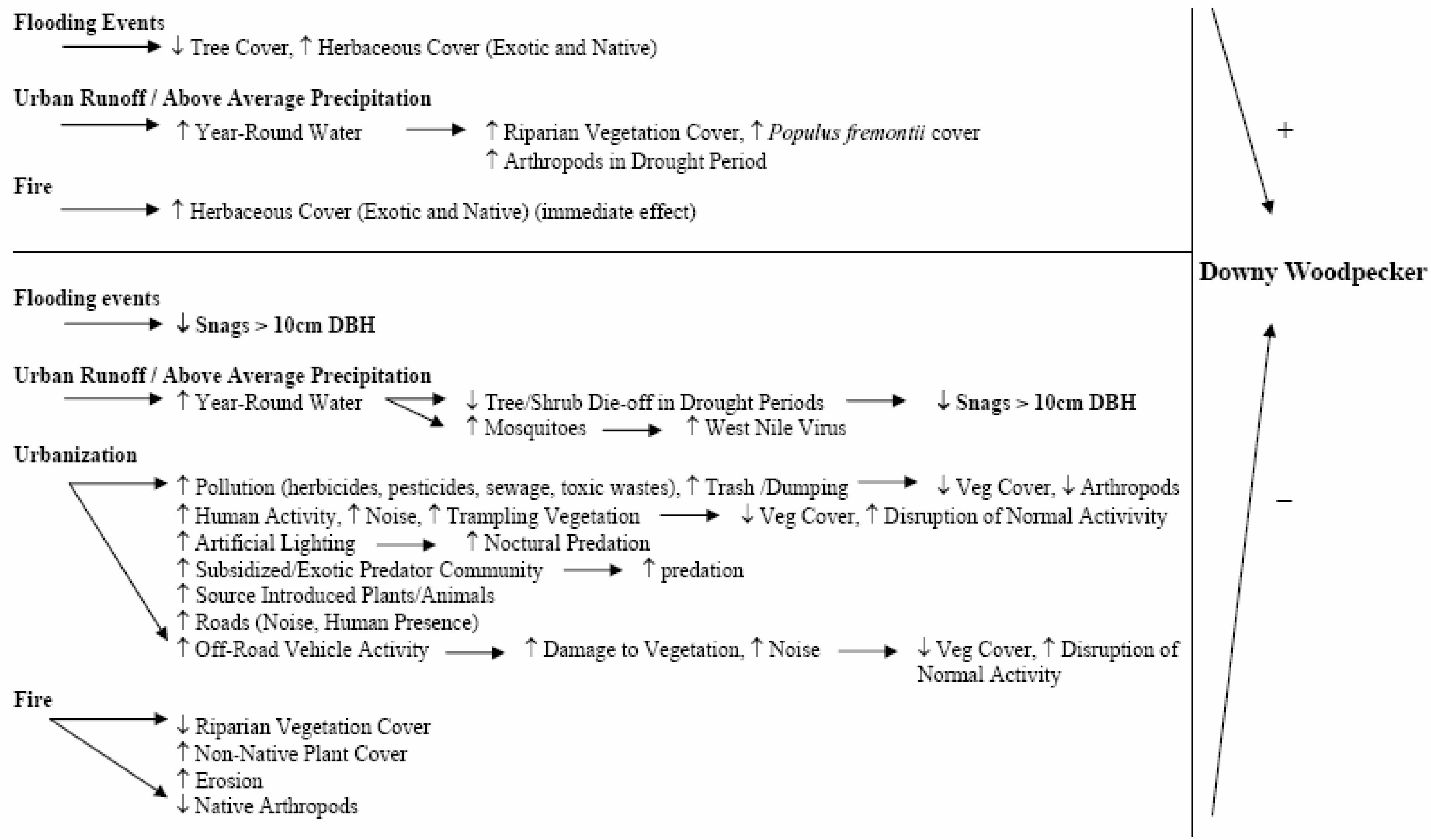


Figure 11.3 Envirogram for the Least Bell's Vireo in the Plan Area illustrating hypothesized relationships between environmental processes and population responses.

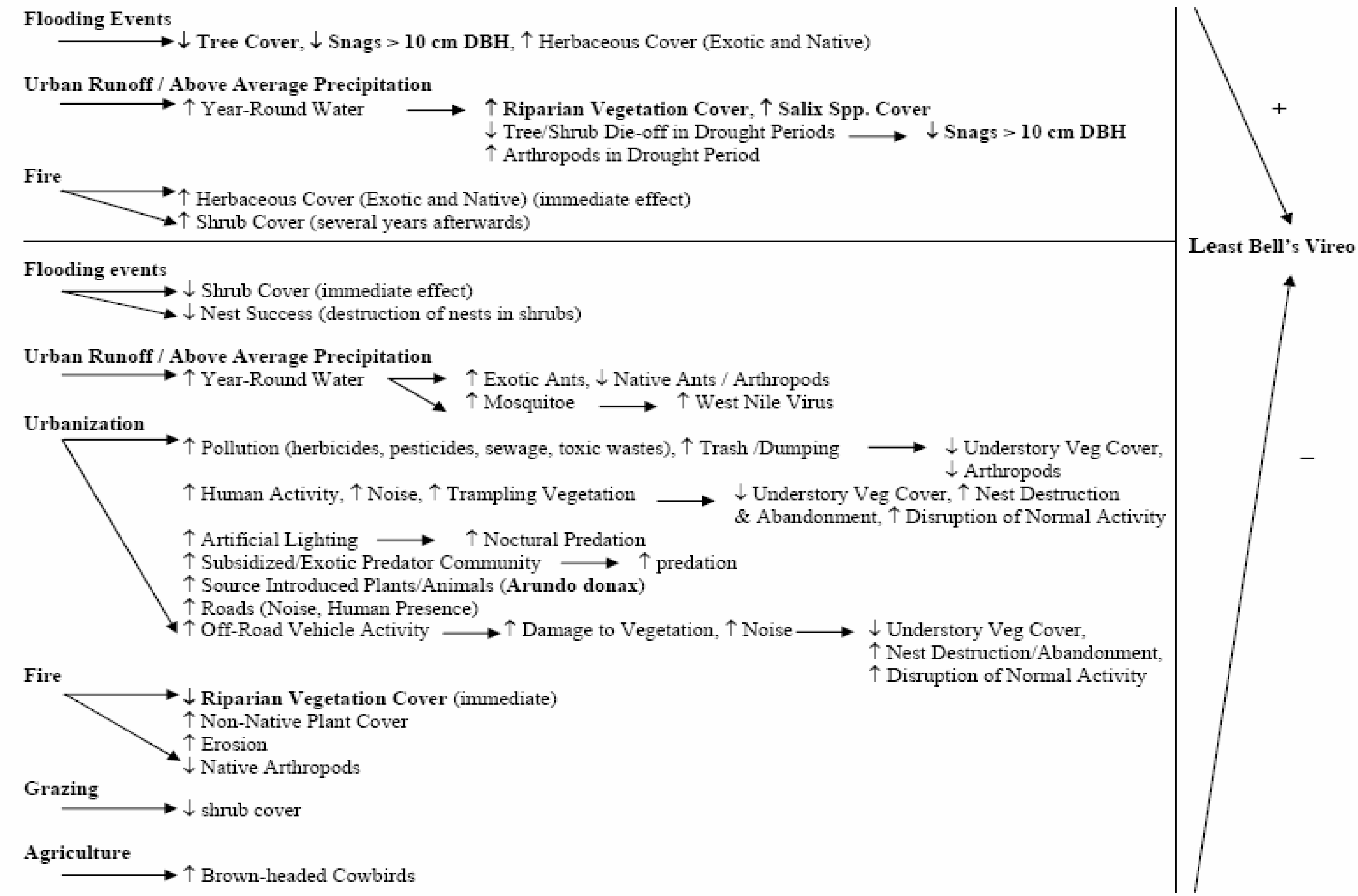


Figure 11.4 Envirogram for the Yellow-breasted Chat in the Plan Area illustrating hypothesized relationships between environmental processes and population responses.

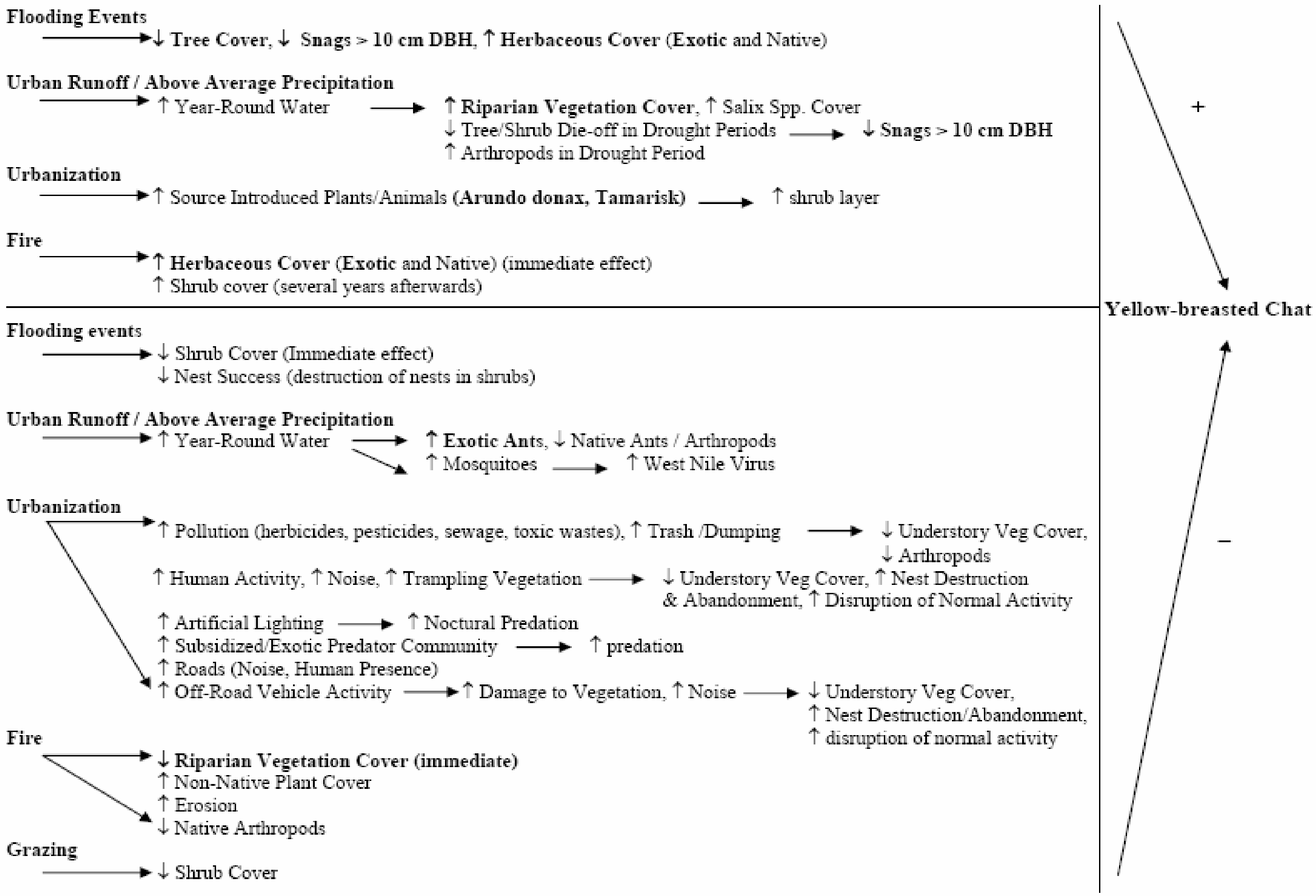


Figure 11.5 Envirogram for the Yellow Warbler in the Plan Area illustrating hypothesized relationships between environmental processes and population responses.

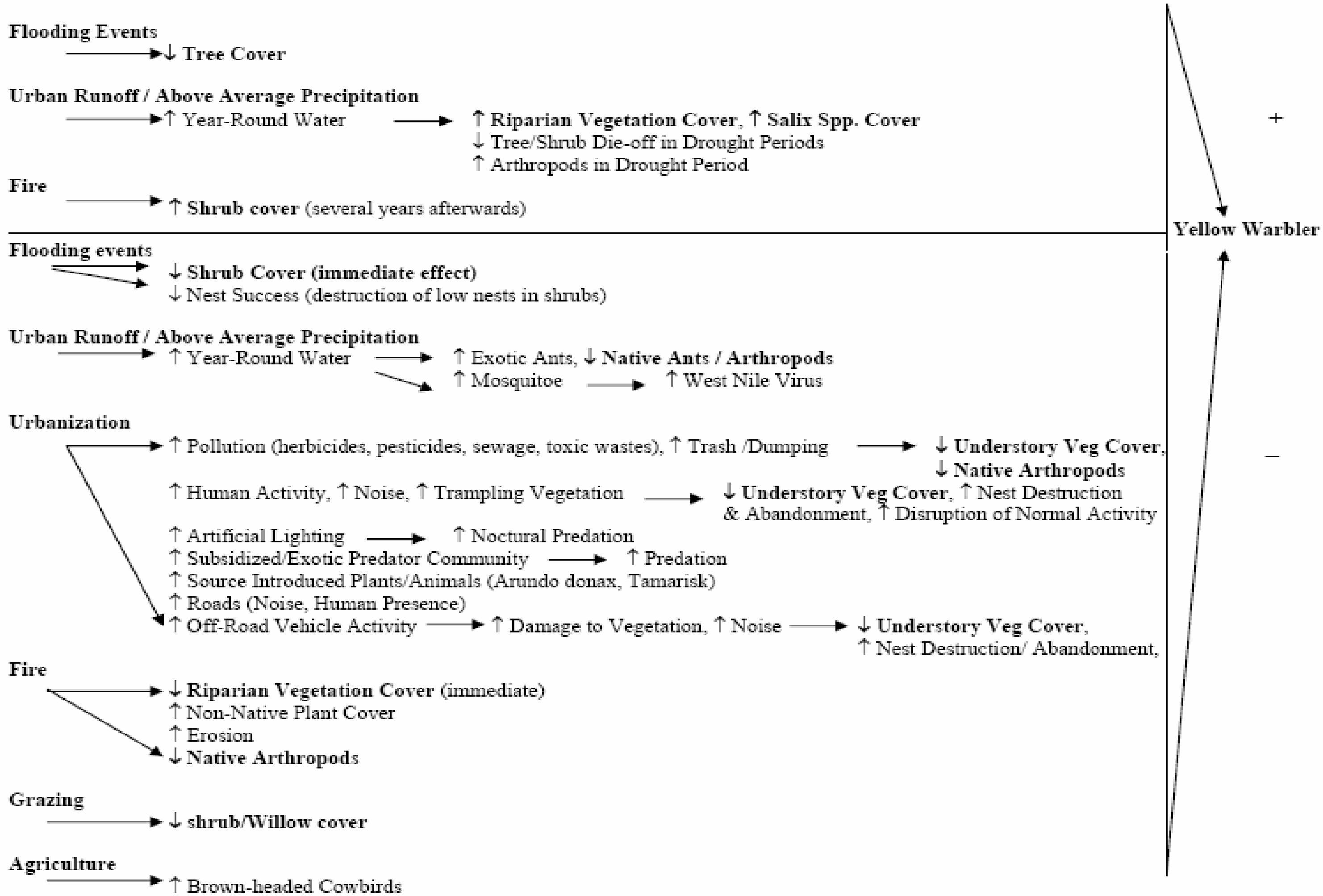


Figure 11.6 Conceptual model for the riparian bird community in the Plan Area illustrating hypothesized relationships between environmental processes and Covered Species population responses.

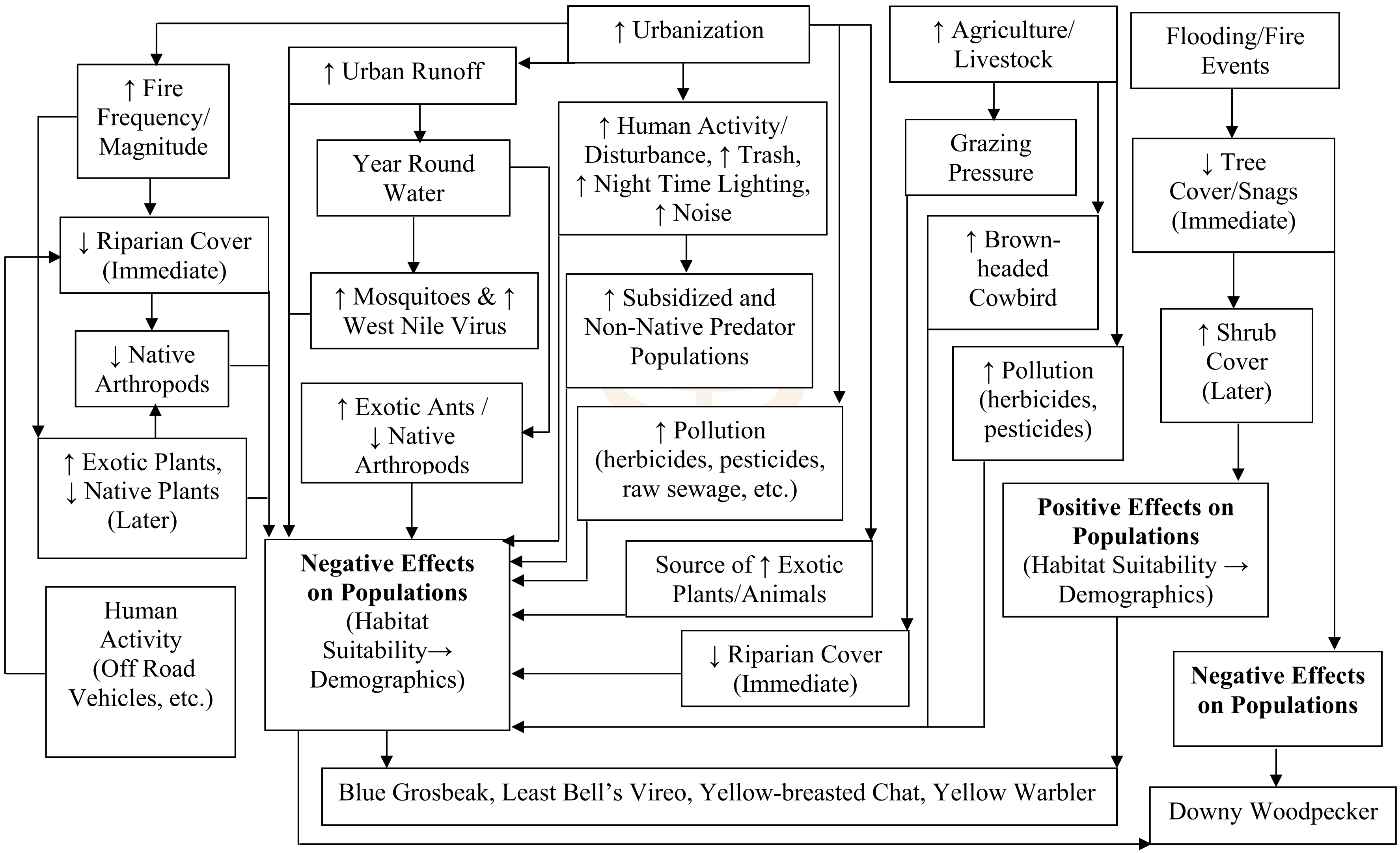
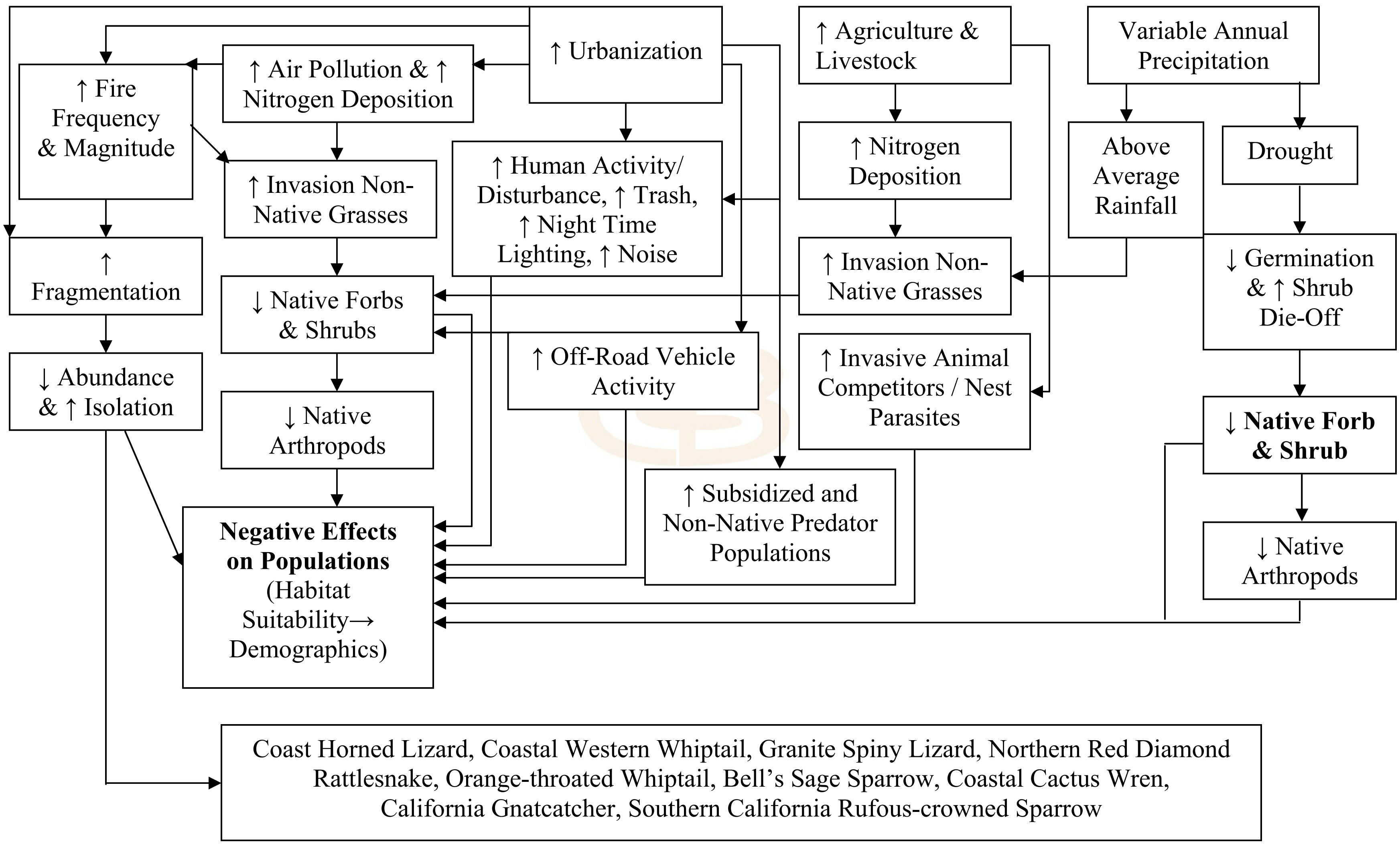


Figure 11.7 Conceptual model for the coastal sage scrub birds and reptiles in the Plan Area illustrating hypothesized relationships between environmental processes and Covered Species population responses.



CHAPTER 12
DEMONSTRATE CONSERVATION SPECIES

Introduction

Section 5.0 of the WRC MSHCP (Dudek and Associates 2003) lists sixteen species (13 plants, 2 birds, and 1 mammal) as "demonstrate conservation species (Appendix Table 1.2). While covered by the Plan, these species require additional information regarding their extent (number of extant populations) and status with the Plan Area. The County of Riverside charged CCB with determining whether the criteria outlined in section 5.0 for each species are met on lands already protected. If not, then additional requirements may be imposed to insure the species needs are met. Efforts for surveying the vertebrate species are outlined below. The results of surveys for the rare plants found on the list are discussed in the rare plant section (Chapter 13).

It is important to note that of the three vertebrate species, San Bernardino flying squirrel (*Glaucomys sabrinus californicus)*, Grasshopper Sparrows (*Ammodramus savannarum*), and Lincoln's Sparrows (*Melospiza lincolnii*), the CCB reviewed the status solely of the latter two species, as the US Forest Service is undertaking surveys for the flying squirrel.

Methods

Grasshopper Sparrow and Lincoln's Sparrow

The Grasshopper Sparrow (*Ammodramus savannarum*) is a resident summer breeder in lowland grasslands in the Plan Area. During the coastal sage scrub community surveys, CCB biologists surveyed eight sites that supported large tracks of non-native grassland habitat for the sparrow. Surveys consisted of point counts conducted at each of the coastal sage scrub/grassland sampling stations. In addition to these surveys, biologist Ginny Short was vigilant for sparrows during surveys for Burrowing Owls *(Athene cunicularia)* in June and July 2004.

Focused surveys for Lincoln's Sparrows (*Melospiza lincolnii*) in the San Jacinto Mountains were scheduled for Spring 2005. Funding constraints have precluded the completion of these surveys.

Results

Grasshopper Sparrow

Grasshopper Sparrows were detected at two of the survey sites. Four singing males and one suspected female were observed at Crown Valley in the Shipley Skinner Multi-Species Reserve in early June. Two singing males were detected at Potrero Canyon in early June, and a third unknown sex individual was observed incidentally on a visit to the site in early March. In addition, a singing male was detected at the entrance to Hidden Valley Ranch Park in late April. During surveys for Burrowing Owls there were no Grasshopper Sparrows detected.

Discussion

The lack of Grasshopper Sparrow sightings may result from inherent rarity or low population numbers resulting from the prolonged drought in Western Riverside County. The exhibited below average rainfall in the region following the driest year on record in 2002 may have reduced reproduction and contributed to low population sizes. Further surveys are recommended, especially in spring 2005 and 2006. If present, the enhanced productivity resulting from the winter rains of 2004-2005 should promote reproduction and increase population sizes.

Grasshopper Sparrows may also be more abundant and easily detected in native grassland habitats, which are rare in the Plan Area. Several of the monitored coastal sage scrub/ grassland sites supported native grass species, although non-native grasses were more abundant. Grasshopper Sparrows generally inhabit moderately open grasslands and prairies with patchy bare ground (Vickery 1996). Their numbers have been in decline as native grasslands sparrows habitats have been developed or converted to agriculture (Sauer et al. 2000). However, some debate exists over whether the sparrow will utilize non-native grasslands that have replaced native grasslands across the species' range (Knopf 1995). If this is true, then the extensive non-native grasslands across Western Riverside County may not provide suitable habitat. The situation may be exacerbated as costal sage scrub habitat is converting to non-native grassland through the effects of fire and enhances nitrification (Allen et al. 1998).

CHAPTER 13
RARE PLANT SURVEYS

Introduction

During the 2003 and 2004 field seasons, and continuing throughout the 2005 field season, CCB biologists conducted surveys for rare plants by revisiting the historic locales of 27 Covered Species listed in the WRC MSHCP. Thirteen of the species also appear on the County's Demonstrate Conservation List. CCB biologists also revisited historic locations of five species covered under the Coachella Valley MSHCP. Surveys for the thirteen WRC Demonstrate Conservation Species concentrated on verifying whether the criteria outlined in Section 5.0 of the MSHCP were met. Many of these species are difficult to find because of their inherent rarity, and because many are annuals and may only germinate following significant seasonal rainfall events. The growing season of 2002 had the lowest precipitation on record, and virtually no germination was observed on plots from an unrelated study underway on the Shipley-Skinner Reserve. Surveys conducted in 2003 and 2004, following below average and average winter and spring rains, increased the likelihood of their detection. However, even under "normal" rainfall conditions, the goals outlined within Section 5.0 of the Western Riverside Plan were not achieved. The surveys are resuming in 2005 following the second wettest winter in southern California in recorded history.

Methods

Various museums, herbaria, and other institutions located in California and elsewhere were queried for all records pertaining to covered plants within the MSHCP areas. The resulting database of site localities included some 1184 historic records for WRC and 220 for CVAG. These numbers include all duplicate records and records found on public as well as private land. The majority of location records were provided in the form of text descriptions. These text descriptions were georeferenced to UTM coordinates using maps and online resources. A large number of records were determined to be too vague to attempt a site visit, while others were located in areas that had been developed. Any records determined to be located on private property were eliminated from further action (i.e. searches for species). Using the remaining records, field teams attempted to visit each site and determine the status of the target species.

The first step in the surveys was to locate the coordinates and determine whether the coordinates matched the text description of the location provided by the source institution. If coordinates did not match text descriptions, it was necessary to attempt to locate the area described in the text description. Near the site described in the text description, field workers (two or more) would conduct a foot search for the species and record the area searched. When located, the field workers would record the presence or absence of the target species, GPS the center of the population, and record coordinates and name of the coordinate waypoint saved in GPS memory. A north-facing photo of the area was taken with a digital camera and a 512m² relevé plot was established around the GPS location with corners in the cardinal compass directions. The number of individuals of the target species in the plot were counted (if population is small enough) or estimated (if population is very large). All species observed in plot were listed, and percent cover of the various plant species and average height of each were also recorded.

Results

Full details of the survey results for the 2003 and 2004 survey seasons appear in Tables 13.1 and 13.2. The location data for the individuals of all Demonstrate Conservation and Covered Species located during the surveys, as well as the historic location information has been provided to CDFG. Of the thirteen demonstrate conservation plants surveyed in 2003 and 2004, only one species, the beautiful hulsea (*Hulsea vestita callicarpha*), met the requirements outlined in Section 5.0 of the WRC MSHCP. In 2004, the beautiful hulsea was found at 64 locations with an average population size of 81 individuals per location. The criteria outlined in Section 5.0 for beautiful hulsea require 16 localities (locality in this sense is not smaller than one quarter section) with no fewer than 50 individuals identified on public land currently under conservation for adequate coverage.

From the tables, it appears that graceful tarplant (*Holocarpha virgata elongata*) also meets the criteria. However, in 2003, population counts were made at only three locations; these locations contained 100,000, 5,000, and 1,000 individuals, respectively. In 2004, population counts were made at 12 locations where there were more than one individual. While the average number of individuals is 4258, only six of the twelve populations contained 1000 or more individuals as required by the MSHCP criteria for that species. Graceful tarplant falls four populations short of adequate coverage. The remaining demonstrate conservation species exhibited too few populations, too few individuals per population, or both.

Discussion

Even though detailed and thorough rare plant surveys were conducted in 2003 and 2004, conditions were far from optimal to conclude that all the Demonstrate Conservation Species Criteria for 12 of the 13 plant species have not been met. The heavy rains of 2005 provide the best conditions to date for definitive surveys. Any conclusions regarding adequate coverage for these species should wait until the conclusion of the 2005 survey period. The ample winter and spring precipitation may reinvigorate populations that have been reduced in size by the drought conditions prevalent in the region since 2001.

The surveys in 2005 will also provide additional information on the remaining covered species not on the Demonstrate Conservation list. As stated in the Theoretical Framework, a technique that may be useful in monitoring the status of species that do not fall into any single ecological community grouping is the occupancy approach. The method utilizes presence-absence data recorded over a period to detect the short-term metapopulation trends for a given species (Hanski 1997). For some of the plant species, an additional year of information may provide enough information to test the occupancy method. At the very least, the additional year of surveys following the very wet winter will provide a better description of the status and extend of these species throughout the Plan area.

Table 13.1 Summary of rare plant survey results for the 2003 survey season.

Latin Name	Common Name	Records		2003 Survey Results			
		Total Records	Records on Private Property	Public Locations Visited	Public Locations Where Species Found	Average Population Number	New Locations Discovered by UCR team
Hulsea vestita callicarpha	beautiful hulsea	129	33	60	28	38	17
Muhlenbergia californica	California muhly	5	5	0	0	0	0
Oxytheca caryophylloides	chickweed oxytheca	16	6	6	2	0	0
Potentilla rimicola	cliff cinquefoil	8	0	8	0	0	0
Astragalus lentiginosus coachellae	Coachella Valley milkvetch	71	61	3	2	252	0
Lasthenia glabrata coulteri	Coulter's goldfields	92	60	14	12	177022	0
Romneya coulteri	Coulter's matilija poppy	88	57	24	23	40	21
Atriplex serenana davidsonii	Davidson's saltscale	17	12	3	3	1	0
Polygala cornuta fishiae	Fish's milkwort	25	16	4	1	10	1
Holocarpha virgata elongata	graceful tarplant	33	8	22	17	35333	15
Lepechinia cardiophylla	heart-leaved pitcher sage	26	7	14	12	82	8
Erodium macrophyllum	large-leaf filaree	14	3	5	3	44	0
Myosaurus minimus apus	little mousetail	57	44	7	4	4	0
Linantus maculatus	little San Bernardino Mtns linanthus	10	7	2	1	343	0
Xylorhiza cognata	Mecca aster	62	15	3	3	0	3
Deinandra mohavensis	Mojave tarplant	43	26	11	6	571	3
Nama stenocarpum	mud nama	3	0	1	0	0	0
Berberis nevinii	Nevin's barberry	58	50	5	3	4	0
Salvia greatae	Orocopia sage	51	28	4	2	8	0
Atriplex parishii	Pparish's brittlescale	13	12	1	0	0	0
Chorizanthe parryi parryi	Pparry's spineflower	79	70	2	0	0	0
Chorizanthe leptotheca	peninsular spineflower	32	26	6	3	123	0
Calochortus plummerae	Plummer's mariposa lily	25	18	3	3	504	1
Navarretia prostrata	prostrate navarretia	10	2	7	5	10000	0
Chorizanthe procumbens	prostrate spineflower	26	9	0	0	0	0
Arctostaphylos rainbowensis	Rainbow manzanita	47	23	22	14	1	10
Atriplex coronata notatior	San Jacinto valley crownscale	96	73	11	4	236	0

Table 13.1 (Cont.) Summary of rare plant survey results for the 2003 survey season.

Latin Name	Common Name	Records		2003 Survey Results			
		Total Records	Records on Private Property	Public Locations Visited	Public Locations Where Species Found	Average Population Number	New Locations Discovered by UCR team
Centromadia pungens	smooth tarplant	128	111	13	7	4500	2
Brodiaea filifolia	thread-leaved brodiaea	47	31	10	7	17700	0
Astragalus tricarinatus	triple-ribbed milkvetch	26	18	1	0	0	0
Ceanothus ophiochilus	Vail Lake ceanothus	31	23	0	0	0	0
	Totals	**1404**	**883**	**275**	**165**	**246816**	**81**

Table 13.2. Summary of rare plant survey results for the 2004 survey season.

Latin Name	Common Name	Records			2004		
		Total Records	Records on Private Property	Public Locations Visited	Public Locations Where Species Found	Average Population Number	New Locations Discovered by UCR Team
Hulsea vestita callicarpha	beautiful hulsea	129	33	86	64	81	25
Muhlenbergia californica	California muhly	5	5	0	0	0	0
Oxytheca caryophylloides	chickweed oxytheca	16	6	8	4	47	2
Potentilla rimicola	cliff cinquefoil	8	0	6	1	34	0
Astragalus lentiginosus coachellae	Coachella Valley milkvetch	71	61	4	2	2	0
Lasthenia glabrata coulteri	Coulter's goldfields	92	60	23	18	36462	2
Romneya coulteri	Coulter's matilija poppy	88	57	15	14	37	2
Atriplex serenana davidsonii	Davidson's saltscale	17	12	3	0	0	0
Polygala cornuta fishiae	Fish's milkwort	25	16	9	7	22	3
Holocarpha virgata elongata	graceful tarplant	33	8	17	14	4258	0
Lepechinia cardiophylla	heart-leaved pitcher sage	26	7	16	16	61	3
Erodium macrophyllum	large-leaf filaree	14	3	3	1	1	0
Myosaurus minimus apus	little mousetail	57	44	8	0	0	0
Linantus maculatus	little san bernardino mtns linanthus	10	7	3	2	928	0
Xylorhiza cognata	Mecca aster	62	15	15	14	72	1
Deinandra mohavensis	Mojave tarplant	43	26	16	11	233	4
Nama stenocarpum	mud nama	3	0	1	0	0	0
Berberis nevinii	Nevin's barberry	58	50	8	6	3	0
Salvia greatae	Orocopia sage	51	28	3	1	50	0
Atriplex parishii	Parish's brittlescale	13	12	1	0	0	0
Chorizanthe parryi parryi	Parry's spineflower	79	70	4	0	0	0
Chorizanthe leptotheca	peninsular spineflower	32	26	4	2	5041	0
Calochortus plummerae	Plummer's mariposa lily	25	18	4	0	0	0
Navarretia prostrata	prostrate navarretia	10	2	8	4	4926	1
Chorizanthe procumbens	prostrate spineflower	26	9	6	0	0	0
Arctostaphylos rainbowensis	Rainbow manzanita	47	23	8	8	6	1
Atriplex coronata notatior	San Jacinto Valley crownscale	96	73	21	15	2608	9

Table 13.2 (Cont.) Summary of rare plant survey results for the 2004 survey season.

Latin Name	Common Name	Records 2004					
		Total Records	Records on Private Property	Public Locations Visited	Public Locations Where Species Found	Average Population Number	New Locations Discovered by UCR Team
Centromadia pungens	smooth tarplant	128	111	13	7	354	3
Brodiaea filifolia	thread-leaved brodiaea	47	31	14	4	39	2
Astragalus tricarinatus	triple-ribbed milkvetch	26	18	2	1	1	0
Ceanothus ophiochilus	Vail Lake ceanothus	31	23	0	0	0	0
Totals		**1404**	**883**	**329**	**216**	**55266**	**58**

CHAPTER 14
BURROWING OWL SURVEYS

Introduction

In the spring of 2003, CCB biologist Ginny Short began a two-year presence/absence survey for Burrowing Owls on public lands throughout the Plan Area. The goals were to survey suitable habitat and to determine the number of owls extant on existing public lands slated for owl conservation. The MSHCP Burrowing Owl species account (MSHCP section B.2.0; Dudek and Associates 2003) designated 12 areas based on historical records as being "core" populations of the owls. Six of the twelve areas were designated as core populations, and as probable conservation priorities in the MSHCP. These populations were thought to be extant in the following areas: along the Santa Ana River; San Jacinto Wildlife Area/Lake Perris/Mystic Lake; Lake Skinner/Diamond Valley; Lake Matthews; and the playa west of Hemet. In addition, the CCB database contained records for 141 historic locations for Western Riverside County requiring surveys. Many of these sites were also visited. The majority of surveys were conducted on public and quasi-public land. Permission was obtained from land owners prior to entering private land before any surveys were conducted.

Methods

Before actual surveys began, historical records, local experts, and maps were consulted to determine locations that may harbor any extant owl populations. Using the Western Riverside MSHCP Burrowing Owl species account, open grassland areas on public and quasi-public land within the core areas were identified and targeted as potential survey areas. Once these areas were identified a driving reconnaissance trip through each location was done to determine where suitable owl habitat remained.

Once suitable habitat was identified, surveys were conducted on foot, bike or from an automobile between dawn and 10 am or between 4 pm to dusk, when owls are to be most active. Surveys were conducted along any and all trails or drivable roads in designated survey areas. Twenty-minute point counts were conducted at approximately one-mile intervals along the roads or trails. Additional point counts were done if the habitat was deemed very good. Point counts were supplemented by walking through suitable habitat when deemed necessary. If any owls were observed, the UTM coordinates (WGS 83) were recorded. The presence or absence of owls at historic locations was noted as well.

Results

Of the potential survey locations listed above, only Lake Mathews and the playa west of Hemet were not surveyed. Access to Lake Mathews was restricted due to security precautions and the playa west of Hemet was found to be under private ownership.

Summary of 2003 Survey Efforts 12 pair total / 8 pairs on protected land

In 2003, surveys were completed in the area surrounding the Santa Ana River, the San Jacinto Wildlife Area and Mystic Lake. Near the Santa Ana River Area, one pair was found in a ditch leading into the Temescal Wash, an area surrounded by homes and businesses. Three pair were observed on dairy property located north of the river. No owls were found on any public or quasi-public land adjacent to the river, and local biologists and naturalists report that owls have not been seen for several years.

Eight pair were located at the San Jacinto Wildlife Area. Three distinct pair and one colony of three pair were located on CDFG property near the Lake, and two pair were observed on the adjacent hunt club properties.

Summary of 2004 Survey Efforts / 8 pairs total

In spring and summer 2004, surveys were focused on the San Jacinto Wildlife Area, Lake Skinner and Johnson Ranch areas. Additional historical locations were also investigated. Eight new pair were discovered. This includes an additional pair of owls discovered at San Jacinto Wildlife Area; however, one of the owl pair located the previous year at the hunt club was no longer there. Surveys at Lake Skinner had negative results. In spite of many hours of surveys, even the few known historical locations had no owls. The area north of Diamond Valley Lake was not surveyed, as permission was not obtained. Johnson Ranch was surveyed with positive results; seven pairs were noted during surveys.

Discussion

Of the main core areas surveyed, only the San Jacinto Wildlife area meets the requirements outlined under Species Objective 2 in Section 9 of the WRC MSHCP. Johnson Ranch, which lies southwest of Lake Skinner, has a separate Habitat Conservation Plan (HCP) that does not cover Burrowing Owls. Protection for the owls at Johnson Ranch is limited.

CHAPTER 15
RAPTOR SURVEYS

Introduction

No single monitoring protocol can address the monitoring needs for all 146 species covered by the WRC MSHCP. Therefore, other approaches, such as the occupancy approach described previously, will be required to serve as ancillary or complimentary methods to the main community-based monitoring efforts. A survey of raptors, conducted in 2003 and 2004 by UCR biologist Allison Rudalevige, utilizes a landscape approach to explore the spatial and temporal dynamics of raptor habitat selection within the urban matrix of the County. As the population in Western Riverside grows, development will usurp natural areas not contained within the MSHCP. This increased urbanization has implications for species known to use marginal habitats. Since raptors prey on a variety of rodent, bird and reptiles, their presence or absence may be indicative of population levels of the prey species, which in turn may be an indicator of population and community health.

As a first approximation of the interaction between raptors and landscape, the objective of the study was to analyze the relationship between raptor distribution and the rapidly urbanizing landscape of Western Riverside County, California. Unlike most other studies, this region encompasses the entire urbanization gradient and is set in a matrix of semi-arid shrubland. Through point count surveys and stepwise logistic regression, we will determine what landscape variables describe the presence/absence of various raptor species.

A study of this nature must consider the scale at which an organism "perceives" its environment and acknowledge that organisms could be using multiple scales for different activities. Being highly mobile and wide-ranging, birds especially have the potential to use multiple scales for foraging, breeding, or wintering (Cody 1985). Landscape variables are likely to be of importance to raptors, which have large home ranges and so encounter a variety of landscapes in a fragmented environment.

In a review of literature from 1900-2000, Marzluff, Bowman, and Donnelly (2001) found that studies of the effects of urbanization on birds have taken place primarily in the past 20 years. Moreover, from 1990 to 1996, only 25% of avian conservation literature related landscape attributes to birds (Marzluff and Sallabanks 1998). Although the "urbanization gradient" ranges from large native areas of land with few dwellings to rural or exurban housing, to more dense housing in suburban areas, to near total elimination of vegetation in highly industrialized areas, the majority of studies do not consider the entire gradient of urbanization. Finally, most studies of birds in urbanizing landscapes typically take place in a natural matrix of temperate, upland forests.

Methods

The survey protocol consists of 250 points established throughout the Western Riverside Planning Area. GIS randomly generated the points with the following restrictions: all points must lie below 3500 feet elevation, are approximately 3 km apart, and be distributed along public roads excluding major freeways. The surveys were conducted between approximately 9 am and 3 pm from 5/27/03 to 7/15/03. About 5 and-8 points were done per day. Surveys consisted of a 20-minute point count conducted at 160 of the 250 points, where any raptor, crow, or raven seen was recorded. The bird's approximate location was plotted on a map. Additional information recorded included bird activity (flight, perched, etc), where activity occurred (air, telephone pole, telephone wire, ground, tree, etc), any interactions with other birds, additional comments; distance (calculated with a rangefinder) and inclination from observer to bird. The observer was stationary during the surveys and tried to view each of the four cardinal directions for the same amount of time.

Results

In the spring of 2003, two species were present on enough survey points for analysis, the Red-tailed Hawk and Turkey Vulture. The presence of Red-tailed Hawks was significantly associated with increased agriculture, coastal sage scrub, and grassland. The presence of Turkey Vultures was negatively associated with housing. In the winter of 2003, only Red-tailed Hawks and American Kestrels provided a sufficiently large sample size to analyze. The analyses showed that no landscape variables were significantly associated with the presence of either species. In the spring of 2004, four species were found to have significant associations with landscape variables. Red-tailed Hawk presence was associated with decreased development. Turkey Vultures were negatively associated with development but positively associated with riparian shrub vegetation. American Kestrels were positively associated with grasslands. Finally, Red-shouldered Hawks were positively associated with woodlands.

Discussion

The results show that landscape variables can describe the presence/absence of raptor species at specific times of the year. High levels of development within a area tends to limit species distribution. However, certain anthropogenic changes to the landscape may benefit species. For example, in this study, Red-tailed Hawks tended to exhibit a positive association with agriculture. In winter, no association was found between any species and landscape variables. This may result from several factors. Winter migrants may "pack" the landscape, which means that the resident species may be forced off their summer ranges by an increase in migrants that move into the area. This idea requires further testing, but it seems unlikely because spring and winter 2003 had same percentage of points with Red-tailed Hawks. During the winter, resident species may be keying in on details in the landscape that are not captured the landscape level. Smaller scale variables may provide greater resolution. Another reason for the lack of association with specific habitats in winter may be a relaxation territoriality in wintering birds and so can they forage over a wider range of landscapes during a time of scarcity.

Certain species may exhibit a threshold of response to urbanization. By sampling along the urbanization gradient, researchers can determine this threshold. For species that forage in open habitat, like the Red-tailed Hawk, moderate levels of development could facilitate their presence by eliminating dense cover and creating foraging habitat. Higher levels of development might then cause the species decline. This is perhaps the case with Red-tailed Hawks in western Riverside County. They were positively associated with agriculture, an altered landscape, but negatively associated with the more urbanized "developed" variable. Likewise, urbanization might benefit species by adding structural complexity to an otherwise open landscape. This could increase the presence of species, such as the Red-shouldered Hawk, that forage in denser habitat like woodland. To examine further potential thresholds of response to urbanization, future analysis will examine the influence additional landscape variables, such as distance to edge and percent fragmentation. Finer scale associations could lead to hypotheses about ecological mechanisms that produce the larger scale patterns and the observed seasonal variation.

CHAPTER 16
USING A PORTABLE FOUR CHANNEL RECORDING SYSTEM TO MONITOR BIRDS

Antonio Celis Murillo

Introduction

The use of acoustic survey techniques to monitor bird species is relatively new (Parker and Bailey 1991, Peterson and Dorcas 1992, Foster et al. 1994, Haselmayer and Quinn 2002, Evans and Rosenberg 2002, Hobson 2002, Brandes, 2004) and, recently, has gained importance in the assessment and evaluation of the environment (Oba 2004). Acoustic techniques have been developed to monitor specific species or individuals using automatic recording systems (Terry and McGregor 2001, Wang et al 2003, Fox, 2004, Chesmore 2004, Oba 2004). Such systems have the ability to monitor for extended periods of time, thereby increasing species' detections (Evans and Rosenberg 2002, Wang et al 2003). However, these types of recording systems are non-mobile systems and are ineffective at surveying large areas and estimating abundances of bird species.

Estimates of bird abundance and composition are dependent upon the accuracy of data collected in the field. Recently bio-acoustic techniques have been developed to help in monitoring bird populations, and just a few studies have been conducted using mobile recording systems (MRS), which have the ability to survey large areas over a short period of time and with relatively low costs. The most important advantage associated with the use of MRS is that it can be used in a manner similar to that of point counts. The use of MRS has resulted in only a few favorable results due to the use of ineffective or unsuitable microphones for monitoring (unidirectional microphones) (Haselmayer and Quinn 2002, Celis and Deppe, unpublish data). However, Hobson et al. (2002) have developed a stereo (two channel) MRS and have shown impressive results in their ability to detect birds, as determined by comparisons with expert field technicians. Similarity measures between recordings and observers in the field for both presence/absence and abundance data range from 83% to 97% (Hobson et al 2002). These results show that an appropriate MRS with an adequate microphone system (two or four channels) deployed in a suitable habitat type can be used to collect accurate data on species composition and relative abundance.

I developed a Portable Four Channel Recording System (P4CRS) to examine the capabilities of acoustic recordings to monitor birds in a manner similar to that of a point counts. The system was developed to record the soundscape and to assist in estimating bird abundances and species composition while avoiding many of the errors and biases that traditionally affect point count data (e.g. inter-observer variation, misidentifications, etc.). P4CRS can be used in the field by inexperienced field technicians to acquire the bird monitoring data. The soundscape recorded by the P4CRS may be stored in the laboratory and later interpreted by a single expert on bird identification. The ability of the interpreter to identify bird sounds and the ability to recreate the soundscape multiple times, allows the interpreter to estimate abundances as well species composition while minimizing errors associated with the misidentification of species and inter- and intra-observer variability. The latter may occur when an individual field technician increases his/her ability in identifying species or estimating abundances over the course of the season as he/she acquires more experience. By having a single interpreter record data from the recordings, this approach effectively eliminates inter-observer biases.

Methods

Study area. The study was conducted in the riparian areas of the Western Riverside County as a part of the bird surveys conducted for the Western Riverside County Multi-species Habitat Conservation Plan (WRCMSHCP). The majority of the riparian areas included anthropogenic disturbances, such as residential disturbances, highways, roads, railroads, etc., although, some of these riparian areas were protected areas in which the disturbances were significantly less.

P4CRS. I developed the recording system using four microphones (Sennheiser ME62-K6) and two DAT recorders (Sony TCD-D8) (Figure 1). The P4CRS uses four omni-directional microphones mounted in a tripod at 90 degrees angles relative to one another. Each microphone was positioned at a 30 degrees angle relative to the horizontal and four plastic dividers separate each of the microphones from the others. Using the microphones in this way, allowed the P4CRS to capture sounds in a 360° radius (each omni-directional microphone has the ability to capture sound in a 90° radius from the center). An advantage of the P4CRS is that each of the microphones captures sound waves from a different direction (two right and two left sides), which enter the recorders via different channels creating a 4 channels recording. These recordings were play-backed using a multi-track playback system allowing me to recreate the soundscape (simulating what an observer would hear in the field) to estimate abundances of the birds as well a species composition. The recordings were transferred to a PowerBook G4 1.5 MHz Macintosh Computer using an external drive USB-Edirol UA5 and digitized using Logic Pro software (emagic).

Monitoring birds in the field. From March to July 2004, I conducted 102 different point counts at the same time I made acoustic recordings using the P4CRS. Land-bird monitoring protocols developed by Ralph et al (1993, 1995) were the basis of the point count methodology. During the 10 min period, I recorded all birds seen and heard. I mapped the location of each bird (distance and direction from point center) onto a data sheet. For each bird detected, I recorded the exact or approximate distance of the bird using a rangefinder Bushnell Scout Pro, the exact time the bird was observed, and the behavior of the bird when it was first observed. For the birds that were recorded by sight alone, I made a special note indicating that the bird never sang or called during the point count. I placed the P4CRS at the point center. Prior to initiating the point, I recorded the location, point count number, UTM coordinates, date, observer name, and start and end time of the point. After start recording soundscape and prior to start the point count, I made a matching sound near to the four microphones (click) to make easier the synchronization of the four channels to record. I started recording at time 0:00 and ended at 10:00. Each point count recording was digitized on the day it was recorded and saved as a WAV file at 44.1 KHz and 16 bit of resolution on a portable hard-drive at the Center for Conservation Biology (CCB). During the digitalization, each recording was labeled with the name of area surveyed, point count number, date and observer's name and became part of the Bio-acoustic Data Base at the CCB.

Interpretation of the acoustic recordings (In progress). I conducted playback sessions using the computer software Logic Pro, a multi-channel playback interface, and four professional speakers amplified by a Home Theater Receiver. For the interpretation of the recordings in the room, I sat in the center of the room and listened to the 10-minute point count recordings and estimated bird abundance as I did in the field (listening, turning around the center to locate the bird sound coming from different locations and recording the birds identified on a data sheet). The same data sheet used in the field was used to transcribe data from the recordings. The multi-track playback enabled me to locate each of the bird sounds and allowed me to record the species identity and the number of individuals detected. In some cases, recordings were listened to again to check on the number of detected individual and to check species identification. When a call or song was difficult to identify, I evaluated the spectrograms of specifics parts of the recording on the computer using the software Raven (Cornell Ornithology Lab). The use of spectrograms makes it easier to estimate the number of birds recorded and to identify unknown bird sounds. The spectrogram gave me opportunity to hear and see each of the vocalizations recorded.

Analysis of data (In progress). From the P4CRS data and the expertise data, I will calculate the number and species of birds identified by (1) both the observer and recording, (2) the observer only, and (3) the recording only. I will also calculate the proportion of birds heard and observed during the point count. Since recordings are unable to detect birds that are not vocalizing, a very low proportion of non-vocalizing individuals are necessary to make the use of P4CRS an effective census technique. I will examine individual species to determine the proportion of individuals identified via vocalizations during the original point count surveys in the field. Some species are more likely to vocalize than others, and the P4CRS will be more efficient at monitoring these species.

To examine if the P4CRS is useful for improving the quality of data collected, I will correct the field observer's data using the P4CRS data to eliminate false positive and false-negative identifications made by the observer. Thereafter, I will compare the corrected data with the raw data. The P4CRS data will only be used to correct data for birds identified via vocalizations. It will be assumed that birds observed visually but that were never heard vocalizing (as indicated by the field observer's data sheet) were correctly identified by the observer. These birds will be included in the corrected data. Using the corrected data I expect to have a higher quality data using the two techniques; P4CRS and traditional point counts by expert observers in the field.

Results (in progress)

Justification

The P4CRS can be made at a medium-low cost and is easy to carry in the field, making it possible to survey relatively inaccessible areas (canyons, riparian areas or areas requiring much hiking). There are many potential advantages to using PMTRS in monitoring birds. First, if the PMTRS proves reliable in estimating bird species composition and abundances at point count locations, it may provide a means of surveying birds with limited involvement of expert field technicians, especially during the breeding period when they are likely to be in short supply. Field assistants with no or limited experience in birds could make the recordings which would later be analyzed by a expert technician or possibly through the use of future software that is currently being developed to identify bird vocalizations. This may reduce variability among observers as one or a few observers would be interpreting or recording data from the recordings. Within season variability in identification, which usually happens as observers increase their ability to identify species throughout the season, would be reduced. Additionally, this would allow projects to conduct a maximum number of censuses over a short period of time using inexperienced field technicians. Researchers will have the opportunity to do multiple surveys simultaneously and with one observer, reducing inter-observer reliability issues. Second, the use of recordings will enhance the ability to detect rare or secretive species in the study area, as these are most often the species with which observers are unfamiliar in the field. Third, the PMTRS allows the researcher to make long-term back-ups of the data and produce an acoustic library that may be used in the future for other projects. For example, the recordings may be used to study variation in vocalizations across a geographic range or produce recordings used in playback experiments. Fourth, the PMTRS can be used as a training tool on bird identification and will be useful as a tool for standardizing skills identification before starting survey work. Each time biologists start a field season, they practice identifying birds by sound. Often they are re-learning the sounds as they are conducting the surveys, which can lead to greater observer error in bird identification early in the season.

CHAPTER 17
CONCLUSIONS & RECOMMENDATIONS

CONCLUSIONS

Conclusions regarding the overall development of the monitoring approach are limited because as an iterative process, the inability to test and refine the models and protocols in 2005-2007 as originally proposed, and then feed these results back into the monitoring plan, precludes completion of the middle and last phases of the monitoring framework (Chapter 1). We were also unable to capture annual variation since sampling occurred over one season for community monitoring, and two seasons for focused surveys.

Successfully monitoring covered species requires a periodic assessment of the status of the species and an identification and evaluation of those threats to populations within the Plan Area. This information guides development and implementation of management plans with the goal of reducing threats to vulnerable populations, particularly those threats of an anthropogenic nature. The monitoring framework that combines single species and ecosystem monitoring into a single community-based monitoring approach (Barrows et al. 2005) has proven to be flexible in that steps may be interchangeable (e.g., community sampling undertaken before construction of niche models in order to gain necessary information to include in the models). In addition, monitoring natural and anthropogenic processes that affect species populations is essential to identify what to manage and what management strategies to be applied. Long-term monitoring will distinguish 'normal' variation in population levels from levels where population persistence may be threatened. A greater understanding of the range of population responses to changing conditions provides managers with the ability to enact adaptive management strategies.

Conceptual models provide testable hypotheses about population responses to environmental processes that may be tested with monitoring data and the results of focused research. These models indicate those types of processes and environmental variables that should be measured in a monitoring program. In this report, CCB presents conceptual models illustrating hypothesized relationships between ecosystem processes and the responses of covered species in coastal sage scrub and riparian communities. For these models to be most useful in guiding monitoring and management of Covered Species in the Plan Area, it is necessary to assess these relationships under a range of environmental conditions.

Niche models predict habitat suitability for Covered Species throughout the Plan Area and these predictions require evaluation. The niche models constructed by CCB identify areas where data on species occurrence should be collected in the next round of monitoring studies. This monitoring data will provide information on the status of Covered Species within the Plan Area and can also be used to test and refine niche models. For a number of species, there was insufficient information to construct niche models. The next round of monitoring may provide enough information to develop preliminary models for these species. Niche models provide a powerful tool to predict species distributions under changing environmental conditions. For example, niche models could be constructed for non-native grasses that incorporate nitrogen deposition information as one of the environmental variables. These models could identify areas most suitable for future expansion of grasslands and would allow managers to identify areas within their reserves that are most vulnerable to conversion from coastal sage scrub to non-native grassland. Research should be conducted to develop management methods to reduce habitat conversion. Niche models could also be constructed to identify areas most suitable for restoration to coastal sage scrub, so that monies and efforts can be efficiently allocated.

The next stage in development of the monitoring framework also requires the continued development and testing of efficient monitoring methods. For example, there is a need to design coastal sage scrub vegetation sampling methods that require less time and effort. The community monitoring data from 2004 show widespread impacts to native coastal sage scrub resulting from the invasion of non-native annual plants within the Plan Area. The condition of coastal sage scrub vegetation should be closely monitored throughout the reserve system to identify areas vulnerable to habitat conversion. In developing monitoring strategies further work is required to identify those variables that are most important to monitor in assessing threats to Covered Species. Taxa such as arthropods may prove to be efficient indicators of habitat quality and the integrity of natural communities.

Preliminary lessons learned in the design of protocols and monitoring strategies:

- Given the volume and variety of data collected, data analysis and final report preparation were limited by time constraints.
- Monitoring should be multi-year to encompass the variation in environmental conditions: Climate impact on survey results (e.g., 1999-2002 Drought conditions affected survey and monitoring efforts, particularly for plants and reptiles)
- For the most effective niche models, it is important to use an accurate and reliable vegetation analysis in constructing vegetation layers used in modeling
- More than one season is required to develop, compare, and refine protocols and monitoring/sampling strategies
- Niche and conceptual models require testing and refinement with independent datasets
- There is a need to develop more efficient coastal sage scrub protocols for community-scale sampling.

Rare Plants and other Demonstrate Conservation Species

Following two years of surveys on twenty-seven species of rare plants, thirteen of which appear on the County's Demonstrate Conservation list, conclusions may be drawn concerning the level of coverage afforded for these latter species on public and quasi public lands under conservation. Only one of the plants on the Demonstrate Conservation Species list, beautiful hulsea (*Hulsea vestita callicarpha*) is adequately covered. The remaining 12 species do not meet the criteria set forth in Section 5 of the WRC MSHCP. CCB biologists did not visit historic locations for these rare plant species located on private land, therefore their status in these areas is not known.

Results for the remaining two Demonstrate Conservation Species remain inconclusive. Surveys for the Grasshopper Sparrow (*Ammodramus savannarum*) revealed the presence of nine individuals at three of eleven sites in the Plan Area, where they were surveyed during the course of coastal sage scrub/grassland community surveys and Burrowing Owl surveys. Many of the surveys, particularly those conducted when surveying for Burrowing Owls, were conducted toward the conclusion of the sparrow's breeding cycle and are not representative of the actual distribution of this species on public and quasi-public land. Surveys for the Lincoln's sparrow (*Melospiza lincolnii*) were to be conducted in spring 2005; therefore, the status of this species is currently not known.

SPECIFIC RECOMMENDATIONS

Monitoring Framework Development

CCB initiated research on developing a monitoring framework for the Plan Area, but much work remains to be done. Work completed to date represents the first two years of a projected five-year framework development timetable. The original scope and timetable of work to be completed is given in Appendix 2. CCB began the process by compiling available data on target species locations, collecting additional field data to augment the database, and creating preliminary niche models for Covered Species in the database with sufficient location information. CCB constructed conceptual models (envirograms) for riparian and coastal sage scrub communities, based on hypothesized interactions between environmental processes and species within these communities. CCB developed preliminary protocols for sampling coastal sage scrub and riparian communities in the Plan Area. CCB biologists also developed protocols to survey for rare plants, reptiles, raptors, and Burrowing Owls. Once the Keeler-Wolf vegetation map becomes available, niche models should be rerun for all species using this updated vegetation map that more accurately reflects current vegetation communities and developed areas.

The next stage in framework development requires testing and refining preliminary niche models and creating new niche models for additional species covered by the plan when the necessary location data becomes available. This requires further sampling to collect location data on sensitive species to test the models and to provide sufficient samples for species that have not yet been monitored. ***It is essential to test the niche models if they are to be most effective at categorizing suitable habitat and identifying environmental factors important in species distributions***.

Protocols developed by CCB were intended for further testing and refinement over the next few years. While the protocols used in 2004 are satisfactory at obtaining high quality data, the methods are time consuming in monitoring coastal sage scrub and riparian habitats over the vast spatial scale that defines the Plan Area. This is evident from the number of hours that CCB spent sampling vegetation in 2004 (Chapter 2). Thus, the vegetation sampling protocols, particularly the sampling strategy for coastal sage scrub needs thorough revision and testing. As habitat relationships are better understood through modeling and focused research studies, vegetation and other monitoring techniques can be designed to focus on specific variables associated with suitable habitat for Covered Species. Some species were not as well sampled and require revisions to community monitoring protocols or the development of species-specific protocols. Further work is also needed to develop an effective survey technique for reptile and mammal communities. Finally, sampling techniques need to be developed that give estimates of annual reproduction, particularly for species where this information is required as part of the conditions for the WRCMSHCP (Dudek and Associates 2003).

Once the protocols are tested and developed and potential drivers influencing plant and animal populations in each major community are identified, it is important to regularly monitor each community type. Monitoring must be conducted often enough to detect and respond to changing conditions that might adversely affect the environment (such as invasions by non-native plants and animals, damage to habitats from human activities, etc.). The following are specific recommendations for further development of the monitoring framework for WRCMSHCP.

Constructing and Testing Conceptual and Niche Models

- Once the Keeler-Wolf vegetation map becomes available, reconstruct niche models for the 16 Covered Species whose niche models were presented in this report. Using the Keeler-Wolf map, develop preliminary niche models for covered riparian bird species.
- Use the niche models to identify areas to survey for Covered Species covering a range of habitat suitability values for each species. These surveys for covered bird, reptile, and plant species should be undertaken at locations within the Plan Area where there are currently no location data. Test and revise the preliminary niche models as part of the iterative process inherent to the monitoring framework. Build up the database for those species that currently have insufficient location information in order to construct niche models for these species in the future (e.g., rare plant species, Grasshopper Sparrow).
- Based upon the evaluated and refined niche models, identify environmental factors consistently associated with suitable habitat for each species. Evaluate these habitat relationships to determine whether any of these variables can be managed to ensure continued persistence of the target species.
- Conduct focused research studies (see below) to test hypotheses in the conceptual models and to determine how this knowledge may be used to manage species.

Identify where management conflicts may arise between species and develop management strategies to minimize these conflicts where feasible.

Further Development of Data Collection Tools and Protocols

- Develop more efficient vegetation sampling methods for coastal sage scrub habitat. Two important goals for sampling coastal sage scrub vegetation are to determine the extent of invasion by non-native annuals and to assess the overall vigor or health of shrub species.
- Develop satellite imagery techniques to monitor the conversion of coastal sage scrub to non-native grasslands and to monitor the vigor and health of shrublands (e.g., identify areas undergoing die-offs or degradation due to human activities such as off-road vehicles). This tool can be developed to track large-scale changes to natural habitats from fire and other environmental factors such as air pollution and the concomitant nitrogen deposition.
- Continue developing and testing community monitoring methods and protocols, particularly those for reptiles and mammals.
- Develop and test methods to assess annual productivity in sensitive animal populations (e.g., Vickery et al. 1992) and incorporate these methods where feasible into community sampling strategies. Compare the effectiveness of avian point count surveys with line transect surveys in monitoring populations of coastal sage scrub birds.
- Develop monitoring protocols and methods for Covered Species that are not well represented or sampled using community monitoring techniques.
- Adapt and test monitoring protocols used in coastal sage scrub/non-native grassland and riparian communities for other community types, such as chaparral, oak woodland, and coniferous forests.
- Continue developing technological capabilities for collecting field data with hand held computers or "PDAs" to reduce the time and cost of data entry.

Future Sampling/Monitoring

- Two types of sampling strategies are recommended to evaluate the status of Covered Species within the Plan Area and to monitor threats to their populations. These strategies could be alternated between years. The frequency of sampling is not yet determined as CCB was unable to conduct multiple years of monitoring under variable environmental conditions (e.g., sampling in above average rainfall years). In the first sampling strategy, reference sites should be set up within each of the core reserve areas to be used for repeated, long-term sampling. Sampling points at these sites should encompass the range of habitat conditions. For example, coastal sage scrub sampling points should be distributed among relatively intact patches as well as patches with substantial non-native herbaceous cover and in areas largely converted to grassland. These points should be repeatedly sampled over the long-term to facilitate an understanding of processes of habitat change. In riparian habitats, sampling points should also encompass multiple drainages reflecting diverse riparian patch sizes, variable community composition, and differing levels of anthropogenic threats. Data collected during repeated sampling at these reference sites would improve our understanding of population responses to environmental processes and would refine conceptual models guiding adaptive management. The second sampling strategy consists of sampling at many locations distributed across the Plan Area in order to assess the status of Covered Species region wide. Niche models could be evaluated and revised as necessary by incorporating this new location data. This second sampling strategy would also provide information on the level of threats and community integrity at different locations within the Plan Area.

- As part of the sampling schemed described above, sample riparian and coastal sage scrub communities to monitor environmental change so that adaptive management actions can be developed and implemented. Survey frequency should be a function of environmental conditions, for example monitoring in wet years will likely maximize species distribution data relative to drought years. Groups that should be sampled include arthropods, amphibians, reptiles, birds, mammals, and vegetation. In particular, arthropods and non-native ant species should be sampled frequently at preserves adjacent to development, to irrigated agricultural areas, and along riparian corridors to determine the abundance of exotic ant species relative to native arthropods. Preserve areas that are not adjacent to irrigated agriculture and development should be monitored for invasive ants during the course of periodic community sampling.
- Begin monitoring other important communities in the Plan Area such as oak woodlands, vernal pools, chaparral, and coniferous forest.
- Many Covered Species will be detected during community sampling. In particular, riparian and coastal sage scrub birds are relatively easily surveyed in the context of community monitoring. However, some Covered Species (e.g., reptiles and mammals) will require periodic, focused surveys to monitor their populations or to gather information on their reproductive status within the Plan Area.
- As part of coastal sage scrub community sampling, monitor areas with high nitrogen deposition rates (e.g., areas subjected to high levels of air pollution) that are most vulnerable to conversion from coastal sage scrub to non-native grassland.
- Monitor plant and animal communities in urban edge habitats and core interior habitats to compare how different species populations are affected over time. In particular, evaluate how vegetation changes, the distribution and abundance of non-native arthropods, and feral and subsidized predator communities affect natural communities.

Rare Plants and other Demonstrate Conservation Species

- As of May 2005, only one of the thirteen of the rare plants found on the Demonstrate Conservation Species List meet the coverage criteria described in the WRC MSHCP. Since 2005 experienced one of the wettest winters on record following five years of drought, soil moisture levels may be optimal for

germination for many of the plants on the list. If plants exist at locations on public and quasi-public land where they were recorded historically, but not recorded during surveys in 2003 and 2004, then 2005 will be the year to detect them. If additional populations are not detected during the 2005 surveys for the twelve species that are not adequately covered, then serious consideration should be given to expanding the rare plant surveys to include historic locations found on private land. Continue periodic rare plant surveys and assess threats to extant populations.
- Surveys should be continued for the two vertebrate species on the Demonstrate Conservation Species List. To our knowledge, no surveys are planned for Grasshopper Sparrows or Lincoln's Sparrows in 2005.

Research Needs

Natural communities in the Plan Area are impacted by the extensive urbanization occurring in this region. In extending the monitoring framework to developing adaptive management strategies and methods that will effectively conserve communities of sensitive plants and animals in the Plan Area, there is a critical need for research into the effects of anthropogenic and natural environmental processes on communities supporting covered species. Understanding these relationships is fundamental to identifying those components of natural communities that should be monitored in the future and for developing management recommendations. The conceptual models created by CCB provide a number of hypothesized relationships between anthropogenic and natural processes and species distributions. Research is needed to test these hypotheses in order to develop effective adaptive management strategies that will facilitate the long-term persistence of covered plant and animal species within the Plan Area. Environmental conditions are highly variable in this region, both in time and space, making it imperative to study how species respond to environmental change. Following are recommendations for research that are important to successfully monitoring, managing, and conserving sensitive plant and animal populations covered by the WRCMSHCP.

- Determine the soil nitrogen threshold level at which coastal sage scrub systems are most vulnerable to conversion to non-native grassland. Develop and test methods for cost effective soil nitrogen reduction that can be used to limit conversion of coastal sage scrub habitats to non-native grasslands. Use this information to prepare and update a management plan to mitigate high soil nitrogen levels and decrease conversion of coastal sage scrub habitat to non-native grassland.
- Study how fire affects time to re-establishment of coastal sage scrub shrub species depending on the levels of soil nitrogen at a site.
- Study the effects of fire on plants and animals in different community types (particularly coastal sage scrub) within the Plan Area. Determine recovery rates for different plant and animal species under different pre- and post-burn environmental conditions. Develop techniques to control the effects of fire on natural communities,

to maintain a mosaic of different stand ages, and to limit the magnitude of habitat destruction in any single fire event.

- Research methods and strategies to decrease the conversion of coastal sage scrub habitats to non-native grasslands. Investigate the most cost effective ways to restore successfully coastal sage scrub habitats.
- Conduct a study to determine the optimal methodology to determine reliably and efficiently annual reproduction for different coastal sage scrub and riparian bird species. Such a method could be based upon techniques developed by Vickery et al. (1994) to look at breeding success in birds. Based on the amount of data CCB collected on successful reproduction in birds during late breeding season surveys, it is anticipated that such a methodology could be designed for species such as California Gnatcatcher, Least Bell's Vireo, Yellow-breasted Chat, and Yellow Warbler that require their reproductive status be assessed every five years at core preserves in the Plan Area (Dudek and Associates 2003). Where feasible, this methodology should be integrated into community monitoring efforts so that data on the reproductive status of Covered Species and on the condition of the community they inhabit are simultaneously collected and available to use in designing management strategies. To test and validate the methodology, the estimated annual productivity and reproduction measures should be compared to similar measures obtained independently from traditional nesting studies.
- Document the impacts of Argentine ant and fire ants on plants and animals in riparian and coastal sage scrub communities throughout the preserve system. Research whether there are barriers to their establishment in native habitats and actions that can be taken to control their spread.
- Conduct research on pollinator communities and their relationship to rare and narrow endemic plant species. Identify where native pollinator-plant systems may be threatened by habitat loss and fragmentation or from anthropogenic processes. Research and develop management actions that can be taken to preserve any vulnerable pollinator-rare plant systems.
- Conduct a study of human activity and trails within the preserve system to determine the effects on covered plant and animal populations. Develop management techniques and strategies to minimize impacts to covered plant and animal populations.

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