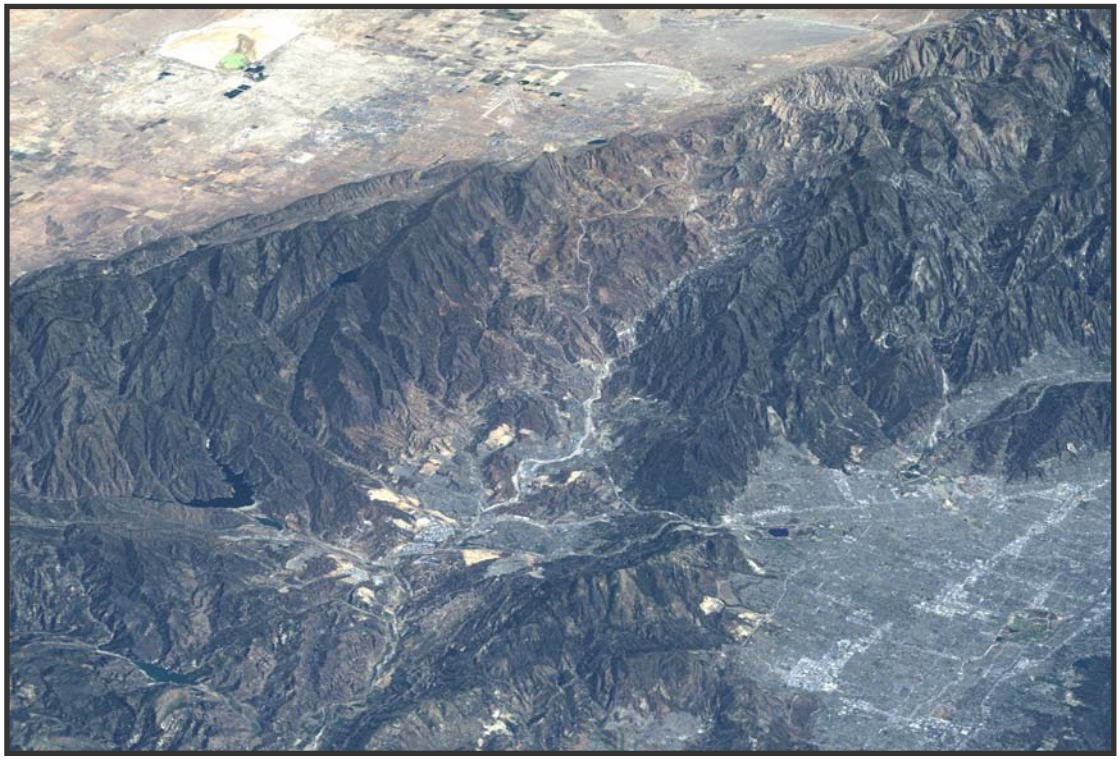
South Coast Missing Linkages Project

A Linkage Design for the San Gabriel-Castaic Connection



South Coast Wildlands

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SOUTH COAST WILDLANDS

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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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Table of Contents

List of Tables & Figures VI

Acknowledgements VIII

Executive Summary XI

Introduction

Nature Needs Room to Move 1
Patterns of Habitat Conversion 1
A Statewide Vision 2
South Coast Missing Linkages: A Vision for the Ecoregion 2
Ecological Significance of the San Gabriel-Castaic Linkage 4
Existing Conservation Investments 5
Threats to Connectivity 6

Conservation Planning Approach

Preface 8
Focal Species Selection 9
Landscape Permeability Analysis 9
Patch Size & Configuration Analysis 13
Minimum Linkage Width 15
Field Investigations 15
Identify Conservation Opportunities 15

Landscape Permeability Analyses

Landscape Permeability Analyses Summary 16
Mountain Lion 17
American Badger 18
Mule Deer 19
Pacific Kangaroo Rat 20
California Spotted Owl 21

Patch Size & Configuration Analyses

Patch Size & Configuration Analyses Summary 22
Mountain Lion 24
American Badger 27
Mule Deer 30
Pacific Kangaroo Rat 33
California Spotted Owl 36
Burrowing Owl 38
California Thrasher 40

Acorn Woodpecker 42
Western Pond Turtle 44
Two-striped Garter Snake 47
California Mountain Kingsnake 50
Monterey Salamander 52
Bear Sphinx Moth 54
California Juniper 56
Scalebroom 58

Linkage Design

Goals of the Linkage Design 60
Description of the Linkage 62
Removing and Mitigating Barriers to Movement 64
Roads as Barriers to Upland Movement 65
Roads in the Linkage Design 65
Types of Mitigation for Roads 66
Recommended Locations for Crossing Structures on State Route 14 68
Recommended Locations for Crossing Structures on Sierra Highway 70
Other Recommendations Regarding Paved Roads Within the Linkage Area 70
Roads as Ephemeral Barriers 71
Rail Line Barriers to Movement 72
Existing and Proposed Rail Lines in the Linkage Design 72
Recommendations to Mitigate the Effects of Rail Lines in the Linkage Design Area 73
Impediments to Streams 74
Impediments to Streams in the Linkage Design Area 74
Examples of Mitigation for Stream Barriers 76
Recommendations to Mitigate the Effects of Stream Barriers in the Linkage Design Area 76
Other Land Uses that Impede Utility of the Linkage 78
Mining Operations 78
Mining in the Linkage Design Area 78
Examples of Mitigation for Mining Operations 79
Recommendations to Mitigate the Effects of Mining in the Linkage Design Area 80
Urban Barriers to Movement 80
Urban Barriers in the Linkage Design Area 81
Examples of Mitigation for Urban Barriers 81
Recommendations for Mitigating the Effects of Urbanization in the Linkage Design Area 81
Recreation 82
Recreation in the Linkage Design Area 83
Examples of Mitigation for Recreation 83
Recommendations for Mitigating the Effects of Recreation in the Linkage Design Area 83
Land Protection & Stewardship Opportunities 83

Summary 93

Literature Cited 95

Appendices (Enclosed CD)

A. Workshop Participants
B. Workshop Summary
C. 3D Visualization of the San Gabriel-Castaic Connection

List of Tables

Table 1. Focal Species Selected
Table 2. Focal Species Movement Criteria
Table 3. Vegetation and Land Cover in the Linkage
Table 4. Major Transportation Routes in the Linkage Design

List of Figures

Figure 1. South Coast Ecoregion
Figure 2. South Coast Missing Linkages
Figure 3. Aggregated Vegetation Types in the Linkage Planning Area
Figure 4. Existing Conservation Investments in the Linkage Planning Area
Figure 5. Interdisciplinary Approach
Figure 6. Permeability Model Inputs: Topography, vegetation, road density, and elevation
Figure 7. Patch Size & Configuration Model Inputs
Figure 8. Least Cost Union
Figure 9. Least Cost Union Displaying Species Overlap
Figure 10. Least Cost Corridor for Mountain Lion
Figure 11. Least Cost Corridor for American Badger
Figure 12. Least Cost Corridor for Mule Deer
Figure 13. Least Cost Corridor for Pacific Kangaroo Rat
Figure 14. Least Cost Corridor for California Spotted Owl
Figure 15. Least Cost Union Additions & Subtractions
Figure 16. Habitat Suitability for Mountain Lion
Figure 17. Potential Cores & Patches for Mountain Lion
Figure 18. Habitat Suitability for American Badger
Figure 19. Potential Cores & Patches for American Badger
Figure 20. Habitat Suitability for Mule Deer
Figure 21. Potential Cores & Patches for Mule Deer
Figure 22. Habitat Suitability for Pacific Kangaroo Rat
Figure 23. Potential Cores & Patches for Pacific Kangaroo Rat
Figure 24. Potential Cores & Patches for California Spotted Owl
Figure 25. Potential Cores & Patches for Burrowing Owl
Figure 26. Habitat Suitability for Burrowing Owl
Figure 27. Potential Cores & Patches for California Thrasher
Figure 28. Habitat Suitability for California Thrasher
Figure 29. Potential Cores & Patches for Acorn Woodpecker
Figure 30. Habitat Suitability for Acorn Woodpecker
Figure 31. Patch Cores for Western Pond Turtle
Figure 32. Patch Cores for Two-striped Garter Snake
Figure 33. Habitat Suitability for Two-striped Garter Snake
Figure 34. Habitat Suitability for California Mountain Kingsnake
Figure 35. Potential Cores for California Mountain Kingsnake
Figure 36. Potential Cores for Monterey Salamander
Figure 37. Patch Configuration for Monterey Salamander
Figure 38. Potential Cores for Bear Sphinx Moth
Figure 39. Habitat Suitability for California Juniper
Figure 40. Habitat Suitability for Scalebroom
Figure 41. Linkage Design for the San Gabriel-Castaic Connection

Figure 42. The Western Branch of the Linkage Design
Figure 43. The Eastern Branch of the Linkage Design
Figure 44. Existing & Proposed Infrastructure in the Planning Area
Figure 45. An example of a vegetated land bridge built to enhance movement of wildlife populations.
Figure 46. A viaduct in Slovenia built to accommodate wildlife, hydrology, and human connectivity.
Figure 47. Arched culvert on German highway, with rail for amphibians and fence for larger animals.
Figure 48. Pipe culvert designed to accommodate small mammals.
Figure 49. Amphibian tunnels allow light and moisture into the structure.
Figure 50. The existing Spring Canyon road underpass is not accessible to an animal in the Santa Clara River.
Figure 51. Removing the fill slope under SR-14 would route Spring Canyon to Bee Canyon and the Santa Clara River.
Figure 52. Agua Dulce Canyon vehicle underpass, with drainage culvert for stream visible to the left of the underpass.
Figure 53. Metrolink running through Soledad Canyon, passing through the Santa Clara River.
Figure 54. Expanded bridge over Santa Clara River with the railroad in the foreground.
Figure 55. Abandoned mine tailings in center of photo still visible in Tick Canyon.
Figure 56. Active aggregate mine in the Linkage Design, at the confluence of Bee and Spring Canyons and the Santa Clara River near SR-14.

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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 San Gabriel-Castaic Connection is perhaps our most threatened linkage, and the last chance for a coastal connection between these ranges.

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 San Gabriel-Castaic Linkage. They identified 15 focal species that are sensitive to habitat loss and fragmentation here, including 2 plants, 1 insect, 1 amphibian, 3 reptiles, 4 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 that are restricted to the linkage planning area (e.g., burrowing owl). 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 15 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.

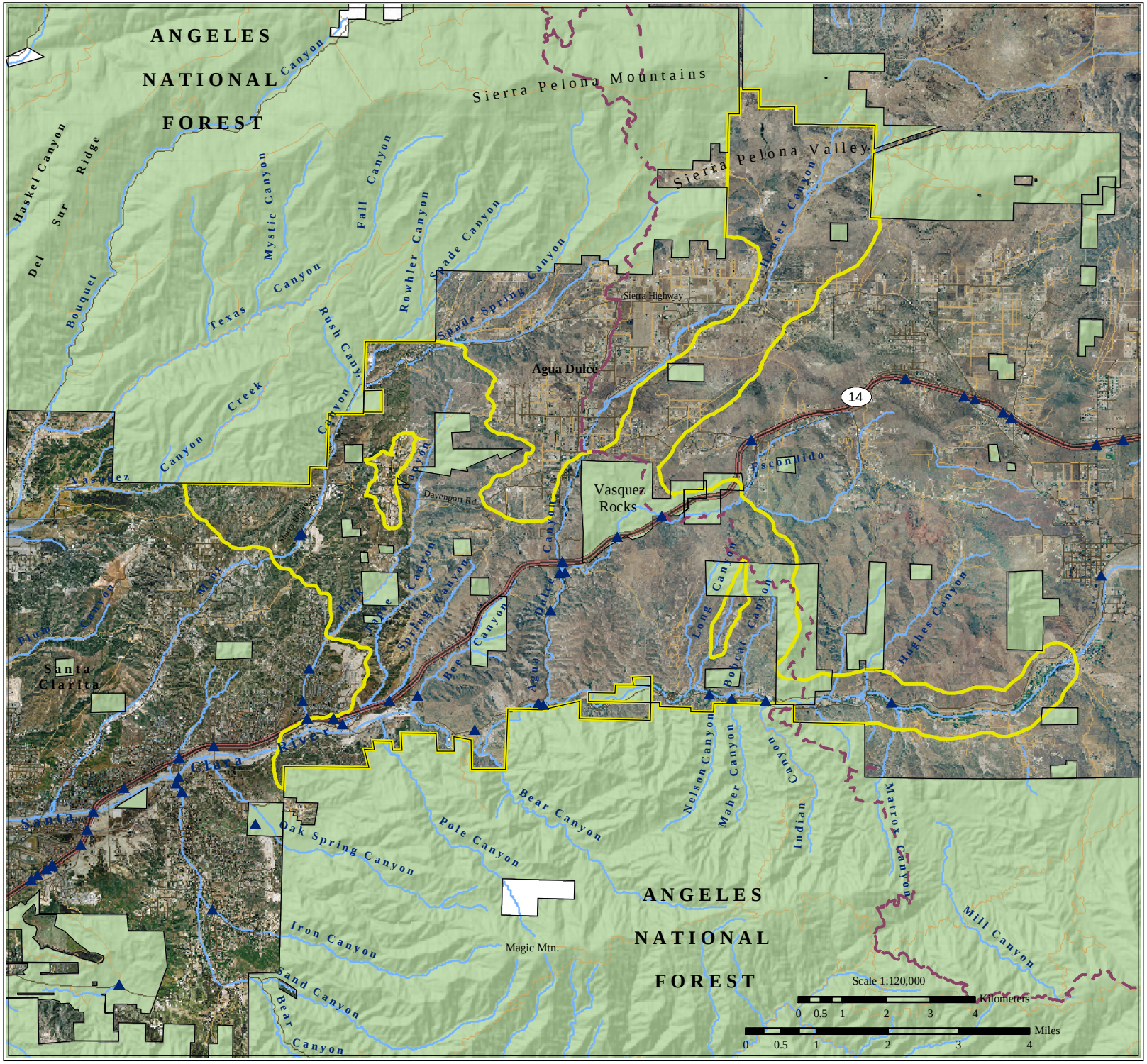
To identify potential routes between existing protected areas we conducted landscape permeability analyses for 5 focal species for which appropriate data were available. Permeability analyses model the relative cost for a species to move between protected core habitat or population areas. We defined 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 15 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

Executive Summary - 1.
Linkage Design

Legend

- Linkage Design
- Potential Crossings Structures
- Pacific Crest Trail
- Highway
- Paved Roads
- Dirt Roads
- Hydrography
- Ownership Boundaries



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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 State Route 14.

The ecological, educational, recreational, and spiritual values of protected wildlands in the South Coast Ecoregion are immense. Our Linkage Design for the San Gabriel-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 San Gabriel 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 Move

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, natural patterns and mechanisms of pollination and seed-dispersal, natural competitive or mutualistic relationships among species, resistance to invasion by alien species, and prehistoric patterns of 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 long been recognized as important for sustaining natural ecological processes and biological diversity (Noss 1987, Harris and Gallagher 1989, Noss 1991, Beier and Noss 1998, Beier and Loe 1992, Noss 1992, Beier 1993, Forman 1995, Hunter 1999, Crooks and Soulé 1999, Soulé and Terborgh 1999, Penrod et al. 2001, Crooks 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 (Figure 1) of California 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 being confronted with a man-made labyrinth of barriers, as roads, homes, businesses,

and agricultural fields 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, Center for Reproduction of Endangered Species, San Diego Zoo, The Nature Conservancy, and U.S. Geological Survey) launched a statewide interagency workshop—Missing Linkages: Restoring Connectivity to the California Landscape—at the San Diego Zoo. 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. 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 ecoregion; 5) facilitation of seasonal movement and climatic change; and 6) addition of value for aquatic ecosystems. Vulnerability was evaluated using recent high-resolution aerial photographs, local planning documents, and other data. This process identified 15 linkages of crucial biological value that are likely to be irretrievably compromised by

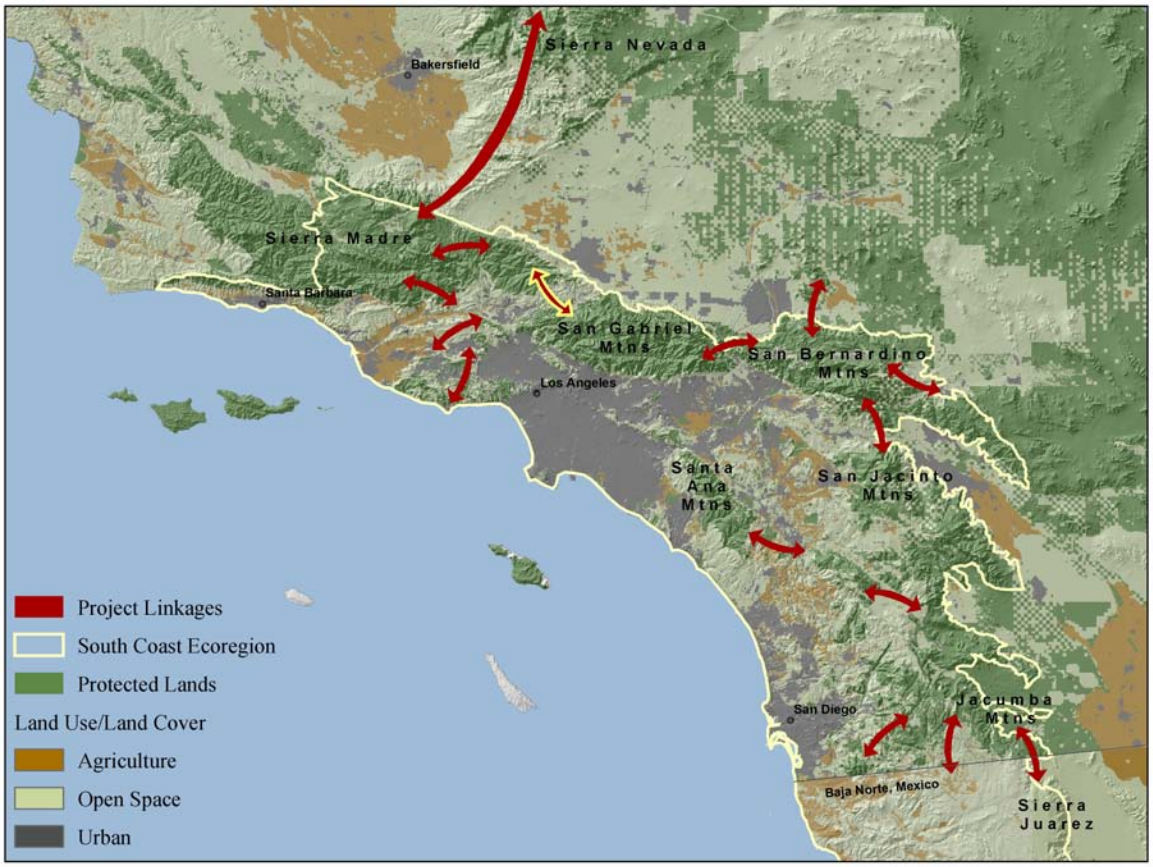

Figure 2. The South Coast Missing Linkages Project addresses habitat fragmentation at a landscape scale, and the needs of a variety of species. The San Gabriel-Castaic Linkage is one of 15 landscape linkages identified as irreplaceable and imminently threatened.

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, Conservation Biology Institute, San Diego State University Field Stations Program, The Nature Conservancy, Environment Now, The Wildlands Project, and the Zoological Society of San Diego Center for Reproduction of 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 effort will serve as a catalyst for directing funds and attention toward the protection of ecological connectivity for the South Coast Ecoregion and beyond.

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 connectivity needs in the ecoregion. South Coast Wildlands has taken the lead in researching and planning for 7 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 8 linkages. The San Gabriel-Castaic Linkage 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.

The 15 Priority Linkages

Santa Monica Mountains-Santa Susana Mountains
Santa Susana Mountains-Sierra Madre Mountains
E. Sierra Madre Mountains-W. Sierra Madre Mountains
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
Otay Mountains-Laguna Mountains
Campo Valley-Laguna Mountains
Otay Mountains-Northern Baja
Peninsular Ranges-Anza Borrego
Jacumba Mountains-Sierra Juarez Mountains

Ecological Significance of the San Gabriel-Castaic Linkage

The planning area encompasses a unique ecological transition zone between coastal and desert habitats (Figure 3). Coastal sage scrub and chaparral blankets the hillsides in the western part of the planning area, with dense coast live oak woodlands in canyons, and high quality riparian scrub and woodlands at lower elevations. The easternmost part of the linkage has a strong desert influence; dominated by desert scrub, with scattered juniper and Joshua tree woodlands. A number of sensitive natural communities occur in the planning area including alluvial fan sage scrub, southern cottonwood willow riparian forest, southern riparian scrub, southern sycamore alder riparian, freshwater marsh, coast live oak riparian forest, vernal pool, mainland holly-leaved cherry woodland, valley needlegrass grassland, and coastal sage scrub. These habitats are among the rarest and most sensitive ecosystem types in the United States.

The Santa Clara River is a prominent feature of the linkage, draining 3108 km^2 (1200 mi^2) of the San Gabriel, Castaic, Santa Susana, and Sierra Madre mountains and cutting transversely through the linkage to a large estuary at the coast. As one of the last free flowing natural riparian systems left in southern California, the Santa Clara River supports a diversity of aquatic, semi-aquatic, and terrestrial organisms. The upper watershed and headwater streams in the planning area are largely intact, providing breeding sites, traveling routes, and other resources for wildlife; natural flood control; recharge of groundwater basins; nutrient cycling; and helping to sustain the river and estuary downstream (Meyers et al. 2003). Maintaining and restoring watershed integrity

Figure 3.
Aggergated Vegetation in the Planning Area

Legend

- Agriculture
- Chaparral
- Coastal scrub
- Coniferous Forest
- Desert scrub/shrub
- Grassland
- Joshua tree
- Oak woodland
- Pinyon-Juniper
- Riparian
- Sagebrush
- Urban/Developed
- Water
- Paved Roads
- Hydrography
- Lakes & Reservoirs
- Aqueduct
- Ownership Boundaries
- County Boundaires

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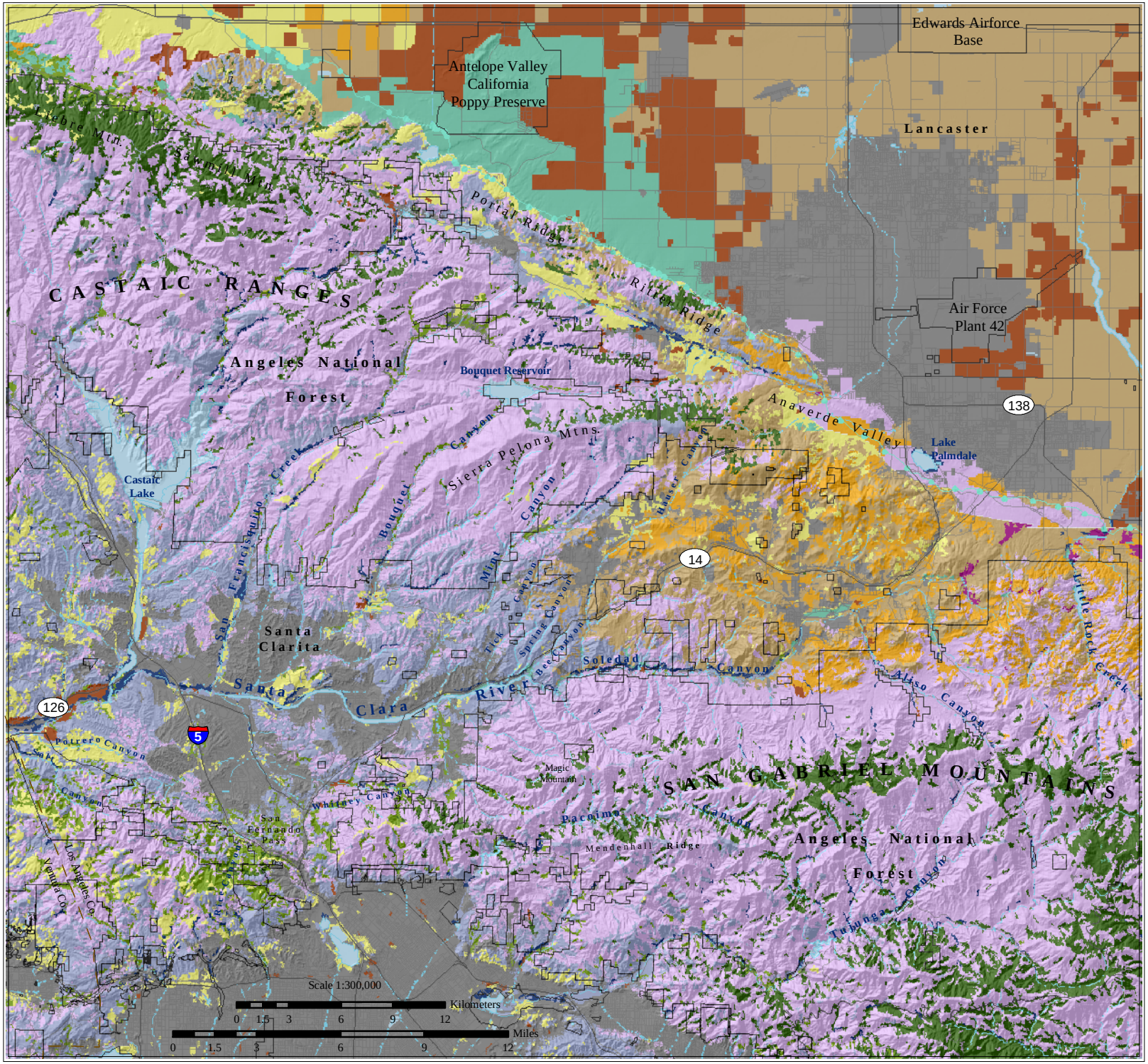


and habitat connectivity in aquatic and terrestrial systems is essential to sustaining the flow of organisms and processes across the landscape.

Many species that depend on low-elevation habitats are now federally and or state-listed as endangered, threatened, or sensitive, many of which have been recorded or have the potential to occur within the vicinity of the planning area (CDFG 2003). All remaining naturally occurring populations of the endangered Unarmored threespine stickleback (*Gasterosteus aculeatus williamsoni*) are in the upper Santa Clara River watershed, in San Francisquito Canyon, Soledad Canyon and Escondido Canyon (Warburton and Fisher 2002). Two other native fish are also present in the planning area; Soledad Canyon is the primary refugia for the federally threatened Santa Ana sucker (*Catostomus santaanae*) and the arroyo chub (*Gila orcutti*) also occurs here. Several listed or sensitive migratory songbirds have the potential to occur, including the endangered southwestern willow flycatcher (*Empidonax traillii extimus*) and least Bell's vireo (*Vireo bellii pusillus*), as well as summer tanager (*Piranga rubra*). The planning area is also home to several listed and sensitive amphibians and reptiles, including the endangered California Red-legged frog (*Rana aurora draytonii*) and arroyo toad (*Bufo microscaphus californicus*), as well as Western spadefoot toad (*Scaphiopus hammondii*), southwestern pond turtle (*Clemmys marmorata*), and San Diego horned lizard (*Phrynosoma coronatum blainvillei*). Species dependent on alluvial fan habitats, such as the federally and state endangered slender-horned spineflower (*Dodecahema leptoceras*) also occur in the planning area. Species restricted to vernal pool habitats, such as the federally endangered Riverside fairy shrimp (*Streptocephalus woottoni*), federally and state endangered California Orcutt grass (*Orcuttia californica*), and federally threatened prostrate navarretia (*Navarretia prostrata*), are also known to occur in the planning area. Species reliant on upland habitats, such as the slender Mariposa lily (*Calochortus clavatus* var *gracilis*), and the federally threatened California gnatcatcher (*Polioptila californica*), also depend on habitat in the linkage. Many recovery plans cite the importance of maintaining habitat in the planning area (USFWS 1993, 1998a, 1998b, 1999, and 2000). In addition to conserving habitat for over a dozen federally or state threatened and endangered species, the linkage provides live-in and move-through habitat for numerous native species that need extensive wildlands to thrive, such as American badger, mule deer, and mountain lion.

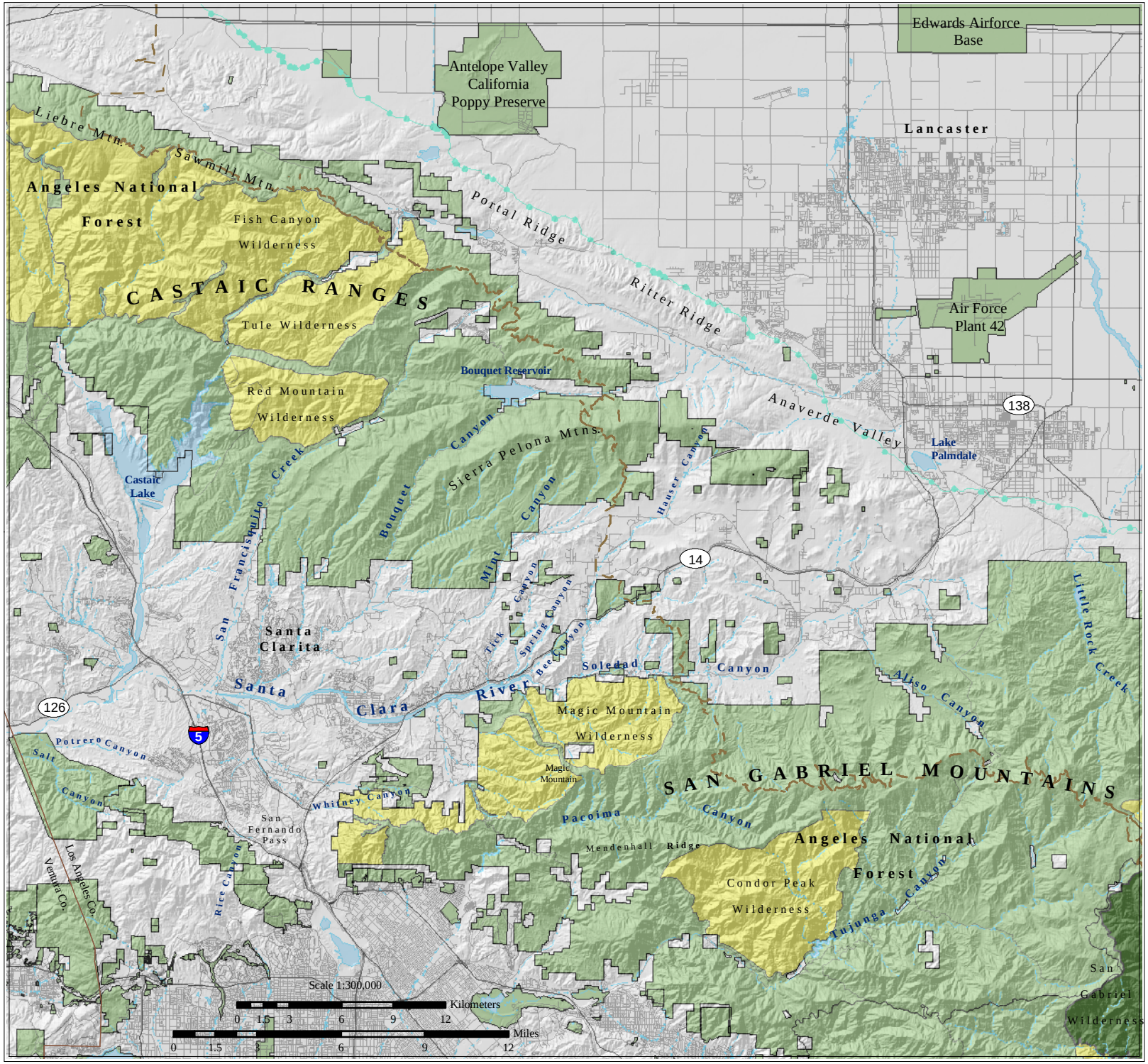
Existing Conservation Investments

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 serves to connect two expansive protected core areas. The majority of both the San Gabriel and Castaic ranges are included in the National Forest system, together forming the Angeles National Forest. Designated Wilderness in the San Gabriel Mountains includes the San Gabriel and Sheep Mountain Wilderness Areas, with several other roadless areas proposed for Wilderness status as part of the California Wild Heritage Act (http://www.californiawild.org), including two areas contiguous with the southern part of the planning area (i.e., Magic Mountain and Santa Clarita Canyons). And, although no designated Wilderness currently exists in the Castaic Ranges, several worthy areas are proposed including 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 (Penrod et al. 2002). 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 Planning Area

Legend

- Ownership Boundaries
- Designated Wilderness
- Proposed Wilderness
- Pacific Crest Trail
- Paved Roads
- Hydrography
- Lakes & Reservoirs
- Aqueduct
- County Boundaires



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There is currently a 6 to 10-mile break in connectivity between the Saugus and Tujunga Ranger Districts of the Angeles National Forest, however the landscape still retains high habitat values and opportunities remain for restoring functional habitat connectivity between these significant blocks of public land. Threats to natural habitats in the linkage itself have been recognized by federal, state, and local agencies and non-governmental organizations that have launched a variety of successful planning efforts. As a result, a number of stepping-stones of secured habitat exist in the linkage (Figure 4). The Bureau of Land Management administers land throughout the linkage planning area in Soledad, Long, Bobcat, Young, Hughes, Escondido, Tapie, Tick, and Mint canyons. Los Angeles County manages two natural areas, Vasquez Rocks and Placerita Canyon, and has proposed three Significant Ecological Areas in the linkage planning area (i.e., Santa Clara River, Cruzan Mesa, and Santa Susana/Simi Hills), as part of their General Plan update. The Santa Monica Mountains Conservancy also manages land in the planning area in Towsley, Elsmere and Whitney Canyons. The City of Santa Clarita recently acquired land in Bee Canyon. Finally, the National Park Service recently secured land along the Pacific Crest Trail. The value of already protected land in the region for biodiversity conservation, environmental education, outdoor recreation, and scenic beauty is immense, but it can be irrevocably degraded if these remaining wildlands become disconnected.

Threats to Connectivity

The linkage is imminently threatened by high-density urban development spreading eastward from the City of Santa Clarita, with massive new developments proposed almost weekly. The Santa Clarita area alone is experiencing a growth rate of 3%, the fastest in Los Angeles County among cities with population of 150,000 or more. The population of the City of Santa Clarita is approximately 158,000, while the population of the Santa Clarita Valley, which includes the planning area, exceeds 200,000. While the population of the City of Santa Clarita is anticipated to hit 175,000 by 2008, the larger Santa Clarita Valley is projected at 240,000 by 2010, and over 350,000 by 2025. Rural residential development in the communities of Aqua Dulce and Acton has also created choke points to wildlife movement, though these areas remain somewhat permeable. However, groundwater extraction in these rural communities creates additional obstacles to movement, especially for aquatic and semi aquatic organisms that rely on surface water and well-developed riparian vegetation.

Aggregate mining in and adjacent to the Santa Clara River in Soledad Canyon has already had tremendous impacts on the natural resources of the watershed. The existing mining lease is to be terminated within the next decade and the habitat restored to a semblance of its former grandeur. However, another massive mining project has been proposed in the linkage planning area that would extract 78 million tons of sand and gravel over the next 20 years; the project is currently in litigation. Fortunately, legislation has been introduced by U.S. Senator Barbara Boxer that would terminate two mining leases in Soledad Canyon and prohibit the issuance of any future mining leases for sand and gravel in Soledad Canyon. Congressman Buck McKeon introduced the House version of this bill (H.R. 3529). The City of Santa Clarita recently purchased this property, though not the mineral rights, to bolster their chances of stopping this project in order to protect residents from further degradation of air and water quality and increased traffic congestion.

It has been estimated that over 90% of the historic riparian habitat in Southern California has been eliminated (Dennis et al. 1984, Bell 1997). In Los Angeles County, over 97% of the wetlands once present are now gone, and the wetland and riparian communities remaining are intensely threatened. This significant loss of habitat has been accompanied by a decline in wildlife populations that depend wholly or in part on riparian systems. Whereas millions of dollars are being spent to restore the Los Angeles and San Gabriel Rivers, which are lined with concrete from the mountains to the sea; the Santa Clara River is still wild, supporting a diversity of species, and providing a multitude of ecosystem services that should be maintained.

A major transportation route is also proposed in the linkage planning area that would create an enormous barrier to wildlife movement. The California High-Speed Rail Authority has proposed a 200 mph bullet train that would connect major cities throughout the state (http://www.cahighspeedrail.ca.gov/eir/). The proposed alignment in the planning area is mostly at grade, and runs from Palmdale, through Soledad Canyon along the Santa Clara River to Interstate 5. The Draft Environmental Impact Report/Environmental Impact Statement calls for high frequency intercity routes, with between 12-20 trains per day. By 2020, they expect 86 weekday trains in each direction, 64 statewide from north to south, and 22 shorter distance routes. Wildlife movement would be further restricted since the railroad rights-of-way would be fenced, not to mention the impacts on species caused by noise and vibration.

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, time is of the essence if we are to secure this regionally important landscape connection.

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 San Gabriel and Castaic ranges 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 generally 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 detailed comprehensive report.

Our approach has been highly collaborative and interdisciplinary. 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).

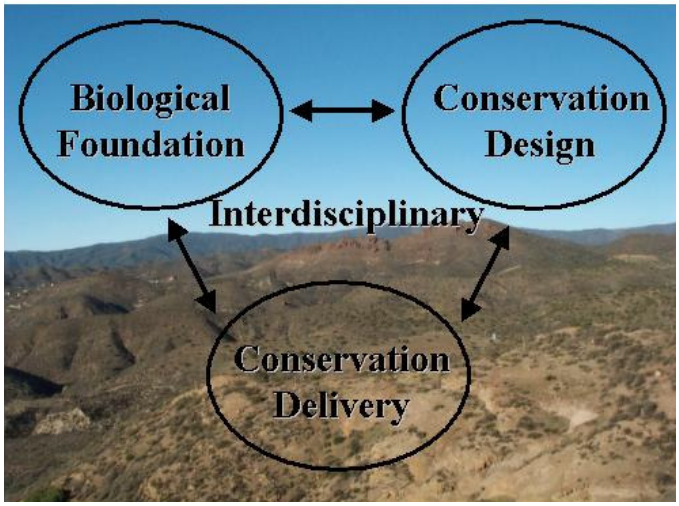

Figure 5. Successful conservation planning requires an interdisciplinary and reiterative approach among biologists, planners and activists (Baxter 2001).

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 15 focal species for the San Gabriel-Castaic Linkage

Common Name	Scientific Name
Mammals	
Mountain lion	*Puma concolor*
American badger	*Taxidea taxa*
Mule deer	*Odocoileus hemionus*
Pacific kangaroo rat	*Dipodomys agilis*
Birds	
California thrasher	*Toxostoma redivivum*
California spotted owl	*Strix occidentalis occidentalis*
Burrowing owl	*Athene cunicularia*
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	*Clemmys marmorata*
Invertebrates	
Bear sphinx moth	*Arctonotus lucidus*
Plants	
Scalebroom	*Lepidospartum squamatum*
California Juniper	*Juniperus californica*

The 15 focal species identified at the workshop included 2 plants, 1 insect, 1 amphibian, 3 reptiles, 4 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 distributions restricted to the linkage planning area (e.g., Burrowing owl). 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, floating, 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 protected core areas: mountain lion, badger, mule deer, Pacific kangaroo rat, and California spotted owl. Ranks and weightings adopted 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

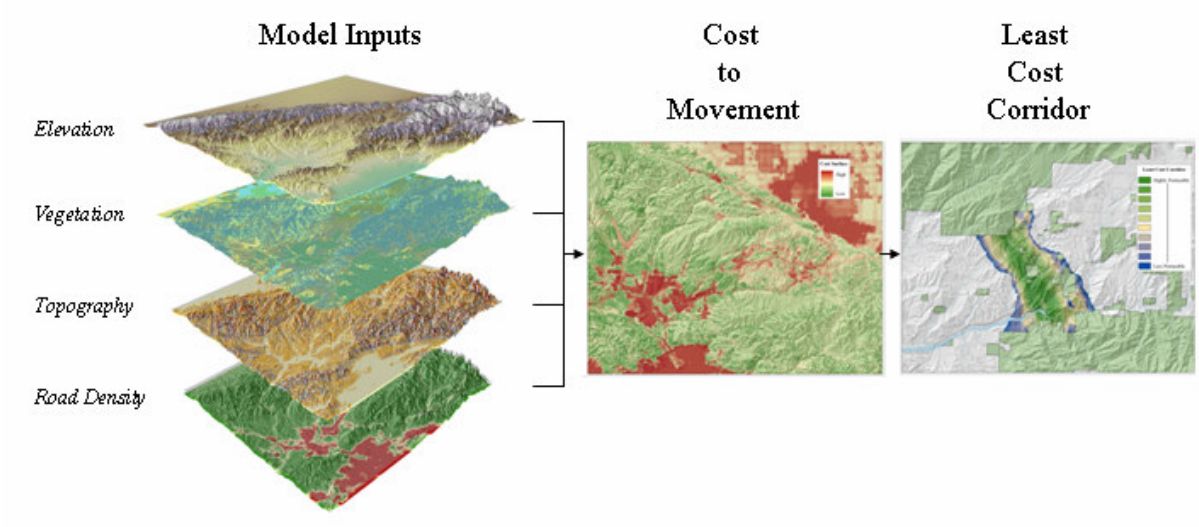

Figure 6. Permeability Model Inputs: elevation, vegetation, topography, and road density.

Table 2. Model Parameters for Landscape Permeability Analyses					
	Strix occidentalis (California Spotted owl)	*Dipodomys agilis* (Pacific k-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
Valley Oak Woodland	3	7	1	4	2

Table 2. cont.	*Strix occidentalis* (California Spotted owl)	*Dipodomys agilis* (Pacific k-rat)	*Odocoileus hemionus* (Mule deer)	*Taxidea taxus* (Badger)	*Puma concolor* (Mountain lion)
MODEL VARIABLES					
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 (e.g., vegetation, road density, topography, elevation) on focal species movements. A unique cost surface was developed for each species. A corridor function was then used to generate a data layer showing the relative degree of permeability between two core areas. For each focal species, the top 1% was designated as the least-cost corridor.

The least-cost corridor output for all species was then combined to generate a Least Cost Union. The biological significance of this Union can best be described as the zone in which species would encounter the least energy expenditure (i.e., preferred travel route) and the most favorable habitat as they move between protected core 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 focal species movement based on the data layers used in the analyses, it does not address whether suitable habitat in the Least-Cost Union occurs in large enough patches to support viable populations or whether dispersal distances would allow individuals to move among habitat patches. To address this need, we 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). Distributional patterns of plants and animals vary spatially and temporally at different biogeographic scales (Ligon and Stacey 1996). For relatively sedentary species like salamanders and terrestrial insects, gene flow will occur over decades by gene flow through a meta-population. Thus, the linkage must accommodated metapopulations of these species if it is to functionally support ecological and evolutionary processes.

A habitat suitability model formed the basis for the patch size and configuration analysis. Habitat suitability models were developed 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, soils, etc. 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. We identified each area of contiguous suitable habitat larger than 25 times the recorded average home range size as a *potential core* and each area of contiguous suitable habitat at least 2 times the minimum recorded home range, but less than a potential core as a *patch*. Potential cores areas may sustain at least 50 individuals and 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).

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. 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 habitat and/or "move-thru" habitat in perpetuity for the species' needs.

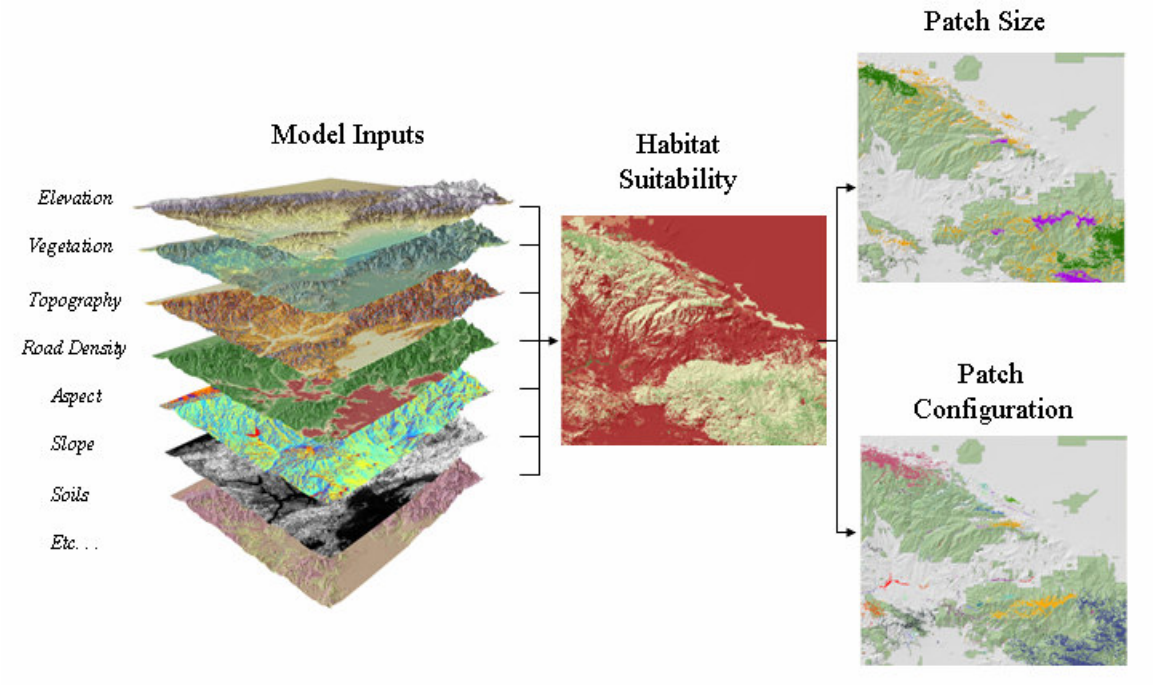

Figure 7. Model Inputs to Patch Size and Configuration Analyses vary by species. Patch size delineates cores, patches, and stepping-stones of potential habitat. Patch Configuration evaluates whether suitable habitat patches and cores are within the dispersal distance of the species.

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 areas of the Least-Cost Union. In areas where the Least-Cost Union was less than 2 km in width, we first added available natural habitats to either side of the Least-Cost Union. If no natural habitats were available, agricultural lands were added since these areas could potentially be restored. Urban developments were not included in these additions.

For a variety of species, including those we did not formally analyze, 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 present the most formidable potential barriers, surveyors 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; vegetative community within and/or adjacent to the passageway. Existing highways and crossing structures are not permanent features of the landscape. In particular, crossing structures can be 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 implementation opportunities for agencies, organizations, and individuals interested in participating in conservation activities in the San Gabriel-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 provide a visualization of the linkage from a landscape perspective (Appendix C).

We conducted landscape permeability analyses for 5 species (i.e., mountain lion, American badger, mule deer, Pacific kangaroo rat, and California spotted owl) as described in the following several pages. The Least Cost Union (i.e., the union of the top 1% for all 5 species) demonstrates the need for habitat connectivity in several major vegetation communities, including both coastal and desert habitats (Figure 8). The most permeable paths for the majority of focal species converged and overlapped considerably, with one species, American badger, diverging to generate an additional route containing its preferred habitat (Figure 9). High permeability areas are sites where focal species encounter the fewest obstacles or hazards, and have the greatest chance of finding food and shelter between protected core areas.

Despite diverse ecological and movement requirements (see following species accounts and Table 2), least cost corridors for the 5 focal species are remarkably similar. The similarity is due in large part to existing constraints on movement posed by the encroaching high-density development from the City of Santa Clarita and rural residential development. The cost of travel is lower through natural habitats than in areas with roads and urban development.

The Least Cost Union extends from the Tujunga Ranger District of Angeles National Forest, south of SR-14, to the Saugus Ranger District of Angeles National Forest, north of SR-14, spanning a distance between roughly 6-10 km (3.73-6.21 mi). Coastal habitats dominate the western branch of the Union, which ranges in width from 4.5-7 km (2.80-4.35 mi). It includes all or portions of Soledad, Bee, Spring, Tapie, Tick, and Mint canyons. The eastern branch of the Union has more of a desert influence, and ranges in width from < 0.5-2.5 km (0.31-1.55 mi). This route includes both riparian and upland habitats in Soledad, Aqua Dulce and Escondido canyons, as well as, an upland connection between Aqua Dulce and Long canyons.

Native vegetation accounts for roughly 95% of land cover in the Least Cost Union, which encompasses 17 distinct vegetation communities. Coastal sage scrub covers the greatest area; other dominant natural communities include desert scrub, mixed chaparral, chamise-redshank chaparral, Coastal oak woodland, juniper woodland, and valley foothill riparian. Existing protected habitat in the Least Cost Union includes multiple parcels administered by the Bureau of Land Management, Vasquez Rocks County Park, City of Santa Clarita Land, and other conservancy lands.

The next several pages summarize the permeability analyses for each of the 5-modeled species. For convenience, the narratives describe the most permeable paths from south to north; our analyses, however 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. The latter analysis expanded the Least Cost Union to provide for critical live-in or move-through habitat for particular focal species.

Figure 8.
Least Cost Union

Legend

- Least Cost Union
- Potential Crossings Structures
- Highway
- Paved Roads
- Dirt Roads
- Hydrography
- Aqueduct
- Ownership Boundaries

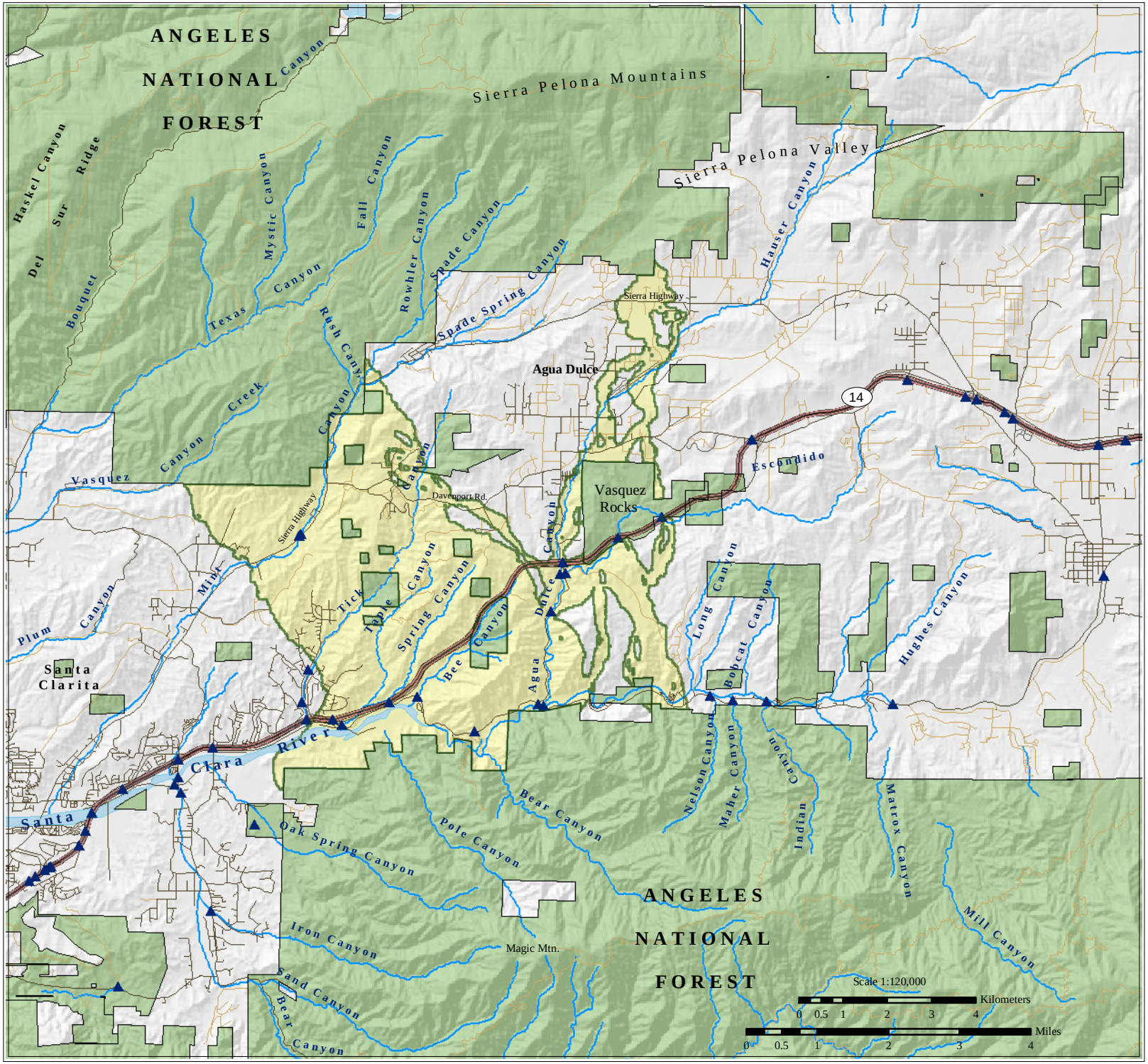

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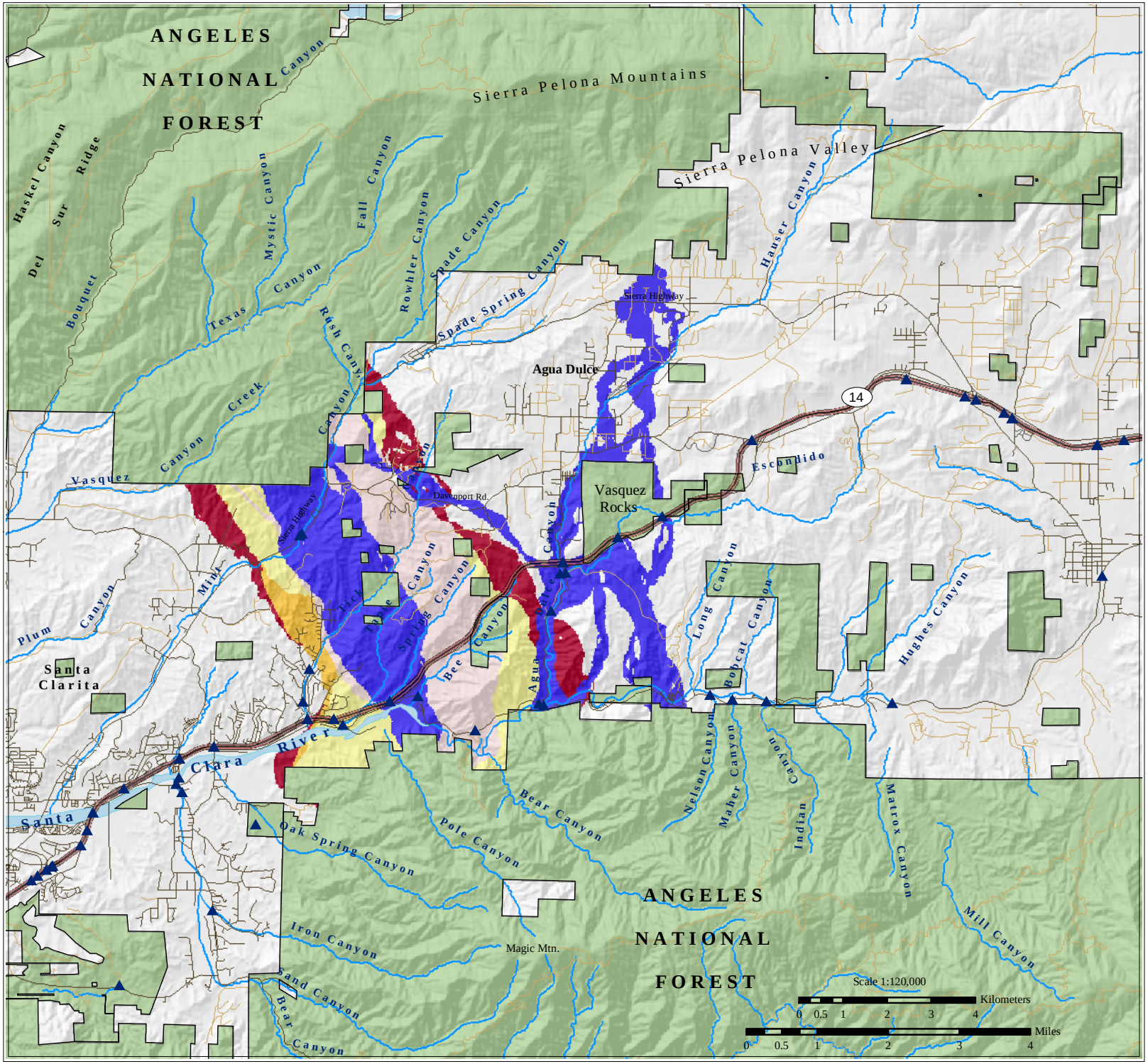
Figure 9.
Least Cost Union
(Species Overlap)

Legend

- American badger
- Mule deer
- Mountain lion
- California spotted owl
- Pacific kangaroo rat
- Potential Crossings Structures
- Highway
- Paved Roads
- Dirt Roads
- Hydrography
- Ownership Boundaries



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Justification for Selection: These area-sensitive species are appropriate focal species (Noss 1991, Noss et al. 1994) because their naturally low densities render them highly sensitive to habitat fragmentation, and loss of large carnivores can have adverse ripple effects through the entire ecosystem (Soule 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 the extensive road network has had detrimental effects on mountain lions by restricting movement, increasing mortality, and increasing association with humans.

Conceptual Basis for Model Development: The species uses brushy stages of a variety of habitat types with good cover (Ahlborn 1988, Spowart and Samson 1986). 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. Please see Table 2 for specific rankings for this species; cost to movement for mountain lion was defined by weighting various inputs, such that:

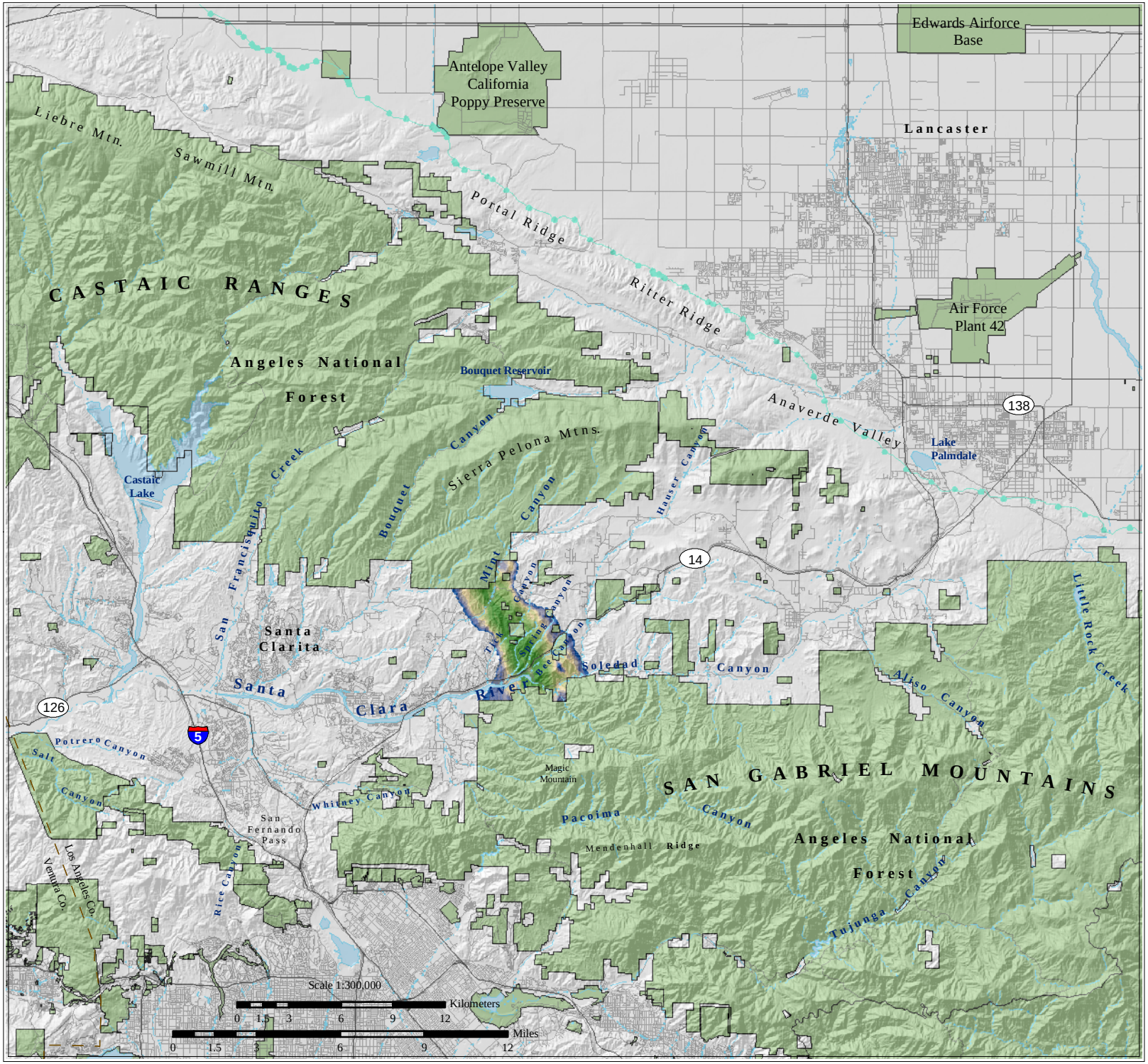
(Vegetation * 40%) + (Road Density * 30%) + (Topography * 30%)

Results & Discussion: The Least Cost Corridor for mountain lion movement between protected core areas is depicted in Figure 10. It is approximately 6 km (3.7 mi) in length, varying in width from 2.7-6 km (1.7-3.7 mi). The most permeable path encompasses the riparian habitats of Pole and Bear Canyon Creeks that flow out of the proposed Magic Mountain Wilderness Area in the San Gabriels into the Santa Clara River; and encompasses portions of Soledad, Bee, Spring, Tapie, Tick, and Mint Canyons, which are dominated by coastal scrub with scattered pockets of mixed chaparral, chamise-redshank chaparral, alluvial fan sage scrub, riparian and grassland habitats. This route encompasses an existing underpass at Spring Canyon, though it is not accessible to an animal in the Santa Clara River traveling north toward the Castaic Ranges.

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

Legend

- Paved Roads
- Hydrography
- Lakes & Reservoirs
- Aqueduct
- Ownership Boundaries
- County Boundaires
- Highly Permeable
- Less Permeable



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

Conceptual Basis for Model Development: Badgers are associated with grasslands, prairies, and other open habitats that support abundant burrowing rodents (Banfield 1974, de Vos 1969, 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, and 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. Please see Table 2 for specific rankings for this species; cost to movement for badger was defined by weighting various inputs, such that:

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

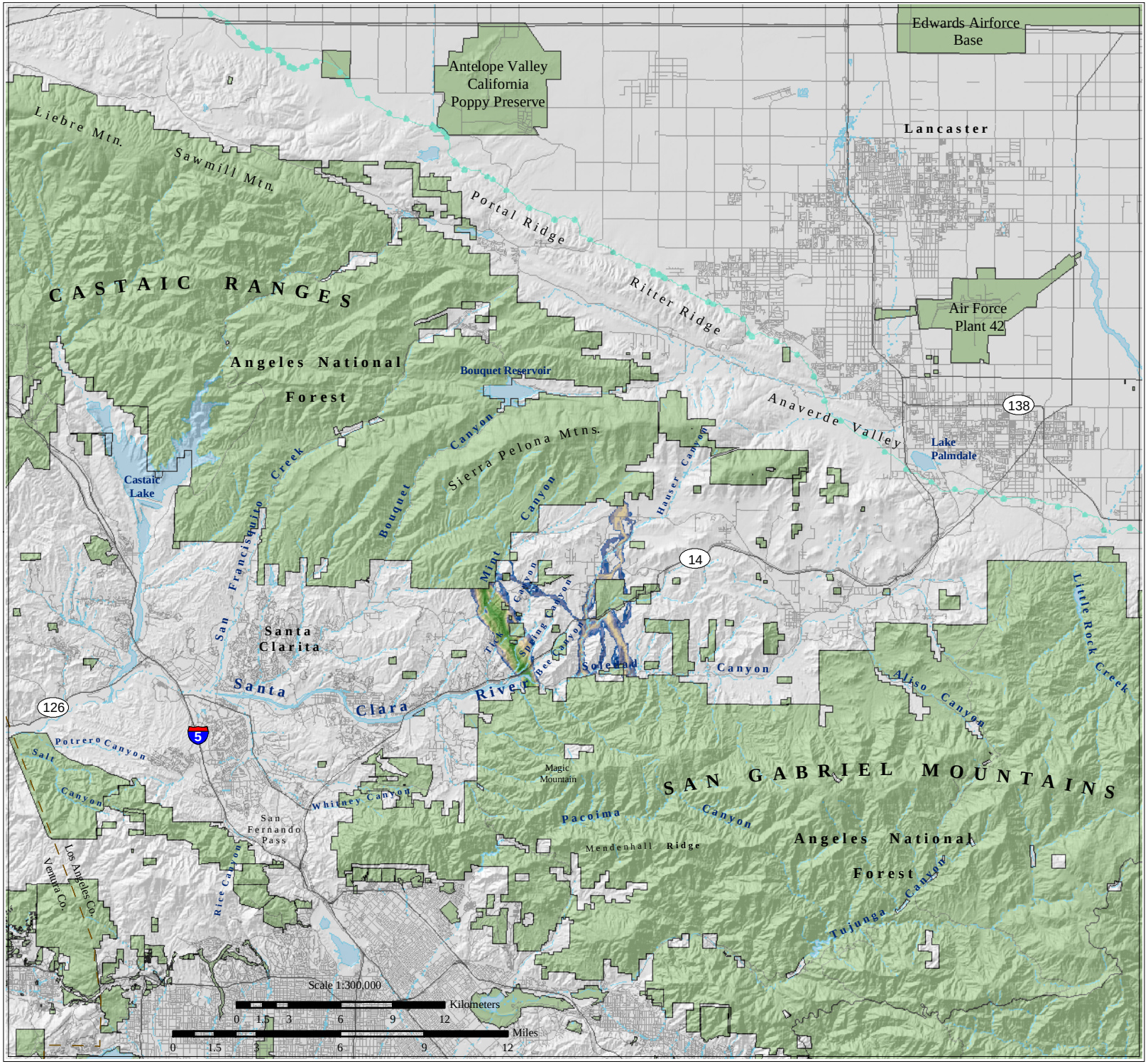
Results & Discussion: Figure 11 delineates the most permeable areas for badger traveling between the San Gabriel and Castaic Ranges protected core areas. A few strong routes emerged from the analysis. Both encompass riparian habitats of the Santa Clara River in Soledad Canyon in the southern part of the Least Cost Corridor. The westernmost route is similar to the output for mountain lion, though narrower, ranging in width from 0.9 km (0.56 mi) to 2.1 km (1.3 mi).

The easternmost route has multiple branches and comprises habitat with a higher degree of suitability for badger. It is approximately 9.2 km (5.7 mi) in length, with branches ranging in width from 0.4-2.5 km (0.2-1.6 mi). It includes the riparian communities of Aqua Dulce and Escondido Canyons; desert scrub and coastal scrub habitats between Aqua Dulce and Long Canyons south of SR-14; desert scrub and mixed chaparral habitats in Vasquez Rocks above SR 14, which transition into juniper woodland and then to the grassland habitats in the Sierra Pelona Valley. There is a minor fork in the easternmost route north of SR-14 and south of the community of Aqua Dulce that extends from Aqua Dulce Creek to upper Mint Canyon, which is dominated by desert scrub. Existing passageways under SR-14, though not ideal, occur at three locations. These include one for Agua Dulce Creek and two for Escondido Creek; the Pacific Crest Trail also utilizes the easternmost structure.

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

Legend

- Paved Roads
- Hydrography
- Lakes & Reservoirs
- Aqueduct
- Ownership Boundaries
- County Boundaires
- Highly Permeable
- Less Permeable



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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; vehicles kill several hundred deer each year.

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. Please see Table 2 for specific rankings for this species; cost to movement for mule deer was defined by weighting various inputs, such that:

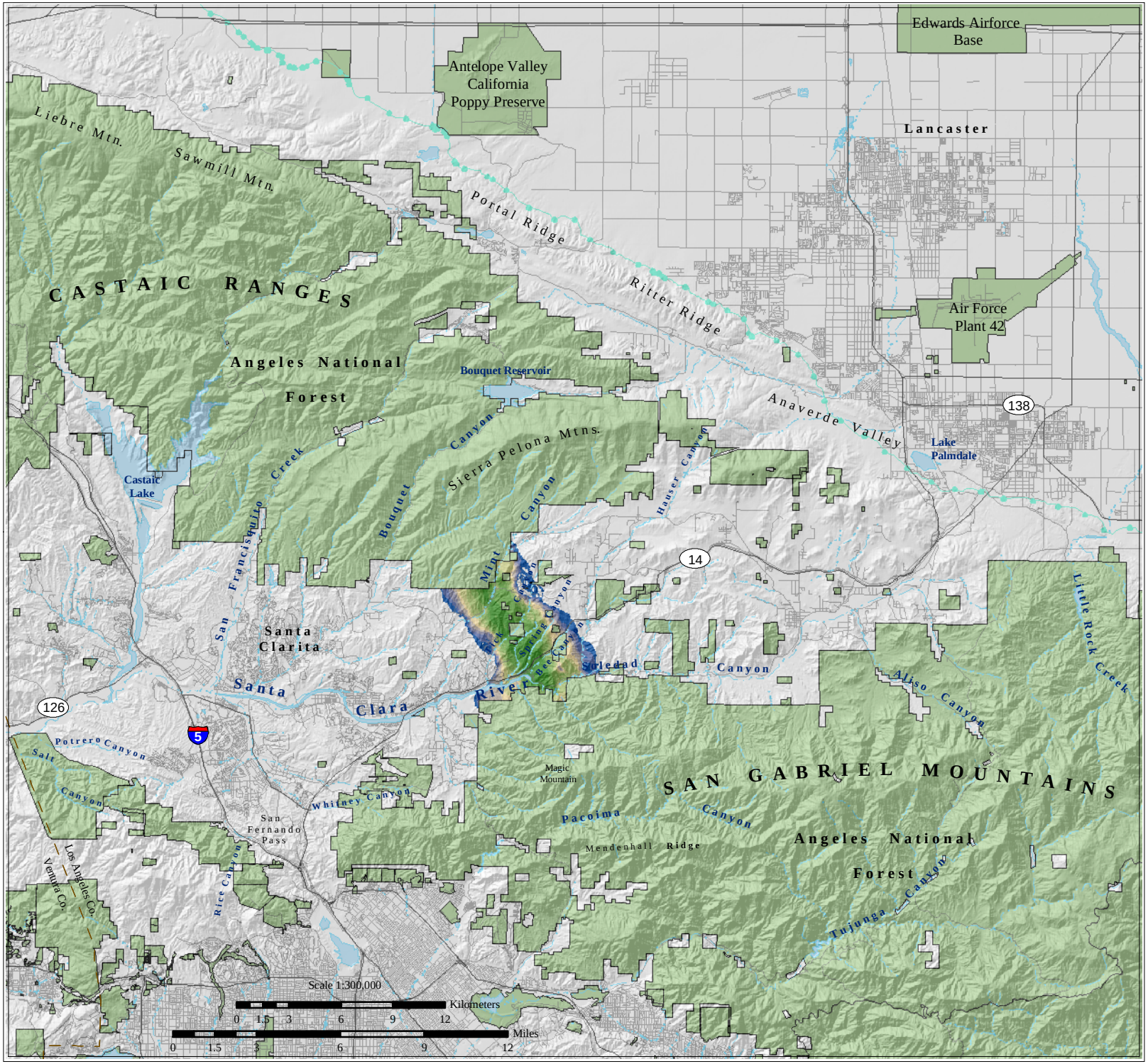
(Vegetation * 65%) + (Topography * 20%) + (Road Density * 15%)

Results & Discussion: The most permeable path for Mule deer moving between the San Gabriel and Castaic Ranges protected core areas follows the same pathway as mountain lion (Figure 12). However, the Least Cost Corridor is broader, ranging in width from 4.5-7.5 km (2.8-4.7 mi). The best travel route for Mule deer also encompasses the existing underpass at Spring Canyon, though the current conditions of this structure are far from ideal since it isn't accessible to animals from the Santa Clara River.

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

Legend

- Paved Roads
- Hydrography
- Lakes & Reservoirs
- Aqueduct
- Ownership Boundaries
- County Boundaires
- Highly Permeable
- Less Permeable



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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. They can navigate roads and other barriers (freeways, agricultural and urban areas) but they are highly susceptible to roadkill (W. Spencer pers. comm.). Barriers are likely similar to other kangaroo rats (roads, 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 (W. Spencer pers. comm.).

Conceptual Basis for Model Development: The Pacific kangaroo rat is associated with a variety of habitats 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 alluvial fan sage scrub (Price et al. 1991) and montane coniferous forests (Sullivan and Best 1997). This species prefers more open areas 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).

This kangaroo rat tends to be more mobile than most rodents of its size, and more so than other kangaroo rats. Most information on movements and ecology are very similar to Merriam's kangaroo rat, although with less supporting literature (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, this species may not be a strictly "orthogonal" linkage species. Because they occupy montane chaparral habitats, they 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. Please see Table 2 for specific rankings for this species; cost to movement was defined by weighting various inputs, such that:

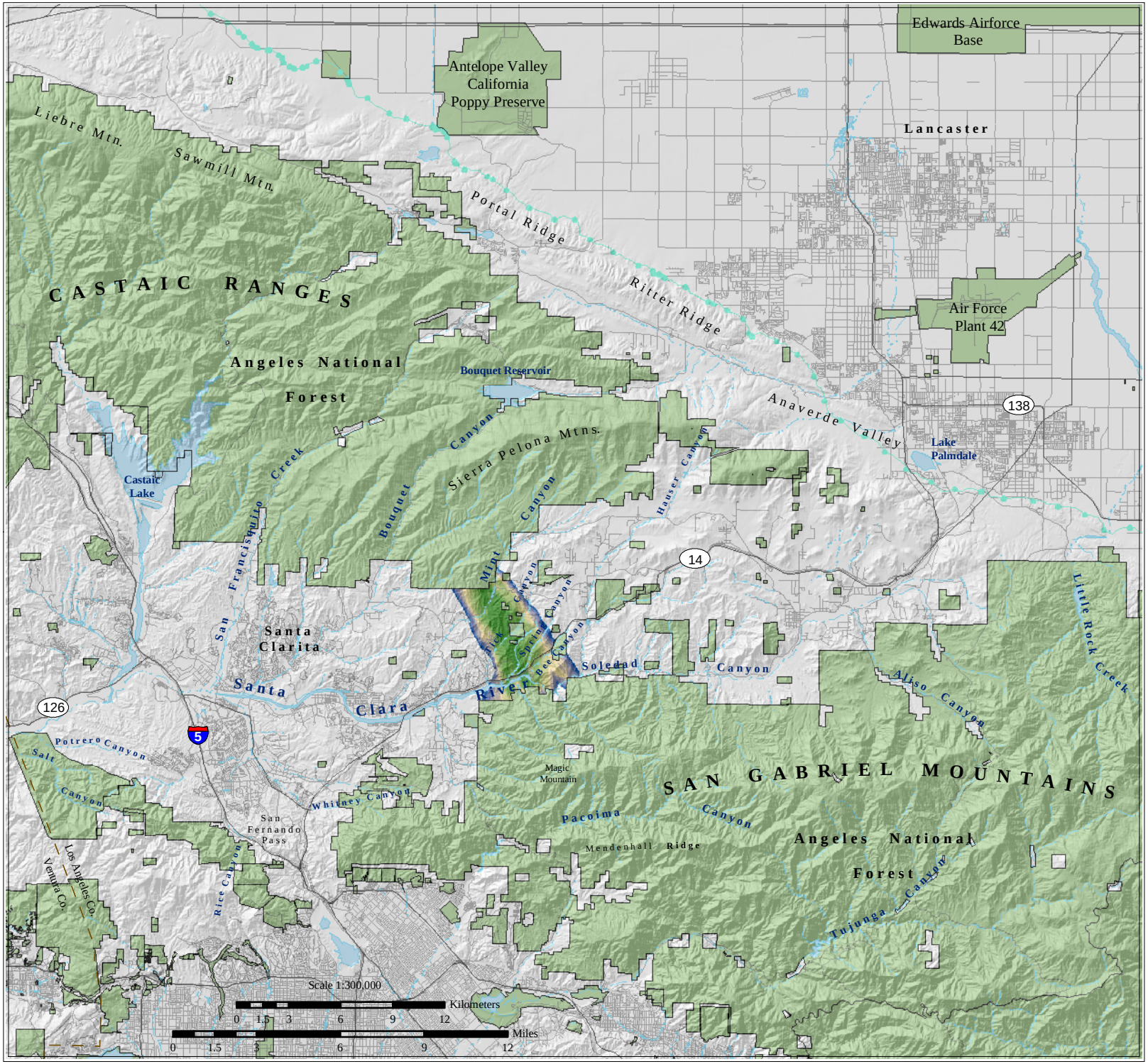
(Vegetation * 70%) + (Road Density * 10%) + (Topography * 10%) + (Elevation * 10%)

Results & Discussion: The Least Cost Corridor for the Pacific kangaroo rat also follows the same general pathway as mountain lion traveling between protected core areas (Figure 13). However, the Least Cost Corridor ranges in width from 3.2-5.7 km (2-3.5 mi).

Figure 13.
Least Cost Corridor
for
Pacific Kangaroo Rat
(Dipodomys agilis)

Legend

- Paved Roads
- Hydrography
- Lakes & Reservoirs
- Aqueduct
- Ownership Boundaries
- County Boundaires
- Highly Permeable
- Less Permeable



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California Spotted Owl (*Strix occidentalis occidentalis*)

Photo by Rob Bennetts

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 a. 1997).

Conceptual Basis for Model Development: 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). Foraging habitat for this subspecies can be more variable than its northern relative, 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. Please see Table 2 for specific rankings for this species; cost to movement for California spotted owl was defined by weighting various inputs, such that:

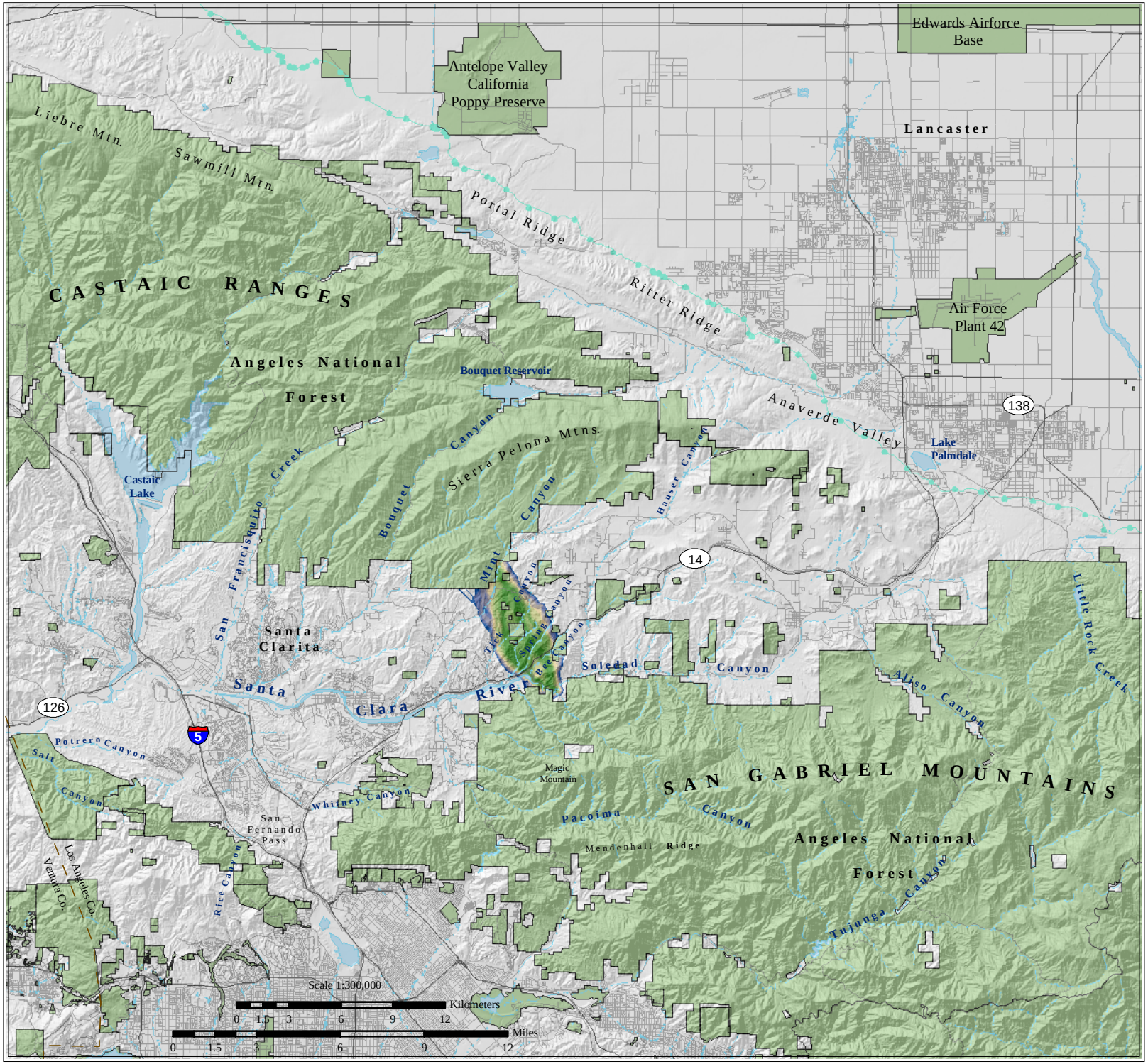
(Vegetation * 75%) + (Road Density * 25%)

Results & Discussion: The Least Cost Corridor for California spotted owl between the San Gabriel and Castaic Ranges protected core areas also follows the same pathway as mountain lion (Figure 14). However, the Least Cost Corridor is much narrower, ranging in width from 2.1 km (1.3 mi) to 3.6 km (2.2 mi). Although the Least Cost Corridor contains no suitable breeding habitat, the California spotted owl is known to hunt for prey in open terrain. Furthermore, with a estimated dispersal distances between 7-72 km (LaHaye et al. 1994, LaHaye et al. 2001), a dispersing individual could easily traverse the linkage in one flight.

Figure 14.
Least Cost Corridor
for
California Spotted Owl
(Strix occidentalis)

Legend

- Paved Roads
- Hydrography
- Lakes & Reservoirs
- Aqueduct
- Ownership Boundaries
- County Boundaires
- Highly Permeable
- Less Permeable



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The Least Cost Union (Figure 8, 9) covered 5277 ha (13040 ac) and encompassed several existing protected areas (e.g., BLM, Vasquez Rocks County Park, City of Santa Clarita conservation lands). It had a narrow, braided eastern arm along upper Aqua Dulce Creek.

We evaluated the size and configuration of potential suitable habitat for each focal species in the linkage area to determine whether each species is likely to be served by the Least Cost Union. Specifically, for each species we evaluated 1) whether potential habitat patches are separated by distances less than the dispersal distance of the species; 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) if a species was not served by the Least Cost Union, whether the species would be accommodated if additional habitat was added. As suggested by these analyses, we modified the Least Cost Union by appropriate deletion and addition of habitat. The patch size and configuration analyses for each focal species follow this 2-page summary.

As a result of this analysis, we eliminated urbanized areas in the village of Agua Dulce, along Davenport Road, in Lower Tapie and Tick canyons, and adjacent areas. This deleted 795 ha (1964 ac) from the Least Cost Union. The deleted areas near Agua Dulce were included in the Least Cost Union based on the permeability analysis for badger. Thus this deletion required us to identify alternate routes for badgers.

Our analyses suggested that the Least Cost Union contains suitable habitat to support either inter- or intra-generational movements between the San Gabriel and Castaic ranges for 7 of the 15 focal species: mountain lion, mule deer, Pacific kangaroo rat, burrowing owl, California thrasher, California juniper, and scalebroom. These focal species appear to be well served by the Linkage Design; model outputs indicated that areas with potential suitable habitat in the Least Cost Union were large enough to support viable populations and or close enough together to allow movement between suitable habitat patches.

Eight focal species were not well served by habitat within the Least Cost Union, namely American badger, California spotted owl, Acorn woodpecker, Monterey salamander, western pond turtle, two-striped garter snake, mountain kingsnake, and Bear sphinx moth. Three of these species (California spotted owl, Acorn woodpecker, and Monterey salamander) had no breeding habitat in the Least Cost Union but significant populations in both protected core areas. Our analyses identified a few minuscule patches of potential habitat for these species within the linkage analysis area, namely along Soledad Canyon and upper Mint Canyon; we added these patches to the Union.

Three of the underserved species (Western pond turtle, two-striped garter snake, and mountain kingsnake) require semi-aquatic habits. We modified the Least Cost Union to include riparian and upland habitat in Soledad Canyon, upper Tick and Mint Canyons, and Long, Bobcat, and Escondido Canyons to create stepping stones of suitable habitat for these species. These added areas encompassed the tiny habitat patches added for California spotted owls, Acorn woodpeckers, and Monterey salamanders.

The last two focal species not served by the Least Cost Union (American badger and Bear sphinx moth) had considerable suitable habitat within the analysis area, namely northwest of Vasquez Rocks County Park in Hauser Canyon and east of upper Agua Dulce Creek. We therefore added an eastern branch of the Union to serve these species, and imposed a minimum width of 2 km to ensure that the functional processes of the linkage are protected. Other species that utilize desert scrub habitats (e.g., California thrasher, California juniper) will also benefit from this addition.

The additions to serve these 8 focal species minus the deletion of urbanized lands in and north of Agua Dulce, resulted in 4414 ha (10907 ac) of additional habitat (Figure 15). The habitat additions lie in 4 general areas:

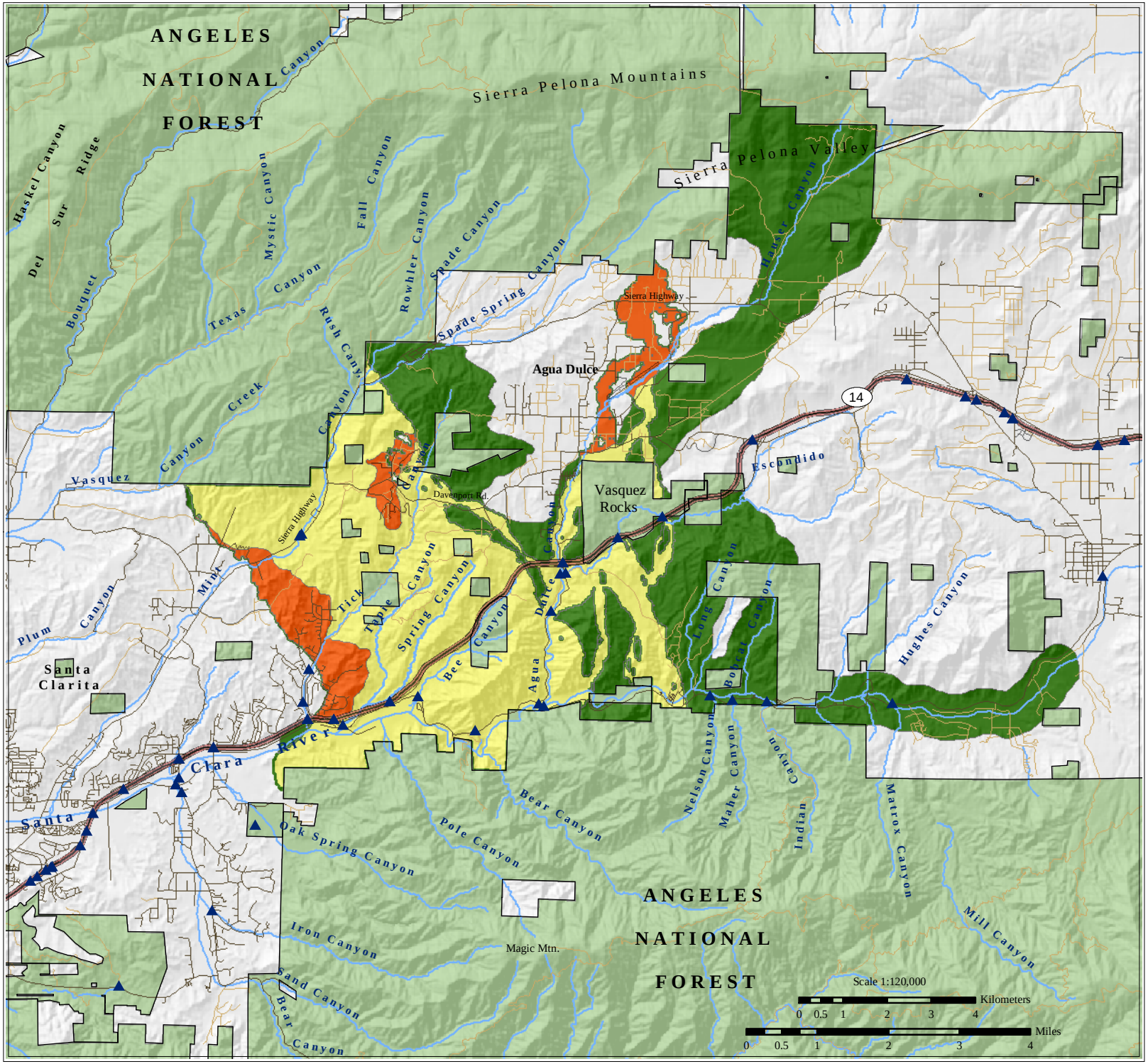
- Soledad Canyon between Acton and the mouth of Agua Dulce Canyon: provides habitat and connectivity for semi-aquatic focal species (Western pond turtle, Two-striped garter snake, Mountain kingsnake, Monterey salamander) and aquatic species not addressed by our analyses (Unarmored three-spine stickleback, Arroyo chub, and Santa Ana Sucker). It also provides small habitat patches for terrestrial species (Acorn woodpecker, and California spotted owl). We include a 1 km (0.6 mi) buffer (0.5 km to either side of the river) to support upland habitat requirements for semi-aquatic species and protect water quality within the linkage and downstream. This addition also provides suitable habitat for 7 other focal species: Mountain lion, badger, Mule deer, Pacific kangaroo rat, Burrowing owl, California thrasher, and Scalebroom.
- Long, Bobcat, and Escondido Canyons: core habitat for semi-aquatic (e.g., Western pond turtle, two-striped garter snake) and terrestrial species. Escondido Canyon also provides aquatic habitat for the endangered Unarmored three-spine stickleback. These additions include riparian and upland habitat between Bobcat and Agua Dulce Canyons, and a 1 km (0.6 mi) buffer (0.5 km to either side of each creek). This addition also benefited most focal species by providing suitable habitat, a secondary riparian movement corridor, or preserving water quality.
- Hauser Canyon area: core habitat and movement areas for American badger and Bear sphinx moth. This branch of the linkage is dominated by desert scrub and juniper woodland habitats. The minimum width of 2 km (3.2 mi) makes this linkage robust to edge effects and provides a habitat configuration for metapopulations of species with low mobility. This addition also provides habitat for Mule deer, Pacific kangaroo rat, Burrowing owl, California thrasher, California juniper, and Scalebroom.
- Upper Mint and Tick Canyons: habitat for California spotted owl, Acorn woodpecker, Monterey salamander, western pond turtle, two-striped garter snake, and mountain kingsnake; almost all other focal species are also served by this addition.

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.

Figure15.
Least Cost Union
Additions & Subtractions

Legend

- Least Cost Union
- Additions
- Subtractions
- Potential Crossings Structures
- Highway
- Paved Roads
- Dirt Roads
- Hydrography
- Ownership Boundaries
- County Boundaires



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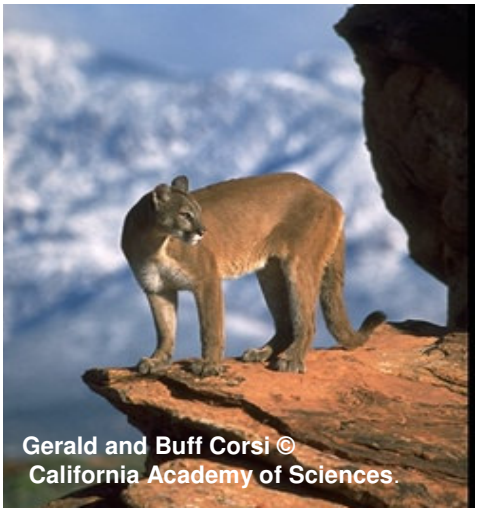

Distribution & Status: Mountain lions are widely distributed throughout the western hemisphere (Currier 1983, Chapman and Feldhamer 1982, Maehr 1992, Tesky 1995). The subspecies *F. c. californica* occurs in southern Oregon, California, and Nevada (Hall 1981), between 1,980 and 5,940 ft (590-1,780 m)(CDFG 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 (CDFG1990, Spowart and Samson 1986). Within these habitats, mountain lions prefer rocky cliffs, ledges, and vegetated ridgetops that provide cover when hunting (Spowart and Samson 1986, Chapman and Feldhamer 1982), 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 (Chapman and Feldhamer 1982; Ingles 1965). 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 densities of prey (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 populations 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. Patch size was classified as $\geq$ 200 km^2 but < 10,000 km^2. Core areas potentially supporting 50 or more individuals were modeled using patches $\geq$ 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 mountain lion in the San Gabriel and Castaic Ranges of the Angeles National Forests. Between these protected core areas, the model identified highly suitable habitat in the Santa Clara River, in Bee, Long, Bobcat, and Escondido canyons, and lower Aqua Dulce canyons, and in Spring, Tapie, Tick, Plum, Mint, and Vasquez canyons, most of which was captured in the Least Cost Union (Figure 16). However, neither the San Gabriel nor Castaic Range protected core areas are $\geq$ 10,000 km^2 (i.e., core areas capable of potentially supporting 50 individuals), illustrating the importance of maintaining connectivity between these ranges (Figure 17). The Least Cost Union is likely to serve this species as sufficient move through habitat was captured in the analysis. Although, habitat added for other focal species will also benefit mountain lion.

The analysis also identified a very vital connection for mountain lion moving between the San Gabriel and Santa Susana Mountains. The model identified habitat in Placerita, Whitney, and Elsmere canyons to the east of S14 in the San Gabriel Mountains; habitat in the San Fernando Pass, between SR-14 and I-5; and extensive habitat in the Santa Susana Mountains, including immediately west of I-5 in East, Rice, Towsley, Salt, and Potrero canyons (Figure 16). Mountain lion was also identified as a focal species for the linkage between the Santa Monica Mountains and the Sierra Madre Range of Los Padres National Forest, which will address habitat connectivity for this species between the Santa Susana and Sierra Madre Mountains. The National Park Service, a partner in the South Coast Missing Linkages Project, is currently conducting a study to evaluate the spatial requirements and movements of mountain lions in this region. They recently equipped a young female lion (i.e., P4) with a GPS collar in the eastern Santa Susana Mountains (Riley et al. unpublished).

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 easily traverse the entire length of the linkage in one night. 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 San Gabriel 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;

Figure 16.
Habitat Suitability
for
Mountain Lion
(Puma concolor)

Legend

- Least Cost Union

Degree of Sutiability

- High
- Medium to High
- Medium
- Low to Medium
- Low
- Paved Roads
- Hydrography
- Lakes & Reservoirs
- Aqueduct
- Ownership Boundaries
- County Boundaires

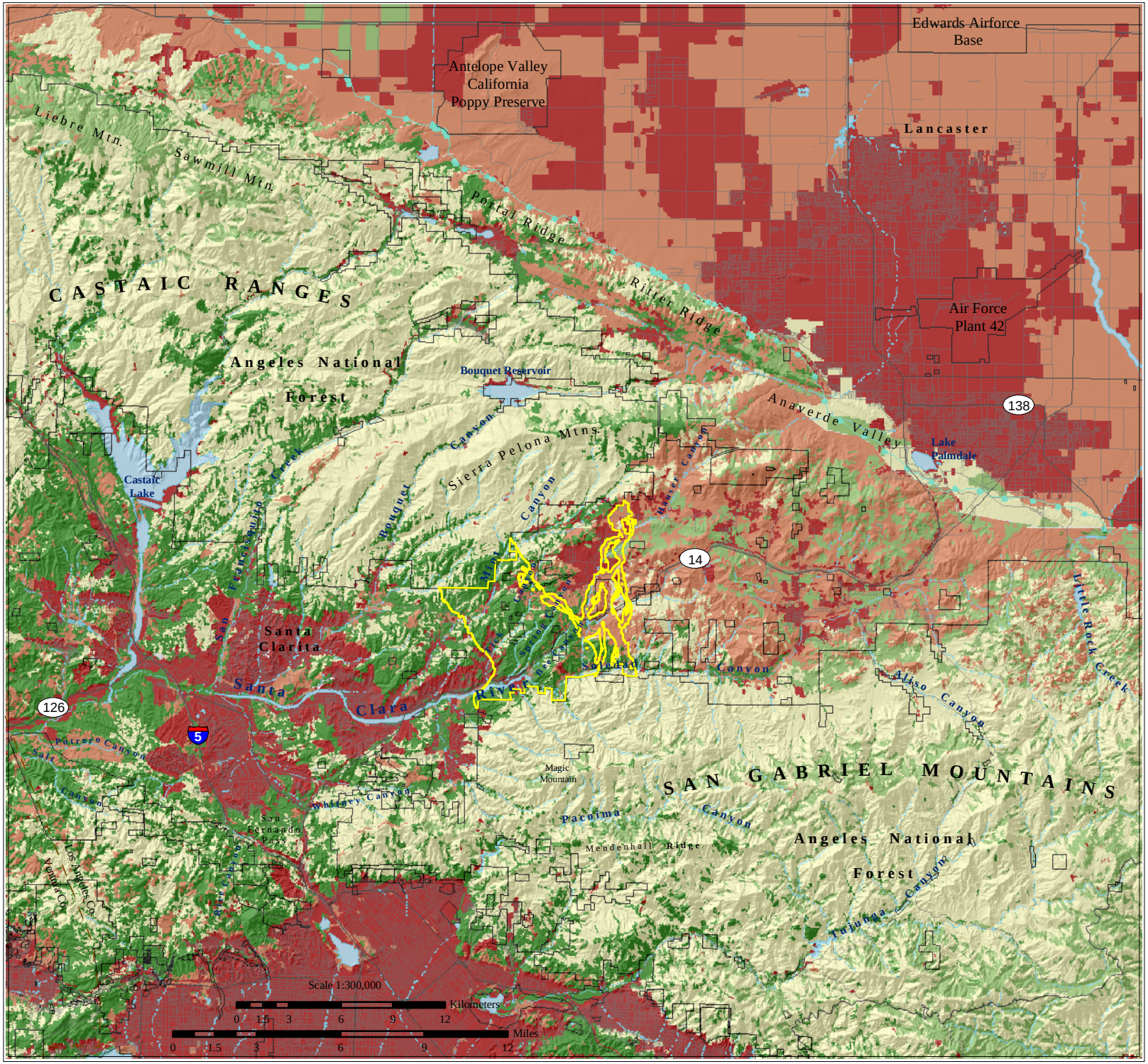

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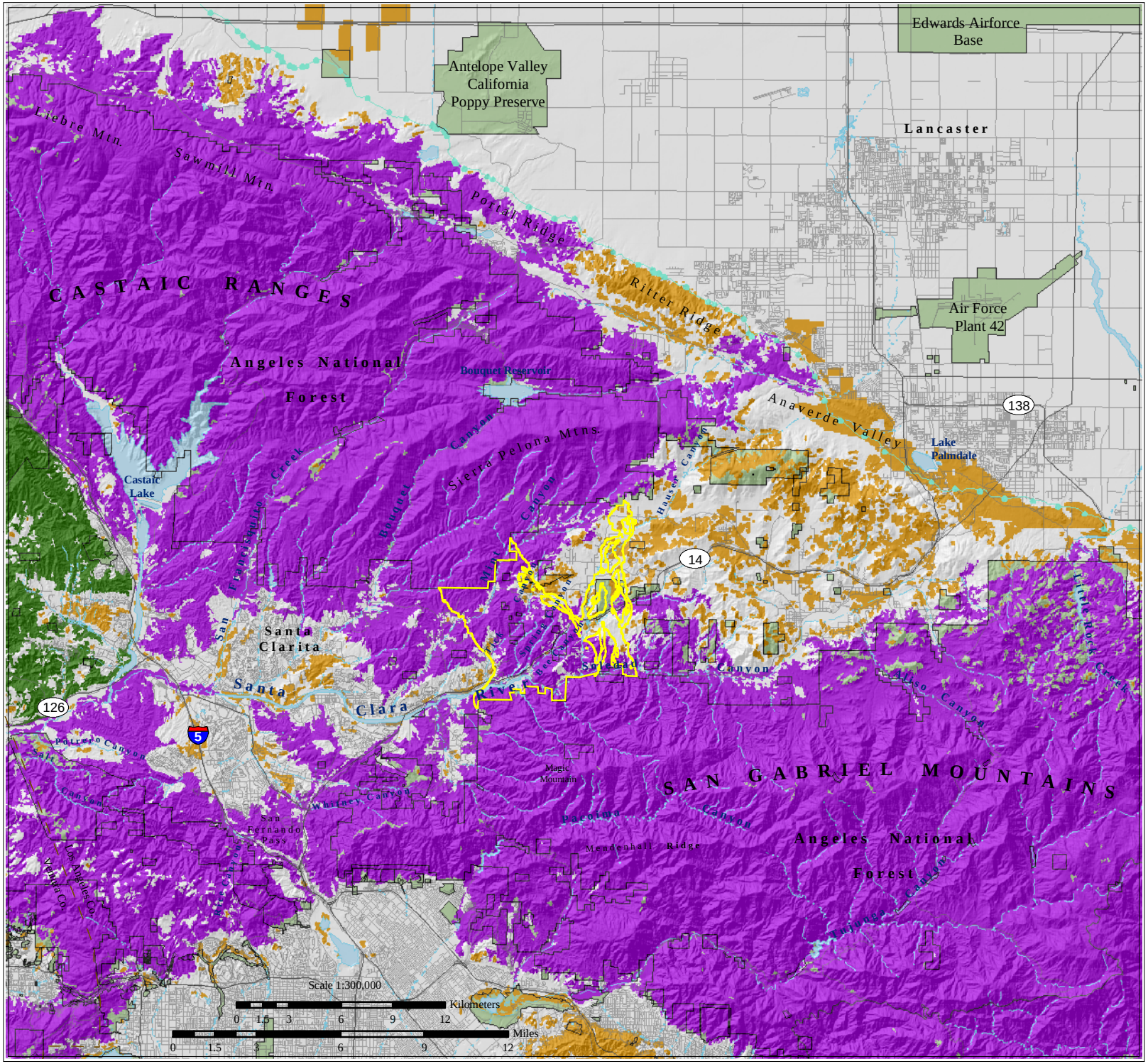
Figure 17.
Potential Cores & Patches for Mountain Lion
(Puma concolor)

Legend

- Least Cost Union
- Core
- Patch
- < Patch
- Paved Roads
- Hydrography
- Lakes & Reservoirs
- Aqueduct
- Ownership Boundaries
- County Boundaires



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- 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.

American Badger (*Taxidea taxus*)

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

Habitat Associations: Badgers are largely considered habitat specialists, associated with grasslands, prairies, and other open habitats (Banfield 1974, de Vos 1969, 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). They prefer friable soils for excavating burrows and require abundant rodent populations (Banfield 1974; de Vos 1969, Sullivan 1996). 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).

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 females at 137-725 ha (Long 1973, Lindzey 1978, Messick and Hornocker 1981, CDFG 1999). Though, 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). Badgers may exhibit seasonal changes in home range size, being more restricted in winter (CDFG 1999). In Minnesota, Sargeant and Warner (1972) radio-collared a female badger, whose overall home range encompassed 850 ha; range was restricted to 725 ha in summer, 53 ha in autumn, and to a mere 2 ha area in winter. In Utah, Lindsey (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, scrubs, riparian, 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 fifty badgers are equal to or greater than 16,000 ha in size. Patch size is $\geq$ 400 ha but < 16,000 ha. Dispersal distance for badgers was defined as 220 km, twice the longest recorded distance.

Results & Discussion: Extensive potentially suitable Badger habitat exists in the San Gabriel and Castaic Ranges of the Angeles National Forests. The model identified vast amounts of habitat for this species between protected core areas, with the most highly suitable habitat in the eastern portion of the planning area, which is dominated by desert scrub and juniper woodland habitats (Figure 18). In the western branch of the Least Cost Union, the model identified habitat in the Santa Clara River, in Bee, Spring, and lower Aqua Dulce canyons, and in Tapie, Tick, Plum, Mint, and Vasquez canyons as potentially suitable habitat, the greater part of which was included in the Least Cost Union (Figure 19). The eastern branch of the Union was delineated by the permeability analysis based solely on the preferred habitat of Badger (Figure 19) and includes almost the entire length of Aqua Dulce Canyon, incorporating riparian, desert scrub and juniper woodlands, as well as the grassland habitats of the Sierra Pelona Valley; portions of Escondido Canyon; and the desert scrub and coastal scrub habitats between Aqua Dulce and Long Canyons south of SR-14.

Extensive core habitat areas also exist outside of the Least Cost Union (Figure 19). To the east of the Union, highly suitable habitat was identified in Hauser, Santa Margarita, Escondido, Hughes, Long, and Bobcat canyons, and on Ritter Ridge. Immediately west of the Union, the analysis identified suitable habitat on Cruzan Mesa and in upper Plum and Bouquet Canyons. We propose habitat be added to the eastern branch of the union, along Agua Dulce and Hauser Canyons, to accommodate badger. The additions to the Union for other focal species would also be advantageous to badger. With the recommended additions, the linkage will also likely serve this species.

The linkage between the San Gabriel and Santa Susana Mountains also emerged from the analysis as a valuable habitat connection for badger (Figure 18, 19). The analysis identified core habitat in Placerita, Whitney, and Elsmere canyons to the east of S14; habitat in the San Fernando Pass, between SR-14 and I-5; and extensive habitat in the Santa Susana Mountains, including immediately west of I-5 in Rice, Towsley, Salt, and Potrero canyons. Badger was also identified as a focal species for the linkage between the Santa Monica Mountains and the Sierra Madre Range of Los Padres National Forest, which will address habitat connectivity for this species between the Santa Susana and Sierra Madre Mountains. All potentially suitable habitat patches are within the 51 km dispersal distance of this species, although barriers to movement may exist between suitable habitat patches.

In Britain, road mortality is the leading cause of death of badgers, with an estimated 50,000 killed on roads each year (Clarke et al. 1998). To restore and protect habitat connections for badger, we recommend that:

- Habitat is added to the eastern branch of the Least Cost Union to a 2 km width;
- Habitat in Soledad, Aqua Dulce, Hauser and Spring Canyons be restored;
- Existing road density be maintained or reduced; no new roads in the Linkage Design;
- Badger tunnels are installed under major transportation routes (e.g., SR-14 and along Sierra Highway);

Figure 18.
Habitat Suitability
for
American Badger
(Taxidea taxus)

Legend

- Least Cost Union

Degree of Suitability

- High
- Medium to High
- Medium
- Low to Medium
- Low
- Paved Roads
- Hydrography
- Lakes & Reservoirs
- Aqueduct
- Ownership Boundaries
- County Boundaires

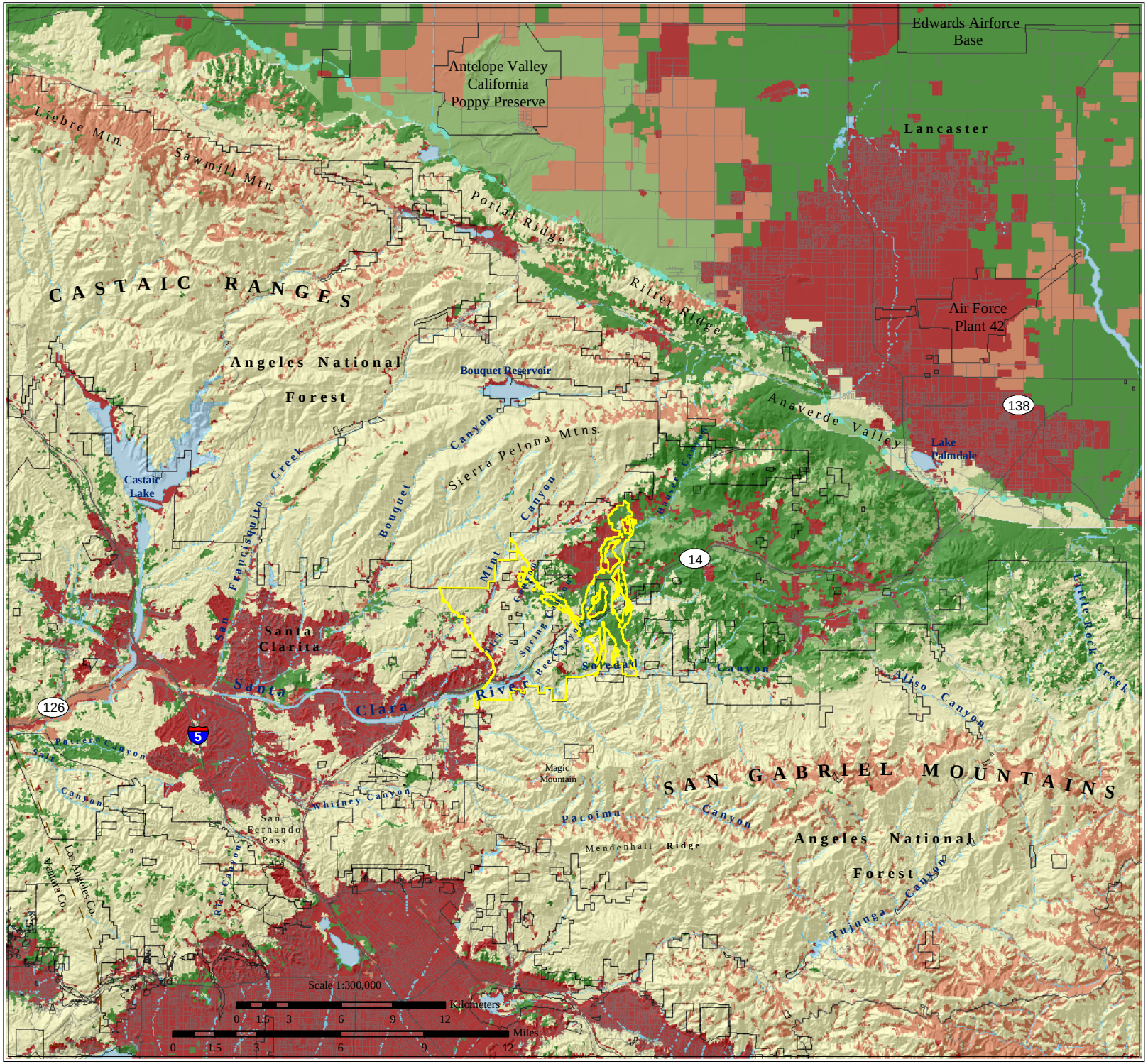

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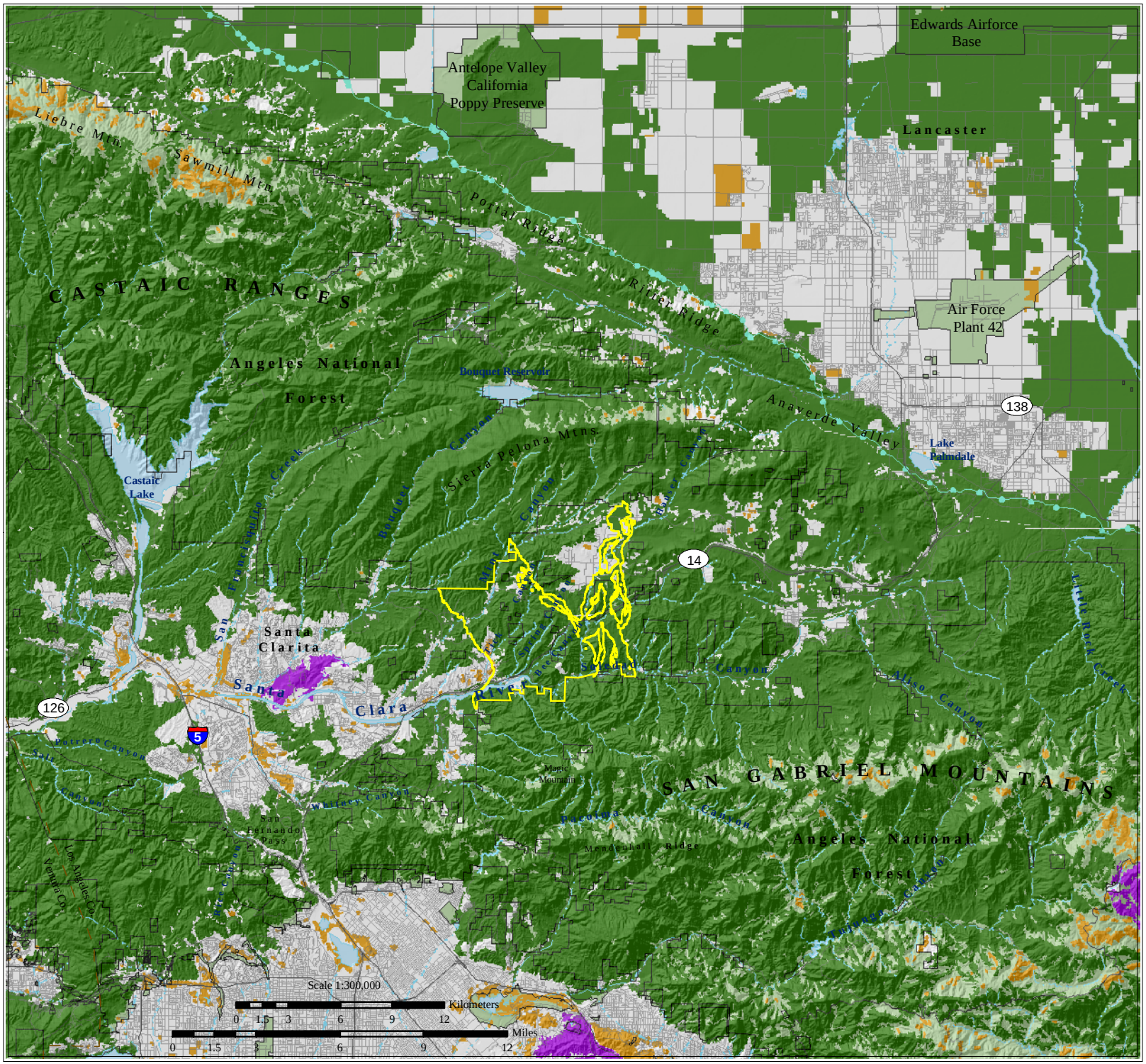
Figure 19.
Potential Cores & Patches
for
American Badger
(Taxidea taxus)

Legend

- Least Cost Union
- Core
- Patch
- < Patch
- Paved Roads
- Hydrography
- Lakes & Reservoirs
- Aqueduct
- Ownership Boundaries
- County Boundaires



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

Mule Deer (*Odocoileus hemionus*)

Photo Courtesy of USFWS

Distribution & Status: Mule deer have a widespread distribution in California and are common to abundant in appropriate habitat; they are absent from areas with no cover, such as 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.

Habitat Associations: This species requires a mosaic of habitat types of different age classes to meet its life history requirements (CDFG 1983). They 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. Several home range estimates exist in the literature, ranging 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 further 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 (Loft et al. 1998, USFS 2002, CDFG 1983, Nicholson et al.1997). 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: They utilize grassland, and meadow habitats, reaching their highest densities in oak woodland. Requires access to perennial water. Patch size was classified as ≥ 100 ha but < 16,000 ha. Core areas potentially supporting 50 or more deer are equal to and greater than 16,000 ha. Dispersal distance was defined as 434, or twice the maximum distance recorded.

Results & Discussion: Extensive core habitat for Mule deer occurs throughout both the San Gabriel and Castaic Ranges. The Least Cost Union captured a contiguous block of habitat between these ranges, supporting highly suitable habitat for Mule deer in the Santa Clara River, in Bee, Spring, Tapie, Tick and Mint canyons (Figure 20). Thus, the linkage will likely serve the needs of Mule deer living in or moving through the linkage (Figure 21).

Other core habitat not incorporated into the Union, occurs immediately to the west in upper Plum, Bouquet and Haskell canyons, and to the east in upper Tick and Mint canyons, and in Long, Bobcat, and Escondido canyons. Further east, large patches of habitat occur in the Anaverde Valley and on Ritter Ridge. The recommended additions to the Union that were added to support other focal species will also benefit Mule deer.

Extensive core habitat for Mule deer also occurs in the Santa Susana Mountains (Figure 21). Thus, the San Gabriel to Santa Susana Mountains Connection also emerged from the analysis as an essential habitat linkage for Mule deer. The analysis identified core habitat in Placerita, Whitney, and Elsmere canyons to the east of S14; habitat in the San Fernando Pass, between SR-14 and I-5; and extensive habitat in the Santa Susana Mountains, including immediately west of I-5 in Rice, Towsley, Salt, and Potrero canyons. Mule deer was also identified as a focal species for the linkage between the Santa Monica Mountains and the Sierra Madre Range of Los Padres National Forest, which will address habitat connectivity for this species between the Santa Susana and Sierra Madre Mountains. 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.

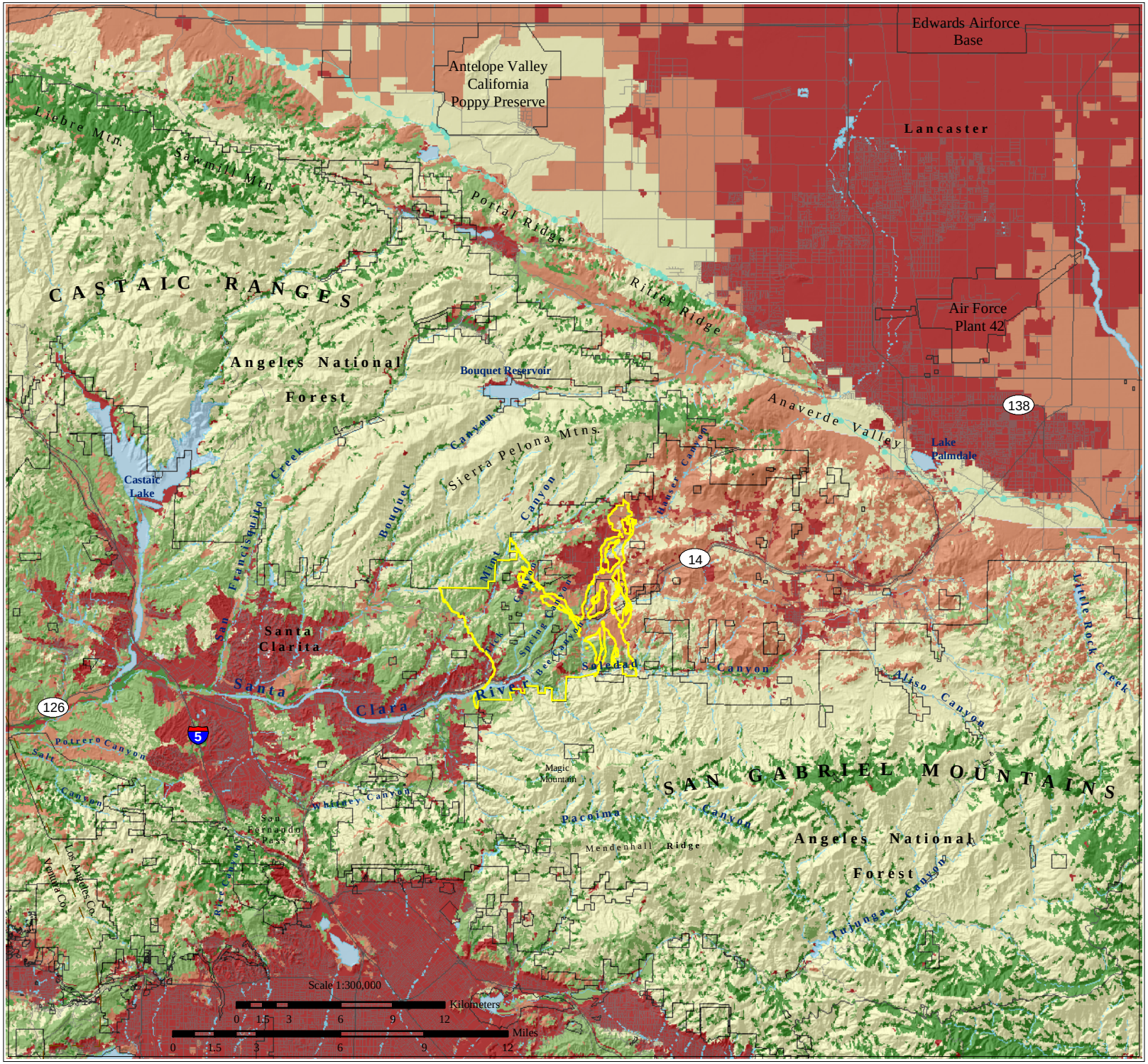
Estimates of the number of deer killed annually on U.S. roads ranges from 720,000 to 1.5 million (Romin and Bissonette 1996, Conover 1997, Forman et al. 2003). Vehichle collisions with deer result in loss of human lives and impacts to the wildlife resource (Reed et al. 1975). To restore and protect habitat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

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

Figure 20.
Habitat Suitability
for
Mule Deer
(Odocoileus hemionus)



Legend

- Least Cost Union

Degree of Suitability

- High
- Medium to High
- Medium
- Low to Medium
- Low
- Paved Roads
- Hydrography
- Lakes & Reservoirs
- Aqueduct
- Ownership Boundaries
- County Boundaires

N

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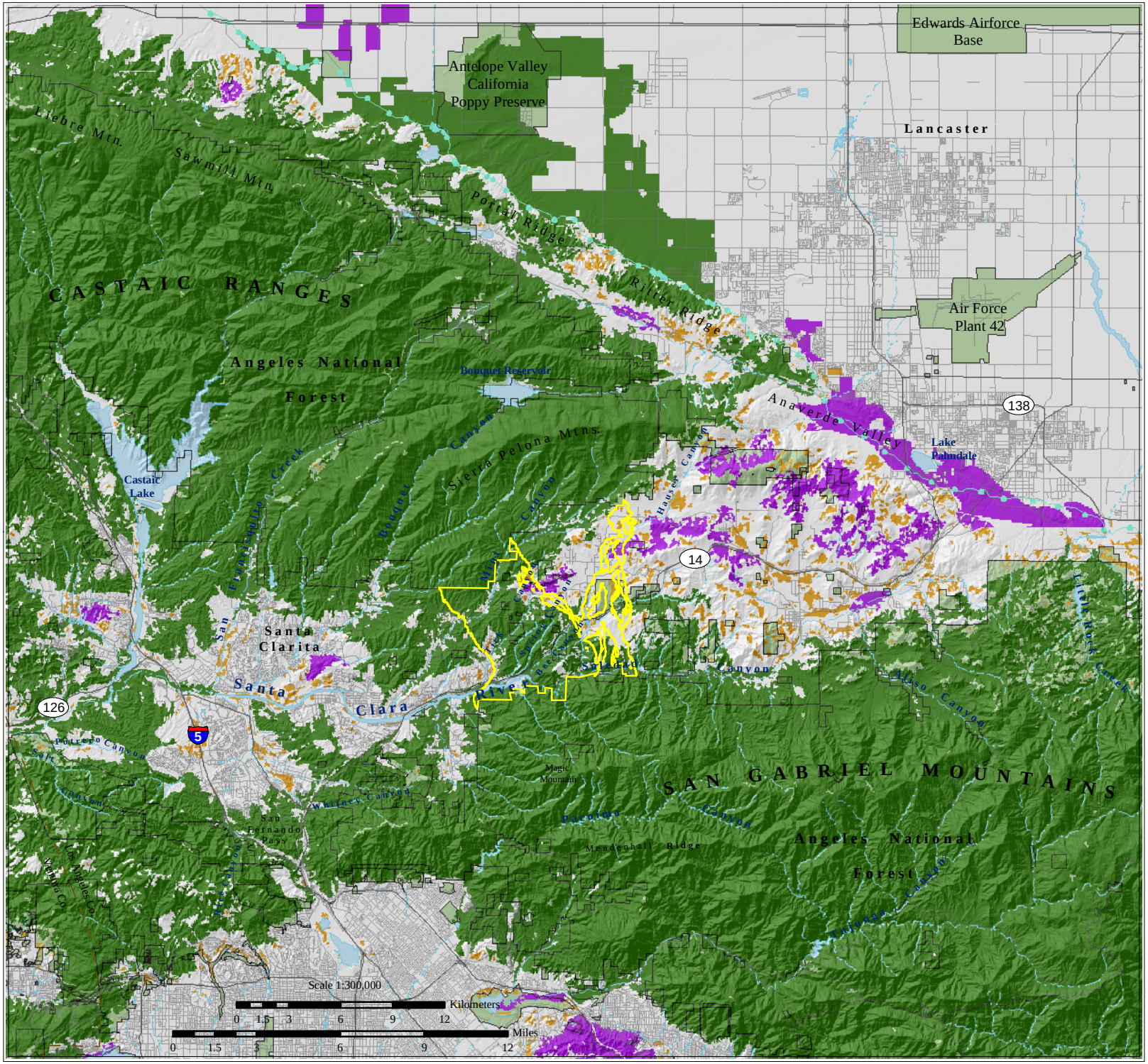
Figure 21.
Potential Cores & Patches for Mule Deer
(Odocoileus hemionus)

Legend

- Least Cost Union
- Core
- Patch
- < Patch
- Paved Roads
- Hydrography
- Lakes & Reservoirs
- Aqueduct
- Ownership Boundaries
- County Boundaires



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- Existing road density be maintained or reduced; no new roads in the Linkage Design; and
- Habitat restoration efforts are initiated in Soledad, Spring, Hauser, and Aqua Dulce Canyons.

Pacific Kangaroo Rat (*Dipodomys agilis*)

Distribution & Status: The Pacific kangaroo rat was recently split into 2 species, D. agilis and D. simulans (Dulzura kangaroo rat); both have the potential to occur within the planning area. The distribution of these species extends from the coastal mountains of Baja California and southern California 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, Sullivan and Best 1997, CDFG 1990). It occurs at higher elevations (up to about 7,000 feet) in scrub and chaparral habitats (W. Spencer pers. comm.) but has been found as high as 2250 m (7400 ft) (CDFG 1990). This species 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 alluvial fan sage scrub (Price et al. 1991) and montane coniferous forests (Sullivan and Best 1997). However, their distribution is somewhat limited by the presence of water (Carpenter 1966, Christopher 1973, CDFG 1990) and they also require friable soils in which to burrow (CDFG 1990). This species may be associated with Atriplex and chenopodium scrubs (W. Spencer pers. comm.) as well as *Croton californicus*, *Cryptantha clevelandi*, and *Corethrogyne filaginifolia* (Meserve 1986). Goldingay and Price (1997) found them to be particularly abundant in ecotonal habitats. It frequents open chaparral and coastal sage scrub vegetation (Keeley and Keeley 1988, M'Closkey 1976, Price and Kramer 1984, Price et al. 1991, Meserve 1976) and increases in abundance following fires that create openings in the 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.

The Pacific kangaroo rat tends to be more mobile than most rodents of their size or than other kangaroo rats. Most information on movements and ecology are very similar to Merriam's kangaroo rat, although with less supporting literature (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; 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 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, they may actually disperse between adjacent mountain ranges via linkages, at least over multiple generations (W. Spencer pers. comm.).

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 below 2,250 meters in elevation. Patch size was defined as $\geq$ 0.5 ha and < 8 ha. Core areas were defined as $\geq$ 8 ha. Dispersal distance for these species hasn't been measured, so twice the dispersal distance for Merriam's kangaroo rat (768 m) was used.

Results & Discussion: Core habitat for this kangaroo rat occurs throughout the planning area. Between the San Gabriel Mountains and Castaic Range protected core areas, the Least Cost Union captured the most highly suitable habitat in Bee, Spring, Tapie, Tick and Mint canyons (Figure 22). Thus, the linkage will also likely serve the needs of the Pacific kangaroo rat (Figure 23).

Other highly suitable core habitat not incorporated into the Union, occurs immediately to the west in upper Plum, Bouquet and Haskell canyons, and to the east in Hauser, Agua Dulce, Long, Bobcat, and Escondido canyons (Figure 22). Further east, highly suitable habitat occurs in the Anaverde Valley and on Ritter Ridge. Land added to the Union to support other focal species will also provide habitat for the Pacific kangaroo rat.

Extensive core habitat also occurs in the Santa Susana Mountains. Thus, the San Gabriel to Santa Susana Mountains Connection also surfaced as an important connection for this species. The analysis identified core habitat in Placerita, Whitney, and Elsmere canyons to the east of SR-14; habitat in the San Fernando Pass, between SR-14 and I-5; and extensive habitat in the Santa Susana Mountains, including immediately west of I-5 in Rice and Towsley canyons. 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:

Figure 22.
Habitat Suitability
for
Pacific Kangaroo Rat
(Dipodomys agilis)

Legend

Degree of Suitability

- High
- Medium to High
- Medium
- Low to Medium
- Low
- Least Cost Union
- Paved Roads
- Hydrography
- Lakes & Reservoirs
- Aqueduct
- County Boundaires

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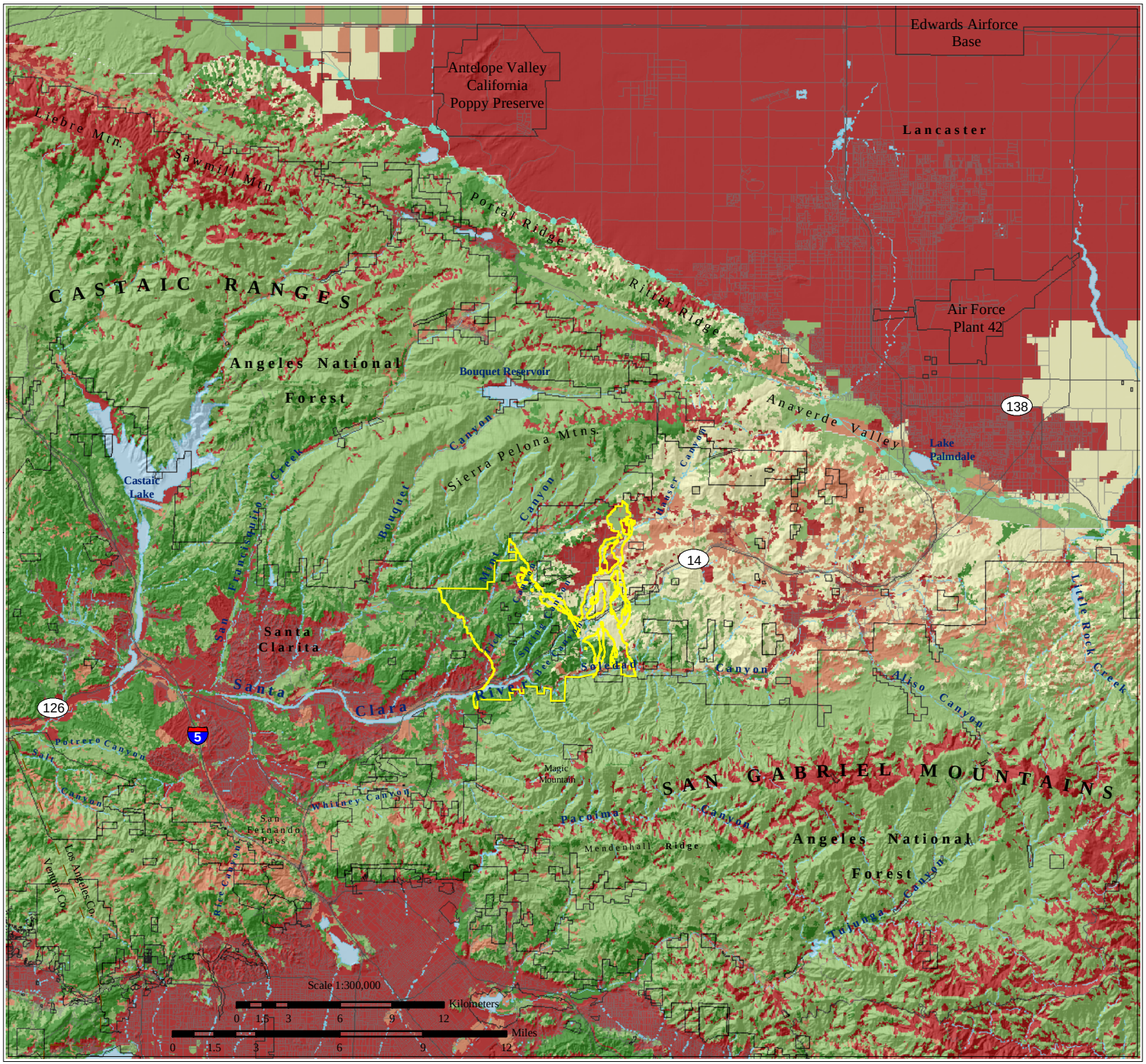
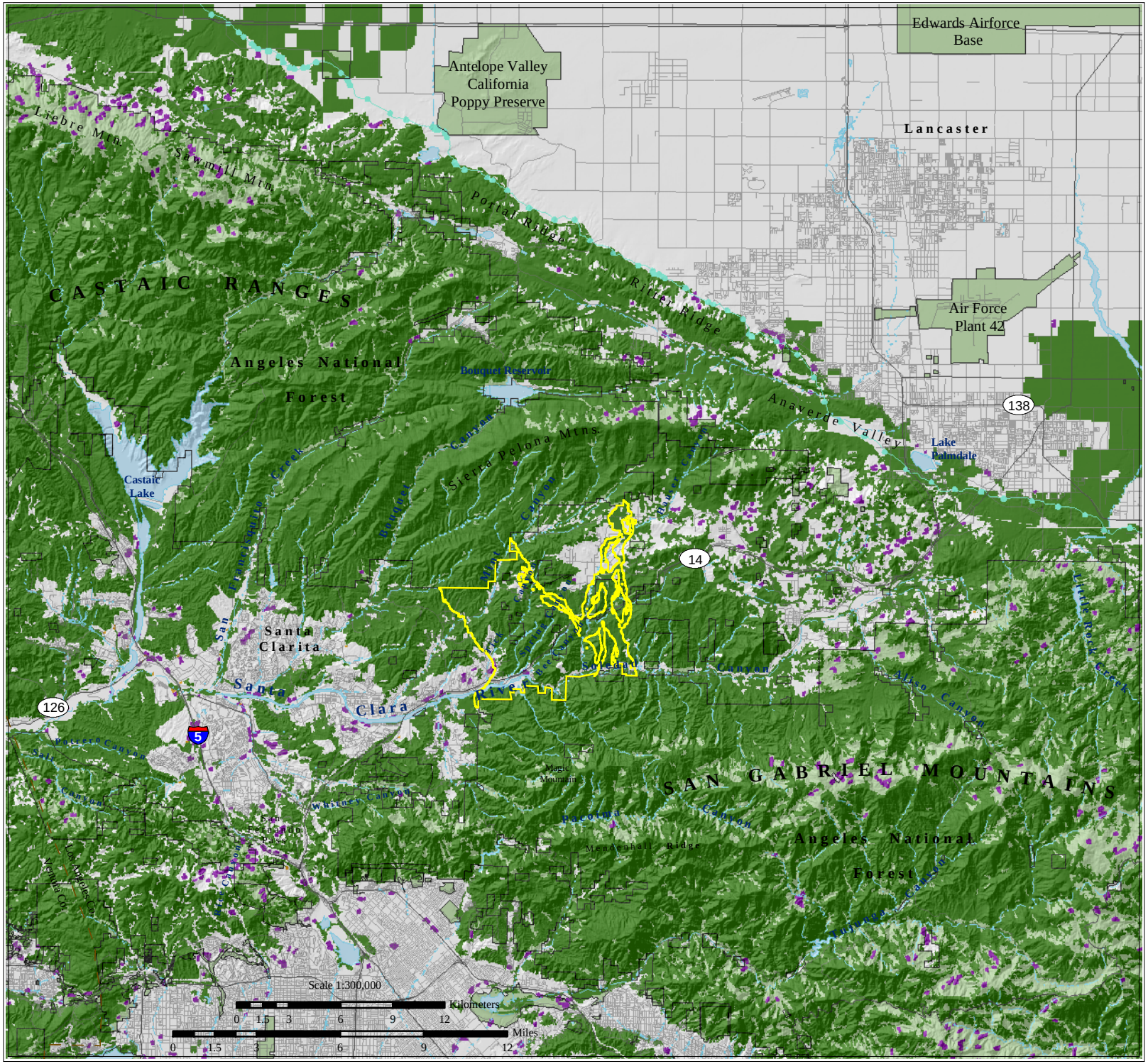


Figure 23.
Potential Cores & Patches
for
Pacific Kangaroo Rat
(Dipodomys agilis)

Legend

- Core
- Patch
- < Patch
- Least Cost Union
- Paved Roads
- Hydrography
- Lakes & Reservoirs
- Aqueduct
- County Boundaires
- Ownership Boundaries



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- Crossing structures for small mammals be placed fairly frequently to facilitate movement across major transportation routes (i.e., SR-14, Sierra Highway) and reduce travel distance (Jackson and Griffin 2000, McDonald and St. Clair 2004);

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

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

- Local residents are informed about the proper use of rodenticides and pesticides to reduce the likelihood of ingestion of these lethal substances on small mammals indigenous to the area.

California Spotted Owl (*Strix occidentalis occidentalis*)

Distribution & Status: The California spotted owl is one of three subspecies that inhabits the Sierra Nevada and southern California 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 of the owl 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). Foraging habitat for this subspecies can be more variable than its northern relative, sometimes hunting in chaparral, relatively open terrain for this species (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 been conducted (Miller et al. 1997, Ganey et al. 1998, Willey and van Riper 2000) that recorded even greater distances, up to 72.1 km (LaHaye et al. 2001).

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

Results & Discussion: Occupied California spotted owl territories are known to occur in suitable montane hardwood and conifer habitats in both the San Gabriel and Castaic protected core areas. Although, the model identified small patches of montane riparian habitat in the upper Santa Clara River, Aqua Dulce Creek, and Mint Canyon, no suitable nesting habitat occurs within the Least Cost Union (Figure 24). However, this species is known to forage in open habitats. All suitable habitat patches are well within the maximum dispersal distance of 72.1 km; an individual could easily traverse the linkage in one night. We conclude that while the Least-Cost Union may not provide live-in habitat, it can sustain movement needs among populations of owls, and serve a critical function of preserving this top predator. The Linkage may serve to protect hunting habitat for California spotted owl, with minimal levels of light pollution and low road density.

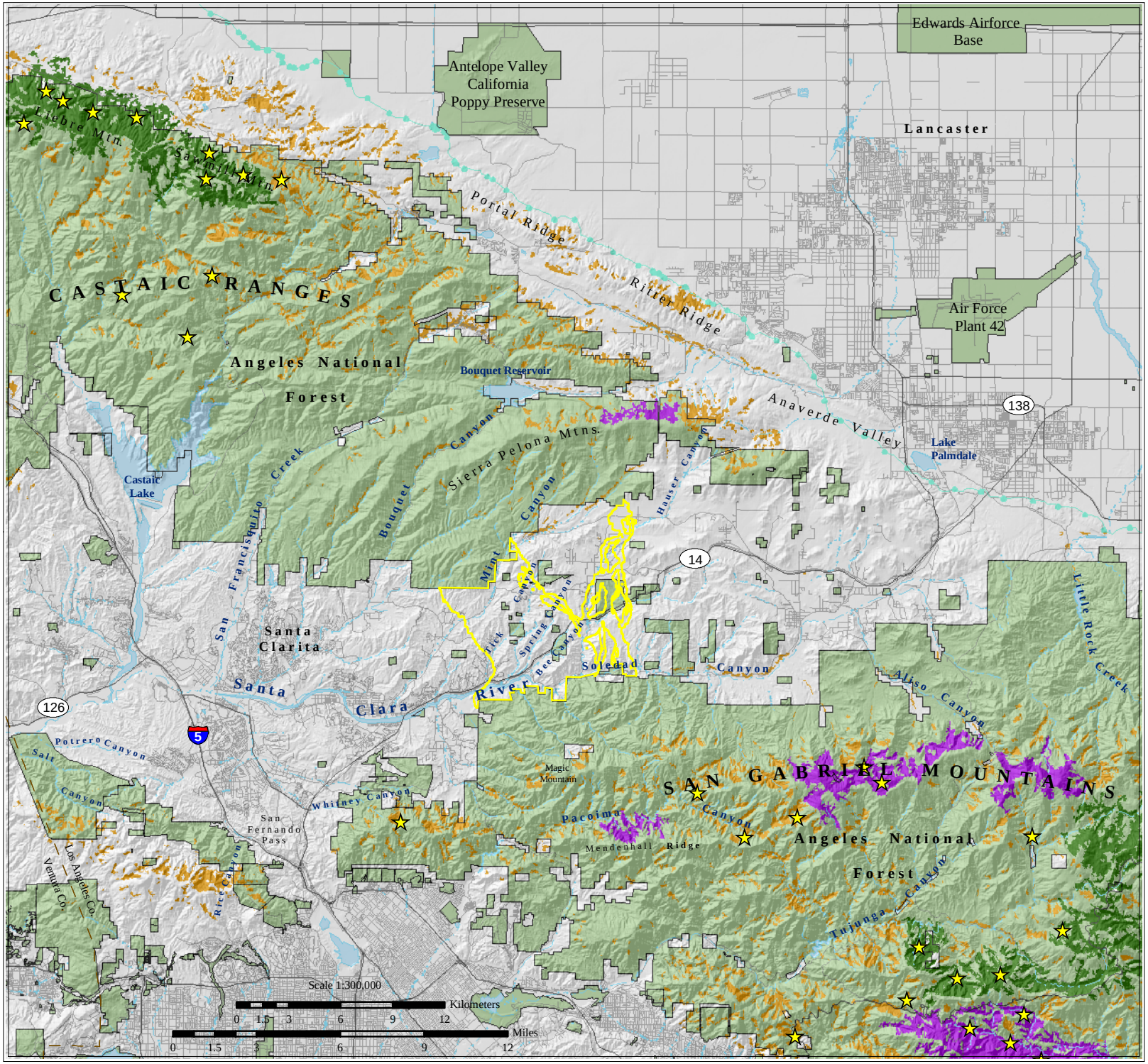
Research shows that northern spotted owls (*S. o. caurina*) living in close proximity to roads experienced higher levels of physiological stress than owls living in areas without roads (Wasser et a. 1997). To maintain and protect landscape level connectivity for California spotted owl between the San Gabriel and Castaic protected core areas, 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);
- Riparian habitat in Agua Dulce and Soledad Canyons be restored; 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)

Legend

- Least Cost Union
- Core
- Patch
- < Patch
- Recorded Occurence
- Paved Roads
- Hydrography
- Lakes & Reservoirs
- Aqueduct
- County Boundaires
- Ownership Boundaries



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Burrowing owl (*Athene cunicularia*)

Photo credit: Sharon Cummings

Justification for Selection: Burrowing owl is sensitive to habitat loss and fragmentation from agricultural and urban land uses (Grinnell and Miller 1944, Zarn 1974, Remsen 1978, CDFG 1990). They are particularly vulnerable to roadkill (CDFG 1990).

Distribution & Status: Formerly common in appropriate habitat throughout the state, excluding the northwest coastal forests and high mountains. Although recorded at elevation of up to 5,300 ft (1615 m) (CDFG 1990), burrowing owls are primarily associated with low-elevation valleys (USFS 2002). The species is experiencing precipitous population declines throughout most of the western United States, and has disappeared from most of its historical range in California. Nearly 60% of California burrowing owl colonies that existed in the 1980s were gone by the early 1990s (DeSante and Ruhlen 1995, DeSante et al. 1997, USFS 2002). Once widespread, its distribution is now highly localized and fragmented. The Burrowing owl is identified as both a Federal and State Species of Special Concern (CDFG 2001).

Habitat Associations: Prefers open, dry grassland and desert scrub habitats, in areas with little or no vegetation but may also inhabit open shrub stages of pinyon-juniper and ponderosa pine habitats (Small 1994). They may also occupy habitat on the fringe of agricultural areas (including pastures and untilled margins of cropland), or in other edge habitats such as the margins of airports, golf courses, and roads (Millsap and Bear 2000, Haug et al. 1993, USFS 2002), though are probably relatively scarce in these environments. Key habitat characteristics include open, well-drained terrain; short, sparse vegetation; and underground burrows. They hunt in open habitats (Haug and Oliphant 1990). Throughout their range they depend on burrows excavated by fossorial mammals and reptiles for roosting and nesting (Karalus and Eckert 1987, USFS 2002). Though they've also been documented using pipes, culverts, or other tunnel like structures, and nest boxes where burrows are scarce (Haug et al. 1993, Robertson 1929, CDFG 1990).

Spatial Patterns: Home range sizes vary drastically, from 0.04 to 481 ha (Thomsen 1971, Haug and Oliphant 1990). Thomsen (1971) calculated home range sizes at Oakland Airport from 0.04-1.6 ha. Grant (1965) reported home ranges sizes from 4.9 to 6.5 ha, while Butts (1973) found home ranges up to 240 ha. The largest home range recorded for this species is 481 ha in Sakatchewan (Haug and Oliphant 1990). Breeding pairs in California are presumed to require a minimum of 2.6 ha of contiguous habitat (CDFG 1995, USFS 2002). Natal dispersal distances up to 30 km have been reported (Haug et al. 1993, USFS 2002).

Conceptual Basis for Model Development: This species prefers the open terrain of grassland and desert scrub communities below 1615 m in elevation. Patch size was defined as greater than or equal to 6 ha but less than 3,000 ha. Core areas were

defined as ≥ 3,000 ha. Dispersal distance was defined by using twice the recorded distance of 60 km (30 km x 2).

Results & Discussion: Suitable habitat for Burrowing owl is not well represented in either the San Gabriel or Castaic protected core areas, although patches of habitat occur within both these ranges. Burrowing owl is an orthogonal species, with the majority of its core habitat occurring at lower elevations, between protected core areas, in the linkage itself. The Least Cost Union captured considerable habitat for this species (Figure 25), enough to perhaps ensure this species persistence in the linkage in perpetuity (i.e., ≥ 3,000 ha). Over 4,500 ha of suitable habitat were included in the Union, more than enough to constitute a core area (i.e., capable of supporting 50 individuals, or 25 pairs). With the recommended additions, the Linkage Design will also likely serve the needs of Burrowing owl living in the linkage.

Highly suitable core habitat not incorporated into the Union, occurs immediately to the west in upper Plum, Bouquet and Haskell canyons. Further west, core habitat was identified in San Francisquito, Castaic, San Martinez Grande, Potrero, and Salt canyons. In addition, significant patches of suitable habitat were identified in Towsley, Rice and East canyons, the San Fernando Pass, and in Placerita, Whitney, and Elsmere canyons. Immediately to the east of the Union, highly suitable habitat was identified in Agua Dulce, Hauser, Long, Bobcat, and Escondido canyons (Figure 26). Other likely core habitat areas exist on Portal and Ritter Ridges on the northeastern slopes of the Castaic Ranges, at the Antelope Valley California Poppy Preserve, and in the open scrub habitats of the desert further east. 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.

To restore and protect habitat for this orthogonal species, we recommend that:

- Habitat is added to the eastern branch of the Least Cost Union to a 2 km width;
- Habitat in Aqua Dulce, Hauser and Spring Canyons be restored;
- 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 25.
Potential Cores & Patches for Burrowing Owl
(Speotyto cunicularia)

Legend

- Least Cost Union
- Core
- Patch
- < Patch
- Paved Roads
- Hydrography
- Lakes & Reservoirs
- Aqueduct
- Ownership Boundaries
- County Boundaires

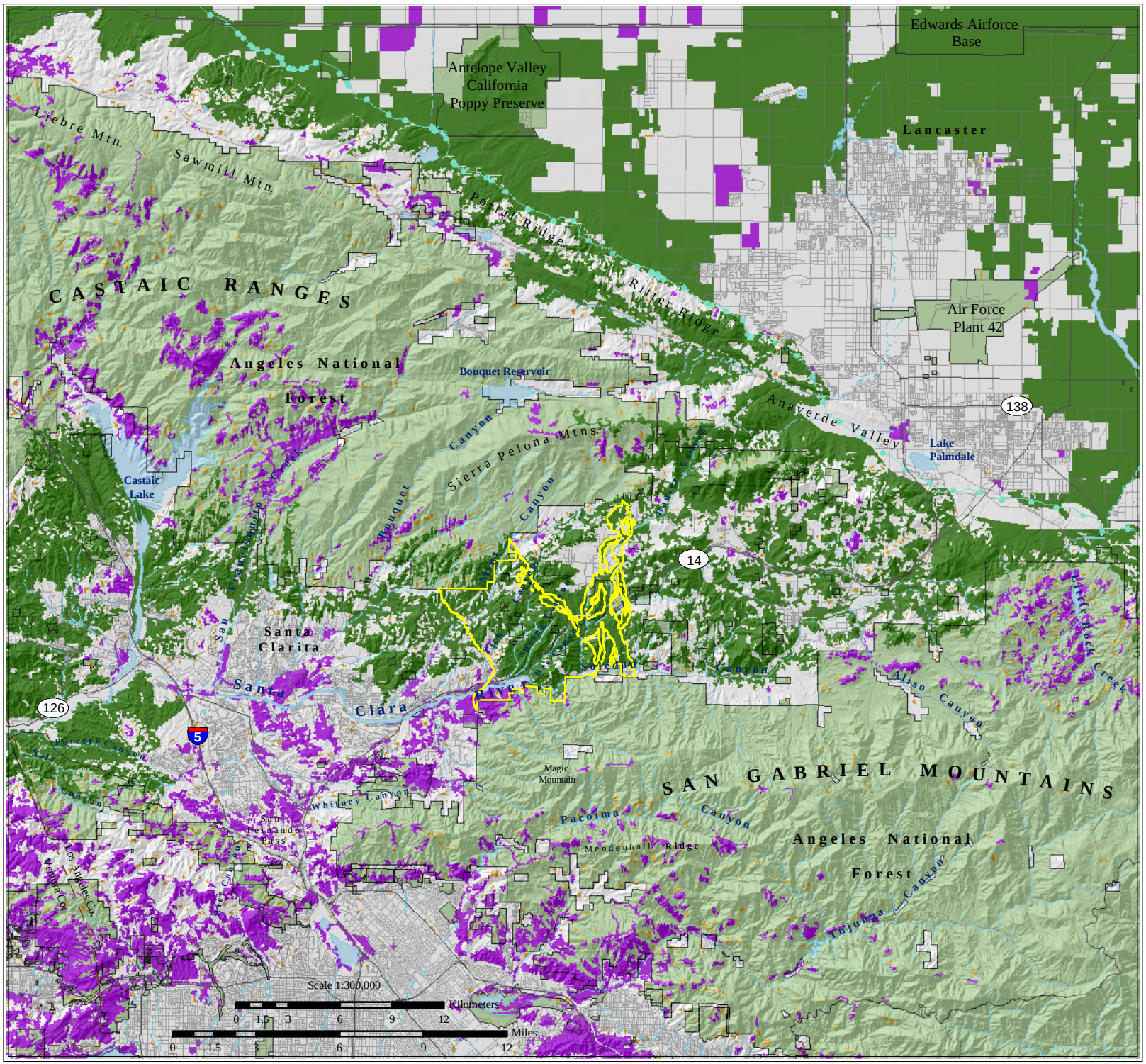

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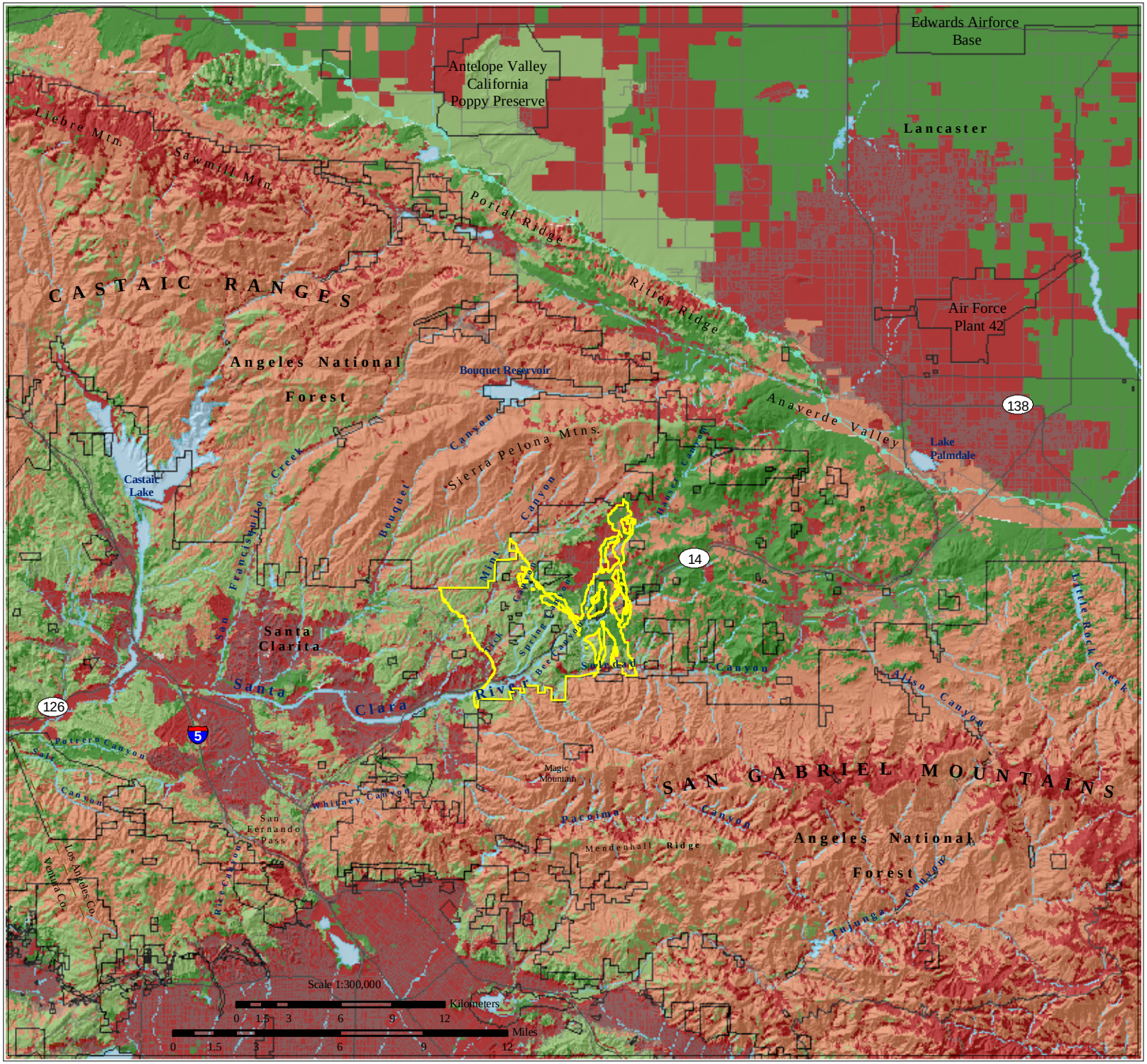
Figure 26.
Habitat Suitability
for
Burrowing Owl
(Speotyto cunicularia)

Legend

- Least Cost Union

Degree of Suitability

- Low
- Low to Medium
- Medium
- Medium to High
- High
- Paved Roads
- Hydrography
- Lakes & Reservoirs
- Aqueduct
- Ownership Boundaries
- County Boundaires



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California thrasher (*Toxostoma redivivum*)

Justification for Selection: This is one of the first species to disappear from isolated fragments (Soulé et al. 1988). Loss of habitat to urban and agricultural development constitutes the most serious threat to populations (Robertson and Tenney 1993, Cody 1998).

Distribution & Status: California thrasher is endemic to the coastal and foothill areas of the California Floristic Province into adjacent areas of northwest Baja California (Cody 1998). In southern California, it occurs in montane chaparral up to 2000 m (6000 ft) (CDFG 1990). This species isn't afforded any special status.

Habitat Associations: California thrasher is primarily associated with dense chaparral though it may also occur in adjacent oak woodland and riparian habitats (Cody 1998). This species avoids oak woodland devoid of understory (Robertson and Tenney 1993), although it may use these habitats outside the breeding season (Cody 1998). Some vegetation communities on desert slopes may also provide habitat, including pinyon-juniper and Joshua tree woodlands (Cody 1998).

Spatial Patterns: Home range size may be up to 20 ha (50 ac) in scrub oak desert habitat (Jehl 1978, CDFG 1990). In the Santa Monica Mountains, territories averaged 1.4 ha (3.5 ac) (Kingery 1962, CDFG 1990). California thrasher is mostly a sedentary resident species, although there may be some local movement in the nonbreeding season (CDFG 1990).

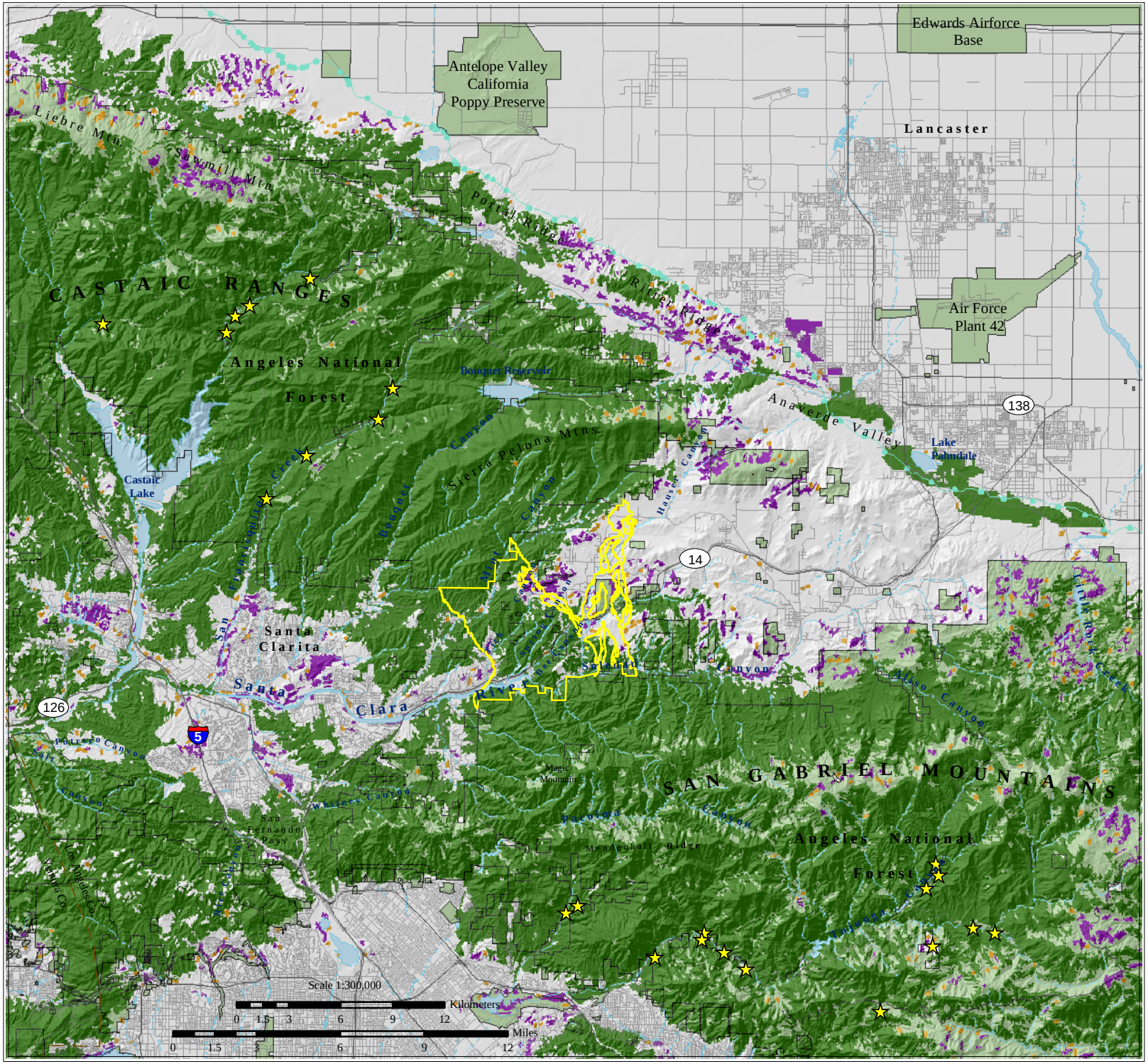
Conceptual Basis for Model Development: This species has a strong preference for chaparral vegetation, though it may also be found in riparian and oak woodland habitats. Home ranges sizes have been recorded between 1.4-20 ha. The minimum patch size was defined as 3 ha, using just over twice the smallest recorded territory (1.4 ha x 2). Patch size was classified as $\geq$ 3 ha but < 300 ha. Core areas potentially supporting 50 or more individuals (i.e., 25 pairs) was defined as $\geq$ 300 ha. Dispersal distance was defined as 6 km.

Results & Discussion: Extensive core habitat exists for California thrasher in the Castaic and San Gabriel protected areas, as well as in the Santa Susana Mountains. The Least Cost Union captured potential core areas of Bee, Spring, Tapie, Tick, and Mint canyons, as well as habitat in lower Aqua Dulce Canyon and in Vasquez Rocks. The spatial configuration of suitable habitat within the Least Cost Union will likely allow for movement between existing protected areas (Figure 27). Highly suitable habitat not captured in the Union occurs to the east in upper Mint and Tick canyons; in Hauser, Escondido, Hughes, Long, and Bobcat canyons; and on Ritter Ridge. Immediately west of the Union, the analysis identified suitable habitat in upper Plum and Bouquet Canyons

Figure 27.
Potential Cores & Patches
for
California Thrasher
(Toxistoma redivivum)

Legend

- Least Cost Union
- Core
- Patch
- < Patch
- Recorded Occurence
- Paved Roads
- Hydrography
- Lakes & Reservoirs
- Aqueduct
- Ownership Boundaries
- County Boundaires



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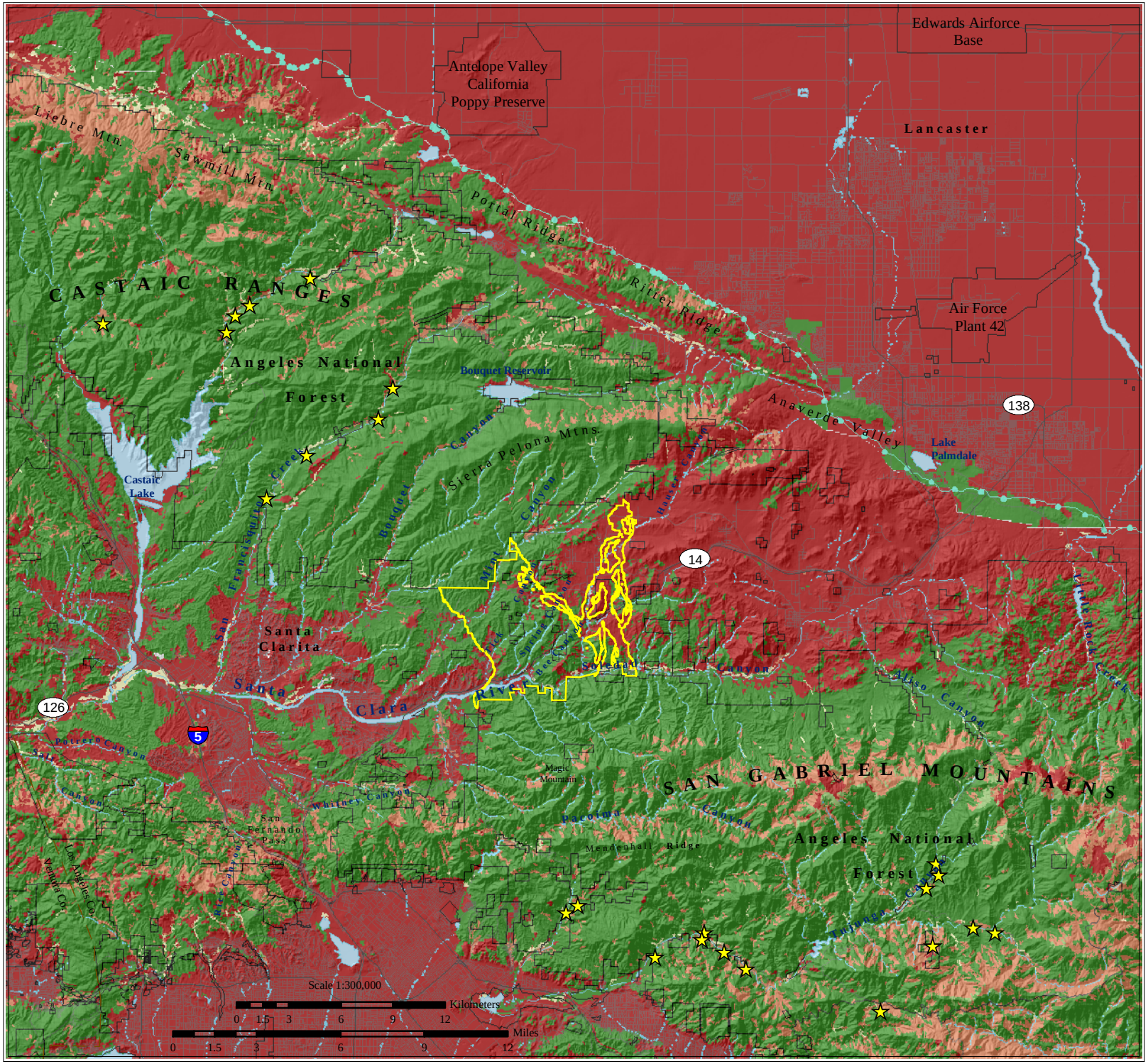
(Figure 28). The additions to the Least Cost Union that were recommended to support other focal species would also benefit California thrasher.

Other core areas not included in the Least Cost Union occur between the San Gabriel and Santa Susana Mountains (Figure 27). Indeed, the analysis identified a very strong connection of contiguous habitat for this species between the San Gabriel and Santa Susana Mountains. California thrasher was also identified as a focal species for the Santa Monica to Sierra Madre Linkage, which will address habitat connectivity for this species between the Santa Susana and Sierra Madre Mountains. All core areas and patches of suitable habitat identified in the analysis are within the dispersal distance of this species.

It seems counterintuitive that birds, because they can fly, would need movement corridors to persist in fragmented landscapes (Machtans et al.1996). However, several studies have shown gaps in habitat may form barriers to songbird movement (Whitcomb et al. 1981, Lynch and Whigham 1984, Lens and Dhondt 1994, Machtans et al. 1996, Debinski and Holt 2000, Bolger et al. 2001). Haas (1995) studied the movement ecology of Brown thrashers (*T. rufum*) and found that wooded corridors channeled movements between habitat patches. To protect and maintain habitat continuity between protected cores areas for California thrasher, we recommend that:

- Existing road density be maintained or reduced; no new roads in the Linkage Design;
- Crossing structures be expansive enough to allow for the development of fairly contiguous habitat;
- Habitat is added to the eastern branch of the Least Cost Union to a 2 km width; and
- Habitat restoration efforts are initiated in Soledad, Aqua Dulce and Spring Canyons.

Figure 28.
Habitat Suitability
for
California Thrasher
(Toxistoma redivivum)



Legend

- Least Cost Union
- Degree of Suitability
  - Low
  - Low to Medium
  - Medium
  - Medium to High
  - High
- Recorded Occurence
- Paved Roads
- Hydrography
- Lakes & Reservoirs
- Aqueduct
- Ownership Boundaries
- County Boundaires

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March 2004
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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 that 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: They 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, dependent on acorns as a major food supply (Ritter 1938, MacRoberts 1970, Bock and Bock 1974; Hannon et al.1987, Koenig and Mumme 1987, Koenig and Haydock 1999, CDFG 1990). 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). Mac Roberts and Mac Roberts (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 in elevation. Home ranges sizes 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: The majority of core habitat for this species occurs within existing protected areas. Although, patches of highly suitable habitat were captured in the Union along the Santa Clara River, in Bear, Aqua Dulce and Mint Canyons, this species needs do not appear to be well accommodated by the Least Cost Union (Figure 29). We recommend additional habitat be added along the Santa Clara River and in upper Mint Canyon to accommodate this species. Theoretically, Acorn woodpecker could move between the San Gabriel and Castaic protected cores areas, as all patches of suitable habitat are within the dispersal distance of this species.

The model actually predicted a much stronger connection for this species between the San Gabriel and Santa Susana Mountains, reinforcing the need to conserve this critical connection. Hardwood and conifer habitats, preferred by this species, occur within and between these ranges in a somewhat contiguous distribution (Figure 30). The analysis identified highly suitable habitat in Whitney and Elsmere canyons to the east of S14; habitat in the San Fernando Pass, between SR-14 and I-5; and extensive habitat in the Santa Susana Mountains, including immediately west of I-5 in Rice and Towsley canyons. Workshop participants also chose Acorn woodpecker as a focal species for the linkage between the Santa Monica Mountains and the Sierra Madre Range of Los Padres National Forest. The movement needs of this species will be addressed by a future report that will deal with Acorn woodpeckers living in, or traveling between the Santa Monica and Sierra Madre Mountains.

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 with 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;
- Crossing structures be expansive enough to allow for the development of fairly contiguous habitat; and
- Habitat restoration efforts are initiated in Soledad and Aqua Dulce Canyons.

Figure 29.
Potential Cores & Patches
for
Acorn Woodpecker
(Melanerpes formicivorus)

Legend

- Least Cost Union
- Core
- Patch
- < Patch
- Recorded Occurence
- Paved Roads
- Hydrography
- Lakes & Reservoirs
- Aqueduct
- Ownership Boundaries
- County Boundaires

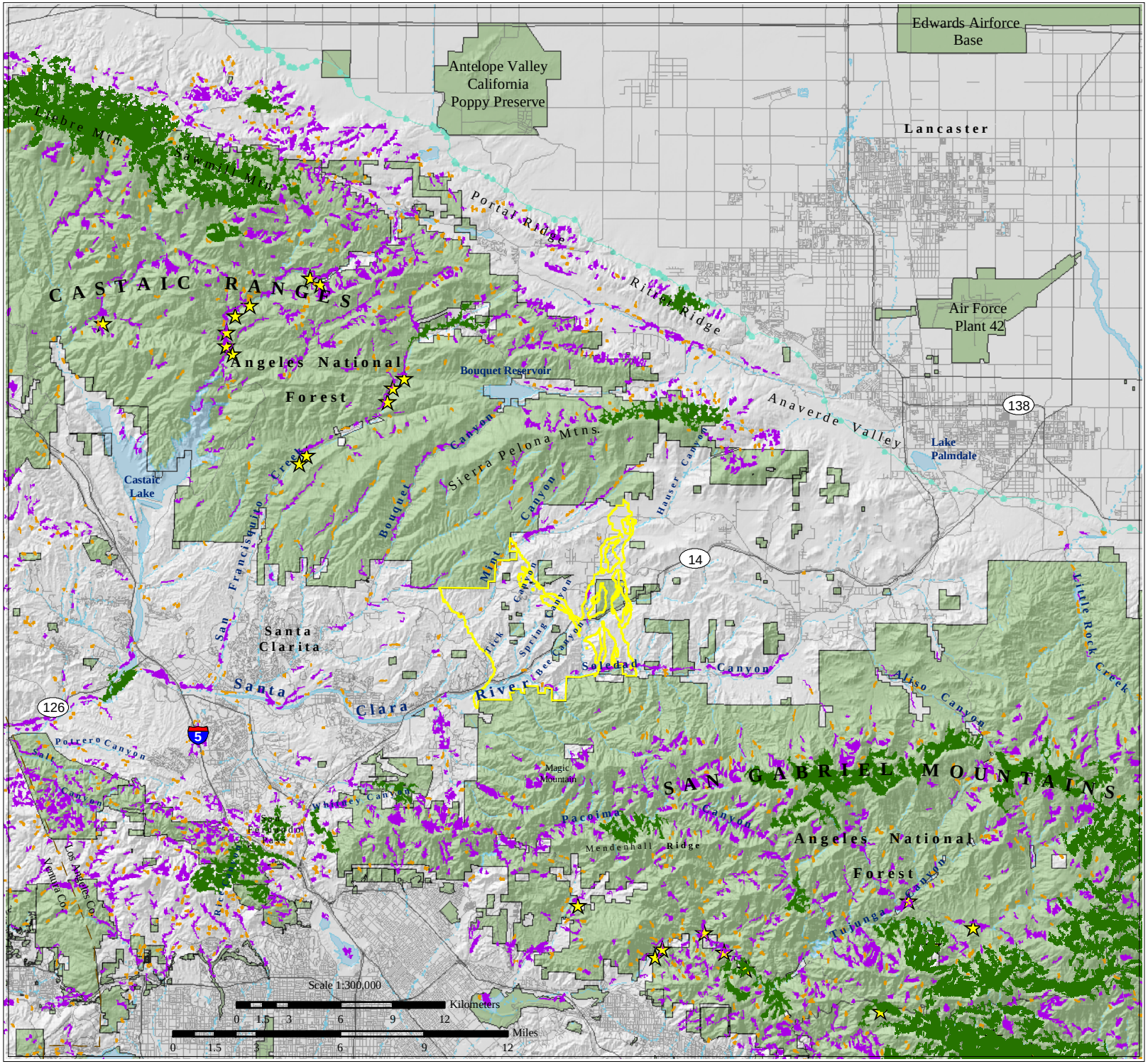

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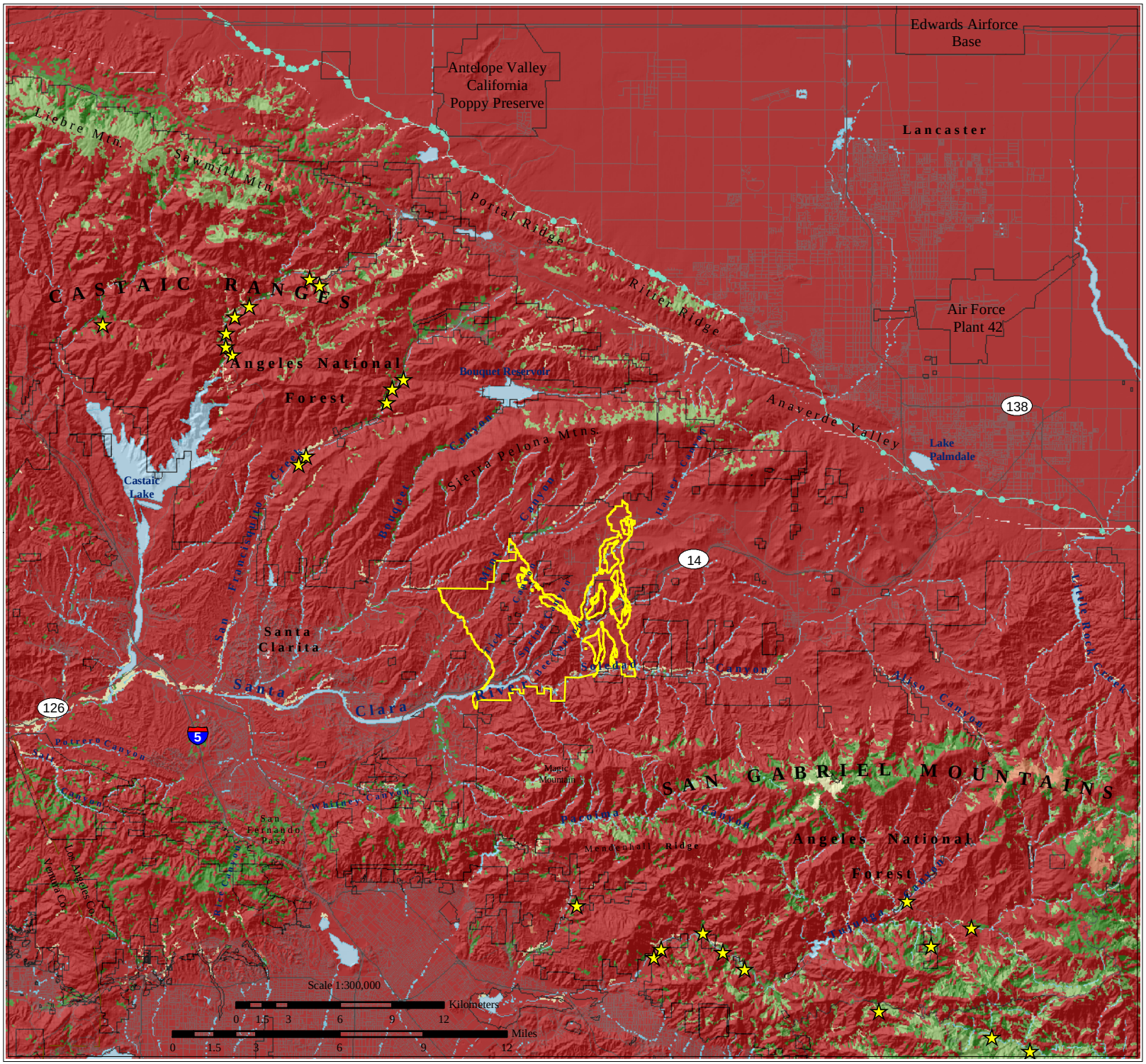
Figure 30.
Habitat Suitability
for
Acorn Woodpecker
(Melanerpes formicivorus)

Legend

- Least Cost Union

Degree of Suitability

- Low
- Low to Medium
- Medium
- Medium to High
- High
- Recorded Occurence
- Paved Roads
- Hydrography
- Lakes & Reservoirs
- Aqueduct
- Ownership Boundaries
- County Boundaires



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Western Pond turtle (*Clemmys marmorata*)

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 (*Clemmys marmorata marmorata*) and the southwestern pond turtle (*Clemmys marmorata 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 travel long dispersal 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 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 (Reese and Welsh 1997, Rathburn et al. 1992, Holland 1994). 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).

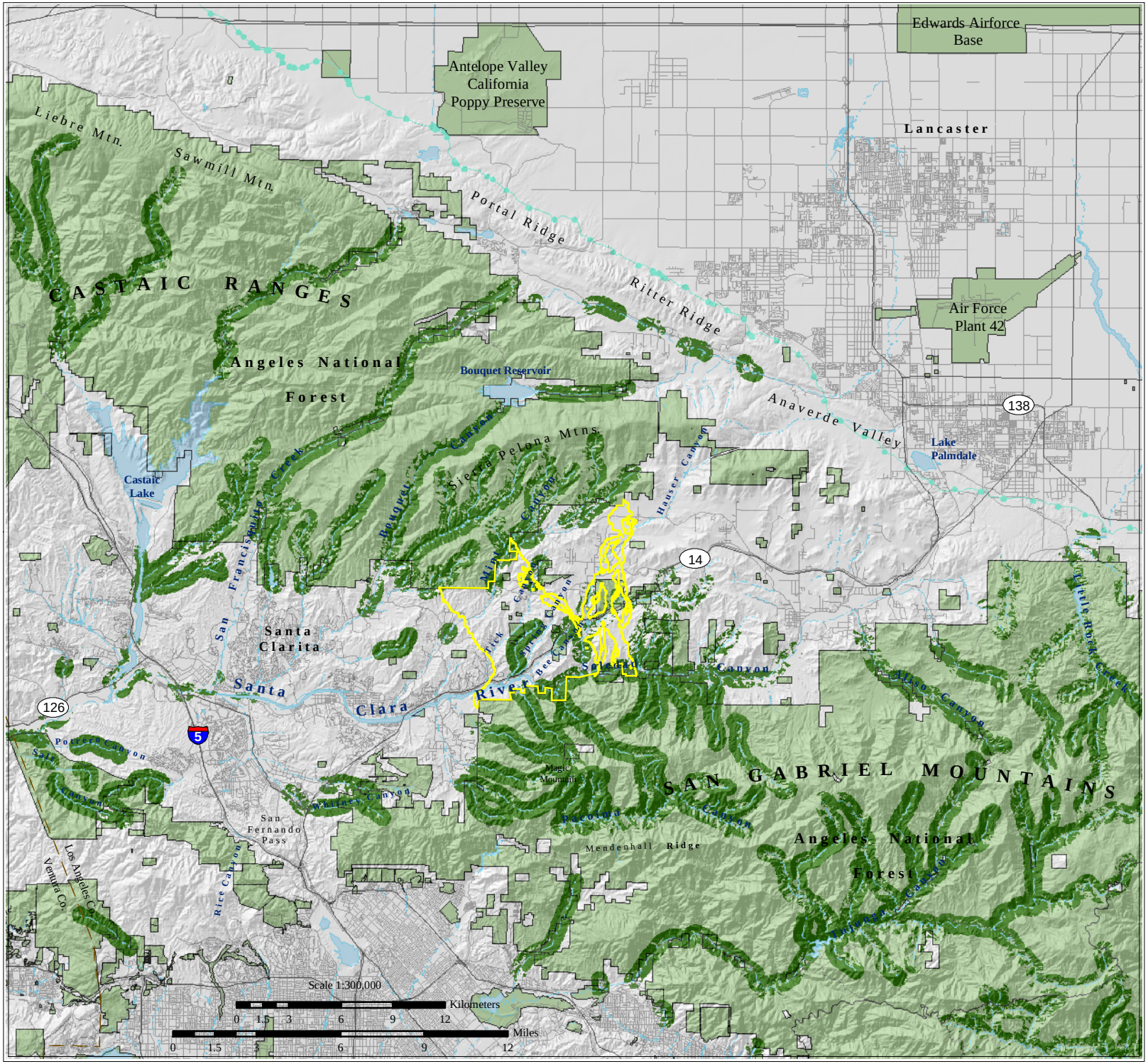
Conceptual Basis for Model Development: Movement between protected core areas in the linkage is multigenerational. Turtles travel most easily along watercourses and in riparian vegetation. Movements through a variety of natural upland habitats are common but may be slightly more difficult, especially 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: The linkage may not adequately serve this species due to the amount and configuration of habitat in the Least Cost Union boundary (Figure 31). Riparian and aquatic habitats in the planning area historically contained large populations of pond turtles, but changes to these habitats through time have eliminated pond turtles from much of their historic range. Potential core areas not captured in the Least Cost Union include habitat along the Santa Clara River; in Long, Bobcat, and Escondido canyons, and in Upper Tick and Mint canyons (Figure 31). These and other creeks included in the Least Cost Union would allow for a wealth of habitat restoration opportunities to enhance existing populations of pond turtles, and possibly re-introduce them into subwatersheds from which they have been eliminated. 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 provide suitable habitat if core areas currently outside of the Least Cost Union were added to the design.

Figure 31.
Potential Cores
for
Western Pond Turtle
(Clemmys marmorata)

Legend

- Least Cost Union
- Potential Habitat
- Paved Roads
- Hydrography
- Lakes & Reservoirs
- Aqueduct
- Ownership Boundaries
- County Boundaires



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Research suggests that existing regulations governing riparian and wetland communities are inadequate to protect populations of aquatic and semi-aquatic species. 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). To restore and protect habitat for pond turtles between the San Gabriel and Castaic protected core areas, we recommend that:

- Additional habitat along the Santa Clara River, in upper Tick and Mint canyons, and in Agua Dulce, Long, Bobcat, and Escondido canyons be added to the Least Cost Union;
- Riparian buffers of 1km be added along each riparian route in the Least Cost Union;
- 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 Least Cost Union;
- 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);
- 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;
- Historical flow regimes be mimicked and water quality compromised by urban and industrial runoff be restored; and
- Anti-poaching laws be 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 (i.e., 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 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 (CDFG 2003, SDNHM 2001). In summer, snakes have relatively small home ranges in streamside environments, averaging 1,500 m^2 (range 80-5,000 m^2; N=7). While 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 50-9,000m^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 (i.e., 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 within both the San Gabriel and Castaic protected core areas. Between these ranges, the model predicted suitable habitat to occur along the Santa Clara River, and perennial and intermittent streams in Bee, Spring, Tapie, Tick, Mint, Vasquez, Agua Dulce, Long, Bobcat, and Escondido canyons, much of which was captured in the Least Cost Union (Figure 32). However, due to the spatial configuration of highly suitable habitat for this species, we recommend additions to the Union in upper Tick and Mint canyons, as well as, along the Santa Clara River and in Long, Bobcat and Escondido canyons (Figure 33).

In order for garter snakes to be persist in the linkage, 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 garter snakes between protected cores areas, we recommend that:

- Additional habitat along the Santa Clara River, Long, Bobcat, and Escondido canyons, and upper Tick and Mint canyons be added to the Least Cost Union;
- Riparian buffers of 1km be added along each riparian route in 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;

Figure 32.
Potential Cores
for
Two-striped Garter Snake
(Thamnophis hammondii)

Legend

- Least Cost Union
- Potential Cores
- Recorded Occurence
- Paved Roads
- Hydrography
- Lakes & Reservoirs
- Aqueduct
- Ownership Boundaries
- County Boundaires

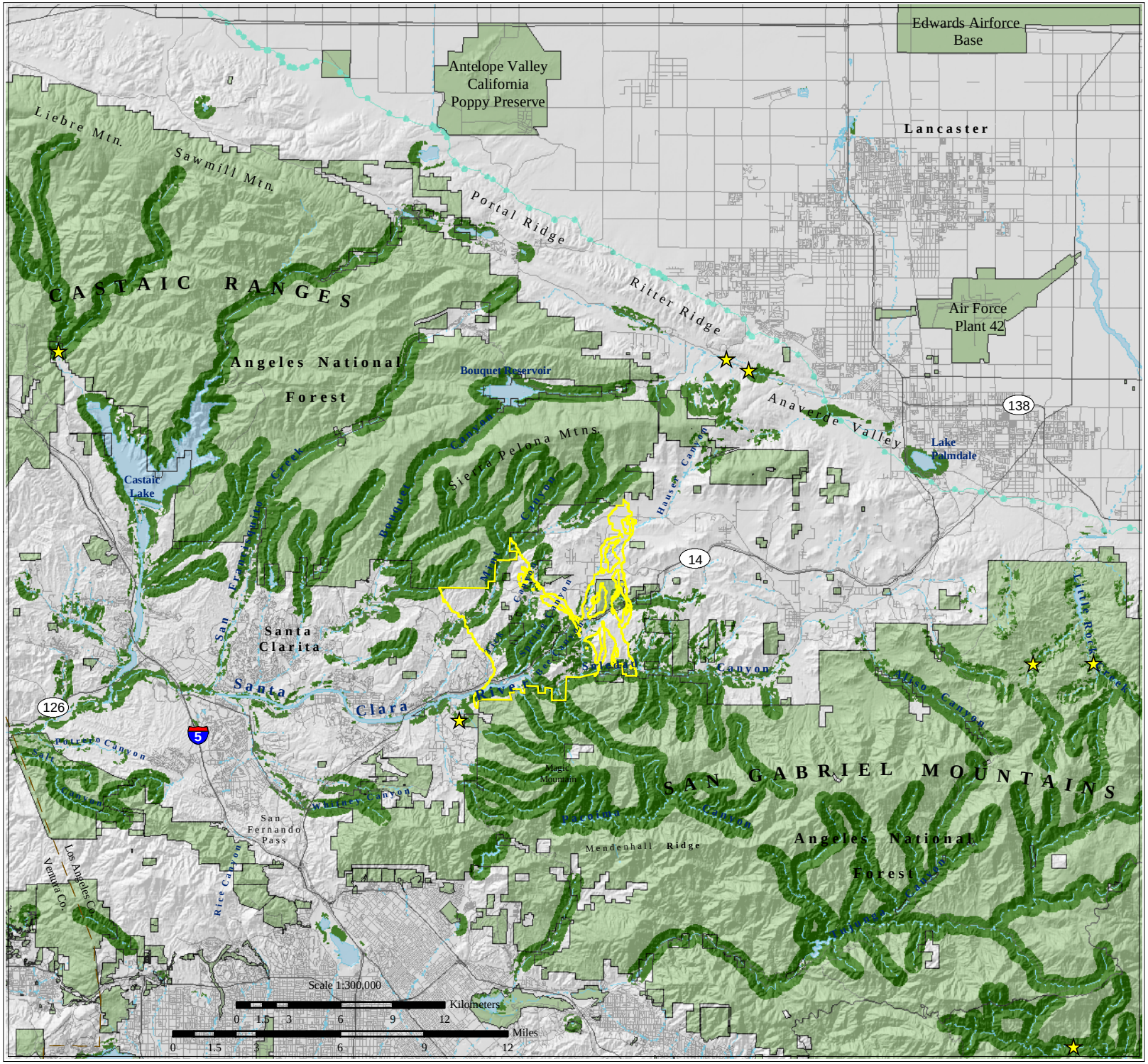

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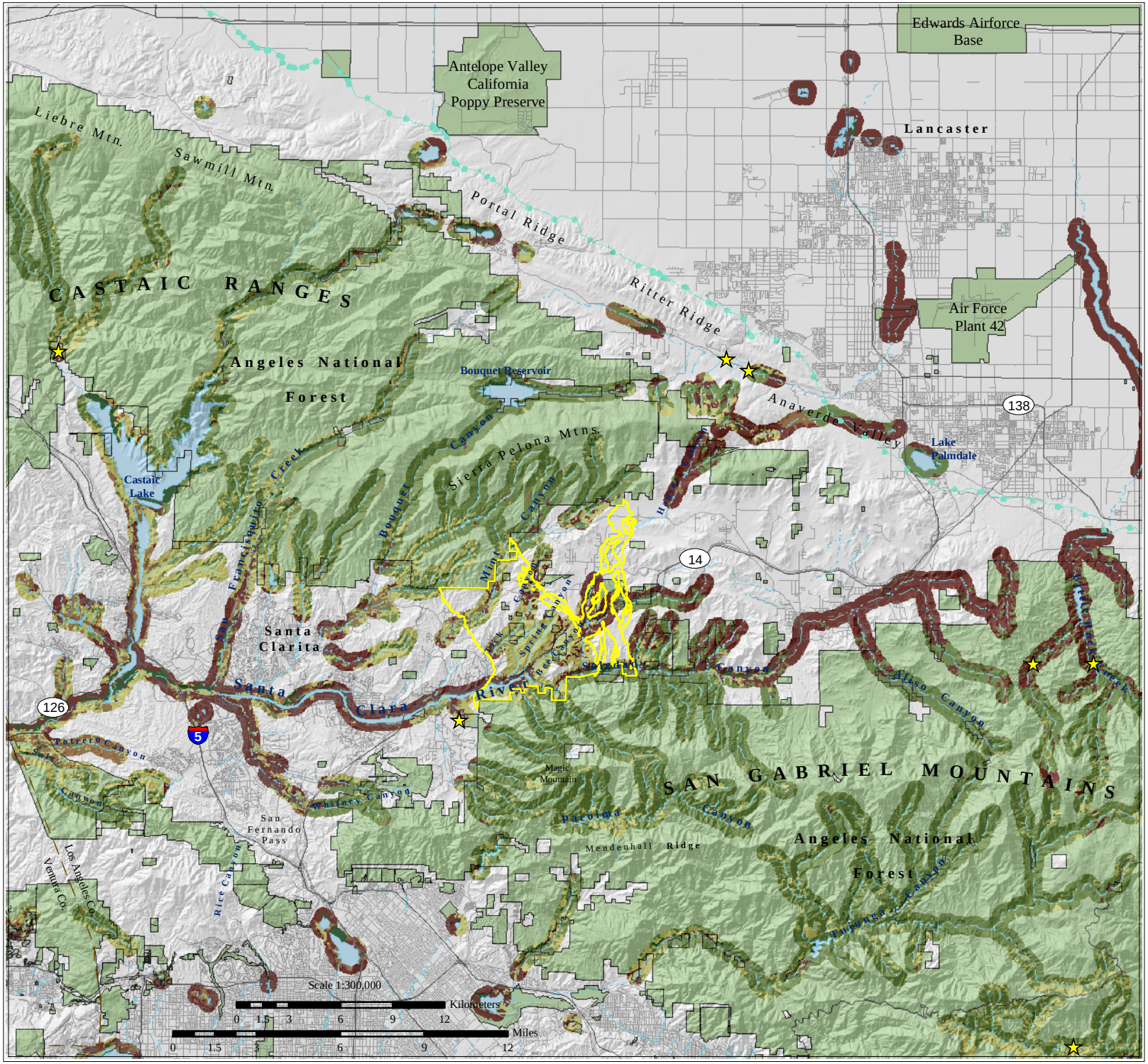
Figure 33.
Habitat Suitability
for
Two-striped Garter Snake
(Thamnophis hammondii)



Legend

- Least Cost Union

Degree of Suitability

- Low
- Low to Medium
- Medium
- Medium to High
- High
- Recorded Occurence
- Paved Roads
- Hydrography
- Lakes & Reservoirs
- Aqueduct
- Ownership Boundaries
- County Boundaires

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- 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 compromised by urban and industrial runoff be restored; and
- Anti-poaching laws be 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 (1372-1981m) (McGurty 1988), it may occur from sea level up to 8,036 feet (2450 m; Stebbins 1985, CDFG 2003).

This incredibly beautiful species is declining in the wild due 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 this species, 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 McGurty (1988) 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. Since no data is available on the home range size of this species, all suitable habitat patches 1 ha or greater were used in the analysis. Dispersal distance was not estimated for this species.

Results & Discussion: Extensive California mountain kingsnake habitat occurs in both the San Gabriel and Castaic protected core areas, with the most highly suitable habitats occurring in the high elevation mixed coniferous forests and along drainages (Figure 34). The Least Cost Union captured small patches of suitable habitat along the Santa Clara River, in Pole, Bear, Bee, and Aqua Dulce canyons south of SR-14, and in Spring, Tick, and Mint canyons, and in Vasquez Rocks north of SR-14 (Figure 35). However, the linkage is not likely to serve the needs of California mountain kingsnake due to the spatial configuration and limited amount of suitable habitat within the Union. Therefore, we added riparian and upland habitats in upper Tick and Mint canyons immediately northeast of the western branch of the Union, and habitat along the Santa Clara River and in Long, Bobcat and Escondido canyons south of SR-14 to support the needs of this species living-in or moving through the linkage. With the recommended additions, the linkage 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:

- Additional habitat along the Santa Clara River, and Agua Dulce, Long, Bobcat, and Escondido canyons be added to the Least Cost Union;
- Riparian buffers of 1km be added along each riparian route in the Least Cost Union;
- 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 compromised by urban and industrial runoff be restored; and
- Anti-poaching laws be enforced.

Figure 34.
Habitat Suitability
for
California Mountain Kingsnake
(Lampropeltis zonata)

Legend

- Least Cost Union

Degree of Suitability

- Low
- Low to Medium
- Medium
- Medium to High
- High
- Paved Roads
- Hydrography
- Lakes & Reservoirs
- Aqueduct
- Ownership Boundaries
- County Boundaires

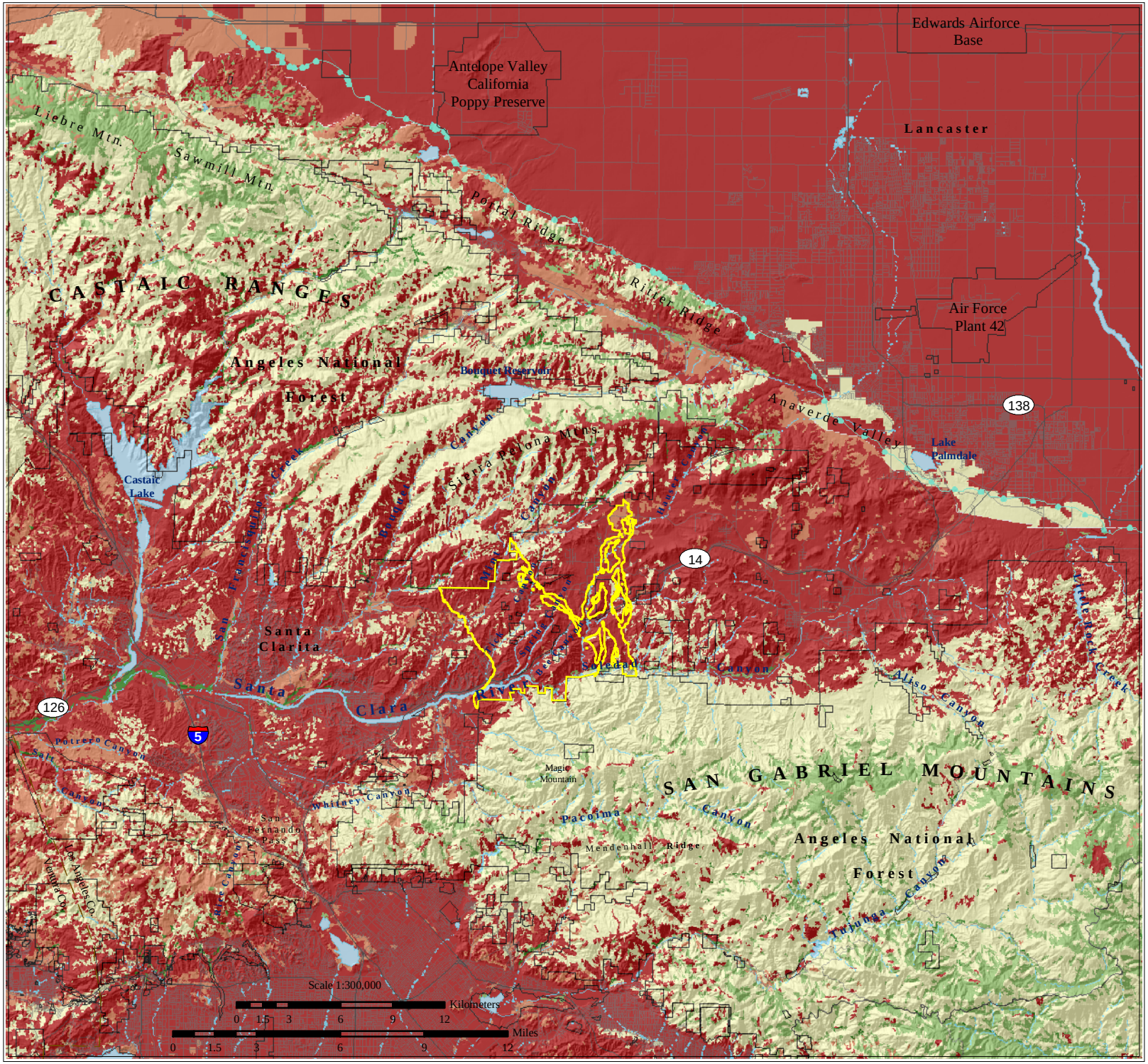

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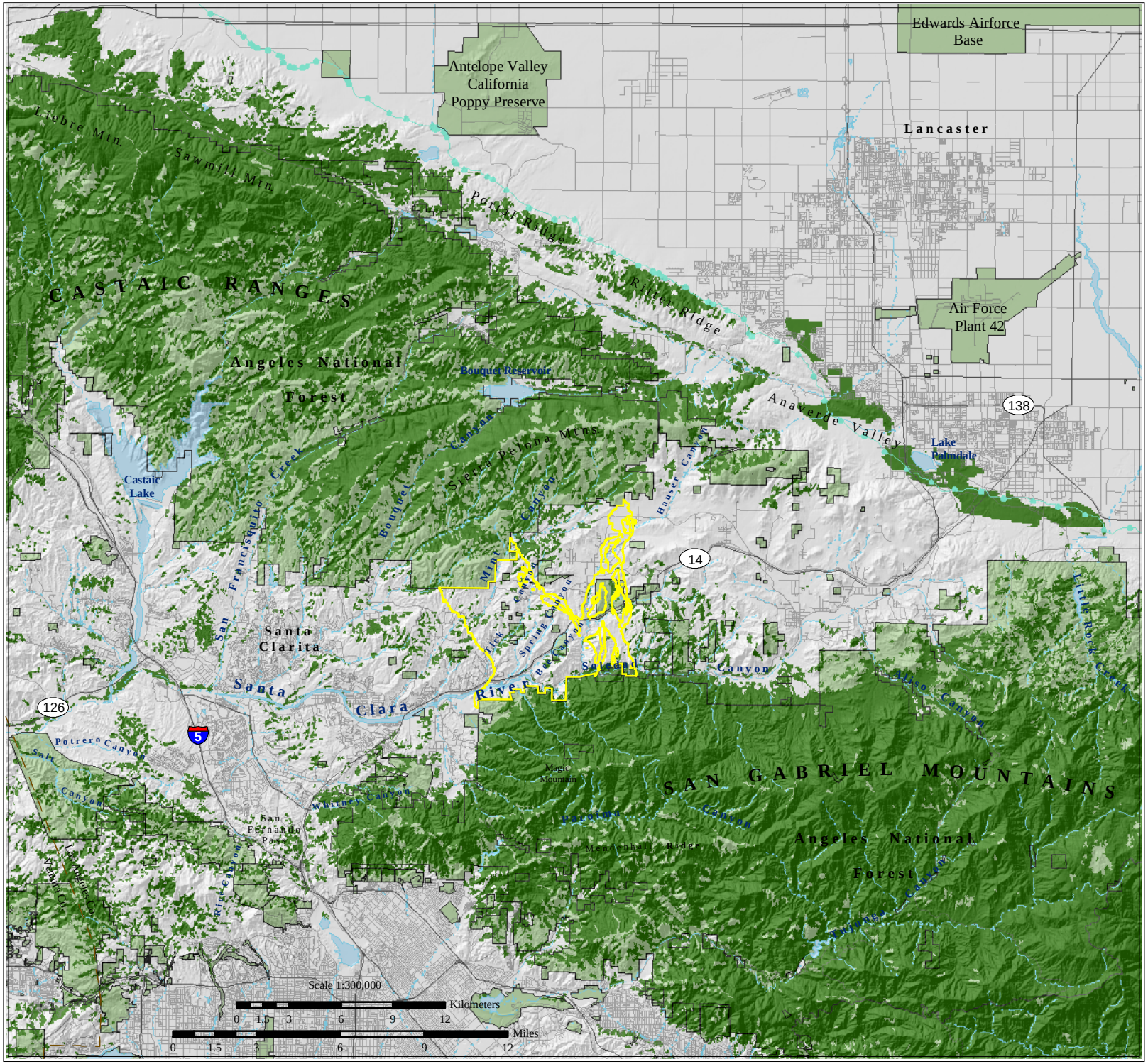
Figure 35.
Potential Cores
for
California Mountain Kingsnake
(Lampropeltis zonata)

Legend

- Least Cost Union
- Potential Cores
- Paved Roads
- Hydrography
- Lakes & Reservoirs
- Aqueduct
- Ownership Boundaries
- County Boundaires



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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 (Ovaska 1988, Grialou et al. 2000, Stebbins 1954).

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 41m^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 on north-facing slopes between 200-1700 m in elevation. 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: The majority of core habitat for this species occurs within existing protected areas. Although, highly suitable habitat patches were captured in the Union along the Santa Clara River, in Bear Canyon, and along upper Aqua Dulce, this species needs do not appear to be well accommodated by the Least Cost Union (Figure 36). We recommend additional habitat be added to the Union along the Santa Clara River and in upper Mint Canyon to accommodate this species.

The model actually predicted a much stronger connection for this species between the San Gabriel and Santa Susana Mountains, reinforcing the need to conserve this critical connection. Hardwood and conifer habitats, preferred by this species, occur within and between these ranges in a somewhat contiguous distribution (Figure 36). The analysis identified highly suitable core habitat in Whitney and Elsmere canyons to the east of S14; habitat in the San Fernando Pass, between SR-14 and I-5; and extensive habitat in the Santa Susana Mountains, including immediately west of I-5 in Rice, East and Towsley canyons. 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 the Santa Susana Mountains, San Fernando Pass, and the westernmost San Gabriel Mountains are within the dispersal distance of this species (Figure 37), though barriers to movement exist between suitable habitat patches.

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:

- 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 36.
Potential Cores
for
Monterey Salamander
(Ensatina eschscholtzii eschscholtzii)

Legend

- Least Cost Union
- Potential Cores
- Paved Roads
- Hydrography
- Lakes & Reservoirs
- Aqueduct
- Ownership Boundaries
- County Boundaires

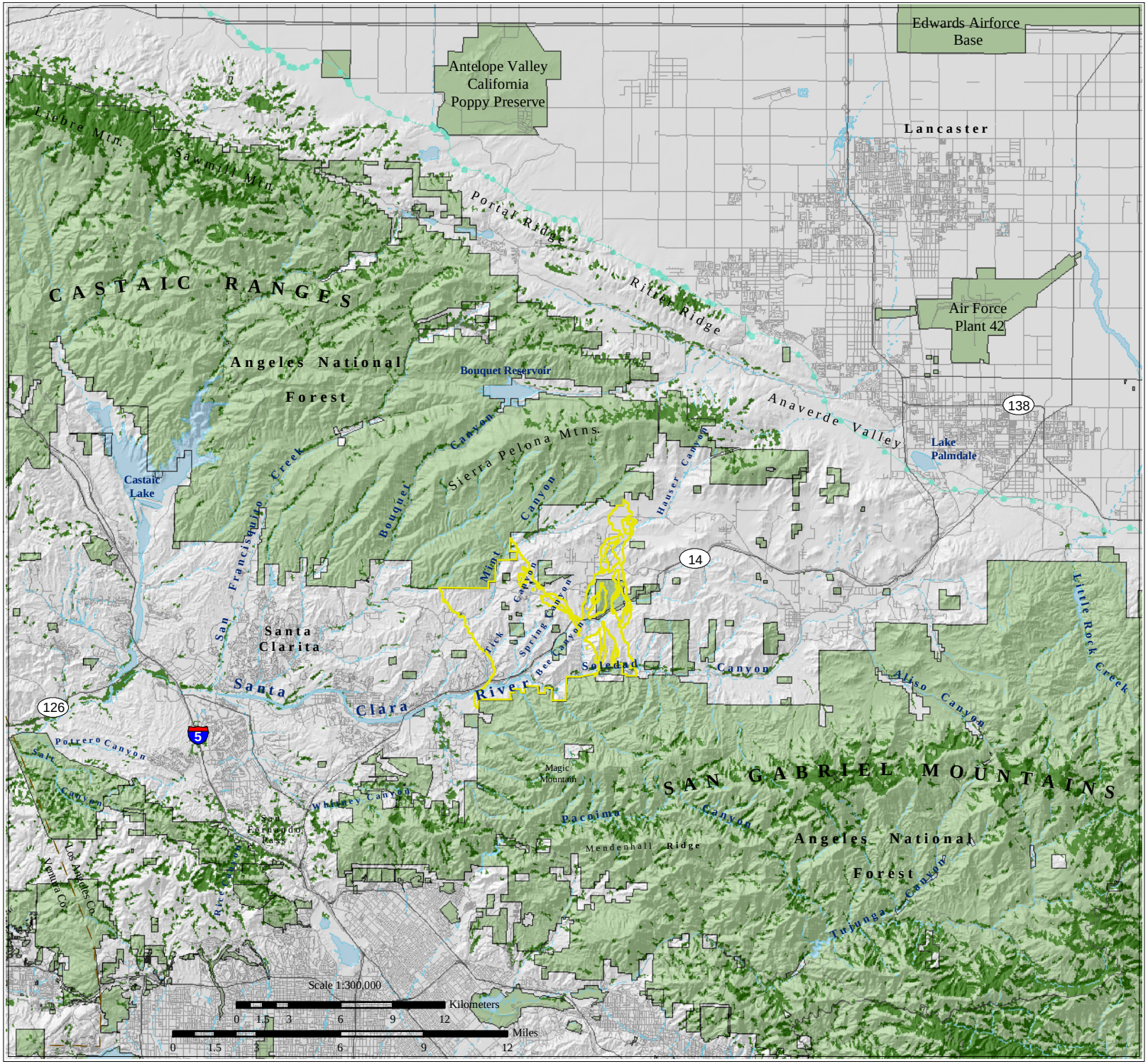

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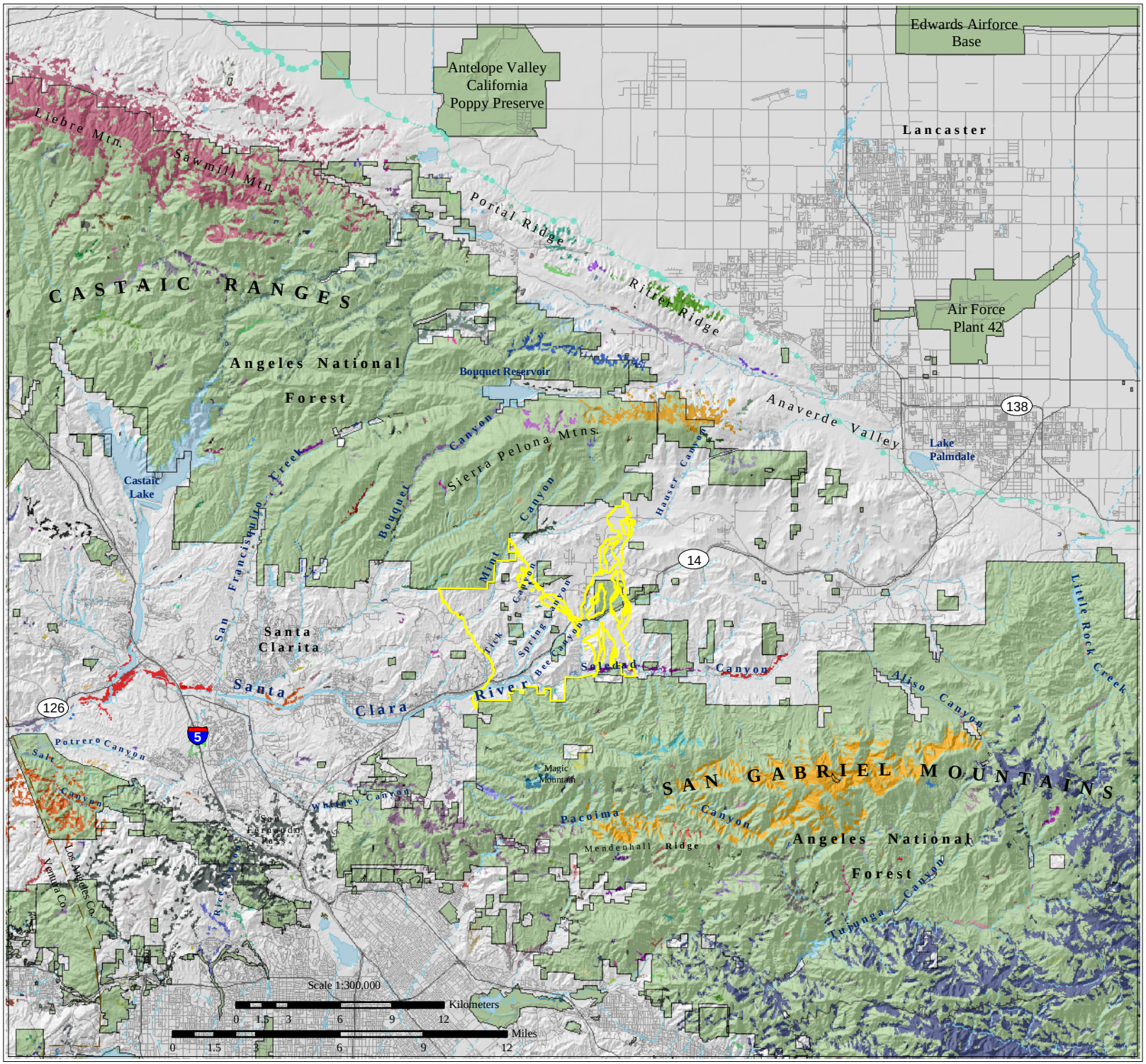
Figure 37.
Patch Configuration
for
Monterey Salamander
(Ensatina eschscholtzii eschscholtzii)

Legend

- Least Cost Union
- Paved Roads
- Hydrography
- Lakes & Reservoirs
- Aqueduct
- Ownership Boundaries
- County Boundaires

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



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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. They require extensive landscapes with little or no disturbance, development and artificial light (K. Osborne pers.comm.). Cattle grazing may also impact this species due to the 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.). Populations of this species occur in and around the Central Valley rim between 500 ft and 4500 ft in elevation (K. Osborne pers.comm.). They have been recorded from the bottom of the Grapvine in Central Valley, and in the vicinity of Fort Tejon, Lebec, and Gorman (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 the San Gabriel and Castaic protected core areas. This species requires large swaths of suitable habitat to allow for dispersal and gene flow across populations (K. Osborne, pers. comm.). Therefore, although the Least Cost Union captured some small patches of habitat (Figure 38), the linkage is not likely to serve this species unless additional habitat is added to accommodate the needs of individuals living in the linkage. Larger patches of suitable habitat are distributed immediately east of the Union, in Long, Bobcat, and Escondido canyons, in Vasquez Rocks, just east of Aqua Dulce Creek (south of Sierra Highway), and in Hauser Canyon. These areas were added to the Linkage Design to allow for 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.).

Other significant patches of potentially suitable habitat between the San Gabriel and Castaic Ranges occur in Anaverde Valley and along Ritter Ridge. Substantial blocks of habitat also occur within the Santa Susana Mountains. All habitat patches are within twice the dispersal distance of this species, although barriers to movement may exist between patches of suitable habitat.

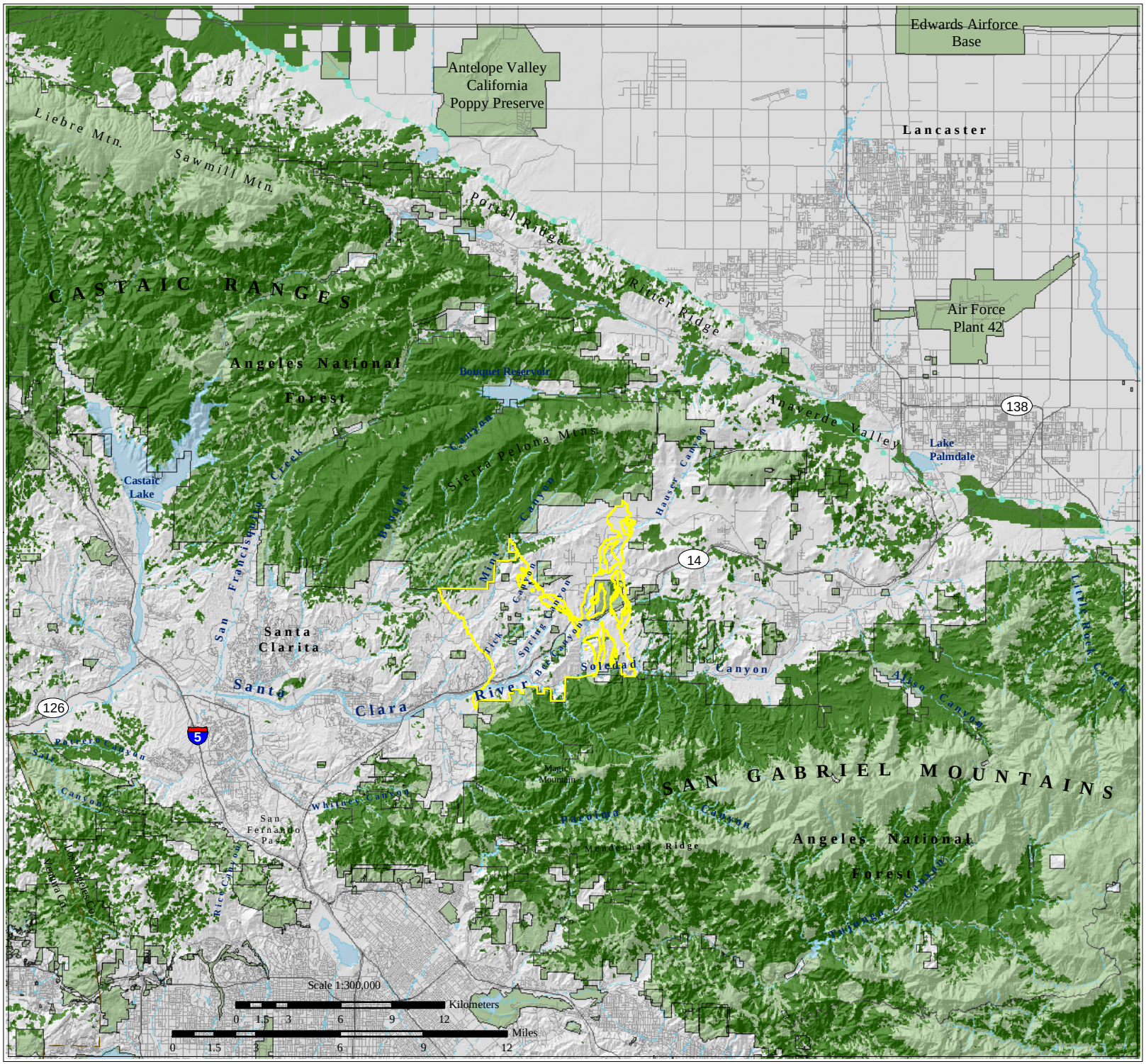
Roadkill affects a wide range of invertebrates, especially insects (H.C. Seibert and Conover 1991) in Trombulak and Frissell 2000). To protect and maintain populations of Bear sphinx moth in the linkage, we recommend that:

- Habitat is added to the eastern branch of the Union in Hauser, Agua Dulce, Long, Bobcat, and Escondido canyons;
- Light is directed away from the linkage, since adults are attracted to artificial light sources; and
- Habitat is restored in Spring, Aqua Dulce and Hauser canyons.

Figure 38.
Potential Cores
for
Bear Sphinx Moth
(Arctonotus lucidus)

Legend

- Least Cost Union
- Potential Core
- Paved Roads
- Hydrography
- Lakes & Reservoirs
- Aqueduct
- Ownership Boundaries
- County Boundaires



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California Juniper (*Juniperus californica*)

Justification for Selection: California juniper provides food and shelter for numerous wildlife species (Frischknecht 1975, Barrett 1983, Meeuwig & Bassett 1983, Blake 1984, Cope 1992), and is also important for watershed protection (Johnsen & Alexander 1974).

Juniper species are a component of an ancient plant community, pinyon-juniper woodland, which has a remarkable migrational history (Wells 1987; Davis 1987, Mehringer & Wigand 1987). Movement of full plant communities over large spatial and temporal scales requires large expanses of habitat.

Distribution & Status: The distribution of juniper species has been ephemeral over the past 2 million years (Betancourt 1987). Since the last glacial, pinyon juniper woodlands have shifted upward in elevation and has extended northward. Today, this native conifer is distributed from Shasta County, California to Baja California Norte (Bolsinger 1989, Little 1971, Cope 1992), between 50-1500 m in elevation (Munz 1963, Hickman 1993). It is estimated that pinyon-juniper woodland occupies over 30 million acres in the western U.S (Aidon and Loring 1977). In the planning area, California juniper occurs in higher densities in the eastern portion of the linkage in desert scrub and juniper woodland habitats, with lower densities in the transition zone between desert and coastal communities. This species is not afforded any special status, though California juniper is restricted in the western Mojave Desert as a result of habitat conversion to agriculture (Sawyer and Keeler-Wolf 1995).

Habitat Associations: California juniper is adapted to xeric conditions (USDA 1982, Van Devender & Spaulding 1979). It is typically associated with pinyon-juniper woodland and Joshua tree woodland that integrates with chaparral along desert margins (Horton 1951, Munz 1963, Hanes 1981, Meeuwig & Bassett 1983, Cope 1992). It also occurs in the ecotone between desert and coastal communities (Hanes 1971, Vasek & Thorne 1977, Cope 1992); in alluvial fan sage scrub (Hanes 1981, Hanes 1971, Vasek & Thorne 1977, Cope 1992); coastal sage scrub (Munz 1963, Hanes 1981, Hanes 1971, Vasek & Thorne 1977, Cope 1992); and in grasslands and interior live oak woodlands (Bolsinger 1989, Cope 1992).

Spatial Patterns: California juniper occurs in upland habitats on ridges, slopes, and valleys (Munz 1963, Hickman 1993) on bedrock or alluvium derived soils, which are shallow and fairly low in nutrients (Hanes 1981). It may be found on all exposures but most commonly occurs on slopes facing south through west (U.S. Forest Service 1977). Stand densities have been estimated at between 41-73 trees per hectare (Tueller 1987).

The pollination vector for California juniper is wind (Myking 2003). This species flowers in the spring (Johnsen & Alexander 1974, Munz 1963), and seeds germinate in early

spring (Lymbery & Pieper 1983). The highly nutritious juniper berries are consumed by many species of birds and mammals that serve as seed dispersal agents (Frischknecht 1975, Meeuwig & Bassett 1983, Balda 1987, Christensen and Whitham 1991, Cope 1992, Myking 2003). The ability of birds and mammals to move juniper seeds depends upon rates of passage through the digestive tract while the animals are traveling. How far animals move between meal and defecation sites, and the proportion of seeds germinating after ingestion has not been measured.

Conceptual Basis for Model Development: Juniper and Pinyon-juniper woodlands, desert scrub, and sagebrush communities provide the best suitable habitat for germination of California juniper in the planning area. In these habitats, it prefers upland habitats on ridges, slopes, and valleys, between 50-1500 m in elevation. It most commonly occurs on slopes facing south through west.

Minimum patch size for this species is an area large enough to support two individuals. This size is less than the 30 m minimum mapping unit used in the GIS analysis and therefore no habitat patch was considered too small to support this species.

Results & Discussion: Suitable habitat for California juniper is not well represented in either the San Gabriel or Castaic protected core areas, although patches of habitat occur within both these ranges. California juniper is primarily an orthogonal species, with the majority of its core habitat occurring at lower elevations, between protected core areas, in the linkage itself. The Least Cost Union captured considerable habitat for this species (Figure 39) and will also likely serve the needs of its seed dispersal agents, birds and mammals (e.g, Coyote, Mule deer).

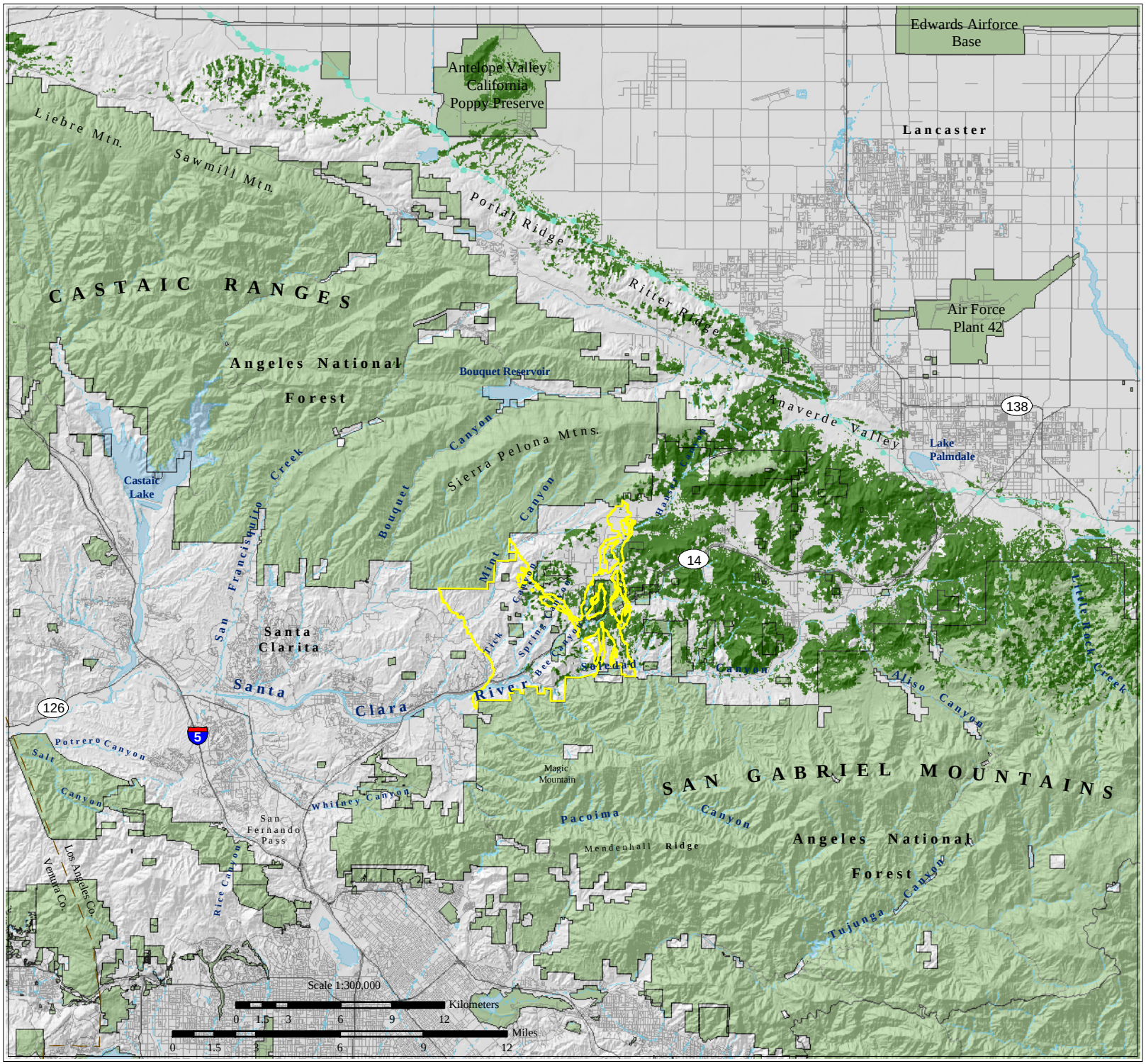
Effective pollination and seed dispersal mechanisms largely determine a plants ability to persist, expand, and colonize habitat in fragmented landscapes (Tewksbury et al. 2002). Research has shown strong indirect effects on plant populations due to increased movement of pollen and seeds by animals (Tewksbury et al. 2002). Genetic diversity is generally highest and adaptive traits stronger in species whose pollen is dispersed by wind (Govindaraju 1988, Baliuckas et al. 2000, Myking 2003), indicating that there are little to no impediments to movement of California juniper pollen in the linkage. Seed dispersal capabilities are more limited in species with heavy seeds dispersed by mammals and birds (Myking 2003), demonstrating the need for maintaining connectivity for California juniper's dispersal agents. To retain this ancient plant species, we recommend that:

- Habitat needed for movement of seed dispersal agents be restored;
- Existing road density be maintained or reduced; and
- Road barriers be modified for seed dispersers to access appropriate habitat for germination of California juniper seeds.

Figure 39.
Habitat Suitability
for
California Juniper
(Juniperus californica)

Legend

- Least Cost Union
- Suitable Habitat
- Paved Roads
- Hydrography
- Lakes & Reservoirs
- Aqueduct
- Ownership Boundaries
- County Boundaires



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Scalebroom (*Lepidospartum squamatum*)

Justification for Selection: Scalebroom is a dominant species in Alluvial fan sage scrub, a highly imperiled plant community in southern California.

Distribution and Status: Scalebroom is distributed from central California to Baja California Norte. It occurs along gravelly washes and stream terraces below 5,000 feet (Munz 1963, Hickman 1993), in the inner South Coast Ranges, Sierra Nevada foothills, southwestern California, and in the Mojave and Colorado deserts (Munz 1963, Baldwin et al. 2002).

Although, this species isn't afforded any special status, the community in which Scalebroom occurs (i.e., Riversidian alluvial fan sage scrub) is designated as a sensitive natural community. This natural community is threatened by changes to alluvial habitats caused by flood control, residential and commercial development projects; pollution from runoff; and off-road vehicles (Dudek and Assoc. 2000).

Habitat Associations: This perennial shrub may be found on sandy and gravelly alluvial fans and stream terraces along intermittent streams in coastal sage scrub, chaparral, oak woodland, and Joshua tree woodland habitats (Munz 1963, Hickman 1993, McAuley 1996). Scalebroom may be the dominant species in alluvial fan sage scrub, or it may be codominant with California Buckwheat (*Eriogonum fasciculatum*), California Sagebrush (*Artemisia californica*), White Sage (*Salvia apiana*), and *Encelia* species (USDA Forest Service 2003). The federal and state listed Slender-horned spineflower and Santa Ana River woollystar grow in some stands of alluvial fan sage scrub where Scalebroom is dominant (Skinner and Pavlik 1994). Species composition varies greatly among stands, other species may also occur, including *Opuntia* spp., Chaparral Yucca (*Yucca whipplei*), and California Juniper (*Juniperus californica*; USDA Forest Service 2003).

Spatial Patterns: Scalebroom occurs on alluvial fans, in sandy or gravelly washes, and stream terraces throughout much of southern California away from the immediate coast (Raven 1966, Baldwin et al. 2002). Alluvial scrub habitats require infrequent but severe flood events for regeneration (Hanes et al. 1989).

This species blooms from August to October (Munz 1963). Scalebroom is likely wind pollinated (Ileene Anderson, pers. comm.), though, it may also be visited by a variety of arthropods, similar to a related species, Gypsum scalebroom (*L.* burgessii; Turner 1977). Seed dispersal agents are unknown for this species.

Conceptual Basis for Model Development: Gravelly or sandy soils on alluvial fans provide the best suitable habitat for germination of Scalebroom seeds in the planning area. In these habitats, it is found below 5,000 feet in elevation.

Results and Discussion: Suitable habitat for Scalebroom is not well represented in either protected core area. Core habitat for this species is primarily found at lower elevations in the linkage itself. The Least Cost Union captured suitable habitat for this species in lower Tick Canyon and along the Santa Clara River (Figure 40). With the recommended additions along the Santa Clara River and in Hauser Canyon, the linkage will likely serve this species.

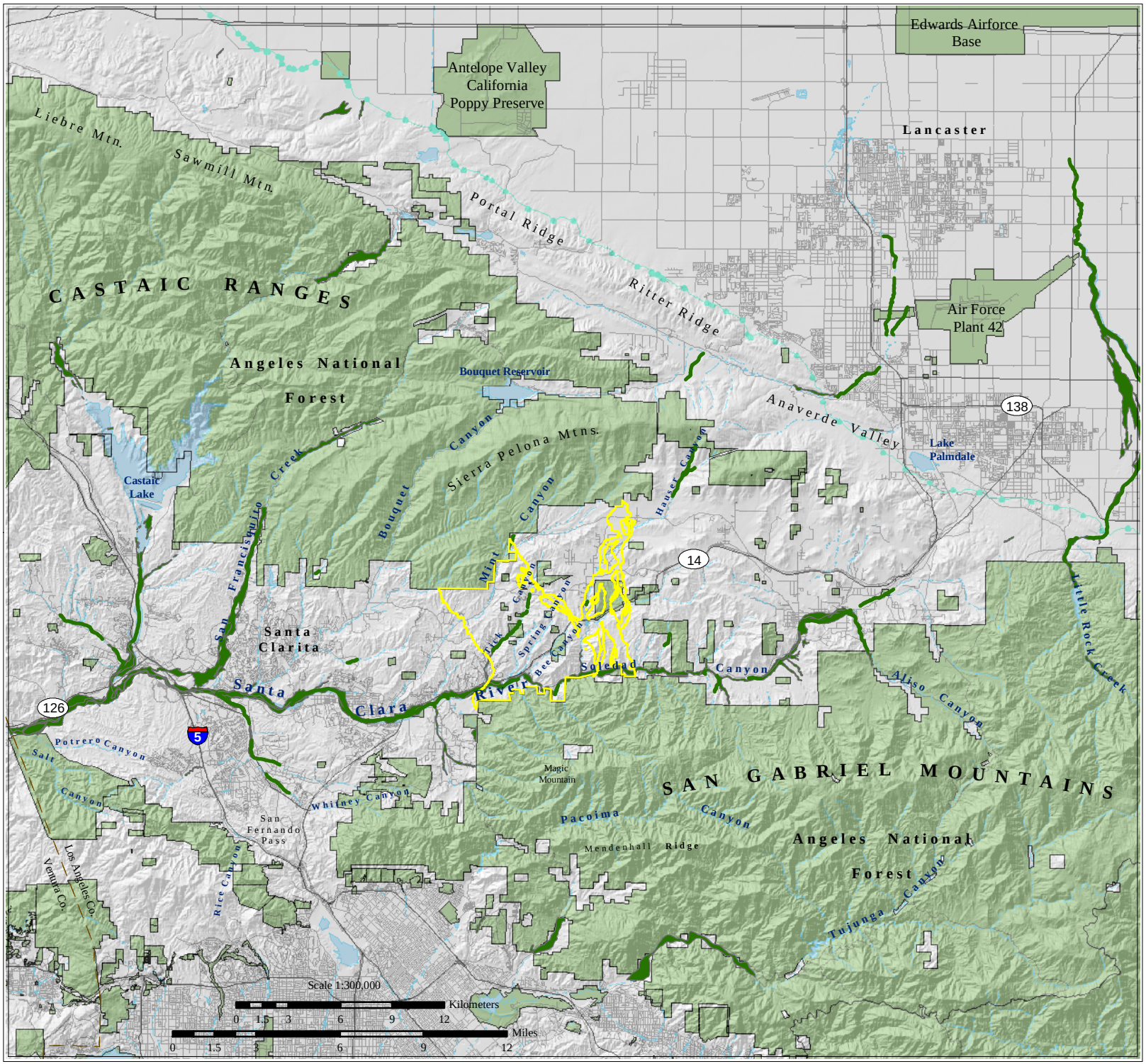
Genetic diversity is typically highest in species in which their pollen is dispersed by wind (Govindaraju 1988, Baliuckas et al. 2000, Myking 2003), indicating there are little to no impediments to movement of Scalebroom pollen in the linkage. If this species seeds were also dispersed by wind, then it would appear to have very good dispersal capability (Myking 2003). However, should this species be dependent on invertebrates to disperse its seed, the implication would be to maintain connectivity for its seed dispersal agents, since linkages are preferentially used by some insects, resulting in higher fruit set in connected patches (Tewksbury et al. 2002). Furthermore, if this species is dependent on water to disperse its seed, then a flood regime that mimics natural community dynamics is necessary to sustain this species. To retain this plant species, we recommend that:

- No stream channelization projects be implemented in the Linkage Design;
- Further research is conducted to determine mechanisms for seed dispersal;
- Research is conducted on historical flow regimes to determine appropriate flooding frequency needed to sustain alluvial habitats; and
- Regulations protecting riparian communities are enforced.

Figure 40.
Habitat Suitability
for
Scalebroom
(Lepidospartum squamatum)

Legend

- Least Cost Union
- Suitable Habitat
- Paved Roads
- Hydrography
- Lakes & Reservoirs
- Aqueduct
- Ownership Boundaries
- County Boundaires



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This chapter is the heart of the report. In it, we summarize the goals of the Linkage Design, present a map of the Linkage Design, and describe the land included in it. However, conserving a linkage is more complex than circumscribing the important acres on a map. While developing the Linkage Design, we conducted field work to identify barriers to movement or land use practices that may prevent species from moving through the linkage. The bulk of this chapter is a description of the existing barriers and prescriptions for actions needed to ensure that the Linkage Design is effective.

Goals of the Linkage Design

To accommodate the range of species and ecosystem functions it is intended to serve, the Linkage Design (Figure 41) attempts to: 1) provide live-in and move-through habitat for multiple species; 2) support metapopulations of smaller species; 3) ensure the availability of key resources; 4) buffer against edge effects; 5) reduce contaminants in streams; 6) allow natural processes to operate with minimal constraints from adjacent urban areas; and 7) allow species and natural communities to respond to climatic changes. To help the reader appreciate why the linkage encompasses such a large area, we elaborate on these seven goals in the following several paragraphs.

The Linkage Design must be wide enough to provide live-in habitat for species with dispersal distances too short to allow movement through the entire length of the Least-Cost Union. 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 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 Design.

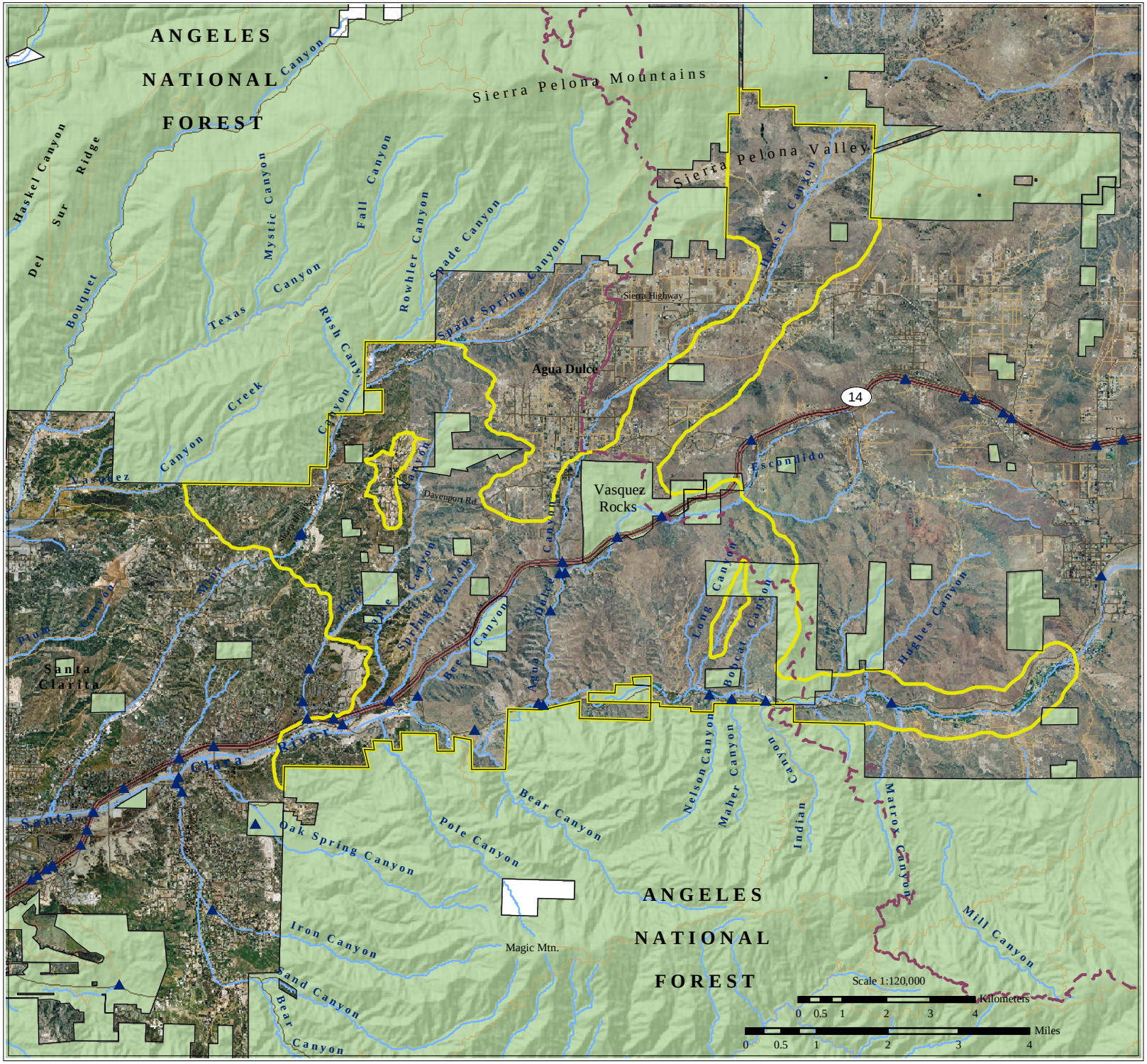
The Linkage Design must support metapopulations of less vagile species. Many small animals, such as salamanders and turtles, require dozens of generations to move between Core Areas. These species need a linkage wide enough to support a constellation of metapopulations, with movements among subpopulations, over decades. Although there are no estimates of widths needed to support metapopulations of any species, 2 km is probably adequate for most species, although it may be narrow for species with little suitable habitat in the linkage.

The Linkage Design is expected to ensure the availability of key resources for all species of native plants and animals, including host plants (e.g., for butterflies), pollinators, predator-free areas, or other elements. For example, many species commonly found in riparian areas depend on upland habitats during some portion of their cycle. These species include butterflies that use larval host plants in upland areas and drink from water sources as adult, western pond turtles that live most of their lives in water but lay their eggs in sandy upland habitats, and western toads that spend the summer in upland burrows but return to the water to breed. In addition, most fish feed on the aquatic larvae of insects, many of which depend on terrestrial habitats as adults. Although the width of upland habitats needed beyond the streams edge has rarely been estimated for these

Figure 41.
Linkage Design

Legend

- Linkage Design
- Potential Crossings Structures
- Pacific Crest Trail
- Highway
- Paved Roads
- Dirt Roads
- Hydrography
- Ownership Boundaries



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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.

The Linkage was designed to buffer against edge effects even after adjacent land is converted to urban and suburban uses. Human activities in neighboring areas can have undesirable effects on protected areas. These “edge effects” include artificial night lighting, predation by species supported by human activities (e.g., pets, released pets, and native predators such as raccoons that reach high density due to availability of garbage), elevated soil moisture and stream flow from irrigation, pesticides & pollutants, noise, hobby animals that increase risk of interactions with native predators, and removal of natural vegetation. Edge effects (Murcia 1995) 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) 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 ant population due the invasion of argentine ants up to 200 m (650 ft) from irrigated areas (Suarez et al. 1998), and predation by pet cats which decimate small vertebrate populations (Churcher and Lawton 1987, Hall et al. 2000) 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). In addition, homeowners may clear vegetation up to 61 m (200 ft) around their homes to reduce fire risk and meet insurance requirements at the wildland-urban interface (Longcore 2000).

In areas of the Linkage with streams, upland habitat protection is needed to prevent the degradation of aquatic habitat quality. 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 allow natural processes of disturbance and subsequent recruitment to operate with minimal constraints from adjacent urban areas. Linkage width should be sufficient such that the temporary devastation caused by fires, floods and other natural processes does not affect all habitats in the linkage simultaneously. Fire as a natural process is especially challenging to sustain in a relatively small linkage area. Large fires, such as those occurring under Santa Ana wind conditions, could easily burn all habitats in the Least-Cost Union. Before human occupation, naturally occurring fires (due to lightning strikes) were relatively rare in the coastal ranges of southern California (Radtke 1983). As populations in the region soared, fire frequency has also increased dramatically (Keeley and Fotheringham 2000). Homeowners at the wildland-urban interface, alarmed by the devastation of these wildland fires are further promoting the use of prescribed burns to reduce fuels in surrounding natural areas. Although fire has been shown to reduce the occurrence of exotic species in native grasslands (Teresa and Pace 1996), in shrublands it has the opposite effect (Giessow and Zedler 1996), encouraging the invasion of non-native plants. While the pattern of disturbance caused

by this altered fire regime is unpredictable, wider linkages with broader natural communities may be more robust to these disturbances.

The Linkage Design must also allow species to respond to climate change. Over the past century, the earth's warming rate has increased four-fold, and predictions for changes in California's weather include warmer winters with increases in flooding and fire (Field et al. 1999). Plant and animal distributions are predicted to change with the climate, expanding and contracting and rising and falling in elevation (Field et al. 1999). The Linkage width must be broad enough to allow for these wholesale movements in natural communities, and should encompass a diversity of microhabitats (e.g., slopes, aspects, elevations, and soil types) that allow species to colonize new areas.

Description of the Linkage Design

The final Linkage Design has several branches to accommodate diverse species and ecosystem functions (Figure 41). The northwest branch is dominated by coastal sage scrub and chaparral and encompasses all or portions of Bee, Spring, Tapie, Tick, and Mint Canyons (Figure 42). It serves most of the focal species, including puma, mule deer, Pacific kangaroo rat, and California thrasher. The eastern branch connects a series of desert scrub and juniper woodland habitats (Figure 43), thereby linking habitat for species such as American badger, Burrowing owl, and Bear sphinx moth that prefer the open habitats that are prevalent in desert plant communities. The third distinct branch of the Linkage Design follows the Santa Clara River and Soledad Canyon and provides large stepping-stones of habitat for semi-aquatic species, such as the western pond turtle, two-striped garter snake, and mountain kingsnake; it also serves a suite of aquatic and riparian-dependent species (e.g., Unarmored three-spine stickleback, Santa Ana Sucker, Arroyo chub, California red-legged frog, Arroyo toad), not addressed by our analyses.

Although the three branches described above resulted from our modeling efforts, participants in the September 30, 2002, Biological Foundations Workshop, anticipated their existence. It was a common perception amongst biologists familiar with this region that the needs of coastal, desert, and aquatic species would not be met by a simple linear linkage design. This has been substantiated by our analyses.

As expected in this unique ecological transition zone, the Linkage Design encompasses a diversity of natural communities, including 15 different major vegetation types (Table 3). Although natural vegetation comprises most of the Linkage Design, agriculture and urban development cover roughly 3% of its area. Approximately 12% (2,772 out of 23,947 total acres) of the Linkage Design currently enjoys some level of conservation protection, mostly in BLM parcels and Vasquez Rocks County Park.

Coastal, desert, and riparian habitats within the linkage are similar to those found in the two Core Areas. Coastal scrub, chaparral, desert scrub, and juniper woodland communities predominate. Chaparral is the dominant plant community in both core areas, with coastal sage scrub at lower elevations on south-facing slopes, pinyon-juniper woodlands on desert slopes, and montane hardwood and hardwood conifer habitats at higher elevations. Riparian habitats occupy roughly 3% of the Linkage Design. Coast live oak and Valley foothill riparian vegetation occurs along Soledad Canyon and drainages flowing from the San Gabriel Mountains, while alluvial fan sage scrub

Figure 42. The western branch of the Linkage Design is dominated by coastal sage scrub and chaparral habitats. Photo by Andrew Harvey, VisualJourneys.net

Figure 43. The eastern branch of the Linkage Design is dominated by desert scrub and juniper woodland habitat.

occupies Bee Canyon. Coastal Sage Scrub is the primary habitat in the western part of the linkage, extending through Bee, Spring, Tapie, Tick, and Mint canyons. Desert scrub and juniper woodland community connections occur primarily east of Agua Dulce Canyon from below SR-14 to the Sierra Pelona Valley.

Table 3. Approximate Vegetation and Land Cover in the Linkage

Vegetation Type	**Hectares**	**Acres**
Water 0.001%	1.8	4.5
Pinyon-Juniper Woodland 0.004%	4.4	11.0
Agriculture 0.01%	11.9	29.4
Montane Riparian 0.02%	18.9	46.7
Coastal Oak Woodland 0.05%	52.3	129.2
Desert Wash 0.05%	56.5	139.7
Sagebrush 1.1%	108.7	268.7
Annual Grassland 1.3%	127.1	314.0
Barren 1.6%	163.2	403.2
Valley Foothill Riparian 1.7%	168.1	415.4
Urban 3%	321.3	794.0
Juniper 3.8%	373.0	921.6
Chamise-Redshank Chaparral 4%	385.2	951.9
Mixed Chaparral 17%	1660.0	4101.9
Desert Scrub 30%	2936.7	7256.7
Coastal Scrub 34%	3301.9	8159.2
Total	**9,691**	**23,947**

Removing and Mitigating Barriers to Movement

Five types of features impede species movements through the Linkage: roads, railroads, impediments to stream flow, industrial operations, and rural residential development. Although these comprise only a small portion of the Linkage Design area, their adverse effects on species movements are disproportionately large, and ameliorating them is essential to 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 structures to cross movement barriers. This broader context also allows awareness of a wider variety of restoration options for maintaining functional linkages. Despite the necessary emphasis

on crossing structures in this section, 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 (Forman et al. 2003, Trombulak and Frissell 2000, Forman and Deblinger 2000, Jones et al. 2000, Reijnen et al. 1997, Noss 1983, Harris 1984, Wilcox and Murphy 1985, Wilcove et al. 1986, Noss 1987). Roads cause fragmentation by killing animals in vehicle collisions, by creating discontinuities in natural vegetation (the road itself and induced urbanization), by altering animal behavior (noise, artificial light, human activity), by promoting invasion of exotic species, and by degrading the chemical environment (Lyon 1983, Noss and Cooperrider 1994, Forman 1998). Roads present 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 genetic isolation of populations caused by roads is an increasing cause of concern. For example, Ernest (2003) 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). Fragmentation by roads increases inbreeding and genetic drift, potentially contributing to extinction of local populations.

The impact of a road on animal movement varies with species (e.g., the same freeway would have different impact on ground beetles, coyotes, or birds), 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 slow-moving amphibians approaching breeding ponds (Stephenson and Calcarone 1999), but a similar road on a ridgeline would have negligible impact on the population. Virtually all documented impacts on animal movement concern paved roads; dirt roads are of less concern and may even facilitate movement of some species (Dickson et al. 2004).

Roads in the Linkage Design: At the time of this report, there are 118 km (73 mi) of paved roads in the Linkage Design area. Two of these roads (i.e., SR-14 and Sierra Highway) are major transportation routes and pose the greatest barriers to wildlife movement. By far the largest of these impediments is SR-14, which bisects the southern part of the linkage for a distance of 13 km (8 mi). A survey of these roads found a variety of bridges, culverts, and drainage pipes that might be useful for implementing road mitigation projects (Figure 44).

Table 4. Major transportation routes in the Linkage Design.

Road Name	Length (km)	Length (mi)
State Route 14	13	8
Sierra Highway	7	4
Soledad Canyon Road	18	11
Davenport Road	3	2
Other Paved Roads	36	23
Total Length of Paved Roads	**118**	**73**

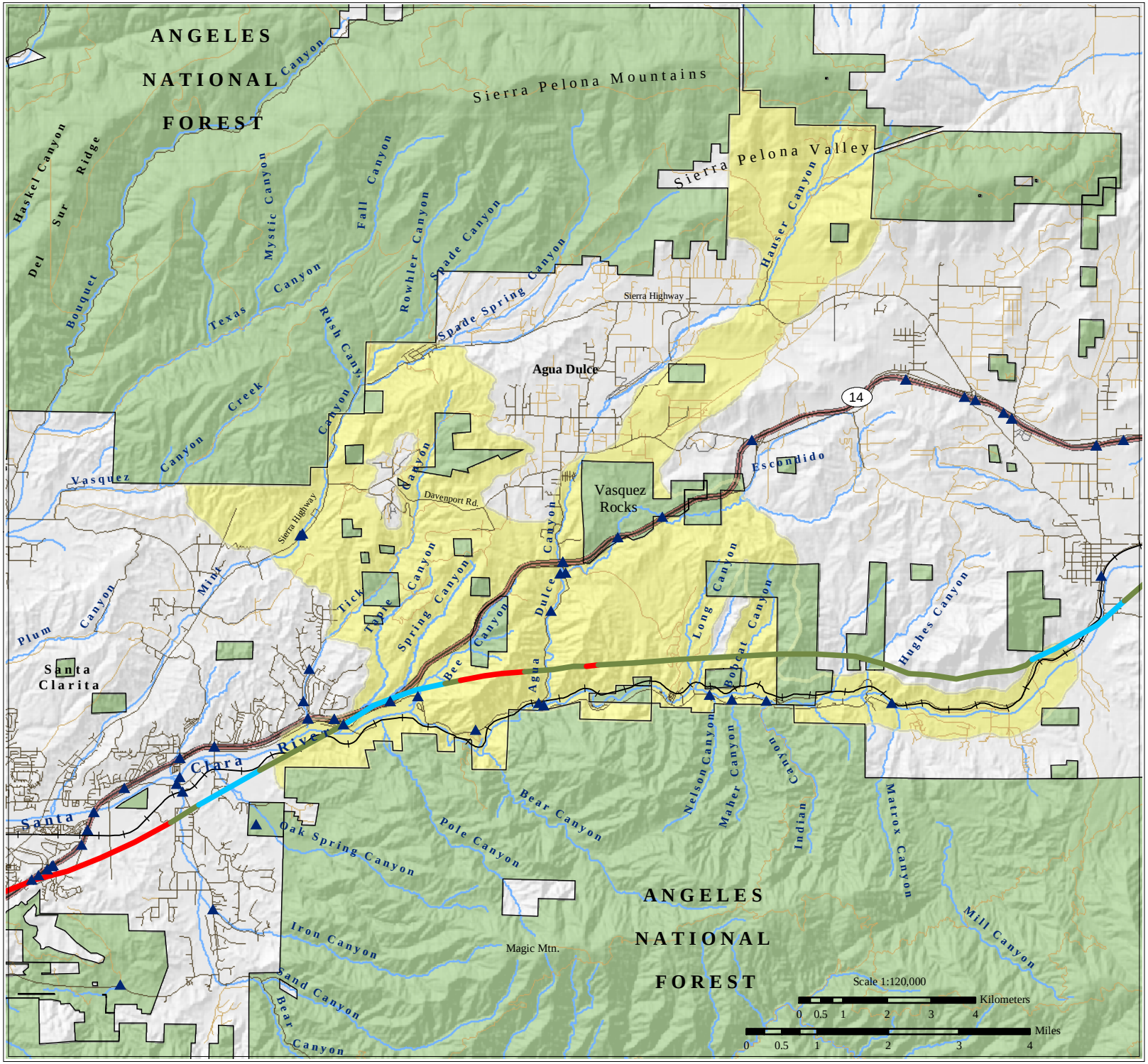
Figure 44.
Existing & Proposed Infrastructure in the Planning Area

Legend

- Linkage Design
- Potential Crossings Structures
- Highway
- Railroad
- Paved Roads
- Dirt Roads
- Hydrography
- Ownership Boundaries

Proposed High-Speed Rail

- At-Grade
- Aerial
- Tunnel



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Types of Mitigation for Roads: Forman et al. (2003) suggest several ways to mitigate the ecological impact of roads on landscape 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 have been documented to be useful for wildlife movement. Research and monitoring have 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 45) in Europe, Canada, Florida, Hawaii, New Jersey, and Utah (Evink 2002, Forman et al. 2003). They range in width from 50 m (164 ft) to more than 200 m wide (656 ft) (Forman et al. 2003). Soil depth ranges from 0.5 to 2 m, allowing for the development of herbaceous, shrub and tree cover (Jackson and Griffin 2000). Wildlife fencing is necessary to funnel animals towards passageways and away from roads (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). Habitat connectivity can be enhanced for small ground-dwelling animals by ensuring contiguous vegetation, or by placing branches, logs, and other cover along the overpass (Forman et al. 2003). 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, birds associated with woodland habitats 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).

Figure 45. An example of a vegetated land bridge built to enhance movement of wildlife populations. Photo by David Poulton.

Bridges over waterways should be wide enough to permit growth of both riparian and upland vegetation along both stream banks (Forman et al. 2003, Evink 2002, Jackson and Griffin 2000). The extended bridge is the most successful and cost-effective means of providing connectivity (Evink 2002). 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 46), 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 for most species, culverts are also effective (Jackson and Griffin 2000). For carnivores and other large mammals, large culverts (Figure 47) are most effective, and natural earthen substrate flooring is preferable to concrete or metal (Evink 2002). Gloyne and Clevenger (2001) suggest that underpasses for ungulates should be at least 4.27 m in height and 8 m wide, with an openness ratio of 0.9 (openness ratio=height x width/length). Noise, artificial night lighting, and other human activity can deter animal use of a passageway (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 crossing 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).

Figure 46. A viaduct in Slovenia built to accommodate wildlife, hydrology, and human connectivity.

Figure 47. Arched culvert on German highway, with rail for amphibians and fence for larger animals.

For rodents, pipe culverts (Figure 48), 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 (Forman et al. 2003, Clevenger et al. 2001). In places where a bridged, vegetated undercrossing or overcrossing is not feasible, placing pipe culverts alongside box culverts can help serve movement needs of both small and large animals. Special crossing structures that allow light and water to enter the structure have been designed to accommodate amphibians (Figure 49). Short retaining walls should be installed, where necessary, along paved roads to deter small mammals, amphibians, and reptiles from accessing roadways (Jackson and Griffin 2000). Concrete retaining walls are relatively maintenance free, and a great deal better than wire mesh, which must be buried and regularly maintained.

Figure 48. Pipe culvert designed to accommodate small mammals.

Figure 49. Amphibian tunnels allow light and moisture into the structure.

Recommended Locations for Crossing Structures on State Route 14: State Route 14 is the most substantial impediment to movement within the Linkage Design. It bisects the southern part of the linkage for 13 km (8 mi) and currently lacks adequate crossing structures (Figure 44). Given the continental importance of this linkage, we have identified four locations at which first-class crossing structures should be located. At each of these locations, we recommend ample bridged undercrossings large enough to allow natural vegetation to grow throughout the structure.

1. Near the confluence of Spring Canyon, Bee Canyon, and the Santa Clara River. The least cost corridors for puma, badger, mule deer, and Pacific kangaroo rat cross the freeway here, and appropriate habitats for California thrasher and Burrowing owl also occur along this part of freeway. Natural habitat abuts the freeway in most of this area. Finally, this area offers maximum continuity for coastal sage scrub along SR-14, and thus would best serve the needs of most species associated with coastal sage, including species that were not used in our permeability analyses. This is the last opportunity to ensure a connection of coastal habitats between the San Gabriel and Castaic Ranges.

The bridged underpass for Spring Canyon Road (Figure 50) is inadequate to accommodate species movement. The existing structure is not accessible to an animal in the Santa Clara River, due to the steep fill slope for Soledad Canyon Road (Figure 50). Although somewhat more permeable in the southbound direction, the steep drop off and lack of natural vegetation on the south side of the freeway, asphalt pavement in the 2-lane underpass, and the mining operation in the Santa Clara River make it unlikely that this structure and the surrounding habitat can be restored to provide meaningful connectivity in the foreseeable future.

We recommend a new bridge about 400 m east of the existing underpass, and redirecting the main channel of Spring Canyon under this new bridge, so that Spring Canyon would join Bee Canyon just south of SR-14, near the Santa Clara River (Figure 51). The new bridge would replace a section of fill slope along the low ridge between lower Spring and Bee Canyons (Figure 51). We also recommend enhancement of the vegetation underneath and approaching the bridge. This design would be the only location in which a long and essentially undisturbed canyon (Spring Canyon) would funnel animals toward a SR-14 underpass from the north. The south side of the freeway is close to both riparian and upland habitats, and away from the gravel mine.

2. Agua Dulce Creek. At present Agua Dulce Creek passes under SR-14 via an oversized concrete pipe culvert (Figure 52), with concrete flooring, poor visibility to the other side, and no vegetation in the structure, reducing the likelihood for plant and animal movement. South of SR-14, the riparian vegetation is well developed with cottonwoods, sycamores, and willows, and no significant riparian or upland impediments between SR-14 and Soledad Canyon (and the Angeles NF boundary) about 2 miles to the south. Immediately north of the freeway, the riparian vegetation is much reduced, and the town of Agua Dulce lies about 1 mile north, impeding meaningful riparian connectivity at this time. About a dozen homes along Agua Dulce Road between SR-14 and the town of Agua Dulce are probably compatible with linkage function. The least cost path of Badger crosses SR-14 here, and suitable habitat for several semiaquatic focal species, such as pond turtle, two-striped garter snake, and kingsnake, occurs in this area. To maximize the utility of Agua Dulce Creek as a movement area, we recommend removing the fill slope under SR-14 and upgrading the existing vehicle underpass to a bridged undercrossing that spans the canyon. Improving this structure could help animals get to Vasquez Rocks or funnel them toward the middle branch of the Linkage Design to Spring, Tapie, and Tick Canyons.

3 & 4. Escondido Creek. Escondido Creek crosses SR-14 twice in less than a mile, in the transition zone between coastal and desert scrub habitats. Vasquez Rocks County Park lies on the north side of SR-14 at both crossings. The riparian vegetation of Escondido Creek is lush, with mature Sycamores and willows. Least cost paths of American badger cross SR-14 in this area, which also provides the best habitat connectivity for Bear sphinx moth and several semiaquatic species. The extensive desert scrub in upland areas suggests it would be useful for a number of species

Figure 50. The existing Spring Canyon road underpass is not accessible to an animal in the Santa Clara River.

Figure 51. Removing the fill slope under SR-14 would route Spring Canyon to Bee Canyon and the Santa Clara River.

Figure 52. Agua Dulce Canyon vehicle underpass, with drainage culvert for stream visible to the left of the underpass.

associated with desert habitats whose needs we did not analyze. The western existing structure is a long concrete box at the bottom of a deep fill slope, with concrete flooring, poor visibility, and no vegetation in the structure. We recommend replacing the fill slope and culvert with a bridge. The Pacific Crest Trail runs through the eastern box culvert; the fill slope and culvert at this location should also be replaced with a bridge. Although the land south of the freeway at the eastern crossing is in private ownership, steep slopes, poorly consolidated soils, and seismic constraints may limit its development potential.

Recommended Locations for Crossing Structures on Sierra Highway: The Sierra Highway is a 2-lane road with heavy traffic volumes during rush hour (Figure 44). It is used as a commuter route between Santa Clarita and the communities of Sleepy Valley, Aqua Dulce, and White Heather. Sierra Highway stretches through 7 km (4 mi) of the Linkage Design. Although it doubtless contributes to wildlife mortality and is avoided by most species, it is not presently an impermeable barrier, especially at night. However, if lanes are added wildlife passage should be accommodated via bridged undercrossings that encompass both riparian and upland vegetation within the crossing structure. Three crossing structures should be built (at the time of road upgrading) in the section of Sierra Highway north of The Old Dirt Road and south of the community of Sleepy Valley. The highway runs along Mint Creek, crossing it 5 times in this stretch of road. When the road is upgraded, the number and location of crossings will probably change, but at least 3 crossing structures should be built. One should facilitate movement near the confluence of Rowher Canyon, Rush Canyon, allowing access to Rowher and Rush Canyons from the steep ridges southeast of the Highway. This area is currently in public ownership. The exact location of the other two structures will depend on conservation of the private lands that abut Sierra Highway in the rest of this area. Currently there are few dwellings or significant infrastructure (besides the highway). We recommend maintaining the rural character of the landscape southwest of the village of Sleepy Valley, with appropriate measures to confine light and noise pollution to the vicinity of the village. The second area for which we propose a bridged crossing structure is in the juniper woodlands, between Sierra Vista Drive and Shady Lane, in the eastern branch of the Linkage Design, where Willow Spring Gulch flows under Sierra Highway. There are a few dwellings in this area but they are widely spaced and retain most of the native vegetation. We emphasize that these improvements are not needed until significant road improvements (wide shoulders, realignment, or additional lanes) are undertaken.

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.

- Transportation agencies should 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). Promote the use of earthen substrate flooring. In locations where a bridge is not feasible and only a culvert can be provided, install a pipe culvert (designed to remain free of water) parallel to the box culvert 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 it al. 1997, Linden 1997, Clevenger and Waltho 1999, McDonald and St. Clair 2004). Work with the California Native Plant Society, local Resource Conservation District or other non-profit organization 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 and keep them off the highway. Install escape structures, such as earthen ramps, 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 both freeways and other paved roads, minimize artificial night lighting, and direct the light onto the roadway and away from adjacent wildland.

Roads as Ephemeral Barriers: Structures designed for wildlife movement are increasingly common. In southern California, 26 wildlife crossing structures were installed along 22-miles of State Route 58 in the Mohave Desert specifically for desert tortoise movement (Evink 2002). In the South Coast Ecoregion, 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 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. Smaller wildlife crossings on State Route 29 in south Florida have proved nearly as effective (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 fact demonstrates that the existing low permeability across SR-14 should not be accepted as 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 Interstate-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 a road, an urban development creates a barrier that cannot be corrected by building crossing structures. Urban and suburban areas make particularly inappropriate landscapes for movement of all large carnivores, most reptiles and amphibians, and many nocturnal small mammals. Thus development along freeways creates significant new and more permanent obstacles to landscape connectivity, above and beyond that presented by a freeway alone.

Representatives from CalTrans have attended each of the four workshops of the South Coast Missing Linkages effort, and the agency is eager to spend its mitigation dollars in the most important linkage areas. For example, CalTrans recently proposed building a wildlife overpass over SR-118, and in February 2003 CalTrans started removing pavement from the Coal Canyon interchange in Orange County and transferred the property to California State Parks expressly to allow wildlife movement between Cleveland National Forest and Chino Hills State Park. In the case of SR-14, improvements may not occur during the next 10-20 years, during which gene flow will continue to be disrupted. However, once connectivity is restored, genomes of all affected species should rapidly recover.

Rail Line Barriers to Movement

Like highways, railroads also can impede plant and animal movement across roads (Messenger 1968, Niemi 1969, Klein 1971, Stapleton and Kiviat 1979, Muehlenbach 1979, Lienenbecker and Raabe 1981, Forman et al. 1995), though there are some differences. Railroads tend to follow straighter lines than roads, trigger more and larger fires, and scatter deleterious particles widely over the land bordering the rail line (Forman and Boerner 1981, Forman et al. 2003). Roadkill rates are likely a great deal lower per train than per vehicle on roads, though trains have been derailed from collisions with large mammals. Grain spilled from trains can attract deer and bears to feed on the rail line; such events have caused significant mortality to grizzly bears in Montana (Federal Register Feb 11 2004. 69: 6683-6685; C. Servheen, University of Montana, personal communication). Freight trains transporting cargo also disperse non-native seeds, insects, and perhaps mammals along railroad networks (Thomson 1940, Stapleton and Kiviat 1979, Forman et al. 2003).

Existing and Proposed Rail Lines in the Linkage Design Area: The main line of the Southern Pacific Railroad has run through Soledad Canyon since 1876. Metrolink currently uses the tracks through Soledad Canyon between the Antelope Valley and Los Angeles with 10 trips in each direction per day, running from 4:00 am to 10:00 pm (Figure 53). The train tracks run parallel to the riverbed and the Angeles National Forest boundary in the Linkage Design area (Figure 44). In highly constricted areas in Soledad Canyon the tracks grasp the side of the canyon, scarcely outside of the riverbed (AMEC 2004). After a century, plants have recolonized cut and fill slopes, the River's braids and meanders have adapted to channel alterations, and mature riparian vegetation has re-established. Thus the railroad's narrow and often gently sloped footprint is probably fairly permeable to movement of plants and some animals (Figure 54).

The California High-Speed Rail Authority has proposed a 200 mph bullet train that would connect major cities throughout the state. The proposed route through the Linkage Design in Soledad Canyon is part of the Bakersfield to Los Angeles route, an alternative route is also being considered that would follow Interstate 5 from Bakersfield through the Tejon Pass. The proposed route through the Linkage Design area would create a barrier to wildlife movement much more severe than the current railroad because (a) the proposed alignment is mostly at-grade in the planning area, (b) the entire ROW would be fenced, (c) there would be massive cut and fill slopes along 30.9 km (19.20 mi) of Soledad Canyon alone, with additional impacts in the Santa Clara River, and (d) by 2020 86 weekday trains will travel 200 mph in each direction, creating 172 noise and vibration events per day.

The Draft Program Environmental Impact Report/Environmental Impact Statement for the project (http://www.cahighspeedrail.ca.gov/eir/) only evaluated impacts 0.8 km (0.5 mi) on either side of the proposed rail line, though impacts to existing conservation investments would go far beyond this area. Riparian and aquatic habitat would be seriously impacted by cut and fill slopes. Impacts to jurisdictional waters include loss or alteration of 12.6 ha (31.2 ac) of lacustrine waters, 10.1 ha (25 ac) of palustrine waters, 2.3 ha (5.7 ac) of riverine habitat, and 2.7 km (1.7 mi) of "non-wetland" intermittent streams and 45 m (146 ft) of "non-wetland" perennial streambeds associated with Agua Dulce Canyon Creek, Aliso Canyon Creek, Placerita Creek, and the Santa Clara River.

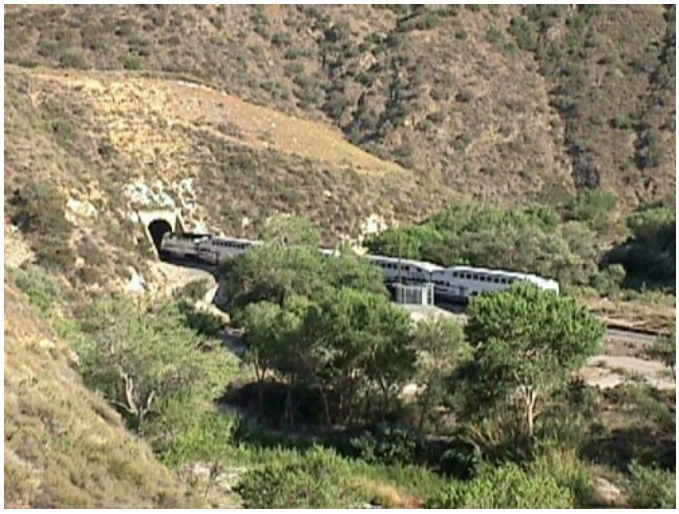

Figure 53. Metrolink running through Soledad Canyon, passing through the Santa Clara River.

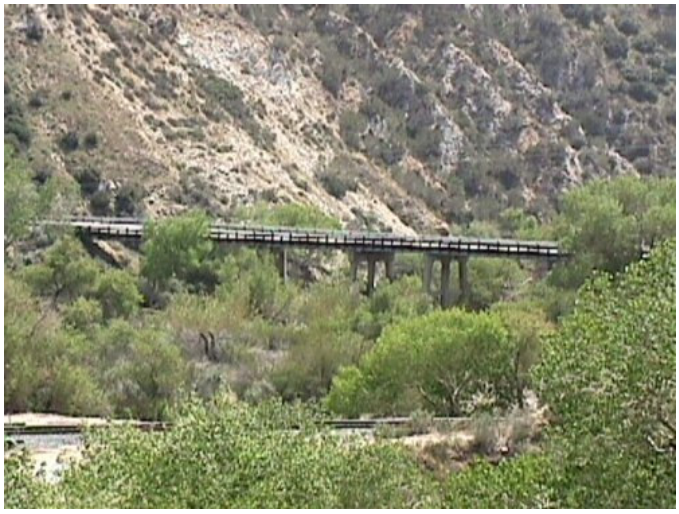

Figure 54. Expanded bridge over Santa Clara River with the railroad in the foreground.

Recommendations to Mitigate the Effects of Rail Lines in the Linkage Design Area: We believe that the existing rail line, as currently operated, does not require special mitigation measures. At the time the line is altered, the responsible agencies should use construction as an opportunity to improve wildlife permeability across the railroad. Mitigating the adverse affects of railroads is similar to that for roads, providing viaducts, bridged underpasses, tunneling, etc. (Reed and Schwarzmeier 1978, Borowske and Heitlinger 1981, Forman et al. 1995).

We recommend that the High Speed Rail project adopt a policy of no net loss of wildland connectivity. It may be impossible to do with the currently proposed alignment in Soledad Canyon. We recommend considering an alternative alignment following SR-14, perhaps in the highway median. By building sound walls to reduce noise and light pollution along the combined rail and road corridor, and sharing the cost of the 4 SR-14 crossing structures recommended above, the project could actually create a net benefit to the utility of the linkage. Transportation agencies could use this as an opportunity to work together to install wildlife-crossing structures (i.e. ecological infrastructure) under SR-14.

Impediments to Streams

Wetland and riparian habitats occupy less than 1% of the total land area in the western U.S., yet are used by up to 80% of terrestrial vertebrate species (Kreuper 1992). The ninth annual report of the U.S. Council on Environmental Quality (1978) states, "no ecosystem is more essential than the riparian system to the survival of the nation's fish and wildlife" (Horwitz 1978, Faber et al. 1989). Despite their importance to biological communities, over 90% of the historic wetland and riparian vegetation in Southern California has been eliminated or severely altered by urban and agricultural activities (Peters and Noss 1995). Coastal watersheds, in particular, have suffered due to dams, diversions, channelization, development, livestock grazing, and land disturbance (Dennis et al. 1984, Bell 1997). This extensive loss of habitat has resulted in declines in wildlife and plant populations that depend wholly or in part on riparian systems (Faber et al. 1989).

Terrestrial organisms moving through rugged landscapes also often use riparian areas as travel routes. Some invertebrates, such as butterflies, preferentially move through streamside areas (USGS 2002a, Orsack 1977). Some species of frogs are restricted to streamside movements (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 through riparian corridors (Beier 1995, Dickson et al. 2004).

For plants and animals associated with streams or riparian areas, impediments are presented by 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 streambeds. 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).

Impediments to streams in the Linkage Design: The Linkage Design encompasses several connections for semi-aquatic and riparian species. Soledad Canyon (Santa Clara River) is the most prominent riparian feature in the Linkage Design, meandering along the Forest Service boundary in the southern part of the linkage, from Acton west to Pole Canyon. None of the tributaries of the Santa Clara River (Long, Bobcat, Escondido, Agua Dulce, Bee, Spring, Tapie, Tick, and Mint) provides a direct riparian connection between the two Core Areas. Two of these tributaries – Agua Dulce Creek and Mint Creek – historically provided a continuous avenue along which aquatic and semi aquatic species could journey between the San Gabriel and Castaic ranges. Today the lower 3 miles of Mint Canyon are heavily urbanized, and riparian vegetation is absent from over 2 miles of the middle reaches of Agua Dulce Creek within the town of Agua Dulce (Darling Road nearly to Sierra Highway). Although fragmented, the remaining riparian areas are crucial for sustaining populations of water-dependent species (e.g., western pond turtle, two-striped garter snake, mountain kingsnake) in the Linkage Design area, and may function as steppingstones that allow movement by semiaquatic species. The pond turtle, for instance, is known to make overland

movements among drainages (Holland unpubl.). They can also provide travel routes for terrestrial organisms, such as mountain lion, which are known to move along riparian corridors (Spotwart and Samson 1986, Beier and Barrett 1993, Dickson et al. 2004).

The Linkage Design encompasses the headwaters of the Santa Clara River. A number of tributaries drain the San Gabriel Mountains from the Tujunga Ranger District of the Angeles National to the Santa Clara River: Pole, Bear, Nelson, Maher, Indian, Matrox, Mill, and Arrastre creeks. Vegetation along these drainages is a mixture of oak woodland, willow scrub, mulefat, sycamore, and cottonwood depending on the availability of water along these creeks. Tributaries draining the Castaic Ranges from the Saugus Ranger District or originating in the linkage itself include Vasquez, Rowher, Spade, Spade Spring, Mint, Tick, Tapie, Spring, Bee, Agua Dulce, Lettreau, Hauser, Willow Springs, Escondido, Long, and Bobcat creeks. Vegetation along these drainages varies widely, from high quality riparian scrub, woodland, and forests, and alluvial fan sage scrub to areas where riparian vegetation is reduced or absent (i.e., Agua Dulce), due to groundwater pumping or diversions. Riparian and upland vegetation along the river, while spectacular, has also been impacted. There are a number of recreational camps along the river that have greatly altered and infringed upon the stream channel and there is a large mining operation in the riparian zone off of Soledad Canyon Road near SR-14.

Historically runoff from the San Gabriel and Castaic Ranges supported riparian and aquatic habitat along the river and its tributaries. The presence of broad sandy washes suggests that flows may have been seasonal along some stretches but close enough to the surface to sustain riparian vegetation. The continuous stands of sycamore and cottonwood riparian forest, willow woodland and riparian scrub provided avenues for riparian and aquatic species to move between the river and its tributaries. Winter rains likely facilitated fish dispersal and allowed arroyo chub, Santa Ana sucker, and Unarmored three-spine stickleback to move among tributaries and the main stem of the river. Historical records indicate an intermittent flow regime in the mainstem of the river, with seasonal surface flows in years of high precipitation, and infrequent but torrential floods (Schwartzberg and Moore 1995, AMEC 2004).

Ground water pumping has drastically altered the hydrology of the Santa Clara River and its tributaries and has likely triggered a substantial reduction in riparian vegetation. There are a number of wells that extract groundwater from the aquifers at rates greater than 100 gallons per minute and several small volume private wells scattered throughout the planning area. The major water purveyors are Los Angels County Water Works District, Acton Camp, a trailer park, and a few large private wells installed in the southern part of the Acton Valley Groundwater Basin, with 21 private wells in the Soledad Canyon Alluvial Channel (AMEC 2004). Concerns over groundwater supplies arose as early as the 1920s (Schwartzberg and Moore 1995). Groundwater levels have been declining ever since due to an increase in industrial, commercial and residential uses in conjunction with prolonged drought (AMEC 2004). Groundwater supplies are now at record lows, with several wells in the upper watershed at catastrophically low levels.

Water quality on the main stem and several tributaries has also been impaired. Mint Canyon and several reaches of the Santa Clara River were listed as impaired under Section 303(d) of the Clean Water Act due to excessive total dissolved solids, sulfate and chloride in 2002 (RWQCB). Total dissolved solids are measured as the amount of

material that is dissolved in water and can include carbonate, bicarbonate, chloride, sulfate, phosphate, nitrate, calcium, magnesium, sodium, organic ions, and other ions. These listings make these riparian stretches eligible for the development of intensive management plans called Total Maximum Daily Load (TMDL) plans. TMDLs are implemented by the Regional Water Quality Control Board, which evaluates the cause of water quality deterioration and then enacts an implementation plan to return water quality to targeted values. Other water quality efforts either completed or in progress include development of a chloride TMDL (Total Maximum Daily Load) for the upper reach of the River, a nutrient TMDL, and on-going NPDES permit related monitoring (AMEC 2004).

Examples of Mitigation for Stream Barriers: The primary goal of many restoration projects has been to restore habitat for targeted species; however, few restoration projects have focused on the natural dynamics of the systems on which these species depend (Bell 1997). In riparian systems, annual floods are a major component of ecosystem function. Many riparian plants are considered pioneer species, and have developed adaptations such as rhizomes, stolons, and wind- and water-disseminated seeds, that allow seedlings to become quickly established on newly deposited soils (Ohmart 1994). Because of the adaptation and resilience of riparian plants to high-disturbance regimes such as floods, revegetation can be a natural process if threats (i.e. invasive species) are removed from the system and physical processes are restored (e.g., dams and diversions are mitigated or removed, natural flow regimes restored).

Continuity between upland and riparian vegetation types is also a key component of viable riparian ecosystems. Many species commonly found in riparian areas depend on upland habitats during some portion of their cycle. These species 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 streams edge has rarely been estimated for these 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.

Conservation measures to minimize the impacts of development on aquatic habitats primarily focus on the use of riparian buffer zones. Regulations exist to limit development along or near streams and rivers (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. A functional buffer must encompass a sufficient amount of 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 National Marine Fisheries Service, California Department of Fish and Game, Los Angeles County Department of Public Works, Water Districts, 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/riparian conditions based on parameters developed by NFMS (1996).

- Mitigate the effects of road crossings in riparian zones. Coordinate with the California Department of Transportation, National Marine Fisheries Service, and California Department of Fish and Game to evaluate existing stream crossings and upgrade culverts, stream crossings, bridges, and roads that impede movement (USFWS 1998). 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. Install specialized culverts and bridges in streams for improved fish passage to address outfall height, water velocities, and water depth for adequate upstream fish passage (Carey and Wagner 1996, Evink 2002).

- Restore riparian vegetation in all drainages and upland vegetation within 1 km (0.6 mi) of streams and rivers. These areas may restrict plant or animal movements and compromise water quality by increasing erosion and non-point sources of pollution. If restored, these areas would support aquatic and semi-aquatic species and enhance movement through both aquatic and riparian habitats. Discourage the construction of concrete-banked streams and other channelization projects.

- Remove exotic aquatic plants and animals from streams, rivers, and lakes. Work with the Biological Resources Division at USGS, U.S. Forest Service, Bureau of Land Management and other relevant agencies to survey streams and drainages for invasive species and develop a comprehensive removal strategy. The survey and removal should document and recommend how to deal with ephemeral drainages that are becoming increasingly perennial due to urban and agricultural runoff, and 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 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 in the Santa Clara Watershed. 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.

- 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.

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, Bureau of Land Management, 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.

Mining Operations

Mining operations harm species, habitat, and ecological systems through direct impacts from the mining operation, impacts on water and air quality, impacts due to the associated infrastructure (roads, pipeline, power lines), habitat loss and fragmentation, non-native species invasions, release of pollutants, and increased motorized access (Penrod et al. 2002). All types of mining activity, from simple prospecting to the use of sluice boxes and suction dredges, can harm aquatic species. Mining alters habitat in a way that promotes the presence of harmful non-native species, for instance, suction dredging creates deeper pools, which provide habitat for nonnative predatory species such as sunfish and bullfrogs. Surface and groundwater quality can be degraded, and water quantity diminished through the direct use of water in the mining process. Mining impairs air quality through the generation of fugitive dust from blasting and crushing activities, roads, pipeline corridors, and other infrastructure disturbances. Both riparian and terrestrial habitats can be heavily impacted by mining activities (USFWS 2001).

Mining in the Linkage Design Area: Mining has a long history in Soledad Canyon, dating back to around 1860, when gold was discovered. Mining camps emerged along the river near the canyon's rich veins of silver and copper. An assortment of log cabins and tents, given the name "Soledad City," migrated up and down the canyon with each new strike. By the time the railroad came through Soledad Canyon in 1876, most of the large mines were already inactive. The existing communities of Acton and Ravenna are old mining towns that still retain their rural character.

Historically, there was also an active mine in Tick Canyon, the Sterling Borax mine (also known as the Lang Mine) that was active from 1908-1918. Colemanite was also mined through two vertical shafts, each 350 feet deep; pumping was required to keep the lower levels free of water. The mine closed in 1922, and the plant was dismantled in 1926.

The workings have now been back filled and the surface recontoured. However, Tick Canyon is still well known to rock hounds, being most famous for its high quality howlite nodules and the very rare strontium borate veatchite. As late as 2000, the U.S. Borax Co. still owned the site and allowed access to the Sierra Pelona Rock Club of Newhall (Wilkins and Housley 2000). Though reclamation has been carried out, tailings from the abandoned mine in Tick Canyon are still visible today (Figure 55).

Figure 55. Abandoned mine tailings in center of photo still visible in Tick Canyon.

Today, sand and gravel mining is the primary form of resource extraction on the Santa Clara River. In the Linkage Design area, an active mine occurs along the Santa Clara River near SR-14 (Figure 56) that is scheduled to cease operations within a decade, at which time reclamation will take place. Several listed and sensitive species and natural communities are known to occur in the vicinity of the operation; agencies with regulatory oversight include U.S. Fish and Wildlife Service, California Department of Fish and Game, Army Corps of Engineers, Regional Water Quality Control Board, U.S. Forest Service, and Los Angeles County.

Figure 56. Active aggregate mine in the Linkage Design, at the confluence of Bee and Spring Canyons and the Santa Clara River near SR-14.

Another mining project, CEMEX, has been proposed on 460 acres of public land in Soledad Canyon. The initial phase is proposed to span 20 years, with excavation 6 days a week, sixteen hours a day, and blasting planned for twice a week for 10 years, then four times a week for the subsequent 10 years. Materials transport is estimated at 694 trips per day, mostly via SR-14. Significant adverse impacts would include habitat loss, impairment of wildlife movement corridors, changes in surface and groundwater levels, siltation, and modification of channel capacity during floods (AMEC 2004). Legislation has been proposed that, if passed, would prohibit this mine from coming on line.

Examples of Mitigation for Mining Operations: Mining operations eliminate and degrade habitat and create movement barriers that cannot be readily removed, restored, or mitigated. Preventing any further mining operations in key areas of the Linkage

Design through administrative withdrawals will have the greatest effect on preserving linkage function. Existing mining operations can be targeted for regulatory actions that reduce the effects of these industrial activities. These include, limiting noise from blasting, minimizing night lighting, reducing traffic in sensitive areas or constriction points, monitoring water quality and quantity, minimizing the use of harmful chemicals, and increasing enforcement of existing regulations. The California Surface Mining and Reclamation Act (1975) require that land used in mining operations be restored.

Recommendations to Mitigate the Effects of Mining in the Linkage Design Area: We provide the following initial recommendations regarding mining activities in the Linkage Design area:

- No new mining operations in the Linkage Design. Apply for administrative withdrawals to promote recovery of listed and sensitive species and their habitats;

- Prohibit surface occupancy within riparian zones. Mining operations should avoid disturbance of natural waterways, rare or imperiled habitat or species, wildlife movement corridors, and other biological resources;

- Placement of mine tailings, soil and overburden, and industrial waste in riparian zone should be prohibited;

- Monitor facilities and mining residue in or adjacent to riparian zones to ensure that discharges are not causing detrimental effects to listed or sensitive species or their habitat;

- Monitor mining operations for the presence of non-native aquatic species and develop eradication programs;

- Monitor compliance with all regulations, the approved plan of operations, and with state and federal law;

- Monitor the off-site effects of mining activities on key physical and biological resources and downstream conditions; and

- When existing lease is up in Soledad Canyon, reclaim under guidelines set forth by the 1975 California Surface Mining and Reclamation Act.

Urban Barriers to Movement

Urban development, unlike a road or an aqueduct creates a barrier 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). Apart from the direct loss of habitat caused by the construction of buildings and associated infrastructure, urban developments have negative effects far beyond the boundaries of the construction footprint. These effects, known as edge effects, can significantly reduce plant and animal populations and impede ecosystem functions in surrounding areas. Most terrestrial mammals that move at night will avoid areas that have artificial night lighting (Beier, in press). Pet cats can hunt in a 3 ha area (Hall et al.

2000) and significantly depress populations of small vertebrates (Churcher and Lawton 1987, Crooks 1999, Hall et al. 2000). Irrigation of landscapes surrounding homes can encourage 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 with habitat disturbance from human use show decreases in bird and small mammal populations (Sauvajot unpubl.).

Urban Barriers in the Linkage Design Area: Urban developments comprise just 3% of the Linkage Design area. The most significant area of urban encroachment is from the City of Santa Clarita, in lower Tapie, Tick, and Mint canyons. Scattered rural residential development extends along portions of Soledad Canyon Road, Davenport Road, Agua Dulce Road, Escondido Canyon Road, and Sierra Highway. Rural communities in or adjacent to the Linkage Design include Sleepy Valley, Aqua Dulce, White Heather, Vasquez Rocks, Ravenna, and Acton. The remainder of the Linkage Design area is mostly zoned as rural residential.

Throughout the Linkage Design, most homes are on lots larger than 5 acres that retain most of the native vegetation, and avoid chain-link fences. Relatively small expanses of such developments, such as that in the community of Sleepy Valley, probably cause minimal impediment to animal movement. Larger expanses, such as in Agua Dulce, are much less permeable due to increased traffic volume, higher traffic speed, increased numbers of pets (predators on small wildlife, prey of large carnivores), increased lighting and noise and other impacts presenting a serious threat to connectivity. We strongly recommend a public education campaign, such as the On The Edge program developed by the Mountain Lion Foundation, which encourages residents at the urban wildland interface to become active stewards of the land. Such voluntary cooperation is essential to functioning of the linkage, to limit impacts of lighting, roads, domestic livestock, pets, and traffic on wildlife movement in the Linkage Design area.

Examples of Mitigation for Urban Barriers: Urban developments, unlike roads, create movement barriers that cannot be readily removed, restored, or mitigated. Preventing urban developments in key areas through acquisition or conservation easements with willing landowners will have the greatest effect on preserving linkage function. Mitigation for existing urban developments focuses on designing buffers that reduce penetration of undesirable effects into natural areas (Marzluff and Ewing 2001). These buffer areas can be targeted for management actions that reduce the effects of urban activities. These include fencing in pets, reducing human traffic in sensitive areas or constriction points, limiting noise and lighting, reducing traffic speeds, minimizing use of irrigation, minimizing the use of pesticides, poisons and other harmful chemicals, and increasing enforcement of existing regulations.

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

- Homes abutting the linkage area should have minimal outdoor lighting, always directed toward the home and yard rather than into the linkage. Homeowners should 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, which encourages residents at the urban wildland interface to become active stewards of the land by reducing penetration of undesirable effects into natural areas. Such voluntary cooperation is essential to preserving linkage function. 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, minimizing the use of pesticides, poisons and other harmful chemicals, and effective reporting of violations.

- Work with Los Angeles County on their 2025 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 (http://www.mountainlion.org) 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.

- Work with 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.

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: Areas currently available for recreation include the US Forest Service lands in the Core Areas, and Vasquez Rocks County Park, the Pacific Crest Trail, and several water camps along the Santa Clara River in Soledad Canyon in the Linkage Design area. The County lands contain riparian, desert scrub and juniper woodland habitats that are flanked by a growing number of homes. The County lands form a particularly critical portion of the Linkage Design area, supporting both riparian and upland species movements through an already constricted portion of the linkage. The Pacific Crest Trail is being encroached upon by rural residential development, diminishing the value of this national scenic treasure. The Linkage Design provides an opportunity to reroute the trail north of Vasquez Rocks. A number of water camps currently exist along the river in Soledad Canyon that have diverted water from the river to form pools for water play. The activities of these water camps are fairly unrestricted, further exacerbating the depletion of water resources in the river and creating unnatural habitats favored by invasive and predatory aquatic species.

Examples of Mitigation for Recreation: If recreational activities are effectively monitored, most negative impacts can be avoided or minimized by limiting types of use, directing recreational activities away from particular locations, sometimes only for particular seasons, and with reasonable precautions.

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;

- 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; and

- Enforce existing regulations on types of recreational use currently established.

Land Protection & Stewardship Opportunities

A variety of planning efforts addressing the conservation and use of natural resources are currently underway in the Linkage Design area. The South Coast Missing Linkages Project supports and enhances existing efforts by providing information on regional linkages critical to achieving the conservation goals of each planning effort. Since the South Coast Missing Linkages Project addresses connectivity needs for the major linkages associated with the South Coast Ecoregion, it can provide a landscape context to localized planning efforts to assist them in achieving their conservation goals. This Project is deeply committed to collaboration and coordination to achieve the vision of a wildlands network for the South Coast Ecoregion and beyond.

In this section, we provide information on planning efforts, agencies, and organizations in the region that may represent potential collaborative opportunities for conserving the San Gabriel – Castaic Linkage. While this list is not exhaustive, it is meant to provide a starting point for persons interested in becoming involved in preserving and restoring linkage function.

Antelope Valley Trails, Recreation and Environmental Council: The primary goal of AVTREC is to create a system of interlinking trails for the entire Antelope Valley. AVTREC drafted a Master Trails Plan for the Antelope Valley, which ties into the Pacific Crest Trail. The council seeks to preserve the natural environment, create wildlife corridors and include equestrians, hikers and bicyclist in the Master Trails Plan. Working with public agencies and other groups, AVTREC has already secured 90 miles of trails from Leona Valley to Acton in the North County Trail System. AVTREC realizes trails are not easily established once highways, housing developments and commercial centers are in place. For more information on AVTREC, visit http://www.avtrec.av.org.

Arundo Task Force: The Ventura County and Los Angeles County task forces coordinate Arundo removal and control efforts. The Ventura Resource Conservation District is spearheading the Upper Santa Clara River Watershed Arundo Donax and Tamarisk Eradication Program funded through Proposition 13. This long-term project will map infested areas, monitor removal efforts, and conduct outreach to help restore watershed integrity, improve facultative filtration, remove large trash components in stream runoff, and improve groundwater recharge. For more information on the project go to: http://www.swrcb.ca.gov/rwqcb4/html/programs/nps/prop13_contract.html.

Bureau of Land Management: BLM sustains the health, diversity and productivity of the public lands for the use and enjoyment of present and future generations. BLM owns several key parcels in the Linkage Design Area. Their South Coast Resource Management Plan designates all BLM parcels in the San Gabriel-Castaic Linkage as "Land Available for Transfer," presumably to the US Forest Service (BLM 1996). A revised Resource Management Plan is expected in the coming years that may establish acquisition priorities in the Linkage Design area. Representatives from BLM have attended each of the South Coast Missing Linkages workshops. For more information on lands administered by the BLM, visit http://www.ca.blm.gov.

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 is undertaking a collaborative effort with local entities to develop an effective water quality monitoring plan in the watershed that will accurately 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 Santa Clara River system. Reclamation will also oversee the restoration of the existing mining operation in the Linkage Design once operations have ceased. 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. For more information on the Department, visit their website at 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 are eager to spend their mitigation dollars on the most important linkage areas; they 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 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 will 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. Two of the proposed Wilderness Areas are associated with the Linkage Design, Magic Mountain (12,080 ac) and Santa Clarita Woodlands (4,200 ac). 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.

City of Santa Clarita's River Corridor Plan: The City of Santa Clarita is concentrated on land acquisition along the river to develop a park and trail system; the regional river trail serves as the backbone of the trail system. The City hosts an Annual River Rally to highlight the importance of natural habitats along the Santa Clara River. The City's recent purchase in Bee Canyon was a critical acquisition in the Linkage Design. The City adopted policies on Managed Growth and Open Space Acquisition in 2002 that discuss creation of an open space buffer surrounding the City; open space in the Linkage Design is consistent with those adopted policies. For more information on the City's programs, go to http://www.santa-clarita.com.

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). The segment of the Linkage Design that falls within Los Angeles County has been proposed as part of the Santa Clara River SEA (PCR 2000), which includes several important wildlife movement areas. Two other SEAs also occur in the vicinity of the linkage, Cruzan Mesa and the Santa Susana-Simi Hills. 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: Los Angeles County also manages Vasquez Rocks Natural Area Park, a key protected area in the Linkage Design. This 745-acre park of unique geological rock formations is located north of SR-14 in the high desert near Agua Dulce Springs. The park features important biological and cultural resources. Working with the Department of Parks and Recreation will be critical to implementing the Linkage Design. 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, they have 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

Friends of the Santa Clara River: The Friends have been actively engaged in with watershed activities along the length of the river with a focus on the protection, enhancement, and management of the river's resources. The Friends are involved in several efforts including planning activities, habitat management, habitat restoration, and public education and outreach regarding the resource values of the river. The Friends own and manage a 230-acre river terrace property near the city of Santa Paula with over a mile of river frontage called the Hedrick Ranch Natural Area. Visit their website for more information at http://www.FSCR.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 & enforcement; acting as a technical advisor, member, and/or 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: The purpose of this program is to provide 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.

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." The National Park Service recently secured land in the Linkage Design, along the Pacific Crest Trail, on both sides of SR-14. NPS is a partner in the South Coast Missing Linkages Project. For more on the National Park Service, see http://www.nps.gov.

Pacific Crest Trail Association: The mission of the Association is to protect, preserve and promote the Pacific Crest National Scenic Trail so as to reflect its world-class significance for the enjoyment, education and adventure of hikers and equestrians. The Association works to: promote the Pacific Crest National Scenic Trail as a unique educational and recreation treasure; provide a communications link among users and land management agencies; and assist the U.S. Forest Service and other agencies in the maintenance and restoration of the Pacific Crest National Scenic Trail. The Pacific Crest Trail crosses through portions of the Linkage Design and may be helpful in directing federal funds to secure land in the linkage. To find our more about the Association, visit them at http://www.pcta.org.

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 waters in the Linkage Design area. Mint Creek, a tributary to the Santa Clara River, is one of the first Total Maximum Daily Load (TMDL) planning efforts undertaken in the state to identify sources of pollutants and restore water quality for an impaired water body. Other impaired water body listings in the Santa Clara Watershed include the stretches of the Santa Clara River, the Santa Clara River estuary, and Bouquet Creek. For more information, visit their website at http://www.swrcb.ca.gov.

Resource Conservation Districts (RCD): The federal district has two offices with responsibilities in the Linkage Design area, the Antelope Valley RCD and Ventura 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. The RMC is actively engaged in conservation planning efforts in the Linkage Design area. To find out more about the RMC, visit their website at http://www.rmc.ca.gov.

Santa Clara River Enhancement and Management Plan: The purpose of the SCREMP is to provide a guidance document that addresses the preservation, enhancement, and sustainability of resources for the entire length of the river, encompassing all land within the 500-year floodplain. The plan identifies land in the Linkage Design as having significant regional conservation value and calls for maintaining existing habitat values and river channel connectivity (AMEC 2004). The plan developed from a highly collaborative process that involved numerous stakeholders that is coordinated by the Ventura County Watershed Protection District and Los Angeles County Department of Public Works. The plan may provide opportunities for protecting land along the river in the Linkage Design area. The plan is currently out for public review, and can be viewed at http://sdgis.amec.com/scremp/index.htm.

Santa Clara River Trustee Council: The Santa Clara River Trustee Council, made up of representatives from the U.S. Fish and Wildlife Service and the California Department of Fish and Game, is administering $1.5 million to fund ecological restoration projects in the Santa Clara River watershed in Ventura and Los Angeles counties. Ecological restoration projects include habitat improvement, and ecological research, monitoring, and educational efforts associated with habitat restoration. The funds are from the settlement of claims for natural resource damages resulting from an ARCO pipeline oil spill into the Santa Clara River. Several projects have been proposed that would contribute to the protection and restoration of habitats in the Linkage Design. For more information on the Council, visit http://www.ventura.fws.gov/ SCRiverPlan/SCR.

Santa Clarita Organization for Planning the Environment (SCOPE): SCOPE has been engaged in educating the public about planning and environmental issues in the Santa Clarita Valley, including those involving the river. SCOPE informs the public

about environmental and planning projects in the SCV, and takes action to promote the quality of life in the Santa Clarita Valley. More information about this group can be found at their website http://www.scope.org.

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. The Conservancy manages parkland in both the Castaic (i.e., Sierra Pelona) and San Gabriel (i.e., Santa Clarita Woodlands) protected core areas. They also manage land in the surrounding ranges, in the Santa Monica Mountains, Simi Hills, and Santa Susana Mountains as part of their Rim of the Valley Trail Corridor plan. The SMMC is a partner in the South Coast Missing Linkages effort. For more information on SMMC, visit them at http://www.smmc.ca.gov.

Sierra Club's Santa Clara River Greenway Campaign: The stated goal of this effort is to bring the entire 500-year floodplain of the river from Fillmore to Acton into public ownership and protection. The campaign has identified a number of protection needs including water quality and quantity, plant and wildlife species habitats, movement corridors for wildlife, open space attributes and aesthetics, river fluvial dynamics, and agricultural resources. For more information on the Sierra Club's campaigns, go to http://www.sierraclub.org.

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 key 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.

***Trust for Public Land*:** The Trust for Public Land conserves land for people to enjoy as parks, gardens and other natural places, ensuring livable communities for generations to come. TPL's Western Rivers Program works to reestablish and protect the natural function of river systems. TPL has protected over 30,000 acres of river, wetland, and watershed lands in California. For more information on their efforts, go to http://www.tpl.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.). They 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. Watershed planning efforts such as this may provide opportunities for restoration of natural water flow and riparian vegetation in the linkage. 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*), California gnatcatcher (*Polioptila californica californica*), southwestern willow flycatcher (*Empidonax traillii extimus*), least Bell's vireo (*Vireo belli pusillus*), and vernal pools. The Santa Clara River is also listed as a potential recovery watershed for southern steelhead trout. 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 Santa Clara Watershed, mostly on U.S. Forest Service land. 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. DFG has strong interests in the linkage and has previously purchased lands along the Santa Clara River. 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.

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 San Gabriel-Castaic Linkage 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, Bureau of Land Management, County of Los Angeles, City of Santa Clarita, and other conservancy lands. Each holding lies within Core Areas or the linkage itself and serves a unique role in preserving some aspect of the connection. 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 each 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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Appendices

Appendix A: Workshop Participants

South Coast Missing Linkage Project: Habitat Connectivity Workshop September 30, 2002			
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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

The South Coast Wildlands is in the process of producing several fly-overs or 3D visualizations of the San Gabriel – 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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