Developing a Conservation Strategy for Southern California Forests and Woodlands[1]

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Abstract: *We report on efforts to conduct an ecoregion-scale assessment of biological resources in the forests and woodlands of southern California. Key ecological questions under consideration are: How important are undeveloped habitat corridors between southern California mountain ranges? Is there adequate habitat on public lands for species dependent on oak woodlands? What are the long-term, ecological ramifications of current fire management policies? What are the ecological effects of existing and projected future levels of resource utilization and recreation use on public lands? We describe a four-step approach to addressing these questions: (1) compile and integrate spatial data on landscape patterns; (2) determine temporal trends in landscape change based on the influence of ecological processes and human land use; (3) identify local species/habitat relationships; and (4) use spatially explicit models to simulate and predict the effects of landscape change on the distribution and abundance of plant and animal populations.*

Forest and woodland habitats are uncommon in arid southern California. They are scattered among vast expanses of chaparral in the mountains, along streamside corridors, and in foothill savannas. Their location in generally rugged "back country," away from coastal urban centers and the existence of public forest reserves, has allowed sizable portions of southern California's forests and woodlands to remain undeveloped. However, with the coastal lowlands almost completely urbanized, development is rapidly expanding into the foothills, enveloping privately owned oak woodlands and surrounding the public forests. Already disjunct mountain ranges are becoming further separated by urbanization occurring between them. The localized occurrences of forest and woodland habitats in southern California could increase the effect of further habitat loss and fragmentation on dependent wildlife and plant populations, because many of these populations are already small and tenuously interconnected. In addition, there is increasing public demand for resources and recreation areas on public lands, and the cumulative effects of fire suppression and air pollution are thought by some to be threatening the health of montane forests (Minnich and others 1995).

Recognizing these issues and the potential "window of opportunity" that still exists to address them, the Southwestern California Ecoregion Planning Group (SWEPG), a committee representing 25 local, state, federal, and private land management agencies and organizations, recommended developing a conservation strategy for forest and woodland habitats in southern California. The USDA Forest Service has taken the lead on this effort because it administers the majority of public forest lands in the region. Other participating agencies include the USDI Fish & Wildlife Service, California Department of Fish & Game, the California State Parks, and the National Biological Service. The objectives and process steps for this strategy are shown in *table 1*. The focus is on the sustainability and management of public lands, but the influence of private lands on the continued viability of forest and woodland-dependent plants and animals is also being considered.

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Table 1—Objectives and process steps for the southern California forest & woodland conservation strategy.

Conservation Strategy Objectives

1. *To develop, adopt, and implement a scientifically credible strategy for maintaining the biological diversity of forest and woodland habitats in southern California.*
2. *To compile and integrate existing information on local natural resources and land uses by developing data layers and analysis tools that are specific to southern California and useful to land management agencies in future project planning and the pursuit of managing sustainable ecosystems.*

Process Steps

1. ***Conduct an ecological assessment*** - *Target completion date: December 1997*.
   An ecoregion-scale, interdisciplinary assessment of the condition of biological resources in forest and woodland habitats of southern California. It will integrate GIS data layers of landscape patterns, species distributions, and human land uses with ecological models to evaluate spatial and temporal landscape changes and their effects on species' viability. This information is needed to develop a scientifically credible conservation strategy. The focus will be on public lands.
2. ***Develop conservation strategy with cooperating agencies*** - *Target completion date: May 1998*.
   Information from the ecological assessment will be used to develop an interagency conservation strategy that identifies specific objectives, actions, and responsibilities for maintaining biological diversity in the forests and woodlands of the southwestern California ecoregion. This will take the form of one or several Memoranda of Understanding (MOUs) with cooperating agencies.
3. ***Implement strategy recommendations consistent with existing management policies***
   Conservation strategy recommendations that do not conflict with existing management directives (e.g., Forest Land Management Plans, agency policies) can be implemented immediately.
4. ***Pursue updates or amendments to Forest Plans***
   To implement conservation strategy recommendations that require new Forest Plan Standards and Guidelines, the Forest Service will need to initiate the National Environmental Policy Act (NEPA)/National Forest Management Act (NFMA) process for updating or amending those plans. The four southern California National Forests are considering consolidating updates of each Forest's Plan into a single, regional effort.
5. ***Finalize a conservation agreement with the U.S. Fish & Wildlife Service***
   This agreement will document the specific actions and responsibilities for which each party agrees to be accountable in regard to species conservation in the forests and woodlands of southern California. With this agreement, the Fish & Wildlife Service formally recognizes the adequacy of actions being taken by the Forest Service, and other participating agencies, in regard to the protection of species that are covered in the agreement.

Montane coniferous forests in southern California lie predominately on public lands, but most of the region's foothill oak woodlands are privately owned (*fig. 1*). The public lands fall within many different jurisdictional units; there are four separate National Forests, one National Recreation Area, six State Parks, six counties each with small reserve systems, and an unknown number of State Fish & Game Ecological Reserves. Off public lands, some of the 16 Indian Reservations in the region contain extensive oak and conifer woodlands as do several private reserves, such as the Nature Conservancy's Santa Rosa Plateau Preserve. A regional-scale conservation strategy is needed because most of the local land management issues either cross jurisdictional unit boundaries (e.g., plant and animal populations) or are common to many of the jurisdictional units (e.g., fire management, recreation, and resource demands).

This paper describes our efforts to conduct an ecoregion-scale assessment of biological resources. The information compiled and analyzed in this assessment will provide the scientific framework for development of a conservation strategy. Our objective is to conduct a detailed analysis of the following four key ecological issues:

- **How important are undeveloped habitat corridors between the southern California mountain ranges?** Which species exist as regional metapopulations dependent on the movement of individuals between the ranges? Which of these species will be

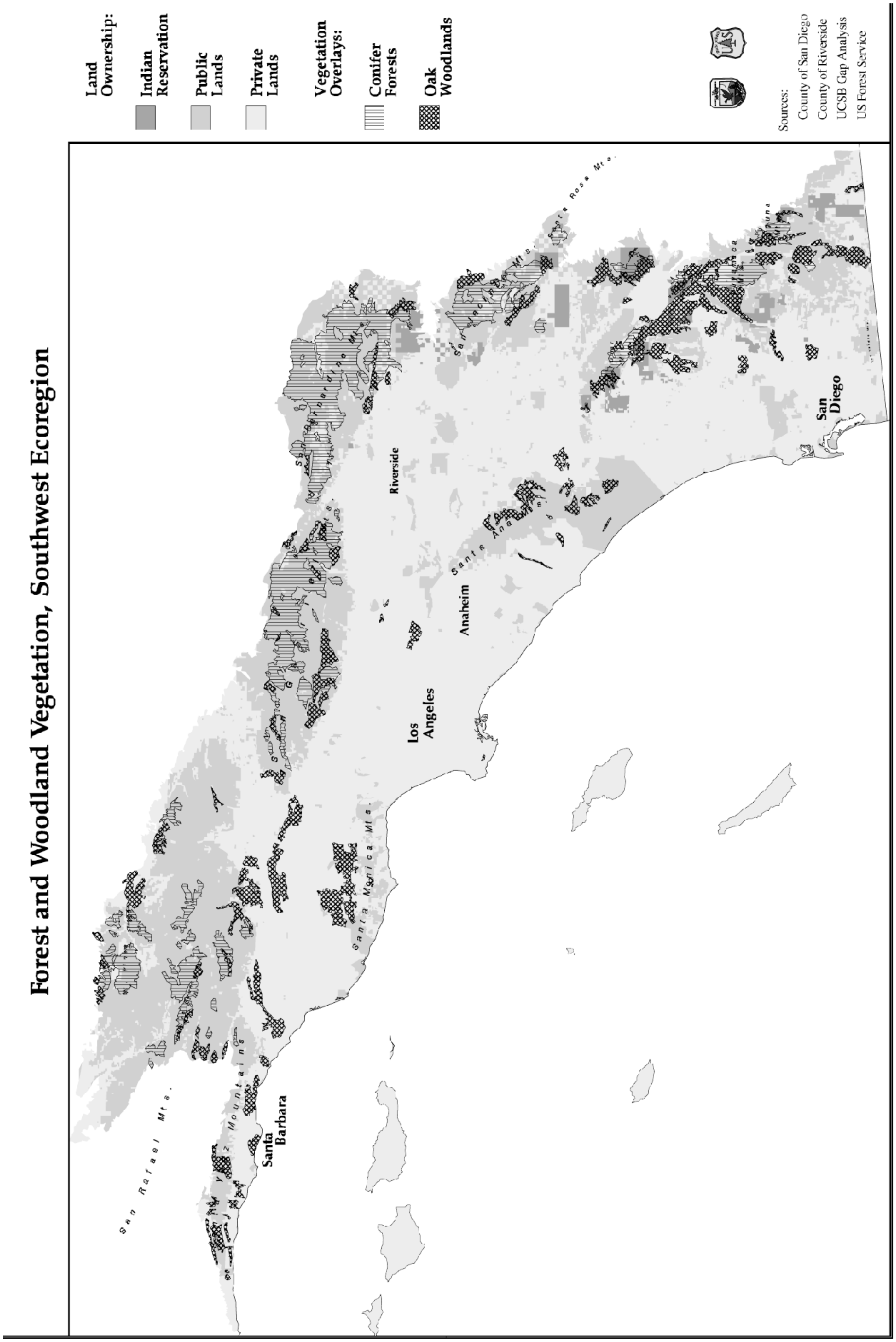


Figure 1—Shows the distribution of oak woodlands and coniferous forests in the southwestern California ecoregion and the underlying land ownership pattern.

seriously affected by further urban and rural development between the ranges? Are there specific linkages that are vital? Can important habitat corridors be identified for these species?

- **What are the ecological effects of further low-density, rural development in foothill oak woodland habitats?** Which species are likely to disappear (or decline dramatically) from oak (*Quercus* spp.) woodlands that become enveloped by low-density, rural development? Is there adequate habitat for these species on public lands?
- **What are the long-term, ecological ramifications of current fire management policies?** Which species and/or plant communities are likely to be seriously affected by current fire regimes? How can fire and habitats be managed to avoid or significantly reduce those effects?
- **What are the ecological effects of existing levels of resource utilization (e.g., grazing, mining, timber, water) and recreation use on public lands?** Which species and/or plant communities are likely to be seriously affected by existing land-use trends on public lands? How can land-use practices be modified to avoid or reduce those effects?

These are basic questions, but difficult ones to investigate because of the dynamic and unpredictable nature of ecological and human processes in both space and time. Hansen and Urban (1992) suggest that knowledge of local landscape patterns and the life histories of local species are needed to predict future animal community dynamics. We agree and add to that the need to understand how prevailing land uses are likely to change landscape patterns over time. Therefore, we have embarked on a 4-step assessment approach:

1. Compile and integrate the best available spatial data on landscape patterns in southern California.
2. Identify temporal trends in human land use and ecological processes (i.e., how have natural disturbance regimes and succession shaped landscape patterns; how have human land-use/ land management practices changed these patterns; what future changes should be expected).
3. Compile information on the distribution, life histories, and habitat requirements of forest- and woodland-dependent plants and animals in southern California. Identify those species, guilds, and communities that may be sensitive to changing landscape patterns or prevailing land uses.
4. Address the key ecological questions through the use of modeling and data analysis: Spatially explicit models will be used to investigate relationships between changes in landscape patterns and species' distributions;
    - Quantitative analyses of population trends (for the few species for which such data are available);
    - Qualitative viability assessments using expert panels.

This process is patterned after assessments conducted for the forests of the Pacific Northwest (Thomas and others 1993, Mellen and others 1995) and the Interior Columbia River Basin (Marcot and others 1995). In the remainder of this paper, I will briefly describe our progress to date for each of the process steps.

Compiling Spatial Data on Landscape Patterns

Reliable, fine-scale maps of landscape patterns are fundamental to assessing and understanding how ecological processes operate across large landscapes. Of particular importance for our analyses are maps of vegetation patterns, abiotic physical patterns (i.e., topography, hydrography, geology, and climate), and human land use/land ownership patterns. While becoming increasingly available in digital format, spatial data invariably exist in a variety of spatial resolutions (defined by minimum mapping units or MMU) and are frequently limited in extent to specific jurisdictional units such as a single county or National Forest.

In southern California, there are many coverages of limited extent and few of the entire ecoregion. A spatial database prepared as part of the national Gap Analysis Program (Davis and others 1995) is one of the few that provides complete ecoregion coverage. It provides mid-scale (100-ha MMU) information on the distribution of vegetation types and land ownership. However, species/habitat relationships models require finer-scale habitat maps. Consequently, we have compiled and combined a variety of more localized maps. Vegetation maps with a 2-ha MMU have recently been developed for the four National Forests and the Santa Monica Mountains National Recreation Area (Franklin and Woodcock, in press). We have integrated these with similar scale maps developed for San Diego, Orange, and Riverside counties. This compilation provides a 2-ha MMU vegetation map for more than 90 percent of non-urban lands in the southwestern ecoregion. We are using the Gap Analysis data to fill in the remaining areas.

Terrain coverages for slope, aspect, and elevation have been derived from 30-m, U.S. Geological Survey (USGS) Digital Elevation Models (DEMs). Hydrography (streams, lakes, and springs) was obtained at a 1:24,000 scale for National Forest lands from Cartographic Feature Files (CFFs) and at a 1:100,000 scale for the rest of the ecoregion from USGS stream reach files. Watershed boundaries were obtained from the State's CalWater project. Climatic data for the entire ecoregion have recently been developed, at a 1-km^2 resolution, by Joel Michaelsen at University of California at Santa Barbara. This dataset provides both monthly and annual averages for precipitation and temperature as well as winter low- and summer high-temperature extremes. Regional fire history maps dating back to the 1920's are also being digitized.

Landownership coverages were obtained from the State's Teale Data Center. Road networks were available from the CFFs at a 1:24,000 scale for the National Forests and at 1:100,000 scale from USGS for the remaining areas. Urban areas were identified in the various vegetation maps; however, rural areas embedded in natural vegetation were often not identified in these maps. Therefore, we used 10-m SPOT satellite imagery and road and structure locations from the CFFs to identify areas of rural development. Developed and dispersed recreation areas, grazing allotments, historic and current timber harvesting areas, water diversion/extraction sites, mines, and air pollution impact zones are also being digitized.

Identifying Temporal Trends in Human Land Use and Ecological Processes

To evaluate and predict landscape change, we must develop an understanding of the primary ecological and human forces that shape the southern California landscape. Aside from climate, topography, and substrate, which are generally beyond human control, the ecological processes of succession and natural disturbance are the primary forces which have shaped natural vegetation patterns. In southern California, fire is clearly the dominant disturbance agent, but floods have also played an important role in shaping riparian systems.

Human land-use practices have also profoundly influenced the landscape patterns we see today. Some of these effects are obvious (e.g., urbanization), while others are much more subtle (e.g., changes in stand structure or species composition). It is important to put today's landscape into context by documenting, to the extent possible, what conditions were like before the arrival of European people. Of course, landscape patterns were not static then either, but fluctuated within a natural range of variability (influenced by the practices of Native American peoples). Characterizing that natural range of variability will provide a baseline condition from which we can more reliabily evaluate how modern land-use activities have changed landscape patterns over time (Toth and others 1994). We are currently reviewing the literature and contacting local experts to determine historic conditions and natural ranges of variability. Of particular interest are historic conditions of the following factors: (1) stand density and tree size distributions for each forest and woodland vegetation type; (2) fire return intervals and burn intensities for each vegetation type; and (3) hydrologic regimes (e.g., streamflow patterns and flood frequencies).

Concurrent with this, information on historic and current land-use trends is being gathered. We intend to document, to the extent possible, the history of timber harvesting, livestock grazing, mining, recreation, water diversion/ extraction and development. Existing studies on air pollution effects in local forests will also be reviewed. For each land-use issue, high-use/impact areas will be identified and mapped. Also, we intend to review trends in acres burned to gauge the effectiveness of fire-suppression actions.

With this information, we should gain insight into how and where specific land uses have influenced changes in landscape patterns over the past century. These insights combined with knowledge of current and expected future land use trends will enable us to predict "landscape trajectories" (Hansen and Urban 1992). For example, it is widely believed that many years of effective fire suppression in western U.S. forests have put these landscapes on a trajectory of increasingly higher stand densities and fuel accumulations that will lead to increased tree mortality and, ultimately, large, high-intensity fires (Minnich 1988, Toth and others 1994, Verner and others 1992). In the foothill oak savannas of San Diego and Riverside counties, the prevalent trajectory of landscape change is a move from intensive livestock grazing to rural, ranchette-style development. By taking a close look at historic changes, it may be possible to detect additional trends that can improve our ability to predict future landscape change.

Compiling Species Life Histories and Information on Land-Use Effects

To predict how animal and plant populations respond to landscape changes, we must identify, to the extent possible, where they occur, what habitat and specific life history requirements they have, and how those requirements are affected by prevailing land uses. For example, many animal species utilize oak woodland habitat, but only a subset of those species can persist in woodlands enveloped by rural development. It is a species' specific life history requirements that determine its ability to tolerate such effects.

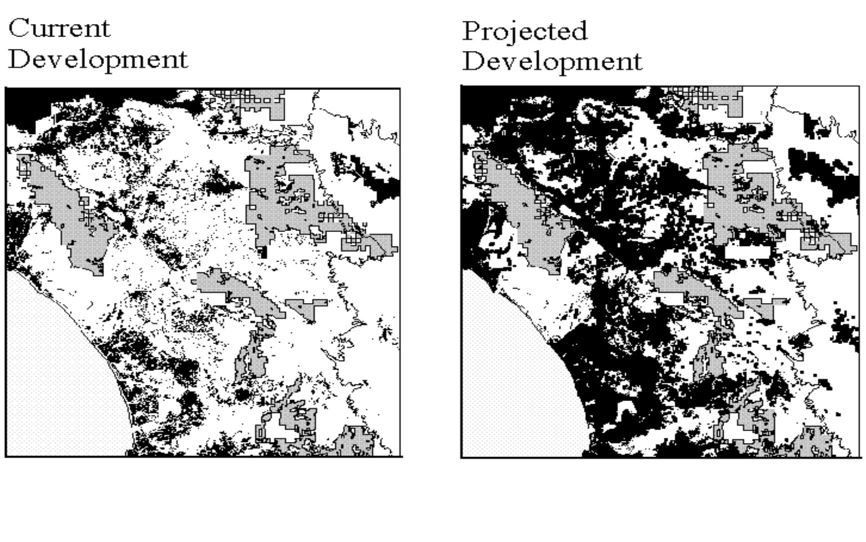
We are gathering species-specific information primarily from existing databases, the scientific literature, and local experts. However, with funding from the National Biological Service we are also working with cooperators at local universities to collect additional field data on the habitat relationships of forest and woodland bats, reptiles, amphibians, and butterflies. All of the information is being entered into a "habitat relationships and land-use effects" database. This Oracle database is specific to southern California and builds upon the statewide California Wildlife Habitat Relationships (WHR) and Natural Diversity Database (NDDB) systems, by emphasizing land-use effects and spatial characteristics such a minimum patch size, home range size, and dispersal capabilities. Sources and confidence levels of the habitat relationships and land-use effects information is also being gathered. We believe this is important because there is a great deal of variability in the amount and reliability of information available on different species.

The database will be used to link species-specific habitat characteristics with spatial GIS (geographic information system) data on landscape patterns. Focus species, guilds, and plant communities are identified on the basis of: (1) *Rarity* — including species formally listed as threatened, endangered, or proposed, Forest Service sensitive species, and State Species of Special Concern; (2) *Sensitivity to prevailing landscape trajectories*—includes species sensitive to habitat fragmentation, species groups dependent on habitat patterns that are negatively influenced by current fire regimes, and species sensitive to specific land uses; (3) *Representative of a habitat type or species group* — includes umbrella or indicator species for specific habitat types or species groups; (4) *Importance to biological diversity* — includes plant communities like riparian and oak woodlands that are particularly important to the maintenance of biodiversity. Current and historic locations of focus species are being compiled and digitized into GIS data layers. We are also obtaining species locations information from the Department of Fish & Game's GIS version of the Natural Diversity Database (NDDB).

Modeling and Analysis

The objective of this project is to meaningfully address the key ecological issues described earlier. Our ability to do this hinges on how effectively we can predict: (1) how the identified land uses and landscape trajectories are likely to change the distribution of habitats over time; and (2) how the focus species will be affected by these landscape changes given their habitat requirements, known distributions, and dispersal capabilities. These spatial interactions can be simulated by integrating information on temporal processes (ecological and human) with our existing data on current landscape patterns.

Figure 2—Shows the existing (left) and projected future (right) spatial pattern of private land development (shown in black) relative to National Forest lands in the southern portion of the ecoregion. Note how development is filling in the areas between Forest lands.



Ideally, we would like to use a stochastic, spatially explicit model to simulate landscape changes from disturbance, succession, and land use (sensu Mladenoff and others l996). However, such models have a large number of mechanistic parameters (e.g., vegetation growth rates, disturbance probabilities, rates of spread) that must be estimated for the specific landscape. Lacking the information and expertise to confidently estimate these parameters, we are using simple GIS-based, deterministic models to reclassify our existing spatial data in ways that simulate temporal land-use trends. Taking what is learned about how, and at what rate, land uses or ecological processes are likely to change specific habitats or geographic areas, we can simulate how these changes will be expressed across the landscape. For example, the spatial distribution of future private land development can be estimated simply by identifying likely areas on the basis of zoning, slope restrictions, and land ownership (*fig.* 2). We also intend to model spatial trends in resource utilization, recreation use, and disturbance/succession interactions. Admittedly, this is a crude way to generate future landscapes, and the predicted spatial and temporal patterns of highly dynamic processes like disturbance/succession interactions will be very hypothetical. However, if our rates of change are within a reasonable range and a series of possible landscape patterns are generated from them, we will have a means to assess the sensitivity of focus species and guilds to current land use trends.

GIS-based predictive models of habitat suitability (sensu Duncan and others 1995, Pereira and Itami 1991) will be developed for all focus species for which there is sufficient information to effectively characterize suitable habitats. Habitat suitability will be modeled for other species on the basis of a guild approach (Mellen and others 1995). These habitat models will incorporate spatial requirements such as minimum patch size, home range size, and maximum dispersal distance. Species will be grouped according to the spatial scale at which they operate (based on home range size) and by the type of habitat pattern they require (patterns being those distinguishable at the 2-ha MMU scale that we have mapped). For example, some species occupy only a single habitat type, while others require two major structural stages or habitat types in proximity (e.g., breeds in mature forests but forages in openings), and others are habitat generalists that use many different vegetation types.

These habitat models will provide an effective way to examine how species distributions are likely to be affected by potential changes in landscape patterns. However, we recognize that many species are strongly affected by habitat attributes that we have not mapped, and thus the described models will be poor predictors of their distribution. Viability concerns for these species will be evaluated qualitatively with the help of individuals who know the most about them.

For the spotted owl and mountain lion, two species that are well studied and identified as being potentially dependent on habitat corridors between the mountain ranges, we will use spatially explicit population models (SEPMs) (Beier 1993, McKelvey and others 1992, Schumaker 1995) to assess population viability and assist in the identification of critical habitats and corridors. SEPMs are stochastic models that incorporate digital maps of the landscape (that can be changed over time) with habitat-specific demographic parameters. Dispersal processes are also simulated. This makes it possible to investigate how landscape changes affect specific population processes like survivorship and dispersal success. However, the complexity of SEPMs and problems associated with parameter estimation have led others to note that they may give the "illusion of exactitude in the absence of hard information" (Doak and Mills 1994). We are cognizant of these issues and will use the models as tools for exploring specific questions rather than as definitive population viability analyses.

We are also analyzing population trends and habitat relationships for riparian bird species using point count observations taken annually from 1988 to 1995 at more than 200 locations in riparian areas across the four southern California National Forests. Observed trends will be compared with land-use changes in these areas to see whether correlations can be detected.

Finally, we will enlist the help of local experts on specific species groups to assist in interpreting the modeling results and to provide qualitative assessments of long-term viability for the focus species and guilds. This will be done either by consulting experts individually or through convening panels.

Conclusions

We have identified key ecological issues concerning the maintenance of biological diversity in the forests and woodlands of southern California and described our approach for addressing them. This approach focuses largely on landscape patterns—what they are today, how they came to be that way, how they are likely to change, and how species are affected by them. Although it is hard to dispute the importance of these factors, unfortunately there are enormous gaps and uncertainties in our knowledge of them. Nevertheless, we believe there is great utility in compiling what is known and using spatially explicit, computer-based analysis tools to explore possible scenarios and identify potentially important patterns and relationships. Unequivocal determinations will be scarce; the nature of the questions and the information we have to bear on them simply will not provide that. However, there is considerable opportunity to gain insights that will improve our ability to recommend conservation actions and to have a means to assess the effect of those actions.

Although many factors threaten the ecological integrity of forests and woodlands in southern California, we remain optimistic that it is possible to conserve and protect these habitats for the long term—as sources of renewable resources, public places for outdoor recreation, and viable refugias for the diverse assemblage of wildlife and plants that depend on them. To make this vison a reality, a regional-scale conservation strategy is needed. The success of that strategy will depend on the degree to which it is implemented in a proactive, adaptive manner, with monitoring to see what does and does not work, and course corrections made accordingly.

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