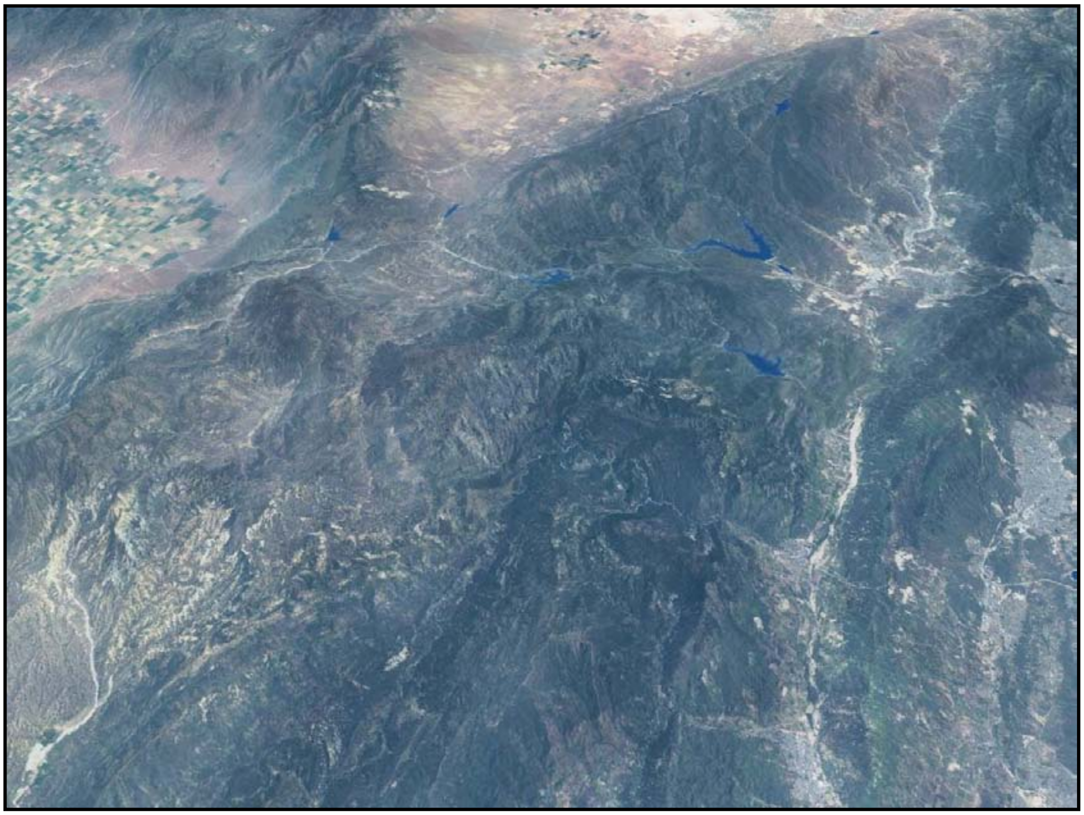
South Coast Missing Linkages Project

A Linkage Design for the Sierra Madre – Castaic Connection



South Coast Wildlands

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March 2005

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Produced by South Coast Wildlands: Our mission is to protect, connect and restore the rich natural heritage of the South Coast Ecoregion through the establishment of a system of connected wildlands.

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Workshop Speakers: Rick Rayburn (California State Parks), Paul Beier (Northern Arizona University), Ileene Anderson (California Native Plant Society), Gordon Pratt (University of California Riverside), Dave Morafka (California State University, Dominguez Hills), Rob Lovich (Camp Pendleton Marine Corps Base), David Clendenen (The Wildlands Conservancy, Wind Wolves Preserve), James Bland (Santa Monica College), Wayne Spencer (Conservation Biology Institute), and Claudia Luke (San Diego State University, Field Stations Program).

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Executive Summary

Habitat loss and fragmentation are the leading threats to biodiversity, both globally and in southern California. Efforts to combat these threats must focus on conserving well-connected networks of large wildland areas where natural ecological and evolutionary processes can continue operating over large spatial and temporal scales—such as top-down regulation by large predators, and natural patterns of gene flow, pollination, dispersal, energy flow, nutrient cycling, inter-specific competition, and mutualism. Adequate landscape connections will thereby allow these ecosystems to respond appropriately to natural and unnatural environmental perturbations, such as fire, flood, climate change, and invasions by alien species.

The tension between fragmentation and conservation is particularly acute in California, because our state is one of the 25 most important hotspots of biological diversity on Earth. And nowhere is the threat to connectivity more severe than in southern California—our nation's largest urban area, and still one of its fastest urbanizing areas. But despite a half-century of rapid habitat conversion, southern California retains some large and valuable wildlands, and opportunities remain to conserve and restore a functional wildland network here.

Although embedded in one of the world's largest metropolitan areas, Southern California's archipelago of conserved wildlands is fundamentally one interconnected ecological system, and the goal of South Coast Missing Linkages is to keep it so. South Coast Missing Linkages is a collaborative effort among a dozen governmental and non-governmental organizations. Our aim is to develop Linkage Designs for 15 major landscape linkages to ensure a functioning wildland network for the South Coast Ecoregion, along with connections to neighboring ecoregions. The Sierra Madre-Castaic Connection, while not our most threatened linkage, is a critical landscape connection to restore and protect.

On September 30, 2002, 90 participants representing over 40 agencies, academic institutions, land managers, land planners, conservation organizations, and community groups met to establish biological foundations for planning landscape linkages in the Sierra Madre-Castaic Connection. They identified 15 focal species that are sensitive to habitat loss and fragmentation here, including 2 insects, 1 amphibian, 3 reptiles, 2 birds and 4 mammals. These focal species cover a broad range of habitat and movement requirements: some are widespread but require huge tracts of land to support viable populations (e.g., mountain lion, badger, California spotted owl); others are species with very limited spatial requirements (e.g., Monterey salamander). Many are habitat specialists (e.g., pond turtle in riparian habitat, or acorn woodpecker in oak woodlands) and others require specific configurations of habitat elements (e.g. two-striped garter snake). Together, these 12 species cover a wide array of habitats and movement needs in the region, so that planning adequate linkages for them is expected to cover connectivity needs for the ecosystems they represent.

To identify potential routes between existing protected areas we conducted landscape permeability analyses for 5 focal species for which appropriate data were available. Permeability analyses model the relative cost for a species to move between protected core habitat or population areas. We defined a least-cost corridor—or best potential route—for each species, and then combined these into a Least Cost Union covering all 5 species. We then analyzed the size and configuration of suitable habitat patches within this Least Cost Union for all 12 focal species to verify that the final Linkage Design would suit the live-in or move-through habitat needs of all. Where the Least Cost Union omitted areas essential to the needs of a particular species, we expanded the Linkage Design to accommodate that species' particular requirements to produce a final Linkage Design (Figure ES-1).

We also visited priority areas in the field to identify and evaluate barriers to movement for our

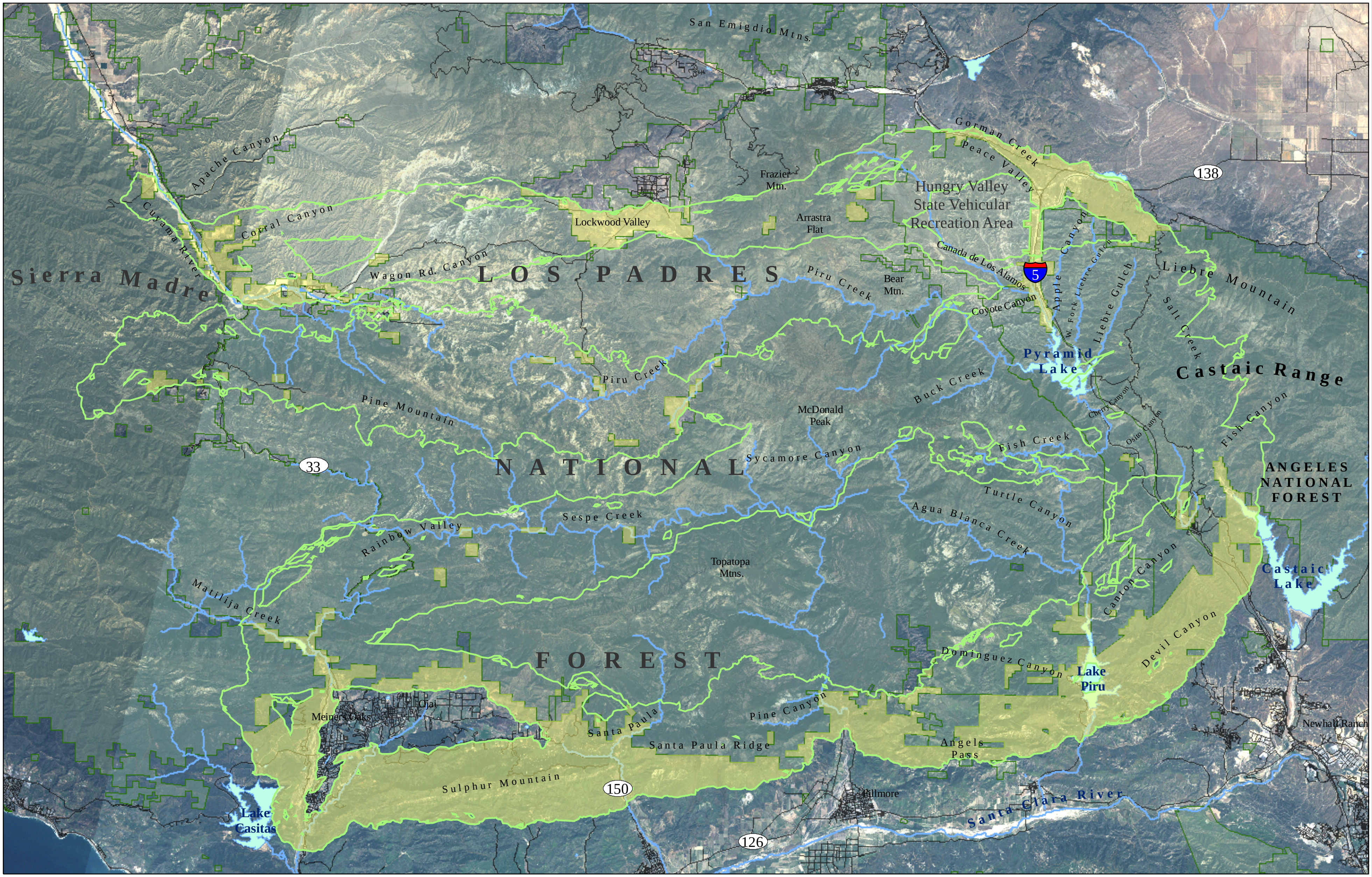

Figure ES-1. Linkage Design for the Sierra Madre - Castaic Connection

- Linkage Design Boundary
- Unprotected Area
- Ownership Boundaries
- Reservoirs and Lakes
- Perennial Streams
- Roads

Scale 1: 340,000

0 2 4 8 12 16 Kilometers

0 2 4 8 12 16 Miles

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focal species. In this plan we suggest restoration strategies to mitigate those barriers, with special emphasis on opportunities to reduce the adverse effects of Interstate-5.

The ecological, educational, recreational, and spiritual values of protected wildlands in the South Coast Ecoregion are immense. Our Linkage Design for the Sierra Madre-Castaic Connection represents an opportunity to protect a truly functional landscape-level connection. The cost of implementing this vision will be substantial—but the cost is small compared with the benefits. If implemented, our plan would not only permit movement of individuals and genes between the Sierra Madre and Castaic Ranges, but should also conserve large-scale ecosystem processes that are essential to the continued integrity of existing conservation investments throughout the region. We hope that our biologically based and repeatable procedure will be applied in other parts of California and elsewhere to ensure continued ecosystem integrity in perpetuity.

Introduction

Nature Needs Room to Roam

Movement is essential to wildlife survival, whether it be the day-to-day movements of individuals seeking food, shelter, or mates, dispersal of offspring (e.g., seeds, pollen, fledglings) to new home areas, or migration of organisms to avoid seasonally unfavorable conditions (Forman 1995). Movements can lead to recolonization of unoccupied habitat after environmental disturbances, the healthy mixing of genes among populations, and the ability of organisms to respond or adapt to environmental stressors. Movements in natural environments lead to complex mosaics of ecological and genetic interactions at various spatial and temporal scales.

In environments fragmented by human development, disruption of movement patterns can alter essential ecosystem functions, such as top-down regulation by large predators, gene flow, pollination and seed-dispersal, competitive or mutualistic relationships among species, resistance to invasion by alien species, energy flow, and nutrient cycling. Without the ability to move among and within natural habitats, species become more susceptible to fire, flood, disease and other environmental disturbances and show greater rates of local extinction (Soulé and Terborgh 1999). The principles of island biogeography (MacArthur and Wilson 1967), models of demographic stochasticity (Shaffer 1981, Soulé 1987), inbreeding depression (Schonewald-Cox et al. 1983; Mills and Smouse 1994), and metapopulation theory (Levins 1970, Taylor 1990, Hanski and Gilpin 1991) all predict that isolated populations are more susceptible to extinction than connected populations. Establishing connections among natural lands has therefore long been recognized as important for sustaining natural ecological processes and biological diversity (Noss 1987, Harris and Gallagher 1989, Noss 1991, Beier and Loe 1992, Noss 1992, Beier 1993, Forman 1995, Beier and Noss 1998, Hunter 1999, Crooks and Soulé 1999, Soulé and Terborgh 1999, Penrod et al. 2001, Crooks et al. 2001, Tewksbury et al. 2002, Forman et al. 2003).

Patterns of Habitat Conversion

As a consequence of rapid habitat conversion to urban and agricultural uses, the South Coast Ecoregion of California (Figure 1) has become a hotspot for species at risk of extinction. California has the greatest number of threatened and endangered species in the continental U.S, representing nearly every taxonomic group, from plants and invertebrates to birds, mammals, fish, amphibians, and reptiles (Wilcove et al. 1998). In an analysis that identified "irreplaceable" places for preventing species extinctions (Stein et al. 2000), the South Coast Ecoregion stood out as one of the six most important areas in the United States (along with Hawaii, the San Francisco Bay Area, Southern Appalachians, Death Valley, and the Florida Panhandle). The ecoregion is part of the California Floristic Province, one of 25 global hotspots of biodiversity, and the only one in North America (Mittermeier et al. 1998, Mittermeier et al. 1999).

A major reason for regional declines in native species is the pattern of habitat loss. Species that once moved freely through a mosaic of natural vegetation types are now confronted with a man-made labyrinth of barriers, such as roads, homes, businesses, and agricultural fields that fragment formerly expansive natural landscapes. Movement patterns crucial to species survival are being permanently altered at unprecedented rates. Countering this threat requires a systematic approach for identifying, protecting, and restoring functional connections across the landscape to allow essential ecological processes to continue operating as they have for millennia.

A Statewide Vision

In November 2000, a coalition of conservation and research organizations (California State Parks, California Wilderness Coalition, The Nature Conservancy, Zoological Society of San Diego Center for Reproduction of Endangered Species, and U.S. Geological Survey) launched a statewide interagency workshop at the San Diego Zoo—Missing Linkages: Restoring Connectivity to the California Landscape. The workshop brought together over 200 land managers and conservation ecologists representing federal, state, and local agencies, academic institutions, and non-governmental organizations—to delineate habitat linkages critical for preserving the State's biodiversity. Of the 232 linkages identified at the workshop, 69 are associated with the South Coast Ecoregion (Penrod et al. 2001).

Figure 1. The South Coast Ecoregion encompasses roughly 8% of California and extends 300 km (190 mi) into Baja California.

South Coast Missing Linkages: A Vision for the Ecoregion

Following the statewide Missing Linkages conference, South Coast Wildlands, a non-profit organization established to pursue habitat connectivity planning in the South Coast Ecoregion, brought together regional ecologists to conduct a formal evaluation of these 69 linkages. The evaluation was designed to assess the biological irreplaceability and vulnerability of each linkage (*sensu* Noss et al. 2002). Irreplaceability assessed the relative biological value of each linkage, including both terrestrial and aquatic criteria: 1) size of habitat blocks served by the linkage; 2) quality of existing habitat in the smaller habitat block; 3) quality and amount of existing habitat in the proposed linkage; 4) linkage to other ecoregions or key to movement through the ecoregion; 5) facilitation of seasonal movement and responses to climatic change; and 6) addition of value for aquatic ecosystems. Vulnerability was evaluated using recent high-resolution aerial

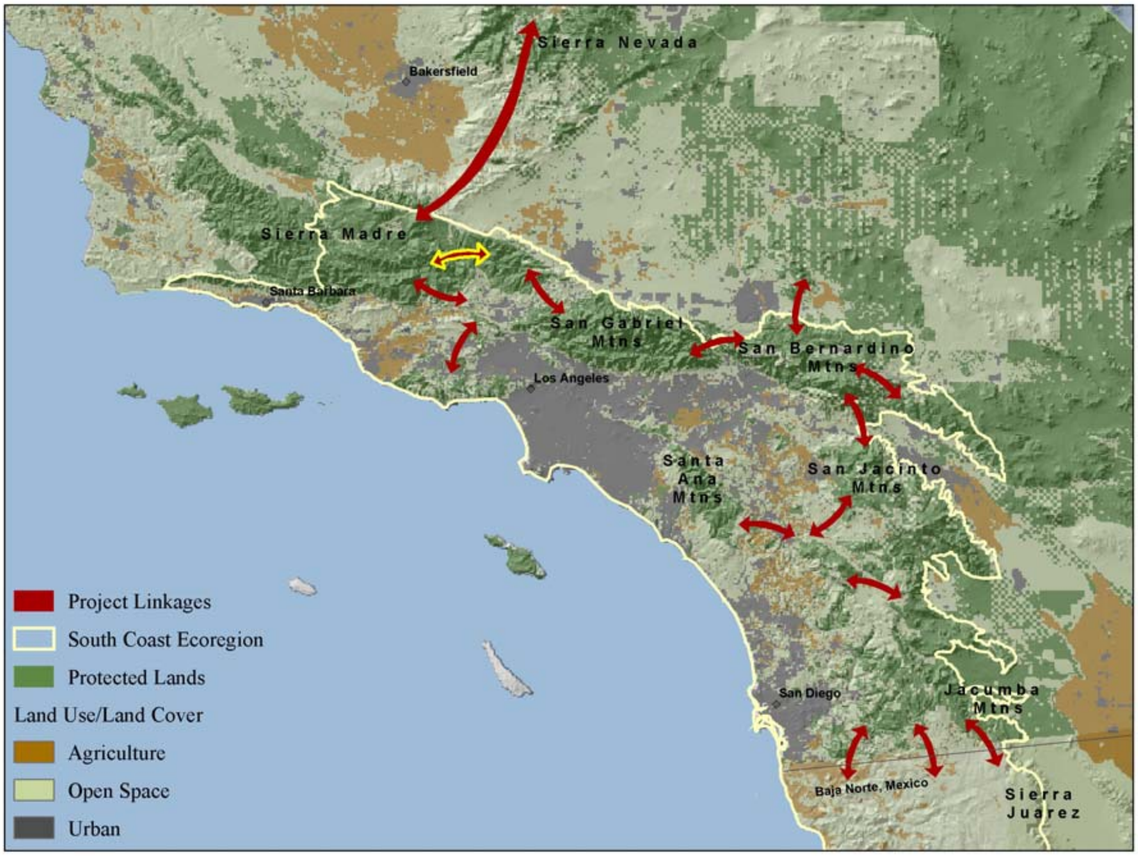

Figure 2. The South Coast Missing Linkages Project addresses habitat fragmentation at a landscape scale, and the needs of a variety of species. The Sierra Madre-Castaic Connection is one of 15 landscape linkages identified as irreplaceable and imminently threatened.

photographs, local planning documents, and other data concerning threats of habitat loss or fragmentation in the linkage area. This process identified 15 linkages of crucial biological value that are likely to be irretrievably compromised by development projects over the next decade unless immediate conservation action occurs (Figure 2). The biological integrity of several thousand square miles of the very best southern California wildlands would be irreversibly jeopardized if these linkages were lost.

Identification of these 15 priority linkages launched the South Coast Missing Linkages Project. This project is a highly collaborative effort among federal and state agencies and non-governmental organizations to identify and conserve landscape-level habitat linkages to protect essential biological and ecological processes in the South Coast Ecoregion. Partners include but are not limited to: South Coast Wildlands, The Wildlands Conservancy, The Resources Agency California Legacy Project, California State Parks, California State Parks Foundation, United States Forest Service, National Park Service, Santa Monica Mountains Conservancy, Rivers and Mountains Conservancy, Conservation Biology Institute, San Diego State University Field Stations Program, The Nature Conservancy, Southern California Wetlands Recovery Project, Environment Now, Mountain Lion Foundation, and the Zoological Society of San Diego Conservation and Research for Endangered Species. Cross-border alliances have also been formed with Pronatura, Universidad Autonoma de Baja California, and Conabio to further the South Coast Missing Linkages initiative in northern Baja. It is our hope that the South Coast Missing Linkages Project will serve as a catalyst for directing funds and attention toward the protection of ecological connectivity for the South Coast Ecoregion and beyond.

The 15 Priority Linkages

Santa Monica Mountains-Santa Susana Mountains
Santa Susana Mountains-Sierra Madre Mountains
Sierra Madre Mountains-Castaic Ranges
Sierra Madre Mountains-Sierra Nevada Mountains
San Gabriel Mountains-Castaic Ranges
San Bernardino Mountains-San Gabriel Mountains
San Bernardino Mountains-San Jacinto Mountains
San Bernardino Mountains-Little San Bernardino Mountains
San Bernardino Mountains-Granite Mountains
Santa Ana Mountains-Palomar Ranges
Palomar Ranges-San Jacinto/Santa Rosa Mountains
Peninsular Ranges-Anza Borrego
Laguna Mountains-Otay Mountain-Northern Baja
Campo Valley-Laguna Mountains
Jacumba Mountains-Sierra Juarez Mountains

To this end, South Coast Wildlands is coordinating and hosting regional workshops, providing resources to partnering organizations, conducting systematic GIS analyses for all 15 linkages, and helping to raise public awareness regarding habitat connectivity needs in the ecoregion. South Coast Wildlands has taken the lead in researching and planning for 8 of the 15 linkages; San Diego State University Field Station Programs, National Park Service, California State Parks, U. S. Forest Service, Santa Monica Mountains Conservancy, Conservation Biology Institute, and The Nature Conservancy have taken the lead on the other 7 linkages. The Sierra Madre-Castaic Connection is one of these 15 linkages, whose protection is crucial to maintaining ecological and evolutionary processes among large blocks of protected habitat within the South Coast Ecoregion.

Ecological Significance of the Sierra Madre-Castaic Connection

The Sierra Madre and Castaic ranges support a rich mosaic of vegetative communities (Figure 3). Pinyon-juniper woodlands, sagebrush, and desert scrub habitats cover northern portions of the planning area, in the rain shadow of the mountain ranges. Mixed conifer, montane hardwood conifer, and Jeffrey pine forests dominate the higher mountain areas, with mixed chaparral, montane hardwood and riparian forests at mid elevations and coastal scrub and oak woodlands in the lower foothills. A number of sensitive natural communities occur in the planning area, including southern cottonwood willow riparian forest, southern sycamore alder riparian forest, coast live oak riparian forest, canyon live oak riparian forest, valley oak woodland, coastal and valley freshwater marsh, coastal sage scrub, and valley needlegrass grassland (CDFG 2004). These include some of the rarest vegetation communities in the United States.

This variety of habitats support a diversity of organisms, including many species listed as endangered, threatened, or sensitive by government agencies (USFWS 1996, 1998, 1999, 2000, 2001, CDFG 2004). One of the most charismatic and endangered of these is the California condor (*Gymnogyps californianus*), which was extirpated from the wild during the 1980s but has since been reintroduced to the planning area with the aid of a captive breeding program. The entire planning area once provided habitat for this

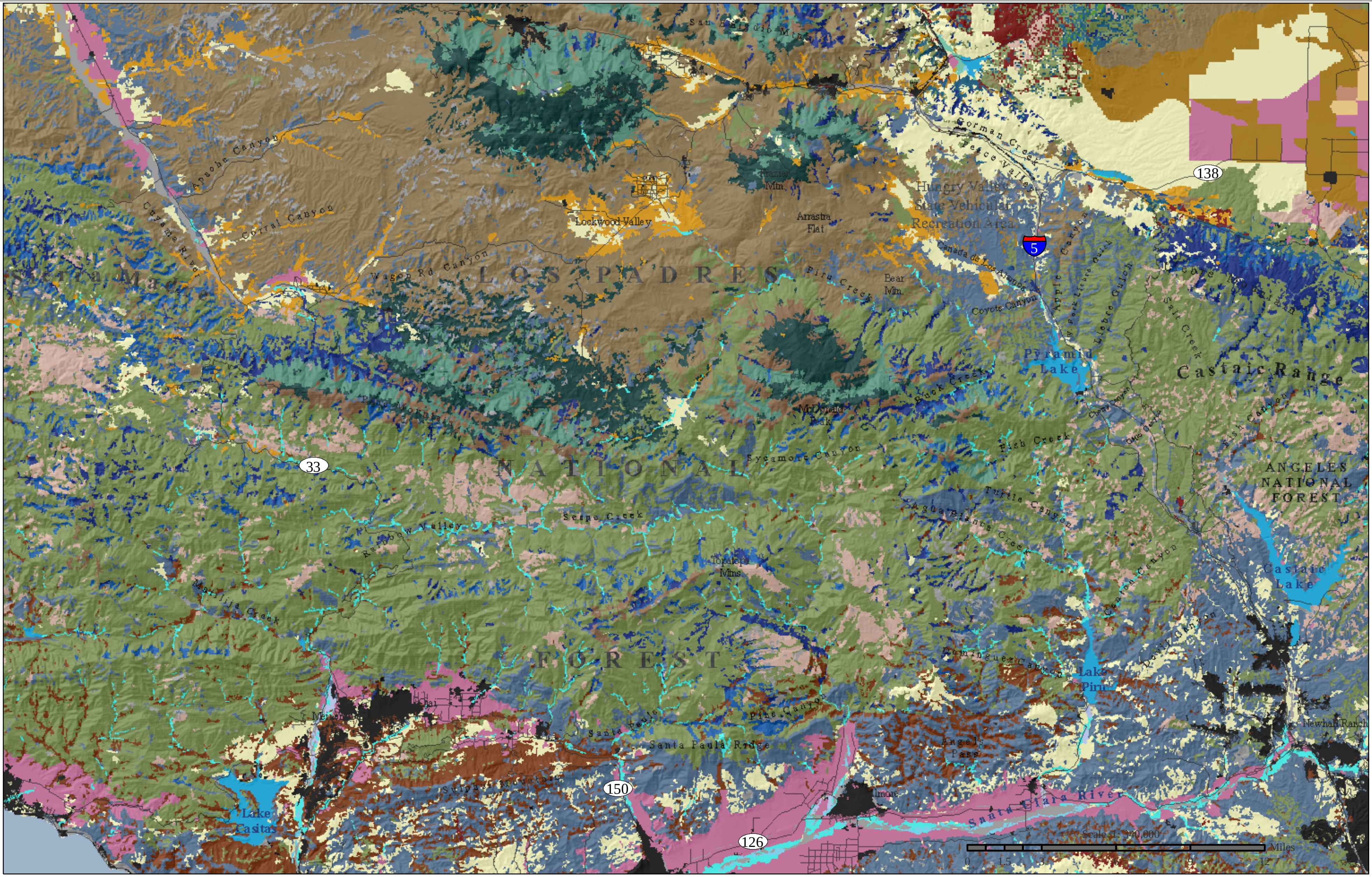

Figure 3.
Vegetation Types
in the
Linkage Planning Area

- Alkali Desert Scrub
- Bitterbrush
- Desert Scrub
- Desert Succulent Shrub
- Joshua Tree
- Juniper
- Pinyon-Juniper
- Sagebrush
- Closed-Cone Pine-Cypress
- Jeffrey Pine
- Montane Hardwood-Conifer
- Ponderosa Pine
- Mixed Conifer
- Subalpine Conifer
- Unknown Conifer Type
- White Fir
- Desert Wash
- Freshwater Emergent Wetland
- Lacustrine
- Montane Riparian
- Saline Emergent Wetland
- Valley Foothill Riparian
- Water
- Wet Meadow
- Blue Oak Woodland
- Blue Oak-Foothill Pine
- Coastal Oak Woodland
- Montane Hardwood
- Unknown Shrub Type
- Valley Oak Woodland
- Annual Grassland
- Chamise-Redshank Chaparral
- Coastal Scrub
- Mixed Chaparral
- Montane Chaparral
- Agriculture
- Barren
- Eucalyptus
- Urban

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magnificent species, and it is hoped that releases at the Sespe Condor Sanctuary on Los Padres National Forest and other sites will re-establish a sustainable population here soon.

A number of rare species depend on the area's high-quality aquatic habitats for at least part of their life cycle, including the Southern steelhead trout (*Oncorhynchus mykiss mykiss*), which return annually to spawn in Sespe Creek, California red-legged frog (*Rana aurora draytonii*), arroyo toad (*Bufo microscaphus*), southwestern pond turtle (*Actinemys marmorata pallida*), and two-striped garter snake (*Thamnophis hammondii*). Sensitive reptiles that prefer drier habitats and sparser vegetative cover, such as coastal western whiptail (*Cnemidophorus tigris multiscutatus*), long-nosed leopard lizard (*Gambelia wislizenii*), and San Diego horned lizard (*Phrynosoma coronatum blainvillei*) also have the potential to occur, as do several riparian songbirds, such as southwestern willow flycatcher (*Empidonax traillii extimus*) and least Bell's vireo (*Vireo bellii pusillus*).

In addition to providing habitat for rare and endangered species, the linkage provides live-in and move-through habitat for numerous native species that may be less extinction prone but that nevertheless require extensive wildlands to thrive, such as American badger, mule deer, and mountain lion.

Existing Conservation Investments

Significant conservation investments already exist in the region (Figure 4), but the resource values they support could be irreparably harmed by loss of connections between them. This linkage connects two expansive core areas that are largely conserved within the Los Padres and Angeles National Forests. The California Department of Fish and Game and Bureau of Land Management also administer land contiguous with the Angeles National Forest boundary, just south of Quail Lake. Although portions of the Hungry Valley Off-Highway Vehicle State Park, in the northern part of the assessment area, are degraded by high-intensity recreation, much of the park still supports high quality habitat and associated species. The value of already protected land in the region for biodiversity conservation, environmental education, outdoor recreation, and scenic beauty is immense.

Roughly 12 linear miles of public lands occur on either side of I-5 within the planning area, and much of this is roadless wildlands. The Sespe Wilderness Area is just west of I-5. Its primary tributary, Sespe Creek, is designated as a Wild and Scenic River and is one of the last remaining undammed streams in southern California. It supports steelhead trout, red-legged frogs, arroyo toads, and pond turtles. Other surrounding roadless areas have been recommended for wilderness status by the California Wild Heritage Campaign. Conserving these effectively would connect the Sespe Wilderness Area with other nearby Wilderness Areas, including the Chumash, Matilija, Dick Smith, and San Rafael Wilderness Areas in the Los Padres National Forest.

Just east of Interstate 5, in the Castaic Ranges of the Angeles National Forest, 4 significant roadless areas have been proposed for Wilderness status: Salt Creek, Fish Canyon, Tule, and Red Mountain. The Liebre Mountain area has also been proposed as a Special Interest Area because of its unique plant associations. A relatively modest investment in connective habitats now can help ensure the integrity of these sites in perpetuity.

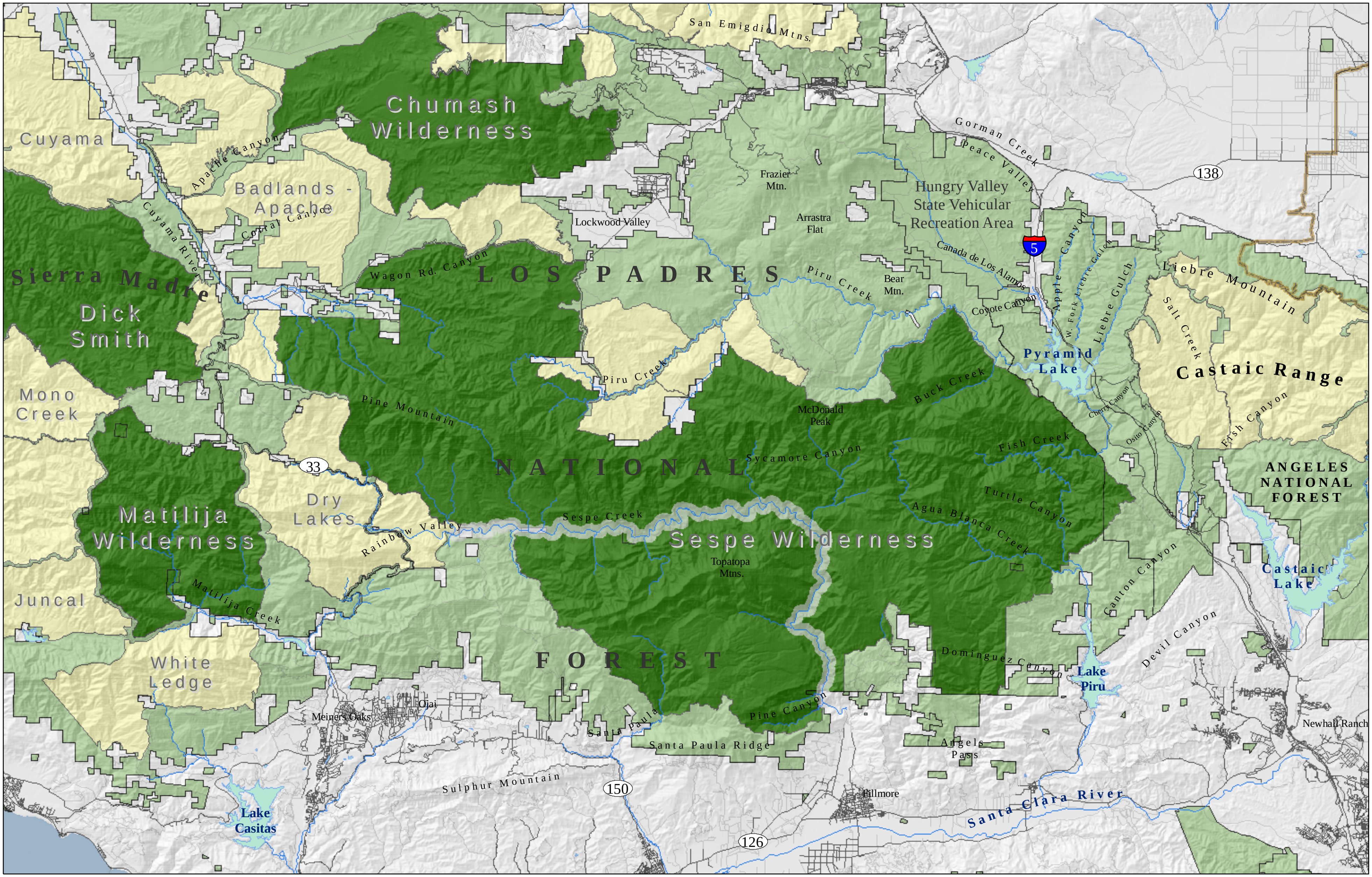

Figure 4. Existing Conservation Investments in the Linkage Planning Area

Designated Wilderness
Proposed Wilderness
Ownership Boundaries
Reservoirs and Lakes
Wild & Scenic River
Perennial Streams
Pacific Crest Trail
Roads

Scale 1: 340,000

Kilometers: 0 2 4 8 12 16

Miles: 0 2 4 8 12 16

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Southern California's remaining wildlands form an archipelago of natural open space thrust into one of the world's largest metropolitan area within a global hotspot of biological diversity. These wild areas are naturally interconnected; indeed, they historically functioned as one ecological system. However, recent intensive and unsustainable activities threaten to sever natural connections, forever altering the functional integrity of this remarkable natural system. The ecological, educational, recreational, and spiritual impacts of such a severance would be substantial. Certainly, restoring functional habitat connectivity to this regionally important landscape linkage is a wise investment.

The goal of linkage conservation planning is to identify specific lands that must be conserved to maintain or restore functional connections for all species or ecological processes of interest, generally between two or more protected core habitat areas. We adopted a spatially hierarchical approach, gradually working from landscape-level processes down to the needs of individual species on the ground. The planning area encompasses habitats between the Sierra Madre Mountains of Los Padres National Forest and the Castaic Ranges (Liebre, Sawmill, and Sierra Pelona mountains) of the Angeles National Forest. We conducted various landscape analyses to identify those areas necessary to accommodate continued movement of selected focal species through this landscape. Our approach can be summarized as follows:

1) *Focal Species Selection:* Select focal species from diverse taxonomic groups to represent a diversity of habitat requirements and movement needs.

2) *Landscape Permeability Analysis:* Conduct landscape permeability analyses to identify a zone of habitat that addresses the needs of multiple species potentially traveling through or residing in the linkage.

3) *Patch Size & Configuration Analysis:* Use patch size and configuration analyses to identify the priority areas needed to maintain linkage function.

4) *Field Investigations:* Conduct fieldwork to ground-truth results of prioritization analyses, identify barriers, and document conservation management needs.

5) *Linkage Design:* Compile results of analyses and fieldwork into a comprehensive report detailing what is required to conserve and improve linkage function.

Our approach has been highly collaborative and interdisciplinary (Beier et al. In Press). We followed Baxter (2001) in recognizing that successful conservation planning is based on the participation of experts in biology, conservation design, and implementation in a reiterative process (Figure 5). To engage regional biologists and planners early in the process, we held a habitat connectivity workshop on September 30, 2002. The workshop gathered indispensable information on conservation needs and opportunities in the linkage. The workshop engaged 90 participants representing over 40 different agencies, academic institutions, conservation organizations, and community groups (Appendix A).

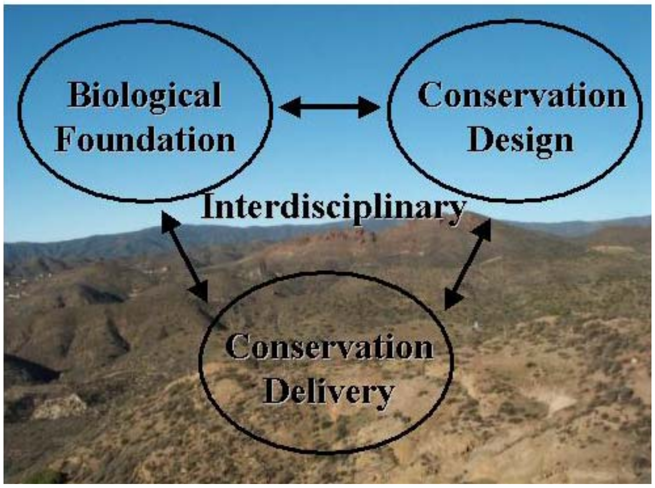

Figure 5. Successful conservation planning requires an interdisciplinary and reiterative approach among biologists, planners and activists (Baxter 2001).

Focal Species Selection

Workshop participants identified a taxonomically diverse group of focal species (Table 1) that are sensitive to habitat loss and fragmentation and that represent the diversity of ecological interactions that can be sustained by successful linkage design. The focal species approach (Beier and Loe 1992) recognizes that species move through and utilize habitat in a wide variety of ways. Workshop participants divided into taxonomic working groups; each group identified life history characteristics of species that were particularly sensitive to habitat fragmentation or otherwise meaningful to linkage design. Participants then summarized information on species occurrence, movement characteristics, and habitat preferences and delineated suitable habitat and potential movement routes through the linkage region. (For more on the workshop process see Appendix B.)

Table 1. Regional ecologists selected 12 focal species for the Sierra Madre-Castaic Connection

Common Name	Scientific Name
Mammals	
Mountain lion	*Puma concolor*
American badger	*Taxidea taxa*
Mule deer	*Odocoileus hemionus*
Pacific kangaroo rat	*Dipodomys agilis*
Birds	
California spotted owl	*Strix occidentalis occidentalis*
Acorn woodpecker	*Melanerpes formicivorus*
Amphibians & Reptiles	
Monterey salamander	*Ensatina eschscholtzii eschscholtzii*
California mountain kingsnake	*Lampropeltis zonata*
Two-striped garter snake	*Thamnophis hammondii*
Western pond turtle	*Actinemys marmorata pallida*
Invertebrates	
Bear sphinx moth	*Arctonotus lucidus*
Rain beetle	*Pleocoma linsleyi*

The 12 focal species identified at the workshop included 2 insects, 1 amphibian, 3 reptiles, 2 birds and 4 mammals. These species capture a diversity of movement needs and ecological requirements, from species that require large tracts of land (e.g., mountain lion, badger, California spotted owl) to those with very limited spatial requirements (e.g., Monterey salamander). They include habitat specialists (e.g., acorn woodpecker in oak woodlands) and those requiring a specific configuration of habitat types and elements (e.g., pond turtles and two-striped garter snakes that require aquatic and upland habitats). Dispersal distance capability of focal species ranges from 120 m to 274 km; modes of dispersal include flying, swimming, climbing, and walking.

Landscape Permeability Analysis

Landscape permeability analysis is a GIS technique that models the relative cost for a species to move between core areas based on how each species is affected by habitat characteristics, such as slope, elevation, vegetation composition, and road density. This analysis identifies a least-cost corridor, or the best potential route for each species between protected core areas (Walker and Craighead 1997, Craighead et al. 2001, Singleton et al. 2002). The purpose of the analysis was to identify which land areas would best accommodate all focal species living in or moving through the linkage. Species used in landscape permeability analysis must be carefully chosen, and were included in this analysis only if:

- We know enough about the movement of the species to reasonably estimate the cost-weighted distance using the data layers available to our analysis.
- The data layers in the analysis reflect the species' ability to move.

- The species occurs in both cores (or historically did so and could be restored) and can potentially move between cores, at least over multiple generations.
- The time scale of gene flow between core areas is shorter than, or not much longer than, the time scale at which currently mapped vegetation is likely to change due to disturbance events and environmental variation (e.g. climatic changes).

Five species were found to meet these criteria and were used in permeability analyses to identify the least-cost corridor between selected roadless areas: mountain lion, badger, mule deer, Pacific kangaroo rat, and California spotted owl. Model parameters used for each species are shown in Table 2.

The relative cost of travel was assigned for each of these 5 focal species based upon its ease of movement through a suite of landscape characteristics (e.g., vegetation type, road density, and topographic features). The following spatial data layers were assembled at 30-m resolution: vegetation, roads, elevation, and topographic features (Figure 6). We derived 4 topographic classes from elevation and slope models: canyon bottoms, ridgelines, flats, or slopes. Road density was measured as kilometers of paved road per square kilometer. Within each data layer, we ranked all categories between 1 (preferred) and 10 (avoided) based on focal species preferences as determined from available literature and expert opinion regarding how movement is facilitated or hindered by natural and urban landscape characteristics. These data layers were then used to create a cost surface; each input category was ranked and weighted, such that:

(Land Cover * w%) + (Road Density * x%) + (Topography * y%) + (Elevation * z%) = Cost to Movement

where w + x + y + z = 100%

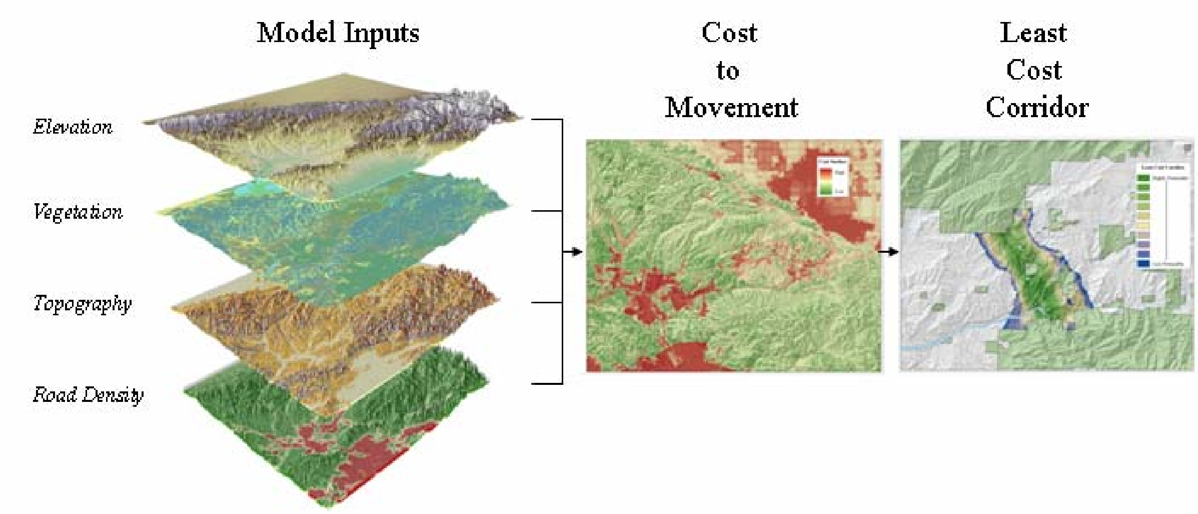

Figure 6. Permeability Model Inputs: elevation, vegetation, topography, and road density. Landscape permeability analysis models the relative cost for a species to move between core areas based on how each species is affected by various habitat characteristics.

Table 2. Model Parameters for Landscape Permeability Analyses					
	Strix occidentalis (California spotted owl)	*Dipodomys agilis* (Pacific kangaroo rat)	*Odocoileus hemionus* (Mule deer)	*Taxidea taxus* (Badger)	*Puma concolor* (Mountain lion)
MODEL VARIABLES					
VEGETATION					
Alpine-Dwarf Shrub	6	10	9	4	4
Agriculture	10	10	9	7	10
Annual Grassland	10	4	9	1	7
Alkali Desert Scrub	10	9	10	2	7
Barren	10	7	10	9	10
Bitterbrush	10	10	3	3	2
Blue Oak-Foothill Pine	3	7	1	5	3
Blue Oak Woodland	3	7	1	5	2
Coastal Oak Woodland	3	7	1	5	2
Closed-Cone Pine-Cypress	10	10	3	6	5
Chamise-Redshank Chaparral	6	5	6	4	5
Coastal Scrub	10	2	3	4	2
Desert Riparian	10	7	4	3	1
Desert Scrub	10	6	9	2	7
Desert Succulent Shrub	10	6	8	2	7
Desert Wash	10	9	5	3	2
Eastside Pine	1	10	1	5	5
Estuarine	10	10	10	10	5
Freshwater Emergent Wetland	10	10	9	9	2
Jeffrey Pine	1	9	2	5	5
Joshua Tree	10	3	8	2	4
Juniper	10	7	5	3	3
Lacustrine	10	10	10	9	10
Lodgepole Pine	3	10	5	6	5
Mixed Chaparral	6	5	6	4	5
Montane Chaparral	6	5	5	4	5
Montane Hardwood-Conifer	1	9	1	6	3
Montane Hardwood	2	9	1	6	3
Montane Riparian	1	10	2	6	1
Perennial Grassland	10	4	7	1	6
Pinyon-Juniper	10	7	4	3	3
Palm Oasis	10	10	7	6	3
Ponderosa Pine	1	9	2	5	5
Riverine	10	10	9	9	1
Red Fir	1	10	4	6	5
Subalpine Conifer	6	10	6	6	5
Saline Emergent Wetland	10	10	10	10	6
Sagebrush	10	10	5	3	7
Sierran Mixed Conifer	1	10	2	6	5
Urban	10	10	10	10	10

Table 2. cont.	*Strix occidentalis* (California Spotted owl)	*Dipodomys agilis* (Pacific kangaroo rat)	*Odocoileus hemionus* (Mule deer)	*Taxidea taxus* (Badger)	*Puma concolor* (Mountain lion)
MODEL VARIABLES					
Valley Oak Woodland	3	7	1	4	2
Valley Foothill Riparian	1	7	1	4	2
Water	10	10	10	10	9
White Fir	1	10	2	6	5
Wet Meadow	8	10	5	4	6
Unknown Shrub Type	6	10	5	5	5
Unknown Conifer Type	3	10	4	5	5
Eucalyptus	10	8	8	6	6
ROAD DENSITY					
0-0.5 km/sq. km	1	1	1	1	1
0.5-1 km/sq. km	1	1	1	1	3
1-2 km/sq. km	1	2	2	2	4
2-4 km/sq. km	3	3	5	2	6
4-6 km/sq.km	3	3	7	4	9
6-8 km/sq. km	10	9	10	7	10
8-10 km/sq.km	10	10	10	10	10
10 or more km/sq. km	10	10	10	10	10
TOPOGRAPHY					
Canyon bottoms	1	3	5	2	1
Ridgetops	10	3	2	7	7
Flats	5	1	8	1	3
Slopes	1	7	1	9	5
ELEVATION (feet)					
-260-0	10	4	6	1	N/A
0-500	10	1	4	1	
500-750	10	1	3	1	
750-1000	10	1	3	1	
1000-3000	1	1	3	2	
3000-5000	1	1	3	3	
5000-7000	1	3	3	3	
7000-8000	1	6	5	5	
8000-9000	1	9	5	5	
9000-11500	10	9	5	5	
>11500	10	10	8	8	
WEIGHTS					
Land Cover	0.75	0.70	0.65	0.55	0.40
Road Density	0.25	0.10	0.15	0.15	0.30
Topography	0.00	0.10	0.20	0.20	0.30
Elevation	0.00	0.10	0.00	0.10	0.00

Weighting allowed the model to capture variation in the influence of each input (vegetation, road density, topography, elevation) on focal species movements. A unique cost surface was thus developed for each species. A corridor function was then performed in GIS to generate a data layer showing the relative degree of permeability between core areas.

Running the permeability model requires identifying the endpoints to be connected. Usually, these targeted endpoints are selected as protected core habitat areas (e.g., National Forests, State Parks) that need to be connected through currently unprotected lands. However, the Sierra Madre-Castaic Connection is unique among the 15 priority linkages in that most land in the linkage is already protected, thus potentially constraining the utility of the model. For this linkage, the principal issue isn't so much which lands represent gaps in protection between core areas as much as where and how to ensure adequate crossing structures at major roadways or other barriers. We therefore selected endpoints for this analysis as roadless areas supporting medium to highly suitable habitat for each species near the far eastern and western extents of the study area, and therefore straddling the major highways of interest. This gave the model broad latitude in interpreting functional corridors across the entire study area, and it forced the model to cross both major highways to assist in identifying key crossing locations. Thus, we did not use the Chumash and Sespe Wildernesses (Figure 4) as "targets" on the Sierra Madre side to address issues related to SR-33, and to give the model some room to function. For each focal species, the most permeable (0.5-1%) area of the study window was designated as the least-cost corridor.

The least-cost corridor output for all 5 species was then combined to generate a Least Cost Union. The biological significance of this Union can best be described as the zone within which all 5 modeled species would encounter the least energy expenditure (i.e., preferred travel route) and the most favorable habitat as they move between targeted roadless areas. The output does not identify barriers (which were later identified through fieldwork), mortality risks, dispersal limitations or other biologically significant processes that could prevent a species from successfully reaching a core area. Rather, it identifies the best zone available for focal species movement based on the data layers used in the analyses.

Patch Size & Configuration Analysis

Although the Least-Cost Union identifies the best zone available for movement based on the data layers used in the analyses, it does not address whether suitable habitat in the Union occurs in large enough patches to support viable populations and close enough together to allow for inter-patch dispersal. We therefore conducted patch size and configuration analyses for all focal species (Table 1) and adjusted the boundaries of the Least-Cost Union where necessary to enhance the likelihood of movement. Patch size and configuration analyses are particularly important for species that require multiple generations to traverse the linkage. Many species exhibit metapopulation dynamics, whereby the long-term persistence of a local population requires connection to other populations (Hanski and Gilpin 1991). For relatively sedentary species like salamanders and terrestrial insects, gene flow will occur over decades through a metapopulation. Thus, the linkage must be able to accommodate metapopulation dynamics to support ecological and evolutionary processes in the long term.

A habitat suitability model formed the basis of the patch size and configuration analysis. Habitat suitability models were developed for each focal species using the literature and expert opinion. Spatial data layers used in the analysis varied by species and included: vegetation, elevation, topographic features, slope, aspect, hydrography, and soils. Using scoring and weighting schemes similar to those described in the previous section, we generated a spectrum of suitability scores that were divided into 5 classes using natural breaks: low, low to medium, medium, medium to high, or high. Suitable habitat was identified as all land that scored medium, medium to high, or high.

To identify areas of suitable habitat that were large enough to provide a significant resource for individuals in the linkage, we conducted a patch size analysis. The size of all suitable habitat patches in the planning area were identified and marked as potential core areas, patches, or less than a patch. *Potential core areas* were defined as the amount of contiguous suitable habitat necessary to sustain at least 50 individuals. A *patch* was defined as the area of contiguous suitable habitat needed to support at least one male and one female, but less than the potential core area. Potential cores are probably capable of supporting the species for several decades (although with erosion of genetic material if isolated). Patches can support at least one breeding pair of animals (perhaps more if home ranges overlap greatly) and are probably useful to the species if the patch can be linked via dispersal to other patches and core areas (Figure 7).

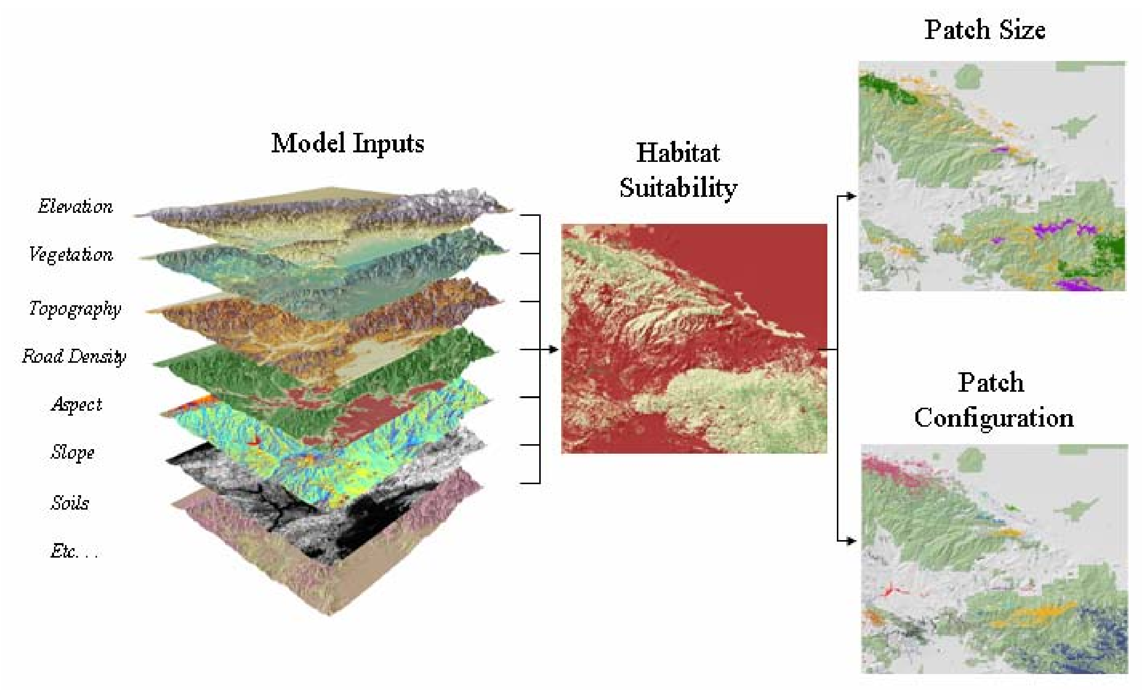

Figure 7. Model Inputs to Patch Size and Configuration Analyses vary by species. Patch size delineates cores, patches, and stepping-stones of potential habitat. Patch configuration evaluates whether suitable habitat patches and cores are within the each species dispersal distance.

To determine whether the distribution of suitable habitat in the linkage supports meta-population processes and allows species to disperse among patches and core areas, we conducted a configuration analysis to identify which patches and core areas were functionally isolated by distances too great for the focal species to traverse. Because the majority of methods used to document dispersal distance underestimate the true value (LaHaye et al. 2001), we assumed each species could disperse twice as far as the longest documented dispersal distance. This assumption is conservative in the sense that it retains habitat patches as potentially important to dispersal for a species even if it may appear to be isolated based on known dispersal distances. Groupings of core areas and patches that were greater than the adopted dispersal distance from other suitable habitat were identified using a unique color.

For each species we compared the configuration and extent of potential cores and patches, relative to the species dispersal ability, to evaluate whether the Least Cost Union was likely to serve the species. If necessary, we added additional habitat to help ensure that the linkage provides sufficient live-in or "move-through" habitat for the species' needs.

Minimum Linkage Width

While the size and distance among habitats (addressed by patch size and configuration analyses) must be adequate to support species movement, the shape of those habitats also plays a key role. In particular, constriction points—areas where habitats have been narrowed by surrounding development—can prevent organisms from moving through the Least-Cost Union. To ensure that functional processes are protected, we imposed a minimum width of 2 km (1.2 mi) for all portions of the final Linkage Design.

For a variety of species, including those we did not formally model, a wide linkage helps ensure availability of appropriate habitat, host plants (e.g., for butterflies), pollinators, and areas with low predation risk. In addition, fires and floods are part of the natural disturbance regime and a wide linkage allows for a semblance of these natural disturbances to operate with minimal constraints from adjacent urban areas. A wide linkage also enhances the ability of the biota to respond to climate change, and buffers against edge effects.

Field Investigations

We conducted field surveys to ground-truth existing habitat conditions, document existing barriers and potential passageways, and describe restoration opportunities. All location data were recorded using a mobile GIS/GPS with ESRI's ArcPad. Because paved roads often present the most formidable potential barriers, biologists drove or walked each accessible section of road that transected the linkage. All types of potential crossing structures (e.g., bridge, underpass, overpass, culvert, pipe) were photo documented and measured. Data taken for each crossing included: shape; height, width, and length of the passageway; stream type, if applicable (perennial or intermittent); floor type (metal, dirt, concrete, natural); passageway construction (concrete, metal, other); visibility to other side; light level; fencing; and vegetative community within and/or adjacent to the passageway. Existing highways and crossing structures are not considered permanent landscape features. In particular, crossing structures can be added or improved during projects to widen and realign highways and interchanges. Therefore, we also identified areas where crossing structures could be improved or installed, and opportunities to restore vegetation to improve road crossings and minimize roadkills.

Identify Conservation Opportunities

The Linkage Design serves as the target area for linkage conservation opportunities. We provided biological and land use summaries, and identified implementation opportunities for agencies, organizations, and individuals interested in helping conserve the Sierra Madre-Castaic linkage. Biological and land use summaries include descriptions and maps of vegetation, land cover, land use, roads, road crossings, and restoration opportunities. We also identified existing planning efforts addressing the conservation and use of natural resources in the planning area. Finally, we developed a flyover animation using aerial imagery, satellite imagery, and digital elevations models, which provides a visualization of the linkage from a landscape perspective (Appendix C).

Landscape Permeability Analyses

The 5 species subject to permeability analyses (mountain lion, American badger, mule deer, Pacific kangaroo rat, and California spotted owl) have very different habitat and movement requirements. As a result, their modeled Least Cost Corridors were all quite different, with little overlap between pairs of species having very different ecological requirements (Figure 8). For example, the Least Cost Corridor for badgers encompasses the more xeric, open habitats along the northern slopes of the mountains (e.g., pinyon-juniper, sagebrush, and grassland), whereas the corridor for spotted owls is restricted mostly to upper elevation forests through the heart of the study area. The Least Cost Corridor for mountain lions runs mostly through mid-elevation or transitional habitats (e.g., chaparral, oak woodlands, and riparian areas), whereas that for Pacific kangaroo rat runs through scrub and grassland habitats in the lower coastal foothills. Mule deer have two primary Least Cost Corridors—one largely coincident with the upper elevations preferred by spotted owls, and another in the lower elevational coastal foothills.

As a result of these species differences, the Least Cost Union (the area combining the top 0.5-1% of the Least Cost Corridors for all 5 species) encompasses 4 relatively parallel swaths of habitat (as well as several minor paths or cross connections between the major swaths) stretching roughly 65 km (40 mi) between roadless areas in the Sierra Madre and Castaic Ranges (Figure 9). This configuration reemphasizes the need for maintaining connectivity across diverse vegetation and physiographic zones to cover the needs of diverse species.

The northernmost swath of the Union (influenced mostly by badger requirements) ranges in width from 1-8 km (0.62-5 mi). From west to east, it follows lower Cuyama River Valley, forks to include both Corral and Wagon Road canyons, then merges in Lockwood Valley, and over to Arrastra Flat. From Arrastra Flat there are two paths: The strongest leads to Peace Valley, crossing I-5 at Gorman Creek and SR-138 to grassland habitats south of Quail Lake. The southern fork follows Hungry Valley to Canada de Los Alamos, crosses I-5 into Apple Canyon and Liebre Gulch and on to Liebre Mountain.

The second major swath of the Union (influenced most by spotted owl and mule deer) ranges from 3-16 km (1.8-9.9 mi) in width and mostly crosses higher elevation (4,000 to 7,000 feet) mountains and valleys across the heart of the study area. From west to east, this swath crosses Highway 33 at Bear Canyon, follows the northern edge of Pine Mountain to Piru Creek, then over Thorn Meadows to McDonald Peak. From there it broadens near I-5 and around Pyramid Lake, where paths of 4 focal species largely converge in the Castaic Range.

The third major swath (influenced most by mountain lion) follows Matilija Creek to Wheeler Gorge, through Rainbow Valley to Sespe Creek, and up Poplar and Alder Creeks to McDonald Peak, where it merges with the second swath to include habitats around Pyramid Lake to the Castaic Range.

The southernmost branch of the Union (influenced most by mule deer and Pacific kangaroo rat, and to a lesser degree by mountain lion) ranges in width from 2-9 km (1.2-5.6 mi) and runs mostly along the mid elevational coastal foothills and canyons (1,000-

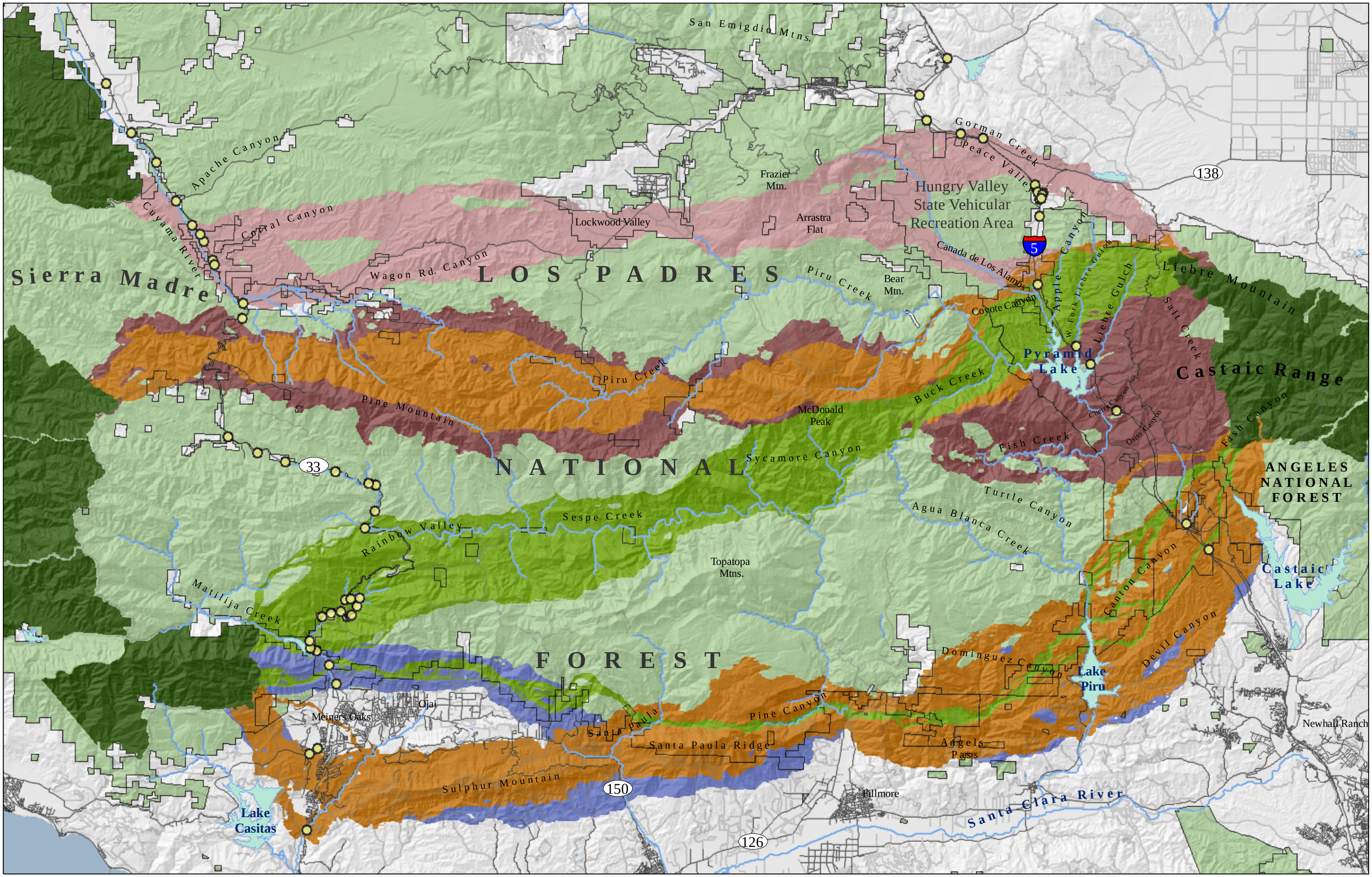

Figure 8. Least Cost Union Displaying Species Overlap

- Mountain lion
- American badger
- Mule deer
- California spotted owl
- Pacific kangaroo rat
- Ownership Boundaries
- Target Roadless Areas
- Reservoirs and Lakes
- Perennial Streams
- Roads
- Potential Crossing Structures

Scale 1: 340,000

0 2 4 8 12 16 Kilometers

0 2 4 8 12 16 Miles

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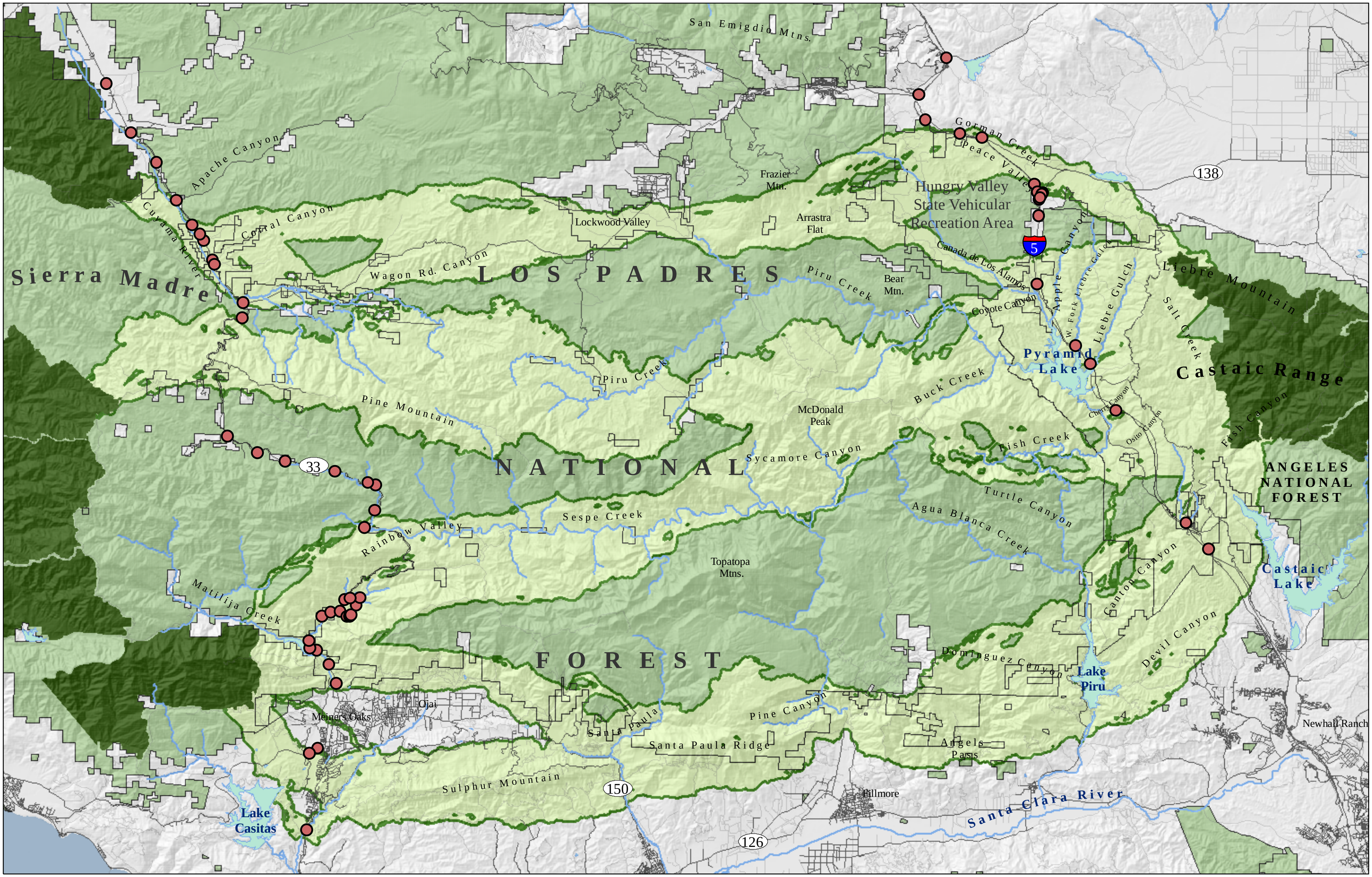

Figure 9. Least Cost Union

- Linkage Union
- Ownership Boundaries
- Target Roadless Areas
- Reservoirs and Lakes
- Perennial Streams
- Roads
- Potential Crossing Structures

Scale 1: 340,000

Kilometers: 0 2 4 8 12 16

Miles: 0 2 4 8 12 16

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5,000 feet). It splits into two paths around Ojai: The northern branch follows Kennedy and Cozy Dell Canyons across Highway 33, while the southern branch crosses Highway 33 south of the community of Oak View to Sulphur Mountain. These paths converge and follow Santa Paula Ridge, through portions of Pine Canyon, over Angels Pass, down Canton and Devil canyons to I-5, then up Castaic Creek to Fish Canyon.

The next several pages summarize the permeability analyses in more detail for each of the 5-modeled species. For convenience, the narratives describe the most permeable paths from west to east, although our analyses gave equal weight to movements in both directions. The following section (Patch Size and Configuration Analyses) describes our procedure to evaluate how well the Least Cost Union would likely serve the needs of all focal species, including those for which we could not conduct permeability analysis.

Mountain Lion (*Felis concolor*)

Justification for Selection: This area-sensitive species is an appropriate focal species (Noss 1991, Noss et al. 1994) because its naturally low densities render it highly sensitive to habitat fragmentation, and because loss of large carnivores can have adverse ripple effects through the entire ecosystem (Soulé and Terborgh 1999). Mountain lions have already lost a number of dispersal corridors in southern California, making them susceptible to extirpation from existing protected areas (Beier 1993). Habitat fragmentation caused by urbanization and an extensive road network has had detrimental effects on mountain lions by restricting movement, increasing mortality, and increasing contact with humans.

Conceptual Basis for Model Development: The species uses brushy stages of a variety of habitat types with good cover (Spowart and Samson 1986, Ahlborn 1988). In southern California, riparian areas are most preferred; grasslands, agricultural areas, and human-altered landscapes are least preferred (Dickson et al. 2004). Preferred travel routes in southern California are along stream courses and gentle terrain, but all habitats with cover are used (Dickson et al. 2004). Dirt roads do not impede movement, but highways, residential roads, and 2-lane paved roads impede movement (Dickson et al. 2004). Juvenile dispersal distances average 32 km (range 9-140 km) for females and 85 km (range 23-274 km) for males (Anderson et al. 1992, Sweanor et al. 2000). The somewhat shorter dispersal distances reported in southern California (Beier 1995) reflect the fragmented nature of Beier's study area. Table 2 presents parameter scores and weights assigned for this species. Cost of movement for mountain lion was defined by weighting the inputs as follows:

(Vegetation * 40%) + (Road Density * 30%) + (Topography * 30%)

Results & Discussion: The Least Cost Corridor for mountain lion movement between targeted roadless areas is depicted in Figure 10. Two pathways emerged from the analysis. The most permeable route follows the montane riparian and hardwood forests of several canyon bottoms with mostly mixed chaparral in the uplands, from Wheeler Gorge to the North Fork Matilija, Sespe, and Poplar creeks, through Sycamore Canyon to the montane chaparral, hardwood, and coniferous forests of McDonald Peak, down Buck Creek to the mixed chaparral and pinyon-juniper habitats in Coyote, Apple, and West Liebre Gulch. Another strong route crosses Highway 33 from Kennedy to Cozy Dell Canyon, rising and falling over a series of chaparral and coastal sage covered hillsides to Santa Paula Ridge, then through the montane-hardwood conifer habitats of Pine Canyon, over Angels Pass and Dominguez Canyon, then down through oak woodlands in Canton Canyon to I-5, and over to Fish Canyon.

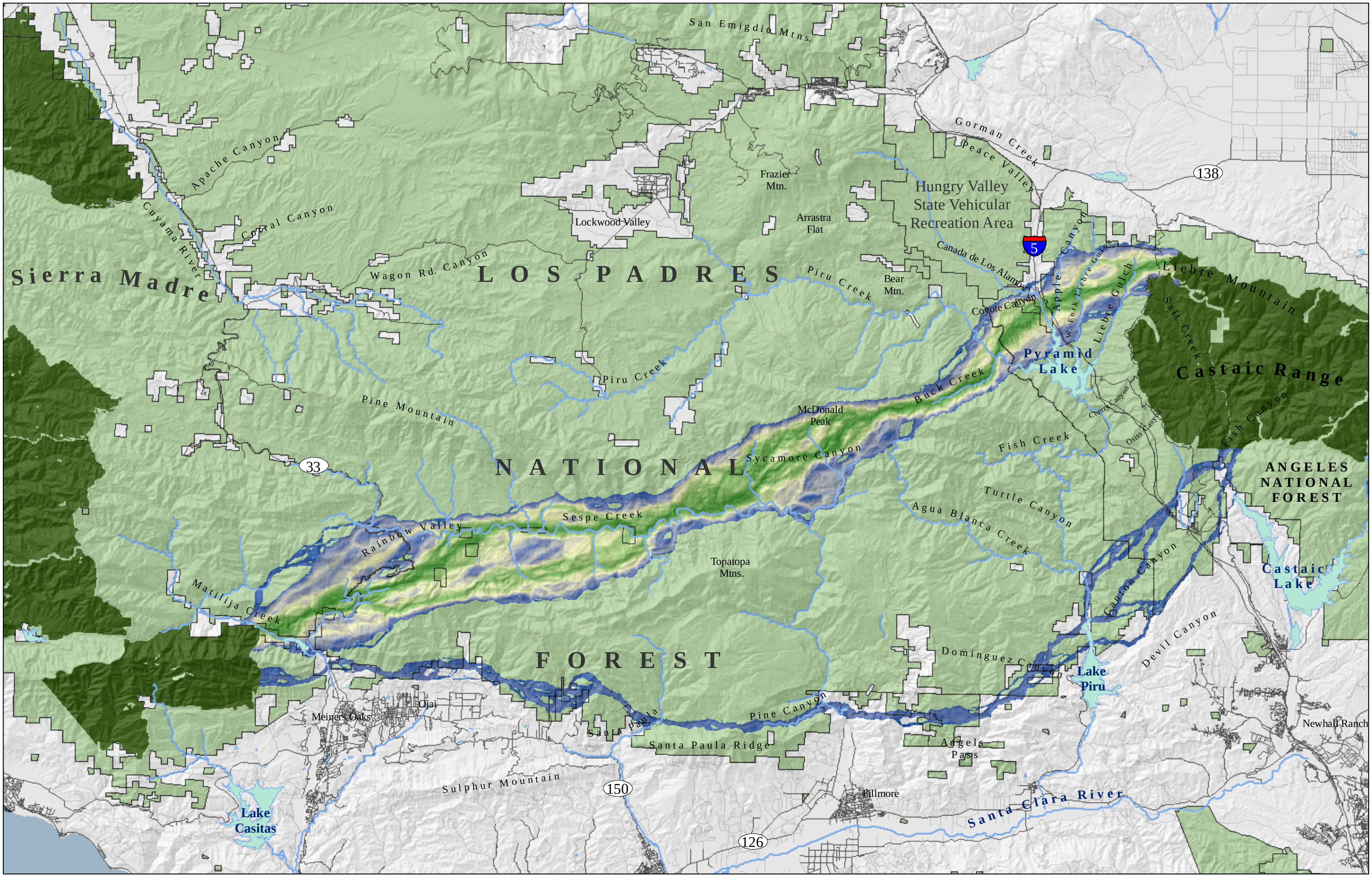

Figure 10. Least Cost Corridor for Mountain lion *(Puma concolor)*

Less Permeable
Highly Permeable
Suitable Habitat*
Ownership Boundaries
Reservoirs and Lakes
Perennial Streams
Roads

Scale 1: 340,000

0 2 4 8 12 16 Kilometers

0 2 4 8 12 16 Miles

*The analysis was run from medium to high suitable habitat within roadless areas.

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American Badger (*Taxidea taxus*)

Justification for Selection: Badger is an area-dependent grassland specialist that is highly sensitive to habitat fragmentation. Roadkill is one of the primary causes of mortality (Long 1973, Sullivan 1996, CDFG 1999).

Conceptual Basis for Model Development: Badgers are associated with grasslands, prairies, and other open habitats that support abundant burrowing rodents (de Vos 1969, Banfield 1974, Sullivan 1996) but they may also be found in drier open stages of shrub and forest communities (CDFG 1999). They are known to inhabit forest and mountain meadows, marshes, riparian habitats, and desert communities including creosote bush, juniper, and sagebrush habitats (Long and Killingley 1983, CDFG 1999). The species is typically found at lower elevations (CDFG 1999) in flat, rolling or steep terrain but it has been recorded at elevations up to 3,600 m (12,000 ft) (Minta 1993).

Badgers can disperse up to 110 km (Lindzey 1978), and preferentially move through open scrub habitats, fields, pastures, and open upland and riparian woodland habitats. Denser scrub and woodland habitats and orchards are less preferred. They avoid urban and intense agricultural areas. Roads are difficult to navigate safely. Table 2 presents parameter scores and weights assigned for this species. Cost of movement for badger was defined by weighting the various inputs, such that:

(Vegetation * 0.55) + (Elevation * 0.10) + (Topography * 0.20) + (Road Density *0.15)

Results & Discussion: Figure 11 delineates the most permeable pathway for badger traveling between the targeted roadless areas in the Sierra Madre and Castaic ranges. It encompasses the pinyon-juniper, grassland, and sagebrush communities in the northern part of the assessment area, representing the most highly suitable habitat for this species in the planning area. The preferred route for badger follows the lower Cuyama River Valley, forks to include both Corral and Wagon Road canyons, then merges and follows the sagebrush and grassland habitats in Lockwood Valley over to Arrastra Flat. From here, two paths emerged from the analysis, the strongest leads through the grassland habitats of Peace Valley, crossing I-5 at Gorman Creek, and then SR-138 to grassland habitats south of Quail Lake. The southern fork follows Hungry Valley to Canada de Los Alamos through grassland, sagebrush, and chaparral habitats, crossing I-5 into Apple Canyon and Liebre Gulch, and on to Liebre Mountain.

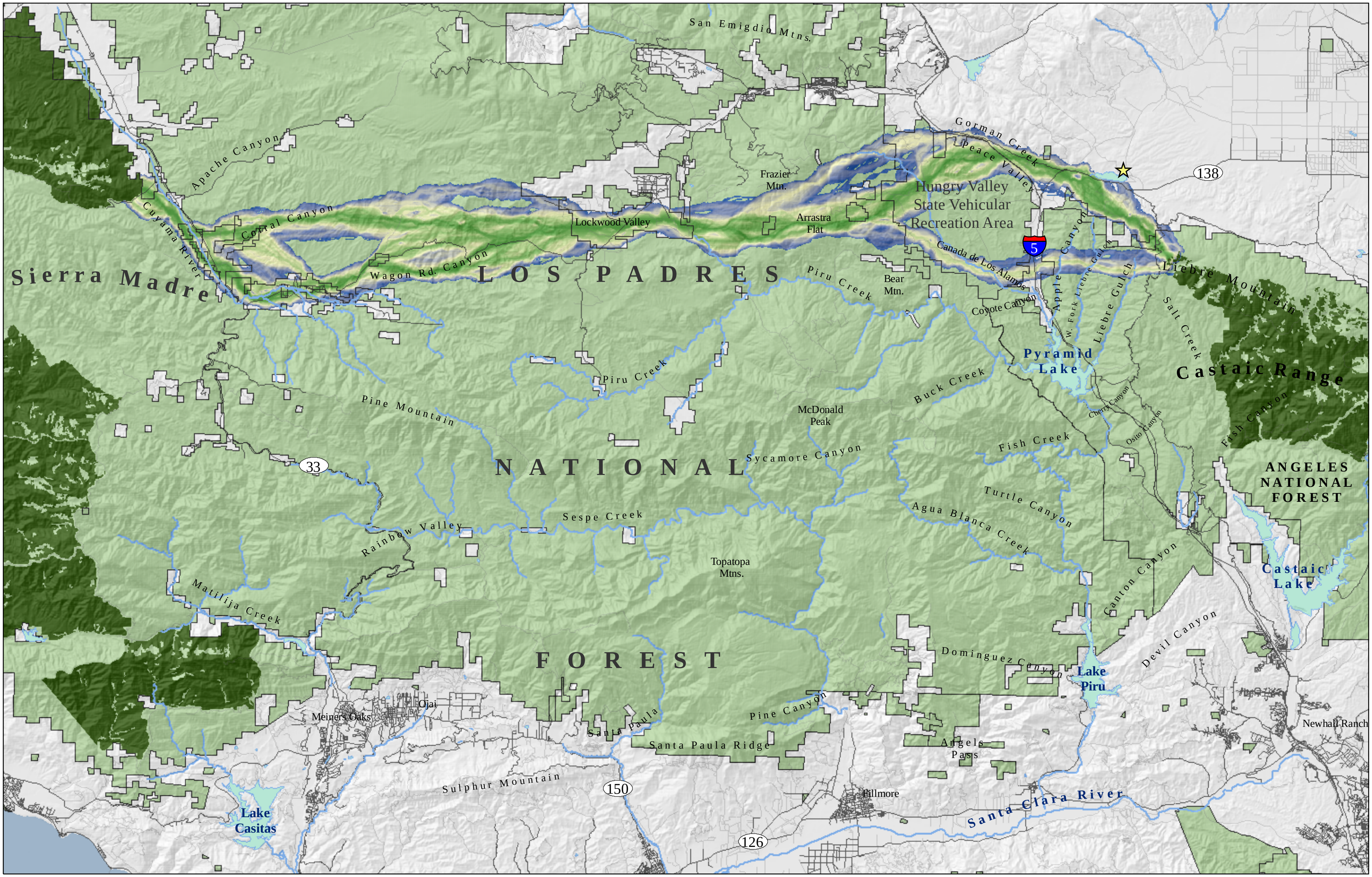

Figure 11. Least Cost Corridor for American badger *(Taxidea taxus)*

Less Permeable — Highly Permeable
Ownership Boundaries
Reservoirs and Lakes
Suitable Habitat*
Perennial Streams
Roads
☆ Species Occurence

Scale 1: 340,000

Kilometers: 0 2 4 8 12 16

Miles: 0 2 4 8 12 16

*The analysis was run from medium to high suitable habitat within roadless areas.

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Mule Deer (*Odocoileus hemionus*)

Justification for Selection: Mule deer was chosen as a focal species to help support viable populations of carnivores (which rely on deer as prey). Deer herds can decline in response to fragmentation, degradation or destruction of habitat from urban expansion, incompatible land uses and other human activities (Ingles 1965, Hall 1981, CDFG 1983). Mule deer are particularly vulnerable to habitat fragmentation by roads and suffer high mortality by roadkill in many areas.

Conceptual Basis for Model Development: Mule deer utilize forest, woodland, brush, and meadow habitats, reaching their highest densities in oak woodlands, riparian areas, and along edges of meadows and grasslands (Bowyer 1986, USFS 2002). Access to a perennial water source is critical in summer. They also occur in open scrub, young chaparral, and low elevation coniferous forests (Bowyer 1986, USFS 2002).

Dispersal distances of up to 217 km have been recorded for mule deer (Anderson and Wallmo 1984). They preferentially move through habitats that provide good escape cover, preferring ridgetops and riparian routes as major travel corridors. Varying slopes and topographic relief are important for providing shade or exposure to the sun. They avoid open habitats, agricultural and urban land cover, and centers of high human activity, even in suitable habitat. Table 2 presents specific parameter scores and weights assigned for this species. Cost of movement for mule deer was defined by weighting the inputs, such that:

(Vegetation * 65%) + (Topography * 20%) + (Road Density * 15%)

Results & Discussion: The analysis revealed two strong potential routes for mule deer moving between these ranges (Figure 12). The most permeable path crosses coastal sage, oak woodland, and grassland habitats in the coastal foothills. This is the same general pathway as the second strongest route for mountain lion, except from Santa Paula Ridge west, the mule deer Least Cost Corridor takes Ojai Valley over to the dense oak woodlands and coastal sage habitats on Sulphur Mountain. It crosses Highway 33 just below the community of Meiners Oaks, then follows the northeast shore of Lake Casitas to the grassland habitats to the north of the lake. Another strong route encompasses higher elevation communities, such as mixed conifer, montane chaparral, and hardwood conifer habitats. This path crosses Highway 33 at Deaf Canyon, follows the swath of hardwood and conifer forests over Pine Mountain, the montane riparian habitats of Piru and Little Mutau creeks, the forested habitats on the northern slope of McDonald Peak to the hardwood habitats of Buck Creek, then through the mixed chaparral and scrub habitats of Coyote Canyon, and across I-5 to Apple Canyon and Liebre Gulch.

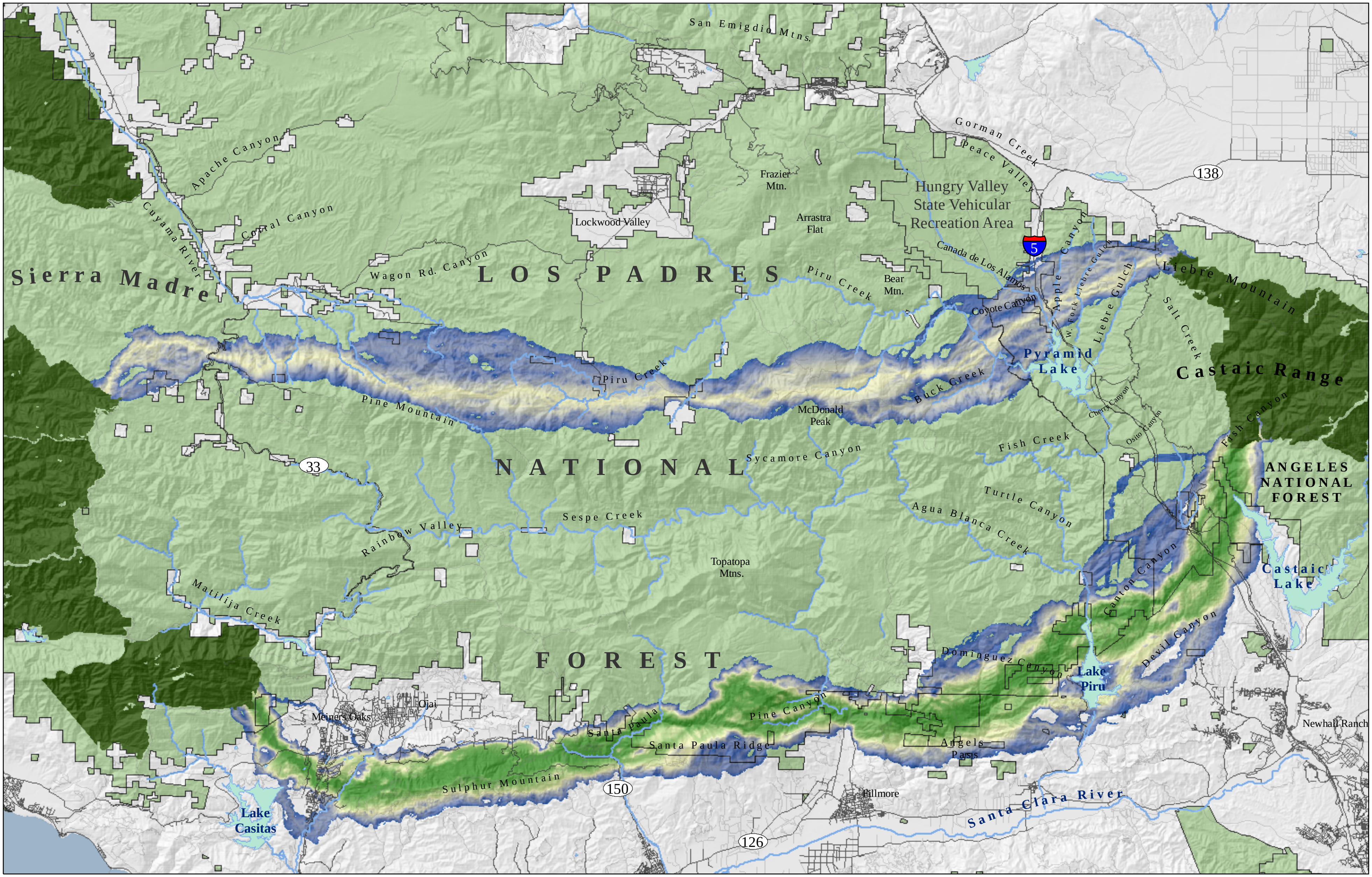

Figure 12. Least Cost Corridor for Mule deer ***(Odocoileus hemionus)***

Less Permeable
Highly Permeable
Ownership Boundaries
Reservoirs and Lakes
Suitable Habitat*
Perennial Streams
Roads

Scale 1: 340,000

Kilometers: 0 2 4 8 12 16

Miles: 0 2 4 8 12 16

*The analysis was run from medium to high suitable habitat within roadless areas.

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Pacific Kangaroo Rat (*Dipodomys agilis*)


USGS, Biological Resource Division

Justification for Selection: The Pacific kangaroo rat is sensitive to habitat loss and fragmentation. Although kangaroo rats can navigate dirt roads, agricultural fields, and some other human land uses, they are highly susceptible to roadkill on paved roads and probably do not cross major freeways or perennial rivers (W. Spencer pers. comm.). Barriers are likely similar to other kangaroo rats (roads, canals or other physical barriers; dense grasses, artificial light), but this species is generally more tolerant of tree or shrub cover and probably better able to navigate through denser vegetation than other species of kangaroo rat (W. Spencer pers. comm.).

Conceptual Basis for Model Development: The Pacific kangaroo rat is associated with a variety of habitats including coastal sage scrub, sparse chaparral, oak woodland, pinyon-juniper woodland, desert scrub, and annual grassland (Bleich and Price 1995, W. Spencer pers. comm.). They've also been recorded in alluvial fan sage scrub (Price et al. 1991) and montane coniferous forests (Sullivan and Best 1997). The species prefers more open areas within these vegetation communities, and is particularly abundant in ecotonal habitats (Keeley and Keeley 1988, M'Closkey 1976, Price and Kramer 1984, Price et al. 1991, Meserve 1976, Goldingay and Price 1997).

Kangaroo rats tend to be more mobile than most similar-sized rodents. Species-specific information on movements and ecology are sparse for the Pacific kangaroo rat, but the species is probably similar in many ways to the better-studied Merriam's kangaroo rat (W. Spencer pers. comm.). Merriam's kangaroo rat typically remains within 1-2 territories (100 m or so) of their birthplace, but the species is capable of longer dispersal (over 1 km). Zeng and Brown (1987) recorded long-distance (= dispersal) movements in adults, concluding that these kangaroo rats are opportunistic in moving into newly available territory areas. However, unlike Merriam's kangaroo rat, the Pacific kangaroo rat may not be a strictly "orthogonal" linkage species, because they occupy montane chaparral habitats and may actually disperse between adjacent mountain ranges via linkages, at least over multiple generations (W. Spencer pers. comm.).

The Pacific kangaroo rat preferentially moves through open habitat in early successional communities. They avoid densely vegetated communities and urban areas. Table 2 presents specific parameter scores and weights assigned for this species. Cost of movement for Pacific kangaroo rat was defined by weighting these inputs, such that:

(Vegetation * 70%) + (Road Density * 10%) + (Topography * 10%) + (Elevation * 10%)

Results & Discussion: The Least Cost Corridor for Pacific kangaroo rat follows the same general pathway as the southerly route for mountain lion and mule deer, except it follows both the Sulphur Mountain and Kennedy Canyon/Cozy Dell routes west of Santa Paula Ridge (Figure 13), and takes in more coastal sage habitat in the foothills.

Figure 13. Least Cost Corridor for Pacific kangaroo rat *(Dipodomys agilis)*

Less Permeable
Highly Permeable
Ownership Boundaries
Reservoirs and Lakes
Suitable Habitat*
Perennial Streams
Roads

Scale 1: 340,000

Kilometers 0 2 4 8 12 16

Miles 0 2 4 8 12 16

*The analysis was run from medium to high suitable habitat within roadless areas.

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California Spotted Owl (*Strix occidentalis occidentalis*)

Justification for Selection: The California spotted owl depends on extensive blocks of mature and old growth forests. Owl demography is strongly affected by forest fragmentation because successful juvenile dispersal depends on the proportion of the landscape that is forested (Harrison et al. 1993). Habitat fragmentation by roads has been shown to cause physiological stress in the northern subspecies (Wasser et al. 1997).

Conceptual Basis for Model Development: This species is associated with structurally complex mature or old growth hardwood, riparian-hardwood, hardwood-conifer, and mixed and pure conifer habitats with substantial canopy cover (>70%) and majestic long-standing trees and snags (Verner et al. 1992, Gutiérrez et al. 1992, LaHaye et al. 1994, Moen and Gutiérrez 1997). Foraging habitat for this subspecies can be more variable than that used by its northern relative, with California spotted owls sometimes hunting in relatively open terrain (Gutierrez et al. 1992).

Spotted owls can disperse up to 72.1 km (LaHaye et al. 2001), and preferentially move through mature wooded and forested habitats. They occasionally hunt in more open habitats but prefer the forest interior; they avoid urban and agricultural areas. Table 2 presents parameter scores and weights assigned this species. Cost of movement for California spotted owl was defined by using vegetation and road densities, with elevation and topography considered to add no additional discrimination power not accounted for by vegetation community. The resultant weighting was thus:

(Vegetation * 75%) + (Road Density * 25%)

Results & Discussion: The Least Cost Corridor for California spotted owl between the targeted roadless areas in the Sierra Madre and Castaic ranges follows the same general pathway as the second strongest route for mule deer, though the eastern part is much wider (Figure 14). East of McDonald Peak, the path for spotted owl becomes much more expansive, including habitats from Buck Creek to south of Osito Canyon. The route identified by the analysis encompasses montane hardwood, hardwood-conifer and pure conifer habitats, the most highly suitable habitat for spotted owl in the planning area. The spotted owl has been recorded all through this Least Cost Corridor. Of particular note is the occurrence just west of I-5 in Piru Gorge, near Cherry Canyon. Furthermore, with estimated dispersal distances ranging from 7-72 km (LaHaye et al. 1994, LaHaye et al. 2001), a dispersing individual could easily traverse the linkage in a very short time.

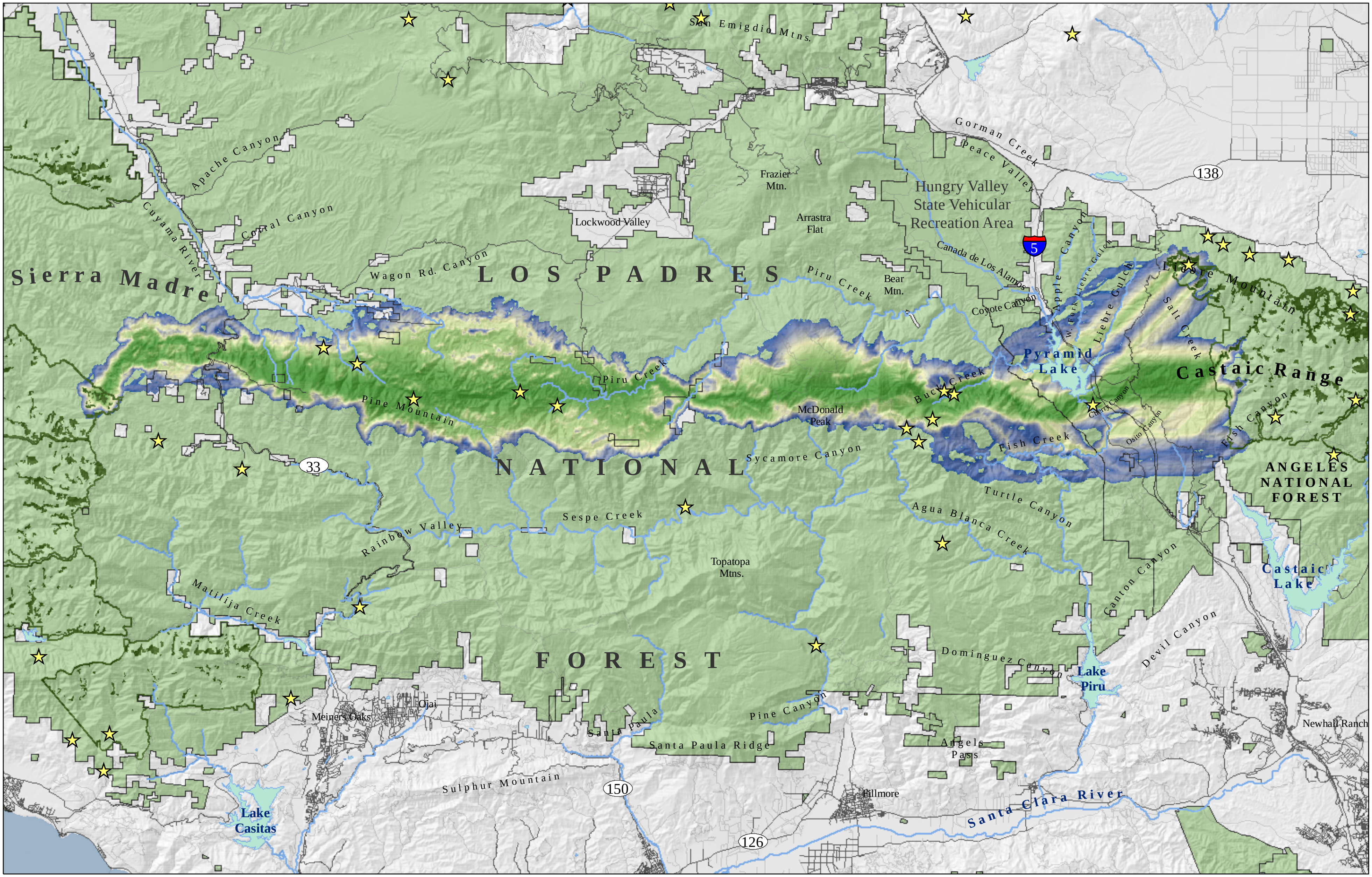

Figure 14. Least Cost Corridor for California spotted owl *(Strix occidentalis)*

Less Permeable / Highly Permeable	Ownership Boundaries	Perennial Streams
	Reservoirs and Lakes	Roads
	Suitable Habitat*	☆ Species Occurence

*The analysis was run from medium to high suitable habitat within roadless areas.

Scale 1: 340,000

Kilometers: 0 2 4 8 12 16

Miles: 0 2 4 8 12 16

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Patch Size & Configuration Analyses

The Least Cost Union (Figures 8 and 9) covers 160,046 ha (395,483 ac), the majority of which is already afforded some sort of conservation status (e.g., Los Padres, Angeles, Hungry Valley, BLM, CDFG, and USFWS conservation lands). We next evaluated the size and configuration of potential suitable habitat for each focal species within the Least Cost Union (including those species not subject to permeability modeling) to determine whether it would adequately serve their linkage requirements. Specifically, for each of 12 focal species we evaluated 1) whether potential habitat patches are separated by distances less than the species' dispersal distance; 2) whether the Least Cost Union is likely to provide the species with sufficient live-in and or move-through habitat; 3) whether the Least Cost Union included highly urbanized lands that should be deleted because restoration is probably not feasible; and 4) for any species not adequately served by the Least Cost Union, whether including additional habitat in the Least Cost Union would serve the species needs.

Our analyses suggest that the Least Cost Union is well suited to support movements between the Sierra Madre and Castaic ranges for 9 of the 12 focal species: mountain lion, badger, mule deer, Pacific kangaroo rat, spotted owl, acorn woodpecker, mountain kingsnake, bear sphinx moth, and rain beetle.

However, three focal species would not be well served by the modeled Least Cost Union: Monterey salamander, western pond turtle, and two-striped garter snake. Each of these species has significant populations in the protected core areas, but there are limited opportunities for movement across major transportation barriers within the Union. We therefore modified the Least Cost Union in creating the Linkage Design (next section) by adding 1,814 ha (4,481 ac) of riparian and upland habitat for these under-served species, near Gorman Creek and the Ventura River (Figure 15). Adding riparian and upland habitat near Gorman Creek created stepping-stones of habitat to accommodate these species, and would also benefit other species, such as mountain lion, badger, and bear sphinx moth. We also added potential habitat for reptile and amphibian species in the coastal foothills, along San Antonio Creek and the Ventura River, and imposed a minimum width of 2 km to ensure adequate linkage function. Other species that use these coastal foothills will also benefit from these additions, including mule deer and Pacific kangaroo rat.

We deleted from the Least Cost Union 413 ha (1,020 ac) of mostly urbanized land in and near the villages of Oak View, Live Oak Acres, Mira Monte, and Meiners Oaks along Highway 33 (Figure 15). Although these areas were included within the modeled Least Cost Corridor for mule deer and Pacific kangaroo rat, these species appear to be adequately served by the Least Cost Union even after these unsuitable acres were removed.

Together, habitat additions and deletions resulted in a net increase of 1401 ha (3462 ac) to the Least Cost Union (Figure 15). These changes are described in more detail in the species-specific analyses that follow. These analyses of patch size and configuration do not address barriers to movement or land use practices that may prevent species from moving through the linkage. Such issues are addressed in the *Linkage Design* section.

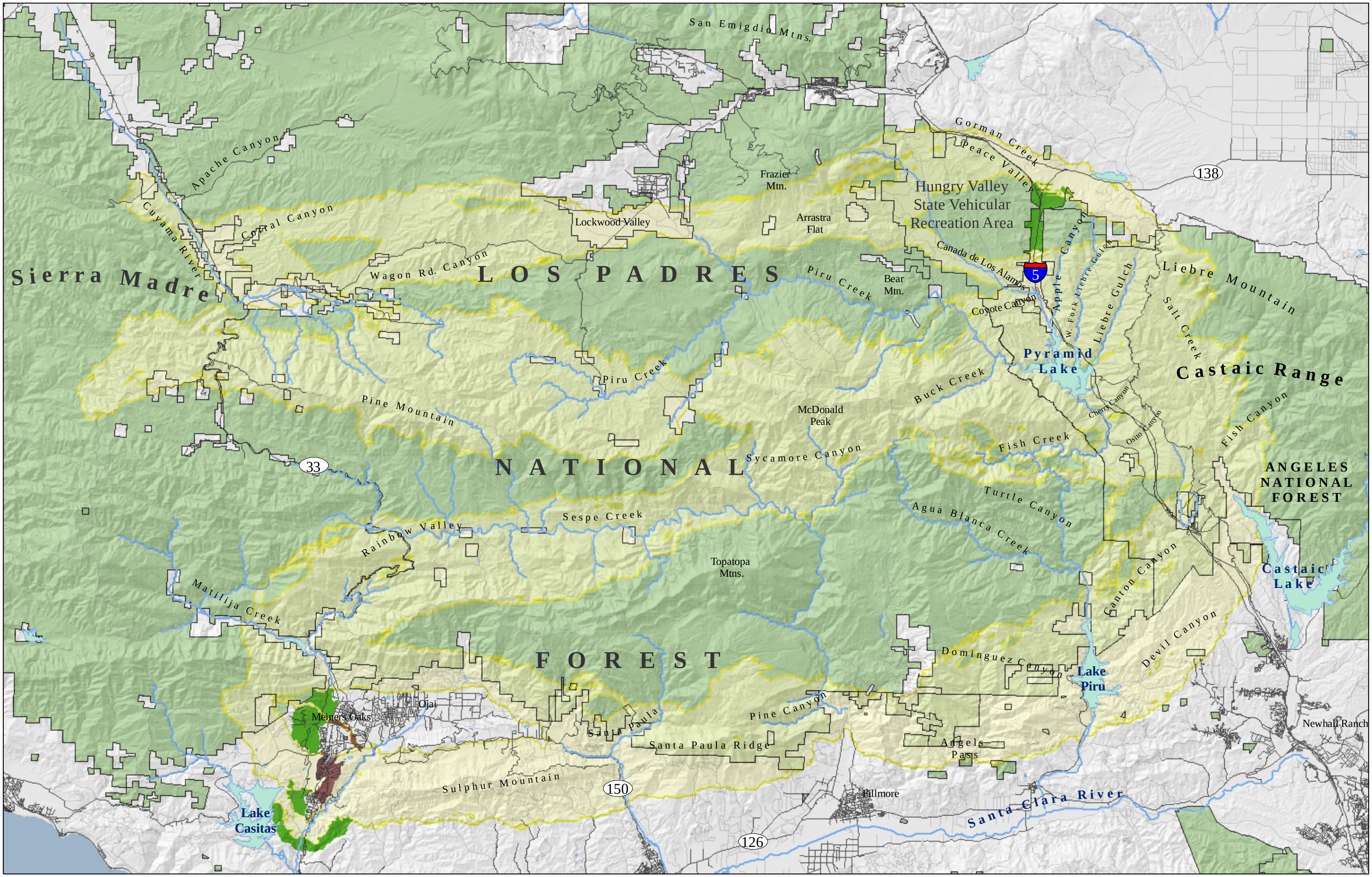

Figure 15. Least Cost Union Additions & Subtractions

- Linkage Union
- Additions
- Subtractions
- Ownership Boundaries
- Reservoirs and Lakes
- Perennial Streams
- Roads

Scale 1: 340,000

0 2 4 8 12 16 Kilometers

0 2 4 8 12 16 Miles

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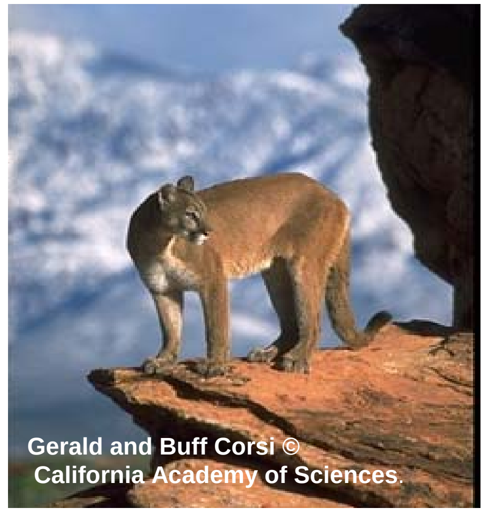
Mountain Lion (*Puma concolor*)



Gerald and Buff Corsi © California Academy of Sciences.

Distribution & Status: Mountain lions are widely distributed throughout the western hemisphere (Chapman and Feldhamer 1982, Currier 1983, Maehr 1992, Tesky 1995). The subspecies *F. c. californica* occurs in southern Oregon, California, and Nevada (Hall 1981), typically between 1,980 and 5,940 ft (590-1,780 m) (CDFG 1990). In 1990, the mountain lion population in California was estimated to be between 2,500-5,000 individuals (CDFG). That same year, Proposition 117 was passed which prohibits hunting and granted puma the status of a California Specially Protected species, though depredation permits are still issued (Torres 2000).

Habitat Associations: The mountain lion is considered a habitat generalist, utilizing brushy stages of a variety of habitat types with good cover (Spowart and Samson 1986, CDFG1990). Within these habitats, mountain lions prefer rocky cliffs, ledges, and vegetated ridgetops that provide cover when hunting prey (Chapman and Feldhamer 1982, Spowart and Samson 1986), which is primarily mule deer, *Odocoileus hemionus* (Lindzey 1987). Den sites may be located on cliffs, rocky outcrops, caves, in dense thickets or under fallen logs (Ingles 1965, Chapman and Feldhamer 1982). In southern California, most cubs are reared in thick brush (Beier et al. 1995). They prefer vegetated ridgetops and stream courses as travel corridors and hunting routes (Spotwart and Samson 1986, Beier and Barrett 1993).

Spatial Patterns: Home range size varies by sex, age, and the distribution of prey. A recent study in the Sierra Nevada documented annual home range sizes between 250 and 817 km^2 (Pierce et al. 1999). Home ranges in southern California averaged 93 km^2 (SD = 50) for 12 adult female and 363 km^2 (SD = 63) for 2 adult male cougars (Dickson and Beier in press). Male home ranges appear to reflect the density and distribution of females (Maehr 1992). Males occupy distinct areas and are tolerant of transients of both sexes, while the home range of females may overlap completely (CDFG 1990, Beier and Barrett 1993). Regional population counts have not been conducted but in the Santa Ana Mountain Range, Beier (1993) estimated about 1.05-1.2 adults per 100 sq km.

Mountain lions are capable of making long-distance movements, and can have multiple strategies of migration that allow them to take advantage of changing prey availability (Pierce et al. 1999). Beier et al. (1995) found mountain lions moved 6 km per night and dispersed up to 65 km. Dispersal plays a crucial role in cougar population dynamics because recruitment into a local population occurs mainly by immigration of juveniles from adjacent populations, while the population's own offspring emigrate to other areas (Beier 1995, Sweanor et al. 2000). Juvenile dispersal distances average 32 km (range 9-140 km) for females and 85 km (range 23-274 km) for males (Anderson et al. 1992). Dispersing lions may cross large expanses of nonhabitat, though they prefer not to do so (Logan and Sweanor 2001). To allow for dispersal of juveniles and the immigration of transients, lion management should be on a regional basis (Sweanor et al. 2000).

Conceptual Basis for Model Development: Puma will utilize most habitats above 590 m in elevation, provided they have cover. Road density is also a significant factor in habitat suitability for mountain lions. Core areas potentially supporting 50 or more individuals were modeled using patches $\geq$ 10,000 km^2. Patch size was classified as $\geq$ 200 km^2 but < 10,000 km^2. Dispersal distance for Puma was defined as 548 km, or twice the maximum reported dispersal distance of 274 km**.**

Results & Discussion*:* Extensive habitat exists for puma in both mountain ranges. Between targeted roadless areas, highly suitable habitat for mountain lion was identified in the coastal foothills; through the montane riparian habitats of Matilija, Sespe, and Buck creeks; and in the pinyon-juniper woodlands in the northern part of the assessment area, most of which was captured in the Least Cost Union (Figure 16). Along I-5, the model identified a stretch of highly suitable habitat south of the I-5/SR-138 interchange and north of Pyramid Lake; through Cherry Canyon, and at Canton Canyon. Figure 17 emphasizes the importance of maintaining this connection, as the Castaic Range protected area is $\leq$ 10,000 km^2 (i.e., not a core area capable of potentially supporting 50 individuals). The Least Cost Union is likely to serve this species as sufficient move-through habitat was captured in the analysis.

This species requires expansive roadless areas to survive and functional connectivity between subpopulations. All habitat patches identified by the analysis are well within the dispersal distance of this species. Individual adults may traverse the entire length of the linkage in a few nights. Maintaining connections between large blocks of protected habitat may be the most effective way to ensure population viability (Beier 1993, 1995, Gaona et al. 1998, Riley et al. 2003). To maintain and protect habitat connections for mountain lion between the Sierra Madre and Castaic protected core areas, we recommend that:

- Existing road density be maintained or reduced; no new roads in the Linkage Design;
- Crossing structures be upgraded to be more amenable to puma movement;
- Lighting is directed away from the linkage and crossing structures. Species sensitive to human disturbance, like puma, avoid areas that are artificially lit (Beier 1995, Longcore 2000); and
- Local residents are informed about the value of carnivores to the system; the use of predator-safe enclosures for domestic livestock and pets; and the habits of being thoughtful and safe stewards of the land in cougar country.

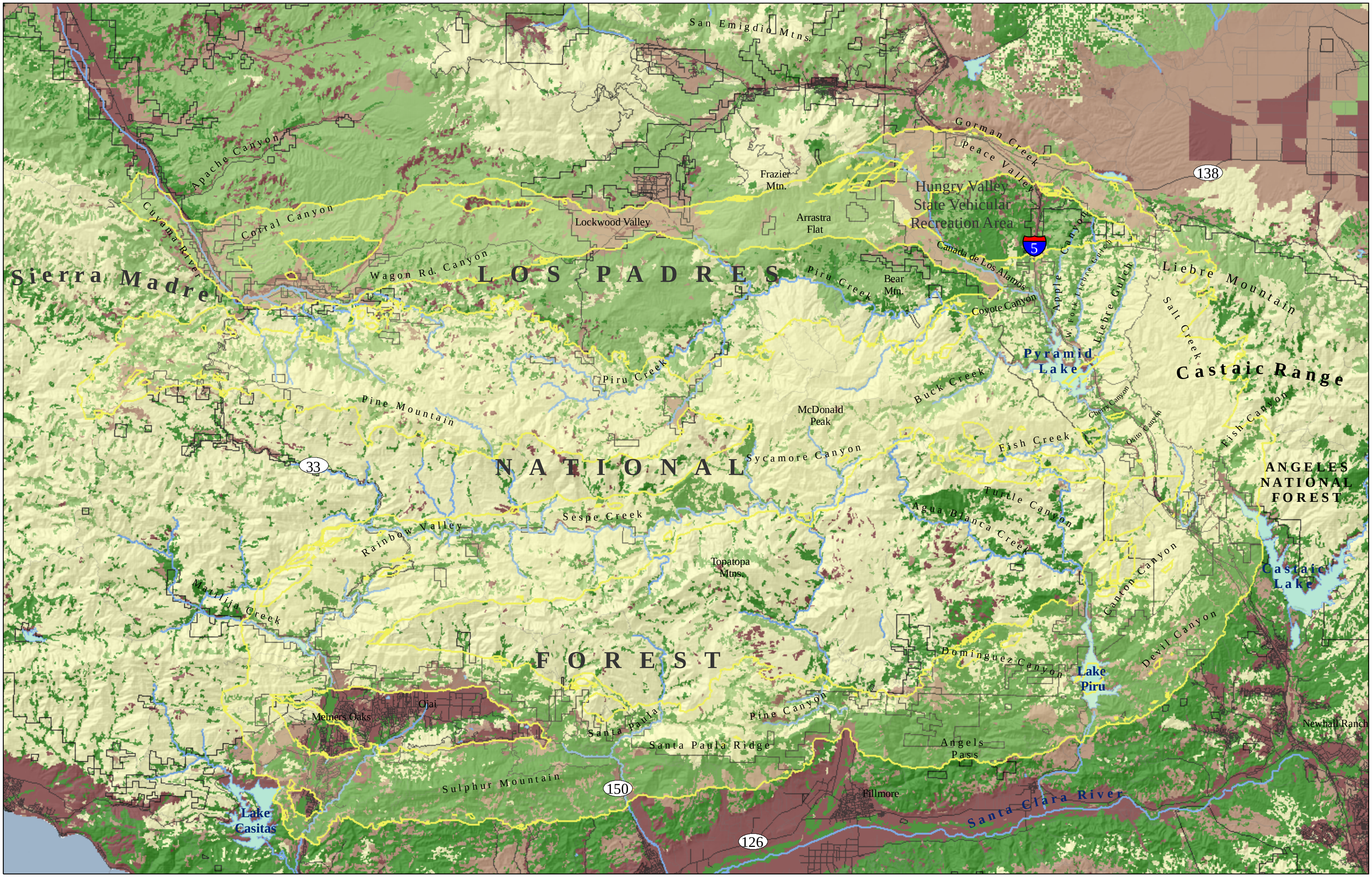


Figure 16. Habitat Suitability for Mountain lion *(Puma concolor)*

Degree of Suitability

- High
- Medium to High
- Medium
- Low to Medium
- Low

- Linkage Union
- Ownership Boundaries
- Reservoirs and Lakes
- Perennial Streams
- Roads

Scale 1: 340,000

0 2 4 8 12 16 Kilometers

0 2 4 8 12 16 Miles

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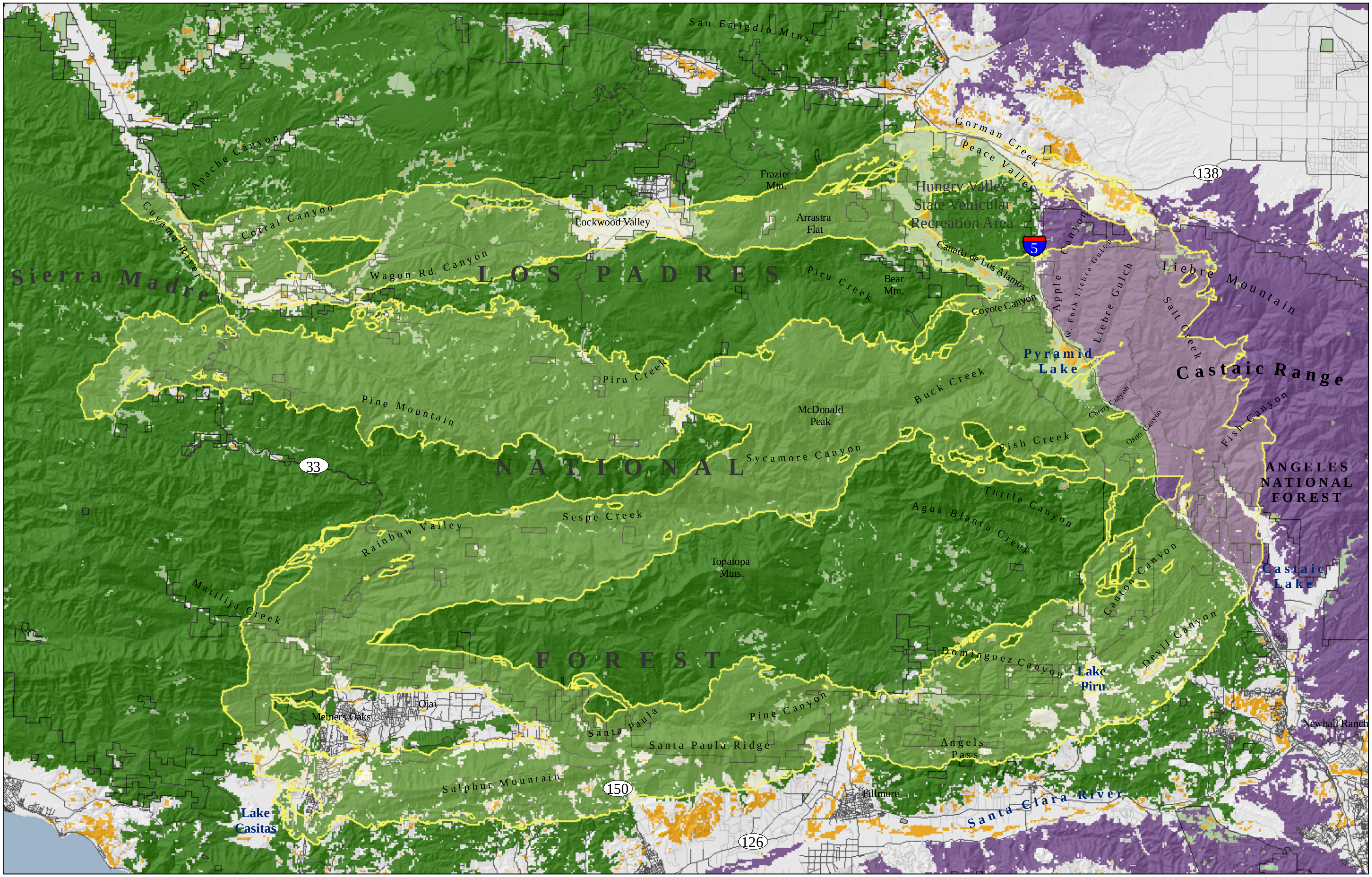

Figure 17. Potential Cores & Patches for Mountain lion *(Puma concolor)*

Core
Patch
< Patch
Linkage Union
Ownership Boundaires
Reservoirs and Lakes
Perennial Streams
Roads

Scale 1: 340,000

Kilometers: 0 2 4 8 12 16

Miles: 0 2 4 8 12 16

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American Badger (*Taxidea taxus*)

Distribution & Status: Once a fairly widespread resident throughout open habitats of California, badgers are now uncommon throughout the state and are considered a California Species of Special Concern (CDFG 1995, CDFG 1999).

Habitat Associations: Badgers are considered habitat specialists, associated with grasslands, prairies, and other open habitats (de Vos 1969, Banfield 1974, Sullivan 1996) but they may also be found in drier open stages of shrub and forest communities (CDFG 1999). They are known to inhabit forest and mountain meadows, marshes, riparian habitats, and desert communities including creosote bush, juniper, and sagebrush habitats (Long and Killingley 1983, CDFG 1999). They are occasionally found in open chaparral (< 50% cover) but haven't been documented in mature stands (Quinn 1990, CDFG 1999). Badgers prefer friable soils for excavating burrows and require abundant rodent populations (de Vos 1969, Banfield 1974, Sullivan 1996). The species is typically found at lower elevations (CDFG 1999) in flat or rolling terrain, but it has been recorded at elevations up to 3,600 m (12,000 ft) (Minta 1993).

Spatial Patterns: Home range sizes for this non-migratory species vary both geographically and seasonally. Male home ranges have been estimated between 240-850 ha and female home ranges at 137-725 ha (Long 1973, Lindzey 1978, Messick and Hornocker 1981, CDFG 1999). In northwestern Wyoming, home ranges up to 2100 ha have been reported (Minta 1993). In Idaho, home ranges of adult females and males averaged 160 ha and 240 ha respectively (Messick and Hornocker 1981). In some areas, badgers may exhibit seasonal changes in home range size, being more restricted in winter (CDFG 1999), though this is probably not the case in arid Southern California. In Minnesota, Sargeant and Warner (1972) radio-collared a female badger, whose overall home range encompassed 850 ha. However, her home range was restricted to 725 ha in summer, 53 ha in autumn and to a mere 2 ha in winter. In Utah, Lindzey (1978) found fall and winter home ranges of females varied from 137-304 ha, while males varied from 537-627 ha (Lindzey 1978). Males may double movement rates and expand their home ranges during the breeding season to maximize encounters with females (Minta 1993). Lindzey (1978) documented natal dispersal distance for one male (110 km) and one female (51 km).

Conceptual Basis for Model Development: Prefers grasslands, meadows, open scrub, desert washes and open woodland communities. Terrain may be flat, rolling or steep but below 3,600 m (12,000 ft) in elevation. Core areas capable of supporting 50 badgers are equal to or greater than 16,000 ha. Patch size is $\geq$ 400 ha but < 16,000 ha. Dispersal distance for badgers was defined as 220 km, twice the longest recorded distance (Lindzey 1978).

Results & Discussion: The model identified large amounts of potential habitat for badger in the assessment area, with the most highly suitable habitat in the more open habitats in the north (Figure 18). This area, dominated by pinyon-juniper woodland and desert scrub habitats, emerged from the landscape permeability analysis as the most valuable habitat connection for badger (Figures 9, 11). The Least-Cost Union will likely serve this species as core areas of habitat for badger are widely distributed throughout both ranges (Figure 19). All potentially suitable core areas and habitat patches are within the 51 km dispersal distance of this species, although barriers to movement may exist between suitable habitat patches.

Roadkill is probably a leading cause of death in roaded areas. To restore and protect habitat connections for badger, we recommend that:

- Habitat is added to the Least Cost Union along I-5 at Gorman Creek;
- Existing road density be maintained or reduced; no new roads in the Linkage Design;
- Lighting is directed away from the linkage and crossing structures; and
- Local residents are informed about the value of carnivores to the system.

Figure 18. Habitat Suitability for American badger *(Taxidea taxus)*

Degree of Suitability
- High
- Medium to High
- Medium
- Low to Medium
- Low

- Linkage Union
- Ownership Boundaries
- Reservoirs and Lakes
- Perennial Streams
- Roads

Scale 1: 340,000

Kilometers: 0, 2, 4, 8, 12, 16

Miles: 0, 2, 4, 8, 12, 16

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Figure 19. Potential Cores & Patches for American badger ***(Taxidea taxus)***

- Core
- < Patch
- Linkage Union
- Ownership Boundaries
- Reservoirs and Lakes
- Perennial Streams
- Roads

Scale 1: 340,000

Kilometers: 0, 2, 4, 8, 12, 16

Miles: 0, 2, 4, 8, 12, 16

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Mule Deer (*Odocoileus hemionus*)

Distribution & Status: Mule deer have a widespread distribution in California and are common to abundant in appropriate habitat; they are absent from areas with little cover, such as some desert communities or agricultural areas (Longhurst et al. 1952, Ingles 1965, CDFG 1990). Mule deer are classified by the California Department of Fish & Game as a big game animal.

Photo Courtesy of USFWS

Habitat Associations: This species requires a mosaic of habitat types of different age classes to meet its life history requirements (CDFG 1983). Mule deer utilize forest, woodland, brush, and meadow habitats, reaching their highest densities in oak woodlands, riparian areas, and along edges of meadows and grasslands (Bowyer 1986, USFS 2002). Access to a perennial water source is critical in summer. They also occur in open scrub, young chaparral and low elevation coniferous forests (Bowyer 1981, 1986, USFS 2002). A variety of brush cover and tree thickets interspersed with meadows and shrubby areas are important for food and cover. Thick cover can provide escape from predators, shade in the summer, or shelter from wind, rain and snow. Varying slopes and topographic relief are important for providing shade or exposure to the sun. Fawning occurs in moderately dense chaparral, forests, riparian areas and meadow edges (CDFG 1983); meadows are particularly important as fawning habitat (Bowyer 1986, USFS 2002).

Spatial Patterns: Home ranges typically comprise a mosaic of habitat types that provide deer with various life history requirements. Home range estimates vary from 39 ha (Miller 1970) to 3,379 ha (Severson and Carter 1978, Anderson and Wallmo 1984, Nicholson et al. 1997). Harestad and Bunnell (1979) calculated mean home range from several studies as 285.3. Doe and fawn groups have smaller home ranges, averaging 100-300 ha, but can vary from 50 to 500 ha (Taber and Dasmann 1958, CDFG 1983). Bucks usually have larger home ranges and are known to wander greater distances (Brown 1961, CDFG 1990). A recent study of 5 different sites throughout California, recorded home range sizes between 49-1138 ha (Kie et al. 2002).

Where seasonally nomadic, winter and summer home ranges tend to largely overlap in consecutive years (Anderson and Wallmo 1984). Elevational migrations are observed in mountainous regions in response to extreme weather events in winter, or to seek shade and a perennial water source during the summer (CDFG 1983, Nicholson et al.1997, Loft et al. 1998, USFS 2002). Distances traveled between winter and summer ranges vary from 8.6 to 29.8 km (Gruell and Papez 1963, Bertram and Rempel 1977, Anderson and Wallmo 1984, Nicholson et al. 1997). Robinette (1966) observed natal dispersal distances ranging from 97 to 217 km.

Conceptual Basis for Model Development: Mule deer utilize grassland and meadow habitats, reaching their highest densities in oak woodland. They require access to perennial water. Core areas potentially supporting 50 or more deer are equal to and greater than 16,000 ha. Patch size was classified as ≥ 100 ha but < 16,000 ha. Dispersal distance was defined as 434 km, or twice the maximum distance recorded.

Results & Discussion: The Least Cost Union captured fairly contiguous blocks of highly suitable habitat for mule deer in the coastal foothills; through the montane hardwood conifer habitats of Pine Mountain, Piru Creek, McDonald Peak, and Buck Creek; and in the pinyon-juniper woodlands in the northern part of the assessment area, most of which was captured in the Least Cost Union (Figure 20). Along I-5, the model identified a stretch of highly suitable habitat south of the I-5/SR-138 interchange and north of Pyramid Lake, in Cherry and Osito canyons, and in Canton Canyon. Extensive core habitat for mule deer occurs throughout both the Sierra Madre and Castaic ranges (Figure 21). All core areas and patches (min size to core size) are within the dispersal distance of this species, although barriers to movement may exist between suitable habitat patches. Thus, the linkage will likely serve the needs of mule deer living in or moving through the linkage as long as potential barriers are adequately addressed.

Estimates of the number of deer killed annually on U.S. roads ranges from 720,000 to 1.5 million (Romin and Bissonette 1996, Conover 1997, Forman et al. 2003). Vehicle collisions with deer result in loss of human lives and impacts to the wildlife resource (Reed et al. 1975). To restore and protect habitat connections for mule deer, we recommend that:

- Road barriers are modified to accommodate mule deer movement. Though ungulates much prefer overpasses to underpasses (Gloyne and Clevenger 2001), they will utilize bridged undercrossings if they can see clearly to the other side. Crossing structures for mule deer should have natural flooring and no artificial lighting (Reed et al. 1975);

- Fencing (at least 4m [12 feet] high) be installed to reduce roadkill and guide deer to crossing structures; in conjunction with escape ramps being installed in case deer get caught in the roadway (Forman et al. 2003); and

- Existing road density be maintained or reduced, no new roads in the Linkage Design.

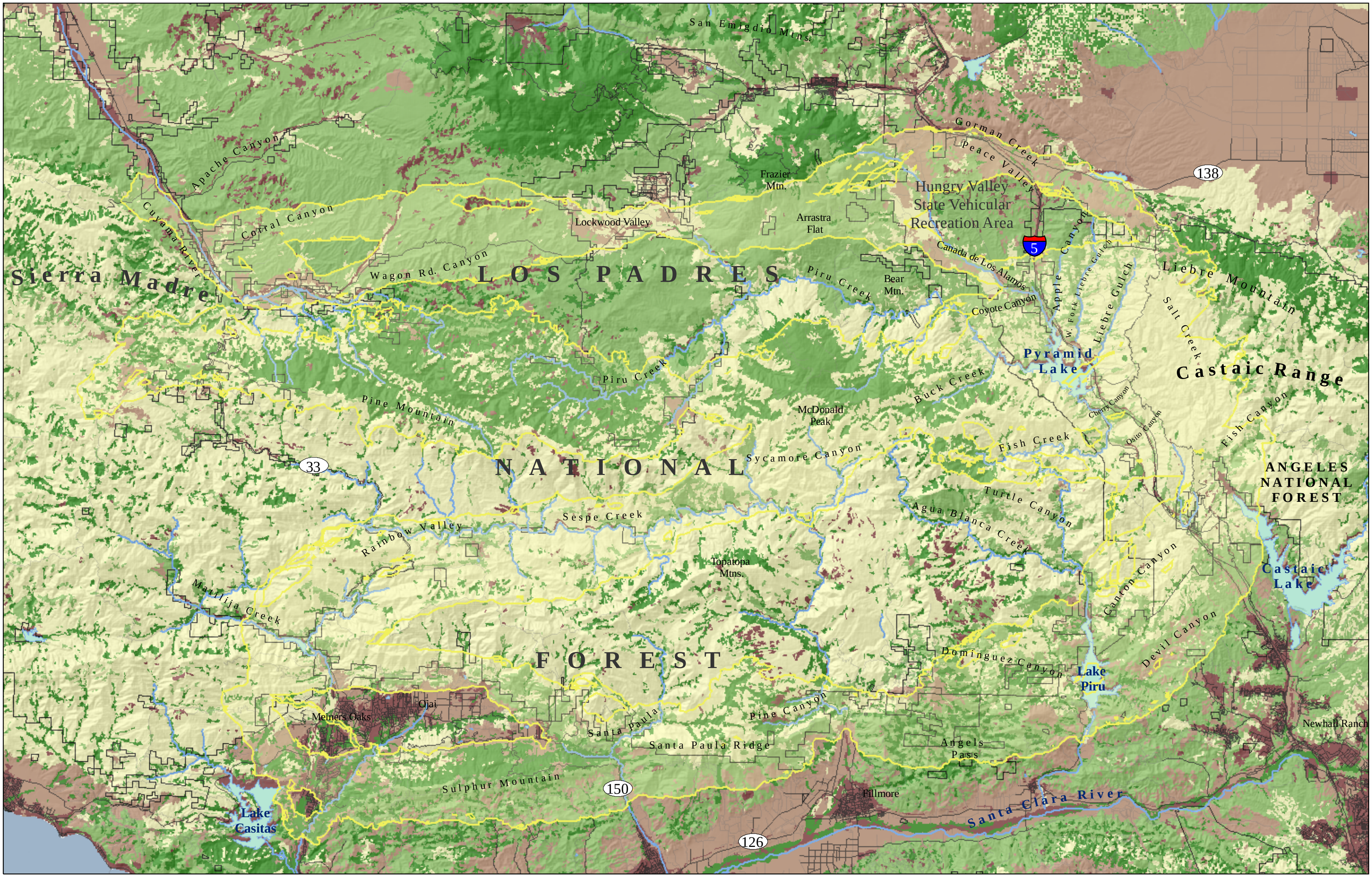

Figure 20. Habitat Suitability for Mule deer ***(Odocoileus hemionus)***

Degree of Suitability

- High
- Medium to High
- Medium
- Low to Medium
- Low
- Linkage Union
- Ownership Boundaries
- Reservoirs and Lakes
- Perennial Streams
- Roads

Scale 1: 340,000

Kilometers: 0 2 4 8 12 16

Miles: 0 2 4 8 12 16

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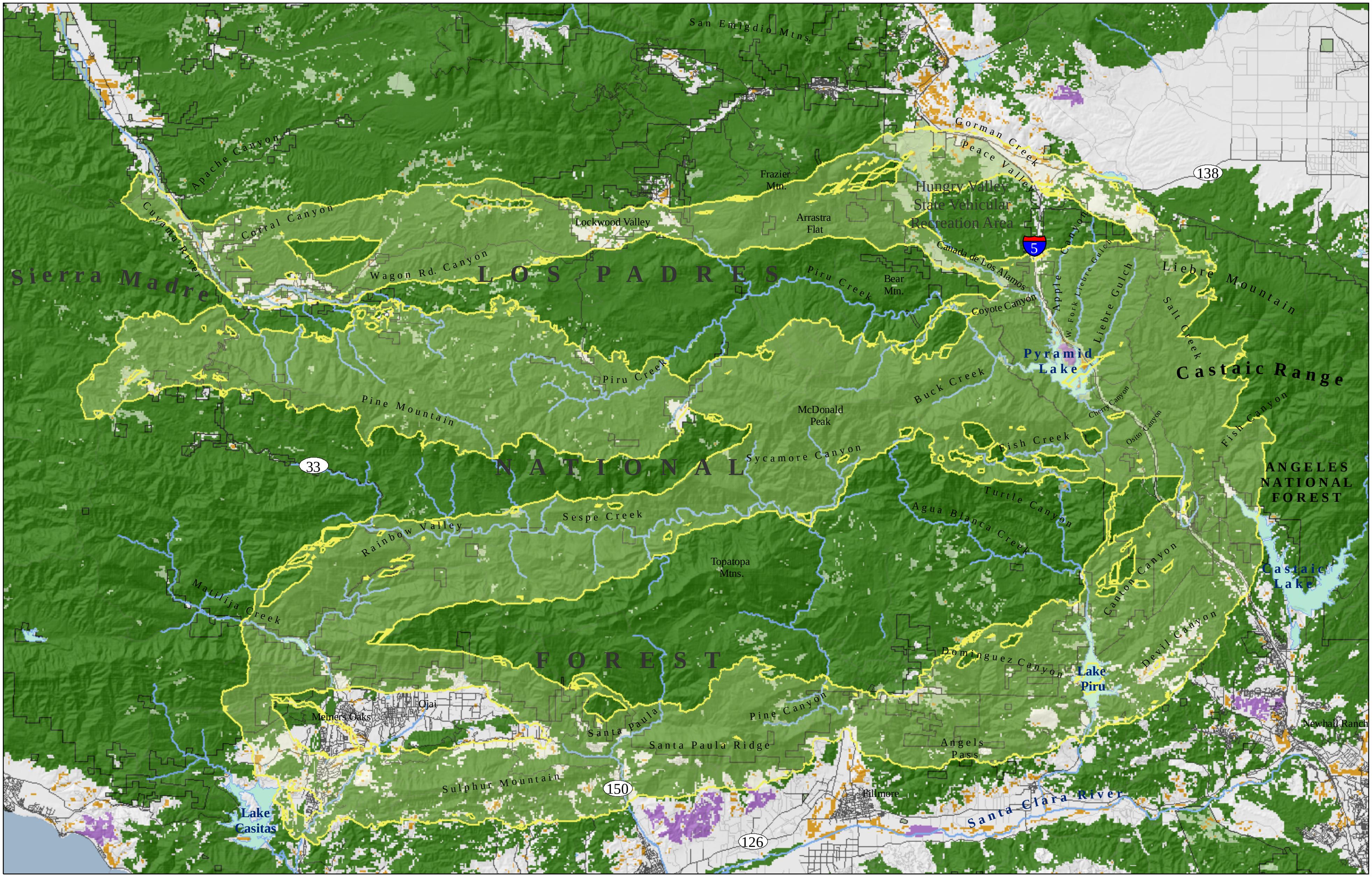

Figure 21. Potential Cores & Patches for Mule deer *(Odocoileus hemionus)*

Patch
Core
< Patch
Linkage Union
Ownership Boundaries
Reservoirs and Lakes
Perennial Streams
Roads

Scale 1: 340,000

0 2 4 8 12 16 Kilometers

0 2 4 8 12 16 Miles

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Pacific Kangaroo Rat (*Dipodomys agilis*)


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Distribution & Status: The Pacific kangaroo rat was recently split into 2 species: *D. agilis* and *D. simulans* (Dulzura kangaroo rat) (Sullivan and Best 1997). Although both species have the potential to occur within the planning area *D. agilis* is likely more widespread and abundant in the study area, and is more likely to be affected by linkage planning here. *D. simulans* is expected to occur only below about 2,500 feet elevation in southern portions of the planning area, whereas *D. agilis* may occur over nearly the entire elevational range and geographic extent of the planning area. Although *D. agilis* is therefore the focus of this analysis, *D. simulans* may also occur and benefit from linkage planning at lower elevations in the southern portion of the planning area.

The distribution of the Pacific kangaroo rat extends from the coastal mountains and valleys of San Bernardino and Riverside Counties, north to the Santa Barbara-San Luis Obispo county line and inland to the Tehachapi and Piute Mountains, as far north as the South Fork of the Kern River (Best 1983, CDFG 1990, Sullivan and Best 1997). Pacific kangaroo rats are most common in mid-elevation scrub and chaparral habitats, but have been found as high as 2250 m (7400 ft) and in open coniferous and other woodlands (CDFG 1990). The Pacific kangaroo rat isn't afforded any special status.

Habitat Association: This species is a habitat generalist, occurring in a variety of open habitats with scattered vegetation including coastal sage scrub, chaparral, oak woodland, pinyon-juniper woodland, desert scrub, and annual grassland (Bleich and Price 1995, W. Spencer pers. comm.). They've also been recorded in montane coniferous forests (Sullivan and Best 1997). They require friable soils in which to burrow (CDFG 1990). Goldingay and Price (1997) found them to be particularly abundant in ecotonal habitats. They increase in abundance following fires that create openings in dense vegetation (Price and Waser 1984, Price et al. 1991, W. Spencer pers. comm.). Quinn (1990) believes *D. agilis* to be most abundant in early succession communities that occurs 2 to 5 years after fire, but smaller numbers of individuals can be found scattered in more limited openings in chaparral. Thus, fire may be an important factor in maintaining long-term linkage occupancy (W. Spencer pers. comm.).

Spatial Patterns: MacMillen (1964) estimated home range size of Pacific kangaroo rat from 0.1 to 0.6 ha (0.4 to 1.5 ac) with a mean of 0.3 ha (0.8 ac). Although fairly widespread and common, they seem to occur at somewhat lower densities than other kangaroo rats, perhaps due to the more patchy nature of their habitat (sparse or open areas within scrub and chaparral, versus more homogeneous desert or grassland habitats), which may be the result of chaparral and scrub habitats providing less food (seeds from annual forbs and grasses) than grasslands and deserts (W. Spencer pers.

comm.). Christopher (1973) measured population densities of the Pacific kangaroo rat to range from 0.9 to 10.8 per hectare.

Kangaroo rat tends to be more mobile than most rodents of their size. Little specific information is available on movements of Pacific kangaroo rat, but they are probably similar to Merriam's kangaroo rat, which is better studied. Merriam's kangaroo rat typically remains within 1-2 territories (100 m or so) of their birthplace, but the species is capable of longer dispersal (over 1 km; Jones 1989). Behrends et al. (1986) found movements of about 10 to 29 meters between successive hourly radio fixes, although they are capable of very rapid movements. For example, Daly et al. (1992) observed individuals moving as much as 100 m in a few minutes to obtain and cache experimentally offered seeds. Zeng and Brown (1987) recorded long-distance (= dispersal) movements in adults, concluding that Merriam's kangaroo rats are opportunistic in moving into newly available territory areas.

Conceptual Basis for Model Development: Movement between protected core areas in the linkage is multigenerational. This species prefers open vegetative communities including coastal sage scrub, alluvial fan sage scrub, chaparral, desert scrub, annual grassland, oak woodland, pinyon-juniper woodland, and montane coniferous forests. They are primarily found between 800 and 2,250 meters in elevation (Sullivan and Best 1997). Core areas were defined as $\geq$ 8 ha. Patch size was defined as $\geq$ 0.5 ha and < 8 ha. Dispersal distance for these species hasn't been measured, so we used twice the dispersal distance for Merriam's kangaroo rat (768 m).

Results & Discussion: The Least Cost Union captured the most highly suitable habitat for this species in southern portions of the Union (Figure 22). The patch size analysis showed a fairly contiguous distribution of potential core habitat for this kangaroo rat between targeted roadless areas (Figure 23). As such, the linkage will also likely serve the needs of the Pacific kangaroo rat (as well as the Dulzura kangaroo rat in southern portions of the area). Distances among all core areas and patches (min size to core size) are within the dispersal distance of this species, although barriers to movement may exist between suitable habitat patches. Many small mammals are reluctant to cross roads, resulting in reduced movement rates and altered spatial patterning in fragmented systems (Merriam et al. 1989, Diffendorfer et al. 1995). To restore and protect connectivity for these kangaroo rats, we recommend that:

- Crossing structures for small mammals be placed fairly frequently to facilitate movement across major transportation routes and reduce travel distance (Jackson and Griffin 2000, McDonald and St. Clair 2004);

- Short retaining walls be installed in conjunction with crossing structures to deter small mammals, amphibians, and reptiles from accessing roadways (Jackson and Griffin 2000); and

- Lighting is directed away from the linkage and crossing structures.

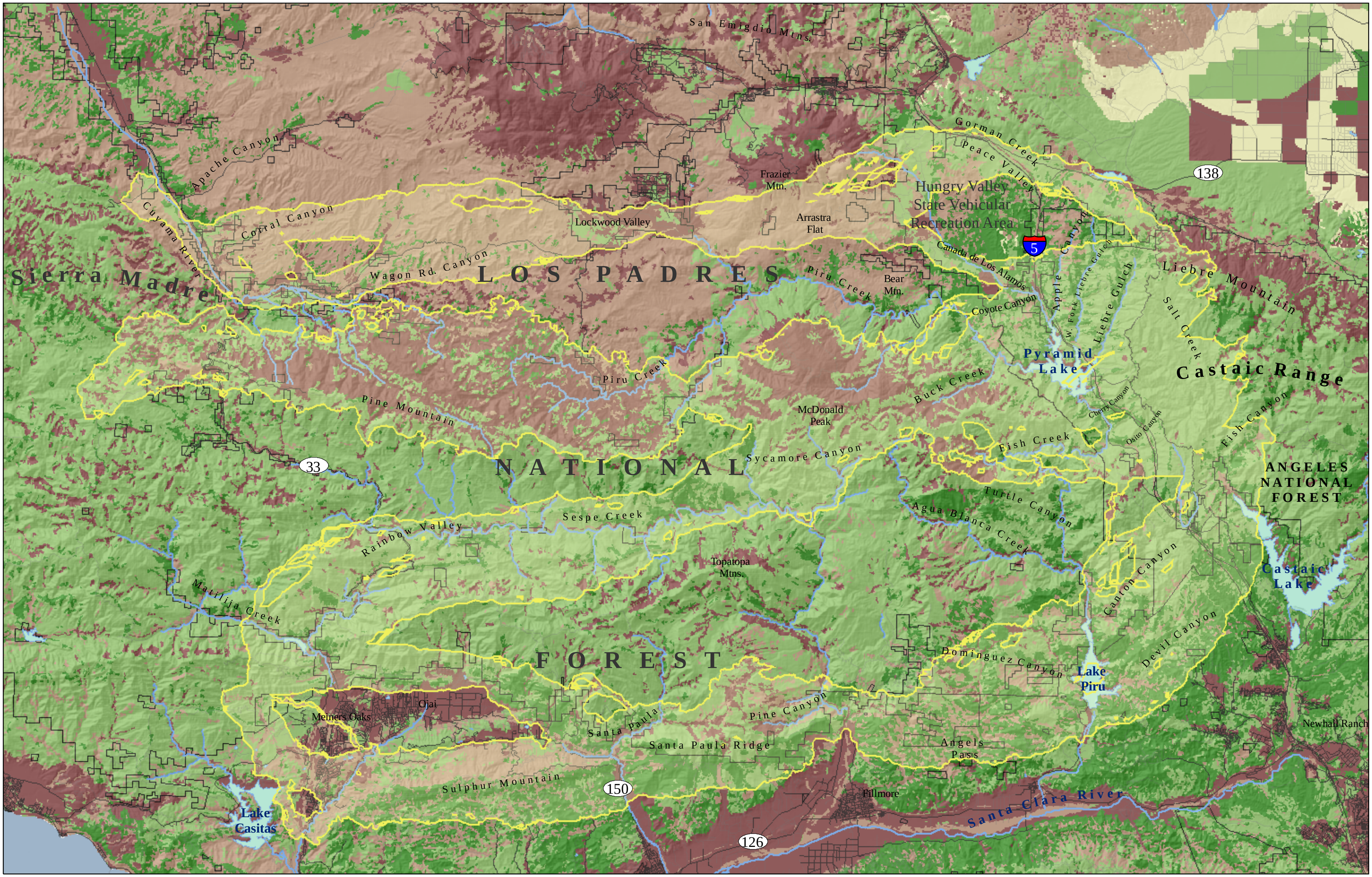

Figure 22. Habitat Suitability for Pacific kangaroo rat ***(Dipodomys agilis)***

Degree of Suitability

- High
- Medium to High
- Medium
- Low to Medium
- Low
- Linkage Union
- Ownership Boundaries
- Reservoirs and Lakes
- Perennial Streams
- Roads

Scale 1: 340,000

0 2 4 8 12 16 Kilometers

0 2 4 8 12 16 Miles

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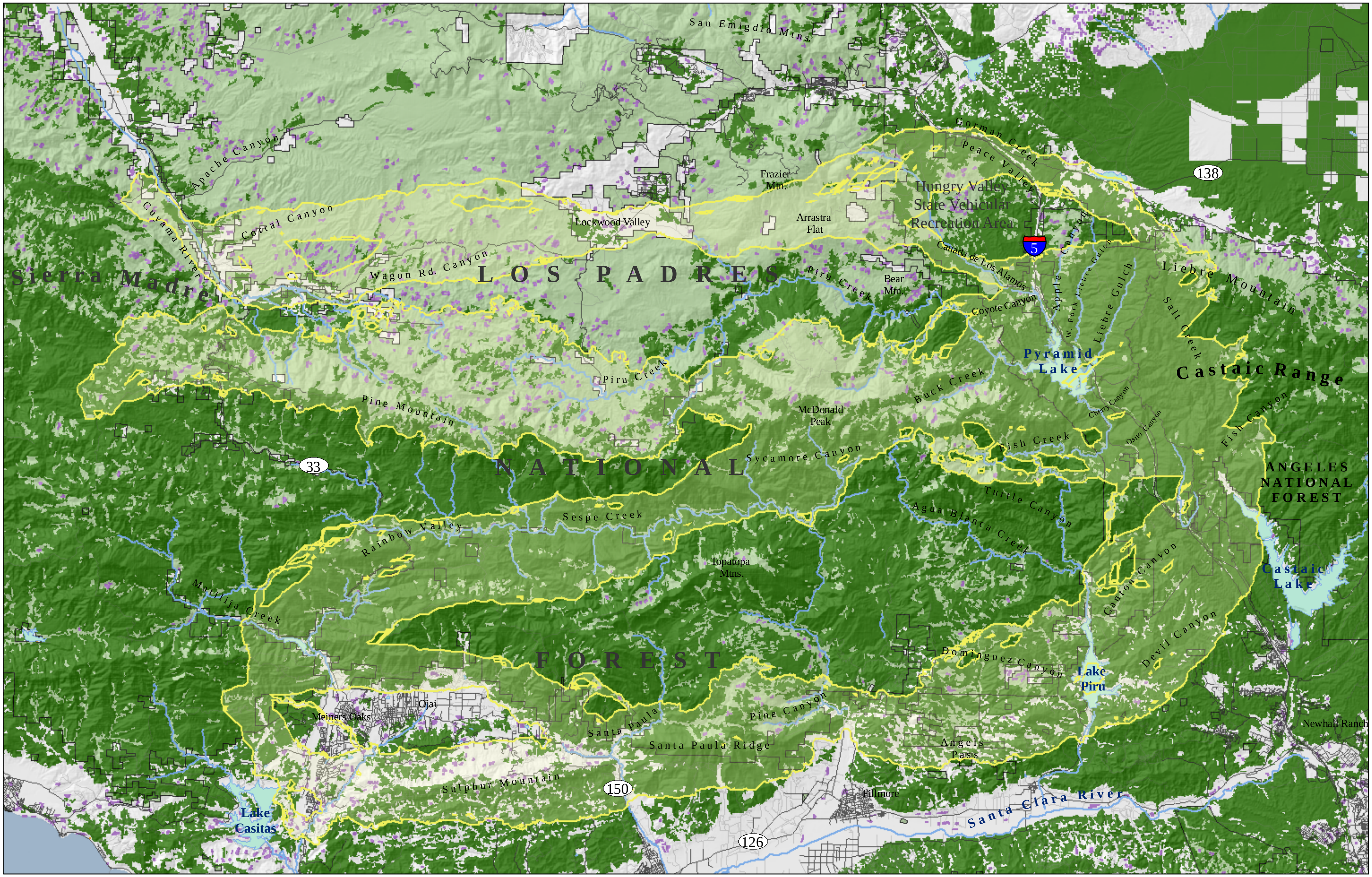

Figure 23. Potential Cores & Patches for Pacific kangaroo rat ***(Dipodomys agilis)***

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California Spotted Owl (*Strix occidentalis occidentalis*)


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Distribution & Status: The California spotted owl is one of three subspecies of spotted owl in California. It inhabits the Sierra Nevada and the coastal, Transverse, and Peninsular ranges (Remsen 1978, LaHaye et al. 1997). The first specimen was collected in 1859 in the Tehachapi Mountains (Gutierrez et al. 1992). The elevational range extends from lower than 1,000 feet to as high as 8,500 feet. It is designated as a Federal and State Species of Special Concern (CDFG 2001) and was recently proposed for listing under the federal Endangered Species Act.

Habitat Associations: This species is associated with structurally complex mature or old growth hardwood, riparian-hardwood, hardwood-conifer, mixed and pure conifer habitats with substantial canopy cover (>70%) and majestic long-standing trees and snags (Verner et al. 1992, Gutiérrez et al. 1992, LaHaye et al. 1994, Moen and Gutiérrez 1997). Nest trees are typically the largest in the stand (Gutiérrez et al. 1992), which usually contains an accumulation of down woody debris with a well-developed soil layer (Verner et al. 1992). This subspecies is more variable in its selection of foraging habitats than its northern relatives, which are highly restricted to dense forests. Unlike them, the California spotted owl is sometimes found foraging in chaparral (Gutierrez et al. 1992).

Spatial Patterns: This subspecies incorporates large tracts of mature and old growth forests into its home range (LaHaye et al. 1997), requiring extensive blocks [40-240 ha (100-600 ac)] that contain suitable nesting and roosting habitat, as well as available water (Forsman1976, CDFG 1990). In the mature Douglas-fir/hemlock forests of Oregon, Forsman et al. (1977) found home range to vary between 120-240 ha (300-600 ac), and similar home range sizes have been recorded in the Sierra Nevada (Gould 1974, CDFG 1990). The distribution of prey has been found to strongly influence the size of an owl's home range (Carey et al. 1992, Zabel et al. 1995, Smith et al. 1999), and habitat use patterns (Carey et al. 1992, Carey and Peeler 1995, Zabel et al. 1995, Ward et al. 1998, Smith et al. 1999). Lower elevation habitats may be more productive due to higher prey densities in surrounding vegetative communities. Occupied habitat at lower elevations is typically dense, mature forest on north-facing slopes and deep canyons (Stephenson and Calcarone 1999).

Home ranges are generally spaced 1.6 to 3.2 km (1-2 mi) apart in appropriate habitat (Marshall 1942, Gould 1974, CDFG 1990). Owl densities are greater in areas with a higher density of old trees in dense groves (Gutierrez et al. 1992). Smith (1996) estimated owl density for the San Bernardino population to be 0.43 per km^2 for oak/big-cone fir, 0.20 per km^2 for conifer/hardwood, and 0.11 owls per km^2 for mixed coniferous forests. Owl densities in Sequoia Kings Canyon National Parks have been recorded at

12.8 pairs per 100 km^2, while densities of 10.0 pairs per 100 km^2 have been estimated for the Sierra National Forest (North et al. 2000). LaHaye et al. (1997) suggested higher densities might reflect smaller territory sizes, which could result from increased prey densities.

Metapopulation analyses have estimated dispersal distances of 7-60 km (LaHaye et al. 1994). However, shorter dispersal distances have been recorded. In the San Bernardino Mountain population, 67 males and 62 females dispersed 2.3-36.4 km and 0.4 –35.7 respectively (LaHaye et al. 2001). Dispersal distances for spotted owls in other populations range from 5.8 (Ganey et al. 1998) to 56 km (Gutierrez et al. 1996). Several radio telemetry studies have recorded even greater distances, up to 72.1 km (LaHaye et al. 2001, Miller et al. 1997, Ganey et al. 1998, Willey and van Riper 2000).

Conceptual Basis for Model Development: This species prefers mature and old growth forests below 8,500 feet. Home range sizes have been recorded from 40-240 ha. Core areas potentially supporting 50 or more individuals were defined as $\geq$ 4,000 ha. Patch size was classified as $\geq$ 80 ha but < 4,000 ha. Dispersal distance was defined as 144 km.

Results & Discussion: The patch size analysis identified 4 potential core areas for California spotted owl (Pine Mountain, McDonald Peak, San Emigdio Mountains, and Liebre Mountain), and several substantial patches of suitable habitat, most notably in Buck Creek (Figure 24). California spotted owl are known to occur in suitable montane hardwood and conifer habitats in both the Sierra Madre and Castaic ranges (Figure 24). However, this species is also known to forage in more open habitats. Note the occurrence in the vicinity of I-5 in Piru Gorge, near Cherry Canyon (Figure 24). All suitable habitat patches are well within the maximum dispersal distance of 144 km. We conclude that the Least-Cost Union can sustain movement needs among populations of owls, and serve a critical function of preserving this top predator.

Research shows that northern spotted owls (*S. o. caurina*) living in close proximity to roads experienced higher levels of physiological stress than owls living in areas without roads (Wasser et a. 1997). To maintain landscape level connectivity for California spotted owl between the Sierra Madre and Castaic ranges, we recommend that:

- Existing road density be maintained or reduced; no new roads in the Linkage Design;
- Lighting is directed away from the linkage to provide a dark zone for nocturnally active species. Species sensitive to human disturbance avoid areas that are artificially lit (Beier 1995, Longcore 2000); and
- Local residents are informed about the proper use of rodenticides and pesticides to reduce the likelihood of ingestion of these lethal substances by the natural predators of rodent species.

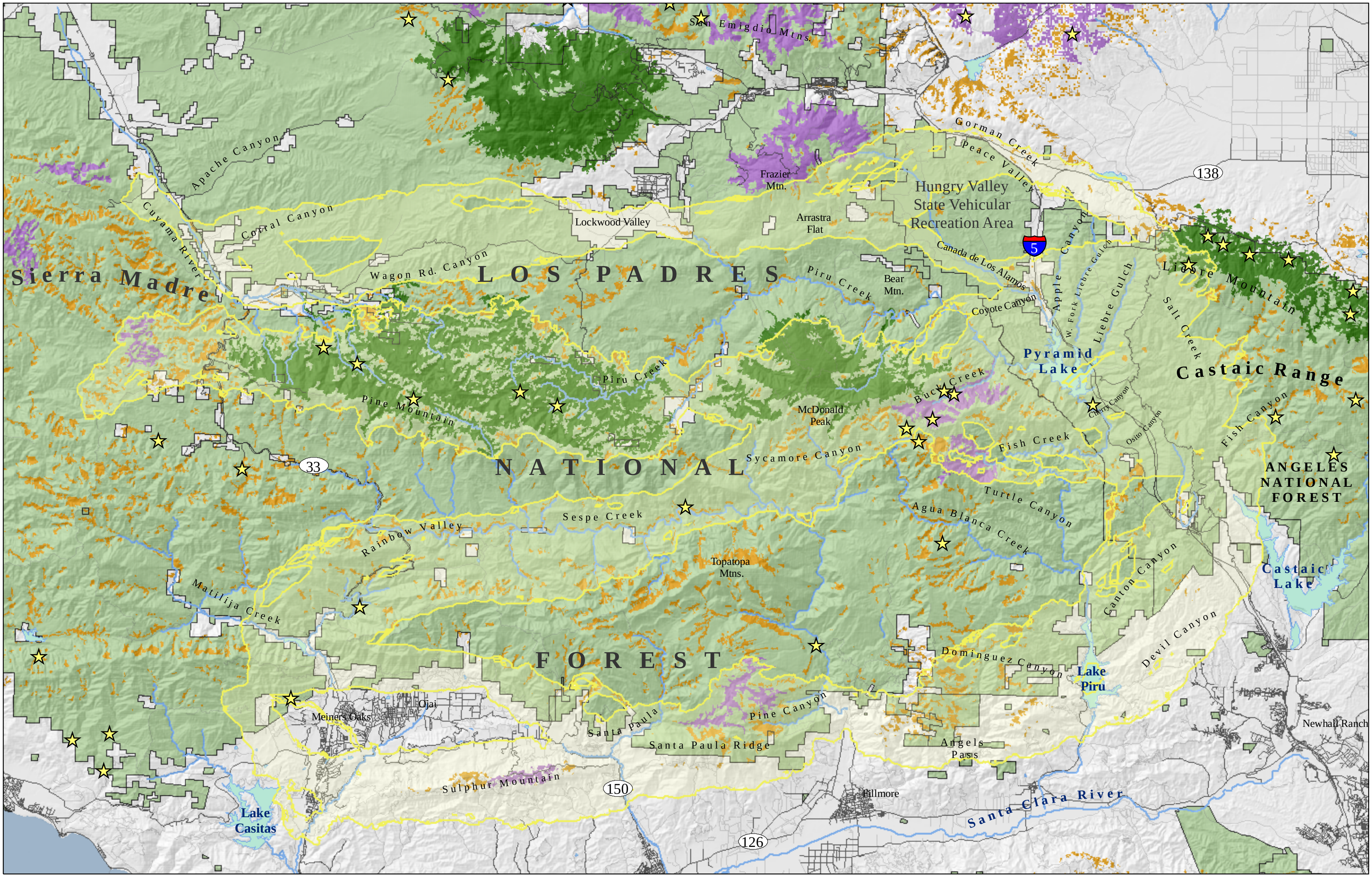

Figure 24. Potential Cores & Patches for California spotted owl *(Strix occidentalis)*

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Acorn woodpecker (*Melanerpes formicivorus*)

Justification for Selection: The continued elimination of oaks is a threat to the existence of this species in California (Verner and Boss 1980, CDFG 1990). Overgrazing causes reduced regeneration of oaks. As a cavity nester, this species is also indicative of intact bird communities; they are highly susceptible to competition with invasive non-native birds such as European starlings, which are associated with degraded habitats.

Distribution & Status: Acorn woodpeckers occur from northwestern Oregon, California, the American Southwest, and western Mexico through the highlands of Central America, as far south as northern Columbia (Koenig and Haydock 1999). They are typically found below 2100 m, though most good habitats are below 915 m in elevation (CDFG 1990). This species isn't considered sensitive by any government entities.

Habitat Associations: Acorn woodpeckers are residents of foothill and montane hardwood and hardwood-conifer habitats as far south as pines occur (Roberts 1979, CDFG 1990). The acorn woodpecker relies on large stands of old trees (Ligon and Stacey 1996). They excavate cavities in winter and spring in live trees or snags of oaks, sycamores, or conifers (CDFG 1990), though snags are preferred (Hooge et al. 1999). The acorn woodpecker is a highly specialized species that lives in a close association with oaks, because they depend largely on acorns for their winter diet (Ritter 1938, MacRoberts 1970, Bock and Bock 1974; Hannon et al.1987, Koenig and Mumme 1987, CDFG 1990, Koenig and Haydock 1999). Oak species diversity influences the distributional limit of this species, because the probability of acorn crop failure declines with increasing oak species (Koenig and Haydock 1999). Bock and Bock (1974) found oak species richness to have a nearly exponential relationship to woodpecker abundance.

Spatial Patterns: Acorn woodpeckers are cooperative breeders that live in social groups of 2 to 15 individuals (MacRoberts and MacRoberts 1976; Koenig et al. 1995, Hooge et al. 1999). Territory size is based on the key resource, the roost cavity and granary tree (Ligon and Stacey 1996). MacRoberts and MacRoberts (1976) found territory sizes from 3.5 to 9 ha (8.7 to 22.2 ac), while Swearingen (1977) found average territory size to be 4.7 ha (11.5 ac) in the Central Valley, with a range from 1.5 to 8.1 ha (3.8 to 20 ac). Smaller territory sizes have been recorded for the Coast Ranges (CDFG 1990).

On the western slope of the Sierras, upslope movement occurs in fall to mixed conifer habitat with black oak (Verner and Boss 1980, CDFG 1990). Dispersal distances of 0.22

$\pm$ 0.48 km for males and 0.53 $\pm$ 0.52 km for females have been recorded. The usual avian pattern of greater dispersal distance by females holds true for acorn woodpeckers (Koenig et al. 2000). The maximum-recorded dispersal distance for this species is 4.3 km (Baker et al. 1995, Koenig et al. 2000).

Conceptual Basis for Model Development: This species prefers mature oak woodlands and hardwood coniferous forest below 2100 m. Home ranges have been recorded between 1.5-9 ha. The minimum patch size was defined as 2 home ranges (3 ha), using the smallest recorded range (1.5 ha x 2). Patch size was classified as $\geq$ 3 ha but < 100 ha. Core areas potentially supporting 50 or more individuals were defined as $\geq$ 100. Dispersal distance was defined as 8.6 km, using twice the maximum reported distance of 4.3 km.

Results & Discussion: Oak woodlands are fairly widespread in the planning area (Figure 25). Several potential core areas and patches of highly suitable habitat were captured in the Least Cost Union (Figure 26). Along I-5, patches of suitable habitat were identified along Gorman Creek, in lower Cañada de Los Alamos and Coyote Canyon, in Piru Gorge near Cherry Canyon, and in Canton Canyon. All potential cores and patches of suitable habitat identified by the analysis are within the dispersal distance of this species. As such, acorn woodpecker appears to be well accommodated by the Least Cost Union.

As cavity-nesting birds, Acorn woodpeckers are susceptible to being extirpated by birds associated with urban areas, such as European starlings, that can out compete woodpeckers for nesting cavities. To protect and maintain habitat continuity between protected cores areas for Acorn woodpecker, we recommend that:

- Existing road density be maintained or reduced; no new roads in the Linkage Design; and
- Grazing is discouraged in oak woodlands to allow for regeneration.

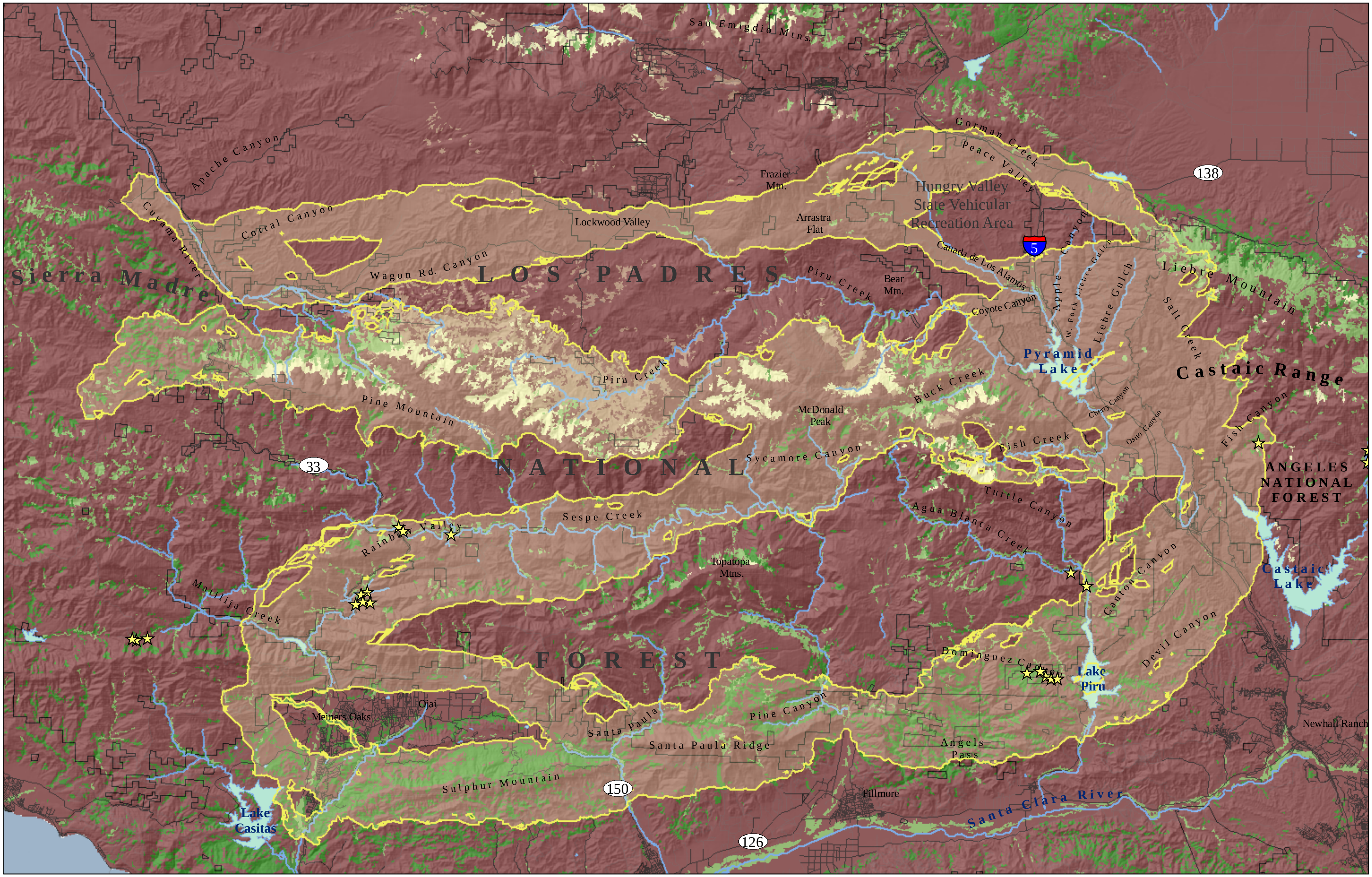

Figure 25. Habitat Suitability for Acorn woodpecker *(Melanerpes formicivorus)*

- Low
- Low to Medium
- Medium
- Medium to High
- High
- Linkage Union
- Ownership Boundaries
- Reservoirs and Lakes
- ☆ Species Occurence (Source: USFS)
- Perennial Streams
- Roads

Scale 1: 340,000

Kilometers: 0 2 4 8 12 16

Miles: 0 2 4 8 12 16

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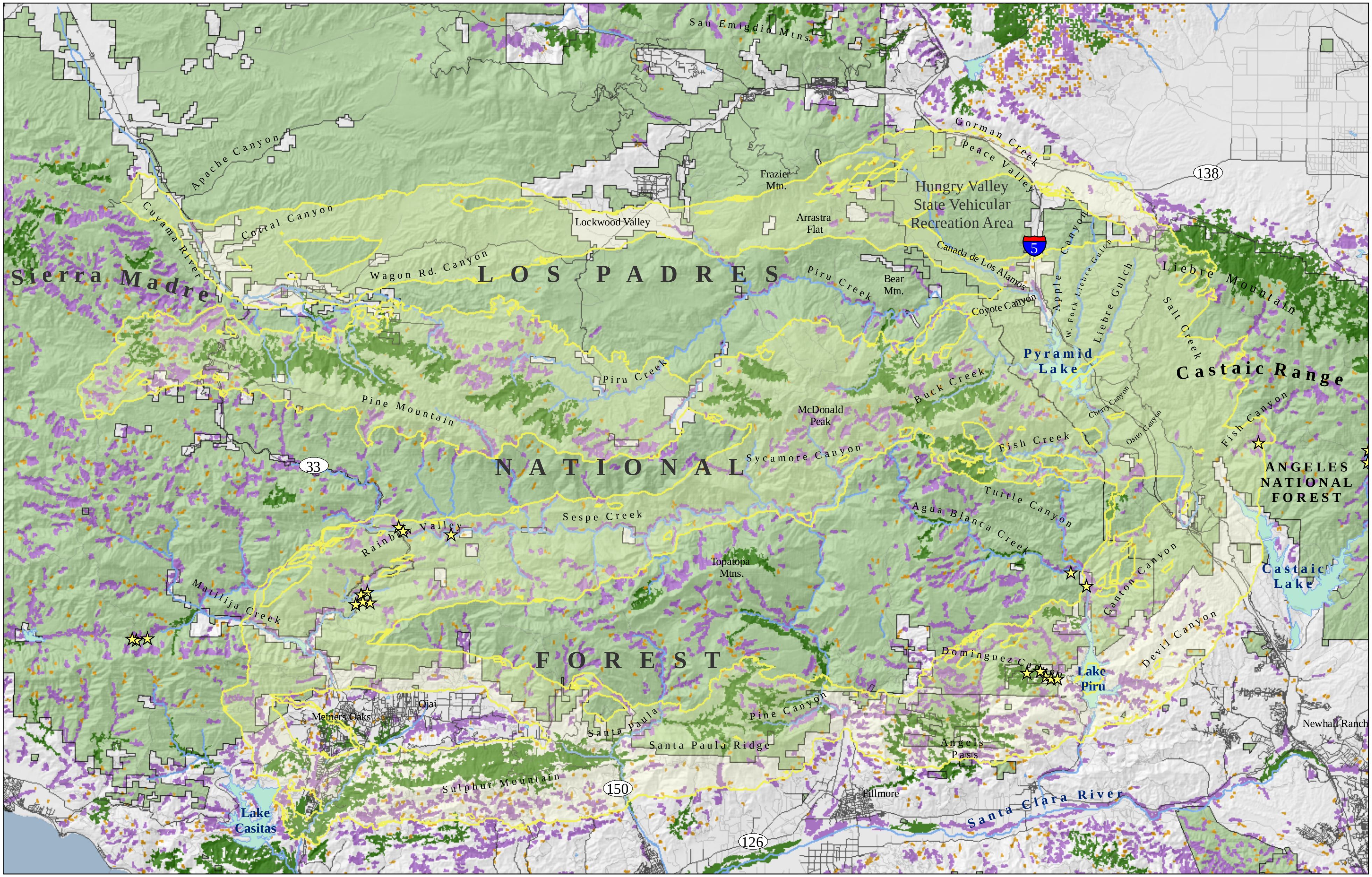

Figure 26. Potential Cores & Patches for Acorn woodpecker ***(Melanerpes formicivorus)***

Core
Patch
< Patch
Linkage Union
Ownership Boundaries
Reservoirs and Lakes
Species Occurence (Source: USFS)
Perennial Streams
Roads

Scale 1: 340,000

Kilometers: 0 2 4 8 12 16

Miles: 0 2 4 8 12 16

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Western Pond turtle (*Actinemys marmorata pallida*)

Justification for Selection: The Western pond turtle is the only native freshwater turtle remaining in California. It is an indicator of connections within and between aquatic and upland habitat. The main threat to the pond turtle is the alteration and loss of both terrestrial and aquatic habitats by dams, water diversions, stream channelization and development in adjacent upland areas. Protecting and restoring habitat for the long-lived turtle will benefit the entire ecosystem.

Distribution & Status: The species may occur below 1830 m (6000 ft) elevation in suitable aquatic habitat throughout California (Morey 1988). There are 2 currently recognized subspecies, with the Central Valley considered a contact zone between the two subspecies: the northwestern pond turtle (*A. m. marmorata*) and the southwestern pond turtle (*A. m. pallida*); the southwestern subspecies occupies the area from central coastal California southward into northern Baja California Norte (Stebbins 1954; Holland 1992, 1994; Holland and Bury in press). However, more recent work (Holland 1992) indicates that there may be 3 separate species. The pond turtle's current distribution is a mere fraction of its historic range; it is considered federally Sensitive and a California Species of Special Concern (Jennings and Hayes 1994, CDFG 2001).

Habitat Associations: Pond turtles typically occur in permanent ponds, lakes, streams, irrigation ditches, or permanent pools along intermittent streams (Morey 1988). They tend to favor habitats with abundant basking sites such as partially submerged logs, rocks, mats of floating vegetation, or open mud banks (Bury 1972, Morey 1988), but can also occur where basking sites are scarce (Holland 1985). Pond turtles tend to aggregate in large, deep pools along streams, especially those with cover (boulder piles) or underwater escape sites (undercut banks, and tangles of roots) (Bury 1972). Access to sandy banks is needed for nesting (Storer 1930, Rathburn et al. 1992).

Spatial Patterns: In northern California, pond turtles have relatively small home ranges in aquatic habitats (Bury 1972, 1979). Male home ranges average 1 ha (range: 0.2 - 2.4 ha) of water surface and they move an average of 367 m along watercourses among years. Female home ranges average 0.3 ha (range: 0 - 0.7 ha) with movements up and down stream of 149 m. Turtle abundance has been positively correlated with number of basking sites (logs, boulders), and pond size and depth (Bury 1972). In high quality habitat, this species may exceed 1000 individuals per hectare of water surface and may constitute the dominant element of the vertebrate biomass (D. Holland pers. comm.).

Males and females can disperse long distances along watercourses and overland. Males tend to move greater average and total distances than females or juveniles and can move over 1.5 km along watercourses (Bury 1972). Both males and females can move overland 0.5 km from nearest watercourse (Holland unpubl.), and a small proportion of the population even makes long distance movements among drainages: of 1200 individuals marked between 1981 and 1991 in the central coast of California, less than 10 recaptures were outside of the original drainage (Holland unpubl.). The maximum linear distance between capture and recapture was 2.5 km. These movements can be rapid. One marked turtle moved 1.5 km in 2 weeks (Bury 1972) and a radio-tagged male pond turtle in northern California traveled 700 m in 4 days (Bury 1972).

Nesting movements for most females are typically within 50 m of water (Rathburn et al. 1992, Reese and Welsh 1997), but they can make long overland treks up to 0.4 km and 90 m in elevation rise to deposit their eggs at suitable nesting sites in sandy banks or open, grassy fields (Storer 1930, Rathburn et al. 1992, Lovich and Meyer 2002). In southern California, 2 of 4 radio-tracked female pond turtles traveled about 1 and 2 km upstream between 19 May and 9 August (Rathburn et al. 1992). A nesting female moved 14 to 59 m roughly perpendicular from the water's edge when excavating nests. Turtles may also make seasonal movements, such as out of the flood plain during winter months to escape flooding (Rathburn et al. 1992, Holland 1994, Reese and Welsh 1997). Due to nesting and overwintering movement requirements, upland habitat corridor width of 0.5 km to either side of the watercourse may be needed to support pond turtle populations (Rathburn et al. 1992).

Conceptual Basis for Model Development: Movement between protected core areas in the linkage is multigenerational. Turtles travel most easily along watercourses and in riparian vegetation. Movements through a variety of natural upland habitats are common but may be slightly more difficult, especially those habitats with dense canopy cover that do not provide opportunities to thermoregulate. Turtles avoid urban and intensive agricultural areas. They are good climbers and probably avoid only the steepest slopes. Roads are very difficult for turtles to move across. They are slow moving and have been found crushed on roads up to 200 m from watercourses (Holland unpublished). Perennial stream drainages with riparian vegetation types are required for turtles to establish home ranges. Sandy soils within 0.4 km of riparian areas are needed for nesting. Core Areas containing fifty turtles are at least 0.5 km^2 in size (1 ha x 50). The minimum patch size needed to sustain a breeding turtle is 1 ha. Dispersal distance was defined as 5 km—twice the maximum recorded distance (2.5 km).

Results & Discussion: Pond turtles have been recorded in numerous drainages in the assessment area (Figure 27). Potential core areas within the Least Cost Union include lower Cuyama River, North Fork Matilija Creek, Ventura River, San Antonio Creek, Sespe Creek, and Pine Canyon. Additional habitat may occur in the vicinity of I-5 in Cañada de Los Alamos, Piru Creek above and below Pyramid Dam, Cherry Canyon, Big Oak Flat, and Canton Canyon. The patch configuration analysis identified two potential areas that may allow movement of this species across the I-5 barrier: along Gorman Creek down to Cañada de los Alamos, and from Canton Canyon to Big Oak Flat (Figure 28). Along Highway 33, 4 potential riparian crossings were identified, at Cuyama River, Sespe Creek, Matilija Creek, and Ventura River. Riparian and aquatic habitats in the planning area historically contained large populations of pond turtles, but habitat changes have eliminated pond turtles from much of their historic range. Pond turtles can move significant distances from water, and can cross ridges from one canyon to another under certain conditions. For these reasons, the linkage is likely to serve this species if habitat is added along Gorman Creek and the Ventura River, and if threats to the species persistence are countered with restoration and management.

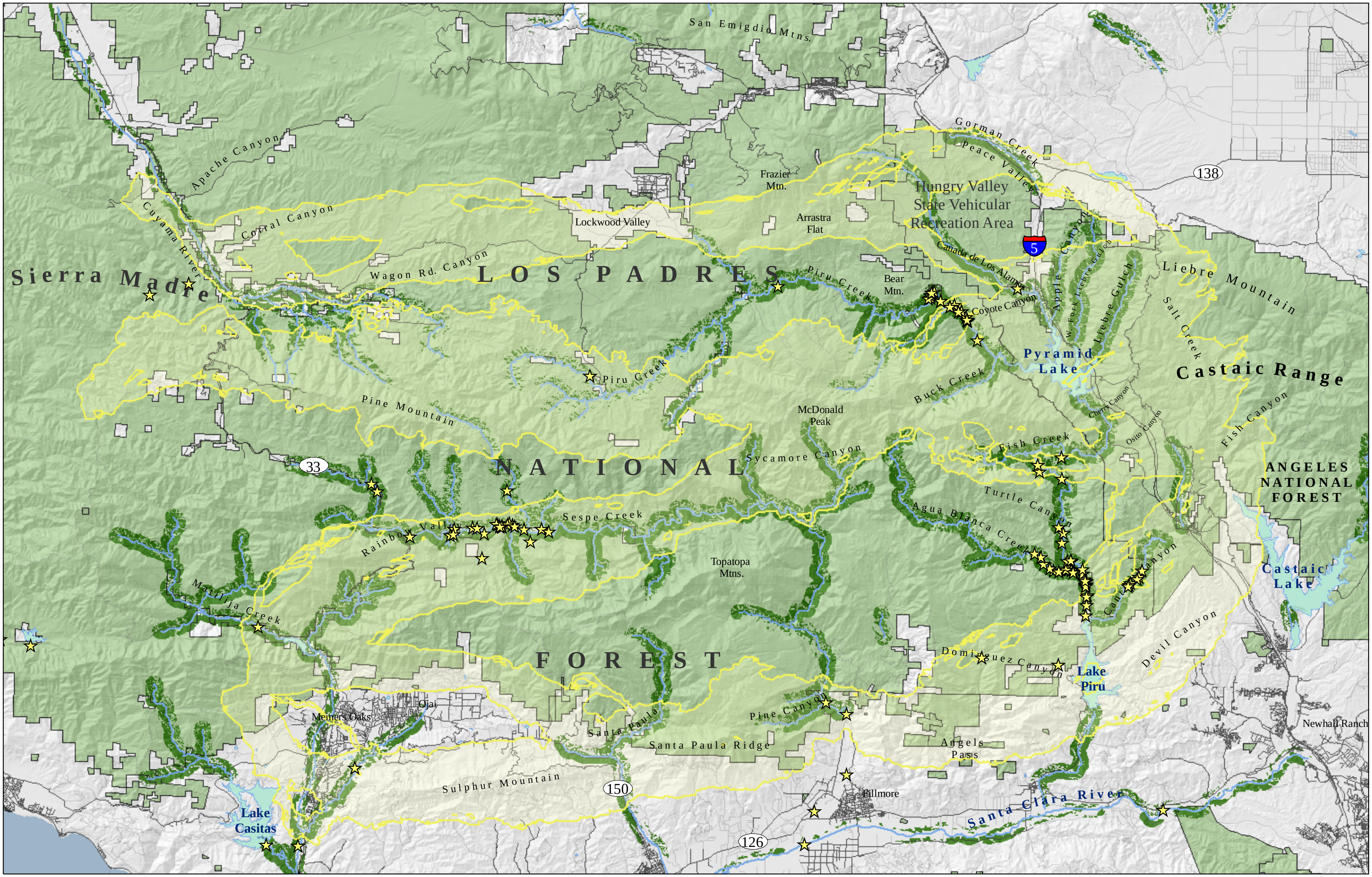

Figure 27. Potential Cores for Western pond turtle ***(Actinemys marmorata)***

Potential Cores
Linkage Union
Ownership Boundaries
Reservoirs and Lakes
Species Occurence (Source: USFS)
Perennial Streams
Roads

Scale 1: 340,000

Kilometers: 0 2 4 8 12 16

Miles: 0 2 4 8 12 16

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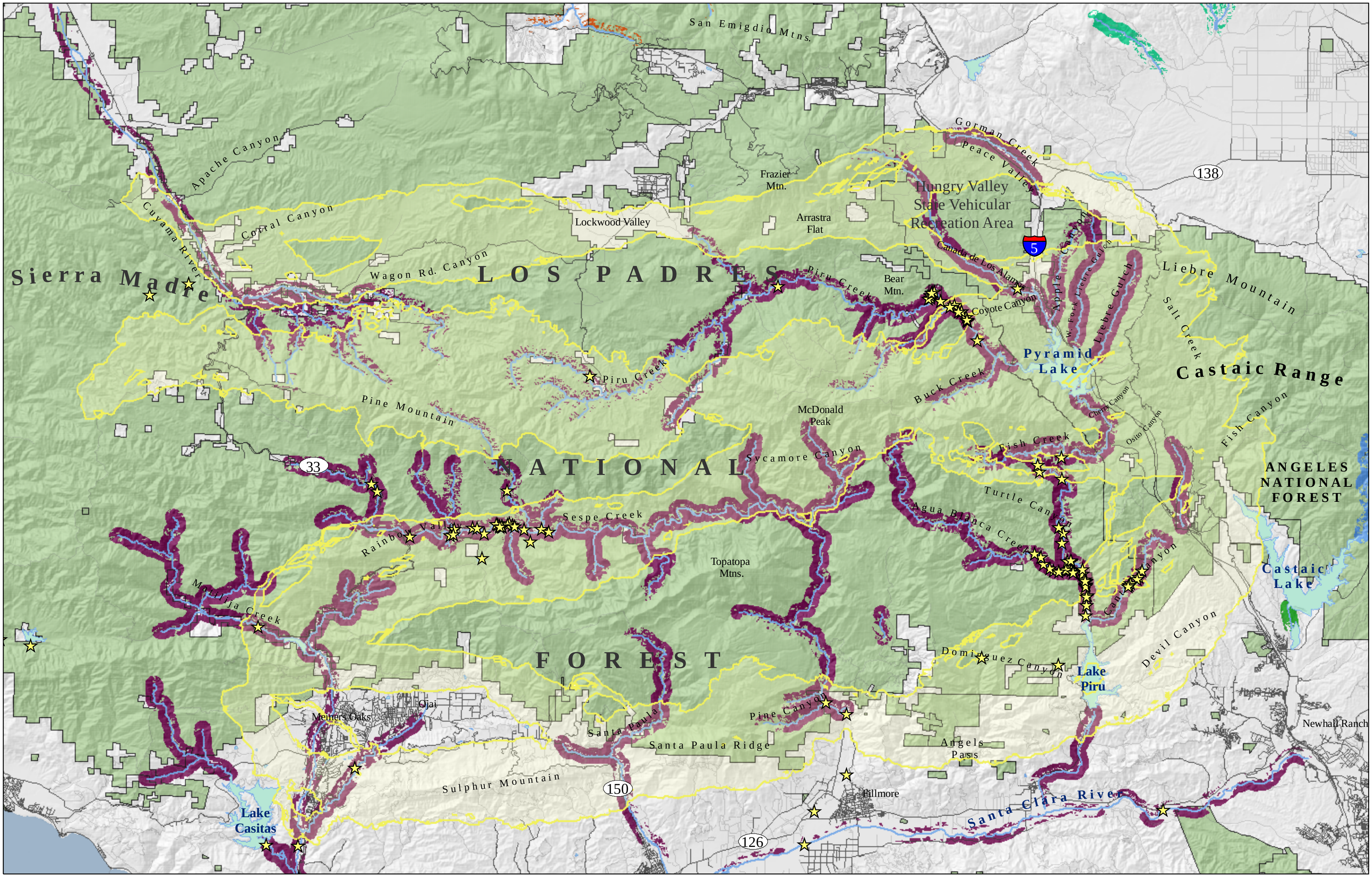

Figure 28. Patch Configuration for Western pond turtle ***(Actinemys marmorata)***

- Linkage Union
- Ownership Boundaries
- Reservoirs and Lakes
- ☆ Species Occurence (Source: USFS)
- Perennial Streams
- Roads

Scale 1: 340,000

Kilometers: 0 2 4 8 12 16

Miles: 0 2 4 8 12 16

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*Colors signify patches of suitable habitat that are within twice the dispersal distance.

Research suggests that existing regulations governing riparian and wetland communities are inadequate to protect populations of aquatic and semi-aquatic species (Wilson and Dorcas 2003). Functional buffer zones must include enough upland habitats to maintain the water-quality attributes and habitat features required by organisms dependent on these systems (Brosofske et al.1997, Wilson and Dorcas 2003). Roadkill is a significant threat to turtles, especially for females seeking nesting habitat. To restore and protect habitat for pond turtles between the Sierra Madre and Castaic ranges, we recommend that:

- Habitat is added to the Least Cost Union in Gorman Creek and along the Ventura River;
- Historical flow regimes be mimicked and water quality restored where necessary;
- Invasive species that destroy pond turtle habitat (e.g. giant reed), prey upon hatchlings (e.g., bullfrogs), and compete with turtles or carry diseases be eradicated;
- Riparian and upland habitats needed for breeding and movement be restored;
- Existing road density be maintained or reduced; no new roads in the Linkage Design;
- Road barriers be modified to allow turtles to move along water courses throughout the cores areas and Linkage Design;
- Short retaining walls be installed, where necessary, along paved roads in the Linkage Design to deter turtles from accessing roadways and funnel them toward crossing structures (Jackson and Griffin 2000); and
- Anti-poaching laws are enforced.

Two-striped garter snake (*Thamnophis hammondii*)

Justification for Selection: This attractive non-venomous snake was selected as a habitat quality indicator due to its reliance on high-quality aquatic environments that support their primary prey (native amphibians) and are free of introduced predators (e.g., bullfrogs, African clawed frogs). Bullfrogs are known to consume all life stages of *T. hammondii* (S. Sweet, pers. Comm. *in* Jennings and Hayes 1994), and also compete with them for prey. Jennings et al. (1992) predicted that declines of amphibians would lead to a decline in garter snakes.

Distribution and Status: The range of the two-striped garter snake extends through the Coast and Peninsular ranges, from central California as far south as the La Presa region in northwestern Baja. In southern California, this species is found in suitable habitat from the coast to the foothills and mountains, with an elevational range between sea level and 8,000 feet (Stebbins 1985, McGuire 1989, Jennings and Hayes 1994, SDNHM 2001).

Habitat loss, fragmentation and degradation due to urban and agricultural development and the associated modifications to the hydrological system threaten the survival of this species (Stebbins 1985, Jennings and Hayes 1994). Snakes are also highly sensitive to habitat fragmentation by roads (Dodd et al. 1989, Bonnet et al. 1999, Kjoss and Litvaitis 2001). This species has been extirpated from about 40% of its historical range (Jennings and Hayes 1994) and is designated as a California Species of Special Concern (CDFG 2001).

Habitat Associations: The two-striped garter snake is primarily associated with perennial or intermittent streams but may also occupy ponds, lakes, and vernal pools (Jennings and Hayes 1994, SDNHM 2001). They are also known to inhabit large sandy riverbeds, such as the Santa Clara River (Jennings and Hayes 1994). Essential habitat elements include dense riparian vegetation, streamside rocks, and the availability of prey (Jennings and Hayes 1994, Matthews et al. 2002). Although, this species is regarded as one of the most aquatic of garter snakes (Rossman, et al. 1996), it will also utilize upland plant communities, such as oak woodland, chaparral, coastal scrub, and grassland (Rathburn et al. 1993).

Spatial Patterns: Garter snakes are non-territorial (SDNHM 2001, CDFG 2003). In summer, snakes have relatively small home ranges in streamside environments, averaging 1,500 m^2 (range 80-5,000 m^2; N = 7). In winter they occupy nearby uplands (coastal sage scrub and grassland) and typically expand the size of their home range to an average of 3,400 m^2 (range 50-9,000 m^2; N = 3; Rathburn et al.1993).

Research on the movement ecology of two-striped garter snakes has not yet been undertaken. However, Shine et al. (2001) conducted radio telemetry studies for a related species, red-sided garter snake (*T. sirtalis parietalis*). Of the 36 individuals monitored over the course of their study, females moved greater distances (738.0 m $\pm$ 894.5 m) than males (185.0 m $\pm$ 211.9 m). Their study also indicated that males wander among dens (Shine et al. 2001).

Conceptual Basis for Model Development: Movement between protected core areas in the linkage is multigenerational. Suitable habitat was defined as perennial or intermittent streams, ponds, lakes, and vernal pools and contiguous upland plant communities (within a 1-km buffer), including oak woodland, chaparral, coastal scrub, and grassland. Because habitat quantity is a poor predictor of population density in garter snakes, we did not designate a minimum patch size, and included all suitable habitat as potential cores areas for this species. Dispersal distance was defined as 3,264 m, or two times the longest dispersal distance (1632 m) recorded for an allied species, the red-sided garter snake.

Results and Discussion: Extensive core habitat was identified for two-striped garter snake in the linkage planning area. The model predicted suitable habitat to occur along Boulder and Spail canyons, Reyes, Beartrap, and Matilija creeks, tributaries around Lake Casitas, the Ventura River, Sespe and Piru creeks and their major tributaries, and Lockwood, Gorman, Snowy, Buck, Fish, Agua Blanca, and Salt creeks, much of which was captured in the Least Cost Union (Figure 29). Garter snakes have been recorded in several drainages in the assessment area; of particular interest are those occurrences near I-5 in Gorman Creek, lower Cañada de Los Alamos, and Canton Canyon (Figure 29). The spatial configuration of suitable habitat suggests a potential connection across I-5 from Cañada de Los Alamos to Apple Canyon (Figure 30). However, since the construction of Pyramid Lake Dam this connection is no longer viable. Two other potential pathways occur along I-5: along Gorman Creek down to Cañada de los Alamos, and from Canton Canyon to Big Oak Flat. Across Highway 33, potential connections exist at Sespe and Matilija creeks, and from San Antonio Creek to the Ventura River. Though this last area appears to be beyond the dispersal distance of this species, there is potential for movement along the Ventura River northward. Due to the number of dams and diversions in this region, we recommend habitat additions to the Union in Gorman Creek south of the I-5/SR138 interchange not captured in the Union. With these additions and implementation of recommendations for mitigating the effects of dams, diversions and other barriers, the Least Cost Union should serve the needs of this species.

In order for garter snakes to persist in the linkage and cores areas, populations of native amphibians, their primary prey, must also be conserved (Blaustein and Wake 1990, Haliday 1998, Houlihan et al. 2000, Matthews et al. 2002). Native aquatic and semi-aquatic species rely on a myriad of habitat characteristics and water-quality attributes that can be sustained by conserving contiguous upland habitats that surround riparian and wetland systems (Brosofske et al.1997, Wilson and Dorcas 2003).

Habitat loss and fragmentation affects reptiles in many ways (Madsen et al. 1996, Cunningham and Moritz 1997, Kjoss and Litvaitis 2001). Snakes are often the victims of roadkill due to their propensity to use warm roads to thermoregulate (Dalrymple and Reichenbach 1984, Trombulak and Frissell 2000). To protect and maintain habitat for

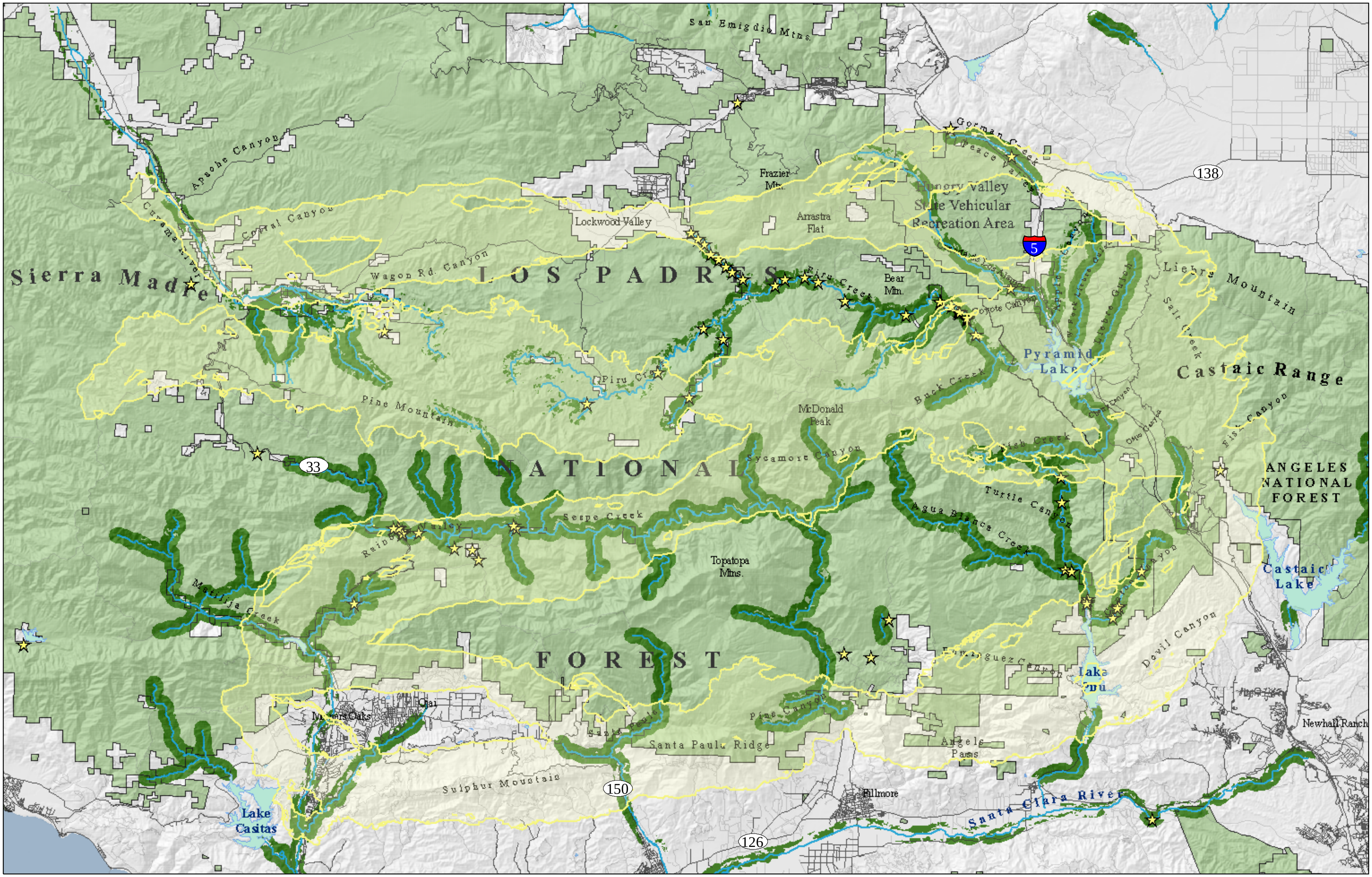

Figure 29. Potential Cores for Two-striped garter snake *(Thamnophis hammondii)*

- Potential Cores
- Linkage Union
- Ownership Boundaries
- Reservoirs and Lakes
- ☆ Species Occurence (Source: USFS & CNDDB)
- Perennial Streams
- Roads

Scale 1: 340,000

0 2 4 8 12 16 Kilometers

0 2 4 8 12 16 Miles

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Figure 30. Patch Configuration for Two-striped garter snake *(Thamnophis hammondii)*

Linkage Union
Ownership Boundaries
Reservoirs and Lakes
Species Occurence (Source: USFS & CNDDB)
Perennial Streams
Roads

Scale 1: 340,000
Kilometers 0 2 4 8 12 16
Miles 0 2 4 8 12 16

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*Colors signify patches of suitable habitat that are within twice the dispersal distance.

garter snakes between protected cores areas, we recommend that:

- Additional habitat in Gorman Creek and along the Ventura River be added to the Least Cost Union;
- Riparian and upland habitats needed for breeding and movement be restored to support garter snakes and their primary prey (i.e., native amphibians);
- Existing road density be maintained or reduced; no new roads in the Linkage Design;
- Road barriers be modified to allow garter snakes to move along water courses and upland habitat throughout the cores areas and Least Cost Union;
- Invasive species that destroy garter snake habitat (e.g. giant reed), or prey upon and compete with garter snakes (e.g., bullfrogs) be eradicated;
- Historical flow regimes be mimicked and water quality restored; and
- Anti-poaching laws are enforced.

California Mountain Kingsnake (*Lampropeltis zonata*)

Justification for Selection: This species is attracted to warm roads in the evening in late spring and summer, making them particularly susceptible to roadkill (McGurty 1988).

Distribution & Status: California mountain kingsnake is distributed in mountainous terrain, from southern Washington to northern Baja California, and on South Todos Santos Island, off Ensenada (McGurty 1988, Rodriguez-Robles et al. 1999). In the South Coast Ecoregion, it occurs in the Coast, Transverse, and Peninsular ranges (McGurty 1988). Though this species is primarily found at elevations between 4500 and 6500 feet (1372-1981 m) (McGurty 1988), it may occur from sea level up to 8,036 feet (2450 m; Stebbins 1985, CDFG 2003).

This attractive species is declining in the wild due to heavy collecting pressure, habitat loss and degradation (McGurty 1988). Regulatory agencies have instituted a law to ban the taking of this species from the wild, but the California mountain kingsnake, in all its striking variations, is still, unfortunately, a hot commodity. This species is considered a Federal and State Species of Special Concern (CDFG 2001).

Habitat Associations: California mountain kingsnake may be found in montane and mixed coniferous forests, valley-foothill riparian, riparian woodland, wet meadow, and oak woodland habitats (Stebbins 1985, McGurty 1988, CDFG 2003). At higher elevations, it prefers rock outcrops in mixed coniferous forests, while at lower elevations it's primarily found in riparian habitats (McGurty 1988). Rotting logs and rock outcrops are important microhabitats for this species (Stebbins 1985). Due to its strong association with coniferous forests and riparian woodlands, McGurty (1988) suggested that this species was a relic that once had a more continuous, widespread distribution.

Spatial Patterns: Most occurrences recorded in San Diego County were in rock outcrops associated with open hardwood conifer habitats between 5000 and 6000 feet (1524-1829 m; McGurty 1988). Typically, this species is more abundant in rock outcrops on ridges and hillsides than in any other microhabitat (McGurty 1988). The species is also often found in rocky riparian habitats (McGurty 1988).

Research on home range size, density estimates and movement ecology for California mountain kingsnake is lacking. Although, this species is presumed to seasonally migrate over relatively short distances to and from winter hibernacula, no distance estimates were found in the literature.

Conceptual Basis for Model Development: Movement between protected core areas in the linkage is multigenerational. Suitable habitat for the kingsnake was defined as montane and mixed coniferous forests, valley-foothill riparian, riparian woodland, wet meadow, and oak woodland habitats, below 2450 m. Since no data are available on home range size, all suitable habitat patches 1 ha or greater were used in the analysis. Dispersal distance was not estimated for this species.

Results & Discussion: Potential habitat for California mountain kingsnake is extensive in the assessment area, with the most highly suitable habitats occurring in high elevation montane hardwood and mixed conifer forests and along drainages (Figure 31). Both the central and southern branches of the Least Cost Union include large areas of potential core habitat for this species (Figure 32), with the largest concentration of highly suitable habitat along Pine Mountain, Piru Creek, McDonald Peak and Buck Creek (Figure 31). We conclude that the Least Cost Union is likely to serve the needs of this species.

Snakes are particularly vulnerable to roadkill, since they preferentially aggregate on or near warm roads to thermoregulate (Trombulak and Frissell 2000). To protect and restore habitat for kingsnake, we recommend that:

- Riparian and upland habitats needed for breeding and movement be restored;
- Existing road density be maintained or reduced; no new roads in the Linkage Design;
- Road barriers be modified to allow kingsnakes to move along water courses and suitable upland habitat throughout the cores areas and Least Cost Union;
- Historical flow regimes be mimicked and water quality restored; and
- Anti-poaching laws are enforced.

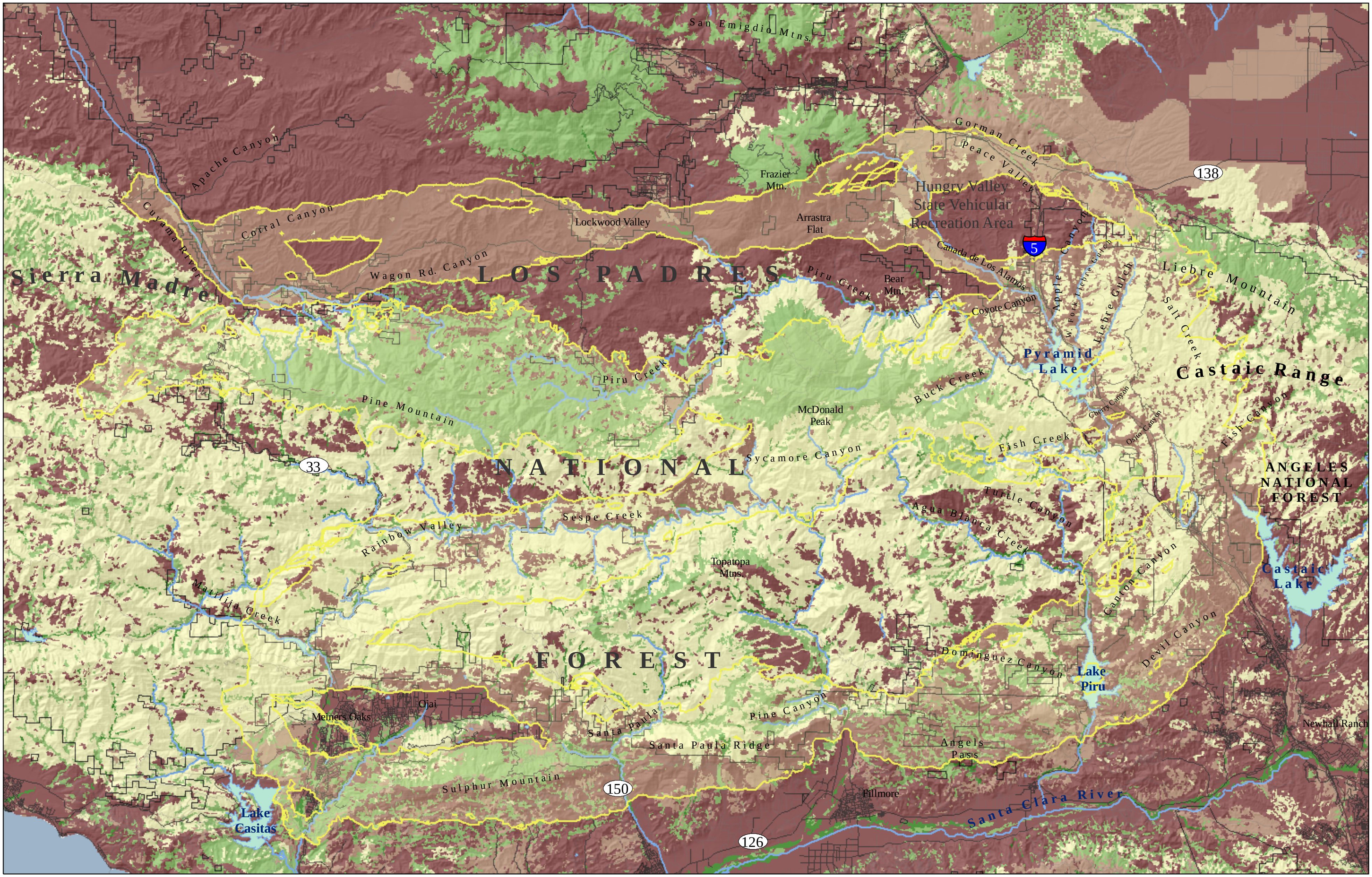

Figure 31. Habitat Suitability for California mountain kingsnake *(Lampropeltis zonata)*

Degree of Suitability

- Low
- Low to Medium
- Medium
- Medium to High
- High

- Linkage Union
- Ownership Boundaries
- Reservoirs and Lakes
- Perennial Streams
- Roads

Scale 1: 340,000

Kilometers: 0, 2, 4, 8, 12, 16

Miles: 0, 2, 4, 8, 12, 16

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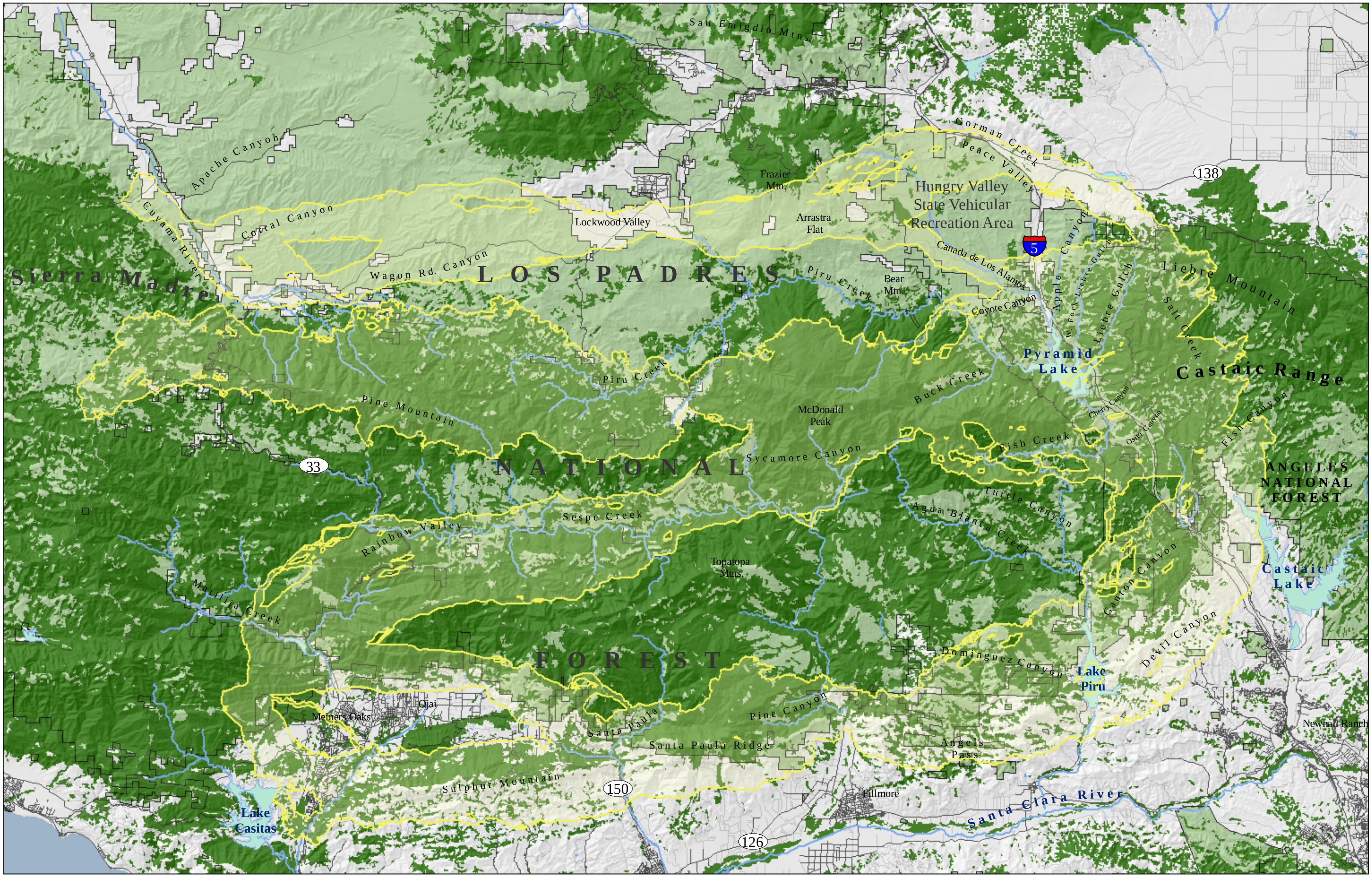

Figure 32. Potential Cores for California mountain kingsnake *(Lampropeltis zonata)*

- Potential Cores
- Linkage Union
- Ownership Boundaries
- Reservoirs and Lakes
- Perennial Streams
- Roads

Scale 1: 340,000

Kilometers 0 2 4 8 12 16

Miles 0 2 4 8 12 16

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Monterey Salamander (*Ensatina eschscholtzii eschscholtzii*)

Justification for Selection: Salamanders have been touted as bioindicators of environmental integrity (Barinaga 1990, Vitt et al. 1990, Wilson and Dorcas 2003). They play an important role in both evergreen and deciduous forest ecosystems, and can be the most abundant vertebrates in their habitat (Burton and Likens 1975, Pough et al. 1987, Bury 1988, Grialou et al. 2000). Logging and other land use changes may inhibit movement and dispersal capabilities of this species (Stebbins 1954, Ovaska 1988, Grialou et al. 2000).

Distribution & Status: *Ensatina eschscholtzii* is found from southwestern British Columbia to southern California along the Pacific coast, inland to the Cascades and Sierra Nevada (Rosenberg et al. 1998), at elevations ranging from sea level to around 3050 m (10,000 ft) (CDFG 1988). The Monterey salamander (*E. e. eschscholtzii*) is one of 7 subspecies; it is largely restricted to the coastal counties, extending from the Central Coast Ranges to Baja California Norte. The *Ensatina eschscholtzii* complex is thought to illustrate stages in the speciation process, as it intergrades with yellow-blotched (*E. e. croceator*) and large-blotched salamanders (*E. e. klauberi*) in parts of its range, known as contact zones (Stebbins 1985, Wake 1997).

Most scientists consider habitat loss and degradation the most important threat to amphibian populations (Orser and Shure 1972, Olson 1992, Alford and Richards 1999). Both the yellow-blotched and large-blotched salamanders are Federal and State Species of Concern (CDFG 2001).

Habitat Association: This species occurs under rocks, downed wood, and branches in both deciduous and evergreen forests, including montane hardwood, hardwood conifer, and mixed coniferous forests (Stebbins 1985, Jennings and Hayes 1994). They may also be found on north-facing slopes in well-shaded canyons at lower elevations in oak woodland or old chaparral (Stebbins 1985). This fully terrestrial salamander can subsist with or without a permanent water source (Stebbins 1985, Wake 1997). They typically reach their highest densities in forests with deep organic soils and abundant woody debris (Rosenberg et al. 1998).

Spatial Patterns: Estimated mean home range for a related species, yellow-blotched salamander (*E. e. croceater*), differed among sexes, with 10.0 m^2 for females and 19.5 m^2 for males (Rosenberg et al. 1998). Much larger ranges were found in 1995, with females ranging up to 23 m^2 and males up to 41 m^2 (USFS 2002). This species may be the most abundant vertebrate in the community, reaching densities of up to 1300 individuals per hectare in high quality habitat (Stebbins 1954, Rosenberg et al. 1998).

Monterey salamander movement ecology hasn't been researched. Movements of yellow-blotched salamander have been estimated to average 20 m (65 ft) for mature males and 10 m (33 ft) for females (USFS 2002), though Staub et al. (1995) documented movements of up to 120.4 m for males and 60.6 m for females in the Sierra Nevada. Staub et al. (1995) found animals achieve higher rates of movement and survival in suitable habitat than in the unsuitable habitat of the matrix.

Conceptual Basis for Model Development: Movement between protected core areas in the linkage is multigenerational. This species has the potential to occur in montane hardwood, hardwood conifer, and mixed coniferous habitats. Because habitat quantity is a poor predictor of population density in salamanders, we did not designate a minimum patch size, and included all suitable habitat as potential cores areas for this species. We then evaluated the distance between core areas of suitable habitat to determine if they were within twice the maximum-recorded dispersal distance (240 m) of this species.

Results & Discussion: Hardwood and conifer habitats, preferred by this species, are widespread in the linkage analysis area. Although highly suitable habitat patches were captured in the central branch of the Union along the northern slopes of Pine Mountain and McDonald Peak, and in the southern branch of the Union on Sulphur Mountain, this species' needs do not appear to be well accommodated by the Least Cost Union (Figure 33).

Through both evolutionary and ecological time this area has been a major connection for this species complex (Stebbins 1985, Wake 1997). The patch size and configuration analysis for this species indicates populations in Piru Creek, along the northern slopes of Pine Mountain to the lower Cuyama River across Highway 33, are within the dispersal distance of this species, as are the coastal oak woodland and riparian habitats in the foothills (Figure 34), though barriers to movement exist between suitable habitat patches. In the vicinity of I-5, some miniscule patches of suitable habitat were identified in Gorman Creek and near Big Oak Flat. We recommend additional habitat be added to the Union along Gorman Creek and the Ventura River to accommodate this species.

Land use decisions must be considered at the watershed level to preserve salamander populations (Wilson and Dorcas 2003). To protect and restore habitat for Monterey salamander, we recommend that:

- Habitat be added to the Union in Gorman Creek and along the Ventura River;
- Riparian and upland habitat be restored;
- Existing road density be maintained or reduced; no new roads in the Linkage Design;
- Road barriers be modified to accommodate salamander movements; and
- Short retaining walls be installed in conjunction with crossing structures along paved roads in the Linkage Design, where necessary, to deter amphibians, reptiles, and small mammals from accessing roadways (Jackson and Griffin 2000).

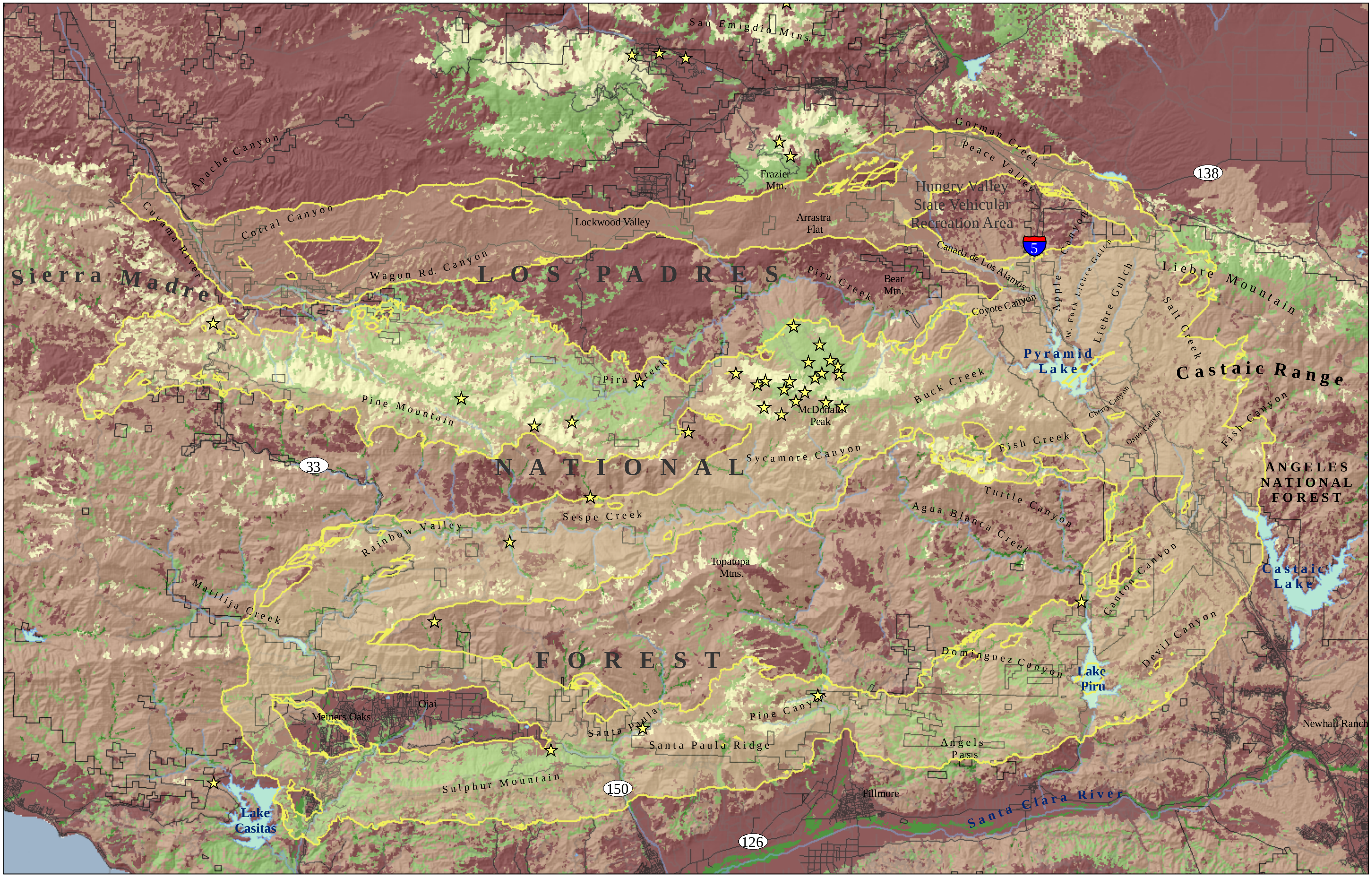

Figure 33. Habitat Suitability for Monterey salamander ***(Ensatina eschscholtzii eschscholtzii)***

Degree of Suitability

- Low
- Low to Medium
- Medium
- Medium to High
- High

- Linkage Union
- Ownership Boundaries
- Reservoirs and Lakes
- Perennial Streams
- Roads
- ☆ Species Occurence (Source: USFS)

Scale 1: 340,000

Kilometers: 0 2 4 8 12 16

Miles: 0 2 4 8 12 16

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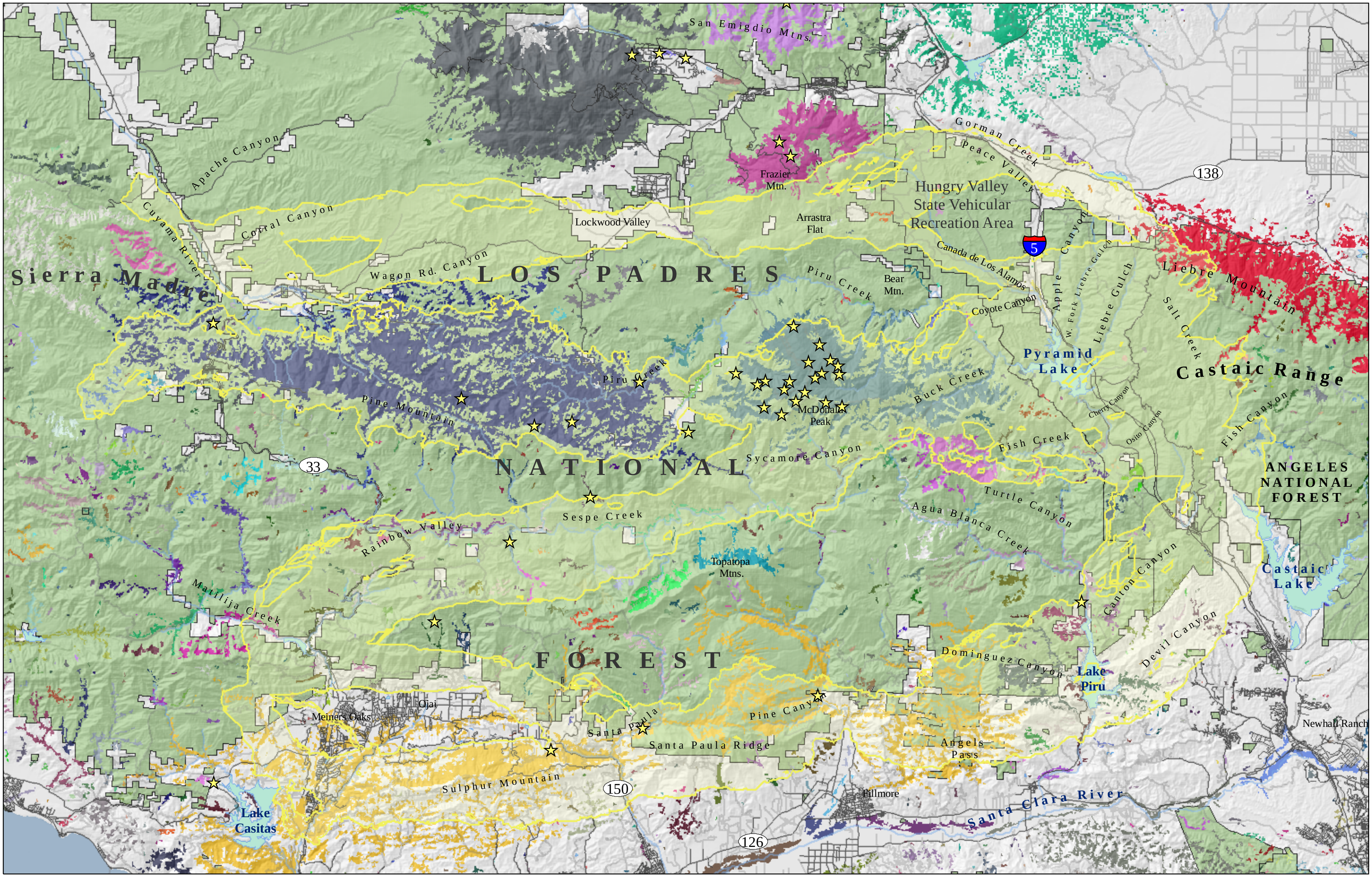

Figure 34. Patch Configuration for Monterey salamander ***(Ensatina eschscholtzii eschscholtzii)***

- Linkage Union
- ☆ Species Occurence (Source: USFS)
- Ownership Boundaries
- Reservoirs and Lakes
- Perennial Streams
- Roads

*Colors signify patches of suitable habitat that are within twice the dispersal distance.

Scale 1: 340,000

Kilometers: 0 2 4 8 12 16

Miles: 0 2 4 8 12 16

Map Produced By:

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Bear Sphinx moth (*Arctonotus lucidus*)

Justification for Selection: This species is sensitive to habitat loss and degradation from urban development, and also affected by light pollution. It requires extensive landscapes with little or no disturbance, development, and artificial light (K. Osborne pers.comm.). Cattle grazing may also impact this species due to loss of host plants.

Distribution & Status: In California this moth can be found locally in foothill regions of the San Gabriel, Western Sierra Madre, Coast Ranges, and the Tehachapi Mountains (K. Osborne pers. comm.). This species occurs between 500 ft and 4500 ft in elevation (K. Osborne pers. comm.). This species isn't afforded any special status.

Habitat Associations: Oak woodlands and grasslands are typical habitats of this species, which is found in broad and undeveloped woodlands, hills, and canyons (K. Osborne pers.comm.). Larvae feed on plants of the evening primrose family (Comstock and Henne 1942) such as *Clarkia* and *Camissonia* species (Osborne 2000). Species in the *Clarkia* genus may be found in the following vegetation communities: annual grassland, perennial grassland, blue oak woodland, blue oak-foothill pine, Jeffrey pine, chaparral, mixed chaparral, montane chaparral, chamise-redshank chaparral, upper Sonoran subscrub, pinyon juniper, and juniper woodlands (Twisselman 1967).

Spatial Patterns: No home range data was found in the literature. Adults fly during the early evening, into night, in foothill woodland and grassland habitats. The bear sphinx moth may fly up to a few kilometers; however this is based solely on relative numbers of observations in associated habitat versus out-of-habitat during flight seasons (K. Osborne pers. comm.).

Conceptual Basis for Model Development: Movement between protected core areas in the linkage is multigenerational. This species prefers oak woodland and grassland communities but may also utilize other habitats where food plants occur in abundance, including open coniferous forests, chaparral, and desert scrub and woodland communities, between 500-4500 feet in elevation. Urban and agricultural areas may be important impediments due both to habitat alteration and adult attraction to artificial light sources. To address the effects of light pollution, we integrated a 500-m buffer from urban areas into the analysis. Since no home range estimates were found in the literature, all patches of suitable habitat 1 ha or greater were used in the analysis. Dispersal distance was defined as 4 km.

Results & Discussion: Large expanses of suitable habitat for Bear sphinx moth occur in both protected core areas. This species requires large swaths of suitable habitat to allow for dispersal and gene flow across populations (K. Osborne, pers. comm.). The south-central branch of the Least Cost Union captured a fairly contiguous block of suitable habitat stretching from Matilija, through Rainbow, Sespe, and Sycamore, to Fish, Cherry, and Osito canyons (Figure 35). Thus, the linkage is likely to serve intergenerational movements of Bear sphinx moth between protected core areas. This species prefers wide-open landscapes, thus narrow linkages would not likely suffice in maintaining this species (K. Osborne pers. comm.). All habitat patches are within twice the dispersal distance of this species, although barriers to movement may exist between patches of suitable habitat.

Roadkill affects a wide range of invertebrates, especially insects (H.C. Seibert and Conover 1991, Trombulak and Frissell 2000). To protect and maintain populations of Bear sphinx moth in the linkage, we recommend that:

- Light is directed away from the linkage, since adults are attracted to artificial light sources.

Figure 35. Potential Cores for Bear sphinx moth *(Arctonotus lucidus)*

- Potential Cores
- Linkage Union
- Ownership Boundaries
- Reservoirs and Lakes
- Perennial Streams
- Roads

Scale 1: 340,000

0 2 4 8 12 16 Kilometers

0 2 4 8 12 16 Miles

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Linsley's rain beetle (*Pleocoma linsleyi*)


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Justification for Selection: Linsley's rain beetle is restricted to the Tehachapi Mountains and the San Andreas rift zone.

Distribution & Status: *Pleocoma linsleyi* was described (Hovore, 1971) from near the northern crest of the Old Ridge Route (N-2), close to the site of the old Sandbergs hotel. The species ranges throughout the Tehachapi Mountains and along the San Andreas fault zone west to the slopes and ridges surrounding Mt. Pinos, and east to at least Lake Hughes, wherever suitable soils and vegetation occur. The overall distribution of the species suggests an ancient original distribution, probably pre-Miocene, with subsequent fragmentation by orographic changes, including fault movement. This species isn't afforded any special status.

Habitat Associations: Larvae of *Pleocoma* live within the soil, usually within bands with heavy clay content, and feed upon roots of a variety of plants. *Pleocoma linsleyi* larvae appear to favor canyon oak (*Quercus chrysolepis*) as the primary host, where available, but are not necessarily restricted to this species. Collections from the slopes of Mt. Pinos strongly suggest that *P. linsleyi* occurs not so much in association with any particular habitat or host plant type, but more likely where soils provide a suitable substrate for larval movement and development. While canyon oak appears to be the preferred larval host at many localities, some higher elevation collection sites on Mt. Pinos, possess only scattered *Q. kelloggii*, *Q. berberidifolia*, or no oak species of any kind, and are open, park-like mixed conifer forest (F. Hovore, pers. comm.).

Spatial Patterns: Female *Pleocoma* are flightless and move only short distances through the soil during their emergence and mating activities. Metapopulations therefore tend to be limited in extent to areas of suitable sub-soils and hosts, and appear to be concentrated, if not restricted, to north-facing slopes and steeper canyons. Males are capable of strong flight, and can easily cross such obstacles, which provides some genetic dispersal, but larvae and female beetles are limited to substrate travel, and cannot cross impenetrable surfaces. The precise parameters of any given population cannot easily be determined, but some units may be very limited in areal extent, while others may spread across relatively broad areas of suitable substrate and hosts (F. Hovore, pers. comm.).

Conceptual Basis for Model Development: Potentially suitable habitat was delineated as core areas for this species. Movement in the linkage would be by males flying between habitat areas, which probably occur only rarely, and females of this species are unable to disperse across any sort of unnatural barrier. Major landform breaks (deep canyons, exposed rock, rivers, lakes, etc.) are significant barriers to *Pleocoma* movement, as would be freeways, concrete channels, aqueducts, etc. (F. Hovore, pers. comm.).

Results & Discussion: The species would likely be served by the Least Cost Union since the distribution is relictual, and probably entirely natural (Figure 36). There is no way of determining the potential for population maintenance via linkages *a priori*, but male dispersal probably would occur occasionally between the patches. Minor surface changes likely do not extirpate *Pleocoma*, but excavation and creation of hardscape barriers would be significant to population dispersal and persistence. This species probably can persist locally within a sequence of relatively small habitat patches, provided that the overall linkage is "tight" enough to provide regular gene exchange between patches (F. Hovore, pers. comm.).

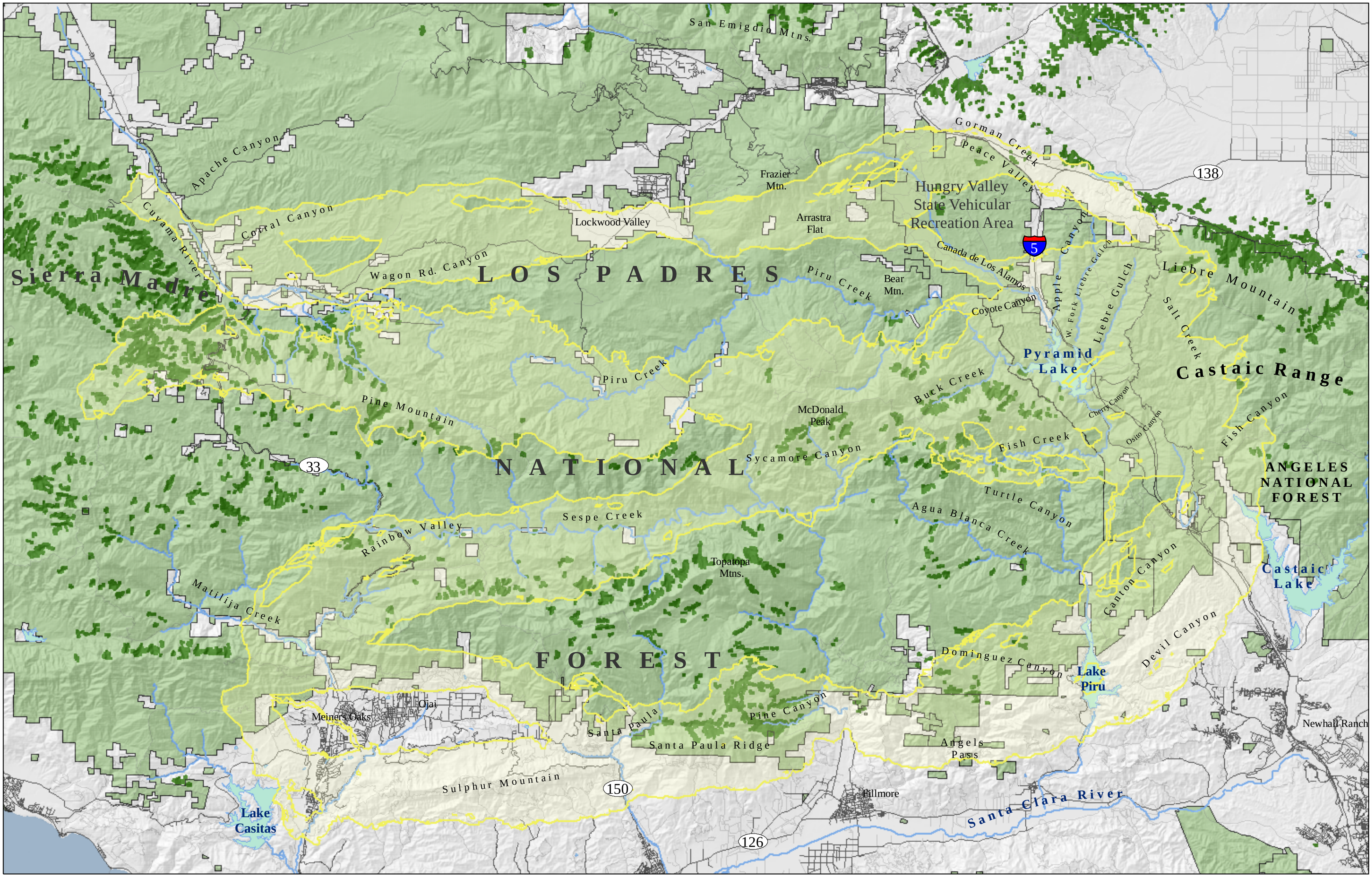

Figure 36. Potential Cores for Rain beetle *(Pleocoma linsleyi)*

- Potential Cores
- Linkage Union
- Ownership Boundaries
- Reservoirs and Lakes
- Perennial Streams
- Roads

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This chapter is the heart of the report. It summarizes the goals of the Linkage Design and presents a map and description of the land within it. However, assessing and maintaining linkage function requires us to also identify barriers to movement within the area, including land uses that may hinder or prevent species from moving through the linkage. Much of this chapter therefore describes existing barriers within the linkage and prescribes actions to improve linkage function.

Goals of the Linkage Design

To accommodate the full range of target species and ecosystem functions, the Linkage Design (Figure 37) should: 1) provide live-in and move-through habitat for multiple species; 2) support metapopulations of smaller species; 3) ensure availability of key resources; 4) buffer against edge effects; 5) reduce contaminants in streams; 6) allow natural processes to operate; and 7) allow species and natural communities to respond to climatic changes. We elaborate on these goals below.

The Linkage Design must be wide enough to provide live-in habitat for species with dispersal distances shorter than the linkage. Harrison (1992) proposed a minimum corridor width for a species living in a linkage as the width of one individual's territory (assuming territory width is half its length). Thus, our minimum corridor width of 2 km should accommodate species with home ranges of up to about 8 km^2 (3 mi^2). This would accommodate all focal species except mountain lion, as well as larger non-focal species such as bobcats. Fortunately, because they can move long distances in a single night, mountain lions do not need live-in habitat throughout the Linkage, and should be able to move through the linkage.

The Linkage Design must support metapopulations of less vagile species. Many small animals, such as salamanders and turtles, require dozens of generations to move between core areas. These species need a linkage wide enough to support a constellation of populations, with movements among populations occurring over decades. We believe 2 km is probably adequate to accommodate most target species.

The Linkage Design is expected to provide resources for all target species, such as host plants for butterflies and pollinators for plants. Some of our conservation targets, such as western toads and western pond turtles, require uplands as well as wetlands. Although the width of upland habitats needed beyond the streams edge is undocumented for many species, information on the western pond turtle suggests that a 1-km (0.6-mi) upland buffer (i.e., 0.5 km to either side of the stream) is needed to sustain populations (Holland 1991).

The Linkage was designed to buffer against "edge effects" even if adjacent land is developed. "Edge effects" are adverse ecological changes that invade open space from nearby developed areas, such as weeds, artificial night lighting, predation by house pets, increases in populations of opportunistic species like raccoons, elevated soil moisture from irrigation, pesticides and pollutants, noise, trampling, and domesticated animals that attract native predators. Edge effects have been best-studied at the edge between forests and adjacent agricultural landscapes, where negative effects extend 300 m (980 ft) or more into the forest (Debinski and Holt 2000, Murcia 1995) depending on forest type, years since the edge was created, and other factors (Norton 2002). The best available data on edge effects for southern California habitats include reduction in leaf-litter and declines in populations of some species of birds and mammals up to 250 m (800 ft) in coastal scrub (Kristan et al. 2003), collapse of native plant and animals communities due the invasion of argentine ants up to 200 m (650 ft) from irrigated areas (Suarez et al. 1998), and predation by house cats which reduce small vertebrate populations 100 m (300 ft) from the edge (K. Crooks, unpublished data). Domestic cats may affect wildlife up to 300 m (980 ft) from the edge based on home range sizes reported by Hall et al. (2000).

Upland buffers are needed adjacent to riparian vegetation or other wetlands to prevent aquatic habitat degradation. Contaminants, sediments, and nutrients can reach streams from distances greater than 1 km (0.6 mi) (Maret and MacCoy 2002, Scott 2002, Naicker et al. 2003), and fish, amphibians, and aquatic invertebrates often are more sensitive to land use at watershed scales than at the scale of narrow riparian buffers (Goforth 2000, Fitzpatrick et al. 2001, Stewart et al. 2001, Wang et al. 2001, Scott 2002, Willson and Dorcas 2003).

The Linkage Design must also allow natural processes of disturbance and recruitment to operate with minimal constraints from adjacent urban areas. The Linkage should be wide enough that temporary habitat impacts due to fires, floods, and other natural processes do not affect the entire linkage simultaneously. Wider linkages with broader natural communities may be more robust to changes in disturbance frequencies by human actions.

The Linkage Design must also allow species to respond to climate change. Plant and animal distributions are predicted to shift (generally northwards or upwards in elevation in California) due to global warming (Field et al. 1999). The linkage must therefore accommodate at least elevational shirts by being broad enough to cover an elevational range as well as a diversity of microhabitats that allow species to colonize new areas.

Description of the Linkage Design

The Linkage Design encompasses 161,447 ha (398,944 ac), of which 75% is already protected. It covers very diverse ecological settings and encompasses 25 different major vegetation types (Table 3). It has several main branches, reflecting variation in the habitat needs of different sets of target species (Figure 37). The northern branch is dominated by pinyon-juniper woodland, sagebrush, and desert scrub habitats and serves linkage needs of badger, puma, and mule deer. The central branches connect at generally higher elevations, including a series of hardwood, conifer, chaparral, and riparian habitats. They serve the needs of numerous focal species, including puma, mule deer, Pacific kangaroo rat, California spotted owl, acorn woodpecker, mountain kingsnake, pond turtle, two-striped garter snake, Monterey salamander, and Bear sphinx moth. The southernmost branch of the Linkage Design follows the southern foothills and is dominated by coastal oak woodland, coastal sage scrub, Valley foothill riparian, and grassland habitats. It provides the only fairly contiguous belt of coastal habitats in the Linkage Design, and provides connectivity for mule deer; Pacific kangaroo rat, acorn woodpecker and Monterey salamander, as well as many other species not addressed by our analyses.

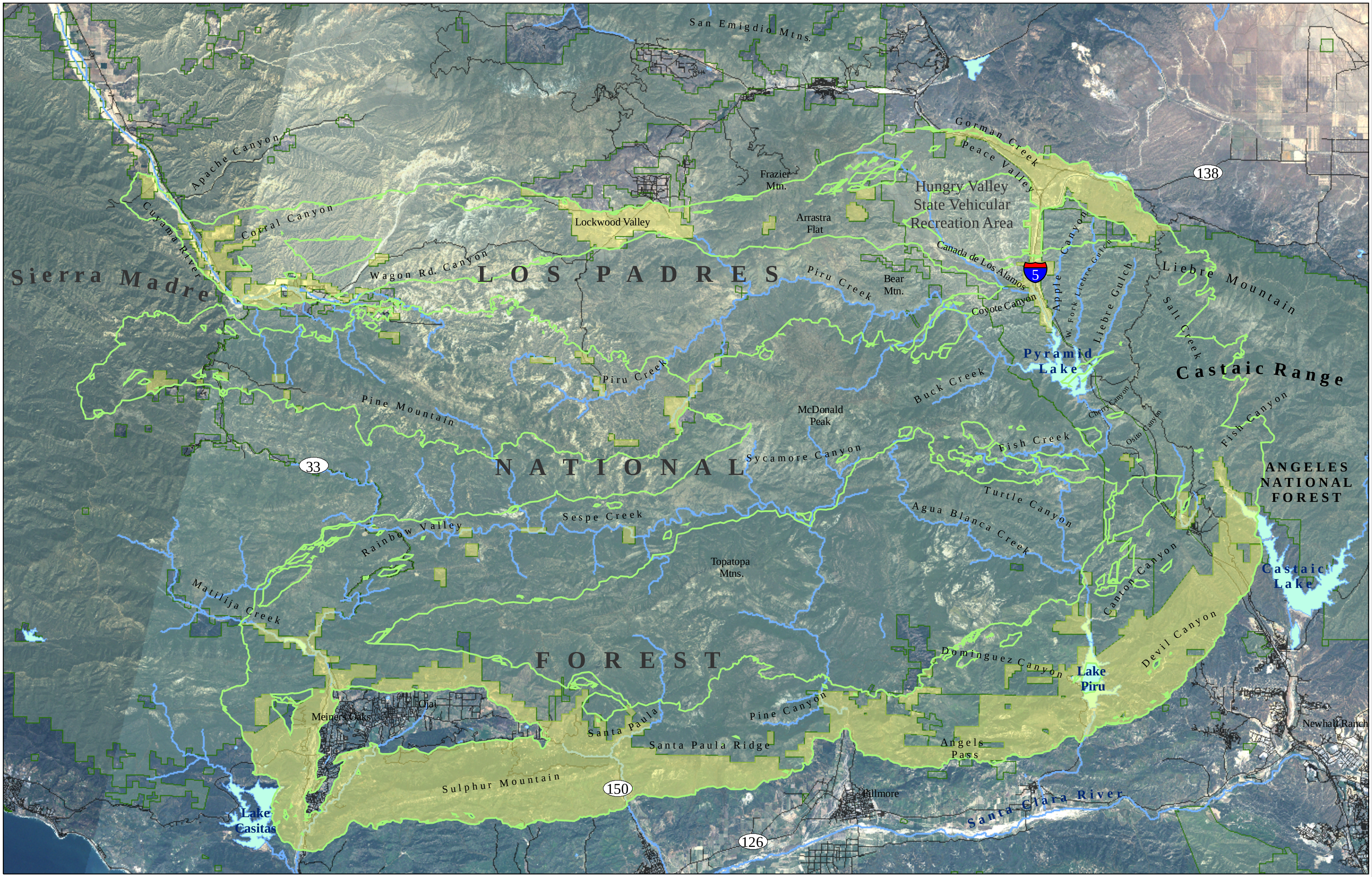

Figure 37. Linkage Design for the Sierra Madre - Castaic Connection

- Linkage Design Boundary
- Unprotected Area
- Ownership Boundaries
- Reservoirs and Lakes
- Perennial Streams
- Roads

Scale 1: 340,000

Kilometers: 0 2 4 8 12 16

Miles: 0 2 4 8 12 16

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Table 3. Approximate Vegetation and Land Cover in the Linkage Design			
Natural Vegetation Communities	**Acres**	**Hectares**	**% of Total Area**
Blue Oak-Foothill Pine	8.53	3.45	0.002
Desert Scrub	20.96	8.48	0.005
Freshwater Emergent Wetland	21.15	8.56	0.005
Juniper	121.82	49.30	0.031
Blue Oak Woodland	136.57	55.27	0.034
Valley Foothill Riparian	176.69	71.50	0.044
Valley Oak Woodland	233.65	94.55	0.059
Desert Wash	444.63	179.94	0.111
Water	2,177.98	881.40	0.546
Montane Riparian	5,580.72	2,258.44	1.399
Barren	6,218.62	2,516.59	1.559
Sagebrush	6,974.25	2,822.38	1.748
Montane Hardwood-Conifer	9,456.62	3,826.96	2.370
Montane Chaparral	9,845.35	3,984.27	2.468
Montane Hardwood	10,206.67	4,130.49	2.558
Chamise-Redshank Chaparral	11,076.95	4,482.68	2.777
Mixed Conifer	14,970.64	6,058.40	3.753
Jeffrey Pine	20,461.80	8,280.60	5.129
Coastal Oak Woodland	23,633.07	9,563.96	5.924
Annual Grassland	25,531.36	10,332.18	6.399
Pinyon-Juniper	43,786.73	17,719.86	10.976
Coastal Scrub	70,195.05	28,406.93	17.595
Mixed Chaparral	132,925.68	53,793.12	33.319
Total Natural Vegetation	**394,205.50**	**159,529.30**	**98.811**
Non-Habitat			
Urban	1,343.66	543.76	0.338
Agriculture	3,395.81	1,374.24	0.851
Total Non-Habitat	**4,739.47**	**1,918**	**1.189**
Total Area in Linkage Design	**398,944.97**	**161,447.30**	**100%**

Removing and Mitigating Barriers to Movement

Five types of features may impede species movements through the Linkage: roads, impediments to stream flow (e.g., dams and diversions), industrial operations, residential development, and recreational activities. Although these features cover only a small portion of the Linkage Design (which is already largely conserved), their adverse effects on species movements may be disproportionately large. Ameliorating these effects would help maintain or restore functional linkages. This section describes these impediments and suggests where and how their effects may be mitigated to improve linkage function.

This discussion focuses on structures to facilitate movement of terrestrial species across roads, and on structures to facilitate stream flow under roads. Although some documents refer to such structures as "corridors" or even "linkages," we use these terms in their original sense to describe the entire area required to link the landscape and facilitate movement between large protected core areas. Crossing structures represent only small portions, or choke points, within an overall habitat linkage or movement corridor. Investing in specific crossing structures may be meaningless if other essential components of the linkage are left unprotected. Thus it is essential to keep the larger landscape context in mind when discussing existing or proposed crossing structures. This broader context also fosters awareness of restoration options. Despite the necessary emphasis on crossing structures, we urge the reader keep sight of the primary goal of conserving landscape linkages to promote movement between core areas over broad spatial and temporal scales.

Roads as Barriers to Upland Movement: Wildland fragmentation by roads is increasingly recognized as one of the greatest threats to biodiversity (Noss 1983, Harris 1984, Wilcox and Murphy 1985, Wilcove et al. 1986, Noss 1987, Reijnen et al. 1997, Trombulak and Frissell 2000, Forman and Deblinger 2000, Jones et al. 2000, Forman et al. 2003). Roads kill animals in vehicle collisions, create discontinuities in natural vegetation (the road itself and induced urbanization), alter animal behavior (due to noise, artificial light, human activity), promote invasion of exotic species, and pollute the environment (Lyon 1983, Noss and Cooperrider 1994, Forman 1998). Roads also fragment populations by acting as semi-permeable to impermeable barriers for non-flying animals (e.g., insects, fish, amphibians, reptiles, and mammals) and even some flying species (e.g., butterflies and low-flying birds). The resulting demographic and genetic isolation increases extinction risks for populations (Gilpin and Soulé 1986). Ernest (2003) has documented little flow of mountain lion genes between the Santa Ana and Palomar ranges (where I-15 is the most obvious barrier), and between the Sierra Madre and Sierra Nevada (where I-5, and urbanization along SR-58, are the most obvious barriers).

The impact of a road on animal movement varies with species, context (vegetation and topography near the road), and road type and level of traffic (Clevenger et al. 2001). For example, a road on a stream terrace can cause significant population declines in amphibians that move between uplands and breeding ponds (Stephenson and Calcarone 1999), but a similar road on a ridgeline may have negligible impact. Most documented impacts on animal movement concern paved roads. Dirt roads may actually facilitate movement of some species, such as mountain lions (Dickson et al. 2004), while adversely impacting other species, such as snakes that sun on them and may be crushed even by infrequent traffic.

Roads in the Linkage Design: There are 511 km (318 mi) of paved roads in the Linkage Design area. Two of these (I-5 and State Highway 33) are major transportation routes and are the greatest barriers to wildlife movement. By far the largest of these impediments is I-5, which bisects the linkage for a distance of 43 km (27 mi). A survey of these roads found a variety of bridges, culverts, and drainage pipes that might be useful for implementing road mitigation projects when transportation improvement projects are undertaken (Figure 38).

Figure 38. Existing Infrastructure in the Planning Area

- Linkage Design
- Unprotected Area
- Potential Crossing Structures
- Roads
- Railroads
- Aqueduct
- Dams
- Perennial Streams
- Reservoirs and Lakes
- Ownership Boundaries

Scale 1: 340,000

Kilometers: 0 2 4 8 12 16

Miles: 0 2 4 8 12 16

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Table 4. Major transportation routes in the Linkage Design.

Road Name	Length (km)	Length (mi)	Description
Interstate 5	42.7	26.51	Most significant barrier to movement; high roadkill
State Highway 33	36.7	22.78	Fairly permeable north of Ojai; high roadkill to south
Ridge Route	28.71	17.84	Recreational route, little traffic
Old Golden State Highway	10.1	6.28	Recreation and worker access, little traffic
Other Paved Roads	393.1	244.26	Various degree of permeability
Total Length of Paved Roads	**511.24**	**317.67**	

Types of Mitigation for Roads: Forman et al. (2003) suggest several ways to mitigate the impact of roads on linkages by creating wildlife crossing structures and reducing traffic noise and light, especially at entrances to crossing structures. Wildlife crossing structures have been successful both in the United States and in other countries (Transportation Research Board 2002), and include underpasses, culverts, bridges, and bridged overcrossings. Most structures were initially built to accommodate streamflow, but research and monitoring have also confirmed the value of these structures in facilitating wildlife movement. The main types of structures, from most to least effective, are vegetated land-bridges, bridges, underpasses, and culverts.

There are about 50 vegetated wildlife overpasses (Figure 39) in Europe, Canada, and the U.S. (Evink 2002, Forman et al. 2003). They range from 50 m (164 ft) to more than 200 m (656 ft) in width (Forman et al. 2003). Soil depths on overpasses range from 0.5 to 2 m, allowing growth of herbaceous, shrub, and tree cover (Jackson and Griffin 2000). Overpasses maintain ambient conditions of rainfall, temperature, light, vegetation, and cover, and are quieter than underpasses (Jackson and Griffin 2000). In Banff, large mammals preferred overpasses to other crossing structures (Forman et al. 2003). Similarly, woodland birds used overpasses significantly more than they did open areas without an overpass. Other research indicates overpasses may encourage birds and butterflies to cross roads (Forman et al. 2003). Overpass value can be increased for small, ground-dwelling animals by supplementing vegetative cover with branches, logs, and other cover (Forman et al. 2003).

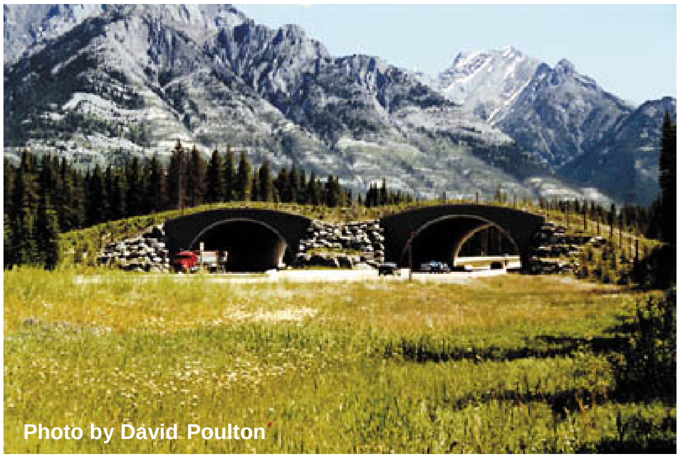

Figure 39. An example of a vegetated land bridge built to enhance movement of wildlife populations.

Bridges over waterways are also effective crossing structures, especially if wide enough to permit growth of both riparian and upland vegetation along both stream banks (Jackson and Griffin 2000, Evink 2002, Forman et al. 2003). Bridges with greater openness ratios are generally more successful than low bridges and culverts (Veenbaas and Brandjes 1999, Jackson and Griffin 2000). The best bridges, termed *viaducts* (Figure 40), are elevated roadways that span entire wetlands, valleys, or gorges, but are cost-effective only where topographic relief is sufficient to accommodate the structure (Evink 2002).

Although inferior to bridges, culverts can be effective crossing structures for some species (Jackson and Griffin 2000). Only very large culverts are effective for carnivores and other large mammals (Figure 41). Gloyne and Clevenger (2001) suggest that underpasses for ungulates should be at least 4.27 m high and 8 m wide, with an openness ratio of 0.9 (where the openness ratio = height x width/length). Earthen flooring is preferable to concrete or metal (Evink 2002).

Figure 40. A viaduct in Slovenia built to accommodate wildlife, hydrology, and human connectivity.

Figure 41. Arched culvert on German highway, with rail for amphibians and fence for larger animals.

For rodents, pipe culverts (Figure 42), about 1 ft in diameter without standing water are superior to large, hard-bottomed culverts, apparently because the overhead cover makes them feel secure against predators (Clevenger et al. 2001, Forman et al. 2003). In places where a bridged, vegetated undercrossing or overcrossing isn't feasible, placing pipe culverts alongside box culverts can help serve movement needs of both small and large animals. Special structures that allow light and water to enter the structure have been designed to accommodate amphibians (Figure 43). Retaining walls should be installed, where necessary, along paved roads to deter small mammals, amphibians, and reptiles from accessing roadways (Jackson and Griffin 2000). Retaining walls are relatively maintenance free and better than wire mesh, which must be buried and regularly maintained.

Figure 42. Pipe culvert designed to accommodate small mammals.

Figure 43. Amphibian tunnels allow light and moisture into the structure.

Noise, artificial night lighting, and other human activity can deter animal use of a crossing structure (Yanes et al. 1995, Pfister et al. 1997, Clevenger and Waltho 2000, Forman et al. 2003), and noise can deter animal passage (Forman et al. 2003). Shrub or tree cover should occur near the entrance to the structure (Evink 2002). Existing structures can be substantially improved with little investment by installing wildlife fencing, earthen berms, and vegetation to direct animals to passageways (Forman et al. 2003). Regardless of crossing type, wildlife fencing is necessary to funnel animals towards road crossing structures and keep them off the road surface (Falk et al. 1978, Ludwig and Bremicker 1983, Feldhammer et al. 1986, Forman et al. 2003). Earthen one-way ramps can allow animals that wander into the right of way to escape over the fence (Bekker et al. 1995, Rosell Papes and Velasco Rivas 1999, Forman et al. 2003).

Recommendations for Crossing Structures on Interstate 5: I-5 is the most substantial impediment to movement within the Linkage Design. It bisects the entire linkage for 42 km (26 mi) and currently lacks adequate crossing structures (Figure 38). Given the continental importance of this linkage, we follow the recommendations for crossing structures provided by Clevenger and Waltho (2005), Clevenger and Wierzchowski (2005), and the Western Riverside County Multi-Species Habitat Conservation Plan (2004). Accordingly, there should be at least one large mammal crossing every 1.5 kilometers (1 mile), and crossing structures for reptiles, amphibians, and small mammals every 150-300 meters, from the south end of the village of Gorman to the north edge of the town of Castaic. The small structures should vary in size to accommodate a variety of mammal species. We do not expect the transportation agencies to initiate a project solely to build these structures. Instead, these improvements may be made when major work (adding a traffic lane or shoulder, reconfiguring a ramp) is undertaken in a particular area.

We call attention to 5 particular areas where large crossing structures are needed. These 5 areas are important because they provide opportunities for movement of animals via riparian and upland habitats and correspond to least-cost corridors for focal species. At each of these 5 locations, we recommend replacing existing culverts with bridged undercrossings large enough to allow natural vegetation to grow throughout the structure.

1. Gorman Creek: A priority for greatly improved crossing structures along I-5 is a 3½-mile stretch of freeway south of the village of Gorman to just south of the interchange with SR138. The least cost path of the American badger crosses I-5 here, and suitable habitat for several other focal species, such as Pacific kangaroo rat, acorn woodpecker, and bear sphinx moth, occurs in this area. This area was also identified as an important movement route in the Linkage Design developed for the Tehachapi Connection (Penrod et al. 2003).

Figure 44. Gorman Creek flows through a series of concrete box culverts.

Figure 45. Gorman Creek undercrossing just south of I-5/SR-138 interchange, entering the State Water Project where it is funneled to Pyramid Lake.

From just south of the village of Gorman to the 138 interchange, there are 4 concrete box culverts about 5 feet tall and wide that are spaced 0.5-1 mile apart, suggesting good locations for bridged undercrossings. Each culvert opens directly into Hungry Valley State Park on the west, and into Gorman Valley on the east (Figure 44). For Gorman Creek to be a viable movement corridor, connectivity across SR-138 and the California Aqueduct below Quail Lake must also be addressed. Opportunities for improving connectivity are offered by 3 vehicle underpasses that allow access to a 100- to 150-acre triangle formed by the interchange of I-5 and SR-138. These 2 roads (Quail Lake Rd and Zenobia Road) are wide and paved but with very little traffic. These roads serve only the water facility, about 8 buildings in Trust Me Canyon, and about 3 buildings in Peace Valley (Gorman Creek). There is a nice line of cottonwoods on Gorman Creek running through the triangle and beyond. The real impediment in this area is the mile-long concrete overflow canal that lies above the buried penstock. Fortunately, most of the aqueduct lies outside of the Linkage Design, with the exception of the 2-miles of aqueduct west of Quail Lake and the concrete overflow canal that extends another mile west. This overflow canal sits atop the buried penstock and approximately follows the border of Angeles NF. It is 6 to 7 ft deep, sheer-sided, 8 ft wide, and bordered on each side with 6-ft chain link topped by 3 strands of barbs. We recommend a vegetated land bridge, at least 300 ft wide, over some portion of the aqueduct west of Quail Lake.

Just south of the SR 138 interchange, Gorman Creek flows through a large bridged undercrossing with concrete flooring (Figure 45). It is then diverted to a concrete channel and funneled toward Pyramid Lake. The channel is fenced with chain link and barbed wire. We recommend removing the concrete flooring of the structure, the entire length of the concrete channel, and the fencing; restoring riparian habitat through the structure; and, if necessary, tapping the water resources of Gorman Creek farther south. Coordination with the California Department of Water Resources and other appropriate agencies will be essential to restore Gorman Creek.

The western freeway frontage is Hungry Valley State Park; the eastern side is private property, with the Angeles National Forest boundary just south of the I-5/SR 138 interchange. The Department of Fish and Game and Bureau of Land Management also administer land near the Forest boundary. East of the freeway, there are about 8 to 12 homes along the old Gorman Post Road. These seem generally compatible with linkage function; however, much of the vegetation on the steep slopes appears to have been overgrazed and now lacks woody cover except in drainage bottoms (Figure 44). Thus, removing or reducing grazing pressure, and perhaps active habitat restoration, would improve linkage function. The extensive desert scrub in upland areas suggests connectivity in this area would be useful for a number of desert species, whose needs we did not analyze.

Figure 46. Coyote Canyon with riparian habitat in Cañada de Los Alamos in the foreground.

2. Coyote Canyon. The least-cost corridors for both mountain lion and mule deer cross I-5 in this area, from Coyote Canyon (Figure 46) to upper Apple Canyon, W. Liebre, and Liebre gulches. This zone along I-5 also provides habitat connectivity for mountain kingsnake, bear sphinx moth, and several semi aquatic species. This area is situated in a transition zone between coastal and desert scrub habitats, though mixed chaparral is the dominant upland community. Cañada de Los Alamos is a lush gallery forest that flows through a substantial valley just north of Coyote Canyon. The stream

Figure 47. Smoky Bear bridged undercrossing.

course then heads south, joining Gorman Creek, which flows into Pyramid Lake.

Prior to the construction of Pyramid Lake in 1973, opportunities for crossing I-5 existed at Apple Canyon, W. Liebre, and Liebre gulches, but each of these drainages now feed into Pyramid Lake. The Smoky Bear interchange (Figure 47) is the only undercrossing in the vicinity of Coyote Canyon. This interchange is used by recreationists to access Pyramid Lake and Hungry Valley State Vehicular Recreation Area, and by workers at Warne Powerplant above Pyramid Lake. We recommend working with the California Department of Transportation to make this structure more amenable to wildlife movement whenever transportation improvements are made in this area. The bridged undercrossing should be widened and vegetative cover restored on either side of and through the structure.

3. Cherry Canyon: The least-cost corridor for California spotted owl traverses I-5 at Cherry Canyon, and suitable habitat for puma, mule deer, Pacific kangaroo rat, and Bear sphinx moth also occurs in this area. At present Cherry Canyon leads to a steep fill slope at I-5 (Figure 48). There is an existing trail leading up to I-5 (undrivable FS Road 6N30, going up Cherry Canyon from its junction with Piru Creek). There are many deer trails on this slope, and a major deer trail up Cherry Canyon to the toe of the fill slope. The slope on the west side of Cherry Creek below I-5 is awash in deer pellets and criss-crossed with deer trails right up to I-5. Clearly deer are walking up and crossing at grade, and the topography would allow a vegetated landbridge, or wildlife overpass, on either the west or the east ridge of Cherry Canyon at I-5.

Figure 48. Potential site for vegetated landbridge on I-5 on the east ridge of Cherry Canyon. Currently, deer and other species are crossing at grade and the topography would permit construction of a vegetated overpass here.

Figure 49. View looking up Cherry Canyon toward I-5. Just below this point, Cherry Creek flows under Old Golden State Highway through a concrete boxed to join Piru Creek.

Vegetation in Cherry Canyon is structurally complex with mixed chaparral on the slopes and oaks and willows in the canyon bottom (Figure 49). Since this is one of the largest canyons crossing I-5, and it offers a direct link to Piru Creek below Pyramid dam, we suggest connectivity improvements when road upgrades are next made in the area. We recommend either a wildlife overpass be constructed at the western or eastern canyon rims (where existing cut banks occur) or a bridged undercrossing be installed at least 300 m long where I-5 sits on a massive fill slope across the main wash of the canyon. The canyon bottom underneath this bridge should follow the contours that existed before the fill slope was created.

4. Forest Road 6N43: There is a sizeable underpass for forest road 6N43, a 1-lane box culvert that leads into a substantial canyon on the west side of I-5, near Fisher Spring (Figure 50). The least cost corridor for mule deer crossed I-5 in this vicinity and suitable habitat occurs for puma, mountain kingsnake, Monterey salamander, and acorn woodpecker.

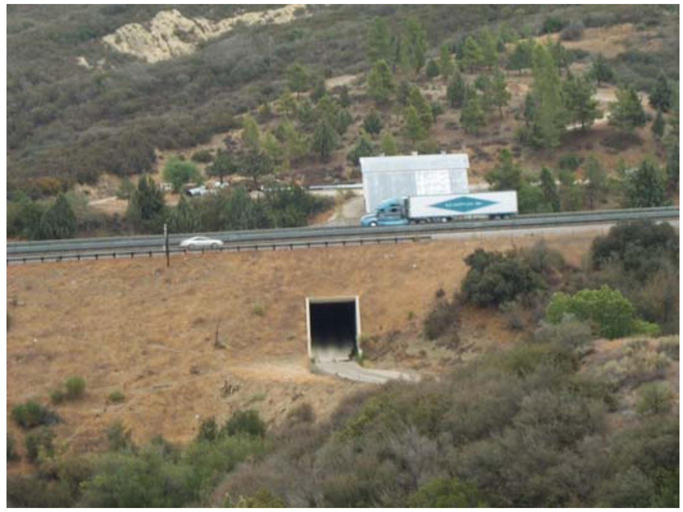

Figure 50. Box culvert for Forest Service Road 6N43 under I-5.

The existing structure gets very little vehicular traffic. We recommend replacing the existing box culvert and fill slope with a bridge that would provide room for both vehicular and wildlife movement under the freeway. Flooring in the structure should consist of a natural substrate. Native vegetation could be planted to provide wildlife cover in and near the crossing structure.

5. Big Oak Flat & Canton Canyon: The least-cost corridors for puma, mule deer, and Pacific kangaroo rat cross the freeway here, and appropriate habitats for two-striped garter snake and pond turtle also occur in the vicinity. Natural habitat abuts the freeway in most of this area, which offers the best riparian connection between core areas in the Linkage Design.

Figure 51. Riparian vegetation in Big Oak Flat Canyon east of I-5. Note trailer park on right.

Big Oak Flat is just northwest of Canton Canyon, and although the existing culvert under I-5 isn't ideal, it is currently the best connection between core areas for aquatic and semi aquatic species. The Big Oak Flat tributary joins Canton Canyon west of both I-5 and the old Golden State Highway. Deciduous and evergreen oaks and willows are prevalent, and the riparian vegetation is well developed on both sides of the structure (Figure 51). There is an oval culvert approximately 10' wide and 5' high under I-5 (Figure 52), and a small pipe culvert under the old Golden State Highway. We recommend upgrading the structure on I-5 to a bridged undercrossing when the next transportation improvement project is implemented in this area. The Paradise Valley Trailer Park is immediately east of the freeway adjacent to Big Oak Flat Creek, and about 5 homes are located west of old Golden State Highway. These homes may be compatible with linkage function if lighting, fencing, and water quality issues are addressed. We suggest an outreach program on environmental stewardship in this community. We also urge that existing regulations governing riparian habitats be enforced (e.g., no horse corrals in creek beds).

Figure 52. Spectacular riparian forest and oval concrete culvert under I-5 at Big Oak Flat (center).

Figure 53. Canton Canyon flowing towards I-5, with broadleaf oaks in the canyon.

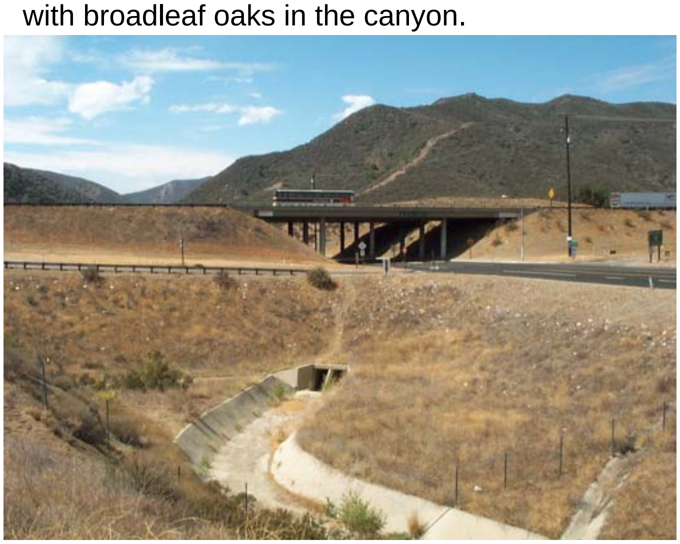

Figure 54. Templin Highway underpass.

The bridged underpass for Templin Highway at Canton Canyon is the only large underpass south of Pyramid Lake (Figure 53). It will become less important if new bridged crossings are constructed along I-5 (as recommended above) but it currently provides one of the safest I-5 crossings (Figure 54). It contains 4 lanes of pavement, which are used by (a) the residences of the Paradise Valley Trailer Park, (b) about 10 homes in Canton Canyon, (c) about 5 homes west of I-5, (d) a few recreationists using the old Golden State Highway to access Piru Creek, and (e) workers at the Castaic power plant. Until other crossing structures can be upgraded, we recommend working with landowners in upper Canton Canyon to minimize land uses that compromise linkage function. If landowners can collaborate to maintain or enhance the usefulness of upper Canton Canyon as a funnel toward I-5, then we urge reducing the pavement in the underpass from 4 lanes to 2 lanes, redirecting Canton wash from the concrete culvert into an open surface channel, making the bridge long enough to accommodate the wash, and revegetating the wash through the interchange. This would provide ample room to enhance and restore natural vegetative cover underneath and approaching the bridge, while still providing the necessary vehicular access.

Recommendations for Crossing Structures on Highway 33: The Linkage Design crosses SR 33 in four areas. The northern branch crosses SR 33 along the Cuyama River. Four Wilderness Areas border Highway 33 in the two middle branches of the Linkage Design: Matilija, Sespe, Dick Smith and Chumash. The 4th branch of the Linkage Design crosses SR-33 south of Ojai, just west of Sulphur Mountain. Highway 33 is also known as the Jacinto Reyes Scenic Byway and is designated as a Forest Scenic Byway.

SR 33 experiences heavy traffic volumes in and out of Ojai, but north of this community, SR 33 is used mostly for recreational and Forest Service access, though it's also used to transport goods between the Cuyama Valley and coastal cities. Although the 33 doubtless contributes to wildlife mortality and is avoided by most species, it is not presently an impermeable barrier above the community of Ojai, especially at night. We recommend that if lanes or paved shoulders are added to this highway, transportation agencies should use this opportunity to construct at least one large mammal crossing every 1.5 kilometers (1 mile), and crossing structures for reptiles, amphibians, and small mammals every 150-300 meters (450-900 feet), from the north end of Meiners Oaks and Ojai to the confluence of Apache Canyon with the Cuyama River.

SR-33 poses a significant impediment south of Ojai, as vehicle speeds and traffic lanes increase. The best existing structure (Figure 55) is where San Antonio Creek passes under the 33 to join the Ventura River. If lanes are added, wildlife passage should be accommodated via a major bridged undercrossing at least 400 m (1/4 mile) long that encompass both riparian and upland vegetation within the crossing structure. We emphasize that these improvements are not needed until significant road improvements (widening shoulders, realignment, or additional lanes) are undertaken. Finally, we recommend maintaining the rural character of the landscape, with appropriate measures to confine light and noise pollution to the vicinity of existing communities.

Figure 55. San Antonio Creek passing under Highway 33 to join the Ventura River.

Other Recommendations Regarding Paved Roads Within the Linkage Area:

- Consider existing crossing structure as indicators of the approximate location of freeway crossings, not as fixed elements of a Linkage Design.

- Use each road improvement project as an opportunity to replace fill slopes and pipe culverts with box culverts (large enough to allow a clear view to the other side) or bridges (large enough to allow vegetation to grow), with earthen substrate flooring. In locations where a bridge is not feasible, install a pipe culverts (designed to remain free of water) parallel to all box culverts to provide for passage of small mammals, amphibians, and reptiles.

- Encourage woody vegetation leading up to both sides of crossing structures to provide cover for wildlife and to direct their movement toward the crossing structure (Hunt et al. 1987, Rodriquez et al. 1996, Rosell et al. 1997, Santolini et al. 1997, Linden 1997, Clevenger and Waltho 1999, McDonald and St. Clair 2004). Work with the Forest Service, California Native Plant Society, local Resource Conservation District or other non-profit organizations active in restoration efforts in the area to restore riparian communities and vegetative cover at passageways.

- Install appropriate wildlife fencing along the freeway to guide animals to crossing structures. Install escape structures, in conjunction with fencing, to allow animals to escape if they get trapped on the freeway.

- Use fine mesh fencing to guide amphibians and reptiles to crossing structures.

- On freeways and other paved roads, minimize artificial night lighting, and direct the light onto the roadway and away from adjacent wildland.

- Install signs to alert drivers to wildlife crossing locations and reduce roadkill.

Roads as Ephemeral Barriers: Structures designed for wildlife movement are increasingly common. In southern California, the Coal Canyon interchange on State Route 91 is now being converted, through a partnership with CalTrans, California State Parks, and Hills for Everyone, from a vehicle interchange into a wildlife underpass to facilitate wildlife movement between the Chino Hills and the Santa Ana Mountains. About 8 wildlife underpass bridges and viaducts were installed along State Route 241 in Orange County, although urbanization near this toll road has compromised their utility (Evink 2002). Elsewhere, several crossing structures, including 3 vegetated overpasses, have been built to accommodate movement across the Trans-Canada Highway in Banff National Park (Clevenger et al. 2001). In south Florida, 24 underpasses specifically designed for wildlife were constructed along 64km of Interstate 75 in south Florida in about 1985. The structures are readily used by endangered Florida panthers and bears, and have reduced panther and bear roadkill to zero on that route (Lotz et al. 1996).

Almost all of these structures were designed specifically for wildlife movement along existing highways and were not part of the original road design. This demonstrates that the existing low permeability across I-5 should not be considered irreversible. Most importantly, the current lack of permeability should not be used as an excuse to develop lands adjacent to the freeway on the grounds that the freeway is a permanent and absolute barrier. Indeed, at least 2 pumas crossed bustling I-15 near Temecula in the early 1990's (Beier 1996, and unpublished data), and another crossed SR-118 near Simi Valley several times since 2002 (Ray Sauvajot, National Park Service, unpublished data). In contrast to roads, an urban development creates absolute and permanent barriers to movement for many species.

Representatives from CalTrans have attended each of the four workshops of the South Coast Missing Linkages effort, and have consistently demonstrated leadership with their willingness to improve wildlife crossings as part of their transportation improvement projects. In the case of I-5, improvements may not occur for many years during which time gene flow will continue to be disrupted. However, once connectivity is restored, genomes of all affected species will have the chance to recover.

Impediments to Streams

Organisms moving through rugged landscapes often use riparian areas as travel routes. For example, many butterflies and frogs preferentially move along stream corridors (Orsack 1977, USGS 2002, Kay 1989). Although southwestern pond turtles are capable of overland movements of up to 0.5 km (0.3 mi) (Holland 1991), they preferentially move along stream courses (Bury 1972). Even large, mobile vertebrates, such as mountain lions, have shown preferences for moving along riparian corridors (Beier 1995, Dickson et al. 2004).

For plants and animals associated with streams or riparian areas, impediments are presented by dams, road crossings, exotic species, increased scouring of native vegetation by urban runoff, water recharge basins, dumping and runoff of agricultural waste and fertilizers, farming in streambeds, gravel mining, and concrete structures that stabilize stream banks and beds. Increased urban and agricultural runoff also can create permanent streams in areas that were formerly ephemeral; permanent waters can support aggressive invasive species, such as bullfrogs and exotic fish that prey on native aquatic species, and giant reed that supplants native plant communities (Fisher and Crooks 2001).

Most large rivers in southern California have been dammed or diverted, changing natural flows, vegetation structure and composition, and sediment transport and deposition. These changes affect the ability of these systems to support native species. Sudden water releases from reservoirs, especially during summer, can wipe out an entire year's reproductive effort for sensitive species, such as the arroyo toad, red-legged frog, and southwestern pond turtle. Perennial flows created by increased runoff into streams that were previously dry in summer foster the spread of exotic predators, such as bullfrogs, sunfish, bass, bluegill, and crayfish (Sweet 1992, Stephenson and Calcarone 1999), which can eliminate native species. Not only do dams degrade habitat, they also create additional obstacles to movement, especially for aquatic and semi-aquatic organisms.

Impediments to Streams in the Linkage Design: The Linkage Design encompasses several connections for semi-aquatic and riparian species, though only Big Oak Flat Creek currently provides a direct riparian connection between the two Core Areas. Dams and diversions have drastically altered the hydrology of the planning area, triggering substantial changes to these riparian systems. Many tributaries in the vicinity of I-5 (e.g., Gorman, Cañada de Los Alamos, Piru, Apple, W. Liebre Gulch, Liebre Gulch, Cherry, Osito, and Canton) historically provided continuous avenues along which aquatic and semi aquatic species could journey between the Sierra Madre and Castaic ranges. Today, these riparian connections have essentially been severed, with most being diverted into reservoirs (Figure 56). Other streams (e.g., Canton, Cherry, Osito) are impeded by fill slopes and other engineered infrastructure along I-5. Although fragmented, the riparian communities near I-5 still provide habitat for many native species, including the southwestern willow flycatcher, least Bell's vireo, and California condor (USDA Forest Service 2004), and opportunities remain for restoring connectivity here.

Figure 56. West Fork Liebre Gulch east of I-5. Note riparian vegetation in the canyon.

Several reservoirs are in or near the Linkage Design, including Quail Lake, Pyramid Lake, Castaic Lake, Lake Piru, Lake Casitas, and Matilija. Most of these are operated by the California Department of Water Resources to supply water, flood control, energy generation, and recreation. The West Branch of the California Aqueduct delivers water south to Quail Lake, Pyramid Lake and finally into Castaic Lake, while Lake Piru is fed by several tributaries. Due to water and energy needs in the region, and development in floodplains, only one of these dams is likely to be removed in the foreseeable future. The Army Corps of Engineers is currently evaluating the removal of Matilija Dam, which would restore connectivity for steelhead and other species in the watershed.

Despite so many dams and diversions in the area, the Linkage Design contains some of the highest quality riparian habitats in southern California, some of which provide important movement routes. Several listed and sensitive aquatic species inhabit the Sespe watershed, including arroyo toad and southern steelhead trout (USDA Forest Service 2004). Sespe Creek provides the most significant east west riparian movement corridor in the Linkage Design. Even Piru Creek, although dammed in 2 places (Pyramid Lake and Lake Piru), supports several special status species, including arroyo toad, western pond turtle, and two-striped garter snake. The Cuyama River contains a population of the endangered California red-legged frog and habitat for southwestern willow flycatcher. North-facing slopes in the Liebre and Sawmill mountains contain montane riparian forests dominated by canyon live oak, which sustain several California spotted owl territories. Vegetation along drainages in the study area varies widely, from coast live oak riparian forests to deciduous forests dominated by canyon live oak, cottonwood, or sycamores.

Mitigating for Stream Barriers: Few restoration projects have focused on restoring the natural dynamics of riparian systems (Bell 1997), where annual floods are a major component of ecosystem function. Many riparian plants are pioneer species that establish quickly following soil disturbance by floods (Ohmart 1994) as long as threats like invasive species are controlled and physical processes restored (e.g., by removing dams and diversions or by mimicking natural flow regimes.

Continuity between upland and riparian vegetation is also important to maintaining healthy riparian communities. Many species commonly found in riparian areas depend on upland habitats during some portion of their lifecycle. These include butterflies that use larval host plants in upland habitat and drink as adults, western pond turtles that lay their eggs in sandy upland habitats, and western toads that summer in upland burrows. Most fish feed on the aquatic larvae of insects that depend on terrestrial habitats as adults. While the width of upland habitats needed beyond the stream's edge is unknown for many species, information on the western pond turtle suggests that a 1-km (0.6-mi) upland buffer (i.e., 0.5 km to either side of the stream) (Holland 1991) is needed to sustain populations of this species.

Measures to minimize development impacts on aquatic habitats focus on establishing riparian buffer zones (Barton et al. 1985, Allan 1995, Wilson and Dorcas 2003). However, although these buffers are intended to prevent erosion and filter runoff of contaminants (U.S. Environmental Protection Agency), research suggests that current regulations are inadequate to protect populations of semiaquatic reptiles and amphibians (Wilson and Dorcas 2003). Buffers must contain enough upland habitat to maintain water-quality and habitat characteristics essential to the survival of many aquatic and semiaquatic organisms (Brosofske et al.1997, Wilson and Dorcas 2003). However, maintaining riparian buffers will not suffice for some species, for instance, to preserve salamander populations in headwater streams, land use must be considered at the watershed level (Wilson and Dorcas 2003).

Recommendations to Mitigate the Effects of Streams Barriers in the Linkage Design Area: To enhance species use of riparian habitat and restore riparian connections through the Linkage Design area, we recommend:

- Wherever possible restore the natural historic flow regime or create a regime that provides maximum benefit for native biodiversity. Work with the Forest Service, National Marine Fisheries Service, California Department of Fish and Game, the California Department of Water Resources, Los Angeles County Department of Public Works, Los Angeles County Department of Parks and Recreation, watershed groups and others to investigate the historic flow regimes and develop a surface and groundwater management program to restore and recover properly functioning aquatic and riparian conditions.

- Mitigate the effects of road crossings in riparian zones. Coordinate with the California Department of Transportation, National Marine Fisheries Service, California Department of Fish and Game, California Department of Water Resources and the Forest Service to evaluate existing stream crossings and upgrade culverts, stream crossings, bridges, and roads that impede movement (NFMS 1996, USFWS 1998).

- Work with the California Department of Water Resources and other appropriate agencies to restore Gorman Creek by removing the concrete flooring, concrete channel, and fencing; restoring riparian habitat through the structure; and, if necessary, tapping the water resources of Gorman Creek further south.

- Where necessary, install specialized culverts and bridges in streams to improve fish passage by addressing outfall height, water velocities, and water depth (Carey and Wagner 1996, Evink 2002). Use strategies identified in *Guidelines for Salmonid Passage at Stream Crossings* (NFMS 2000), including information on preferred crossings, designing new culverts, retrofitting or replacing culverts, general recommendations, post construction evaluation, maintenance and long term assessment.

- Support the protection of riparian and adjacent upland habitats on private lands. Pursue cooperative programs with landowners to improve conditions in riparian and upland habitats on private land in the Linkage Design. For instance, work with the community of Paradise Ranch off Templin Highway to enhance the best existing riparian connection across I-5, at Big Oak Flat (See Roads Section).

- Restore riparian vegetation in all drainages and upland vegetation within 1 km (0.6 mi) of streams and rivers. Discourage the construction of concrete-banked streams and other channelization projects.

- Remove exotic plants and animals from streams, rivers, and lakes. Work with the Biological Resources Division at USGS, Forest Service, and other relevant agencies to survey streams and drainages for invasive species and develop a comprehensive removal strategy for whole watersheds. The survey and removal strategy should document and recommend how to deal with ephemeral drainages that are becoming increasingly perennial, supporting exotic fish and bullfrogs.

- Enforce existing regulations protecting streams and stream vegetation from alteration, manure dumping, and vegetation removal. Agencies and regulations with applicable jurisdiction include Forest Service, California Department of Fish and Game, Streambed Alteration Agreements, Army Corps of Engineers, Clean Water Act, Native Plant Protection Act and Oak Tree Ordinances. In high abuse areas, post signs that prevent vehicles from driving in the creek bottom. Review existing regulations relative to linkage goals and develop additional restrictions or recommend closures in sensitive areas.

- Aggressively enforce regulations restricting farming, gravel mining, and building in streams and floodplains.

- Increase and maintain high water quality standards. Work with the Resource Conservation District to help establish use of Best Management Practices for all agricultural operations in the watershed, including alternatives to the standard practices of fertilizer use. Work with Regional Water Quality Control Board and the Total Maximum Daily Load (TMDL) process to reduce nutrient levels in impaired reaches of the watershed.

Other Land Uses that Impede Utility of the Linkage

Land management policies in the Core Areas and the Linkage can have substantial impact on habitat and movements of species through the Linkage Design area. It is essential to work with major land-management entities, including U.S. Forest Service, California State Parks, and County Parks to integrate the results of the linkage planning effort into their existing policies and regulations. In this report, we limit our discussion to activities in the Linkage Design area.

Oil & Gas Development

Oil and gas drilling activities contribute to habitat loss, degradation, and fragmentation; air, water and soil pollution; soil compaction, erosion and sedimentation of waterways; fire hazards; and hazardous waste. The proliferation of roads and associated infrastructure from oil and gas development can create substantial impediments to wildlife movement (Penrod et al. 2002). Once a well has been tapped for production, miles of pipeline must also be constructed to transport the oil and gas for consumption. Pipelines placed above ground can create additional barriers to wildlife movement.

Oil & Gas Development in the Vicinity of the Linkage: Los Padres National Forest produces roughly 700,000 barrels of oil annually, through 22 different Special Use Permits covering 14,618 acres. Oil and gas development is ongoing in portions of Cuyama, Piru and Sespe watersheds, with the majority of the oil produced coming from the Sespe Oil Field near Fillmore. Most lease areas (Sespe Oil Field, South Cuyama, Bates Canyon, Deer Park Canyon and Sulphur Springs) do not have wells on Forest Service land, and oil is pumped from adjacent private land (USDA Forest Service 2001).

Additional oil and gas drilling activities have been proposed. All lands within Los Padres National Forest that have not been withdrawn from mineral entry by Congress are now being considered for additional oil and gas leasing (USDA Forest Service 2001). The only areas not under consideration are designated Wilderness areas, the Santa Ynez watershed, and the Big Sur coastal zone. Roughly 74% of the 140,000-acre areas estimated to have high potential for oil and gas production are within Inventoried Roadless Areas (IRA). Congress is considering these IRAs for wilderness status (www.californiawild.org), concurrent to the Draft Environmental Impact Statement being issued and evaluated. Approximately 90 million barrels are estimated to remain beneath the Forest—only five days of our nation's oil supply.

Recommendations to Mitigate the Effects of Oil & Gas Development: Given the significant habitat loss and fragmentation caused by oil and gas drilling, additional leases are undesirable in the Linkage Design. For existing leases, we provide the following initial recommendations:

- Reclaim and revegetate all disturbed surfaces as soon as possible after project completion, including well pads, pipelines, access roads and associated infrastructure.

- Leave service roads unfenced to allow wildlife movement. Redesign existing fences to permit wildlife passage and prevent entanglement.

- Avoid drilling activities during periods of intensive wildlife use (e.g., nesting, birthing and rutting areas).

- Bury pipelines and associated utilities along existing roads to minimize disturbance and fragmentation.

- Use such technologies as directional drilling, horizontal drilling, multiple wells per drilling pad, and smaller well pads to reduce habitat loss and fragmentation.

- Use closed-loop drilling systems (pitless drilling) and water-based drilling fluids to protect water quality. If pits are unavoidable, they should be fenced and covered to prevent entry by birds and wildlife.

- Prohibit on-site waste disposal to avoid contamination of water, soil, and vegetation.

- Implement all Best Management Practices (BMPs) and strategies outlined in the EPA Sector Notebook, "Profile of the Oil and Gas Extraction Industry," (at http://es.epa.gov/oeca/sector/index.html#oilgasex, Publication number EPA/310-R-99-006).

Urban Barriers to Movement

Urban development, unlike roads or aqueducts, creates barriers that cannot be corrected by building crossing structures. Urban and suburban areas make particularly inappropriate landscapes for movements of most plants and animals (Marzluff and Ewing 2001). In addition to direct habitat removal, urban development creates edge effects that reach well beyond the development footprint. Most terrestrial mammals that move at night will avoid areas with artificial night lighting (Beier, in press). Pet cats can significantly depress populations of small vertebrates near housing (Churcher and Lawton 1987, Crooks 1999, Hall et al. 2000). Irrigation of landscapes surrounding homes encourages the spread of argentine ant populations into natural areas, where they cause a halo of local extinctions of native ant populations extending 200 m (656 ft) into native vegetation (Suarez et al. 1998, Bolger et al. 2000). Similar affects have been documented for amphibians (Demaynadier and Hunter 1998). Habitat disturbance caused by intense human activity (e.g., off-road vehicle use, dumping, camping and gathering sites) also tends to rise in areas surrounding urban developments. Areas disturbed by human use show decreases in bird and small mammal populations (Sauvajot unpubl.).

Urban Barriers in the Linkage Design Area: Urban or rural residential developments comprise just 1.2% of the Linkage Design area. The most significant area of encroachment is from the City of Ojai and surrounding communities (e.g., Meiners Oaks, Mira Monte, Oak View, Casitas Springs), while high-density urban development in Santa Clarita is spreading northward toward Castaic. Other rural communities in or adjacent to the Linkage Design include Lockwood Valley, Frazier Park, Gorman, Santa Paula, and Fillmore. In addition, scattered rural residential development extends along portions of Highway 33 immediately north of Ojai, the length of Highway 150 north of Santa Paula, and along Templin Highway (i.e., Paradise Valley Trailer Park, about 10 homes in

Canton Canyon, and 5 homes west of I-5). Urban development near Forest Service boundaries is spurring illegal ORV routes and trails onto the Forests (USDA Forest Service 2004).

Other massive development projects are proposed that would eliminate vast expanses of natural habitats and create irreversible barriers to wildlife movement. In the northeastern part of the linkage along SR-138, Tejon Ranch has proposed the Centennial Specific Plan covering 11,676 acres, which would create an entire city (22,998 residential and commercial units) at the base of the Tehachapi and Liebre mountains near Quail Lake. This proposed development would severely restrict wildlife passage between the Sierra Madre and Castaic ranges, and forever eliminate opportunities for wildlife movement between the Castaic and Tehachapi ranges. Another considerable development has been proposed between Interstate 5 and Castaic Lake called North Lake Ranch, which would consist of 1,400 acres, including an 18-hole championship golf course and country club, 3,000± mixed-use residential units, commercial, parks and schools.

Most homes in the study area are on large lots that retain most of the native vegetation. Relatively small expanses of such developments, such as that in the community of Lockwood Valley, probably cause minimal impediment to animal movement. Larger expanses, such as in Ojai, are much less permeable due to increased traffic volume, higher traffic speed, increased numbers of pets, increased lighting and noise, and other impacts that threaten connectivity.

Recommendations for Mitigating the Effects of Urban Barriers in the Linkage Design Area: We provide the following initial recommendations regarding urban, suburban, and rural developments in the Linkage Design area:

- Encourage land acquisition and conservation easements with willing private lands owners in the Linkage Design

- Minimize outdoor lighting at homes abutting the linkage area. Direct lighting away from wild areas. Use fences to keep dogs and domestic livestock from roaming into the linkage area. In the case of existing homes, this can best be arranged as a voluntary agreement among landowners.

- Develop a public education campaign, such as the On the Edge program developed by the Mountain Lion Foundation (http://www.mountainlion.org), which encourages residents at the urban wildland interface to become active stewards of the land by reducing penetration of undesirable effects into natural areas. Education topics should include fencing in pets, constructing predator-safe enclosures for livestock, reducing human traffic in sensitive areas or constriction points, limiting noise and lighting, reducing traffic speeds, minimizing use of irrigation, promoting use of native plants and the avoidance of non-native invasive plants, minimizing the use of pesticides, poisons and other harmful chemicals, and effective reporting of violations.

- Work with the counties of Ventura and Los Angeles County on their General Plan updates to encourage zoning of rural areas of the Linkage Design to larger lot sizes (e.g., 40-80 acres).

- Discourage major new residential or urban developments in the Linkage Design area. Where development of single residences or small subdivisions does occur, we recommend restrictions that limit edge effects (above). A few estates on large lots (such as 50 acres or larger) may be compatible with the linkage. However, the total extent of any development should be limited. As a condition of such new subdivisions, the developer should implement a mechanism whereby purchasers of lots accept loss of pets and livestock to wild predators without demanding compensation or a depredation permit. The Mountain Lion Foundation has also worked to develop predator safe domestic livestock enclosures and works with several ranchers and farmers to help keep livestock safe, with the ultimate goal of reducing the number of depredation permits issued for mountain lions.

- Restrict land use in Canton Canyon to those that are compatible with wildlife movement. Work with residents to limit night time lighting and noise; improve water quality in Canton Canyon and Big Oak Flat creeks; and ensure pets and domestic livestock are kept in predator safe enclosures.

- Discourage urbanization in the southern arm of the linkage south of Meiners Oaks. We recommend no additional urbanization between Casitas Springs and Oak View, no new urbanization within 500 m of Lake Casitas, and no new urbanization between Lake Casitas north or west to the Los Padres National Forest boundary.

- All proposed developments in the Linkage Design (e.g., Centennial, North Lake Ranch) should specifically address the effects of the proposed project on wildlife movement in the linkage, and should be consistent with the Linkage Design standards outlined in this document. The project proponents should work with a panel of reviewers early in the site planning phase to maximize the potential to maintain habitat connectivity. They should be required to set aside key wildlife movement areas as open space as mitigation.

- Work with the Forest Service, Fire Safe Councils and California Department of Forestry and Fire Protection to develop fire preparedness plans that do not compromise linkage function. County regulations should be revised to prevent vegetation removal in protected areas of the Linkage Design area. All development projects should be designed so that required fuel clearance areas are on land that is part of the project.

Recreation

Recreational use is not inherently incompatible with wildlife movement through the Linkage Design. However, intense recreational activities have been shown to cause significant impacts to wildlife and plants (Knight and Gutzwiller 1995). Even such relatively low-impact activities as wildlife viewing, hiking, and horse-back riding have been shown to displace wildlife from nutritionally important feeding areas and prime nesting sites (Anderson 1995, Knight and Cole 1995). The increased time and energy spent avoiding humans can decrease reproductive success and make species more susceptible to disease (Knight and Cole 1995). In addition, humans, horses and pets can carry seeds of invasive species into natural areas (Benninger 1989, Benninger-Traux et al. 1992), with potentially devastating effects.

Recreation in the Linkage Design Area: Dispersed recreational activities abound in the assessment area with the most intensive recreational activities are centered on 4 reservoirs: Pyramid Lake, Castaic Lake, Quail Lake, and Lake Piru. In 1994, annual visitor use exceeded 600,000 for Pyramid and Castaic (http://wwwswpao.water.ca.gov/publications/bulletin/95/view/text/cha14.htm). Each of the manmade lakes is stocked with fish, including bass, trout, catfish, blue gill, and crappie. The Department of Fish and Game also maintains wild trout fisheries on Piru and Lockwood Creeks, which provide fly-fishing opportunities. Concentrated water-based recreational activities along riparian zones, such as Frenchman's Flat, are impacting natural resources. Driving for pleasure is another popular activity, especially along the Old Ridge Route. Currently, off-road vehicle use is most prevalent in the northern part of the linkage area, especially the Hungry Valley State Vehicular Recreation Area and the Back Country Discovery Trail. Another off road vehicle park has recently been proposed in the southeast portion of the Linkage Design, in Marple Canyon, just south of Canton Canyon.

Recommendations to Mitigate the Effects of Recreation in the Linkage Design Area: We provide the following initial recommendations to prevent or mitigate negative effects of recreation in the Linkage Design area:

- Monitor trail development and recreational use to provide a baseline for decisions regarding levels, types, and timing of recreational use.

- Monitor riparian systems in the vicinity of reservoirs to ensure they aren't infested with non native predatory species (e.g., bullfrogs, some sport fish) and implement an ongoing invasive species management plan.

- Monitor potential impacts (e.g., trail degradation, soil erosion and compaction, water quality, conflicts with threatened and endangered species) from mountain bikes, off road vehicles (legal and illegal), and equestrian use to prioritize trail maintenance and enhancement projects, habitat restoration projects, and to identify trails that need to be rerouted for resource protection.

- Work with regional monitoring programs, such as the State's Resource Assessment Program, to collect information on special status species, species movements, and vegetation disturbance in areas of high recreational activity.

- Enforce existing regulations (e.g., leash laws for dogs, road closures) on types of recreational use currently established.

Land Protection & Stewardship Opportunities

A variety of conservation planning efforts is currently underway in the Linkage Design area. The South Coast Missing Linkages Project supports these efforts by providing information on linkages critical to achieving their conservation goals at a landscape scale.

This section provides information on planning efforts, agencies, and organizations that may represent opportunities for conserving the Sierra Madre–Castaic Connection. This list is not exhaustive, but provides a starting point for persons interested in becoming involved in preserving and restoring linkage function.

Bureau of Reclamation: Reclamation's Southern California Area Office (SCAO) is responsible for water conservation, reclamation and reuse projects to enhance water management practices throughout southern California. Reclamation undertakes collaborative efforts with local entities to develop effective water quality monitoring plans to identify impaired water bodies (pursuant to section 303(d) of the Clean Water Act), support the development of water quality recovery plans (Total Maximum Daily Load plans), and estimate the assimilative capacity for nutrients in the system. For more details, visit http://www.usbr.gov/lc/region/scao/sccwrrs2.htm.

California Department of Fish and Game: CDFG manages California's diverse fish, wildlife, and plant resources, and the habitats upon which they depend, for their ecological values and for their use and enjoyment by the public. Acquisition dollars for CDFG projects are authorized through the Wildlife Conservation Board as part of their Concept Area Protection Plan (CAPP) process (http://www.dfg.ca.gov).

California Department of Transportation**:** CalTrans strives to achieve the best safety record in the nation, reduce traveler delays due to roadwork and incidents, deliver record levels of transportation system improvements, make transit a more practical travel option, and improve the efficiency of the transportation system. CalTrans representatives have attended each of the South Coast Missing Linkages workshops and have shown leadership and a willingness to improve linkage function in most important linkage areas. CalTrans recently proposed building a wildlife overpass over SR-118. In February 2003, CalTrans started removing pavement from the Coal Canyon interchange on SR 91 in Orange County and transferred the property to California State Parks expressly to allow wildlife movement between the Santa Ana Mountains of the Cleveland National Forest and Chino Hills State Park. To find out more about the innovative plans being developed by Caltrans, visit their website at http://www.dot.ca.gov.

California Department of Water Resources: DWR operates and maintains the State Water Project, including the California Aqueduct. The State Water Project is a water delivery system of 29 reservoirs, 17 pumping plants, 5 power plants, and 660 miles of aqueducts and canals. The department also provides dam safety and flood control services, assists local water districts in water management and conservation activities, promotes recreational opportunities, and plans for future statewide water needs. Major reservoirs in the Linkage Design that are part of the State Water Project include: Quail Lake, Pyramid Lake, and Castaic Lake. For more information on DWR, visit their website at http://wwwdwr.water.ca.gov/.

California State Parks: California State Parks provides for the health, inspiration and education of the people of California by helping to preserve the state's extraordinary biological diversity, protecting its most valued natural and cultural resources, and creating opportunities for high-quality outdoor recreation. The Department is actively engaged in the preservation of the State's rich biological diversity through their acquisition and restoration programs. Ensuring connections between State Park System wildlands and other protected areas is one of their highest priorities. CSP is involved in the Coal Canyon habitat connection restoration project to preserve mountain lion movement under SR 91 at the north end of the Santa Ana Mountains. CSP co-sponsored the statewide Missing Linkages conference and is a key partner in the South Coast Missing Linkages effort. For more information, visit their website at http://www.parks.ca.gov.

California Wilderness Coalition: The California Wilderness Coalition builds support for threatened wild places on a statewide level by coordinating efforts with community leaders, businesspeople, decision-makers, local organizations, policy-makers, and activists. CWC listed the Santa Clara River as one of the most threatened areas in California (California Wilderness Coalition 2004). CWC was also a co-sponsor of the statewide Missing Linkages effort. For more information, visit them at http://www.calwild.org.

California Wild Heritage Campaign*:* The mission of the California Wild Heritage Campaign is to ensure the permanent protection of California's remaining wild public lands and rivers. Congresswoman Hilda Solis has introduced the Southern California Wild Heritage Act. The bill would significantly expand the National Wild & Scenic Rivers System and the National Wilderness Preservation System on federally managed public lands in Southern and Central California. A total of 13 new Wild & Scenic Rivers are included in the bill, totaling more than 312 miles, and 47 new Wilderness Areas and Wilderness Additions totaling 1,686,393 acres. The Campaign builds support for wilderness and wild & scenic river protection by compiling a detailed citizen's inventory of California's remaining wild places; organizing local communities in support of those places; building a diverse, broad-based coalition; and educating the general public, government officials and the media about the importance of protecting California's wild heritage. For more information on the status of the Act, visit http://www.californiawild.org.

County of Los Angeles: Los Angeles County is currently engaged in a 2025 General Plan update, which will likely include proposed revisions and expansions to existing Significant Ecological Areas (SEA). Some segments of the Linkage Design that fall within Los Angeles County have been proposed as SEAs. The Santa Clara River SEA (PCR 2000) includes several important wildlife movement areas, including the River, San Francisquito and Castaic creeks. The San Andres Rift Zone SEA (PCR 2000) is proposed in the northeast part of the linkage and includes a connection between the Castaic and Tehachapi Mountains. The General Plan update also provides an opportunity to ensure zoning in the Linkage Design is conducive to conserving linkage function. For more information on the General Plan update go to http://www.planning.co.la.ca.us.

County of Los Angeles, Department of Parks and Recreation: The Castaic Lake State Recreation Area is operated by the Los Angeles County Department of Parks and Recreation. Although the park is intensely used for recreational activities, important biological and cultural resources also occur there. For more information, visit them at http://www.parks.co.la.ca.us.

Environment Now: Environment Now is an active leader in creating measurably effective environmental programs to protect and restore California's environment. Since its inception, the organization has focused on the preservation of California's coasts and forests, and reduction of air pollution and urban sprawl. Environment Now uses an intelligent combination of enforcement of existing laws, and application of technology and process improvements to eliminate unsustainable practices. To find out more about their programs, visit their website at http://www.environmentnow.org

Heal the Bay: Founded in 1985, Heal the Bay works to make Santa Monica Bay and Southern California coastal waters safe and healthy for people and marine life. To reach their goals, they use research, education, community action and policy programs. Heal the Bay's science and policy experts engage in reviewing and commenting on countless discharge permits; testifying before the L.A. and California water quality boards on laws and enforcement; acting as a technical advisor, member, and leader on numerous task forces and project committees; and working with elected officials to author laws and enable projects to improve water quality. To find out more about Heal the Bay, visit them at http://www.healthebay.org.

Los Angeles County Aquatic Resource In-Lieu Fee Mitigation Program: This program provides a voluntary alternative compensatory mitigation option that results in better designed and managed aquatic resource restoration projects. Program funds may be used for activities directly related to aquatic habitat creation, restoration, or enhancement, to include exclusively the following activities: land acquisition; purchase of easements, purchase of water rights; development of mitigation and monitoring plans; permit fees; implementation of mitigation and monitoring plans; administrative costs; and long-term management of mitigation parcels. To find out more about this program, go to http://www.spl.usace.army.mil/regulatory/pn/200200035.pdf.

Mountain Lion Foundation: The Mountain Lion Foundation works to ensure naturally sustaining populations of mountain lions. Using research, education, advocacy, legislation, and litigation, MLF works across the American West to stop unnecessary killing of mountain lions and to protect the ecosystems upon which they depend. MLF partners with groups whose mission directly impacts mountain lions and is proud to be a founding board member of South Coast Wildlands. MLF's Southern California office focuses on "Living with Lions" to reduce conflicts between people, pets and lions. MLF helps livestock owners build predator-safe enclosures, helps those suburban residents "On the Edge" understand how their personal choices may affect wildlife for miles around, as well as helps those working and playing "In the Wild" feel safer. For more information on the MLF's programs, visit their website at http://www.mountainlion.org.

National Park Service: The purpose of the National Park Service is "...to promote and regulate the use of the...national parks...which purpose is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." NPS is a partner in the South Coast Missing Linkages Project. For more on the National Park Service, see http://www.nps.gov.

Regional Water Quality Control Board: The State WQCB strives to preserve, enhance and restore the quality of California's water resources, and ensure their proper allocation and efficient use for the benefit of present and future generations. The RWQCB oversees water quality in the Linkage Design area and initiates planning efforts to identify sources of pollutants and restore water quality to impaired water bodies. For more information, visit their website at http://www.swrcb.ca.gov.

Resource Conservation Districts (RCD): This non-profit agency supports conservation of natural ecosystems through programs that reduce the effects of on-going land-use practices on the environment. A major portion of their effort is to advise residents on the management of soil, water, soil amendments and other resources used for agriculture and home gardening. RCDs are supported by state and local grants. They provide leadership in partnership efforts to help people conserve, maintain, and improve our natural resources and environment. Programs include Emergency Watershed Protection, Environmental Quality Incentives, Resource Conservation and Development, Soil Survey Programs, Soil and Water Conservation Assistance, Watershed Protection, River Basin, and Flood Operations, Wetlands Reserve & Wildlife Habitat Incentives. They do not enforce regulations but instead serve the interests of local residents and businesses. To find out more about their programs, go to http://www.carcd.org.

San Gabriel and Lower Los Angeles Rivers and Mountains Conservancy: The Rivers and Mountains Conservancy is a state agency working to create a Parkways and Open Space Plan for the San Gabriel River and lower Los Angeles River watersheds. The RMC works to preserve open space and habitat for present and future generations. To fulfill that mission, the RMC is engaged in multiple projects that provide low-impact recreation, education, wildlife and habitat restoration, and watershed improvements. To find out more about the RMC, visit their website at http://www.rmc.ca.gov.

Santa Monica Mountains Conservancy: This state agency was created by the Legislature in 1979 and is charged with the primary responsibility for acquiring land with statewide and regional significance. Through direct action, alliances, partnerships, and joint powers authorities, the Conservancy's mission is to strategically preserve, protect, restore, and enhance treasured pieces of Southern California's natural heritage to form an interlinking system of parks, open space, trails, and wildlife habitats that are easily accessible to the general public. SMMC is a partner in the South Coast Missing Linkages effort. For more information on SMMC, visit them at http://www.smmc.ca.gov.

South Coast Wildlands: South Coast Wildlands is a non-profit group established to create a protected network of wildlands throughout the South Coast Ecoregion and is the administrator and coordinator of the South Coast Missing Linkages Project. For all 15 priority linkages in the Ecoregion, South Coast Wildlands supports and enhances existing efforts by providing information on regional linkages critical to achieving the conservation goals of each planning effort. For more information on SCW, visit their website at http://www.scwildlands.org.

***South Coast Missing Linkages Project*:** SCML is a coalition of agencies, organizations and universities committed to conserving 15 priority landscape linkages in the South Coast Ecoregion. The project is administered and coordinated by South Coast Wildlands. Partners in the South Coast Missing Linkages Project include but are not limited to: The Wildlands Conservancy, The Resources Agency California Legacy Project, California State Parks, California State Parks Foundation, United States Forest Service, National Park Service, Santa Monica Mountains Conservancy, Conservation Biology Institute, San Diego State University Field Station Programs, The Nature

Conservancy, Environment Now, and the Zoological Society of San Diego Center for Reproduction of Endangered Species. For more information on this ambitious regional effort, go to http://www.scwildlands.org/pages/sc_missinglinks.php.

Southern California Wetlands Recovery Project: The Southern California Wetlands Recovery Project is a partnership of public agencies working cooperatively to acquire, restore, and enhance coastal wetlands and watersheds between Point Conception and the International border with Mexico. Using a non-regulatory approach and an ecosystem perspective, the Wetlands Project works to identify wetland acquisition and restoration priorities, prepare plans for these priority sites, pool funds to undertake these projects, implement priority plans, and oversee post-project maintenance and monitoring. The goal of the Southern California Wetlands Recovery Project is to accelerate the pace, the extent, and the effectiveness of coastal wetland restoration in Southern California through developing and implementing a regional prioritization plan for the acquisition, restoration, and enhancement of Southern California's coastal wetlands and watersheds. The Wetlands Project is actively engaged in many activities in the Santa Clara Watershed. For more information on this exciting project, visit their website at http://www.coastalconservancy.ca.gov/scwrp.

The Nature Conservancy**:** TNC preserves the plants, animals and natural communities that represent the diversity of life on Earth by protecting the lands and waters they need to survive. The Nature Conservancy has undertaken significant conservation planning efforts in the Santa Clara watershed, including conserving properties along the main stem of the Santa Clara River. TNC is actively acquiring land and conservation easements in the river floodplain, having conserved over 1,000 acres thus far. TNC has also partnered with the National Oceanic and Atmospheric Administration's (NOAA) "Community-Based Restoration Program" to help promote southern steelhead recovery and sustainable fisheries. TNC is a partner in the South Coast Missing Linkage Project. For more information on their activities, go to http://www.tnc.org.

The Wildlands Conservancy: The Wildlands Conservancy is a non-profit, member-supported organization dedicated to land preservation, river preservation, trail development and environmental stewardship through education. Their Save the Saints Program brings together multiple land trusts and conservancies to identify key lands for acquisition within National Forest boundaries and lands contiguous with the Forests in the Santa Ana, San Gabriel, San Jacinto, and San Bernardino Mountains. TWC is a vital partner in the South Coast Missing Linkages project. For more information on TWC, please visit their website at http://www.wildlandsconservancy.org.

US Army Corps of Engineers**:** The mission of the ACOE is to provide quality, responsive engineering services for planning, designing, building and operating water resources and other civil works projects (Navigation, Flood Control, Environmental Protection, Disaster Response, etc.). The Corps is currently evaluating the removal of Matilija Dam. They also recently completed a Reconnaissance Study of the Santa Clara River Watershed to determine federal interest in completing a Feasibility Study for a Santa Clara River Watershed Protection Plan that would cover the entire watershed. This plan would involve an assessment of historic and current conditions and involve modeling of various future scenarios to evaluate watershed processes and riparian system integrity. The results would be used to better understand how land use affects water flow and quality. The goals of the project are to involve state, federal, and local stakeholders in establishing protection and management areas for activities regulated under the 404 permitting process. For more information, go to http://www.usace.army.mil.

US Fish and Wildlife Service: The U.S. Fish & Wildlife Service works to conserve, protect and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people. The agency can provide support for prosecuting violations to the Endangered Species Act, law enforcement, permits, and funding for research on threatened and endangered species. USFWS has developed recovery plans for several threatened or endangered species that occur or have the potential to occur in the Linkage Design area: California condor (*Gymnogyps californianus*) arroyo toad (*Bufo* microscaphus), California red-legged frog (*Rana aurora draytonii*), southwestern willow flycatcher (*Empidonax traillii extimus*), and least Bell's vireo (*Vireo belli pusillus*). The federal Endangered Species Act as amended (16 U.S.C. 1534) authorizes USFWS to acquire lands and waters for the conservation of fish, wildlife, or plants with the Land and Water Fund Act appropriations. The added protection provided by the Endangered Species Act may also be helpful for protecting habitat in the linkage from federal projects. For more information, visit their website at http://www.fws.gov.

US Fish and Wildlife Service Partners for Fish & Wildlife Program: This program supplies funds and technical assistance to landowners who want to restore and enhance wetlands, native grasslands, and other declining habitats, to benefit threatened and endangered species, migratory birds, and other wildlife. This program may be helpful in restoring habitat on private lands in the Linkage Design. For more information on this Program, please go to http://partners.fws.gov.

US Forest Service: The mission of the USDA Forest Service is to sustain the health, diversity, and productivity of the Nation's forests and grasslands to meet the needs of present and future generations. The four southern California Forests (Los Padres, Angeles, San Bernardino, and Cleveland) are in the process of jointly revising their Resource Management Plans. The biological importance and feasibility of connecting the four forests to the existing network of protected lands in the region is being evaluated in the Draft Environmental Impact Statement. The USFS is allocated Land and Water Conservation Funds annually, which are designed to protect recreational open space, watershed integrity, and wildlife habitat and may be a source of funds for protecting land in the planning area. The Forest Service is taking a proactive role in habitat connectivity planning in the region as a key partner in the South Coast Missing Linkages Project. For more information, go to http://www.fs.fed.us/r5/scfpr.

US Geological Survey, Biological Resources Division: The Biological Resource Division (BRD) works with others to provide the scientific understanding and technologies needed to support the sound management and conservation of our Nation's biological resources. BRD develops scientific and statistically reliable methods and protocols to assess the status and trends of the Nation's biological resources. BRD utilizes tools from the biological, physical, and social sciences to understand the causes of biological and ecological trends and to predict the ecological consequences of management practices. BRD enters into partnerships with scientific collaborators to produce high-quality scientific information and partnerships with the users of scientific information to ensure this information's relevance and application to real problems. BRD is engaged in several research projects in the region. For more information, go to http://www.biology.usgs.gov.

Ventura Coast Keepers/Wishtoyo Foundation: The Ventura Coastkeeper is affiliated with the National Waterkeeper Alliance, dedicated to protecting, preserving and restoring marine habitat, coastal waters, and watershed integrity. The Keeper organizations fill the gap between water pollution laws and the government's ability to enforce them. Wishtoyo is a Native American organization that utilizes traditional Chumash cultural values and practices to foster environmental awareness. For more information please visit them at http://www.wishtoyo.org.

Wildlife Conservation Board: The Wildlife Conservation Board administers capital outlay for wildlife conservation and related public recreation for the State of California. The Wildlife Conservation Board, while a part of the California Department of Fish and Game, is a separate and independent Board with authority and funding to carry out an acquisition and development program for wildlife conservation. Conceptual Area Protection Plans are internal DFG documents used to help determine acquisition priorities. For more information on WCB, go to http://www.dfg.ca.gov/wcb.

Zoological Society of San Diego: The Applied Conservation Division of the Society's Center for Reproduction of Endangered Species is working to conserve natural habitats and species in southern California, as well as other parts of the world. For example, the Applied Conservation Division supports conservation of southern California ecosystems through seed banking of endangered plant species, and ongoing studies of local birds, reptiles, and mammals and their habitats. The Applied Conservation Division of the Society is a key partner in the South Coast Missing Linkages effort. For more information on ZSSD, go to http://www.sandiegozoo.org.

A Scientifically Sound Plan for Conservation Action

In the South Coast Ecoregion, humans have become significant agents of biogeographic change, converting habitat to urban and agricultural uses and altering the movements of organisms, nutrients, and water through the ecosystem. The resulting fragmentation of natural landscapes threatens to impede the natural processes needed to support one of the world's greatest biological warehouses of species diversity.

This interaction among human development and unparalleled biodiversity is one of the great and potentially tragic experiments of our time. It creates a unique challenge for land managers and conservation planning efforts – to mitigate catastrophic changes to a once intact ecosystem. The conservation plan for the Sierra Madre-Castaic Connection addresses these challenges by seeking to influence regional patterns of development in a manner that best preserves landscape level processes in the Ecoregion.

The prioritization of this linkage for conservation and the demarcation of lands requiring protection in the linkage are based on the best available conservation techniques and expertise of biologists working in the region. This project provides a strong biological foundation and quantifiable, repeatable conservation design approach that can be used as the basis for successful conservation action.

Next Steps

This Linkage Design Plan acts as a scientifically sound starting point for conservation implementation and evaluation.

The plan can be used as a resource for regional land managers to understand their critical role in sustaining biodiversity and ecosystem processes, both locally and in the South Coast Ecoregion. Existing conservation investments in the linkage are already extensive including lands managed by the US Forest Service, California State Parks, Bureau of Land Management, California Department of Fish and Game, U.S. Fish and Wildlife Service, and other conservancy lands. Incorporating relevant aspects of this plan into individual land management plans provides an opportunity to jointly implement a regional conservation strategy.

Additional conservation action will also be needed to address road, stream, urban, and industrial barriers. Recommended tools include road renovation, construction of wildlife crossings, watershed planning, habitat restoration, conservation easements, zoning, acquisition, and others. These recommendations are not exhaustive, but are meant to serve as a starting point for persons interested in becoming involved in preserving and restoring linkage function. We urge the reader keep sight of the primary goal of conserving landscape linkages to promote movement between Core Areas over broad spatial and temporal scales, and to work within this framework to develop a wide variety of restoration options for maintaining linkage function. To this end, we provided a list of organizations, agencies and regional projects that provide collaborative opportunities for implementation.

Public education and outreach is vital to the success of this effort – both to change land use activities that threaten species existence and movement in the linkage and to generate an appreciation and support of the conservation effort. Public education can encourage residents at the urban-wildland interface to become active stewards of the land and to generate a sense of place and ownership for local habitats and processes. Such voluntary cooperation is essential to preserving linkage function. The biological information, figures and tables from this plan are ready materials for interpretive programs. We have also prepared a visual journey through the linkage (Appendix C on the enclosed CD). The flyover animation consists of color aerial photographs draped over a digital elevation map.

Successful conservation efforts are reiterative, incorporating and encouraging the collection of new biological information that can increase understanding of linkage function. We strongly support the development of a monitoring and research program that addresses movement (of individuals and genes) and resource needs of species in the Linkage Design area. The suite of predictions generated by the GIS analyses conducted in this planning effort provides a starting place for designing long-term monitoring programs.

The remaining wildlands of the South Coast Ecoregion form a patchwork of natural open space within one of the world's largest metropolitan areas. Without further action, our existing protected lands will become isolated in a matrix of urban and industrial development. Ultimately the fate of the plants and animals living on these lands will be determined by the size and distribution of protected lands and surrounding development and human activities. With this linkage conservation plan, the outcome of land use changes can be altered to assure the greatest protection for our natural areas at the least cost to our human endeavors. We envision a future interconnected system of natural space where our native biodiversity can thrive.

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South Coast Missing Linkages Workshop Minutes
September 30, 2002 at the Frazier Park Recreation Building

Rick Rayburn, California State Parks – *Welcome and Opening Remarks*

Biography: Mr. Rayburn has been Chief of the Natural Resources Division at California State Parks since 1986. In this capacity, his responsibilities over natural resource management for the State Park System have included classification of state park units, resource elements of park general plans, stewardship funding programs, policy formulation and natural resource acquisitions. Prior to this position, he spent eight years as the Regional Director for the North Coast (San Francisco to Oregon) California Coastal Commission. Primary responsibilities included land use planning and regulatory oversight for coastal conservation and development. Mr. Rayburn attended UCLA and Humboldt State University, majoring in management and forest ecology.

- Speaker participates in acquisition planning for State Parks, Wildlife Conservation Board, and California Department of Fish & Game; South Coast Missing Linkages Project is crucial to this (most important acquisition planning effort going on in the state)
- Many biological reports discuss habitat fragmentation and conversion, and the need to establish linkages to maintain biodiversity, but recommendations are lacking in how to overcome obstacles and actually plan for connectivity
- For major land managing agencies in California (including the military), land acquiring agencies, and nonprofit organizations, fragmentation is a difficult issue to address
- Most linkages involve lands connecting areas that have already been preserved due to on-site habitat values; there is less enthusiasm to protect connective habitats as they may seem less desirable based on habitat characteristics – but these areas are essential to preserve existing regional biodiversity, and should no longer “fall between the cracks”; it is time for land acquisition agencies to start addressing this issue
- Coal Canyon was recently preserved (and will soon be restored) to re-establish a connection between the Santa Ana Mountains and Puente Chino Hills
- Connections necessary to protect previous investments in preserved areas
- Acquisition planning is limited throughout the state; usually driven by opportunity purchases, lacking thorough assessment; this project will establish locations of important habitat linkages based on biological needs of focal species and practical design, not just according to cost and opportunity
- Next round of workshops will involve land planners and agents for conservation design
- California State Parks’ top acquisition program objective for natural resources is maintenance of landscape linkages, which will support quality of already protected lands; this timely effort will identify key areas for land purchases and conservation easements
- This project will also help agencies enforce laws to avoid subdivision and land conversion in priority connectivity areas to allow wildlife movement
- Thank you to David Myers of The Wildlands Conservancy (for supporting this project and protecting the Wind Wolves Preserve), Kristeen Penrod, and SCWP board members
- September 2002 Discover Magazine article highlighted and publicized this effort

Paul Beier, Northern Arizona University – *Regional Overview of Linkage Planning Area*

- Speaker presented virtual tour with photographs and maps of the three linkage planning areas; illustration and overview of major existing impediments to connectivity (SR-14, I-5, SR-58, SR-138, industrial and residential developments, and the California aqueduct)
- San Gabriel - Sierra Madre Mountains: this linkage is seriously threatened and needs swift action to maintain a connection; no continuous natural routes exist across SR-14 (100 to 300-foot filled slopes with no bridges); break is 4-7 miles wide between Angeles National Forest protected lands; two potential corridors for terrestrial wildlife discussed:
  - Route through Soledad, Bee, Spring (quiet underpass), Agua Dulce (busy underpass) and Tick Canyons; about ¼ mile wide at narrowest area; will be challenging for animals to move through corridor while avoiding developed areas
  - Ritter Ranch route crosses SR-14 at major highway interchange that will be difficult to span, with railroad tracks, access roads, parking areas, and trenches
- Eastern - Western Sierra Madre Mountains: crossing I-5 between Angeles and Los Padres National Forests is main concern; no bridged streams; filled slopes along I-5; only large vehicle underpass is on private property (Canton Canyon); second vehicle underpass is large box culvert (gravel dispenser); third possible option is bridge or over-pass at Cherry Canyon (lots of deer here); these routes connect to Piru Creek
- Sierra Madre - Tehachapi - Sierra Nevada Mountains: million-acre core habitat area
  - I-5, SR-138 and aqueduct are barriers in southern area; six small box culverts present; triangle of land at quiet, well-bridged highway interchange is undeveloped and prime candidate for connectivity between Angeles National Forest, Tehachapi foothills and Hungry Valley SVRA – also includes Gorman Creek riparian area; fenced aqueduct and overflow canal are serious barriers
  - SR-58 is movement barrier for terrestrial wildlife in central linkage area; 3 quiet vehicle underpasses present; 5-foot-high concrete divider down center of highway; heavy traffic; some bridges and one paved overpass exist near Tehachapi, where much natural habitat remains; BLM owns land located east of Tehachapi near three good underpasses (Cache Creek, Sand Creek Rd, railroad) and one overpass (Cameron Rd, where Pacific Crest National Scenic Trail crosses); potential corridor leads through windfarms

Ileene Anderson, California Native Plant Society – *Linkages from a Plant Perspective*

Summary: The workshop's geographic area is rich in diversity of plant species / associations due to the convergence of a variety of physiographic features. Thoughtful evaluation of species / associations' basic ecological requirements is required to retain ecological functioning that enables plant persistence over time. The diversity of plant associations numbers well into the hundreds (with some not currently identified) due to the unique geographic location of the workshop planning area. It also includes the San Andreas Rift Zone. The ecotonal nature of the area is another important component to consider when appraising linkages. Focus on indispensable mutualisms, dispersal mechanisms, great regional diversity of species, and rare plant issues should help to frame the vegetation theme, and provide context for the afternoon breakout sessions. Some considerations involved in assessing viable habitat corridors regarding plants are that abiotic and biotic pollen and propagule dispersal needs for plants are essential functions that linkages provide. Pollination of flowering plants in fragmented landscapes is significantly increased by corridors, and highly correlated to the size and number of those corridors (Townsend and Levey 2002). Different dispersal strategies are used by different plant species, and all must be considered when linkages are identified. Dispersal opportunity is a factor in determining species richness in successional stands of vegetation (Matlack 1994). Linkages must provide opportunities for plant movement across the landscape over the long-term. On the geologic timescale, plants move in elevation and latitude to exploit changes in climatic conditions – historically from glacial / interglacial periods, but contemporarily from human-caused changes (global warming). Rare plants are often associated with unique substrates. Linkages promote an increased chance of persistence in rare plants that utilize these naturally occurring fragmented habitats through propagule dispersal (Kirchner et al. 2002).

Biography: Ileene Anderson works as the southern California regional botanist for the non-profit California Native Plant Society. She received her Masters degree at California State University, Northridge for her work on the systematics of shrubby *Atriplex.* Prior to her focus on southern California, Ileene consulted on projects throughout the southwest. Her current interests include sensitive species distributions, impact evaluations to sensitive botanical resources, and restoration.

- There are many ways in which linkages favor long-term plant persistence
- Linkages are essential for pollination; wind and water transfer pollen between populations for some species, but wildlife movement is needed for pollination of many plants; linkages reduce effects of fragmentation; recent studies have shown benefits of corridors for plants, particularly through insect pollination
- Dispersal of seeds, other plant materials, and spores is also a linkage issue, accomplished by wind, water, erosion of unstable soils, and critters (including insects) that cache seeds, ingest them, and otherwise move them around
- Rare plant studies show that substrate-specific species live in naturally fragmented landscapes; linkages between such sites are important for seed dispersal and pollination
- Disturbance regimes (fire, flood): if vegetation is wiped out and propagules destroyed, linkages are essential to allow return of native plant material to site
- Geologic timescale: plants move around over time; connectivity is important for long-term persistence of vegetation communities; plants need linkages to move around as they have historically to disperse across the landscape in response to global changes; must consider elevational and latitudinal linkages
- Study area includes Transverse Ranges, Great Valley, Tehachapi Mountains, and Southern Sierra Nevada Mountains, and is a meeting area for multiple ecoregions / ecotones leading to great botanical diversity; plant species of Carrizo Plains were evolutionarily connected to western deserts (consider long-term geologic timescales)
- CNPS manual of California vegetation identifies plant communities at lower levels as series, alliances, or associations; overlapping habitats result in hundreds of such series in the linkage planning area (and many have not yet been identified due to limited access); some Pleistocene relicts include great basin sagebrush and blackbrush scrub, which need connectivity to remain viable into the future
- Photographs shown: great basin sagebrush, California juniper association (threatened by increasing human activity and fire occurrence), San Gabriel Mountains, desert scrub, Joshua tree woodland (not adapted to fire - causes type conversion to desert scrub)

- In the southern Sierra Nevada Mountains, hydrology and soils dictate naturally occurring fragments of mountain meadows in pinyon forest; alluvial processes provide opportunity for movement of plant propagules
- Botanically exciting area with localized populations of possible undescribed species (such as new onion found on pebble-based soils with no exotic weed competition); substrate-specific rare plants present
- Linkages encourage plant movement, but may also allow spread of exotic weeds; corridors with disturbed habitats may allow invasive plants to exploit resources
- Some plant communities require fire for persistence (such as chaparral); desert plants not adapted to fire, and may type convert to support invasive species
- In San Gabriel Mountains and Great Valley, nitrogen deposition from poor air quality may effect vegetation by supporting exotic species over native vegetation

Gordon Pratt, University of California, Riverside - *Connecting Arthropods in the Southern Sierra Nevada Area*

Summary: Terrestrial arthropods, 95% of which are insects, play a large and important role in the health of the environment. Practically everything depends on them: they do most of the pollination of flowering plants, most of the recycling of dead plants and animals, and are the major food resources for insectivorous fish, birds, lizards, and mammals. By encouraging insects into the corridors, birds, lizards, and mammals will also be more likely to use them. Dispersal is extremely variable throughout the different groups, with even different life history stages exhibiting different types of dispersal abilities. The dispersal capabilities of over half of the many nocturnal species are unclear at this time. The insects most affected by corridors between mountain ranges are those adapted to the lower elevations of the mountains being connected. Most endemic species that are restricted to higher elevations have small ranges and poor dispersal capabilities. Although lower elevation species often have wide ranges, isolation of populations would allow large area extirpations through events such as wildfires, droughts, etc. and in time multiple events could cause their extinction. These species with wide ranges may also depend on much larger gene pools than locally restricted endemic species. Some experts believe this sort of isolation between populations may have caused the endangered status of the Quino checkerspot in southern California. At least one rare butterfly, the San Emigdio Blue, is found to be interconnected only in this region (southwestern Inyo, San Luis Obispo, northwestern Los Angeles, Kern, Ventura, and possibly northeastern Santa Barbara Counties). This blue is not only restricted in distribution but, because of its uniqueness, has been placed in its own genus.

Biography: Pratt began his academic career with a bachelor's of science in biology at Northeastern University in Boston, Massachusetts. He finished a master's degree in Molecular Biology isolating and identifying mRNAs for specific proteins of the blowfly at Queen's University in Kingston, Ontario Canada. Pratt then did a Ph.D. on the evolution of the *Euphilotes enoptes* and the *E. battoides* complexes (small blue butterflies adapted to buckwheats) at the University of California at Riverside, California. Afterwards he did a post-doctorate on the sympatric evolution of treehoppers at the University of Delaware. Presently Pratt is a researcher at the University of California at Riverside working on endangered butterflies and the diversity of insects in various desert areas. He co-teaches a course on the ecology of butterflies of southern California through extension at

UCR. Pratt has authored and coauthored 36 papers on insects, most of which are on different aspects of butterfly evolution and biology.

- Development has created major dispersal problems in southern California for crawling and flying insects
- Illinois study showed that roads in the state were responsible for an estimated 20 million butterflies and moths killed per week; if roads create such a movement barrier for flying species, it must be very difficult for terrestrial invertebrates, such as tarantulas, to cross
- Arthropods exhibit a wide variety of dispersal capacities: crawling, flying, hopping; maybe 75% of insects are nocturnally active; seasonal differences in movement; differences between sexes (for example, only male velvet ants are winged)
- Butterflies may follow ridges and hilltops; life stage differences (Quino checkerspot butterfly larvae actually disperse a bit by grazing and searching for food plant)
- Insect world is the center of everything: estimated 10 arthropod species exist for every plant species; insects are food sources for wildlife (especially birds, frogs and lizards)
- Introduced non-native insect species include Argentine ants, which displace native ants to the detriment of horned lizards
- Insects recycle nutrients (feces, dead animals) and pollinate plants (proboscis length and shape for butterflies correspond to certain plant species for nectaring)
- Only 12 known populations exist of San Emigdio blue butterfly with type locality at Wind Wolves Preserve; larvae specific to *Atriplex canescens* (but also use *A. lentiformis* and *A. polycarpa*); ants protect larvae against predators and parasites, getting nutritive rewards from scales in exchange
- Insect dispersal issues seen with Quino checkerspot butterfly, which flies 2-4 feet above ground when dispersing, and prefers bright sunny areas devoid of vegetation; attracted to roads as open barren dispersal habitat; probably will not utilize underpasses
- Must identify all host plants for herbivorous feeding by focal species to plan for linkages; butterfly biology is related to blooming periods
- Possible focal species for this region: *Hesperia columbia* (rare butterfly that prefers hilltops to search for mates); California dogface (state butterfly that feeds exclusively on *Amorpha* spp.); Coronis fritillary (could be used to monitor dispersal); Lorquin's Admiral (larvae feed on willows; females oviposit on leaf tips that can be identified in field surveys); many additional regional butterflies mentioned with various host plants

Dave Morafka, California State University, Dominguez Hills – *Herpetofaunal Biodiversity in the Southeastern Sierra Nevada Mountains*

Summary: This brief overview will address the surprising diversity of herpetofauna in the southeastern Sierra Nevada Mountains, and the proximate 'sky island' ranges circumscribed by the Pleistocene Owens River drainage. These sky islands herpetofauna are sometimes distinguished by a "deep" rather than a "shallow" paleoecological history. Examples include the undescribed bolitoglossine salamanders of the genera *Hydromantes*, as well as the described taxon, *Batrachoseps campi*. Toads of the *Bufo boreas* complex include two regional endemics, *B. canorus, B. exsul,* and just peripherally, *B. nelsoni*. The distinctiveness of two snakes further supports this pattern: the blackhead snake, *Tantilla hobartsmith,* and the endemic putative "subspecies", the Panamint rattlesnake, *Crotalus mitchelli stephensi* - so do newly described members of the *Eumeces skiltonianus-gilberti* complex. The status of the endemic alligator lizard, *Elgaria panamintina* will also be

reviewed. Both historical contingency and favorable contemporary topography play a role in sustaining this remarkable herpetofauna, one which is far more regionally differentiated and richer in local endemics than its better known counterpart, the herpetofauna of the 'sky islands' of southeastern Arizona and southwestern New Mexico. The latter, while very rich in terms of alpha diversity, are the products of "shallow" history, and are almost entirely derived from a more robust assemblage of conspecific taxa in the adjacent Sierra Madre Occidental. A summary will be provided of historical and ecological factors, especially wetlands (in the broadest sense) which contribute to the differentiation and diversity of this herpetofauna. A first assessment will be offered of the current vulnerability of key / critical habitats. Recommendations will be submitted for identifying riparian habitats which might serve as corridors for particular amphibian and reptile taxa endemic to these ranges.

Biography: Dr. David Morafka is a Ph.D., Emeritus, Lyle E. Gibson Distinguished Professor of Biology at California State University, Dominguez Hills where, from 1972 to date, he has been teaching environmental biology, general zoology, paleontology, evolution, and herpetology. Dr. Morafka received his BS in Zoology with honors from the University of California at Berkeley in 1967, and completed the R.C. Stebbins supervised honor thesis on the microhabitats of the night lizard, *Xantusia vigilis* at Pinnacle, NM. David then earned his Ph.D. in Biology under Jay M. Savage (*A biogeographical analysis of the Chihuahuan Desert through its herpetofauna*). Research publications include one book, several chapters in symposium, and several dozen referred journal publications. Research interests include: neonatology of reptiles, especially the desert tortoise; desert biogeography, especially the differentiation and definition of North American deserts, the Chihuahuan Desert and 'sky islands of the northern Mojave - Great Basin interfaces in Inyo, Mono, and San Bernardino counties. Special focus is on the Panamint alligator lizard and Panamint rattlesnake, and the biogeography and systematics of fringe-toed lizards. David Morafka has earned external funding from the U.S. Army to study desert tortoise neonatology, along with efficacy of hatchery-nursery field stations at Ft. Irwin and Edwards Air Force Base. Scope of projects also includes: the conservation biology and auto-ecology of the Panamint alligator lizard, funded by the U.S. Army, USDA Forestry (Bishop), CDFG (Bishop) and USGS Species at Risk (SAR) program; Panamint rattlesnake ecology, genetics and systematics, funded by the U.S. Army; and the Mojave fringe-toed lizard conservation biology, ecology and genetics, funded by the U.S. Army and Anteon Corporation on behalf of the BLM.

- Ranges encapsulated by Pleistocene Owens River drainage constitute “the other sky islands” - apart from the well-known treasured montane relict and endemic communities in southeast Arizona and uplands of the arid southwest
- California sky islands located in northeastern part of linkage planning area; biogeographic context important for genetic and systematic views, and development of conservation argument; fossil and molecular evidence indicates salamanders may have been present since the Miocene; area of endemic herpetofauna
- Region contains montane communities, springs and wetlands, and riparian corridors; riparian woodlands across valleys are extremely important as potential corridors connecting montane areas for some species; core montane areas determined, but peripheries vary through time depending on available moisture (in wet years, ranges may be interconnected directly or by riparian corridors, while isolated during dry years)
- Panamint alligator lizard typically found at 4,000-7,000 feet, but can range down to 2,500 feet, occasionally following riparian corridors down mountainside; many montane desert species follow wetlands to lower elevations, with connectivity potential during wet years

- Vegetation structure in arid climates alternates over time depending on rainfall
- Concentration of endemic herpetofauna found in desert mountain ranges
- Panamint canyons contain perennial snow-fed streams and waterfalls, chain ferns and orchids, and diverse riparian vegetation, although very close to Death Valley; endemic rattlesnake, slender salamander and alligator lizard found in Panamint sky islands
- There may be more undescribed salamanders in this region of California than in tropical Guatemala; one salamander species lives in ice-melt under rock crevices and dies of heatstroke at temperatures over 60° F; many unique endemic herpetofauna must be described to properly manage habitats in southern and central Sierra Nevada Mountains
- California's Sierra ranges are a national hotspot of amphibian and reptile endemism; some species (such as western fence lizard) are ice age relics that occur in almost every range of the southwest U.S.; others are unique endemics not closely related to regional species, but morphologically similar to fossils from Mio-Pliocene and have existed on certain ranges for 5-10 million years or longer in relative isolation; Panamint alligator lizard is between these two extremes, with several partially differentiated populations
- Herpetofauna diversity based on:
  - Large size of ranges located in huge basins with available surface water
  - Old age of tectonic events forming these ranges (12-15 million years old)
  - Tremendous topographic relief and wide variety of habitats
  - Important wetlands between ranges with temporary connections during wet years
  - Insulation against change to some extent; "buffered bench" hypothesis says that ranges rise up like benches with steep ridge on one side and rolling plateaus on the other side; snow-melt from high peaks feeds lower plateau streams to sustain surface water year-round at buffered latitude and altitude, conditions which can sustain populations in relatively mesic habitats for millions of years rather than thousands of years; creates a treasure of relic herpetofauna in a "Miocene Park"

Rob Lovich, Camp Pendleton Marine Corps Base - *Hop, Crawl, or Slither? Contrasting Corridors for Herpetofauna*

Summary: The intersection of the Sierra Mountains, Coast, Transverse, and Peninsular Ranges is a dynamic contact zone for several biogeographic regions, and is home to a diverse array of amphibians and reptiles. Many of these species are uniquely adapted to particular habitats. In designing corridors to support natural movements for these species, consideration of different habitat requirements is essential. Ideally corridors should be designed to capture the full suite of environmental characteristics and allow for long-term maintenance of the rich biodiversity that characterizes the region. With respect to herpetofauna, natural barriers that preclude the movement of some species may represent corridors to other species. This presentation includes some examples of this, and contrasts some of the different habitat requirements of amphibian and reptile species found within the focal corridors. The importance of understanding differential habitat needs will provide information on how to address herpetofaunal habitat requirements in corridor design.

Biography: Robert is a herpetologist with academic degrees from the University of Hawaii at Manoa (B.S.), and Loma Linda University (M.S.). His research on the region's herpetofauna has focused primarily on their natural history and evolution. While his research is considered more of a hobby than a vocation, Robert has broad interests and is currently a wildlife biologist for Marine Corps Base Camp Pendleton in San Diego. When Robert is not working, he enjoys spending time with his wife and daughter, restoring his Pontiac GTO, and surfing.

- Multiple ecoregions (Northern Great Basin, Mojave, Sonoran, Peninsular, Transverse, Coast, Sierra, and Great Central Valley) converge within linkage planning area, resulting in high dynamic biodiversity for all taxa
- High levels of endemism important for herpetofauna specific to certain substrates and microhabitats, so use of corridors in an area of such varied habitat types may take place over evolutionary time; some endemism is result of natural habitat barriers
- Potential corridors include riparian and aquatic habitats, valleys, and mountain ridges
- Corridor design based on habitat requirements for focal species (vegetation community, range in elevation, etc.); at the statewide Missing Linkages planning workshop (2000), biologists identified spadefoot toad, arroyo toad, and western pond turtle as focal species, but these were all riparian species; species inhabiting other habitats and higher elevations were overlooked
- Red-legged frog inhabits coastal ranges and Caliente Creek in Tehachapi Mountains
- Extremely high level of endemism for slender salamander species found in planning area, but they are specific to microhabitats (thin riparian bands) and may not cross mountain ridges, valleys, deserts, etc.; ensantina complex found from Sierra Nevada through Tehachapi Mountains, but distributional gap occurs at San Gabriel Mountains
- Arroyo toad is a federally endangered coastal drainage species that occurs in riparian habitats, and moves linearly along streams through desert areas; streams and watersheds do not seem to match general linkage paths defined for focal species planning; planners can still attempt to conserve viable populations within corridors
- For linkage planning, try to encompass multiple microhabitats within corridors and populations of endemic or sensitive herpetofauna
- High-elevation mountain kingsnake and rubber boa are good species to represent use of corridors connecting montane habitats over ecological (not evolutionary) time frame; mountain kingsnake occurs on Alamo Mountain, Mount Pinos, and in Coastal, Transverse and Peninsular ranges, but not in Tehachapi Mountains; it is sometimes found at surprisingly low elevations and atypical habitats; genetic studies have shown distinctions between different mountain ranges, indicating little gene flow between populations historically
- Desert night lizard is abundant in Mojave Desert and may be good focal species
- Elevational profile of land acquisition may determine fate of some species
- Long-nosed leopard lizard found on desert slopes of San Gabriel Mountains and on Mojave Desert side of Tehachapi Mountains; federally endangered blunt-nosed leopard lizard found at lower slopes and canyon mouths of Tehachapi Mountains and Coast ranges; the two leopard lizards infrequently interbreed in the Tehachapi area
- “Ring species concept” is a result of numerous molecular studies, and outlines a “ring” linking San Francisco Bay, northern California, southern Cascades, Sierra Mountains, and Coast ranges, where montane herpetofauna have been interbreeding over evolutionary time; great opportunity for conservation exists based on this concept; this area is one of the most important biogeographic connections in the country

David Clendenen, The Wildlands Conservancy, Wind Wolves Preserve – *Birds Can Fly: An Overview of the Conservation Challenges in the Southern San Joaquin Valley*

Summary: On the face of it, birds … because they can fly, would seem to be less susceptible to the negative effects of habitat fragmentation than other more terrestrially bound vertebrates. In reality, as a group, birds display a high degree of variance with regard to their susceptibility to habitat fragmentation. Adaptable generalists such as the common raven are thriving in the southern San Joaquin Valley ecoregion. Specialists, such as the Yellow-billed cuckoo and the southwest willow flycatcher are endangered. Other species, such as the purple martin and Lewis' woodpecker embody issues that go beyond habitat fragmentation. The Wildlands Conservancy's Wind Wolves Preserve and Stubblefield Ranch property, together with the Los Padres National Forest, the Bitter Creek National Wildlife Refuge, and the Carrizo Plain National Monument, create a vast block of connected habitats. However, great challenges remain. The San Joaquin Valley has largely been converted to monoculture farming. Recently proposed and expected future development projects on Tejon Ranch represent a tremendous threat to habitat connectivity. Aggressive and creative conservation action, combined with delicate politics will be required to maintain and re-create functioning habitat connectivity in the San Joaquin ecoregion.

Biography: David Clendenen has been Preserve Manager at The Wildlands Conservancy's Wind Wolves Preserve for the past five years. He worked for 15 years on the California Condor Recovery Program, as a biologist for the U.S. Fish and Wildlife Service, also serving on the Condor Recovery Team until 2001. David participated in reintroduction efforts for bald eagles and peregrine falcons following receipt of a BS degree in Wildlife Biology from Cal Poly State University, San Luis Obispo in 1981.

- San Joaquin Valley is highly altered ecosystem; habitat fragmentation, degradation, and loss is most severe on valley floor; 270,000-acre Tejon Ranch is currently proposed for development of 23,000-house Centennial community, a 1,450-acre warehouse complex, and ranchettes at Tejon Lake, creating an immediate threat to regional habitat continuity
- American crows and various blackbirds utilize crops, but use of pesticides impacts avian populations; it seems that crow and blackbird populations have dramatically declined
- Historic population trends for most birds in this region have not been documented
- Rim of valley floor has potential for maintaining connectivity; foothills on eastern side are relatively intact through Tehachapi and Sierra Nevada Mountains
- The Wildlands Conservancy has conserved nearly 100,000 acres, including Wind Wolves Preserve, near the Stubblefield property, Los Padres National Forest, Bitter Creek National Wildlife Refuge, and Carrizo Plain National Monument, which together create a vast, contiguous block of connected habitats
- Region is ecologically unique at convergence of Transverse Ranges, Coast Ranges, Sierra Nevada Mountains, western Mojave Desert, and San Joaquin Valley; elevation range of over 8,000 feet; impressive mosaic of habitats and biodiversity
- Diverse avifauna found here with variance in reaction to fragmentation; for example, common raven is flourishing to point that it negatively impacts other native species
- American kestrels found even near agriculture; white-tail kite is nomadic predator; turkey vultures capitalize on road kill, livestock mortality, and garbage; golden eagles found in foothills, and require undisturbed habitat (hazards posed by highways and power lines)
- Tricolor blackbird population numbers less than 200,000 and is declining; nesting habitat in valley is mostly gone, and breeding attempts in agricultural fields often unsuccessful
- Captive breeding process and sub-optimal rearing and release methodologies have dramatically changed behavior of re-introduced California condors

- In general, sedentary habitat specialists are good focal species for linkage planning; participants should focus on habitat types to highlight species with special significance
- Grasslands, although altered by exotic annual grasses, should be preserved and managed to maintain biodiversity; they provide wintering habitat for long-billed curlew, mountain plover, and ferruginous hawk; possible focal species: ground nesting birds (horned larks, lark sparrows, and meadowlarks), savanna sparrow, burrowing owl
- Saltbush scrub focal species: sage sparrow, LeContes thrasher, and loggerhead shrike
- Riparian habitats need restoration (such as removal of salt cedar); possible focal species: willow flycatcher, least Bell's vireo, yellow warbler, and yellow-breasted chat
- Oak savanna requires conservation and management; must provide habitat for cavity nesters and excavators such as acorn woodpecker; also important are western bluebirds and purple martins; need to control European starlings and restore oak recruitment
- Montane areas are less threatened, except for fragmentation caused by logging in Sierra Nevada Mountains; an obvious potential focal species for this habitat is the spotted owl

James Bland, Santa Monica College - *Blue Grouse, Exit Stage Right*

Summary: Blue Grouse are birds of the Boreal Forest. The Transverse Ranges of Southern California are the southwestern limit of the species' continental range. In the early 1900s, the Mount Pinos subspecies of Blue Grouse ranged from the Kings River Canyon, south and west across isolated mountaintops of Kern County, to the Mount Pinos area of Ventura County. The subspecies has apparently been declining since the 1940s. It was last documented in the Mount Pinos area in the late 1970s. The surveys I conducted last spring indicate the species' range has receded to the main Sierra Nevada ranges, near the Tulare-Kern County line. Although field studies have not been conducted to confirm the causes of this decline, habitat degradation is the most likely culprit. Biologists are only beginning to understand the unique habitat requirements of Blue Grouse in the Sierra Nevada Region. Having studied Blue Grouse throughout California over the past ten years, I have been able to piece together a tentative explanation for the disappearance of Blue Grouse from Southern California, one in which timber harvest, fire suppression, catastrophic fire, development, and the loss of habitat connectivity have degraded the habitat features that are essential to Blue Grouse.

Biography: James Bland is an Assistant Professor of Biology at Santa Monica College. He has a Master's Degree in Wildlife Ecology and is working on a PhD in Geography. His primary research interests are in forest ecology and gallinaceous birds, in the Sierra Nevada and in the Himalaya Mountains.

- Blue grouse inhabit coniferous forests of western North America; Mount Pinos blue grouse subspecies occurs at southwest limit of species distribution; most of planning area considered marginal habitat; limited scientific knowledge; recognized as gamebird
- Population has been declining since the 1930s; 1928 record from Mount Pinos area estimated a maximum of 50 pairs; 1978 marks the last documented sighting; field surveys have shown that they no longer occur in Kern County; range contraction probably caused by habitat degradation related to the logging industry

- Blue grouse more abundant in old growth forests; hooting males found in massive firs; habitat requirements in central Sierra Nevada Mountains have 3 seasonal components:
    - Spring courtship: males vocalize (hoot) to attract females in mixed mature conifer forests from 6,000-9,000 feet; require open glades with patchy mosaic of woody shrubs and herbs, and massive firs; usually group of about five males return to specific site until canopy closes over, which rarely happens in California
    - After hatching, females move chicks to summer brood-rearing habitat, a moist montane meadow with lush herbaceous growth in walking vicinity of hooting site
    - Over-wintering site (this site may be same as hooting habitat)
- More grouse found in protected mature forests (with firs over one meter in diameter and well over 100 years old) than in cleared or selectively harvested areas
- Fire suppression allows open glades needed for hooting to fill in with shrubs and young firs; also, catastrophic fires can kill the massive firs and also reduce grouse habitat
- Reforestation after clear-cut or burn: blue grouse need mixed conifers, but many areas have been planted as pine plantations / monocultures lacking firs and canopy openings
- Grazing livestock degrade soil, change hydrology, cause erosion, and trample herbaceous layer in brood-rearing habitat; blue grouse also impacted by encroachment of meadows for residential development and campgrounds, and OHV disturbance
- Linkages may restore blue grouse to southern California; protected mixed conifer "stepping stones" needed from Sierra Nevada Mountains into Tehachapi area, which has been used for timber production; protect mountain meadows; restore natural fire regime

Wayne Spencer, Conservation Biology Institute - *Considering Small Mammals in Linkage Planning for the South Coast Ecoregion*

Summary: For good reasons, linkage planning between major mountain ranges tends to focus on large, wide-ranging mammals. Smaller mammals should not be ignored in these efforts, however, because they can play numerous important roles in maintaining or monitoring linkage functionality. For example, small mammals are essential prey for larger carnivores within landscape linkages, may represent ecological "keystone species," and may be useful indicators for monitoring effects of fragmentation. Small mammals could be classified by their irreplaceability and vulnerability for assessing linkage function, by their major habitat associations or ecological functions, or by their dispersal tendencies. Although a few small mammals may use inter-montane linkages to disperse from one mountain range to another, those species living completely within linkages at lower elevations may be even more important for assessing inter-montane linkages. Linkage planning should therefore consider "orthogonal linkages," or those that follow elevational bands or drainages crossed by inter-montane linkages. Other general guidelines concerning small mammals in linkage planning include: (1) provide live-in habitat for prey species; (2) provide for natural processes like fire and erosional-depositional forces that replenish habitats; (3) provide for the full range of ecological gradients across the linkage, such as the full range of geologically sorted substrates in alluvial fans; (4) provide for upslope ecological migration in response to climate change; and (5) consider the limited dispersal tendencies of small mammals relative to dispersal barriers, such as roads and canals, and avoid creating death traps for them when designing crossings for larger species. Linkage planning should also consider ways to provide niches for habitat specialists, such as creating bat roosts in bridges or overpasses designed to accommodate wildlife movement.

Biography: Dr. Spencer is a wildlife conservation biologist who specializes in applying sound ecological science to conservation planning efforts. He has conducted numerous field studies on sensitive wildlife species, with a primary focus on rare mammals of the western U.S. Dr. Spencer has studied martens, fishers, and other carnivores in forest and taiga ecosystems, as well as rare rodent species and communities in the southwestern U.S. In the South Coast Ecoregion he has served as principal investigator for research designed to help recover the critically endangered Pacific Pocket Mouse and has worked intensively on efforts to conserve endangered Stephens' Kangaroo Rats, among other species. Dr. Spencer is currently serving as Editor in Chief for a book on the mammals of San Diego County. He also serves as a scientific advisor on a variety of large-scale conservation planning efforts in California, including the San Diego MSCP and MHCP, and the eastern Merced County NCCP/HCP. He is increasingly being asked by state and federal wildlife agencies to help facilitate scientific input in conservation planning efforts, and to help train others in science-based conservation planning.

- Large wide-ranging obligate carnivores (megafauna) are key for linkage planning, as they must move between large habitat areas to survive and reproduce
- Linkages should provide habitat for smaller and more dispersal-limited habitat specialists that are critical prey for carnivores; species will use corridors over "evolutionary time"
- Some small mammals have disproportionate effects on regional ecology and are considered keystone species: burrowing rodents (pocket gophers and kangaroo rats) modify soil, impact plant distribution, and create habitat for other species
- Habitat specialists: pocket mouse subspecies are adapted to specific vegetation types and geological substrates; high degree of genetic differentiation for small mammals due to geographic isolation (micro-habitats, topographic relief, distance, vegetation, etc.)
- Conservation planning recognizes irreplaceability and vulnerability by incorporating and connecting habitat for rare endemic species with limited geographic ranges
- For most small mammals, individuals will not move through inter-montane linkages and across elevation gradients from one range to another, but rather will benefit from long-term genetic exchange and adaptation, and from living within preserved linkages
- Orthogonal linkage concept: for small mammals distributed in elevational bands in particular plant communities or soil strata, breadth of linkage is important; habitat may be located at right angle to linkage direction; connect both across and along linkages
- Important opportunity for low elevation, gently sloping valley floor connectivity through Wind Wolves Preserve and Tejon Ranch (for kit fox, kangaroo rat, pocket mouse, pocket gopher); ecological up-slope migration may be needed for future climate change
- Aqueduct is major barrier for terrestrial species movement; safe crossings needed
- Possible focal species should help secure connectivity for various parts of broad landscape linkages, representing multiple habitats and mountain ranges:
    - Low elevation: Tehachapi, San Joaquin, and yellow-eared pocket mice (scrub and Joshua tree habitat); badger (grassland specialist, small carnivore, effected by roads, edges, and fragmentation); kit fox (found on Tejon Ranch)
    - Mid-elevation: Pacific kangaroo rat (scrub and chaparral, natural fire regimes)
    - Upper elevation: grey squirrel and chipmunk
    - Additional: dusky-footed woodrat (dispersal limited in scrub and chaparral habitats); Tulare grasshopper mouse (carnivorous, wide-ranging, rare); pocket gopher (manipulates vernal pool soils; often poisoned near agricultural lands)
- Plans for bat roosting habitat can be incorporated into bridge and overpass structures

- Linkages should provide live-in habitat for small mammal prey base, except where goal is simply to move wildlife across and away from roads; consider location of rare and endemic species to compliment linkage design (protect key habitats within linkage area)
- With climate change, expect upslope migration; linkages should be broad enough to accommodate natural processes (flood scour and deposition, fire, etc.); capture complete environmental gradients to protect multiple specialized species

Paul Beier, Northern Arizona University – *Cougars, Corridors, and Conservation*

Summary: Because the puma or cougar lives at low density and requires large habitat areas, it is an appropriate umbrella species for landscape connectivity in the South Coast Ecoregion. A crucial issue, however, is whether connectivity is provided by narrow corridors through urban areas (an artificial substitute for natural landscape connectivity). In particular, corridors decrease extinction risk only if they facilitate dispersal of juveniles between mountain ranges. To address this issue, we conducted field work on pumas in the Santa Ana Mountain Range, a landscape containing 3 corridors (1.5, 6, and 8 km long). Each of the 3 corridors was used by 2 or more dispersing juvenile puma. Five of 9 radio-tagged dispersers successfully found and used a corridor. The corridors in this landscape were relict strips of habitat, not designed to facilitate animal movement. Puma doubtless would be even more likely to use well-designed linkages. Puma will use corridors that lie along natural travel routes, have < 1 dwelling unit per 50 acres, have ample woody cover, lack artificial outdoor lighting, and include an overpass or underpass integrated with roadside fencing at high-speed road crossings. “If we build it, they will come.”

Biography: Paul Beier is Professor of Conservation Biology and Wildlife Ecology at Northern Arizona University. He has worked on how landscape pattern affects puma, northern goshawk, Mexican spotted owls, white-tailed deer, and passerine birds (the latter in both West Africa and northern Arizona). He serves on the Board of Governors for the Society for Conservation Biology. A full description of his activities is available at: *www.for.nau.edu/~pb1*.

- Pumas exist at low density; functional connectivity needed for movement and dispersal
- Santa Ana Mountains study: 9 radio-collared juvenile dispersers were tracked; three corridors / habitat constrictions present, but not designed for habitat connectivity:
    1. Coal Canyon (short freeway undercrossing near railroad tracks, stables, and golf course); 3 lions attempted to cross (2 successful); M6 was premier user of corridor, crossing under freeway more than 22 times in 18 months - home range included habitat on both sides of freeway; after completion of study, surrounding properties were preserved, and CalTrans agreed to close underpass to traffic, remove asphalt, and turn over to California State Parks for restoration and use as wildlife linkage
    2. Santa Ana – Palomar (longer, I-15 is major impediment, patchwork of land ownership); 2 lions attempted to cross (1 successful); one lion crossed Santa Ana – Palomar linkage by walking across I-15 rather than finding a safer route underneath; point of crossing was just north of border patrol / INS checkpoint; four un-tagged lions were killed crossing at this site – multiple lions are demonstrating preferred crossing site, which should be focus of planning for vegetated freeway overpass

3. Arroyo Trabuco (protected from urban areas by tall bluffs, contains dense riparian vegetation, resident deer population, darkness, water); 3 lions attempted to cross (3 successful); lions spent 2-7 days traveling through this "comfortable" corridor

- Mountain lions do use narrow corridors and artificial linkages; 5 of 9 study animals found and successfully used at least one of the three corridors; these "accidental corridors" were not designed for animal movement, which explains some unsuccessful attempts

Claudia Luke, San Diego State University, Field Stations Program – *Considerations for Connectivity & Overview of Working Group Session*

Summary: This presentation describes the Santa Ana – Palomar Mountains linkage to allow workshop participants to understand purposes of focal species groups, identification of critical biological issues regarding connectivity, and qualities of species that may be particularly vulnerable to losses in connectivity.

Biography: Claudia Luke received her Ph.D. in Zoology from University of California, Berkeley in 1989. She is a Reserve Director of the Santa Margarita Ecological Reserve, an SDSU Field Station, and Adjunct Professor at San Diego State University. She is on the Board of Directors for the South Coast Wildlands Project and has been the lead over the last two years in conservation planning for the Santa Ana – Palomar Mountain linkage.

- At the statewide November 2000 Missing Linkages conference, participants determined which areas within California needed to be connected to allow species movement
- South Coast Ecoregion workgroup selected criteria to prioritize linkages and connect largest protected lands; planning efforts have progressed for the Santa Ana – Palomar Mountains linkage area, and workshops have been held to select focal species
- Global linkage role: preservation of biodiversity hotspot with concentration of endemic species (due to elevational gradients, soil diversity, convergence of ecoregions, etc.)
- Regional linkage role: maintenance of habitat connectivity to prevent extirpations, and considerations for climate change (warmer wetter winters and drier summers may cause extreme floods and wildfires; drier vegetation types may expand to higher elevations)
- Local linkage role: connect protected habitats, considering dispersal methods of focal species; consider impacts to habitat specialists, endemics, edge effects, and gene flow
- Focal species approach to functional linkage planning based on Beier and Loe 1992 corridor design (choose site and focal species, evaluate movement needs, design corridor, monitor); focal species are units of movement used to evaluate effectiveness of linkages; wide diversity of species necessary to maintain ecological fabric; collaborative planning effort based on biological foundation, and conservation design and delivery
- Choose species sensitive to fragmentation and disturbance to represent linkage areas; consider movement patterns, dispersal distances, barriers, impacts of non-native invasive species, commensal relationships (*Yucca whipplei* and its specific pollinator), and natural barriers for habitat specialists (elevational ranges, vegetation types, etc.)
- Each taxonomic working group will choose focal species, delineate movement needs, and record information on natural history, distribution, habitat suitability, current land conditions, and key areas for preservation and restoration; consider metapopulation dynamics so that if a species disappears due to disturbance, habitat can be re-colonized
- Taxonomically diverse focal species data will be displayed on conservation design map and used to guide planning efforts; information will be compiled into connectivity plan for

linkages of South Coast Ecoregion; regional biology-based approach to linkages will help project to gain visibility and leverage to work with multiple agencies and organizations

Appendix C: 3D Visualization

The South Coast Wildlands is in the process of producing several fly-overs or 3D visualizations of the Sierra Madre – Castaic Connection and other linkages throughout the South Coast Ecoregion as part of the South Coast Missing Linkages Project.

The fly over provided on this CD is an .mpg file (media file) which can be viewed using most popular/default movie viewing applications on your computer (e.g. Windows Media Player, Quick Time, Real One Player, etc).

The 3D Visualization provides a virtual landscape perspective of the local geography and land use in the planning area. 2002 USGS LANDSAT Thematic Mapper data was used to build a natural color composite image of this study area.

INSTRUCTIONS ON VIEWING FLY OVER

Simply download the .avi file “3D_Visualization.mpg” from the CD onto your computer’s hardrive. Putting the file on your computer before viewing, rather than playing it directly from the CD, will provide you with a better viewing experience since it is a large file.

Double click on the file and your default movie viewing software will automatically play the fly-over.

If you cannot view the file, your computer may not have any movie viewing software installed. You can easily visit a number of vendors (e.g. Real One Player, Window Media Player, etc.) that provide quick and easy downloads from their websites.

Please direct any comments or problems to:

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