South Coast Missing Linkages Project:

A Linkage Design for the Peninsular-Borrego Connection

November 2006

Prepared by:

Kristeen Penrod
Clint R. Cabañero
Dr. Paul Beier
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Produced by South Coast Wildlands: Our mission is to protect, connect and restore the rich natural heritage of the South Coast Ecoregion through the establishment of a system of connected wildlands.

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Workshop Speakers: Alan Dixson, Zoological Society of San Diego, Center for Reproduction of Endangered Species; Scott Morrison, The Nature Conservancy; Ernesto Franco, CICESE; Tom Oberbauer, Department of Planning and Land Use, County of San Diego; Kathy Williams, San Diego State University; Rob Lovich, Marine Corps Base Camp Pendleton; Philip Unitt, San Diego Natural History Museum; Esther Rubin, Conservation Biology Institute formerly with Zoological Society of San Diego, Center for Reproduction of Endangered Species; Ken Logan, University of California Davis, Wildlife Health Center; Walter Boyce, University of California Davis, Wildlife Health Center; and Claudia Luke, University of California Davis formerly with San Diego State University, Field Stations Program

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Executive Summary

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

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

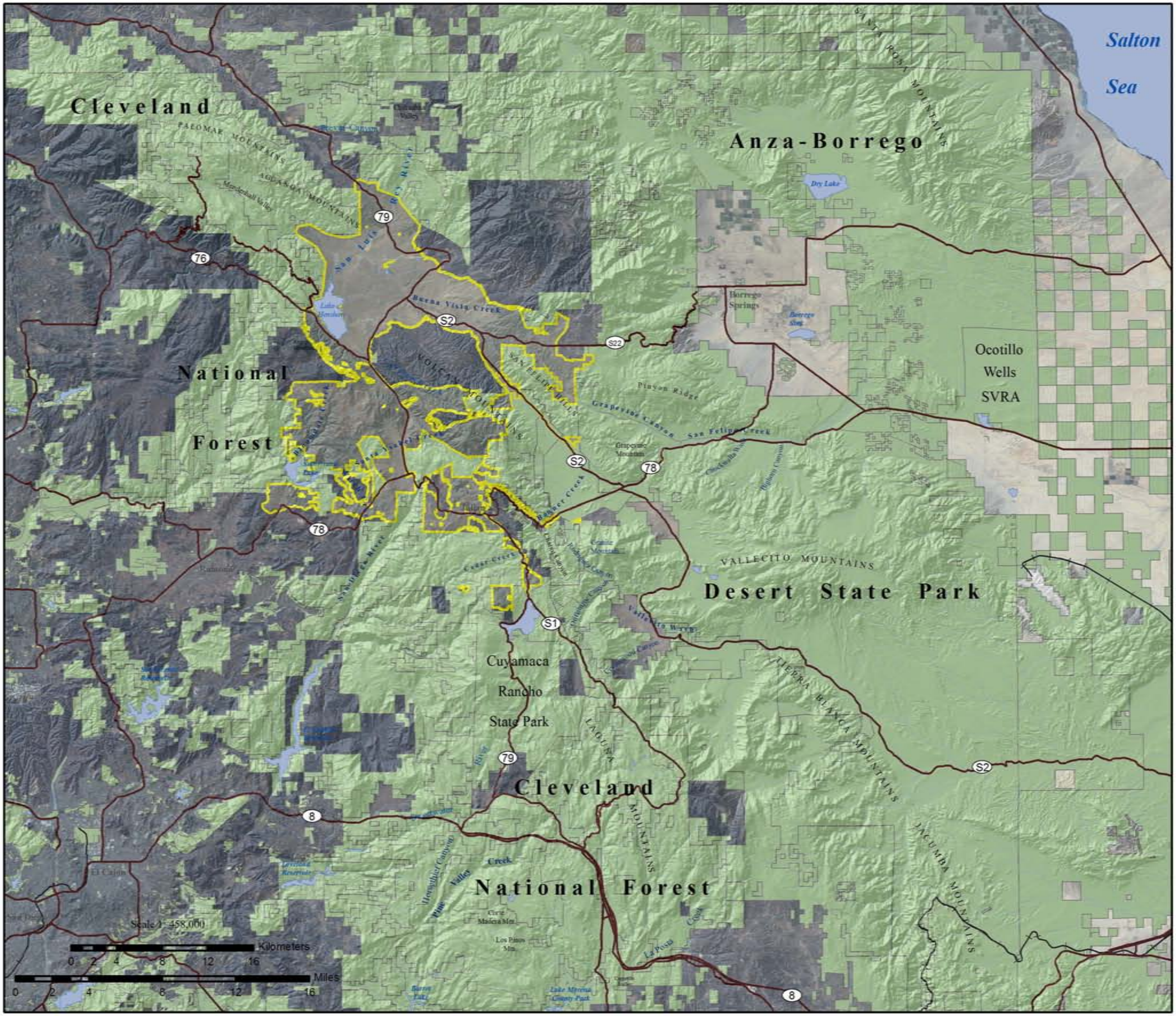
Although embedded in one of the world's largest metropolitan areas, southern California's archipelago of conserved wildlands is fundamentally one interconnected ecological system, and the goal of South Coast Missing Linkages is to keep it so. South Coast Missing Linkages is a collaborative effort among a dozen governmental and non-governmental organizations. Our aim is to develop and implement 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 Peninsular-Borrego Connection links the South Coast Ecoregion to the Mojave and Sonoran deserts. It is an area of extraordinary diversity and a critical landscape connection to maintain and protect.

On June 28, 2002, 70 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 Peninsular-Borrego Connection. They identified 14 focal species that are sensitive to habitat loss and fragmentation here, including 1 plants, 3 insects, 2 reptiles, 3 birds and 5 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, Bighorn sheep, badger); others are species with very limited spatial requirements (e.g., velvet ant). Many are habitat specialists (e.g., grasshopper sparrow) and others require specific configurations of habitat elements (e.g. granite night lizard, barefoot gecko in rocky outcrops). Together, these 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 3 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 3 species. We then analyzed the size and configuration of suitable habitat patches within this Least Cost Union for all 14 selected focal species to verify that the final Linkage Design would serve 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 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 Routes 78 and 79, and S2 and S22.

The ecological, educational, recreational, and spiritual values of protected wildlands in the southern California are immense. Our Linkage Design for the Peninsular-Borrego 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 coastal habitats of the Peninsular Ranges and Anza Borrego Desert State Park, 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.

Executive Summary - 1
Linkage Design



Linkage Design
Protected Lands
Highways
Railroad
Stream/River
Lakes, Ponds, Reservoirs

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Introduction

Nature Needs Room to Roam

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

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

Patterns of Habitat Conversion

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

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

A Statewide Vision

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

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

South Coast Missing Linkages: A Vision for the Ecoregion

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

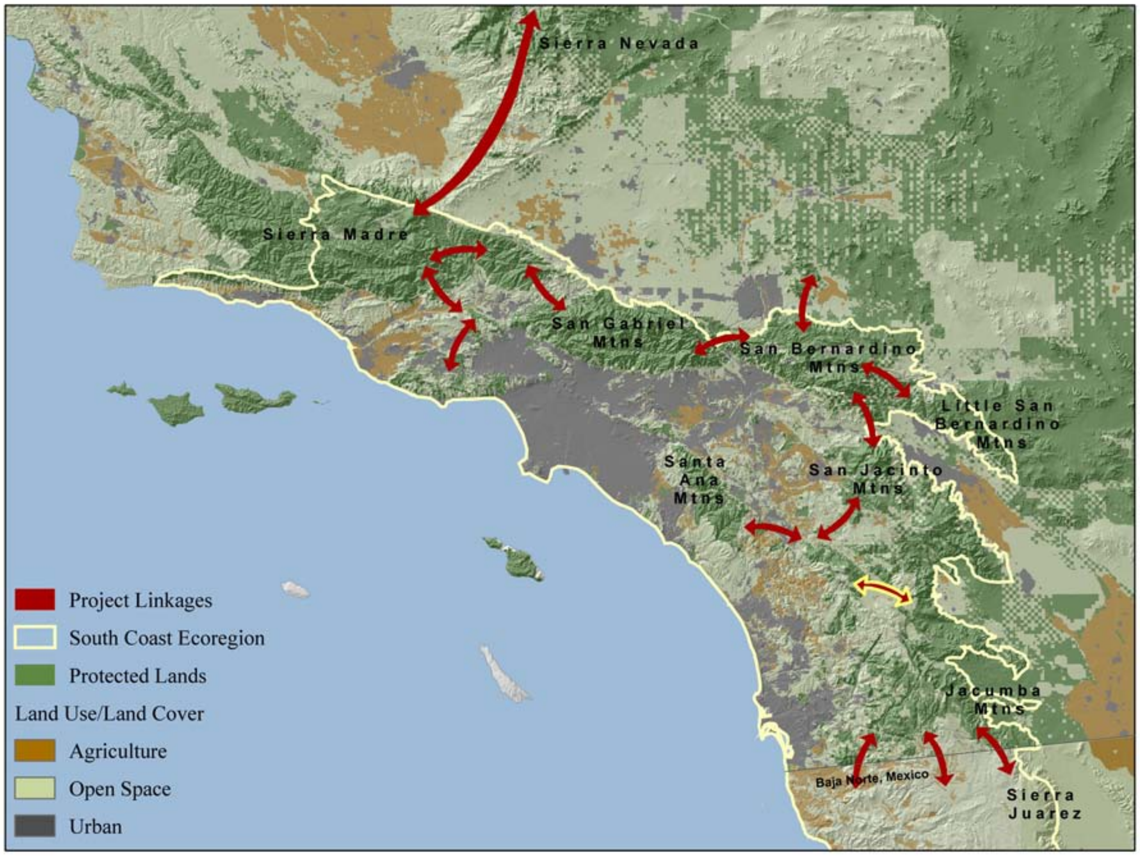

Figure 2. The South Coast Missing Linkages Project addresses habitat fragmentation at a landscape scale, and the needs of a variety of species. The Peninsular-Borrego Connection is one of the 15 landscape linkages identified as irreplaceable and imminently threatened.

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

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

To this end, South Coast Wildlands is coordinating and hosting regional workshops, providing resources to partnering organizations, conducting systematic GIS analyses for all 15 linkages, and helping to raise public awareness regarding habitat connectivity needs in the ecoregion. South Coast Wildlands has taken the lead in researching and planning for 8 of the 15 linkages; while National Park Service, Santa Monica Mountains Conservancy, The Nature Conservancy, San Diego State University Field Station Programs, California State Parks, U. S. Forest Service, and Conservation Biology Institute have taken the lead on the other 7 linkages. The Peninsular-Borrego Connection addresses one of the 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
Sierra Madre Mountains-Castaic Ranges
Sierra Madre Mountains-Sierra Nevada Mountains
San Gabriel Mountains-Castaic Ranges
San Bernardino Mountains-San Gabriel Mountains
San Bernardino Mountains-San Jacinto Mountains
San Bernardino Mountains-Little San Bernardino Mountains
San Bernardino Mountains-Granite Mountains
Santa Ana Mountains-Palomar Ranges
Palomar Ranges-San Jacinto/Santa Rosa Mountains
Peninsular Ranges-Anza Borrego
Laguna Mountains-Otay Mountain-Northern Baja
Campo Valley-Laguna Mountains
Jacumba Mountains-Sierra Juarez Mountains

Ecological Significance of the Peninsular-Borrego Connection

This ecoregional connection links the coastal habitats of the Peninsular Ranges with the desert communities of Anza Borrego Desert State Park. The Palomar, Aguanga, Volcan, Cuyamaca, and Laguna mountains are dominated by grassland, coastal sage scrub, chaparral, oak woodland, riparian forests, montane hardwood conifer forest, and meadows, while desert scrub, juniper woodland, desert wash, and fan palm oases occur in the Santa Rosa, San Ysidro, Vallecito, Tierra Blanca, and Jacumba Mountains of Anza Borrego (Figure 3). A number of sensitive natural communities occur in the planning area, including coastal sage scrub, grassland, meadow, palm oasis, valley foothill riparian, coast live oak riparian forest, and Engelmann oak woodland (Stephenson and Calcarone 1999, CDFG 2005). These include some of the most rare vegetation communities in the United States.

This variety of habitats support a diversity of organisms, including many species listed as endangered, threatened, or sensitive by government agencies (USFWS 1998, 1999, Stephenson and Calcarone 1999, USFWS 2000, 2001, USFS 2002, CDFG 2005a, 2005b). A number of rare species depend on the area's riparian communities, which provide breeding locations for many special status amphibians, such as arroyo toad

Figure 3.
Vegetation Types in the Planning Area

- Agriculture
- Barren
- Eucalyptus
- Urban

- Perennial Grassland
- Annual Grassland
- Chamise-Redshank Chaparral
- Coastal Oak Woodland
- Coastal Scrub
- Mixed Chaparral
- Montane Chaparral

- White Fir
- Closed-Cone Pine-Cypress
- Jeffrey Pine
- Montane Hardwood
- Montane Hardwood-Conifer
- Sierran Mixed Conifer

- Alkali Desert Scrub
- Bitterbrush
- Desert Scrub
- Desert Succulent Shrub
- Juniper
- Pinyon-Juniper
- Sagebrush

- Desert Riparian
- Desert Wash
- Freshwater Emergent Wetland
- Lacustrine
- Montane Riparian
- Palm Oasis
- Valley Foothill Riparian
- Water
- Wet Meadow

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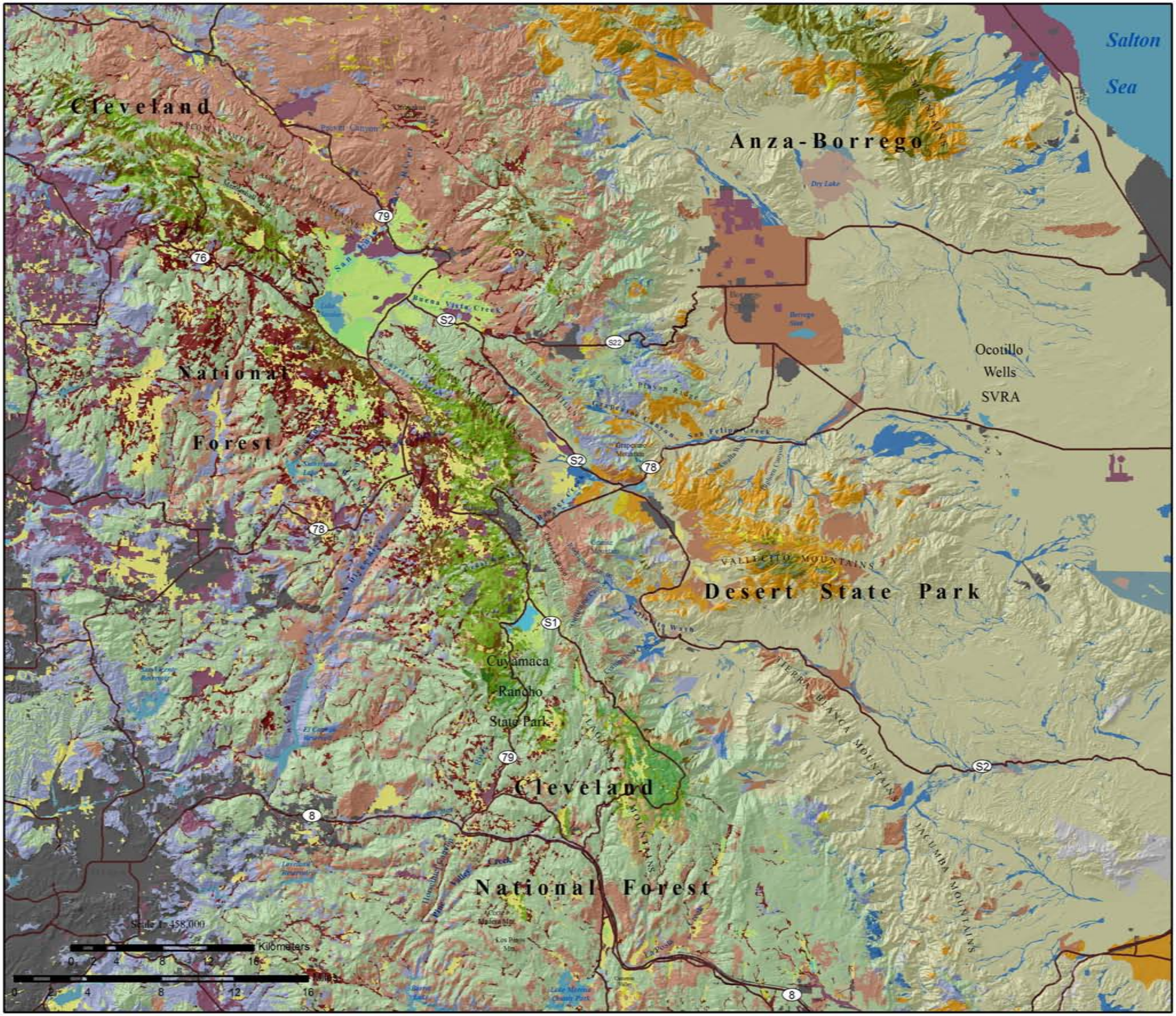


(*Bufo californicus*) and large-blotched salamander (*Ensatina eschscholtzii klauberi*), and critical watering areas for Peninsular bighorn sheep (*Ovis canadensis*). Several riparian songbirds, such as yellow-breasted chat (*Icteria virens*), and the endangered least Bell's vireo (*Vireo bellii pusillus*), and southwestern willow flycatcher (*Empidonax traillii extimus*) have the potential to occur in riparian habitats in the linkage. Sensitive reptiles that prefer drier habitats and sparser vegetative cover, such as rosy boa (*Lichanura trivirgata*), orange-throated whiptail (*Cnemidophorus hyperythrus*), and coast horned lizard (*Phrynosoma coronatum blainvillei*) also have the potential to occur, as do a number of sensitive birds of prey, including Cooper's hawk (*Accipiter cooperii*), golden eagle (*Aquila chrysaetos*), and northern harrier (*Circus cyaneus*). The planning area also provides habitat for a number of imperiled plant species, including the Cuyamaca larkspur (*Delphinium hesperium* Gray ssp. *cuyamacae*) and Borrego bedstraw (*Galium angustifolium ssp. borregoense*).

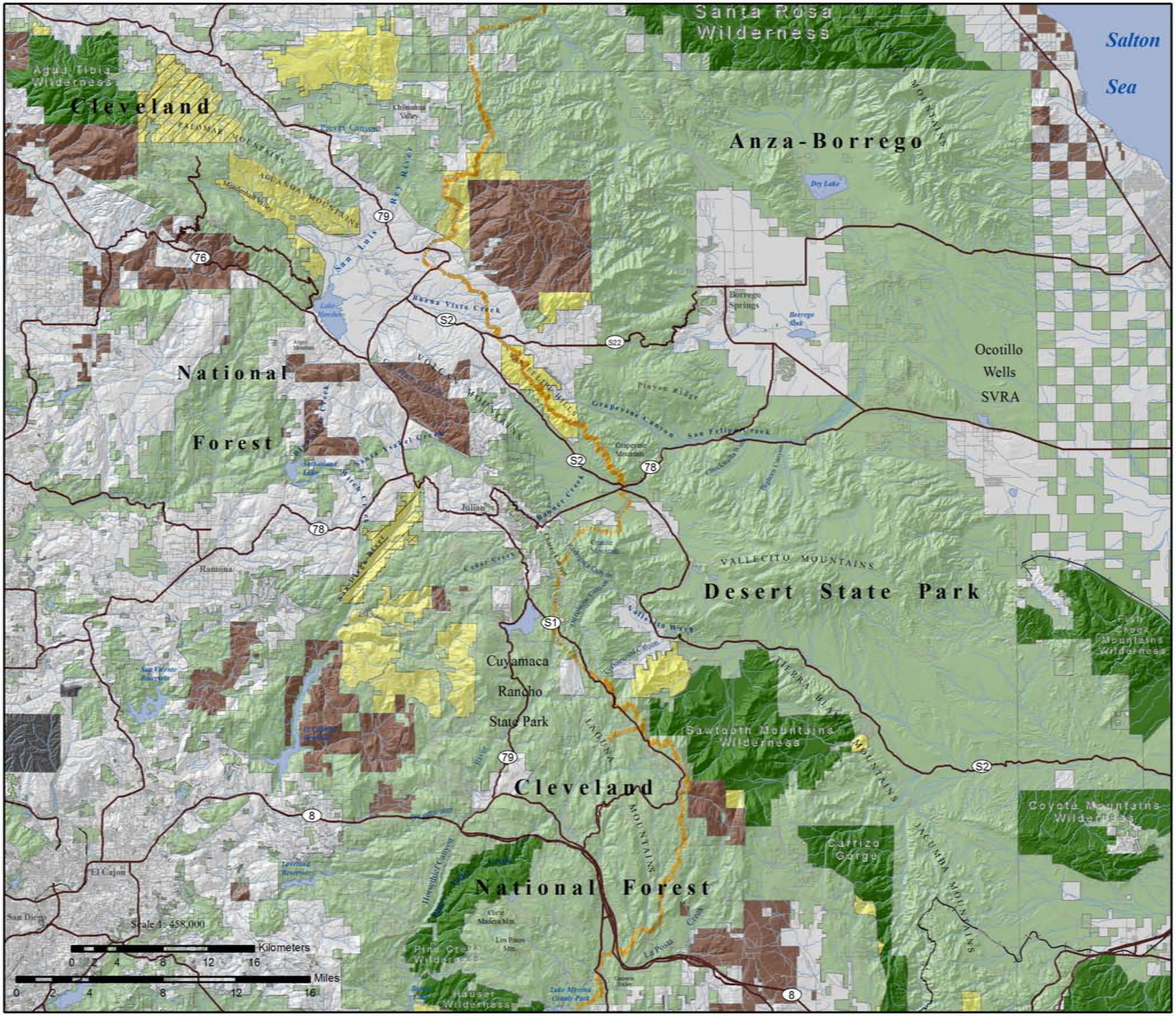
In addition to providing habitat for rare and endangered species, the linkage provides live-in and move-through habitat for numerous native species such as American badger, mule deer, and mountain lion that may be less extinction prone but that nevertheless require extensive wildlands to thrive.

Existing Conservation Investments

Significant conservation investments already exist in the region (Figure 4), but the resource values they support could be irreparably harmed by loss of connections between them. This linkage connects two expansive core areas that are largely conserved within Cleveland National Forest, Anza Borrego and Cuyamaca State Parks, and land administered by the Bureau of Land Management. Several existing Wilderness Areas occur in the planning area and significant roadless areas were proposed for Wilderness status by the California Wild Heritage Campaign, including Cutca Valley, Barker Valley, Caliente, Sill Hill, No Name, Eagle Peak, and the San Diego River Gorge on Cleveland National Forest (www.californiawild.org). There are also several Wilderness Study Areas on lands managed by the Bureau of Land Management, including Beauty Mountain, Los Coyotes, San Felipe Hills, Sawtooth Mountain additions, and Carrizo Gorge additions. The Forest Service (2005) has recommended that Congress designate Cutca Valley and Upper San Diego River as Wilderness Areas, and segments of the mainstem of the San Luis Rey River and Cottonwood Creek as Wild and Scenic Rivers.

Some of the land in the linkage has already been protected through successful conservation planning efforts undertaken by California State Parks, U.S. Forest Service, Bureau of Land Management, The Nature Conservancy, Anza Borrego Foundation, California Department of Fish and Game, and County, City and local agencies and organizations, but gaps in protection remain. San Diego County is currently working on the Multiple Species Conservation Plan for eastern San Diego County, which will likely establish conservation priorities in the linkage. There are also substantial blocks of tribal land (Mesa Grande, Santa Ysabel, Los Coyotes, and La Jolla), and any meaningful plan for securing this regionally important landscape linkage must also recognize the cultural significance of protecting these areas. The value of established protected land in the region for biodiversity conservation, environmental education, outdoor recreation, and scenic beauty is immense.

Figure 4.
Existing Conservation Investments and Other Large Landholders



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

The goal of linkage conservation planning is to identify specific lands that must be conserved to maintain or restore functional connections for all species or ecological processes of interest, generally between two or more protected core habitat areas. We adopted a spatially hierarchical approach, gradually working from landscape-level processes down to the needs of individual species on the ground. The planning area encompasses habitats between the Cleveland National Forest and Cuyamaca and Anza Borrego Desert State Parks. We conducted various landscape analyses to identify those areas necessary to accommodate continued movement of selected focal species through this landscape. Our approach can be summarized as follows:

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

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

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

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

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

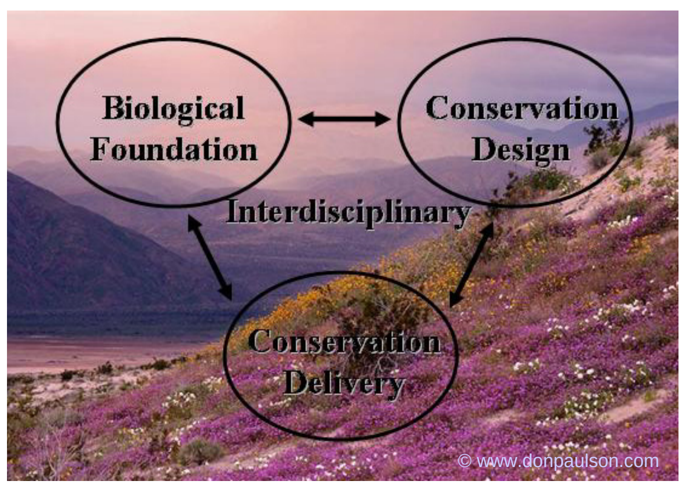

Figure 5. Successful conservation planning requires an interdisciplinary and reiterative approach among biologists, planners and activists (Baxter 2001).

Our approach has been highly collaborative and interdisciplinary (Beier et al. 2006). 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 June 28, 2002 at the San Diego Zoo. The workshop engaged 70 participants representing over 40 different agencies, academic institutions, conservation organizations, and community groups (Appendix A). Indispensable information on conservation needs and opportunities in the linkage was gathered at the workshop.

Focal Species Selection

Table 1. Regional ecologists selected 14 focal species for the Peninsular-Borrego Connection.
PLANTS
Alnus rhombifolia (White alder)
INVERTEBRATES
Dasymutilla coccinea (Velvet ant)
Euphydryas chalcedona (Chalcedon checkerspot butterfly)
Philotes sonorensis (Sonoran blue butterfly)
AMPHIBIANS & REPTILES
Coleonyx switaki (Barefoot gecko)
Xantusia henshawi (Granite night lizard)
BIRDS
Branta bernicla (Black brant)
Ammodramus savannarum (Grasshopper sparrow)
Aquila chrysaetos (Golden eagle)
MAMMALS
Lepus californicus (Black-tailed jackrabbit)
Odocoileus hemionus (Mule deer)
Ovis canadensis (Bighorn sheep)
Taxidea taxus (Badger)
Puma concolor (Mountain lion)

The workshop participants identified a taxonomically diverse group of focal species that are sensitive to habitat loss and fragmentation (Table 1). These species 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 either particularly sensitive to habitat fragmentation or otherwise meaningful to linkage design. Participants then summarized the relevant 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 see Appendix B).

The 14 focal species identified at the workshop capture a diversity of movement needs and ecological requirements, from species that require large tracts of land (e.g., mountain lion, badger, mule deer) to those with very limited spatial requirements (e.g., Granite night lizard). They include habitat specialists (e.g., Peninsular bighorn sheep in steep rocky terrain) and those requiring a specific configuration of habitat types and elements (e.g., chalcedon checkerspot butterfly that utilizes coastal and desert habitats where nectar sources and host plants are available, but engages in hilltopping behavior to attract mates). Dispersal distance capability of focal species ranges from 108 m to 274 km; modes of dispersal include walking, flying, swimming, climbing, hopping, and slithering.

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 land areas, which 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).

Three 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, and mule deer. Ranks and weightings adopted for each species are shown in Table 2.

The relative cost of travel was assigned for each of these 3 focal species based upon its ease of movement through a suite of landscape characteristics (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. Each input category was ranked and weighted, such that: (Land Cover * w%) + (Road Density * x%) + (Topography * y%) + (Elevation * z%) = Cost to Movement, where w + x + y + z = 100%.

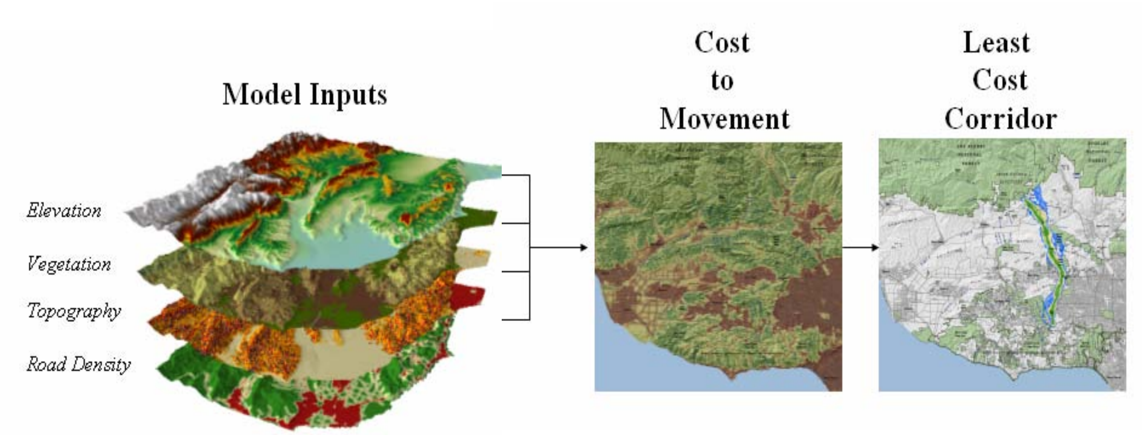

Figure 6. Permeability Model Inputs: elevation, vegetation, topography, and road density. Landscape permeability analysis models the relative cost for a species to move between core areas based on how each species is affected by various habitat characteristics.

Table 2. Model Parameters for Landscape Permeability Analyses

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

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

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

Running the permeability analysis required identifying the endpoints to be connected. We selected endpoints for this analysis as areas supporting medium to highly suitable habitat within the Palomar District of Cleveland National Forest and Anza Borrego Desert State Park. This gave the model broad latitude in interpreting functional corridors across the entire study area. For each focal species, the most permeable area of the study window was designated as the least-cost corridor.

The least-cost corridor output for all 3 species was then combined to generate a Least Cost Union. The biological significance of the Least Cost Union can best be described as the zone within which all 3 modeled species would encounter the least energy expenditure (i.e., preferred travel route) and the most favorable habitat as they move between targeted protected 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 Analyses

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

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

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

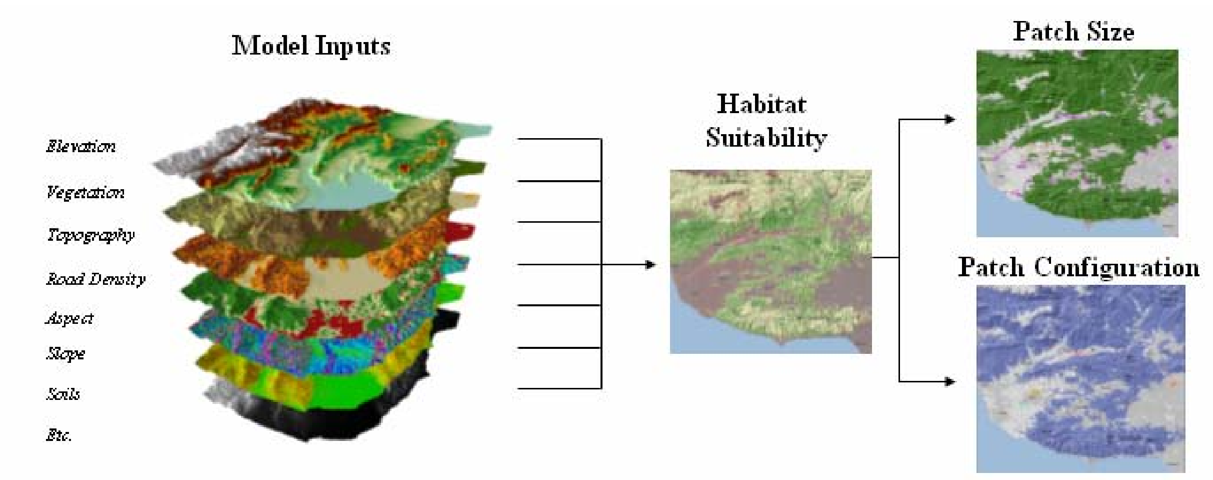

Figure 7. Model Inputs to Patch Size and Configuration Analyses vary by species. Patch size delineates cores, patches, and stepping-stones of potential habitat. Patch configuration evaluates whether suitable habitat patches and cores are within each species dispersal distance.

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

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

Minimum Linkage Width

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

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

Field Investigations

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

Identify Conservation Opportunities

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

Landscape Permeability Analyses

We conducted landscape permeability analyses for 3 focal species (mountain lion, American badger, and mule deer). The least cost corridors for these 3 species were quite distinct due to their diverse ecological and movement requirements (see following species accounts and Table 2). The most permeable paths for these focal species did converge and overlap to some extent in the central part of the linkage, but each species diverged to generate routes that contain their preferred habitat (Figure 8).

The Least Cost Union (i.e., the union of the least cost corridors for all 3 species) stretches about 30 km (19 mi) between targeted protected areas in Cleveland National Forest and Anza Borrego Desert State Park (Figure 9). It encompasses diverse vegetation and physiographic zones to account for the needs of the focal species, including grassland, meadow, coastal sage, chaparral, grassland, oak woodland, riparian woodlands and forests, montane hardwood conifer forest, and the transition to desert scrub habitats.

The branches of the Least Cost Union reflect the distribution of habitat for the three target species, and encompass a variety of vegetation communities and topographic features. Perennial grassland and meadow habitats dominate the upper branch of the Least Cost Union, which ranges in width from about 3 to 7 km (1.9 to 4.4 mi), and includes habitats north and east of Lake Henshaw, and habitats along Buena Vista and San Felipe Creeks. The central branch ranges in width from about 4 to 8 km (2.5 to 5 mi), and encompasses a diversity of natural communities in Bloomdale Creek, Santa Ysabel Valley, Santa Ysabel Creek, and the southern extent of the Volcan Mountains, San Felipe Hills, and San Felipe Creek. The southern branch of the Least Cost Union includes oak woodland, savanna, grassland, and montane hardwood conifer habitats, and splits to include two main swaths of these natural communities. One swath is 2 to 4 km (1.2 to 2.5 mi) wide, and includes habitat between Santa Ysabel Creek, upper San Diego River, and Cedar Creek, with narrow branches 1 to 2 km (0.6 to 1.2 mi) wide that follow Witch Creek, and the Ballena Valley. The other, which is 1 to 3 km (0.6m to 1.9 mi) wide, is about 2 km to the east and runs roughly parallel to the first, taking in more habitat in Santa Ysabel Creek, and oak woodland and grassland habitats to the west and south of the community of Julian before converging with the other swath in Cedar Creek.. The branches of the Least Cost Union identify the areas best suited to facilitate species movement between targeted protected areas based on model assumptions and available GIS data.

The following pages summarize the permeability analyses for each of the 3 modeled species. For convenience, the narratives describe the most permeable paths from west to east, although our analyses gave equal weight to movements in both directions. The following section (Patch Size and Configuration Analyses) describes 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 patch size and configuration analyses expanded the Least Cost Union to provide for critical live-in and/or move-through habitat for particular focal species.

Figure 8.
Least Cost Union
Displaying Species Overlap

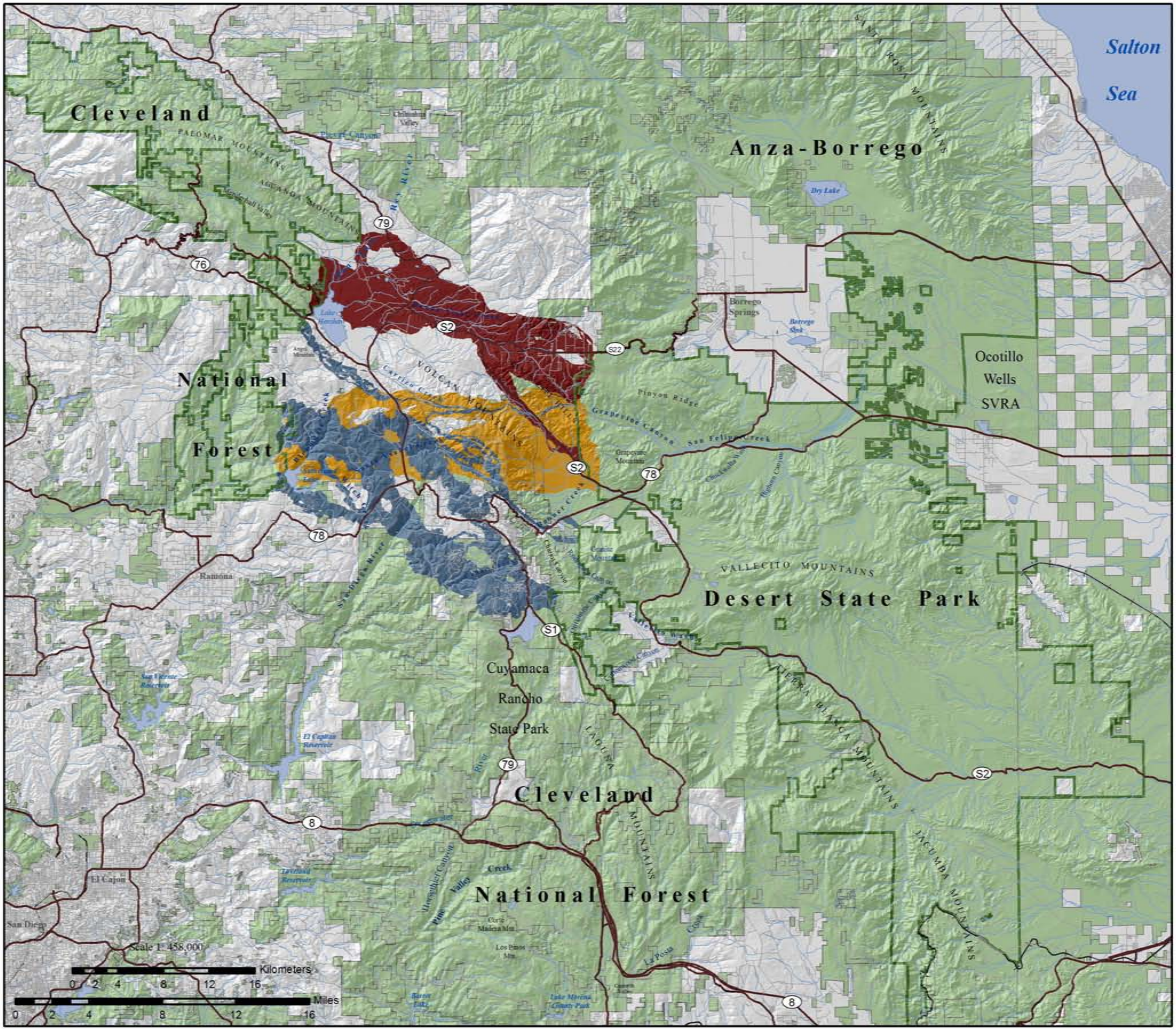

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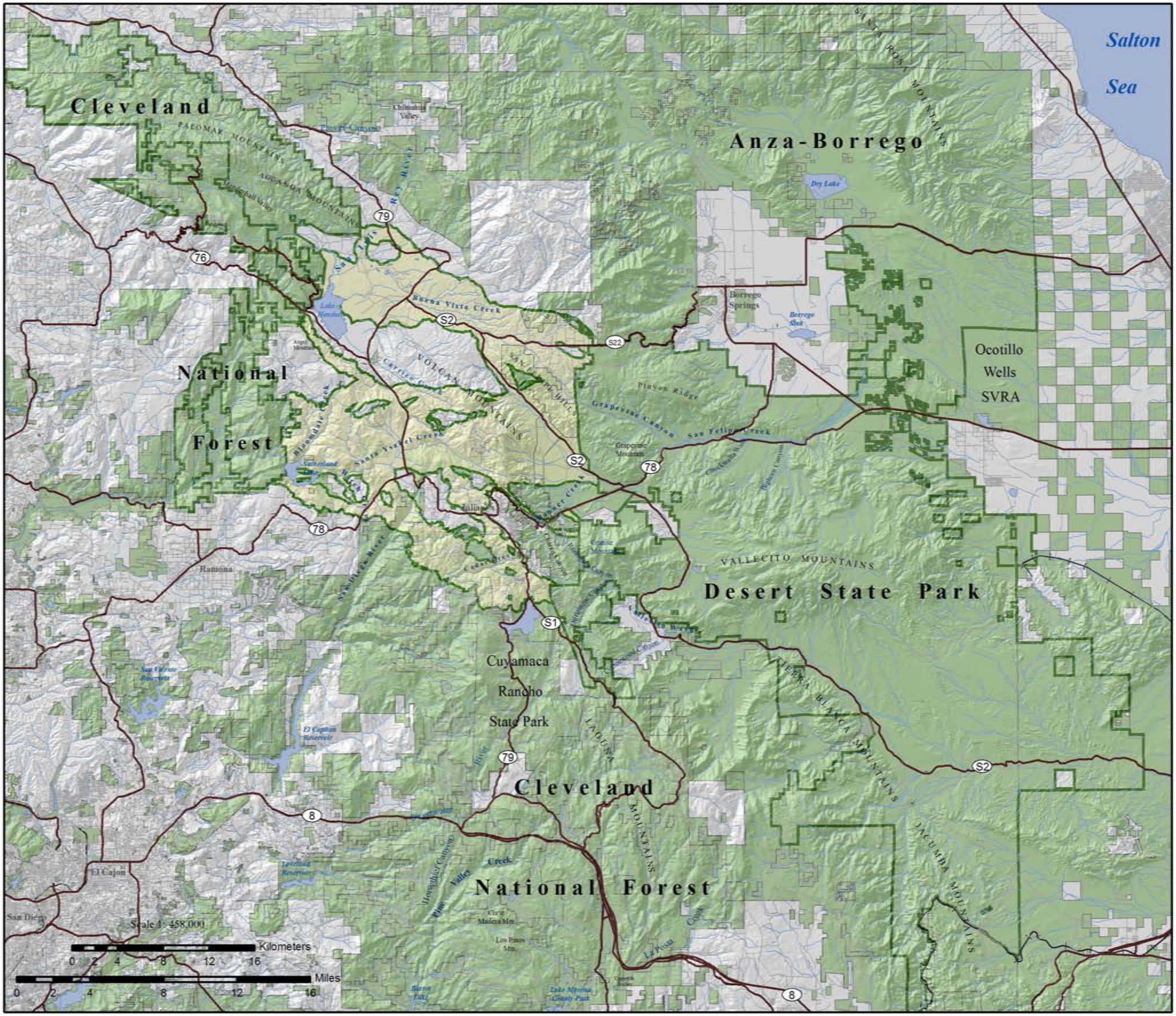
Figure 9.
Least Cost Union



- Least Cost Union
- Target Areas
- Protected Lands
- Highways
- Railroad
- Stream/River
- Lakes, Ponds, Reservoirs

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

Conceptual Basis for Model Development: Mountain lions use brushy stages of a variety of habitat types with good cover (Spowart and Samson 1986, Ahlborn 1988). Preferred travel routes are along stream courses and gentle terrain, but all habitats with cover are used (Beier and Barrett 1993, Dickson et al. 2004). In southern California, grasslands, agricultural areas, and human-altered landscapes are avoided (Dickson et al. 2004). Dirt roads do not impede movement, but highways, residential roads, and 2-lane paved roads do (Beier and Barrett 1993, Beier 1995, Dickson et al. 2004). Juvenile dispersal distances average 32 km (20 mi) for females, with a range of 9-140 km (6-87 mi), and 85 km (53 mi) for males, with a range of 23-274 km (14-170 mi; 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 model variable scorings for this species. Cost to movement for mountain lion was defined by weighting the inputs as follows:

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

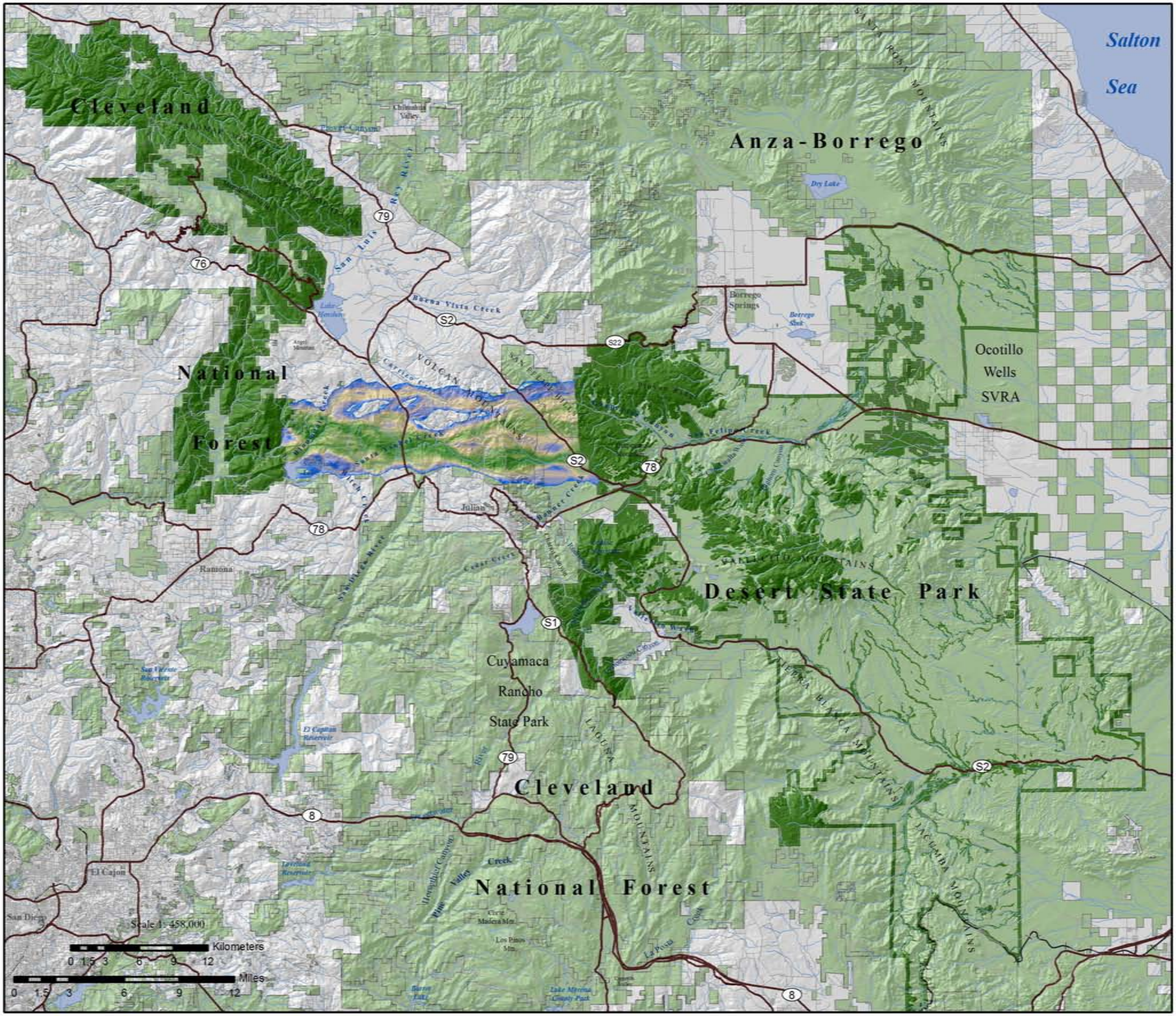
Results & Discussion: The least cost corridor for mountain lion movement between targeted protected areas varies in width from about 4 to 8 km (2.5 to 5 mi.; Figure 10). The most permeable path extends from Black Mountain in Cleveland National Forest and Sutherland Lake, encompassing habitats in Bloomdale Creek and the Santa Ysabel Valley, and then follows Santa Ysabel Creek across SR-79 and San Felipe Creek across S2 to enter Anza Borrego State Park near Grapevine Mountain. Another route follows Bloomdale Creek over to lower Carrizo Creek, then takes in habitat on Santa Ysabel Peak and the southern part of the Volcan Mountains and San Felipe Hills to enter Grapevine Canyon and San Felipe Creek in Anza Borrego State Park. Researchers with the Southern California Puma Project have documented a male lion (M10) using the Volcan Mountains and Santa Ysabel Creek area, and U.S. Geological Survey obtained several puma photos during a wildlife survey of Santa Ysabel Creek, including M10 and at least 4 other un-collared and unidentifiable pumas (Sweanor et al. 2003).

Figure 10. Least Cost Corridor for Mountain lion

(Puma concolor)

Least Cost Corridor
- Highly Permeable
- Less Permeable
- Suitabile Habitat*
- Protected Lands
- Highways
- Railroad
- Stream/River
- Lakes, Ponds, Reservoirs

*This analysis was run from medium to high suitable habitat within the Palomar District of Cleveland National Forest and Anza Borrego Desert State Park south of Route 22.



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American badger (*Taxidea taxus*)

Justification for Selection: Badgers are highly specialized animals that require open habitats with suitable soils for excavating large burrows (de Vos 1969, Banfield 1974, Zeiner et al. 1990, Sullivan 1996). Badgers require expansive wildlands to survive and are highly sensitive to habitat fragmentation. In fact, roadkill is the primary cause of mortality (Long 1973, Zeiner et al. 1990, Sullivan 1996).


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Conceptual Basis for Model Development: Badgers are associated with grasslands, prairies, and other open habitats that support abundant burrowing rodents (de Vos 1969, Banfield 1974, Sullivan 1996) but they may also be found in drier open stages of shrub and forest communities (Zeiner et al. 1990). 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, Zeiner et al. 1990). The species is typically found at lower elevations (Zeiner et al. 1990) in flat, rolling or steep terrain but it has also been recorded at elevations up to 3,600 m (12,000 ft; Minta 1993).

Badgers can disperse up to 110 km (68 mi; 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 model variable scorings for this species. Cost to movement for badger was defined by weighting these inputs as follows:

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

Results & Discussion: The most permeable route for badger extends from Love Valley in Cleveland National Forest, along the northern banks of Lake Henshaw, encompassing the perennial grassland and wet meadow habitats to the north and east of the lake, and then following Buena Vista Creek to the mixed chaparral and oak woodland habitats in the San Felipe Hills, toward Pinyon Ridge in Anza Borrego Desert State Park (Figure 11). Another much narrower branch extends from Aguanga Mountain on the Palomar District of Cleveland National Forest and takes in portions of the San Luis Rey River before joining the main pathway at Buena Vista Creek. The least cost corridor also branches to take in the riparian and grassland habitats along San Felipe Creek. The main portion of the least cost corridor for badger varies in width from 3 to 7 km (1.9 to 4.4 mi), while the branches along San Felipe Creek and the San Luis Rey River are about 1.5 km (0.9 mi) wide. The analysis captured the most suitable habitat for this highly specialized species moving between protected cores areas, encompassing the gently sloping topography of the grassland and meadow habitats wherever possible.

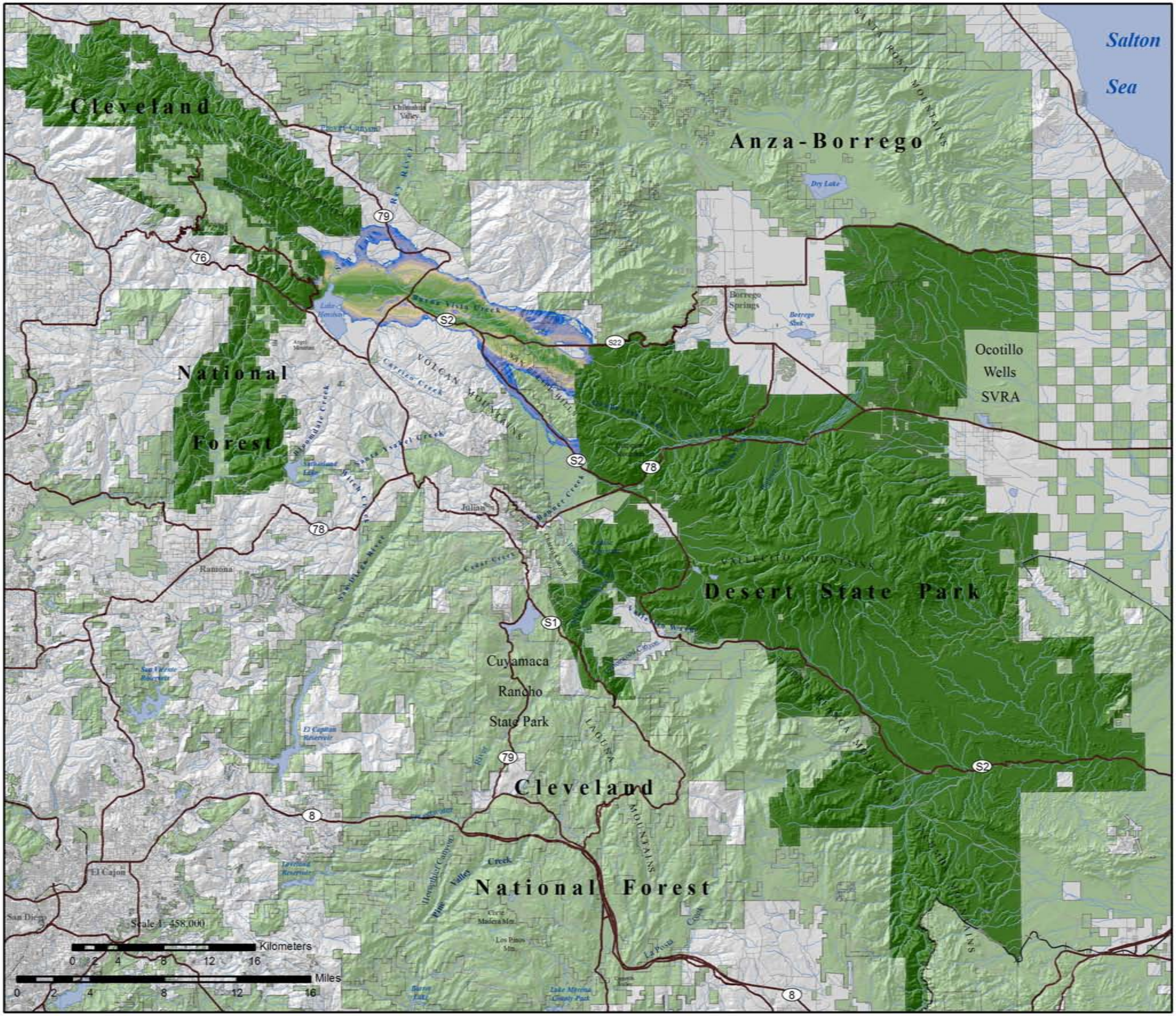
Figure 11. Least Cost Corridor for American badger

(Taxidea taxus)

Least Cost Corridor

- Highly Permeable
- Less Permeable
- Suitabile Habitat*
- Protected Lands
- Highways
- Railroad
- Stream/River
- Lakes, Ponds, Reservoirs

*This analysis was run from medium to high suitable habitat within the Palomar District of Cleveland National Forest and Anza Borrego Desert State Park south of Route 22.



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Mule deer (*Odocoileus hemionus*)

Justification for Selection: Mule deer were chosen as a focal species in part to help support viable populations of large carnivores, which rely on deer as their primary 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. In fact, nationally, vehicles kill several hundred thousand deer each year (Romin and Bissonette 1996, Conover 1997, Forman et al. 2003).

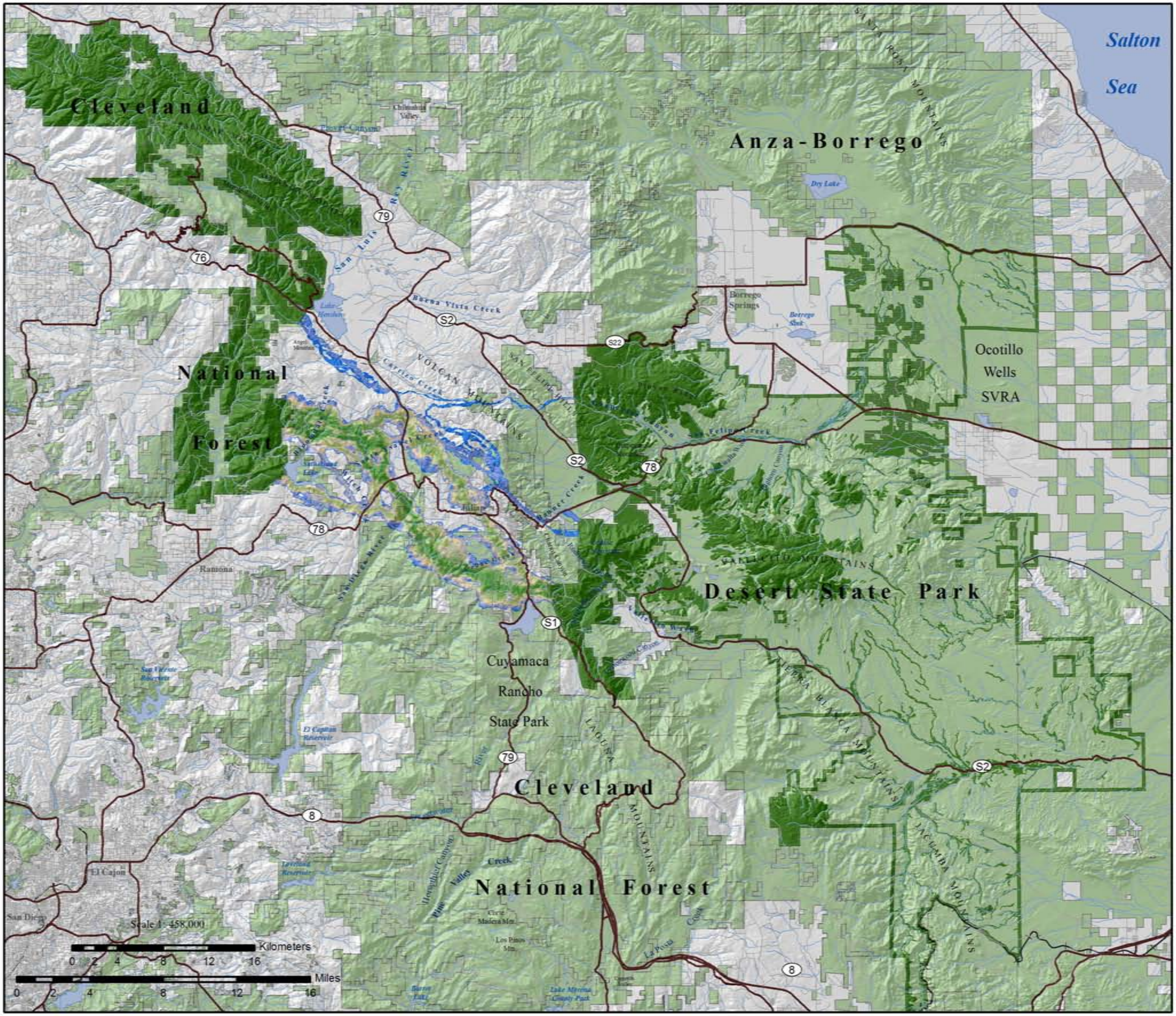
Conceptual Basis for Model Development: Mule deer use forest, woodland, brush, and meadow habitats, and reach their highest densities in oak woodlands, riparian areas, and along edges of meadows and grasslands, although they also occur in open scrub, young chaparral, and low elevation coniferous forests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

Dispersal distances of up to 217 km (135 mi) 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. Mule deer avoid open habitats, agricultural and urban land cover, and centers of high human activity, even in suitable habitat. Please see Table 2 for model variable scorings for this species. Cost to movement for mule deer was defined by weighting these inputs as follows:

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

Results & Discussion: Several potential routes were identified for mule deer traveling between targeted protected areas (Figure 12). The most permeable path extends from Black Mountain in Cleveland National Forest, and follows the belt of oak woodland, savanna, and grassland habitats that encompass portions of Bloomdale Creek, Santa Ysabel Valley and Creek, and upper San Diego River, to the montane hardwood, hardwood conifer habitats along Cedar Creek toward the riparian habitats of Vallecito Wash in Anza Borrego Desert State Park. This route ranges in width from 2 to 4 km (1.2 to 2.5 mi). Two other narrow branches, 1 to 2 km (0.6 to 1.2 mi) wide, extend from Sutherland Lake and merge with the main branch near SR-78. One follows Witch Creek and the other traverses the Ballena Valley. Another highly permeable route was delineated about 2 km to the east, and runs parallel to the main branch. It is 1 to 3 km (0.6 m to 1.9 mi) wide and also contains highly suitable habitat for mule deer. Another potential route was identified that extends from just south of Lake Henshaw to lower Carrizo Creek, and across the Volcan Mountains, and San Felipe Hills to Grapevine Canyon.

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



Least Cost Corridor

- Highly Permeable
- Less Permeable
- Suitabile Habitat*
- Protected Lands
- Highways
- Railroad
- Stream/River
- Lakes, Ponds, Reservoirs

*This analysis was run from medium to high suitable habitat within the Palomar District of Cleveland National Forest and Anza Borrego Desert State Park south of Route 22.

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Although the permeability models and Least Cost Union delineate swatches of habitat that, based on model assumptions and available GIS data, are best suited to facilitate species movement between core habitat areas, they do not address whether suitable habitat in the Least Cost Union occurs in large enough patches to support viable populations or whether patches are close enough together to allow for inter-patch dispersal. Furthermore, they are based on only 3 of the 14 focal species. We therefore performed habitat suitability; patch size and configuration analyses to evaluate the configuration and extent of potentially suitable habitat in the Least Cost Union for all 14 focal species. This helped determine whether there is sufficient habitat within the Least Cost Union to support each species, and whether that habitat is distributed in a pattern that allows the species to move between patches.

Specifically, the patch size and configuration analyses for all 14 focal species addresses 1) whether the Least Cost Union provides sufficient live-in or move-through habitat to support individuals or populations of the species; 2) whether these habitat patches are within the species' dispersal distance; 3) whether any clearly unsuitable and non-restorable habitat (e.g., developed land) should be deleted from the Least Cost Union; and 4) for any species not adequately served by the Least Cost Union, whether expanding the Union to incorporate more habitat would meet the species needs. The patch size and configuration analyses do not address existing barriers to movement (such as freeways) or land use practices that may prevent species from moving through the linkage. These issues are addressed in the next section.

The Least Cost Union contains suitable habitat to support either inter- or intra-generational movements of 8 of the 14 modeled focal species: mountain lion, badger, mule deer, black-tailed jackrabbit, golden eagle, granite night lizard, chalcedon checkerspot butterfly, and Sonoran blue butterfly. Outputs from the patch configuration analyses suggested that habitat patches in the Least Cost Union are not isolated by distances too great for any of these focal species to disperse.

However, four focal species appear to require additional habitat outside of the Least Cost Union for the Linkage Design to serve their needs: grasshopper sparrow, Pacific black brant, velvet ant, and white alder. To ensure that the Linkage Design accommodated all focal species, habitat was added to the Union in 5 general areas (Figure 13):

Upper San Luis Rey River: The Least Cost Union was modified to include riparian and upland habitat along the upper San Luis Rey River to preserve habitat and connectivity for grasshopper sparrow, black brant, and white alder, though numerous other native species will benefit from this addition, including mountain lion, badger, mule deer, black-tailed jackrabbit, granite night lizard and the Sonoran blue butterfly. The connection includes a 2-km (1.2-mi) buffer (1 km to either side of the wash) to protect water quality within the linkage and downstream.

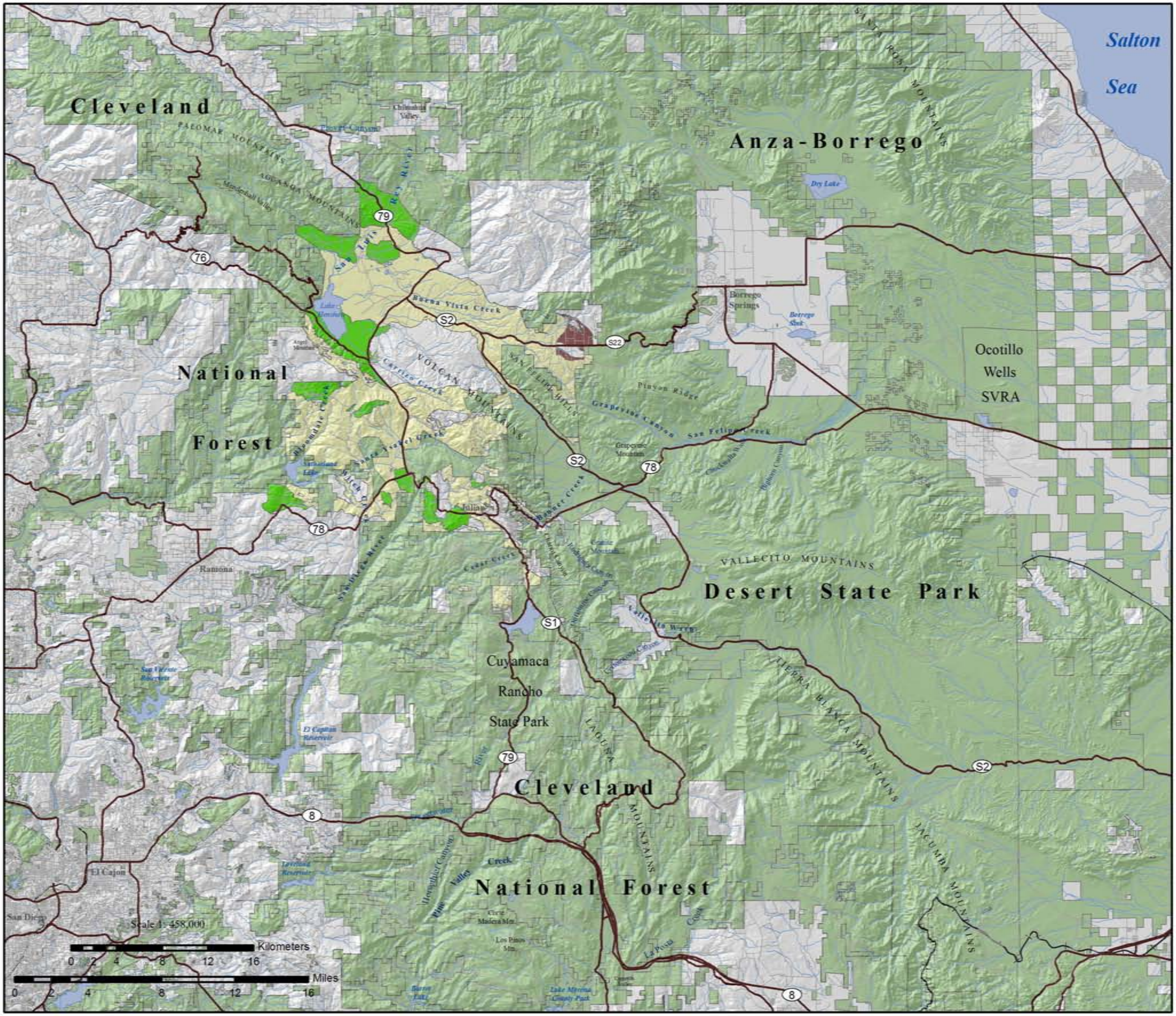
Southeast of Lake Henshaw: Habitat was added to the Union around Lake Henshaw in the Warner Basin to maintain the largest potential core area for grasshopper sparrow in the planning area, and it also provides habitat for the black brant and white alder. The black-tailed jackrabbit, mule deer, and badger will also benefit from this addition, as will several other native species.

Bloomdale Creek: This addition was necessary to maintain a potential core area for grasshopper sparrow, but it will also serve the needs of other focal species, including mountain lion, badger, mule deer, golden eagle, and checkerspot butterfly.

South of Sutherland Lake: The Union was modified to include habitats to the south of Sutherland Lake for grasshopper sparrow, though other species that utilize grassland habitats, such as black brant, black-tailed jackrabbit and badger will also benefit from this addition.

Upper San Diego River Gorge: This addition was also necessary to maintain potential core areas and large patches of suitable habitat for grasshopper sparrow, but numerous other species will also benefit from this connection, including mountain lion, mule deer, black-tailed jackrabbit, and golden eagle.

Figure 13. Least Cost Union Additions & Subtractions



Least Cost Union
Addition
Subtraction
Protected Lands
Highways
Railroad
Stream/River
Lakes, Ponds, Reservoirs

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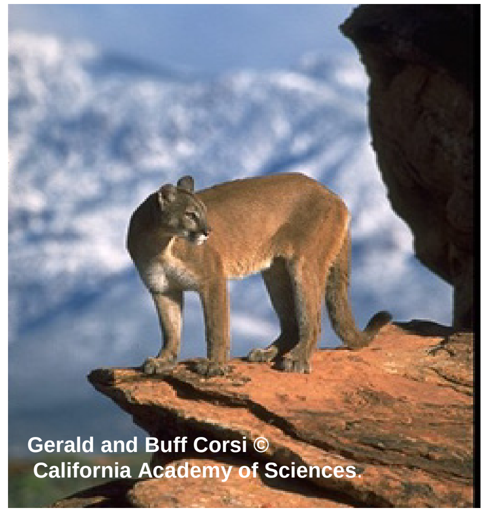
Mountain lion (*Puma concolor*)



Distribution & Status: Mountain lions (also known as pumas or cougars) are widely distributed throughout the western hemisphere (Chapman and Feldhamer 1982, Currier 1983, Maehr 1992, Tesky 1995). The subspecies P*. c. californica* occurs in southern Oregon, California, and Nevada (Hall 1981), typically between 590-1,780 m (1,980 - 5,940 ft) in elevation (Zeiner et al. 1990). California State Parks and University of California, Davis have been studying mountain lion movements and spatial use patterns in the linkage planning area to better understand the relationships of lions to deer, bighorn sheep and people to assist land managers working to maintain large mammal populations and minimize conflicts with humans (Sweanor et al. 2003).

In 1990, the mountain lion population in California was estimated to be between 2,500-5,000 individuals (Zeiner et al.). That same year, Proposition 117 was passed which prohibited hunting and granted mountain lions the status of a California Specially Protected species, though depredation permits are still issued (Torres 2000).

Habitat Associations: Mountain lions are habitat generalists, utilizing many brushy or forested habitats if adequate cover is present (Spowart and Samson 1986, Zeiner et al. 1990). They use rocky cliffs, ledges, and vegetated ridgetops that provide cover when hunting prey, which most frequently consists of mule deer (*Odocoileus hemionus;* Chapman and Feldhamer 1982, Spowart and Samson 1986, Lindzey 1987). Den sites may be located on cliffs, rocky outcrops, caves, in dense thickets, or under fallen logs (Ingles 1965, Chapman and Feldhamer 1982). In southern California, most cubs are reared in thick brush (Beier et al. 1995). They prefer vegetated ridgetops and stream courses as travel corridors and hunting routes (Spowart 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 Mountains documented annual home range sizes between 250 and 817 km^2 (61,776-201,885 ac; Pierce et al. 1999). Home ranges in southern California averaged 93 km^2 (22,981 ac) for 12 adult females and 363 km^2 (89,699 ac) for 2 adult males (Dickson et al. 2004). Male home ranges appear to reflect the density and distribution of females (Maehr 1992). Males occupy distinct areas, while the home ranges of females may overlap completely (Zeiner et al. 1990, Beier and Barrett 1993). Regional population counts have not been conducted but in the Santa Ana Mountain Range, Beier (1993) estimated a density of 1.05-1.2 adults per 100 km^2 (24,711 ac).

Mountain lions are capable of long-distance movements, and often move in response to changing prey densities (Pierce et al. 1999). Beier et al. (1995) reported mountain lions moving 6 km (3.7 mi) per night and dispersing up to 65 km (40 mi). Dispersal plays a crucial role in cougar population dynamics, because recruitment into a local population occurs mainly by immigration of juveniles from adjacent populations, while the population's own offspring emigrate to other areas (Beier 1995, Sweanor et al. 2000). Juvenile dispersal distances average 32 km (20 mi) for females and 85 km (53 mi) for males, with one male dispersing 274 km (170 mi; Anderson et al. 1992). Dispersing lions may cross large expanses of nonhabitat, although 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 use most habitats above 590 m (1,936 ft) elevation provided they have cover (Spowart and Samson 1986, Zeiner et al. 1990). Road density is also a significant factor in habitat suitability for mountain lions. Core areas potentially supporting 50 or more individuals were modeled as $\geq$ 10,000 km^2 (2,471,053 ac). Patch size was classified as $\geq$ 200 km^2 (49,421 ac) but < 10,000 km^2. Dispersal distance for puma was defined as 548 km (340 mi), or twice the maximum reported dispersal distance of 274 km (170 mi).

Results & Discussion: The central and southern branches of the Least Cost Union contain fairly contiguous suitable habitat for lions traveling between protected core areas (Figure 14). The eastern part of the northern branch also provides for a north south connection between Cuyamaca Rancho State Park and Forest Service lands to the north of S2 and S22. We conclude that the Least Cost Union is likely to serve the movement needs of this species. All potential cores and patches of suitable habitat are within the dispersal distance of this species (figure not shown). The patch size analysis for mountain lion (Figure 15) emphasizes the importance of maintaining connectivity between these ranges, as the Palomar, Aguanga, Volcan, Cuyamaca, and Laguna, mountains combined are not large enough to support a viable population without exchange of individuals between ranges to sustain the population.

This species requires expansive roadless areas and functional connectivity between subpopulations. 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 lions, we recommend that existing road density be maintained or reduced in the Linkage Design. Lighting should be directed away from the linkage and crossing structures, as species sensitive to human disturbance, like puma, avoid areas that are artificially lit (Beier 1995, Beier 2006). We suggest local residents be 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.

Figure 14.
Habitat Suitability
for
Mountain lion
(Puma concolor)

Degree of Suitability

- High
- Medium to High
- Medium
- Low to Medium
- Low
- Least Cost Union
- Protected Lands
- Highways
- Railroad
- Stream/River
- Lakes, Ponds, Reservoirs

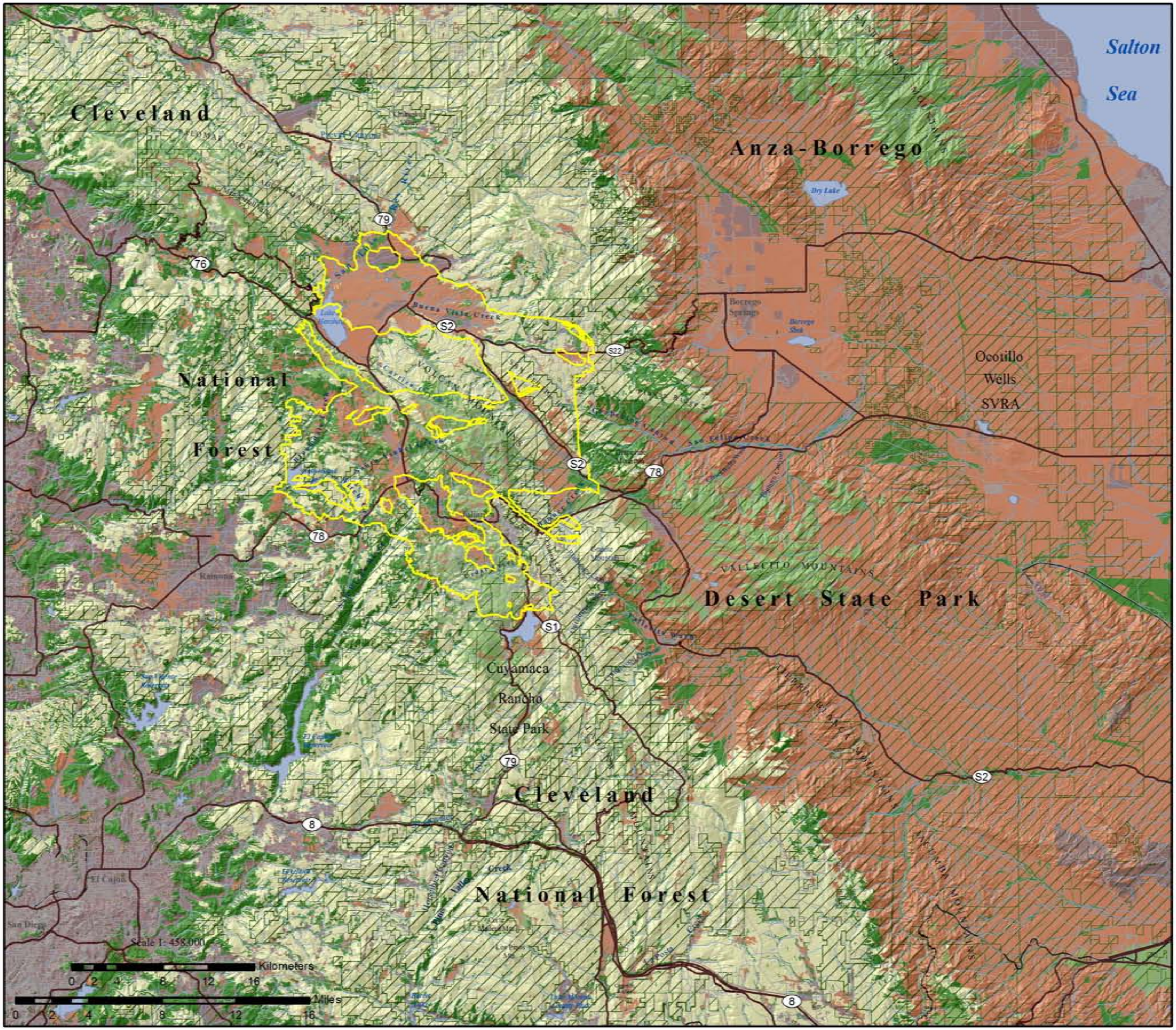


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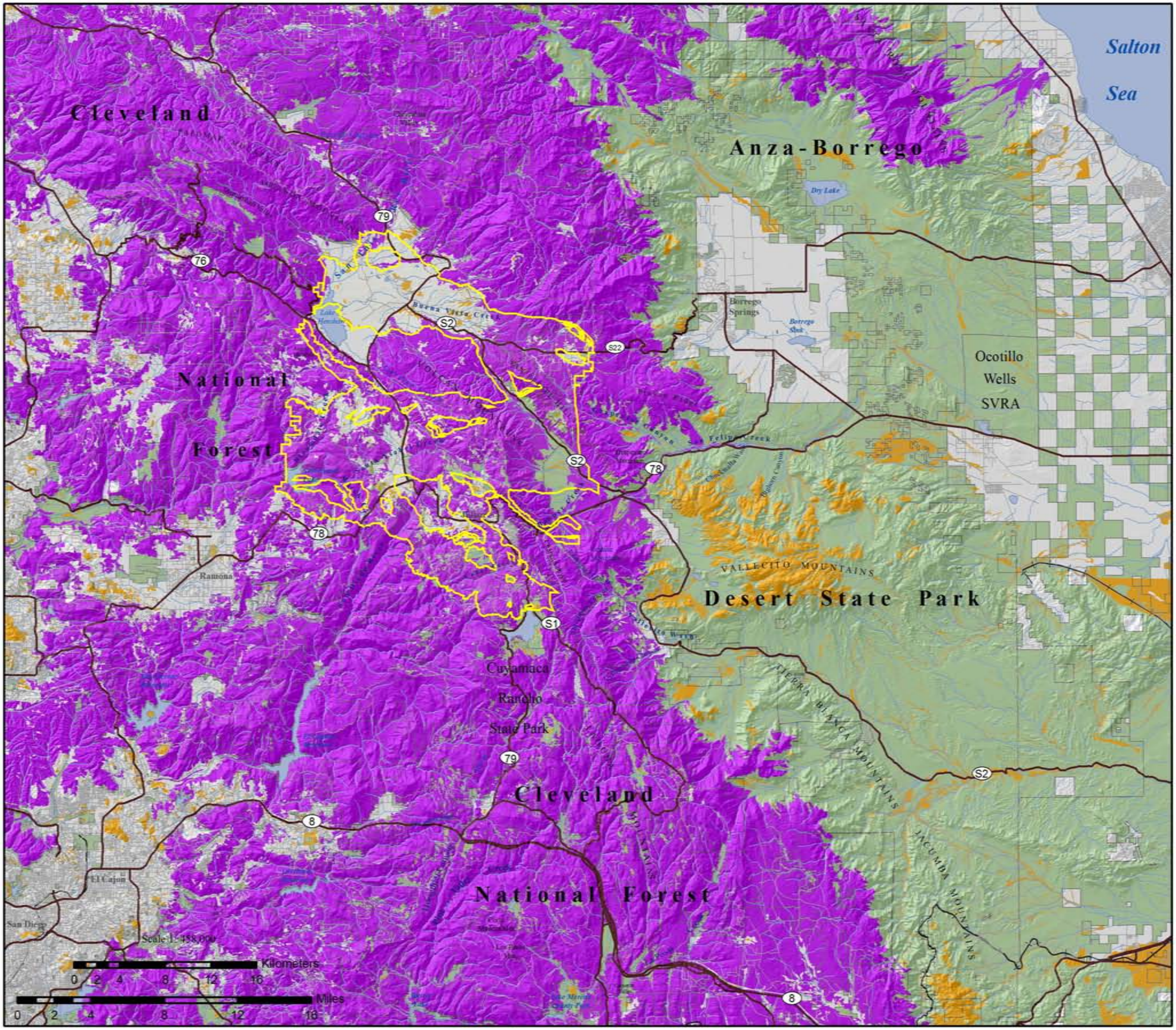
Figure 15.
Potential Cores & Patches for Mountain lion
(Puma concolor)



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Distribution & Status: Once a fairly widespread resident in open habitats of California, the badger is now uncommon throughout the state and is considered a California Species of Special Concern (Zeiner et al. 1990, CDFG 1995).

Habitat Associations: Badgers are habitat specialists, associated with grasslands, prairies, and other open habitats (de Vos 1969, Banfield 1974, Sullivan 1996) but they may also be found in drier open stages of shrub and forest communities (Zeiner et al. 1990). 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, Zeiner et al. 1990). They are occasionally found in open chaparral (< 50% cover) but have not been documented in mature stands of chaparral (Quinn 1990, Zeiner et al. 1990). Badgers prefer friable soils for excavating burrows and require abundant rodent populations (de Vos 1969, Banfield 1974, Sullivan 1996). They are typically found at lower elevations, in flat, rolling, or steep terrain, but have also been recorded at elevations up to 3,600 m (12,000 ft; Zeiner et al. 1990, Minta 1993).

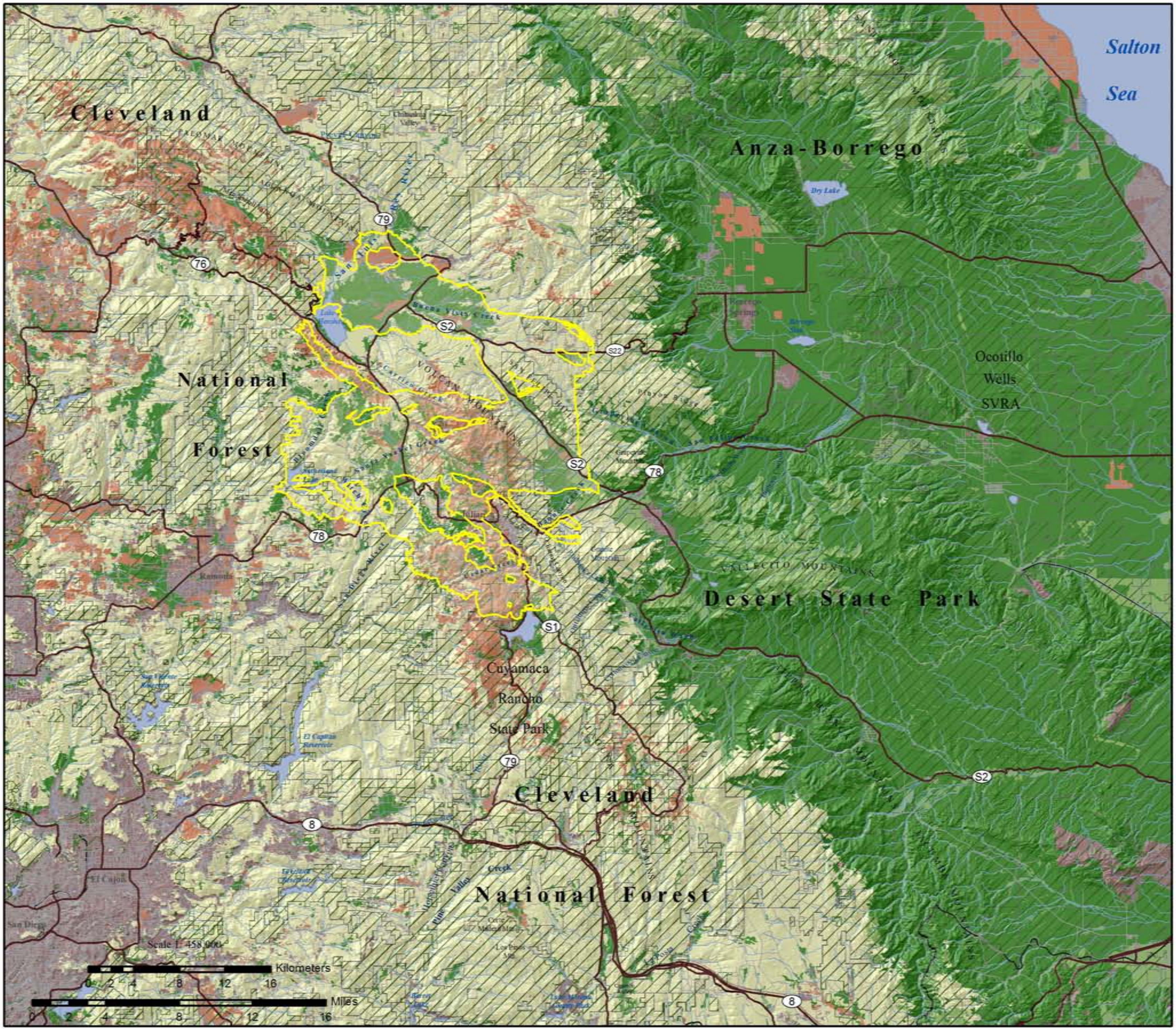
Spatial Patterns: Home range sizes for this species vary both geographically and seasonally. Male home ranges have been estimated to vary from 240 to 850 ha (593-2,100 ac) while reported female home ranges varied from from 137 to 725 ha (339-1,792 ac; Long 1973, Lindzey 1978, Messick and Hornocker 1981, Zeiner et al. 1990). In northwestern Wyoming, home ranges up to 2,100 ha (5,189 ac) have been reported (Minta 1993). In Idaho, home ranges of adult females and males averaged 160 ha (395 ac) and 240 ha (593 ac) respectively (Messick and Hornocker 1981). In Minnesota, Sargeant and Warner (1972) radio-collared a female badger, whose overall home range encompassed 850 ha (2,100 ac). However, her home range was restricted to 725 ha (1,792 ac) in summer, 53 ha (131 ac) in autumn and to a mere 2 ha (5 ac) in winter. In Utah, Lindzey (1978) reported that fall and winter home ranges of females varied from 137 to 304 ha (339-751 ac), while male home ranges varied from 537 to 627 ha (1,327-1,549 ac). 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 at 110 km (68 mi) and one female at 51 km (32 mi).

Conceptual Basis for Model Development: Badgers prefer grasslands, meadows, open scrub, desert washes, and open woodland communities. Terrain may be flat, rolling or steep, and is typically below 3,600 m (12,000 ft) elevation. Core areas capable of supporting 50 badgers are equal to or greater than 16,000 ha (39,537 ac). Patch size is $\geq$ 400 ha (988 ac) but < 16,000 ha. Dispersal distance for badgers was defined as 220 km (136 mi), twice the longest recorded dispersal distance (Lindzey 1978).

Results & Discussion: The model identified abundant suitable habitat for badger in the planning area, with the most highly suitable and contiguous habitat in the northern branch of the Least Cost Union around Lake Henshaw (Figure 16). This branch of the Least Cost Union was delineated by the least cost corridor for badger because it contains the gentle topography and grassland habitats that are preferred by this species (Figure 11). The majority of suitable habitat within the planning area is contiguous, and thus was identified as core habitat for this species (Figure 17). All potential habitat is within badger's dispersal distance (figure not shown), although barriers to movement may exist between suitable habitat patches. The linkage is likely to serve the movement needs of this wide-ranging species.

To restore and protect habitat connections for badger, we recommend that existing road density be maintained or reduced in the Linkage Design. When transportation improvement projects do occur, planners should incorporate crossing structures designed to facilitate badger movement across transportation barriers (See Linkage Design Section). Lighting should be directed away from the linkage and crossing structures for this nocturnal species as well.

Figure 16. Habitat Suitability for American badger
(Taxidea taxus)



Degree of Suitability

- High
- Medium to High
- Medium
- Low to Medium
- Low
- Least Cost Union
- Highways
- Railroad
- Stream/River
- Lakes, Ponds, Reservoirs

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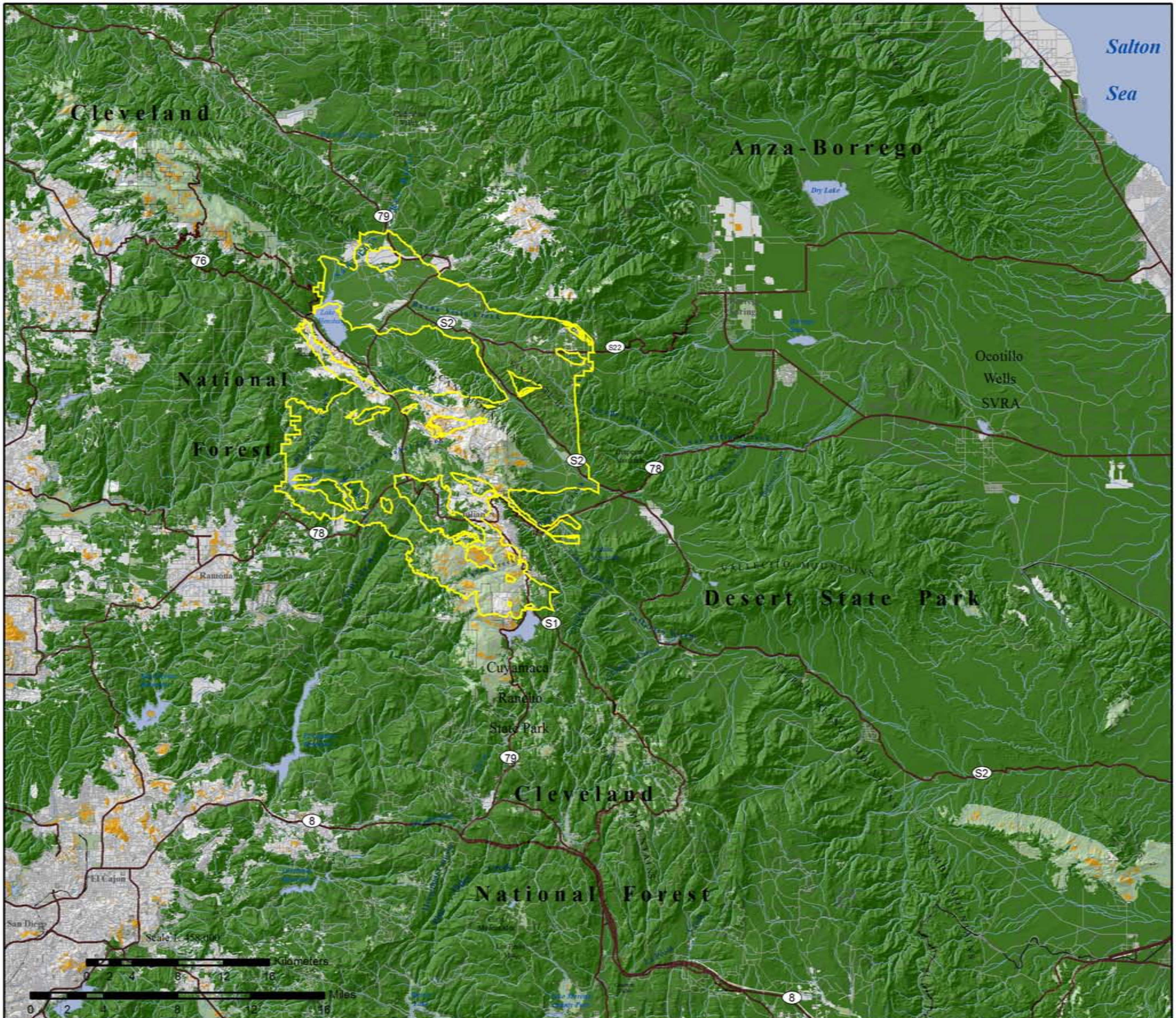
Figure 17.
Potential Cores & Patches for American badger
(Taxidea taxus)



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Bighorn sheep (*Ovis canadensis*)

Justification for Selection: Bighorn sheep need large core wild areas for refuge and security. They have extensive spatial requirements, exhibit seasonal variation in habitat use patterns, and require habitat connectivity between subpopulations. Bighorn sheep are extremely sensitive to habitat loss and fragmentation (Bleich et al. 1996, Rubin et al. 1998, Singer et al. 2000, USFWS 2000).

Distribution & Status: Bighorn sheep are divided into seven subspecies (Freeman 1999). In the Peninsular Ranges, bighorn sheep range from the San Jacinto Mountains in Riverside County, south through the desert ranges of Anza Borrego State Park in San Diego and Imperial counties, and south of the border to Volcan Tres Virgenes near Santa Rosalia in Baja California, Mexico (USFS 2002, FR 63:13134-13150, March 18, 1998, USFWS 2000). Bighorn sheep in the U.S. Peninsular Ranges are typically found below 1,400 m (4,600 ft) in elevation (Jorgensen and Turner 1975, USFWS 2000).

Throughout the southwest, desert bighorn sheep populations have declined substantially and they are now considered one of the rarest ungulates on the continent (Seton 1929, Valdez and Krausman 1999, Krausman 2000). Factors that may have contributed to the decline of desert bighorn sheep, and continue to pose threats today, include habitat loss, degradation, and fragmentation due to urbanization, mining, roads, and recreational activities (Light et al. 1967, Graham 1971, Light and Weaver 1973, Jorgensen 1974, DeForge 1980, Wilson et al. 1980, Holl and Bleich 1983, Krausman et al. 1989, Ebert and Douglas 1993, Stephenson and Calcarone 1999, USFWS 2000, Krausman et al. 2000, Papouchis et al. 2001), livestock grazing, loss of water sources (Beuchner 1960, Bailey 1980, Graham 1980, McCutcheon 1981, Bailey 1984, Geist 1985), predation by mountain lions (Hayes et al. 2000, USFWS 2000, Sweanor et al. 2003), and diseases transmitted by livestock (Cowan 1940, Beuchner 1960, Wishart 1978, Monson 1980, Holl and Bleich 1983, Thorne et al. 1985, Singer et al. 2000). Bighorn sheep in the Peninsular Ranges of southern California are federally listed as endangered and state listed as threatened (USFWS 2000, CDFG 2005).

Habitat Associations: Bighorn sheep are habitat specialists that prefer open habitats in steep rocky terrain (Van Dyke et al. 1983, Risenhoover et al. 1988, Smith et al. 1991, Singer et al. 2000). Escape terrain is typically identified as the single most important habitat component (Beuchner 1960, Welch 1969, Shannon et al. 1975, Hudson et al. 1976, Sandoval 1979, McCullough 1980, Tilton and Willard 1982, Holl and Bleich 1983, Van Dyke et al. 1983, Hurley and Irwin 1986, Bentz and Woodard 1988, Smith and Flinders 1991, Smith et al. 1991, Singer et al. 2000, Singer et al. 2000, Zeigenfuss et al. 2000, USFWS 2000, USFS 2002, Holl et al. 2004).

Provided there is sufficient steep, rocky terrain, bighorn sheep may utilize a variety of vegetation communities, including alpine dwarf shrub, low sage, sagebrush, pinyon-juniper, palm oasis, desert riparian, desert scrub, subalpine conifer, perennial grassland, and montane riparian, however, habitat use differs among mountain ranges and populations (Zeiner et al. 1990, USFWS 2000, E. Rubin, pers. com.). The distribution of desert bighorn sheep is often focused near water during summer (Leslie and Douglas 1979, Monson 1980, Wehausen 1980, Tilton and Willard 1982, Wehausen 1983, and bighorn sheep in some populations use mineral licks seasonally (USFWS 2000). The young learn about escape terrain, water sources, and lambing habitat from elders (USFWS 2000, USFS 2002).

Spatial Patterns: Females form "ewe groups" and have small home ranges, while rams roam over larger areas, moving among ewe groups (Geist 1971). Home ranges of bighorn sheep in the Peninsular Ranges were reported to average 25.5 km^2 (9.8 mi^2) for rams and 20.1 km^2 (7.8 mi^2) for ewes (DeForge et al. 1997, USFWS 2000). Rubin et al. (2002) reported mean female home range sizes of 23.92 km^2 (9.2 mi^2) and 15.02 km^2 (5.79 mi^2) when using adaptive kernel and minimum convex polygon methods, respectively, in the Peninsular Ranges.

The longest recorded movement of a female is 30 km (18.6 mi), although analyses of genetic data suggest that movement of females among groups is rare (USFWS 2000, USFS 2002). Bleich et al. (1996) reported one case of a female emigrating and reproducing in a new mountain range, while McQuivey (1978) reported 4 such movements by ewes (Singer et al. 2000). Similar genetic analyses for rams indicated more frequent movements among ewe groups (USFWS 2000, USFS 2002). A Canadian study estimated that males moved approximately 24 km (14.9 mi.; (Blood 1963). Geist (1971) observed male movements up to 35 km (21.7 mi). Witham and Smith (1979) documented a male moving 56 km (34.8 mi), while DeForge (1980) reported a male moving approximately 10 km (6.21 mi) in the San Gabriel Mountains.

Conceptual Basis for Model Development: Numerous habitat suitability models have been developed for bighorn sheep (Beuchner 1960, Hansen 1980, Holl 1982, Van Dyke et al. 1983, Risenhoover and Bailey 1985, Hurley and Irwin 1986, Bentz and Woodard 1988, Armentrout and Brigham 1988, Cunningham 1989, Smith et al. 1991, Singer et al. 2000, Zeigenfuss et al. 2000); however, applying the results of such models to areas outside of the original study areas may result in spurious results (Andrew et al. 1999).

We derived 4 topographic classes from elevation and slope models: canyon bottoms, ridgelines, flats, or slopes. We then delineated potentially suitable habitat as slopes, ridges, and canyon bottoms in desert scrub, desert succulent scrub, bitterbrush, sagebrush, barren, Joshua tree, juniper, desert riparian, washes, and palm oasis below 1,400 m (4,600 ft) in elevation.

Potential core areas were delineated as areas of suitable habitat greater than or equal to 625 km^2 (154,441 ac). Patches were defined $\geq$ 30 km^2 (7,414 ac) but less than 625 km^2. Dispersal distance for bighorn sheep was defined as 112 km (70 mi), twice the longest recorded distance for a male.

Results & Discussion: The output provided by the habitat suitability analysis corresponds with important habitat areas identified in the recovery plan for this species

(USFWS 2000), and it is also consistent with the critical habitat designation (Figure 18). Although some small areas of suitable habitat were identified for bighorn sheep within the Least Cost Union, this species is typically restricted to the desert ranges within the planning area and is not expected to use the linkage. This wide-ranging species was selected to maintain the integrity of core habitats in Anza Borrego Desert State Park, and because the relatively narrow band of north-south habitat utilized by this species could easily be severed. The patch size analysis identified potential core areas in the Santa Rosa Mountains, Coyote Canyon, San Ysidro Mountains, Vallecito Mountains, Tierra Blanca Mountains, Jacumba Mountains, and Carrizo Canyon (Figure 19). All potential habitat linking core areas and patches are within the species dispersal distance (figure not shown), but barriers to movement exist between areas of suitable habitat.

Bighorn sheep avoid heavily used roads (Jorgensen 1974, Wilson et al. 1980, Krausman et al. 1989, Ebert and Douglas 1993, Rubin et al. 1998, Papouchis et al. 2001), but females will cross roads on rare occasions and rams cross roads more frequently (Rubin et al. 1998). MacArthur et al. (1982) concluded that well designed transportation systems could minimize disturbance to sheep. To restore and protect habitat for bighorn sheep in the Peninsular Ranges, we recommend that no new roads be constructed in occupied or potential habitat (USFWS 2001). No new roads or trails should pass within 100 m of a water source (Holl and Bleich 1983) and established roads or trails close to water should be seasonally closed (April-September). Roads and trails that pass through known lambing areas should be closed during the reproductive season (Holl and Bleich 1983, USFWS 2000, Papouchis et al. 2001, USFWS 2001). Finally, off-road vehicles should be excluded from occupied and historic habitat and closures should be enforced (USFWS 2000, USFWS 2001).

Other measures that should be taken to maintain this species include enforcing leash laws so that dogs are under restraint at all times (USFWS 2000, USFWS 2001, Holl et al. 2004); prohibiting domestic sheep and goats within 9 miles of bighorn sheep habitat to reduce the potential for disease transmission (USFWS 2000, USFWS 2001); and widely publicizing the CalTIP (Californians Turn in Poachers) program’s toll free reporting number (800-952-5400) to inform citizens (Anonymous 1984). We also suggest that parcels within critical habitat are protected through conservation easements, acquisition, fee title agreements, etc.

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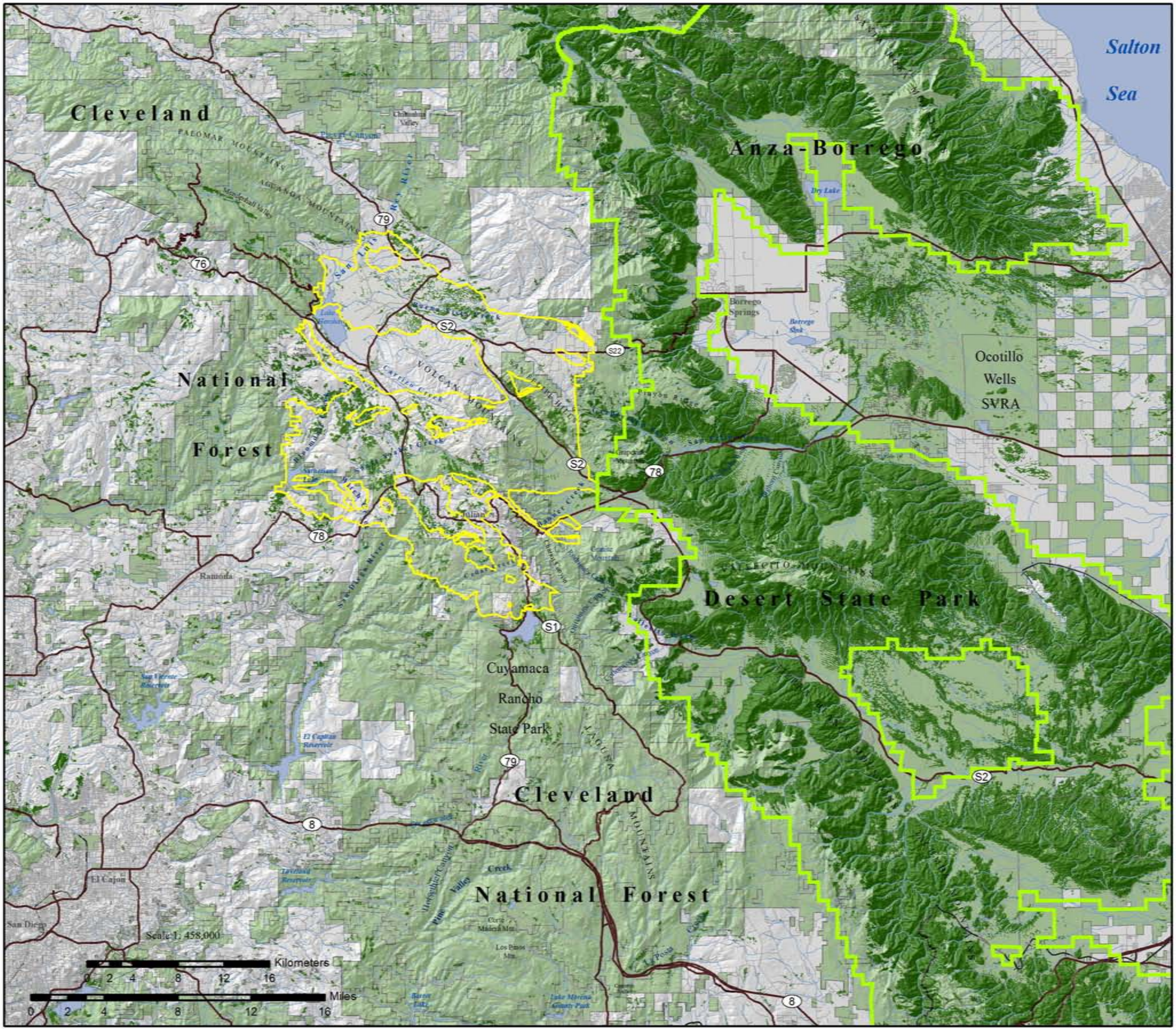
Figure 18.
Potential Habitat
for
Bighorn sheep
(Ovis canadensis)



Potential Habitat
Critical Habitat Boundary
Least Cost Union
Protected Lands
Highways
Railroad
Stream/River
Lakes, Ponds, Reservoirs

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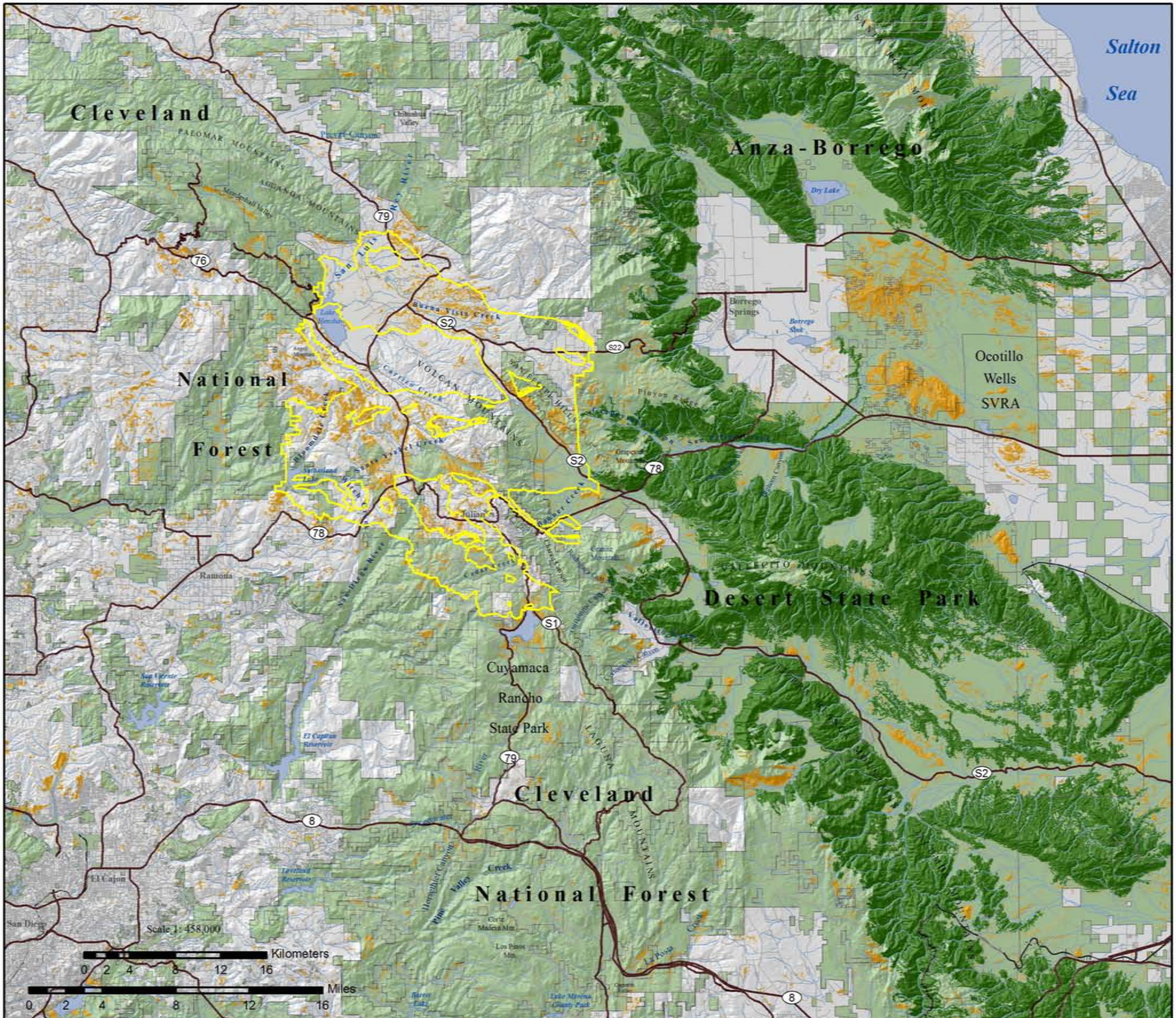
Figure 19.
Potential Cores & Patches for Bighorn sheep
(Ovis canadensis)



Core
< Patch
Least Cost Union
Protected Lands
Highways
Railroad
Stream/River
Lakes, Ponds, Reservoirs

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Mule deer (*Odocoileus hemionus*)

Distribution & Status: Mule deer are widespread in California and are common to abundant in appropriate habitat; they are absent from areas with no cover (Longhurst et al. 1952, Ingles 1965, Zeiner et al. 1990). Mule deer are classified by CDFG as a big game animal.

Habitat Associations: Mule deer require a mosaic of habitat types of different age classes to meet their life history requirements (CDFG 1983). They use 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). They also occur in open scrub, young chaparral and low elevation coniferous forests (Bowyer 1981, 1986, USFS 2002). A variety of brush cover and tree thickets interspersed with meadows and shrubby areas are important for food and cover. Thick cover can provide escape from predators, shade in the summer, or shelter from wind, rain and snow. Varying slopes and topographic relief are important for providing shade or exposure to the sun. Fawning occurs in moderately dense chaparral, forests, riparian areas, and meadow edges (CDFG 1983). Meadows are particularly important as fawning habitat (Bowyer 1986, USFS 2002).

Spatial Patterns: Home ranges typically comprise a mosaic of habitat types that provide deer with various life history requirements. Home range estimates vary from 39 ha (96 ac) to 3,379 ha (8,350 ac; Miller 1970, 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 ha (705 ac). Doe and fawn groups have smaller home ranges, averaging 100-300 ha (247-741 ac), but can vary from 50 to 500 ha (124-1,236 ac; Taber and Dasmann 1958, CDFG 1983). Bucks usually have larger home ranges and are known to wander greater distances (Brown 1961, Zeiner et al. 1990). A recent study of 5 different California sites recorded home range sizes from 49 to 1,138 ha (121-2,812 ac; Kie et al. 2002).

Where deer are 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 perennial water during the summer (CDFG 1983, Nicholson et al.1997, Loft et al. 1998, USFS 2002). Distances traveled between winter and summer ranges vary from 8.6 to 29.8 km (5.3-19 mi; 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 (60-135 mi).

Conceptual Basis for Model Development: Mule deer utilize a broad range of habitats, reaching their highest densities in oak woodlands. They require access to perennial water. Core areas potentially supporting 50 or more deer are equal to or greater than 16,000 ha (39,537 ac). Patch size was classified as ≥ 100 ha (247 ac) but < 16,000 ha. Dispersal distance was defined as 434 km (270 mi), or twice the maximum distance recorded.

Results & Discussion: All branches of the Least Cost Union contain suitable habitat for mule deer, with the central and southern branches providing the most highly suitable habitat (Figure 20). The majority of suitable habitat in the planning area is contiguous and was thus identified as potential core areas for mule deer, including all habitats in the Least Cost Union, with a fairly large patch of habitat identified in the Vallecito Mountains (Figure 21). All core areas and patches of suitable habitat are within the dispersal distance of this species (figure not shown), although barriers to movement may exist between suitable habitat patches. We conclude that the linkage will likely serve the needs of mule deer traveling between targeted protected areas.

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). Collisions with deer also result in the loss of human lives (Reed et al. 1975). To reduce collisions and maintain habitat connections for mule deer, we suggest installing signage to alert drivers to watch for deer and other wildlife, and reducing speeds in areas where deer are known to frequently cross. If transportation projects are undertaken, we suggest structures be installed to accommodate mule deer movement. Alhough ungulates have been found to prefer overpasses to underpasses (Gloyne and Clevenger 2001), they will utilize bridged undercrossings if they can see clearly to the other side. Structures for mule deer should have natural flooring and no artificial lighting (Reed et al. 1975).

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

Degree of Suitability
- High
- Medium to High
- Medium
- Low to High
- Low
- Protected Lands
- Highways
- Least Cost Union
- Railroad
- Stream/River
- Lakes, Ponds, Reservoirs

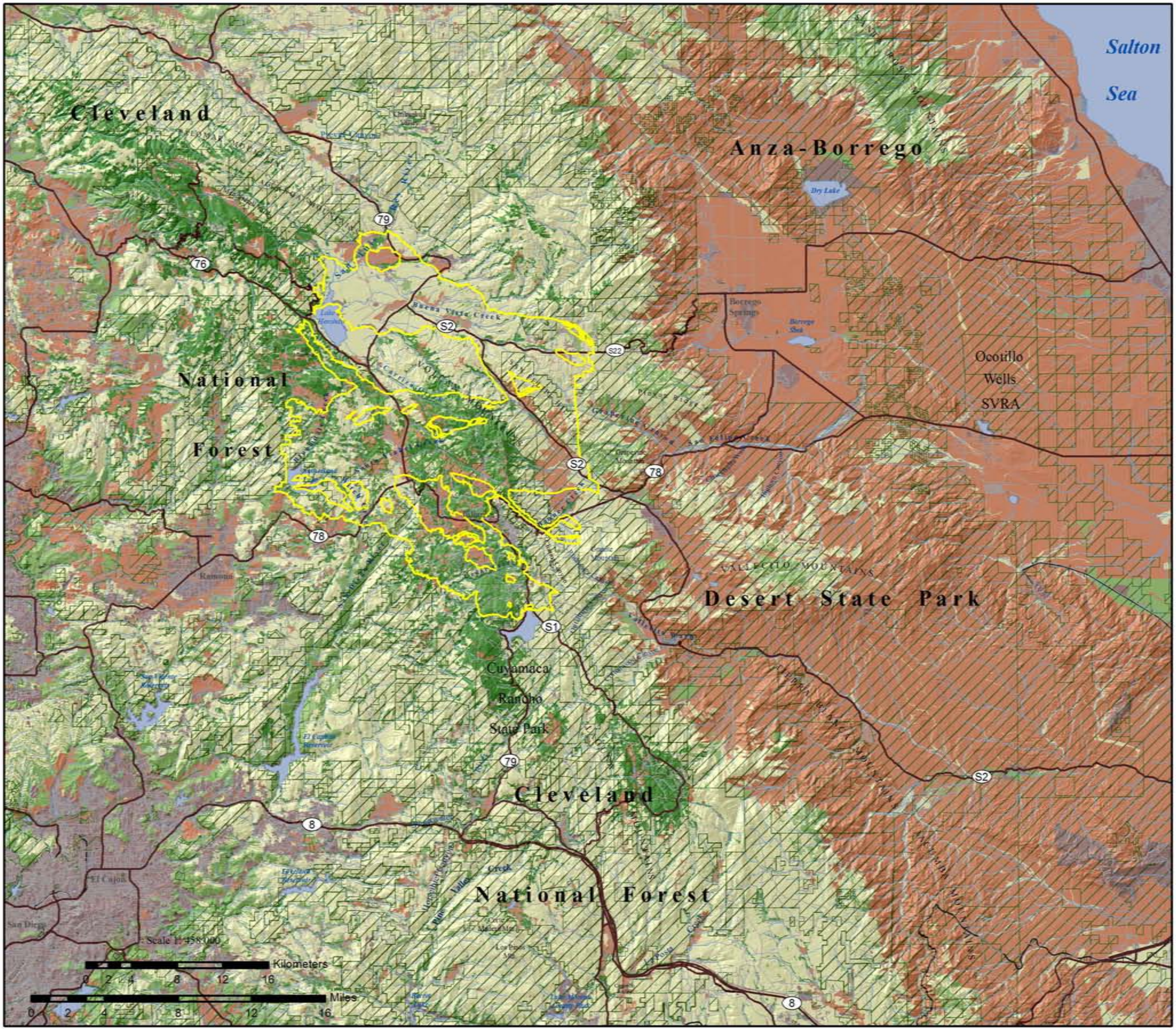

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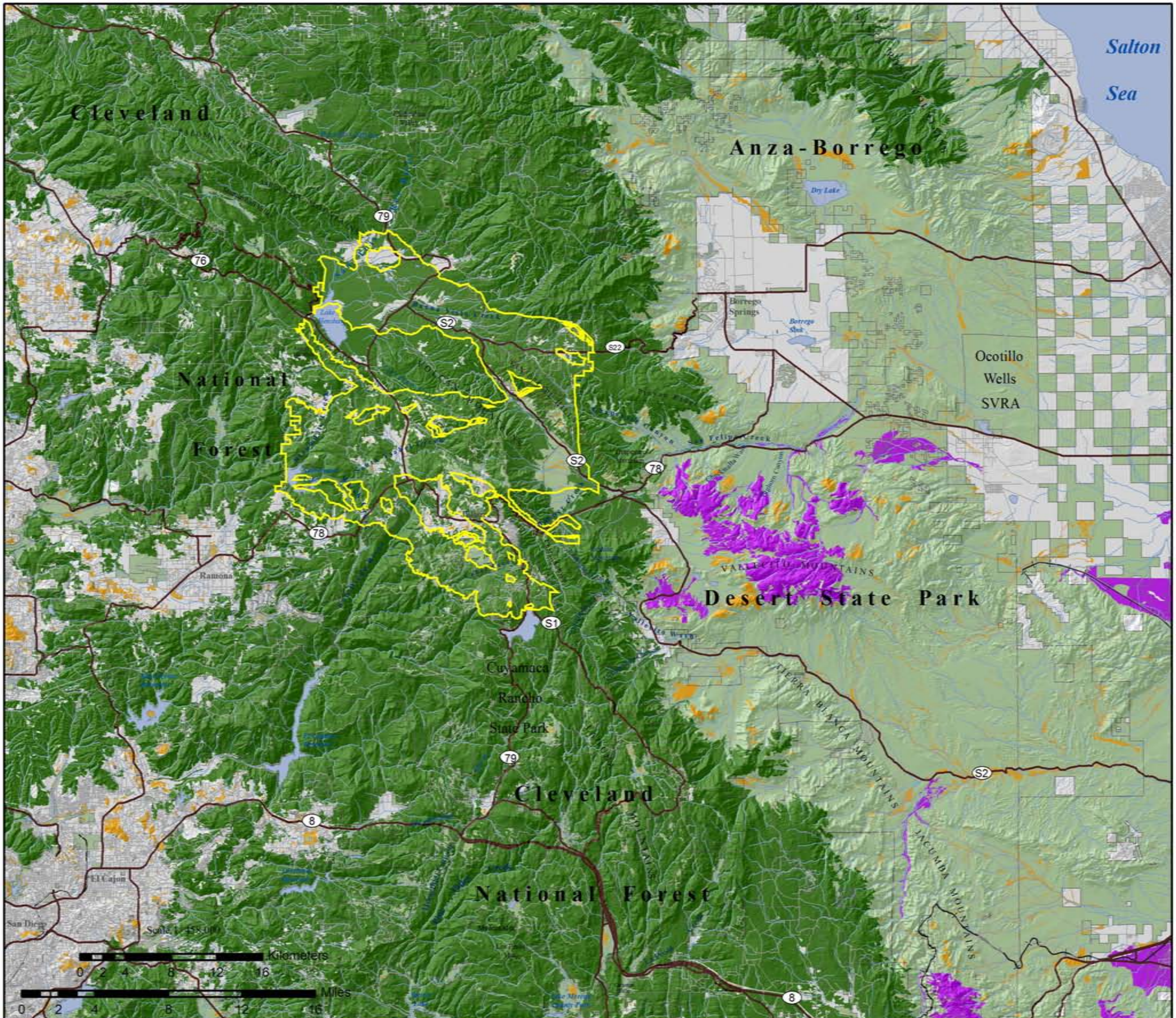
Figure 21.
Potential Cores & Patches for Mule deer
(Odocoileus hemionus)



- Core
- Patch
- < Patch
- Least Cost Union
- Protected Lands
- Highways
- Railroad
- Stream/River
- Lakes, Ponds, Reservoirs

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Black-tailed jackrabbit (*Lepus californicus*)

Justification for Selection: Black-tailed jackrabbits are sensitive to habitat fragmentation and may disappear from a location when the size of the habitat patch declines to some critical point (RCIP 2000). Risk of extirpation from marginal isolated habitat patches may be high, considering their drastic population fluctuations (Smith 1990). Semi-contiguous open habitat (i.e. grassland, open sage scrub), particularly through intermountain valleys, is needed for movement among subpopulations. Black-tailed jackrabbits are also important seed dispersers for several plant species including prickly pear (*Opuntia* spp.; Timmons 1942, Daniels et al. 1993).

Distribution & Status: Black-tailed jackrabbit are found throughout the western United States from central Washington south to northern Mexico and east to Missouri and Arkansas (Jones et al. 1983, Best 1996), usually below 2500 m (8202 ft) in elevation (Jameson and Peeters 1988). Two subspecies occur in the planning area: *L. c. deserticola* is abundant in the desert, while the San Diego (or coastal) black-tailed jackrabbit (*L. c. bennettii*) is a California Species of Special Concern and occurs only on the coastal side of the southern California mountains in suitable habitat (Stephenson and Calcarone 1999). The latter subspecies has been recorded from northern Baja California through San Diego, Orange, Los Angeles, and Ventura Counties, with occurrences reported in San Felipe Valley, Jacumba, Santa Ysabel, and the Tijuana River in San Diego County (Hall 1981).

Threats to jackrabbits include loss and fragmentation of habitat, automobile collisions, hunting, and landowner kills (RCIP 2002).

Habitat Associations: Black-tailed jackrabbits may be abundant at lower elevations in herbaceous and scrub habitats, and in open, early stages of forest and chaparral habitats (Caire et al. 1989). Black-tailed jackrabbits will eat almost any vegetation that occurs in the area, up to about 5 cm (20 in) above the ground. They are typically found in grasslands, savanna, or sparse coastal scrub (Bond 1977). Intermediate canopy stages of shrub habitats, and open edges between shrubs and herbaceous vegetation, or between forested and herbaceous vegetation, provide suitable habitat.

Spatial Patterns: Populations are known to fluctuate markedly, slowly reaching a peak over several years, then falling off rapidly in several weeks or months (Larrison and Johnson 1981). Black-tailed jackrabbits are probably not territorial, and have an average home range in California of 18.5 ha (45 ac; Lechleitner 1958, Tiemeier 1965). In Kansas, Tiemeier (1965) estimated home ranges from 4-79 ha (10-194 ac). Home range varies from less than 1 km^2 to 3 km^2 in northern Utah (Smith 1990). In Utah, densities have been calculated at 100 rabbits per km^2 (260/mi^2; Flinders and Hansen 1973).

Typical dispersal distances are less than 0.25 mile but black-tailed jackrabbits have been known to disperse up to 45 km in a 17-week period (French et al. 1965). L. *californicus* may travel up to a mile from daytime retreats to night feeding areas (Smith 1990).

Conceptual Basis for Model Development: San Diego black-tailed jackrabbits prefer grasslands, meadows, coastal sage scrub, and open chaparral, forest and woodland communities. Potential core areas were defined as > 460 ha (1137 ac), while patch size is $\geq$ 37 ha (91 ac) but < 460 ha. Dispersal distance for black-tailed jackrabbits was defined as 90 km (56 mi), or twice the longest recorded dispersal distance.

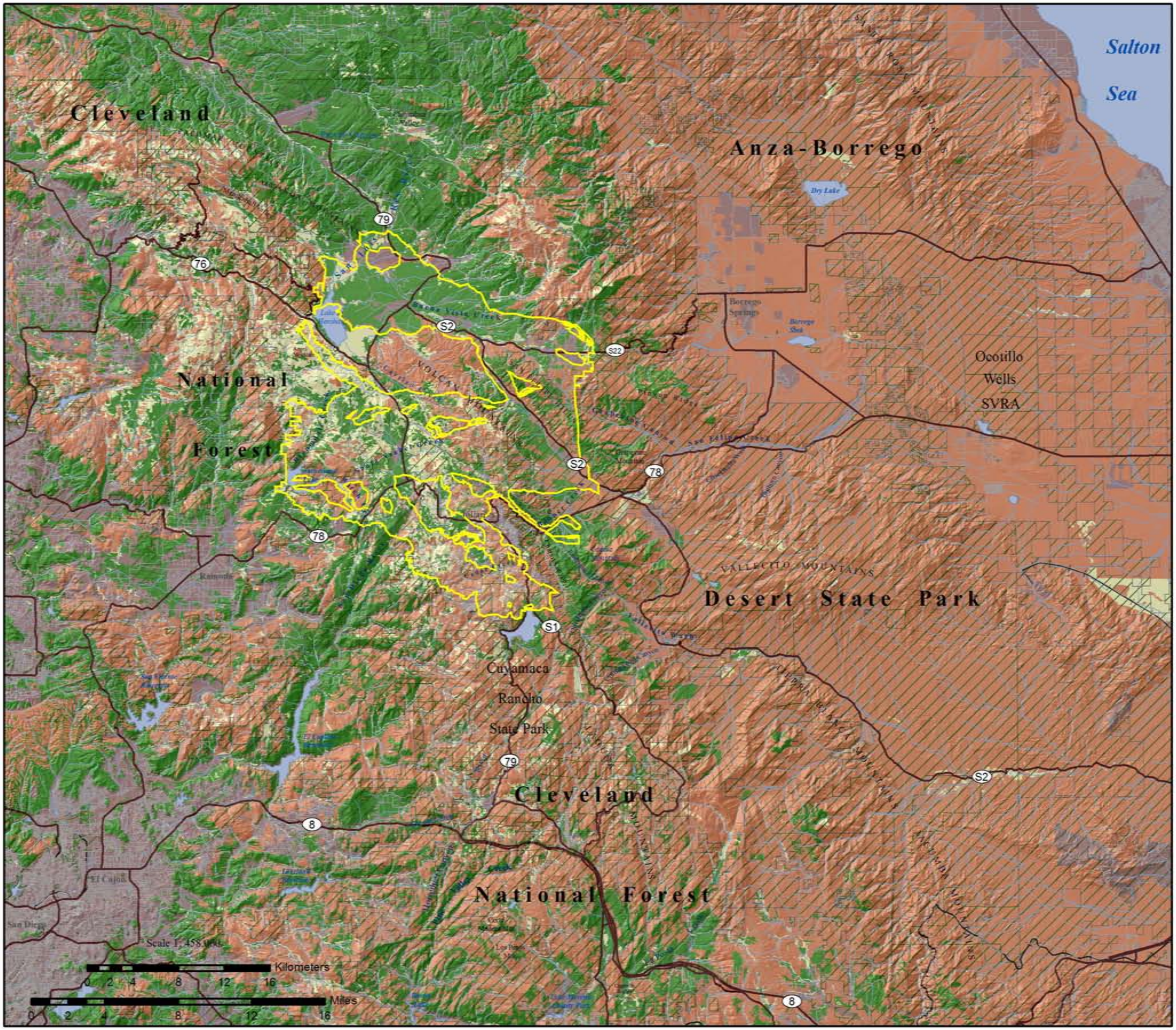
Results & Discussion: Suitable habitat for the San Diego black-tailed jackrabbit is primarily restricted to the western part of the planning area (Figure 22). All three branches of the Least Cost Union contain suitable habitat for the black-tailed jackrabbit with the northern branch containing the most highly suitable contiguous habitat (Figure 22). The patch size analysis delineated the majority of suitable habitat in the planning area as potential core areas (Figure 23). All potential cores and patches of suitable habitat are within the black-tailed jackrabbit's dispersal distance (figure not shown), although barriers to movement may exist between suitable habitat patches. We conclude that the linkage is likely to serve the needs of this species, although habitats added to the Least Cost Union for other species will also benefit the black-tailed jackrabbit.

In southern California, loss of habitat to urban development has reduced the amount of available habitat for this species. Black-tailed jackrabbits are an important prey species for coyotes, hawks, eagles, owls, mountain lions, bobcats, and foxes (Wagner and Stoddart 1972). The local abundance of these predators may be related to the abundance of black-tailed jackrabbit (Best 1996). Thus, maintaining healthy populations of the San Diego black-tailed jackrabbit will benefit other focal species such as the golden eagle and mountain lion.

Top priorities for maintaining connectivity for the black tailed jackrabbit include intermountain valleys such as near Warner Springs and Aquanga, and Santa Ysabel and San Felipe valleys. Open areas should be retained for dispersal, especially contiguous grassland, meadow and coastal sage scrub habitats. Fire frequency should be controlled to prevent type conversion of scrub habitats to nonnative annual grassland (Winter 2003).

We also suggest that crossing structures for small mammals be placed fairly frequently to reduce roadkill and facilitate movement across major highways when transportation projects are undertaken in this area. Hunting of this California Species of Special Concern should also be discontinued.

Figure 22
Habitat Suitability
for
San Diego
Black-tailed jackrabbit
(Lepus californicus bennettii)



Degree of Suitability
- High
- Medium to High
- Medium
- Low to Medium
- Low
- Least Cost Union
- Protected Lands
- Highways
- Railroad
- Stream/River
- Lakes, Ponds, Reservoirs

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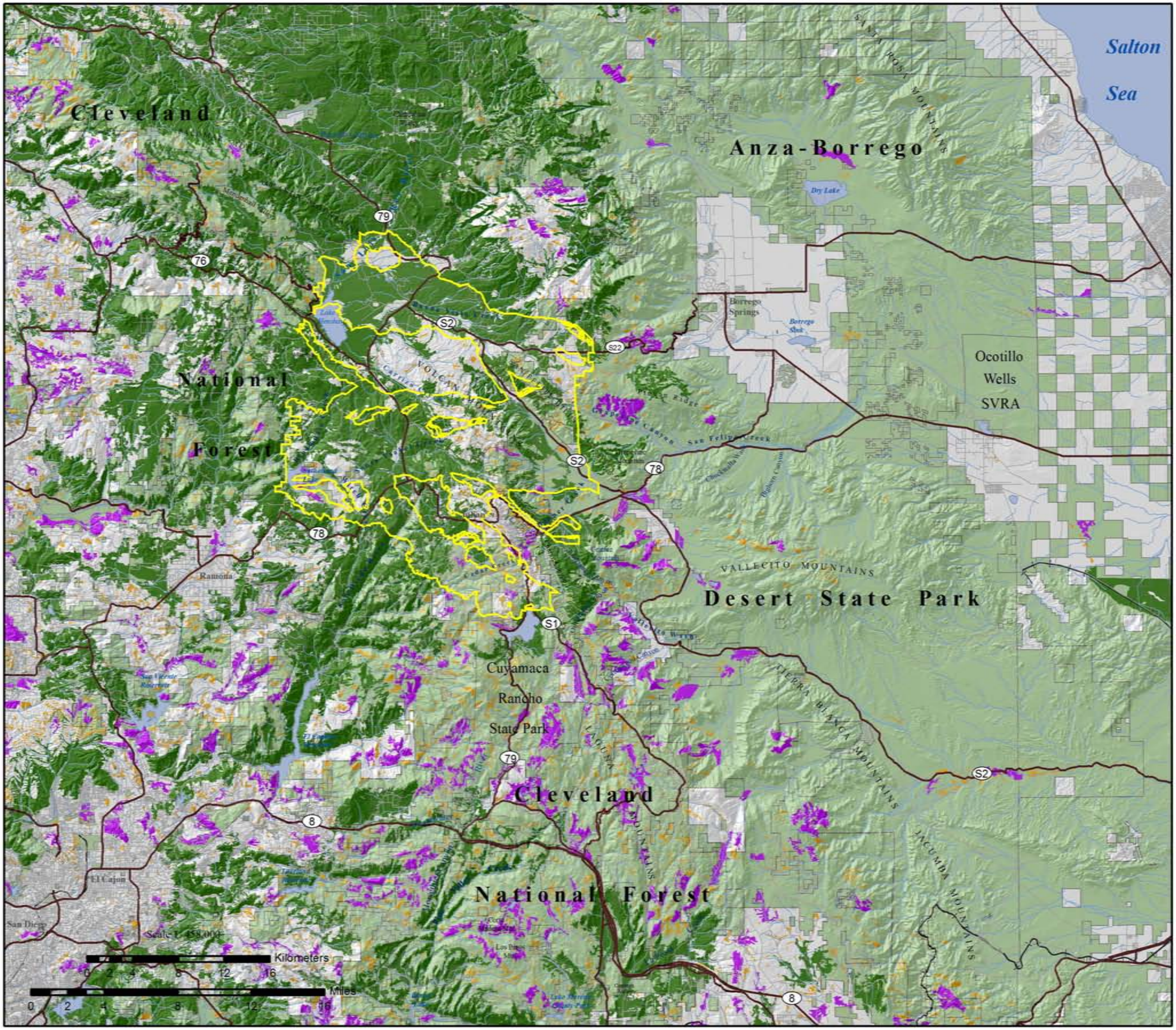
Figure 23.
Potential Cores & Patches for San Diego Black-tailed Jackrabbit
(Lepus californicus bennettii)



Core

Patch

< Patch

Least Cost Union

Protected Lands

Highways

Railroad

Stream/River

Lakes, Ponds, Reservoirs

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Golden eagle (*Aquila chrysaetos*)

Justification for Selection: Golden eagles represent a good keystone species because of their sensitivity to human disturbances. Golden eagles require large expanses of habitat and have shown pronounced declines throughout southern California (Tesky 1994).


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Distribution & Status: Golden eagles occur throughout the northern hemisphere. In North America, they breed from northern Alaska to northern Mexico (Dunstan 1989, DeGraaf et al. 1991). In the planning area, golden eagles are concentrated in the central portion of San Diego County between I-15 and the Laguna Mountains (D. Bittner, Wildlife Research Institute, pers. comm.). There are 42 pairs in San Diego County, with 10 pairs in the desert portion of the county (D. Bittner pers. comm.).

Golden eagles are declining in southern California (50% between 1970 and 2002; D. Bittner pers. comm.). This species survival in southern California is dependent on protection of large open spaces with good mammalian prey base (i.e. black-tailed jackrabbit, cottontail, California ground squirrel) and to a lesser extent on avian prey (ducks, coots, ravens, etc.). Southern California golden eagles are non-migratory, dependent year-round on their territory. Nest site disturbance is responsible for many reproductive failures, and isolation during nesting is critical (D. Bittner pers. comm.).

Habitat Associations: Golden eagles utilize a variety of plant communities including grasslands, scrub, woodlands and forests (Verner and Boss 1980, Collopy 1984, Cooperrider et al. 1986, Palmer 1988, Wassink 1991). In California, they prefer open habitats such as grasslands, scrub with young trees, and open oak woodlands where hunting efficiency is highest (Verner and Boss 1980, Matchett and O'Gara 1991). Eagles typically nest on cliff ledges, overlooking grasslands but will use trees when cliffs are unavailable (Verner and Boss 1980, Cooperrider et al. 1986, DeGraff et al. 1991).

Spatial Patterns: Territory size averaged 57 km^2 (22 mi^2) in Idaho, 171-192 km^2 (66-74 mi^2) in Montana, 23 km^2 (9 mi^2) in Utah, 124 km^2 (48 mi^2) in northern California, and 93 km^2 (36 mi^2) in southern California (Dixon 1937, McGahan 1968, Smith and Murphy 1973, Beecham and Kochert 1975). During the nesting season, eagles usually forage within 7 km (4.3 mi) of the nest (Cooperrider et al. 1986).

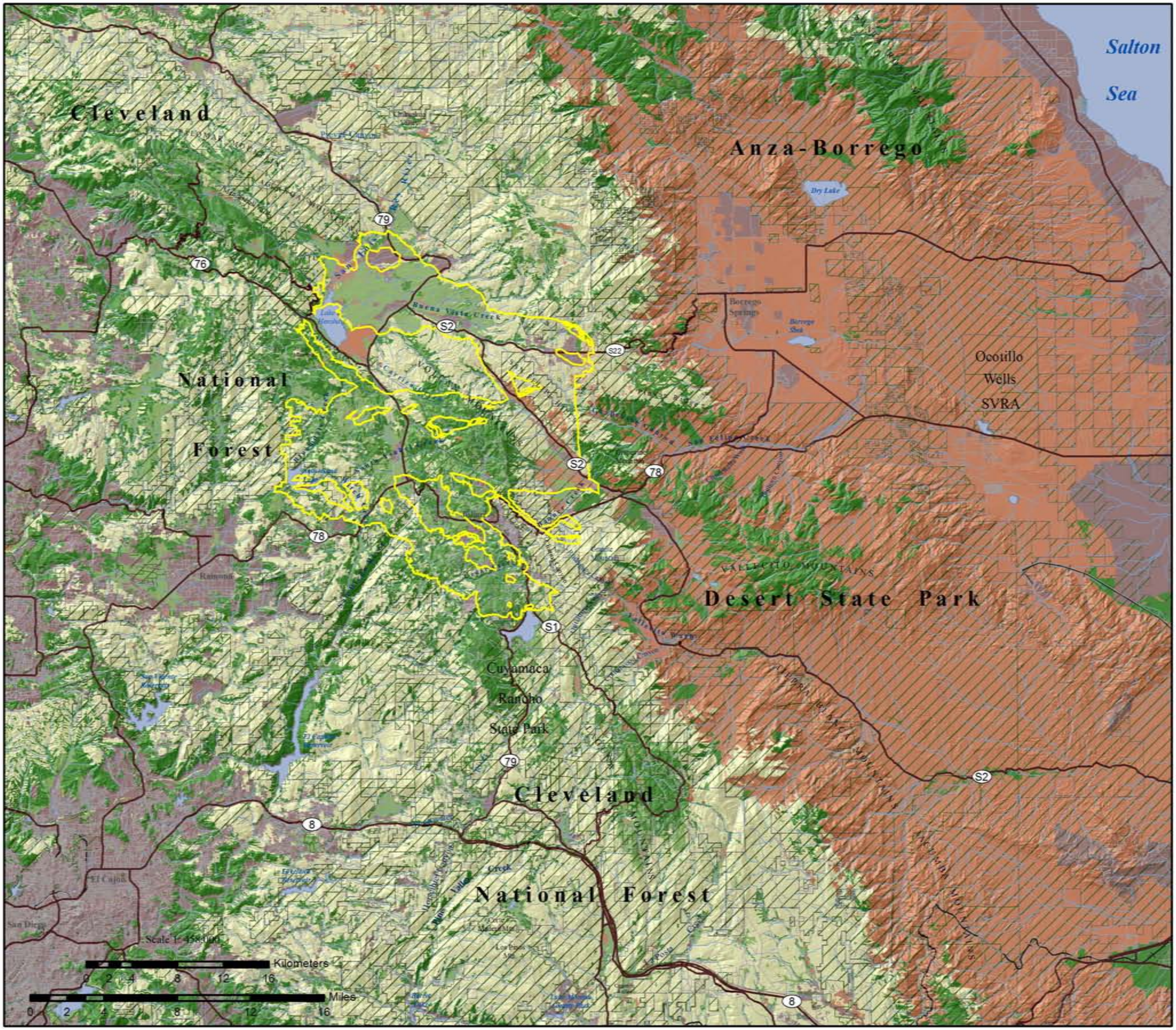
Little is known about natal dispersal distance for resident golden eagle populations. The young often visit their natal nesting site the following year (Brown and Amadon 1968), suggesting that immediate dispersal is not common for immature birds. Although populations in southern California do not migrate, populations in other areas, such as sub-arctic and northern boreal areas are capable of long-distance migratory movements (Tesky 1994).

Conceptual Basis for Model Development: The best suitable habitat for golden eagles is grassland, shrub and woodlands. Minimum patch size is 93 km^2, the average size of golden eagle territories measured in southern California. Minimum core area size is 2,325 km^2 (898 mi^2). Dispersal distance adopted for the model is 120 km (75 mi).

Results & Discussion: Extensive suitable habitat was identified for this top predator in the western portion of the planning area, with all three branches of the Least Cost Union providing suitable habitat for golden eagle (Figure 24). The majority of habitat in the planning area is contiguous and was thus identified as potential core areas (Figure 25). All potential cores and patches of suitable habitat are within the dispersal distance of the golden eagle (figure not shown). We conclude that while the Least Cost Union is not needed to sustain movement needs among populations of eagles, it serves a critical function of preserving this top predator in the linkage.

The remaining golden eagle territories are surrounded and stressed by urbanization and sprawl, preventing recruitment into historic territories. Electric poles and wires are responsible for most golden eagle mortalities, with over 60% attributed to electrocution. We suggest burying utility lines as soon as possible to reduce mortalities. Maintaining and protecting nesting cliffs and large open foraging habitats along the San Diego River, in the Santa Ysabel Valley, Mesa Grande, and around Lake Henshaw is critical to the long-term persistence of many golden eagles in San Diego County (D. Bittner, pers. comm.).

Figure 24.
Habitat Suitability
for
Golden eagle
(Aquila chrysaetos)



Degree of Suitability
- High
- Medium to High
- Meidum
- Low to Medium
- Low
- Least Cost Union
- Protected Lands
- Highways
- Railroad
- Stream/River
- Lakes, Ponds, Reservoirs

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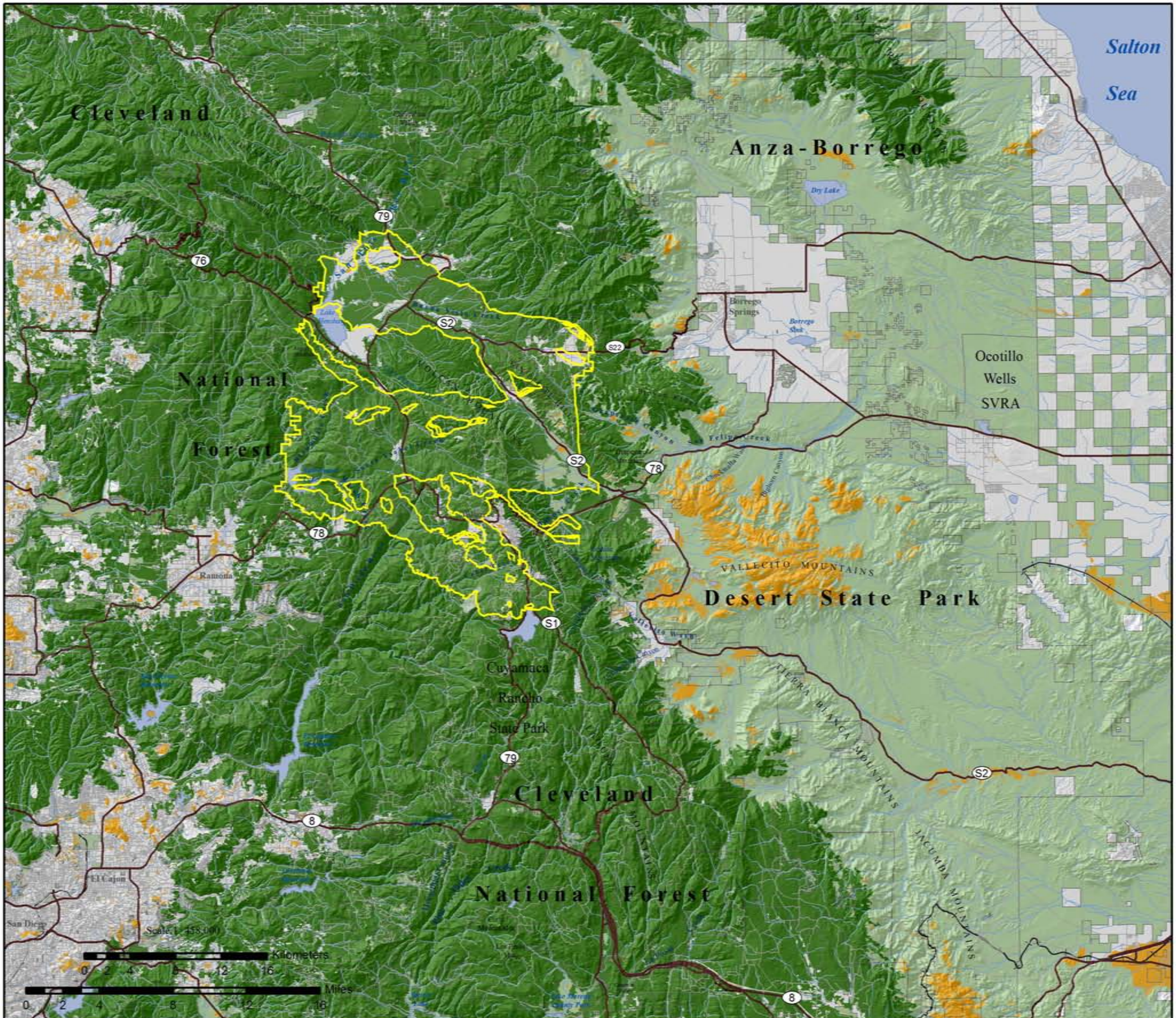
Figure 25.
Potential Cores & Patches
for
Golden eagle
(Aquila chrysaetos)



- Core
- < Patch
- Least Cost Union
- ConservationLand
- Highways
- Railroad
- Stream/River
- Lakes, Ponds, Reservoirs

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Grasshopper sparrow *(Ammodramus savannarum)*

Justification for Selection: Reversing population declines of grasshopper sparrow has been recognized as national and regional conservation priorities (Knopf 1994, Vickery 1996). Grasshopper sparrows use habitats that are naturally patchily distributed in the landscape, thus the species likely requires an archipelago of suitable habitat for long-term survival. The relatively flat grasslands that grasshopper sparrow depend upon in California are the same areas prized for development and agriculture.

Distribution & Status: In California, grasshopper sparrows are a summer visitor in the foothills and lowlands west of the Cascade-Sierra Nevada crest from Mendocino and Trinity counties south to San Diego County (Zeiner et al. 1990, Small 1994). They are typically found below 1500 m (5000 ft; Zeiner et al. 1990). Secretive in winter, they may occur more regularly than indicated by records.(Grinnell and Miller 1944, McCaskie et al. 1979, Garrett and Dunn 1981).

Grasshopper sparrows are a species of management concern and are considered a priority species by the “Partners in Flight” program.. North American Breeding Bird Survey (BBS) data indicate a significant population decline (4.4% per year) in North America between 1966 and 1989 (Droege and Sauer 1990). Conversion to croplands, livestock grazing, reforestation, spread of exotic species, urbanization and disrupted fire regimes all threaten the grassland habitats of grasshopper sparrow (Bock and Webb 1984, Ehrlich et al. 1992, Knopf 1994, Knight et al. 1995, Saab et al. 1995, Vickery and Herkert 1999, Jones and Bock 2002).

Habitat Associations: Grasshopper sparrows use naturally patchy grassland habitats. Optimal habitat for these birds contains short- to medium-height bunch grasses interspersed with patches of bare ground, a shallow litter layer, scattered forbs, and few shrubs. Although shrubs and forbs are used for perching, grasshopper sparrows tend to avoid grassland areas with extensive shrub cover (Smith 1963, Vickery 1996). Consequently, the presence and density of grasshopper sparrows at breeding sites varies annually due to habitat changes such as fire, or overgrazing (Small 1994). They generally prefer sites one year after a burn (Vickery 1996). They breed on lower mountain slopes, rolling hills, lowland plains, and mesas containing grasslands of varying compositions (Grinnell and Miller 1944, Garrett and Dunn 1981, Small 1994).

Spatial Patterns: There is no data on home range sizes for this species in California, but home range sizes are variable elsewhere, including 4-30 pairs per 40 ha (100 ac) in Pennsylvania (Smith 1963), 4 pairs per 40 ha in Washington (Wing 1949), 10-35 pairs per 40 ha in Georgia (Johnston and Odum 1956), and 73 territories averaging 0.9 ha (2.1 ac) with a ranges of 0.3 - 1.7 ha (0.8 - 4.3 ac) in Wisconsin (Wiens 1969).

Grasshopper sparrows are area sensitive, preferring large grassland areas (greater than 40 ha [100 ac]) over small areas (Herkert 1994a,b, Vickery et al. 1994, Bakker et al. 2002). In Colorado, grasshopper sparrows were about three times more abundant in interior grasslands than in areas < 200 meters from suburban development (Bock et al. 1999). The minimum area needed to support a breeding population may be > 30 hectares (Herkert 1994b). The probability of encountering sparrows was highest on large fragments far from a forest edge and > 4 years postburn; however, nest productivity was highest at one year postburn (Johnson and Temple 1986).

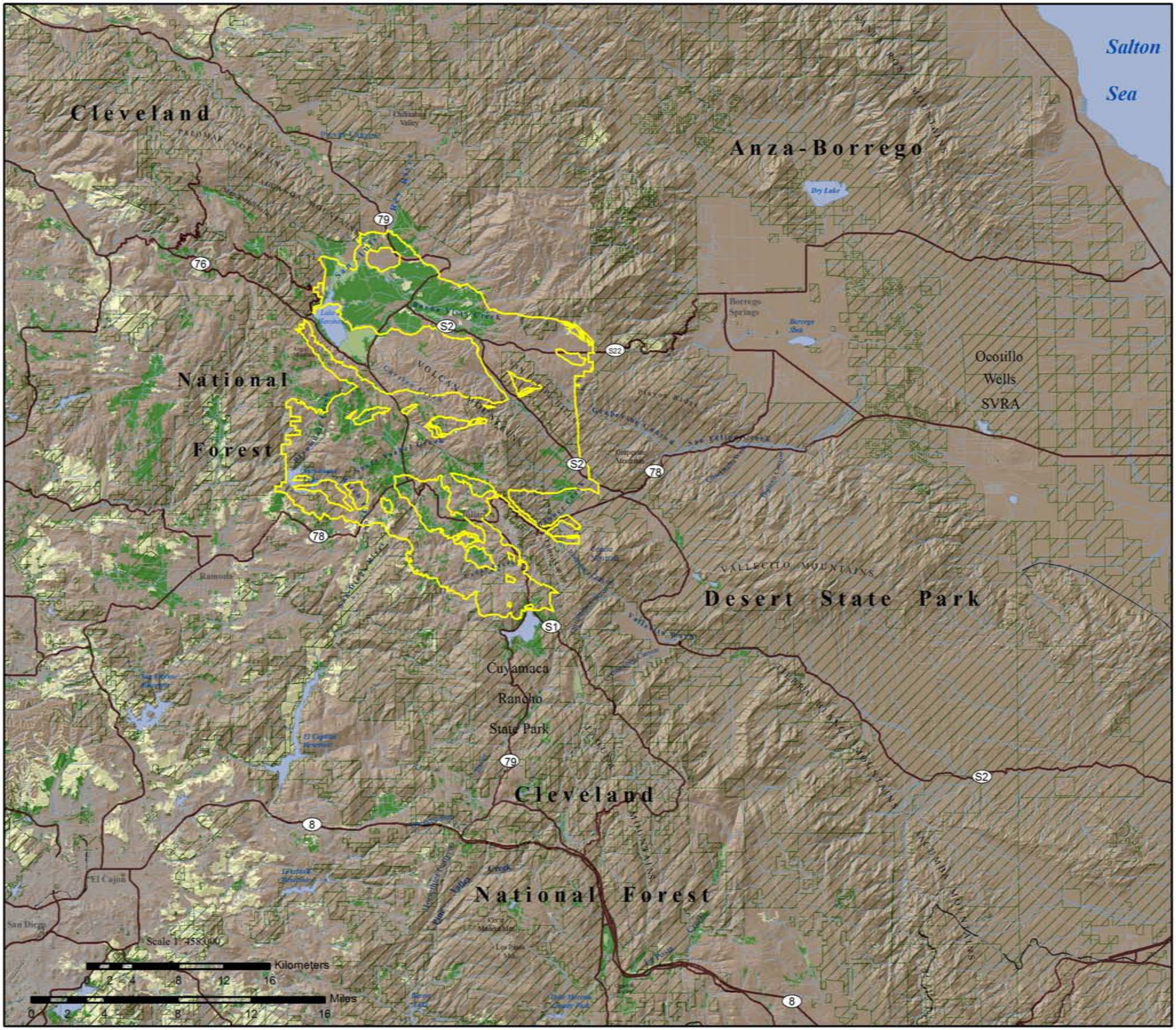
Conceptual Basis for Model Development: Grasshopper sparrows may utilize perennial grassland, annual grassland, and meadow habitats, and occasionally coastal scrub. Core areas were defined as areas of suitable habitat ≥ 1000 ha (2471 ac), patches were delineated as ≥ 80 ha (198 ac) but < 1000 ha. Dispersal distance was not estimated for this species

Results & Discussion: Grasshopper sparrow habitat is very limited in the planning area and poorly represented on existing conservation lands. All branches of the Least Cost Union contain suitable habitat, with the northern branch of the Union containing the most extensive highly suitable habitat (Figure 26). Within the Least Cost Union, the patch size analysis identified a large potential core area around Lake Henshaw in the Warner Basin, with other potential cores around Bloomdale Creek, Santa Ysabel Valley, and the San Diego River (Figure 27). Other core areas were identified to the west, including the Ramona grasslands. We conclude that the linkage is likely to serve the needs of this species if habitat is added to the Least Cost Union along the upper San Luis Rey River, to the southeast of Lake Henshaw, southwest of Sutherland Lake, along Bloomdale Creek, and the upper San Diego River. These additions will help ensure the persistence of grasshopper sparrow and its presence will help maintain the integrity of the linkage.

Three management techniques have been used for this species: grazing, prescribed burning, and mowing. Each has different impacts depending on the type of grassland ecosystem. Intensive grazing on grasslands in the arid west has had a negative impact on grasshopper sparrows (Saab et al. 1995, Vickery 1996), mostly due to nest predation and nest parasitism by brown-headed cowbirds (Heckert 1994b). However, in areas where grass is too tall or dense, grazing offers benefits by creating patchy areas, decreasing vegetation height, and thinning dense areas (Kantrud 1981, Whitmore 1981). Shriver et al. (1996) suggests summer prescribed fires for maintaining early successional habitat, which corresponds to the period of increased natural lightning strikes and wild fires. Treatment schedules should be adjusted during droughts as burning may reduce above-ground productivity to levels unacceptable to birds (Zimmerman 1992). Depending upon location, mowing prior to arrival in spring can improve habitat, and may be preferable to prescribed burning (Swengel 1996).

Herkert (1994a) suggests that on areas > 80 hectares, 20-30% of the total area should be annually treated (burned, mowed, or grazed) to provide a mosaic of successional stages (Renken and Dinsmore 1987, Herkert 1994a, Johnson 1997). Regardless of management treatment, avoid disturbing nesting habitat during the breeding season (Stewart 1975, Whitmore 1981, Rodenhouse et al. 1995, Vickery 1996).

Figure 26.
Habitat Suitability
for
Grasshopper sparrow
(Ammodramus savannarum)



Degree of Suitability

- High
- Medium to High
- Medium
- Low
- Least Cost Union
- Protected Lands
- Highways
- Railroad
- Stream/River
- Lakes, Ponds, Reservoirs

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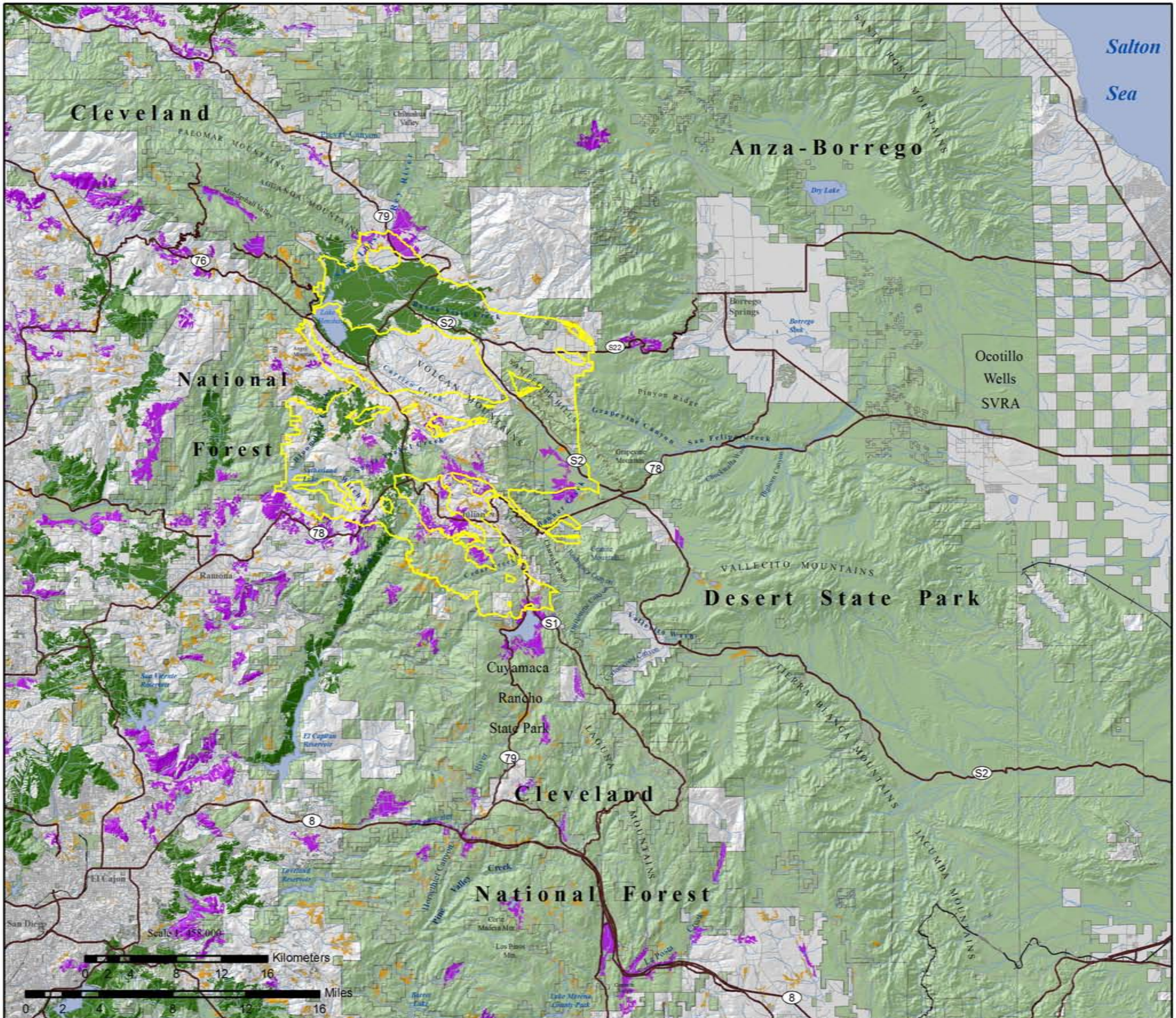
Figure 27.
Potential Cores & Patches for Grasshopper sparrow
(Ammodramus savannarum)



Core
Patch
< Patch
Least Cost Union
Protected Lands
Highways
Railroad
Stream/River
Lakes, Ponds, Reservoirs

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Pacific black brant (*Branta bernicla nigricans*)

Justification for Selection: The black brant follows traditional migration routes that are learned, not instinctive, and it is the species that funnels most tightly through San Felipe Valley as a migration corridor. Other species using the corridor are Surf Scoter, Bonaparte's Gull, many landbirds, and undoubtedly other waterbirds. Most of the black brant population wintering in the Gulf of California probably uses the San Felipe Valley in crossing to the Pacific during spring migration. Disruption of this migration corridor would be a major disturbance to the entire Pacific Flyway (P. Unit, pers. comm. San Diego Natural History Museum).

Distribution & Status: The Pacific Black Brant winters along the Pacific coast from Alaska to Baja California and mainland Mexico. In western North America, about 80% of the total black brant population nests in four major colonies on the Yukon-Kuskokwim delta in western Alaska (Derkson and Ward 1993). Brant are locally common along the whole California coast; they are spring and fall transients during their migration to and from wintering areas in Baja California (Small 1994). They are found primarily in Humboldt, Tomales, Morro and San Diego bays, San Diego River mouth, and Drake's Estero, and also in nearby marine waters (Granholm 1990). In southern California, some northbound spring migrants cross overland from the northern Gulf of California to the Salton Sea, and other interior lakes, to the Pacific Ocean (Small 1994).

A major shift in the winter distribution in western North America occurred during the 1950s and 1960s, with increased numbers using lagoons along the Mexican mainland and much decreased numbers wintering in California. The mid-winter population in California has declined from nearly 40,000 in the 1950's to a small remnant (Cogswell 1977, Pacific Waterfowl Flyway Council 1978, Garrett and Dunn 1981). Human disturbance is thought to be the reason that black brant have largely abandoned former wintering grounds on the west coast of California and Oregon in favor of Mexico (Einarsen 1965, Smith and Jensen, 1970, USFWS 1979). Degradation and loss of important staging and winter estuarine habitats caused by commercial, industrial, and recreational development are cited as the primary reasons for the decline (Derksen and Ward 1993). The wintering flocks on Mission Bay in San Diego disappeared after dredging and filling destroyed the eelgrass (*Zostera* spp.) beds there during the 1960s (Small 1994). Declines in eelgrass may affect habitat use, bird condition, and reproductive success (Wilson and Atkinson 1995).

Habitat Associations: Black brant prefer large shallow coastal lagoons, tidal estuaries and river mouths where eelgrass is plentiful. They may also occur on interior lakes during spring migration through southern California (Small 1994). Habitat use often is limited by the availability of eelgrass, which grows in the brackish waters of intertidal mudflats (Wilson and Atkinson 1995, Ward et al. 1999). Algae (especially sea lettuce), bulrush, other aquatic plants, and upland sedges and grasses also are eaten in winter, especially when eelgrass is not available (Granholm 1990). Young brants presumably eat insects and aquatic invertebrates (Palmer 1976).

Black brant breed on arctic coastal tundra, in low and barren terrain; on islands, deltas, lakes, and sandy areas among puddles and shallows, and in vegetated uplands (Einarsen 1965, Harrison 1978). Adults with broods move from colony sites to rearing habitats along tidal flats (Derksen and Ward 1993). Areas dominated by large freshwater lakes and estuaries provide important summer molting areas (Derksen and Ward 1993).

Spatial Patterns: Brant wintering in Mexico and California migrate northward along the California coast during a 4-month period starting in mid-February, and are mostly absent from California during June - September (Derksen and Ward 1993). The southward migration, which is usually well offshore, begins around mid-August along the western coast of North America (Granholm 1990, Derksen and Ward 1993). Migration is nocturnal as well as diurnal (Johnsgard 1975).

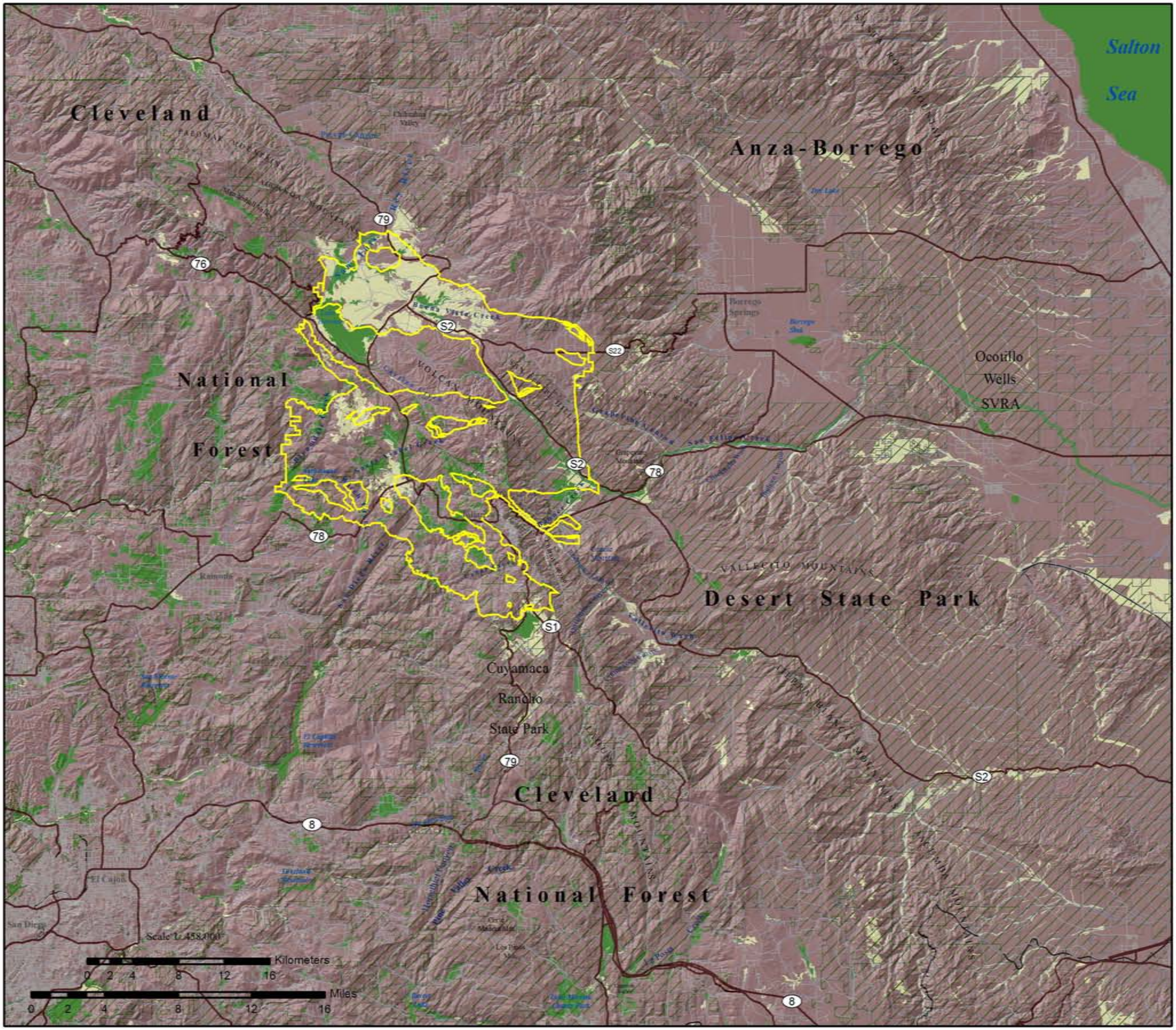
Conceptual Basis for Model Development: The black brant may utilize lakes, grasslands, and riparian habitats. This is a migratory species, so potential cores and patches were not delineated and dispersal distance was not estimated.

Results & Discussion: Suitable habitat for this migratory species is very limited in the planning area, but one of the two largest patches of suitable habitat that occurs is largely encompassed in the northern branch of the Least Cost Union around Lake Henshaw (Figure 28). San Felipe Creek, a known migration corridor for this species, is also captured in the Least Cost Union. The Salton Sea is a major stopover for black brant on the Pacific Flyway, and other lakes in the planning area, such as Sutherland, Cuyamaca, San Vicente, El Capitan, Loveland, and Barrey lakes, also provide suitable habitat for this species. We conclude that the linkage will serve a critical function of preserving habitat along the Pacific Flyway for black brant if habitat is added to the Union around Lake Henshaw, Sutherland Lake, and Upper San Luis Rey River.

Disruption of this migration corridor would be a major disturbance to the entire Pacific Flyway. Human activities have the greatest potential for physically degrading migration and wintering habitats (Pacific Flyway Council 2002). Even where healthy eelgrass habitats are available, brant may be displaced or excluded due to human disturbance (Einarsen 1965, Kramer 1976, Henry 1980, Ward and Stehn 1989). Disturbance factors include increased boating, jet skis, wind surfers, kayakers, commercial and residential development, recreational and commercial shellfish harvest, fishing, and trail developments (Pacific Flyway Council 2002). To maintain migratory habitat for the black brant in the linkage area, we suggest that key habitats be protected, and nighttime lighting be limited for this nocturnal migrant.

Figure 28.
Habitat Suitability
for
Black brant

(Branta bernicla)



Degree of Suitability

- High
- Medium to High
- Medium
- Low
- Least Cost Union
- Protected Lands
- Highways
- Railroad
- Stream/River

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Granite night lizard (*Xantusia henshawi henshawi)*

Justification for Selection: Granite night lizards have limited dispersal capabilities, are slow to reproduce, and are very specific to a particular microhabitat (Lee 1975, Bezy 1988). Discontinuities in habitat will fragment populations and reduce gene flow.

Distribution & Status: Granite night lizards can be found in arid and semi-arid habitats on the coastal and desert slopes of the Peninsula Ranges, including the San Jacinto, Laguna, and Santa Rosa Mountains, other parts of southern California and northern Baja California (e.g., San Pedro Martir Mountains, Arroyo Encanto; Glaser 1970, Wilcox et al. 1995, Stebbins 2003). The elevational range of this species is 120-2,320 meters (400-7,600 feet; Stebbins 2003), but in San Diego and Riverside counties, it has only been found from 130 to 1200 m (425 to 4000 ft; Zeiner et al. 1988).

The granite night lizard is long-lived, slow growing and not very prolific when compared to other sympatric lizards. However it does not appear to be very susceptible to fire or predation and enjoys a relatively high survivorship (Lee 1975, Bezy 1988).

A separate subspecies, *Xantusia henshawi gracilis* (sandstone night lizard), occupies a unique habitat consisting of compacted sandstone and siltstone. The only known occurrence of this subspecies is in a 1.3 km by 3 km outcrop in the eastern part of Anza-Borrego State Park, known as Truckhaven Rocks (Grismer and Galvan 1986). This subspecies is susceptible to illegal collection, habitat destruction and local-scale catastrophic effects (Grismer and Galvan 1986).

Habitat Associations: Night lizards are highly specialized for particular habitats. They live almost exclusively beneath the slabs of weathered granodiorite or metavolcanic boulders in a variety of desert, chaparral, and woodland habitats (Bezy 1972, 1989, Zeiner et al. 1988). Lee (1973, 1975) found that most of the suitable rock outcrop habitat type used by these lizards is within chaparral habitats, chaparral-coastal sage scrub, and chaparral-creosote bush ecotonal areas. However, they may utilize grasslands and other habitats between suitable outcrops for movement (Holland and Goodman 1998).

Spatial Patterns: Little, if any, information is available regarding dispersal, home range, and socio-spatial behavior. *X. henshawi* can be locally common, but patchily distributed (Lee 1976, Holland and Goodman 1998). Holland and Goodman (1998) propose that their cryptic coloration and microhabitat use of crevices and fissures within rocks probably makes diurnal activity difficult to observe.

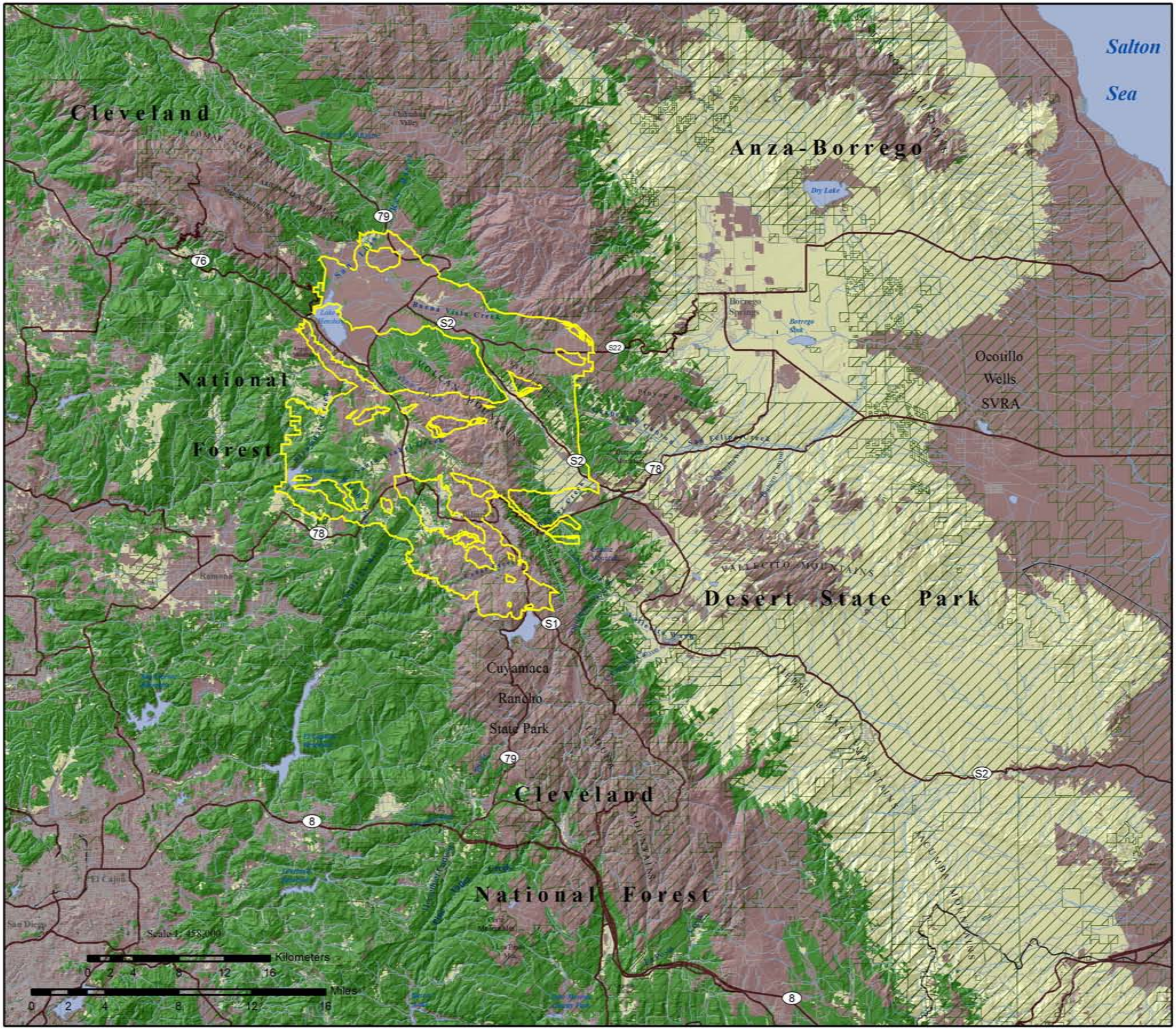
In general, night lizards are characterized by having genetically distinct, disjunct, and highly localized populations (Bezy 1989). As a group, Xantusiid lizards are sedentary (Bezy 1988). Zweifel and Lowe (1966) found that 91 percent of the recapture of *X. vigilis* took place at the original site of capture. The individuals that changed sites moved an average of 108 meters. In a continuing study of another night lizard (*X. riversiana*) on San Clemente Island by Mautz (1987), 45 percent of the recaptures have been at the site of the most recent capture. The average distance moved by the other 55 percent was only three meters. The larger distance moved by *X. vigilis* as compared to *X. riversiana* may reflect the greater patchiness of the Joshua tree habitat as compared to the more uniformly dense rock habitat at the study site on San Clemente Island.

Conceptual Basis for Model Development: Movement of this species through the linkage is multi-generational. Granite night lizards may be found in rocky outcrops within desert scrub, chaparral, coastal sage, and oak woodland communities between 130 and 1200 m (425 - 4000 ft) in elevation. Because little is known about the home range and movement abilities of granite night lizard, potential cores and patches were not delineated and dispersal distance was not estimated.

Results & Discussion: Potential habitat for the granite night lizard appears widespread in the planning area (Figure 29) but this species is largely limited to rocky outcrops within these communities, though they may use grassland and other habitats between suitable outcrops for movement. All three branches of the Least Cost Union contain potentially suitable habitat for this species, with the central branch providing the most contiguous potential habitat between targeted protected areas. We conclude that the linkage is likely to serve the needs of this species.

Efforts should be made to protect rock outcrops where this species is known to occur. Threats to this species are likely to stem from destruction of occupied rock outcrops with fractures, crevices and loose caps by development, agriculture, or collecting (RCIP 2002). Damage to fractures by amateur and pet reptile collectors have permanently ruined necessary habitat features (Zeiner et al. 1988). Lee (1975) proposed that hot fires may increase habitat by creating more fractured rock. Because granite night lizards occur in localized conditions and are secretive and difficult to detect, it will require site-specific management or monitoring activities (RCIP 2002). Because of the high degree of genetic variability detected by Lovich (2001), it is important to conserve representative populations at the limits of the species distribution and range, including longitude, latitude and elevation (RCIP 2002). Continuity of habitats between fault zones shown in Lovich (2001) is critically important to maintenance of genetic diversity.

Figure 29.
Habitat Suitability
for
Granite night lizard
(Xantusia henshawi)



Degree of Suitability
- High
- Medium
- Low
- Least Cost Union
- Protected Lands
- Highways
- Railroad
- Stream/River
- Lakes, Ponds, Reservoirs

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Barefoot gecko (*Coleonyx switaki*)

Justification for Selection: The highly restricted barefoot gecko is a California endemic, occurring only in the Peninsular Ranges of southern California.

Distribution & Status: This gecko occurs along the desert foothills of the eastern face of the Peninsular Ranges, from at least Borrego Springs and Yaqui Pass in northern San Diego County, south into north-central and eastern Baja California to San Ignacio and the Santa Rosalia area (Grismer and Edwards 1988, Grismer 2002, Stebbins 2003). *C. switaki* has been reported as far south as central Baja California, Mexico, and on San Marcos Island in the Gulf of California (Grismer and Ottley 1988, Thelander 1994). Due to the continuity of habitat both to the north and south of its current distribution, *C. switaki* may range as far north as the San Gorgonio Pass in Riverside County, California, and as far south as the Isthmus of La Paz in southern Baja California Sur (Grismer and Edwards 1988). Reported elevational range extends from near sea level to around 700 m (2,300 ft; Stebbins 2003).

C. switaki is considered a threatened species in California. Anza-Borrego Desert State Park affords protection for some gecko habitat, and the California Department of Fish & Game is involved in a habitat management plan for BLM land where the gecko is known to occur (CDFG 1990). Mining, habitat destruction for highways, roads, and urban development, and collection by reptile collectors are potential threats to this species (Thelander 1994, NatureServe 2005). The high market value of the barefoot gecko in the underground pet trade may make subpopulations vulnerable to extirpation.

Habitat Associations: This gecko seems to be restricted to areas dominated by massive rock formations, and spends most of its life in deep rock crevices and subterranean chambers, making population studies difficult (Murphy 1974). This species inhabits rocky desert foothills, volcanic talus and terraces, and canyons, and granitic outcroppings (Grismer and Edwards 1988, Grismer 2002, Stebbins 2003). It appears to prefer areas with large rocky outcroppings of various rock type and size, and sparse vegetation (Grismer and Edwards 1988, Grismer 2002). On Isla San Marcos, *C. switaki* is found primarily in the outcroppings and rubble of gypsum formations that dominate the southern end of the island (Grismer and Edwards 1988). The species has been found on flatlands up to about 100 m from rock outcrops, and it also has been found in arroyos at or near the bottoms of steep washes (Grismer and Ottley 1988).

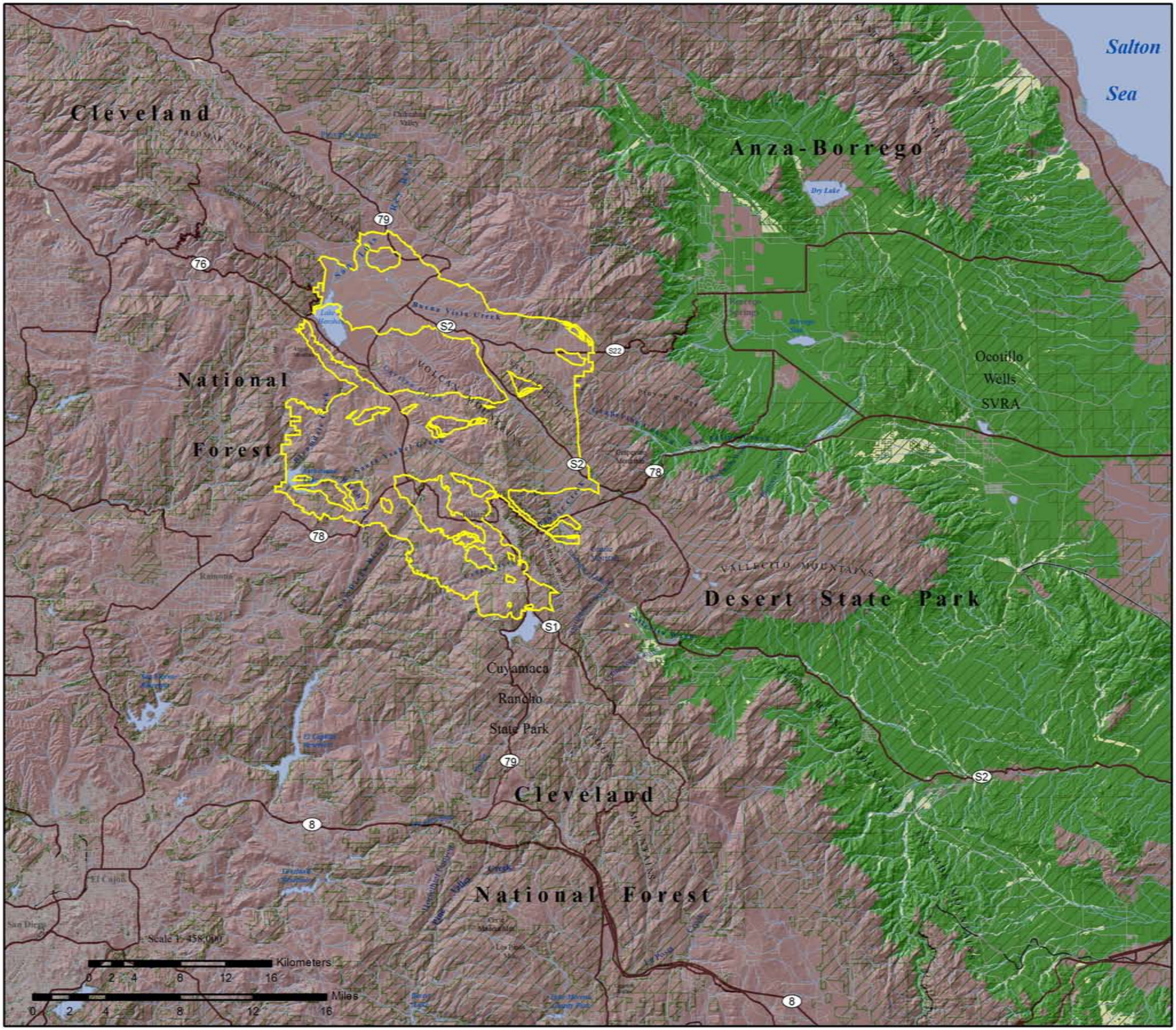
Spatial Patterns: The barefoot gecko emerges from hibernation in early spring, is reproductively active through the summer, and then becomes inactive once again by late September to mid-October. It is secretive, lives in restrictive habitats, is often misidentified, and may have narrow physiological tolerances governing its activity period (Natureserve 2005). Nothing is known about its movements, but it probably does not migrate (Zeiner et al. 1990). In general, geckos appear to be relatively sedentary, but it is likely that some individuals periodically move or disperse at least several hundred meters from one location to another (Natureserve 2005).

Conceptual Basis for Model Development: Movement of this species in the linkage and core areas is multi-generational. Massive rock formations in desert scrub communities provide suitable habitat for the barefoot gecko. Research on home range and movement patterns are lacking, so we did not conduct the patch size and configuration analyses.

Results & Discussion: Potential habitat for the barefoot gecko is limited to rocky outcrops within desert scrub habitats in Anza Borrego in the eastern portion of the planning area, with no suitable habitat identified in the Least Cost Union (Figure 30). This species was selected to maintain the integrity of core habitats in the desert ranges of Anza Borrego and is not expected to use habitats in the linkage. Efforts should be made to protect rock formations where this species is known to occur.

**Figure 30.
Habitat Suitability
for
Barefoot gecko**

(Coleonyx switaki)



- High
- Medium
- Low
- Least Cost Union
- Protected Lands
- Highways
- Railroad
- Stream/River
- Lakes, Ponds, Reservoirs

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Chalcedon checkerspot butterfly (*Euphydryas chalcedona*)

Justification for Selection: Chalcedon checkerspot butterflies are considered an indicator species for undisturbed coastal sage scrub (Hogue 1993). It is also a primary pollinator for many plant species, and may functionally increase the size of a plant's available gene pool and enhance the speed of dissemination of novel genes (G. Ballmer, University of California Riverside, unpublished data).

Distribution & Status: Chalcedon checkerspot butterflies have enormous geographic variation, with 38 subspecies named (Scott 1986). They are treated by some as three separate species: *E. anicia*, *E. chalcedona*, and *E. colon. E chalcedona* are found from Alaska south along the Pacific coast through California and Arizona to Baja California and Mexico, east to Montana, the Dakotas, Wyoming, Colorado, and New Mexico. The species is primarily associated with the coastal foothills (Orsak 1978).

Urbanization and conversion of native grasslands to agriculture have left only small remnants of many formerly extensive grassland ecosystems. Remnants are threatened by further development, isolation, invasion by introduced species, and increasingly by nitrogen deposition (Weiss 1999). Nitrogen deposition from air pollution threatens biodiversity in nutrient-poor grasslands with serpentine soils because nitrogen is the primary limiting nutrient for plant growth on serpentine soils (Weiss 1999).

Habitat Associations: Chalcedon checkerspot butterflies can be found in desert hills, chaparral, coastal sage scrub, oak woodlands, grasslands, open forest and alpine tundra from the Upper Sonoran Zone to Alpine Zone (Scott 1986, Hogue 1993, Heath 2004).

Food plants for the chalcedon checkerspot includes many members of the figwort family (*Scrophulariaceae*), especially bush monkeyflower (*Mimulus aurantiacus*) and coast figwort (*Scrophularia californica*), as well as paintbrushes (*Castilleja* spp.), and Penstemon (*Penstemon antirrhinoides, P. cordifolia*; Orsak 1978). Caterpillar hosts include penstemon and paintbrush, and species from several other plant families including *Caprifoliaceae*, *Boraginacea* and *Rosaceae* (Orsak 1978). Adults are readily attracted to moisture and also to flowers of buckwheat (*Eriogonum* spp.) and yerba santa (*Eriodictyon crassifolium*) in many areas of southern California (Orsak 1978).

Spatial Patterns: Flight time is from March through June, and September through November. The average life span for males is 9-10 days. Males seek females by patrolling all available habitats or by perching on hilltops or on exposed vegetation in clearings. Flight distances between recaptures averaged 65 m and 146 m for males at two different sites, and 18 m for females (Scott 1986).

Conceptual Basis for Model Development: Movement of this species through the linkage is multigenerational. Food and host plants for the chalcedon checkerspot butterfly occur in chaparral, coastal sage scrub, oak woodlands, grasslands, and open forest habitats. No information is available on home range size for this species, so we did not conduct the patch size and configuration analyses.

Results & Discussion: Potential habitat for the chalcedon checkerspot butterfly is widespread in the planning area, with all branches of the Least Cost Union containing suitable habitat (Figure 31). We believe that habitats in the Least Cost Union will support intergenerational movements of this species. The checkerspot butterfly would also benefit from additions added to the Least Cost Union to support other species. To ensure the long-term survival of the chalcedon checkerspot butterfly in the planning area, habitat integrity, host plant colonies and nectar sources need to be maintained and restored.

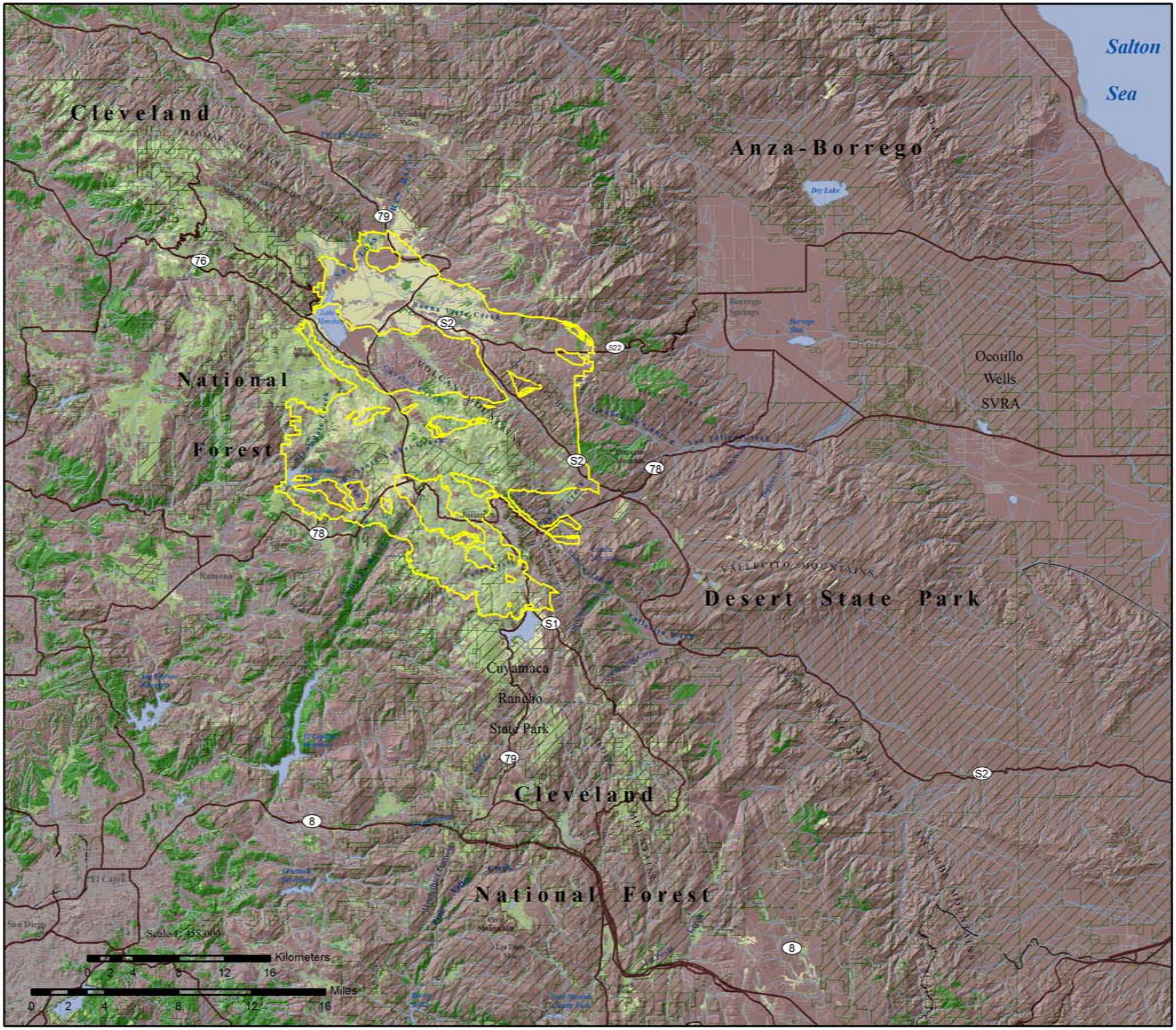
Alternatives to grazing, such as the use of prescribed fire, also need to be examined as a management tool. Several populations of Bay checkerspot butterflies in south San Jose declined following the cessation of cattle grazing, due to rapid invasion by introduced annual grasses that crowded out the larval host plants of the butterfly (Weiss 1999). Weiss (1999) concluded that, although poorly managed cattle grazing can significantly disrupt native ecosystems, moderate, well-managed grazing may be essential for maintaining native biodiversity in the face of invasive species.

Figure 31.
Habitat Suitability
for
Chalcedon checkerspot butterfly

(Euphydryas chalcedona)

Degree of Suitability

- High
- Medium to High
- Medium
- Low
- Least Cost Union
- Protected Lands
- Highways
- Railroad
- Stream/River
- Lakes, Ponds, Reservoirs



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***Sonoran blue butterfly* (*Philotes sonorensis*)**

Justification for Selection: Endemic to California, Sonoran blue butterflies have low dispersal ability and their limited habitat and host plants are becoming increasingly scarce in southern California. Protection of this linkage will allow movement between suitable habitats in rocky chaparral canyons. Populations of this species have already been reduced significantly in coastal areas because of development.

Distribution & Status: This species is distributed from Central California, south through the Coast Ranges, and the Sierra Nevada foothills to southern California, including the edges of the Mojave and Colorado deserts (Langston 1965, Davenport 1988). This species also occurs in northern Baja California where its range is also very limited (Shields 1973, Opler and Wright 1999). Sonoran blue butterflies can occur in a wide range of altitudes and have been found up to 1548 m (5080 ft) in elevation.

Populations of Sonora blue butterflies have apparently declined in numbers in the last 50 years, although additional documentation on population trends is needed. Although some well known populations have been destroyed, this species does not now seem presently imperiled overall (Natureserve 2005). The host plant must be blooming for females to lay eggs. This selective aspect of their reproductive biology, combined with their inflexibility to environmental changes, delicate bodies, and low genetic variation, cause Sonoran blue butterflies to be vulnerable to local extinction. Habitat fragmentation, habitat conversion, and the increase in warm season fires in areas dominated by exotic species are the biggest threats (Natureserve 2005)

Habitat Associations: This species occurs in mountain canyons and cliffs, flats, and washes, as well as chaparral, in close proximity to its larval plant hosts (Scott 1986, Opler and Wright 1999, Heath 2004). This species feeds on live-forever (*Dudleya* sp.) especially *D. lanceolata* and *D. cymosa*, and to a lesser extent *D. calcicola* and *D. saxosa*, but will also utilize the nectar of squaw spurge (*Chamaesyce melanadenia)* in the Anza Borrego Desert (Scott 1986). *D. lanceolata* is a relatively common native succulent found growing on dry, rocky, exposed slopes and banks below 1067 m (3500 ft) and occurs in both chaparral and coastal sage scrub (Boughey 1968).

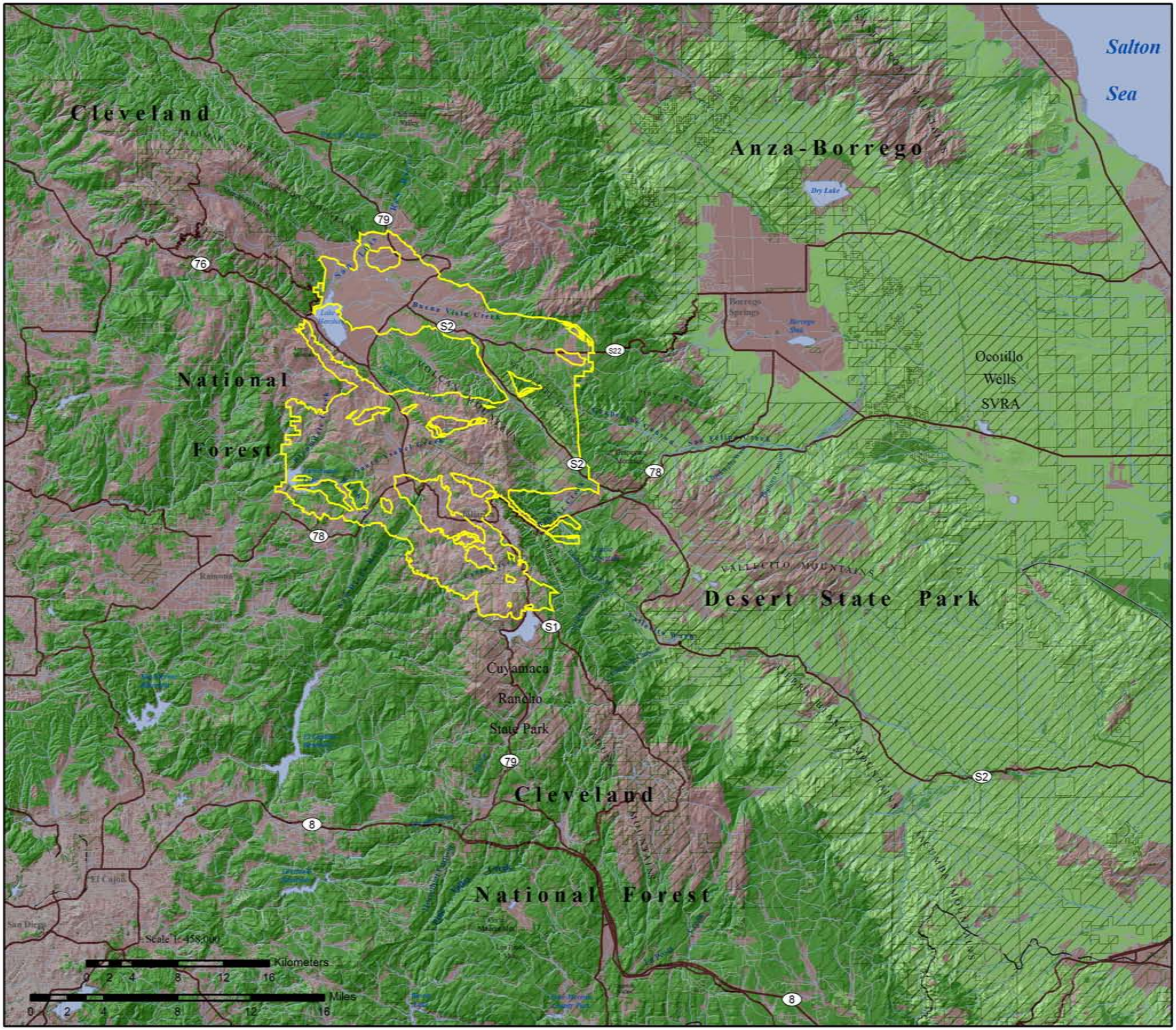
Spatial Patterns: Adults have one flight in spring, mainly from March to May (Opler and Wright 1999). This butterfly overwinters as pupae, which may be found in the debris near the base of the larval foodplant (Orsak 1978). Sonoran blue butterflies move up canyons (for example, from the desert floor to Garnet Peak). Keller et al.(1966) artificially displaced individuals of this species, and discovered that a significant proportion of displaced individuals returned to the site of first capture. These authors suggested that a butterfly may tend to remain in the vicinity of the site of emergence because it uses features of the landscape to orient itself.

Conceptual Basis for Model Development: Movement of this species in the linkage is multigenerational. Sonoran blue butterflies may be found below 1548 m (5080 ft) in elevation in desert scrub, coastal sage, and chaparral habitats where nectar sources occur. Research on home range and movement patterns are lacking, so we did not conduct patch size and configuration analyses for the Sonoran blue.

Results & Discussion: Potential habitat for the Sonoran blue butterflies is widespread in the planning area. Although little contiguous habitat was captured in the Least Cost Union, there is a north-south band of habitat that is captured in the eastern part of the linkage (Figure 32). Breaks in habitat, such as highways, suburbs, agriculture or disturbed habitat within canyons may act as barriers to connectivity. Conserving canyons with *Dudleya* sp. that range from lower to higher elevations is especially important.

Figure 32.
Habitat Suitability
for
Sonoron blue butterfly

(Philotes sonorensis)



High
Medium to High
Low
Least Cost Union
Protected Lands
Highways
Railroad
Stream/River
Lakes, Ponds, Reservoirs

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Velvet ant (***Dasymutilla coccinea***)

Justification for Selection: The velvet ant is an indicator species of dry riverbeds, washes, arroyos, and basins. It has low dispersal ability, and requires dry conditions and ground nesting bees as hosts.

Distribution & Status: This poorly studied insect is not really an ant as its name implies, but rather it is a densely haired wasp. There are approximately 100 species of velvet ants in California. They are thought to be widespread, but declining.

Habitat Associations: Characteristic habitats for velvet ants are dry river beds, washes, arroyos, and basins below mountains where water is seldom present. Vegetation may be riparian, coastal sage, or desert scrub, and is very sparsely vegetated. Velvet ants prefer open and arid areas with loose sandy soils. Although most frequent in deserts and coastal foothills, they may also be found on coastal dunes and bluffs (Hogue 1993). Annual grasses can adversely affect velvet ants.

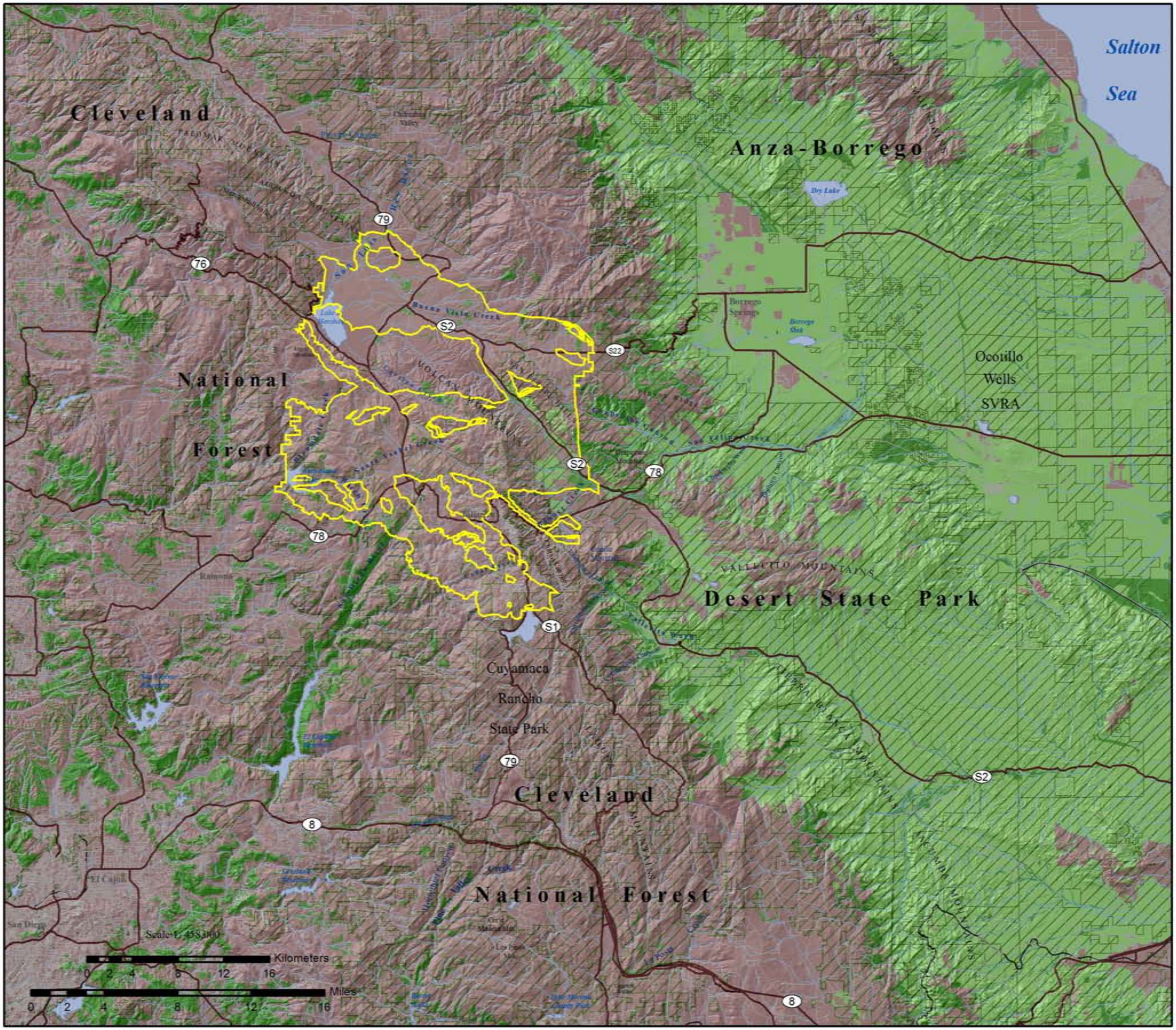
Spatial Patterns: Very little is known about these wasps. It has been suggested that they are parasitic on other ground-nesting wasps and bees, and that their patchy distribution is related to the distribution of ground-nesting bees (Hogue 1993). Males are winged while females are flightless.

Conceptual Basis for Model Development: Movement of this species in the linkage occurs over multiple generations. Coastal sage, desert scrub, desert riparian and washes are potential habitat for the velvet ant. Information on home range and movement patterns is lacking, so we did not conduct the patch size and configuration analyses for this species.

Results & Discussion: Potential habitat for velvet ants is widespread in Anza Borrego Desert State Park but limited to coastal sage and desert scrub habitats in both the Least Cost Union and the western portion of the study area (Figure 33). Very small patches of highly suitable habitat occur in the Least Cost Union but most of these are within existing protected areas. Habitat was added to the Least Cost Union on the western banks of the upper San Luis Rey River and to the southwest edges of Sutherland Lake to support the needs of velvet ants, and other focal species. However, whether the linkage will support intergenerational movements between coastal sage and desert scrub populations is inconclusive since nothing is known about the movement capabilities of this species. Severing corridors can affect populations of ground nesting bees, thus linkages are needed to maintain subpopulation connectivity and gene flow between populations of velvet ants.

Figure 33.
Habitat Suitability
for
Velvet ant

(Dasymutilla coccinea)



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White alder (*Alnus rhombifolia*)

Justification for Selection: White alder contributes to structural diversity in riparian woodlands, and is an important habitat requirement of many bird species that breed in riparian systems (Sands 1979, Gaines 1980, Gray and Greaves 1984, Uchytil 1989).

Distribution & Status: White alder is distributed from the Pacific coast of Baja California, north to southern British Columbia, reaching its eastern limits in Idaho (Johnson 1968, Uchytil 1989). In California, this species is found in the Coast, Transverse, and Peninsular Ranges (Holland 1986), from sea level to over 2438 m (8000 ft) elevation (Griffin and Critchfield 1972).

Riparian woodlands in California are being lost at a staggering rate due to urbanization, stream channelization, and flood control projects (Wheeler and Fancher 1984, Uchytil 1989). Many riparian communities, including those dominated by white alder, are designated as sensitive natural communities (Holland 1986, CDFG 2005).

Habitat Associations White alder is restricted to riparian woodland communities along perennial streams (Arno and Hammerly 1977, Conard et al. 1980, McBride and Strahan 1984, Holstein 1984, Shanfield 1984, Brothers 1985, Uchytil 1989), but may also extend along major streams into other habitats (Johnson 1968, Uchytil 1989). In these communities, it is associated with Fremont cottonwood (*Populus fremontii*), California sycamore (*Platanus racemosa*), willows (*Salix* spp.), ash (*Fraxinus* spp.), California live oak (*Quercus agrifolia*), valley oak (*Q. lobata*), and Douglas-fir (*Pseudotsuga menziesii*) Vogl 1976, Roberts et al. 1980, Roberts 1984, Barbour 1987, Uchytil 1989). White alder is often a dominant species in deciduous riparian forests (Roberts et al. 1980, Holstein 1984, Uchytil 1989).

Spatial Patterns: White alders are wind pollinated. Female catkins develop into woody cones, containing numerous seeds, the majority of which are viable (Schopmeyer 1974, Uchytil 1989). The seeds are transported by wind and water to suitable germination sites in moist areas (Brothers 1985, Uchytil 1989). Seeds are important for colonization of new sites but established alders also regenerate from root or trunk sprouting (Sampson and Jespersen 1963, Shanfield 1984, Uchytil 1989). Alder seeds are consumed by birds, which may also act as dispersal agents (USDA Forest Service 1937, Uchytil 1989).

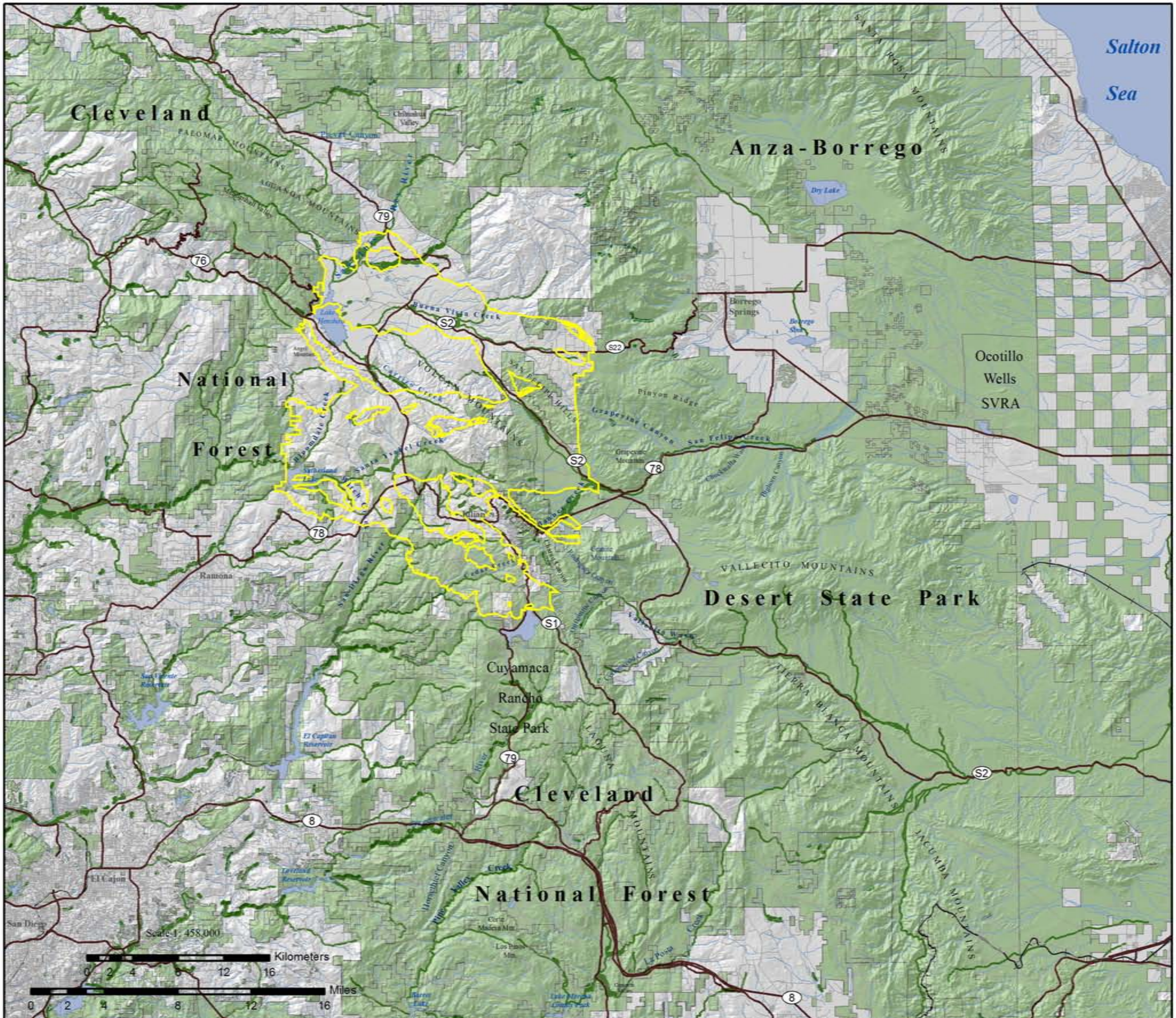
Conceptual Basis for Model Development: Riparian vegetation communities (i.e., white alder riparian forest, California sycamore, Fremont Cottonwood, mixed riparian woodlands) along perennial streams were queried in the GIS and then patches falling below 2438 m were delineated as potentially suitable habitat.

Results & Discussion: All three branches of the Least Cost Union contain potential habitat for white alder, with the northern and central branches providing the best connections between targeted protected areas (Figure 34). We conclude that the linkage is likely to accommodate this species, if additional habitat is added to the Least Cost Union along the upper San Luis Rey River.

Riparian communities are being lost at an alarming rate in the South Coast Ecoregion. To protect and restore habitat for this species, we recommend that riparian buffers at least 2 km wide are imposed throughout the linkage and natural flood dynamics are protected, maintained, and restored. We also suggest that receptive landowners work with US Fish and Wildlife Service Partners for Fish & Wildlife Program to acquire funds and technical assistance to restore and enhance riparian habitat on their land to benefit the many species dependent on riparian systems.

Figure 34.
Potential Habitat
for
White alder

(Alnus rhombifolia)



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

Goals of the Linkage Design

To accommodate the full range of target species and ecosystem functions, the Linkage Design (Figure 35) should 1) provide live-in and move-through habitat for multiple species, 2) support metapopulations of smaller species, 3) ensure availability of key resources, 4) buffer against edge effects, 5) reduce contaminants in streams, 6) allow natural processes to operate, and 7) allow species and natural communities to respond to climatic changes. We elaborate on these goals below.

The Linkage Design must be wide enough to provide live-in habitat for species with dispersal distances shorter than the linkage. Harrison (1992) proposed a minimum corridor width for a species living in a linkage as the width of one individual's territory (assuming territory width is half its length). Thus, our minimum corridor width of 2 km (1.2 mi) should accommodate species with home ranges of up to about 8 km^2 (3 mi^2). This would accommodate all focal species except the largest, such as mountain lions.

The Linkage Design must support metapopulations of less vagile species. Many small animals, such as granite night lizard and many invertebrates may require dozens of generations to move between core areas. These species need a linkage wide enough to support a constellation of populations, with movements among populations occurring over decades. We believe 2 km is adequate to accommodate most target species living as metapopulations within the linkage area.

The Linkage Design was planned to provide resources for all target species, such as host plants for butterflies and pollinators for plants. For example, many species commonly found in riparian areas depend on upland habitats during some portion of their life cycle, such as butterflies that use larval host plants in upland areas and drink from water sources as adults.

The Linkage was also designed to buffer against "edge effects" even if adjacent land becomes developed. Edge effects are adverse ecological changes that enter open space from nearby developed areas, such as weed invasion, artificial night lighting, predation by house pets, increases in opportunistic species like raccoons, elevated soil moisture from irrigation, pesticides and pollutants, noise, trampling, and domesticated animals that attract native predators. Edge effects have been best-studied at the edge between forests and adjacent agricultural landscapes, where negative effects have been documented to extend 300 m (980 ft) or more into the forest (Murcia 1995, 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 plant and animals communities due to the invasion of argentine ants up to 200 m (650 ft) from irrigated areas (Suarez et al. 1998), and predation by house cats which reduce small vertebrate populations 100 m (300 ft) from the edge (K. Crooks, unpublished data). Domestic cats may affect wildlife up to 300 m (980 ft) from the edge based on home range sizes reported by Hall et al. (2000).

Upland buffers are needed adjacent to riparian vegetation or other wetlands to prevent aquatic habitat degradation. Contaminants, sediments, and nutrients can reach streams from distances greater than 1 km (0.6 mi; Maret and MacCoy 2002, Scott 2002, Naicker et al. 2001), 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, Wilson and Dorcas 2003).

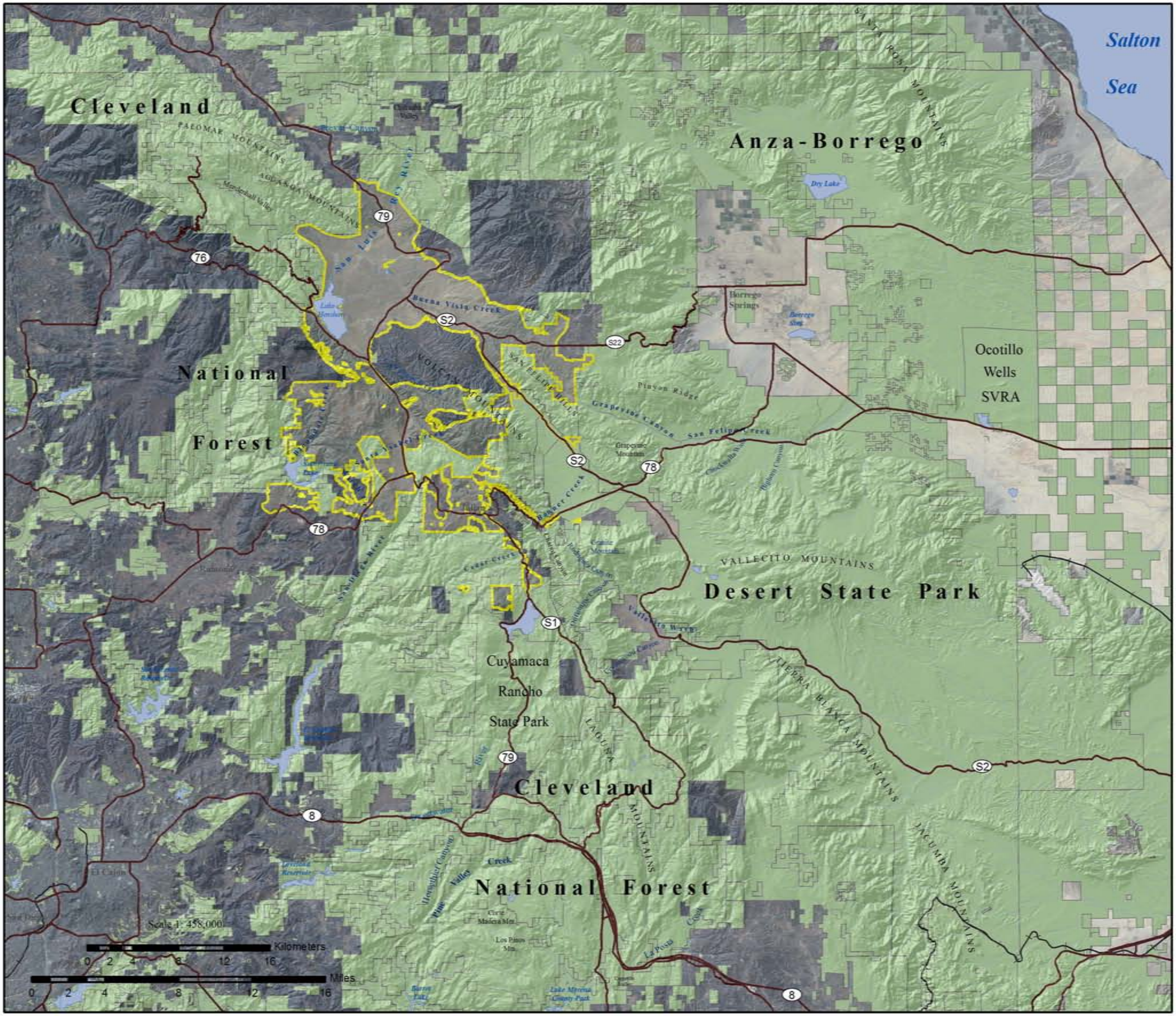
The Linkage Design must also allow natural processes of disturbance and recruitment to operate with minimal constraints from adjacent urban areas. The Linkage should be wide enough that temporary habitat impacts due to fires, floods, and other natural processes do not affect the entire linkage simultaneously. Wider linkages with broader natural communities may be more robust to changes in disturbance frequencies by human actions. Before human occupation, naturally occurring fires (due to lightning strikes) were rare in southern California (Radtke 1983). As human populations in the region soared, fire frequency has also increased dramatically (Keeley and Fotheringham 2003). Although fire can reduce the occurrence of exotic species in native grasslands (Teresa and Pace 1998), it can have the opposite effect in some shrubland habitats (Giessow and Zedler 1996), encouraging the invasion of non-native plants, especially when fires are too frequent. While effects of altered fire regimes in this region are somewhat unpredictable, wider linkages with broader natural communities should be more robust to these disturbances than narrow linkages.

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

Description of the Linkage Design

The Linkage Design has three major swaths or branches of habitat to accommodate diverse species and ecosystem functions (Figure 35). The most northerly branch extends from the Palomar and Aguanga mountains of Cleveland National Forest, encompassing the perennial grassland and wet meadow habitats surrounding Lake Henshaw in the Warner Basin, the riparian habitats along the San Luis Rey River, San Ysidro, Buena Vista, and Matagual Creeks and the mixed chaparral and oak woodland habitats in the San Felipe Hills near Pinyon Ridge in Anza-Borrego Desert State Park (Figure 36). This branch of the linkage was delineated by the landscape permeability analysis for badger but also provides the largest core areas of suitable habitat for grasshopper sparrow and black-tailed jackrabbit in the planning area. This branch will

Figure 35.
Linkage Design



- Linkage Design
- Protected Lands
- Highways
- Railroad
- Stream/River
- Lakes, Ponds, Reservoirs

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also serve the needs of other species that depend on grassland and meadow habitats, such as mule deer, and golden eagle. Focal species that use riparian corridors as traveling routes, such as mountain lion, will also benefit from maintaining connectivity here, as will many other species that live or breed in riparian habitats. For instance, the San Luis Rey River is dominated by a spectacular gallery forest of coast live oak with pockets of cottonwood, willow, and white alder, providing prime breeding habitat for a number of special status species, including the least Bell's vireo (*Vireo bellii pusillus*), southwestern willow flycatcher (*Empidonax traillii extimus*) and arroyo toad (*Bufo californicus;* Stephenson and Calcarone 1999).

Figure 36. The most northerly branch of the Linkage Design is dominated by grassland and meadow habitats around Lake Henshaw, with riparian habitats along the San Luis Rey River, San Ysidro, Buena Vista, and Matagual creeks.

The central branch of the Linkage Design extends from Black Mountain in Cleveland National Forest near Sutherland Lake, and encompasses riparian and upland habitats along Bloomdale Creek, Witch Creek, Santa Ysabel Creek, Santa Ysabel Valley, the southern extent of the Volcan Mountains, Banner Canyon, and San Felipe Creek, entering Anza-Borrego Desert State Park between Pinyon Ridge and Grapevine Mountain (Figure 37). This branch of the linkage was delineated by the landscape permeability analysis for mountain lion but is also intended to serve mule deer, badger, black-tailed jackrabbit, golden eagle, granite night lizard, and chalcedon checkerspot butterfly. It takes in a diversity of habitats including coast live oak forest, woodland and savannas, evergreen and deciduous riparian forests, montane hardwood coniferous forests, with some chaparral and grassland habitats interspersed. Santa Ysabel Creek is especially important for species requiring a contiguous riparian connection, such as white alder, or other species like California treefrog (*Pseudacris cadaverina*) and arroyo toad that were not specifically addressed by our analyses. This branch of the linkage is 4 to 8 km (2.49 to 4.97 mi) wide.

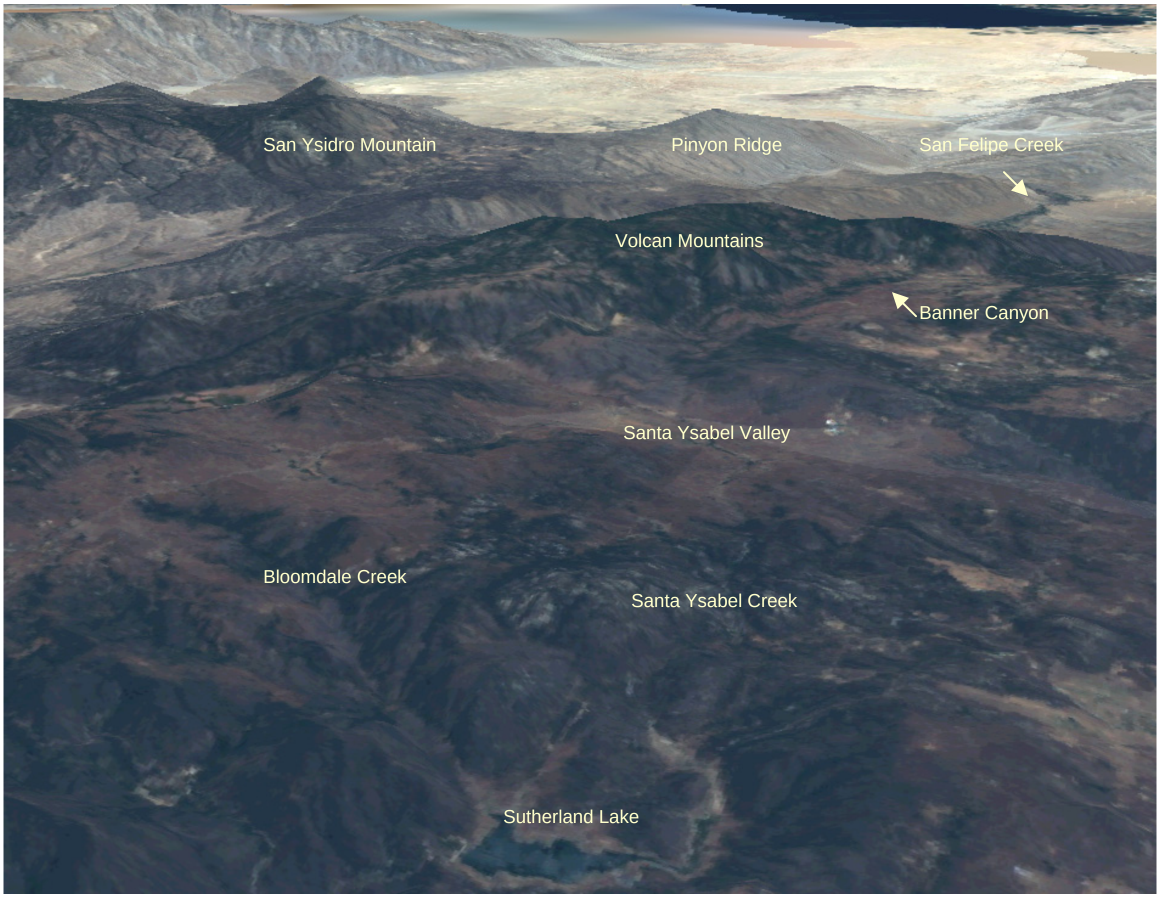


Figure 37. The central branch of the linkage was delineated by the landscape permeability analysis for mountain lion, a species that prefers traveling along riparian corridors and ridges. The model identified Santa Ysabel Creek, which flows from the Volcan Mountains to Sutherland Lake, as the most permeable route for mountain lions.

The southern branch of the linkage extends from Sutherland Lake and follows the belt of oak savanna, and grassland habitats in the Ballena Valley and the riparian habitats of Witch Creek to the upper San Diego River Gorge, and then up Sentenac Creek to the montane hardwood, and hardwood conifer habitats along Cedar Creek to habitats around Lake Cuyamaca in Cuyamaca Rancho State Park and the desert riparian habitats of Vallecito Wash in Anza-Borrego Desert State Park (Figure 38). This branch of the linkage was defined by the landscape permeability analysis for mule deer. It includes both riparian and upland habitats providing live-in and move-through habitat for diverse species, including black-tailed jackrabbit, grasshopper sparrow, granite night lizard, and the Sonoran blue butterfly. In addition to providing habitat and facilitating movements for several focal species, this branch of the Linkage Design supports habitat for several listed species, including California spotted owl (*Strix occidentalis occidentalis*), the large-blotched salamander (*Ensatina eschscholtzii* klauberi), and the arroyo toad (Stephenson and Calcarone 1999, CDFG 2005). Protecting habitat in the headwaters of the San Diego River will also help maintain water quality downstream. This branch of the linkage ranges in width from 2 to 4 km (1.24 to 2.48 mi).

Figure 38. The southern branch of the linkage was delineated by the landscape permeability analysis for mule deer, and encompasses habitats between Sutherland Lake and the San Diego River Gorge, Sentenac Creek and upper Cedar Creek to reach Lake Cuyamaca in Cuyamaca Rancho State Park and Vallecito Valley in Anza Borrego Desert State Park.

The Linkage Design encompasses a diversity of natural communities, including 20 different major vegetation types (Table 3). Although natural vegetation comprises most of the Linkage Design, rural development covers roughly 1% of its area, and agricultural lands cover 3%. The dominant habitat types in the linkage include montane hardwood conifer, coast live oak woodland, mixed chaparral, chamise-redshank chaparral, perennial grassland, and annual grassland. Mixed chaparral is the most common vegetation community in the central and southern branches of the linkage, covering the steep rugged slopes and extending into the desert and coastal foothills at mid-elevations. Grassland habitats are the dominant communities in the northern branch.

A diversity of wetland habitats occur throughout the linkage and core areas, including riparian forests, woodlands, and scrubs, palm oases, alluvial fans, desert washes, springs, and seeps. Santa Ysabel Creek provides the most direct connection between targeted areas for riparian species. Other significant riparian habitat in the Linkage Design occurs along the San Luis Rey River, San Ysidro Creek, Buena Vista Creek, Matagual Creek, Grapevine Creek, San Felipe Creek, Witch Creek, Cedar Creek, and Banner Creek. In this xeric region, riparian and wash habitats support a disproportionately large number of species and are key movement zones for numerous native species.

Table 3. Approximate Vegetation and Land Cover in the Linkage Design

Vegetation Type	Total Area Linkage Design		Area Protected Linkage Design		% protected	% of Total Area
	Acres	***Hectares***	***Acres***	***Hectares***		
Agriculture	3,923.90	1,587.95	440.60	178.31	11%	3%
Annual Grassland	10,892.72	4,408.13	3,345.01	1,353.68	31%	9%
Barren	421.84	170.71	71.46	28.92	17%	0%
Chamise-Redshank Chaparral	15,927.84	6,445.77	7,085.78	2,867.51	44%	12%
Coastal Oak Woodland	14,690.11	5,944.88	4,121.56	1,667.93	28%	11%
Coastal Scrub	5,539.73	2,241.85	1,869.15	756.42	34%	4%
Desert Riparian	22.68	9.18	21.87	8.85	96%	0%
Desert Scrub	3,210.95	1,299.43	2,961.03	1,198.29	92%	3%
Desert Wash	1,187.15	480.42	1,016.59	411.40	86%	1%
Freshwater Emergent Wetland	0.67	0.27	-	-	0%	0%
Juniper	499.42	202.11	443.57	179.51	89%	0%
Mixed Chaparral	21,988.52	8,898.44	11,664.33	4,720.39	53%	17%
Montane Chaparral	63.72	25.79	34.30	13.88	54%	0%
Montane Hardwood	9,164.19	3,708.62	3,758.92	1,521.18	41%	7%
Montane Hardwood-Conifer	13,127.50	5,312.51	7,105.12	2,875.34	54%	10%
Perennial Grassland	20,166.29	8,161.01	566.78	229.37	3%	16%
Sagebrush	661.32	267.63	132.31	53.54	20%	1%
Sierran Mixed Conifer	12.01	4.86	11.24	4.55	94%	0%
Urban	1,135.16	459.38	168.02	68.00	15%	1%
Valley Foothill Riparian	1,260.77	510.22	351.28	142.16	28%	1%
Water	685.58	277.45	352.24	142.55	51%	1%
Wet Meadow	3,205.77	1,297.33	-	-	0%	3%
Total	127,787.84	51,713.90	45,521.17	18,421.76	36%	100%

The central and southern branches of the Linkage Design include substantial public ownerships that protect natural habitats from development, while virtually no conservation lands occur in the northern branch. The final Linkage Design encompasses 51,714 ha (127,788 ac), of which approximately 36% (18,422 ha or 45,521 ac) currently enjoys some level of conservation protection, mostly in land owned by the US Forest Service, California State Parks, Bureau of Land Management, Department of Fish and Game, County of San Diego, The Nature Conservancy, and Volcan Mountain Preserve Foundation. Portions of the Santa Ysabel and Mesa Grande reservations also occur in the linkage.

Removing and Mitigating Barriers to Movement

Four types of features impede species movements through the Linkage: roads, impediments to stream flow, residential development, and recreational activities. This section describes these impediments and suggests where and how their effects may be minimized 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, such as State Route 79. 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 (Noss 1983, Harris 1984, Wilcox and Murphy 1985, Wilcove et al. 1986, Noss 1987, Reijnen et al. 1997, Trombulak and Frissell 2000, Forman and Deblinger 2000, Jones et al. 2000, Forman et al. 2003). Roads kill animals in vehicle collisions, create discontinuities in natural vegetation (the road itself and induced urbanization), alter animal behavior (due to noise, artificial light, human activity), promote invasion of exotic species, and pollute the environment (Lyon 1983, Noss and Cooperrider 1994, Forman and Alexander 1998). Roads also fragment populations by acting as semi-permeable to impermeable barriers for non-flying animals (e.g., insects, fish, amphibians, reptiles, and mammals) and even some flying species (e.g., butterflies and low-flying birds). Roads may even present barriers for large mammals such as bighorn sheep (Rubin et al. 1998). For example Ernest et al. (2003) has documented little flow of mountain lion genes between the Santa Ana and Palomar ranges (where I-15 is the most obvious barrier), and between the Sierra Madre and Sierra Nevada (where I-5, and urbanization along SR-58, are the most obvious barriers). The resulting demographic and genetic isolation increases extinction risks for populations, and fragmentation results in smaller populations, which are more susceptible to extinction due to demographic and environmental stochasticity (Gilpin and Soulé 1986). The impact of a road on animal movement varies with species, context (vegetation and topography near the road), and road type and level of traffic (Clevenger et al. 2001). For example, a road on a stream terrace can cause significant population declines in amphibians that move between uplands and breeding ponds (Stephenson and Calcarone 1999), but a similar road on a ridgeline may have negligible impacts on these species. Most documented impacts on animal movement concern paved roads. Dirt roads may actually facilitate movement of some species, such as mountain lions (Dickson et al. 2004), while adversely impacting other species, such as snakes that sun on them and may be crushed even by infrequent traffic.

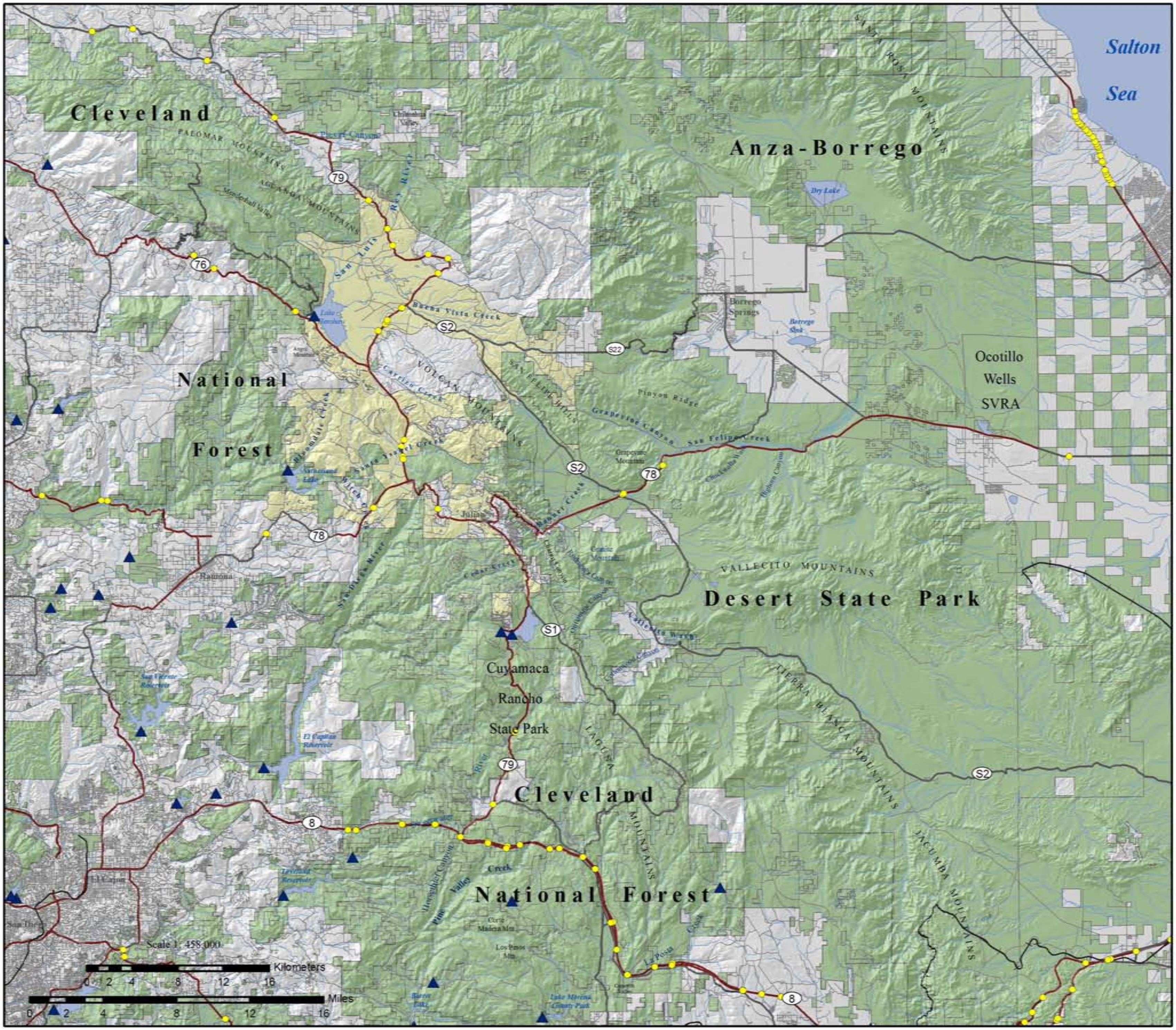
Roads in the Linkage Design: There are currently 112 km (70 mi) of paved roads and 343 km (213 mi) of dirt roads in the Linkage Design (Table 4). State Routes 78 and 79 are the major transportation routes and pose the most substantial barriers to movement (Figure 39). SR-79 bisects the linkage for a distance of roughly 44 km (27 mi), while SR-78 passes through the central and southern branches of the linkage. County road S2 runs along San Felipe Creek at the base of the San Felipe Hills, connecting SR-78 and SR-79, while County road S22 passes through the northern branch of the linkage, and stretches from the community of Borrego Springs to the northwestern base of the San Felipe Hills. A survey of these roads found a variety of existing structures (i.e., bridges, pipes, and culverts) that might be useful for implementing road mitigation projects (Figure 39).

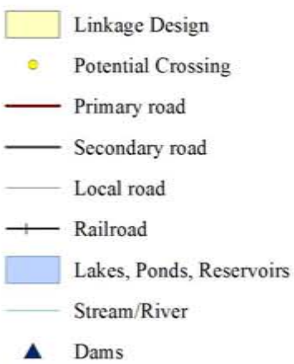
Table 4. Major transportation routes in the Linkage Design.

Road Name	**Length (km)**	**Length (mi)**
State Route 79	44.07	27.39
State Route 78	13.70	8.52
S2 (San Felipe)	25.88	16.08
S22 (Montezuma Valley)	8.64	5.37
Other Paved Roads	19.96	12.40
Total Length of Paved Roads	**112.26**	**69.76**

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

Figure 39. Existing Infrastructure in the Planning Area





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There is a total of about 50 vegetated wildlife overpasses (Figure 40) in Europe, Canada, and the U.S. (Evink 2002, Forman et al. 2003). They range from 50 m (164 ft) to more than 200 m (656 ft) in width (Forman et al. 2003). Soil depths on overpasses range from 0.5 to 2 m (1.6-6.6 ft), allowing growth of herbaceous, shrub, and tree cover (Jackson and Griffin 2000). Wildlife overpasses can maintain ambient conditions of rainfall, temperature, light, vegetation, and cover, and are quieter than underpasses (Jackson and Griffin 2000). In Banff National Park, Canada, large mammals preferred overpasses to other crossing structures (Forman et al. 2003). Similarly, woodland birds used overpasses significantly more than they did open areas without an overpass. Other research indicates overpasses may encourage birds and butterflies to cross roads (Forman et al. 2003). Overpass value can be increased for small, ground-dwelling animals by supplementing vegetative cover with branches, logs, and other cover (Forman et al. 2003).

Figure 40. An example of a vegetated land bridge built to enhance movement of wildlife populations.

Bridges over waterways are also effective crossing structures, especially if wide enough to permit growth of both riparian and upland vegetation along both stream banks (Jackson and Griffin 2000, Evink 2002, Forman et al. 2003). Bridges with greater openness ratios are generally more successful than low bridges and culverts (Veenbaas and Brandjes 1999, Jackson and Griffin 2000). The best bridges, termed *viaducts* (Figure 41), 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).

Figure 41. A viaduct in Slovenia built to accommodate wildlife, hydrology, and human connectivity.

Although inferior to bridges, culverts can be effective crossing structures for some species (Jackson and Griffin 2000). Only very large culverts are effective for carnivores and other large mammals (Figure 42). Gloyne and Clevenger (2001) suggest that underpasses for ungulates should be at least 4.27 m (14 ft) high and 8 m (26 ft) wide, with an openness ratio of 0.9 (where the openness ratio = height x width/length). Earthen flooring is preferable to concrete or metal (Evink 2002).

Figure 42. Arched culvert on German highway, with rail for amphibians and fence for larger animals.

For rodents, pipe culverts (Figure 43), about 1 ft in diameter without standing water are superior to large, hard-bottomed culverts, apparently because the overhead cover makes them feel secure against predators (Clevenger et al. 2001, Forman et al. 2003). In places where a bridged, vegetated undercrossing or overcrossing 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 have been designed to accommodate amphibians (Figure 44). 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 better than wire mesh, which must be buried and regularly maintained.

Figure 43. Pipe culvert designed to accommodate small mammals.

Figure 44. Amphibian tunnels allow light and moisture into the structure.

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

Recommended Crossing Structures on State Route 79: State Route 79 (SR-79) is a 2-lane heavily traveled highway that bisects the linkage for a distance of 44 km (27 mi). SR-79 is likely the most substantial impediment to movement within the Linkage Design. Several crossing structures adequate to accommodate wildlife movement currently exist, while others need to be improved or built. We recommend maintaining these structures, protecting adjacent land from development, and ensuring that future road projects do not degrade these crossing structures but instead improve habitat connectivity.

The San Luis Rey River is an excellent riparian connection dominated by coast live oak riparian forest, with scattered patches of cottonwood, white alder and willow. The River passes under SR-79 through a bridged structure (Figure 45), and animals that follow rivers could then enter the Aguanga and Palomar Mountains. Suitable habitat occurs for a number of focal species in this area, including mountain lion, badger, mule deer, black-tailed jackrabbit, black brant, and Sonoran blue butterfly. Numerous other native species will also benefit from maintaining habitat connectivity here. The bridge measures roughly 4.6 m (15 ft) high, 80 m (262 ft) wide, and 10 m (33 ft) long. While the bridge spanning the San Luis Rey was built to accommodate high water flows in the river, it also facilitates wildlife movement.

Figure 45. Bridge on SR-79 conveying flow of the San Luis Rey River.

A fairly well-designed bridge that allows wildlife movement is found where Canada Verde Creek flows under SR-79 (Figure 46) near the Warner Springs Forest Service Station. Coast live oak riparian forest lines the creek with grassland habitats in the uplands south of the SR-79 and redshank chaparral the dominant upland plant community north of the highway. This bridge measures

Figure 46. Bridge for Canada Verde Creek and the Pacific Crest Trail under SR-79.

roughly 1.8 m (6 ft) high, 10 m (32 ft) wide, and about 7 m (23 ft) long. This bridge is well-suited as a wildlife crossing, as the stream draws animals into the canyon. The National Pacific Crest Scenic Trail also utilizes this passageway, as it passes through unprotected land in the northern branch of the linkage, between Anza-Borrego Desert State Park and BLM land in the San Felipe Hills to USFS lands north of SR-79.

Figure 47. The Buena Vista Creek Bridge on SR-79.

The bridge over Buena Vista Creek on SR-79 is roughly 1.8 m high, 19 m (62 ft) wide, and 7 m long (Figure 47). This branch of the linkage was delineated by badger, but other focal species that use grassland habitats will also benefit from improved connectivity here. Land on both sides of the structure is fenced with barbed-wire, likely to restrict cattle passage, but also impeding movements of many species through the structure. This fencing should be modified to allow wildlife movement. The riparian vegetation is degraded near the structure with a few scattered willows and mule fat in the vicinity. We recommend that habitat restoration efforts be initiated to restore riparian vegetation along the drainage, and that cattle be prevented from grazing in riparian areas. If transportation projects are undertaken along this stretch of highway, the bridge should be enlarged to at least 8 m (24 ft) wide and as close to 4 m (12 ft) high as topography will allow. Land in this area should be targeted for conservation easement, purchase, or other action to maintain its wild character.

Figure 48. Concrete box culvert under SR-79 that connects land administered by the Vista Irrigation District.

Approximately 2 km (1.24 mi) south of Buena Vista Creek there are two concrete box culverts that are spaced roughly a few hundred meters apart. The one pictured here (Figure 48), measures roughly 2 X 2 m (6 X 6 ft), and the other 1 X 1 m (3 X 3 ft; not shown). Both structures have concrete flooring, and each has about a 1 m drop off at the west entrance. Land on both sides of the highway is administered by the Vista Irrigation District. Oak savanna habitats occur to the east of the highway while grassland habitats occur to the west of SR-79. There are also several rocky outcrops on both sides of the highway in the vicinity of these structures, providing potential habitat for the granite night lizard. While some species may currently utilize these structures, they are far from ideal for the smaller less mobile species, due to the steep drop at the western entrances. We strongly recommend fixing the pitch at the western entrances of both culverts, and removing the concrete flooring to provide small mammals, amphibians, reptiles, and flightless insects passage.

Figure 49. Low concrete bridge over Matagual Creek on SR-79.

Matagual Creek passes under SR-79 through a low bridge with natural flooring (Figure 49). The bridge measures roughly 1 m high, 21 m (69 ft) wide, and 7 m long (Figure 49). While the bridge probably accommodates some level of animal movement for smaller species, lands on both sides of the crossing structure are grazed and somewhat degraded. There is not much vegetation in the creek beyond several scattered willows, and uplands are comprised of grassland habitats. This structure was built in 1946. When transportation improvement projects do occur along this stretch of the highway, we recommend replacing this low bridge with an arched bridge that is tall enough and sufficiently wide to provide unobstructed views to the other side. We recommend initiating a riparian restoration project to improve habitat conditions and maintaining the rural character of the landscape in this area.

Figure 50. Unnamed drainage passing under SR-79, just north of Santa Ysabel Creek. Existing structure is in need of enhancements.

In the central branch of the linkage, just north of Santa Ysabel Creek, there is an unnamed drainage that crosses under SR-79 through a small concrete box culvert (Figure 50). The structure was inaccessible and barely discernible due to dense vegetation at each entrance. It is estimated to be about 0.61 m (2 ft) high, 1 m wide, and 7 m long. There is no visibility to the other side. The culvert was built in 1941 and is badly in need of replacement and maintenance. This well-developed riparian zone provides habitat for a number of aquatic and semi aquatic species. We suggest replacing the existing culvert with either a small arched bridge (preferable) or a larger box culvert at least 2 X 2 m, with natural substrate flooring.

The least cost corridor analysis for mountain lion crossed SR-79 using Santa Ysabel Creek, and researchers with the Southern California Puma Project and U.S. Geological Survey have documented puma using Santa Ysabel Creek as a traveling route (Sweanor et al. 2003). There is a well-designed bridge for Santa Ysabel Creek that has natural substrate flooring, provides a clear view to the other side, and measures roughly 10 m high, 12 m (39 ft) wide, and 7 m long (Figure 51). Many species that utilize riparian, grassland, or oak savanna habitats (e.g., badger, mule deer, black-tailed jackrabbit, golden eagle, grasshopper sparrow, and white alder) will benefit from maintaining connectivity here. The riparian and upland habitats along Santa Ysabel Creek provide the most direct riparian connection between targeted protected areas, and most of the canyon is already protected.

Figure 51. Well-designed bridge for Santa Ysabel Creek flowing under SR-79. The creek, though not conveyed in this picture, is dominated by sycamores and willows in the vicinity of the structure.

Recommended Crossing Structures on State Route 78: State Route (SR-78) runs east-west through the central and southern branches of the linkage, from south of Sutherland Lake, through Banner Canyon to its juncture with County road S2. SR-78 then continues through Anza-Borrego Desert State Park, providing access to the community of Borrego Springs and the Ocotillo Wells State Vehicular Recreation Area. This 2-lane scenic road is mostly at grade, with very few existing crossing structures. For much of its length east of the community of Julian, SR-78 runs along the southern slope of Banner Canyon (Figure 52), dropping into the canyon where the road turns to run along the base of Granite Mountain. Valley foothill and coast live oak riparian habitats occur along the drainage, with mixed and redshank chaparral in the uplands that shift to sagebrush and juniper woodlands near the SR-78 and S2 junction.

Figure 52. Looking southeast down Banner Canyon with Granite Mountain in Anza Borrego Desert State Park in the distance.

Where SR-78 runs along the bottom of Banner Canyon, there is a pipe culvert that measures 1.5 m (5 ft) in diameter. This structure is expected to facilitate movements of smaller species, such as the granite night lizard, and other native species not specifically dealt with in our analyses, such as bobcat (*Felis rufus*), striped skunk (*Mephitis mephitis*), raccoon (*Procyon lotor*), and western toad (*Bufo boreas*), but larger mammals cross the road at grade. There are a few private residences, a trailer park, and a few orchards in the vicinity of this structure but natural habitats are largely maintained and this area remains fairly permeable to animal movement. However, there is an infestation of the exotic tree of heaven (*Ailanthus altissima*), which is a prolific seed producer; grows rapidly into monotypic stands; and produces toxins that crowd out native plant species (Whitson et al. 2000). We strongly recommend initiating a restoration project to eradicate the tree of heaven in Banner Canyon. We also suggest replacing the existing pipe culvert with an

Figure 53. Pipe culvert on SR-78 in Banner Canyon.

arched concrete culvert with natural flooring concurrent with the next transportation improvement project in this stretch of highway to better facilitate wildlife movement. We also advise conservation measures be implemented to maintain the rural character in this area and attention to wildlife connectivity during any upgrading of SR-78.

San Felipe Creek runs along S2 at the base of the San Felipe Hills, crosses under SR-78, and then heads east into Anza-Borrego Desert State Park, alongside SR-78. San Felipe Creek runs beneath a multi-chambered bridge on SR-78 near its juncture with S2 (Figure 54). The bridge is roughly 10 m high, 100 m (328 ft) wide and 10 m long. Riparian vegetation in the vicinity of the bridge is somewhat degraded, but the rest of the creek boasts a spectacular gallery forest of cottonwood and willows. The San Felipe Creek area is designated as a National Natural Landmark in Imperial County, as it is one of the last remaining natural perennial desert streams. The San Felipe Valley supports an incredible diversity of species. Many of our focal species have been detected in the area, including mountain lion, badger, mule deer, black-tailed jackrabbit, granite night lizard, golden eagle, and black brant. San Felipe Creek is also recognized as the most important inland flyway in San Diego County, providing habitat for several migratory birds, including many that are threatened or endangered, such as the least Bell's vireo and southwestern willow flycatcher. The wide variety of habitat types available in the San Felipe Valley also provide live-in and move-through habitat for several other native species not addressed by our analyses, such as bobcat, gray fox (*Urocyon cinereoargenteus*), and California kingsnake (*Lampropeltis getula*) (http://www.dfg.ca.gov/lands/wa/region5/sanfelipe/sanfelipe-species.html). Most of the habitat in the San Felipe Hills and Valley is already protected from habitat conversion.

Figure 54. San Felipe Creek flows beneath SR-78 through a well-designed multi-chambered bridge that provides passage for numerous native species.

Recommended Crossing Structures on S2 and S22: As mentioned previously, S2 runs along San Felipe Creek at the base of the San Felipe Hills (Figure 55), connecting

SR-78 and Sr-79. Mule deer, mountain lions, and badgers have all been documented to be hit by vehicles on this road. S22 passes through the northern branch of the linkage, and stretches from the community of Borrego Springs, through Anza-Borrego Desert State Park (Figure 56) to the northwestern base of the San Felipe Hills. Both of these scenic highways are currently one lane in each direction and almost entirely at grade. A few small metal pipe culverts were incorporated into the original road design. Any road improvements should incorporate more regularly spaced pipe culverts and arched concrete culverts into the road design to increase movement opportunities for less mobile species, such as the barefoot gecko and the granite night lizard.

Figure 55. S2 is almost entirely at grade; looking south at San Felipe Creek with Granite Mountain in the distance.

Figure 56. S22 is also almost completely at grade from its juncture with S2 through Anza Borrego Desert State Park to the community of Borrego Springs.

Other Recommendations Regarding Paved Roads within the Linkage Design: Reducing the speed limit through the linkage area is the simplest and most cost effective way to reduce wildlife/vehicle collisions (Bertwistle 1999). We suggest reducing the speed limit on SR-79, SR-78, and S2 to 45 mph or less through the linkage area. We also recommend installing wildlife crossing signs to alert drivers they are entering a wildlife movement corridor. Laser and infrared activated warning signs with flashing lights have been used to alert drivers to slow down for wildlife (Reed 1981, Messmer 2000, Gordon 2001, Robinson et al. 2002, Huijser and McGowen 2003). The system's flashing lights are activated when wildlife step over the sensing device on the approach to the monitored roadway (Gordon 2001). These two actions alone could significantly reduce wildlife mortality in the linkage area but other measures can be taken to improve wildlife movement when the next highway improvement projects are undertaken.

The precise timing and location for constructing new or improved crossing structures may not be critical, and can consider cost, feasibility, and other factors. For cost efficiency, crossing improvements need not be made immediately, but can be incorporated into future road upgrade projects. Open bridges, supplemented by culverts for smaller species should be sited along natural travel routes. Existing crossing structures should be used as indicators of the approximate location of crossings, not fixed elements of a Linkage Design. Other recommendations to improve habitat connectivity across transportation barriers include:

- Transportation agencies should use each road improvement project as an opportunity to replace culverts with bridges (expansive enough to allow vegetation to grow). In locations where a bridge is not feasible and only a culvert can be provided, install a culvert (designed to remain free of water) parallel to the box culvert to provide for passage of small mammals, amphibians, and reptiles.

- Where appropriate, use short retaining walls or fine mesh fencing to guide amphibians and reptiles to crossing structures.

- Encourage native vegetation leading up to both sides of crossing structures to provide cover for wildlife and to direct their movement toward the structure. Work with the USFS, California Native Plant Society, local Resource Conservation District, or other non-profit organizations to restore riparian communities and vegetative cover at passageways.

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

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 Mojave 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 64 km (38 mi) of Interstate 75. The structures are readily used by endangered Florida panthers and bears, and have reduced panther and bear roadkill to zero on that route (Lotz et al. 1996). Almost all of these structures were retrofitted to existing highways rather than part of the original road design. This demonstrates that barrier or filter effects of existing roads are at least partially reversible with well-designed improvements.

Representatives from CalTrans have attended Missing Linkages workshops, and the agency is incorporating wildlife crossing improvements into its projects with a focus on 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. Since then, habitat restoration efforts have been initiated in Coal Canyon and wildlife movement continues to be monitored.

Implementing these recommendations will take cooperation among land managers, planners, land conservancies and other non-profits, and transportation agencies. We urge them to work together to develop a long-term coordinated plan to ensure that wildlife-crossing structures are aligned in a way that maximizes their utility to animals. An overall plan will ensure that, for instance, a planned crossing structure on SR-79 adjoins protected lands or land targeted for conservation.

Impediments to Streams

Organisms moving through rugged landscapes often use riparian areas as travel routes. For example, many butterflies and frogs preferentially move along stream corridors (Orsack 1978, Kay 1989, USGS 2002). Although southwestern pond turtles are capable of overland movements of up to 0.5 km (0.3 mi) they preferentially move along stream courses (Holland 1991). Even large, mobile vertebrates, such as mountain lions, have shown preferences for moving along riparian corridors (Beier 1995, Sweanor et al. 2003, Dickson et al. 2004).

For plants and animals associated with streams or riparian areas, impediments are presented by water diversions and extractions, road crossings, exotic species, water recharge basins, farming in streambeds, gravel mining, and concrete structures that stabilize stream banks and streambeds. Increased runoff can also 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 species associated with riparian systems, with the Santa Ysabel Creek providing the most direct riparian connection between targeted protected areas. The San Luis Rey and San Diego rivers, and San Ysidro, Buena Vista, Grapevine, San Felipe, Carrizo, Bloomdale, Witch, Banner, Sentenac, and Cedar creeks are other key movement areas for both riparian and terrestrial organisms. In times of high surface flows, these tributaries may provide avenues along which aquatic and semi-aquatic species journey between protected areas. Today, riparian habitats are reduced in some places due to a combination of factors, including reservoirs, water diversions, ground and surface water extraction, the effects of which are exacerbated by drought.

Three dams occur in the linkage, creating barriers to movement for aquatic and semi-aquatic species, altering historic flow regimes, and changing the composition and structure of downstream vegetation. The Sutherland Lake Dam is on Santa Ysabel Creek and is under the jurisdiction of the City of San Diego's Reservoirs and Recreation Program; it has a surface area of 557 acres (http://www.sandiego.gov/water/recreation). The Cuyamaca Reservoir located on Boulder Creek covers 110 surface acres of water (Figure 57). The Cuyamaca Dam is the second oldest in California, completed in 1888 to supply water to growing San Diego. Since 1891 several species of fish have been

Figure 57. Looking northwest at Cuyamaca Lake. The Cuyamaca Dam built on Boulder Creek in 1888 is the second oldest dam in California.

stocked. Today facilities are managed by the Lake Cuyamaca Recreation and Park District. (http://www.sdfish.com). Lake Henshaw is a water supply reservoir owned and managed by the Vista Irrigation District (VID). It covers 1,140 surface acres and is located on the San Luis Rey River. Land owned by the District is largely managed to protect water quality, with recreational activities at the lake managed by a concessionaire under contract with the District (VID 2005). Vista Irrigation District has 24 productive wells in the Warner Basin surrounding the lake that pump from depths of 150 to 350 feet. Both natural run-off and groundwater are held as surface water in Lake Henshaw. Increases in the demand for limited water supplies make water extraction a concern for the long-term viability of riparian and aquatic habitats in the Linkage Design.

In addition to loss of surface and groundwater, water quality is also a concern. Thus far, no drainages within the Linkage Design have been listed as impaired under Section 303(d) of the Clean Water Act, but Sutherland Lake Reservoir is listed as impaired (http://www.swrcb.ca.gov/rwqcb9/programs/303dlist/Listed%20Waterbodies-2002.pdf). Water within the linkage is regulated by the San Diego Regional Water Quality Control Board. All lakes, streams, and rivers listed as impaired are eligible for the development of intensive management plans called Total Maximum Daily Load (TMDL) plans. TMDL plans are enacted by the Regional Water Quality Control Board to determine the cause of water quality deterioration and then an implementation plan is developed to return water quality to targeted values.

Invasive plant and animal species also need to be addressed in riparian habitats in the Linkage Design. Although most drainages are dominated by coast live oak (*Quercus agrifolia*), cottonwood (*Populus fremontii*), sycamore (*Platanus racemosa*), white alder (*Alnus rhombifolia*), and willow (*Salix* spp.), invasive exotic species such as tamarisk (or "saltcedar",*Tamarix ramosissima*) and giant cane (or "arundo", *Arundo donax*) have invaded some of these systems. These introduced species escaped cultivation and have invaded stream courses in the arid southwest, out-competing native plant species and forming monocultures that provide little habitat value to wildlife. Tamarisk can transpire at least 200 gallons of water per plant each day and will often dry up ponds and streams to the detriment of native flora and fauna (Whitson et al. 2000, Baldwin et al. 2002). Bullfrogs (*Rana catesbeiana*), crayfish (*Procambarus clarki*), and mosquitofish (*Gambusia affinis*) are just a few of the exotic predators that threaten native amphibians in the planning area (Warburton et al. 2004).

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

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

Measures to minimize development impacts on aquatic habitats often focus on establishing riparian buffer zones (Barton et al. 1985, Allan 1995, Wilson and Dorcas 2003). However, although these buffers are intended to prevent erosion and filter runoff of contaminants (U.S. Environmental Protection Agency), research suggests that current regulations are inadequate to protect populations of semiaquatic reptiles and amphibians (Wilson and Dorcas 2003). Buffers must contain enough upland habitat to maintain water-quality and habitat characteristics essential to the survival of many aquatic and semiaquatic organisms (Brosofske et al.1997, Wilson and Dorcas 2003). However, maintaining riparian buffers will not suffice for some species. For example, 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: To enhance species use of riparian habitat and restore riparian connections through the Linkage Design area, we recommend:

- Wherever possible restore the natural historic flow regime or create a regime that provides maximum benefit for native biodiversity. Work with the CSP, USFS, BLM, CDFG, 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 and riparian conditions.

- Minimize the effects of road crossings in riparian zones. Coordinate with the California Department of Transportation, CSP, USFS, BLM, and CDFG, to further evaluate existing stream crossings and upgrade culverts, Arizona crossings (in stream crossings), bridges, and roads that impede wildlife movement. Use several strategies, including information on preferred crossings, designing new culverts, retrofitting or replacing culverts, general recommendations, post construction evaluation, maintenance, and long-term assessment (Carey and Wagner 1996, Evink 2002).

- 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 in the Linkage Design.

- Restore riparian vegetation in all drainages and upland vegetation within 1 km (0.60 mi) of streams and rivers to encourage plant and animal movement and improve water quality.

- Discourage development in flood prone areas to reduce the need for construction of concrete-banked streams and other channelization projects.

- Remove exotic plants (e.g., tamarisk) and animals (e.g., bullfrogs, African clawed frogs, crayfish) from washes, streams and rivers. Work with the Biological Resources Division at USGS, CSP, USFS, BLM, CDFG, and other relevant agencies and organizations to survey streams and drainages for invasive species and develop a comprehensive removal strategy.

- Ensure containment of stocked fish (trout, Florida bass, smallmouth bass, channel catfish, crappie, bluegill, and sturgeon) to reservoirs to minimize threats to native amphibians and other species. Stream reaches both up and downstream of reservoirs should be inspected after major storm events.

- Enforce existing regulations protecting streams and stream vegetation from illegal diversion, alteration, manure dumping, and vegetation removal. Agencies with applicable jurisdiction include CDFG (Streambed Alteration Agreements), Army Corps of Engineers (Clean Water Act), and Native Plant Protection Act.

- Prevent off-road vehicles from driving in riparian areas and washes and enforce closures. Review existing regulations relative to linkage goals and develop additional restrictions or recommend closures in sensitive areas.

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

- Increase and maintain high water quality standards. Non-point sources of pollution should be identified and minimized.

- Work with the Resource Conservation District to help establish use of Best Management Practices for rural communities in the linkage and surrounding communities.

- Support conservation and efficient water use and education programs that promote water conservation.

Other Land Uses that Impede Utility of the Linkage

Land management policies in the protected areas and the linkage can have substantial impact on habitat and movements of species through the Linkage Design area. It is essential that major land management and planning entities integrate the linkage plan into their policies and regulations.

Urban Barriers to Movement

Urban development, unlike roads, creates barriers that cannot be corrected by building crossing structures. Urban and suburban areas make particularly inappropriate landscapes for movements of most plants and animals (Marzluff and Ewing 2001). In addition to direct habitat removal, urban development creates edge effects that reach well beyond the development footprint. Most terrestrial mammals that move at night will avoid areas with artificial night lighting (Rich and Longcore 2006). Pet cats can significantly depress populations of small vertebrates near housing (Churcher and Lawton 1987, Crooks and Soulé 1999, Hall et al. 2000). Irrigation of landscapes surrounding homes encourages the spread of argentine ant populations into natural areas, where they cause a halo of local extinctions of native ant populations extending 200 m (656 ft) into native vegetation (Suarez et al. 1998, Bolger et al. 2000). Similar affects have been documented for amphibians (Demaynadier and Hunter 1998). Habitat disturbance caused by intense human activity (e.g., off-road vehicle use, dumping, camping and gathering sites) also tends to rise in areas surrounding urban developments. Areas disturbed by human use show decreases in bird and small mammal populations (Sauvajot unpubl.).

Urban Barriers in the Linkage Design Area: Rural development comprises just 1 % of the Linkage Design area. The rural community of Warner Springs occurs in the northern branch of the linkage, while the rustic towns of Santa Ysabel, Wynola, Julian, Whispering Pines, and Kentwood in the Pines occur along SR-78, near the central branch of the linkage. Julian is a historic town that has about 300 residents, while the surrounding communities have a population of around 3,000 (http://www.julianca.com). The small town of Borrego Springs is surrounded by Anza-Borrego Desert State Park and as of the year 2000 had a population of 2,535 (http://www.city-data.com). Some areas within these communities may be somewhat impermeable to wildlife movement due to the large numbers of pets and livestock, and light and noise pollution.

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 is therefore the strongest option. Mitigation for existing urban developments focuses on designing and managing buffers to reduce penetration of undesirable effects into natural areas (Marzluff and Ewing 2001). Management in buffers can include fencing in pets, reducing human traffic in sensitive areas or constriction points, limiting noise and lighting, reducing traffic speeds, minimizing use of irrigation, encouraging the planting of locally native vegetation, minimizing or eliminating 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 recommend the following actions to minimize the effects of rural communities in the Linkage Design area:

- Encourage farmers and ranchers to take advantage of the Farm Security & Rural Investment Act of 2002 (Farm Bill), which provides funding for a broad range of emerging natural resource challenges, including soil erosion, habitat and farmland protection (www.ers.usda.gov/features/farmbill/2002farmact.pdf).

- Encourage homes abutting the linkage area to have minimal outdoor lighting, 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. Residents should be encouraged to keep cats indoors at all times.

- Develop historic, night sky, and land preservation ordinances to maintain the rural character of existing communities in the vicinity of the linkage.

- Develop a public education campaign, such as the On the Edge program developed by the Mountain Lion Foundation (www.mountainlion.org), which encourages residents at the urban wildland interface to become active stewards of the land by reducing penetration of undesirable effects into natural areas. Topics addressed include: living with wildlife, predator-safe enclosures for livestock and pets, landscaping, water conservation, noise and light pollution.

- Work with San Diego County to encourage inclusion of the Linkage Design within the East County Multiple Species Conservation Plan.

- Discourage major new residential or urban developments in key areas of the Linkage Design.

- Encourage land acquisition and conservation easements with willing private landowners in the Linkage Design.

Recreation

Recreational use is not inherently incompatible with wildlife movement. However, intense recreational activities have been shown to cause significant impacts to wildlife and plants (Knight and Cole 1995). Areas with high levels of off-road vehicle use are more readily invaded by invasive plant species (Davidson and Fox 1974), accelerate erosion and reduce soil infiltration (Iverson 1980), and alter habitat use by vertebrates (Brattstrom and Bondello 1983, Nicolai and Lovich 2000). 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).

Recreation in the Linkage Design Area: Anza-Borrego Desert State Park, Cuyamaca Rancho State Park, Cleveland National Forest, BLM lands, County Parks, and other conservation lands provide a wide range of recreational opportunities, from nature-based dispersed recreational activities to high-density recreation in developed sites. Dispersed recreational activities in the vicinity of the linkage include backpacking, hiking, camping, birding, picnicking, horseback riding, biking, and other nature-based activities. The Pacific Crest Trail traverses the entire study area, from the Hauser Wilderness Area on Cleveland National Forest, to the Granite and Grapevine mountains of Anza Borrego Desert State Park and on through BLM land in the San Felipe Hills, crossing Buena Vista Creek in the northern branch of the linkage to Forest Service land north of SR-79. The majority of recreational use is concentrated in developed facilities with road access. Three manmade lakes occur in the linkage, Lake Henshaw, Sutherland Lake, and Lake Cuyamaca, which provide fishing and boating opportunities. Each lake is stocked with various non-native fish (e.g., trout, smallmouth bass, crappie, bluegill, and sturgeon) for recreational purposes. Designated off-road vehicle areas occur at Ocotillo Wells State Vehicular Recreation Area, and in designated areas on Forest Service and BLM lands. Unauthorized road and trail creation (e.g., hill climbs and secondary trails up side canyons) is a concern in some areas (USFS 2005).

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 minimize 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.

- Ensure containment of stocked fish (trout, Florida bass, smallmouth bass, channel catfish, crappie, bluegill, and sturgeon) to reservoirs to minimize threats to native amphibians and other species.

- Work with the land management agencies and non-governmental organizations to develop and conduct on-the-ground, outreach programs to recreational users on how to lessen impacts in sensitive riparian areas.

- Close roads and trails that pass through known bighorn sheep lambing areas during the reproductive season and protect critical water sources from disturbance during the summer (Holl and Bleich 1983, Papouchis et al. 2001, USFWS 2001).

- Prohibit new off-road vehicle routes within bighorn sheep habitat (USFWS 2001).

- Close, obliterate, and restore to natural habitat any unauthorized off-road vehicle routes and enforce closures.

- Enforce leash laws so that dogs are under restraint at all times (USFWS 2001, Holl et al. 2004).

Land Protection & Stewardship Opportunities

A variety of conservation planning efforts is currently underway in the Linkage Design area. The South Coast Missing Linkages Project supports these efforts by providing information on linkages critical to achieving their conservation goals at a landscape scale. This section provides information on planning efforts, agencies, and organizations that may represent opportunities for conserving the Peninsular-Borrego Connection. This list is not exhaustive, but provides a starting point for persons interested in becoming involved in preserving and restoring linkage function.

Anza-Borrego Foundation: The Foundation's mission is to promote conservation in Anza-Borrego Desert State Park and the surrounding ecological region through land acquisition, education, interpretation and scientific studies. The Anza-Borrego Institute is the arm of the Anza-Borrego Foundation dedicated to inspiring people of all ages to value, learn about and conserve this unique but fragile environment through education, interpretation, and research of the natural, historical and cultural resources of this region. The Foundation is a project partner in the South Coast Missing Linkages effort. For more information, visit http://www.theabf.org/.

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. 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. For more details, visit http://www.usbr.gov/lc/region/scao/sccwrrs2.htm.

California Chaparral Field Institute: The purpose of the Institute is to promote an understanding and respect for the chaparral and the Mediterranean climate in which most Californians live in order to: encourage an active interest in learning about the chaparral, the organisms living there, its evolutionary development, and the dynamic relationship it has with fire; facilitate better communication between the scientific and firefighting communities; develop wildland and growth management policies that will lower the risk of fire crossing over the wildland/urban interface; help save lives and homes from wildfire through continuing education efforts; permanently secure the value of protecting chaparral as an important natural resource in public policy for the benefit of future generations; and foster a reconnection to the natural environment. To find out more about the Institute, go to http://www.californiachaparral.com/.

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 have shown leadership and a willingness to improve linkage function in the most important linkage areas. For instance, CalTrans closed 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. In 2003 the pavement was removed and habitat restoration efforts were initiated. To find out more about the innovative plans being developed by Caltrans, visit their website at http://www.dot.ca.gov.

California Native Plant Society: The California Native Plant Society (CNPS) is a statewide non-profit organization of amateurs and professionals with a common interest in California's native plants. The San Diego Chapter serves San Diego and Imperial counties. The Society, seeks to increase understanding of California's native flora and to preserve this rich resource for future generations. Their members have diverse interests including natural history, botany, ecology, conservation, photography, drawing, hiking, and gardening. To learn more about CNPS, go to http://www.cnpssd.org/.

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, such as those available at Anza-Borrego Desert State Park, and Cuyamaca Rancho State Park. 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 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 State Parks Foundation: The Foundation is the only statewide organization dedicated to preserving, advocating and protecting the legacy of California's State Parks. The Foundation supports environmental education, wildlife and habitat preservation, volunteerism, and sound park policy. Since its inception, the Foundation has provided over $110 million for projects and educational programs while building a statewide network of park supporters. These initiatives have helped the parks acquire more land, create more trails, restore wildlife habitat, build visitor centers, construct interpretive displays, and support family camping for underserved youth. CSPF is a partner in the South Coast Missing Linkages Project. For more on their exciting programs, visit www.calparks.org.

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 was also a co-sponsor of the statewide Missing Linkages effort. For more information, visit them at http://www.calwild.org.

California Wild Heritage Campaign: The mission of the California Wild Heritage Campaign is to ensure the permanent protection of California's remaining wild public lands and rivers. Congresswoman Hilda Solis has introduced the Southern California Wild Heritage Act. The bill would significantly expand the National Wild and 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 and Scenic Rivers are included in the bill, totaling more than 312 miles, and 47 new Wilderness Areas and Wilderness Additions totaling 1,686,393 acres. The Campaign builds support for Wilderness and Wild and 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.

California Wolf Center: Based in Julian, the Center's mission is to increase awareness and conservation efforts in protecting and understanding the importance of all wildlife and wild lands by focusing on the history, biology and ecology of the North American Gray Wolf through education, exhibition, and reproduction of endangered species and studies of captive wolf behavior (http://www.californiawolfcenter.org/).

Conservation Biology Institute (CBI): CBI's mission is to provide scientific expertise to support the conservation and recovery of biological diversity in its natural state through applied research, education, planning, and community service. CBI is involved in a number of conservation planning efforts in San Diego County, including the East

County MSCP, and they are a key partner in the South Coast Missing Linkages Project. For more information on their efforts, visit http://www.consbio.org.

Endangered Habitats League: The Endangered Habitats League is dedicated to ecosystem protection and sustainable land use. EHL participates in regional planning to curtail sprawl and preserve intact rural and agricultural landscapes. It actively supports the revitalization of urban areas and the development of vibrant community centers, effective mobility, and affordable housing choices. EHL is engaged in several Natural Community Conservation Planning efforts in the region. For more information, visit them at http://www.ehleague.org.

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

Farm Security & Rural Investment Act of 2002 (Farm Bill): This legislation responds to and provides funding for a broad range of emerging natural resource challenges faced by farmers and ranchers, including soil erosion, wetlands, wildlife habitat and farmland protection. Several programs have been developed through the Farm Bill including the Corridor Conservation Program, Farmland Protection Program, Wetlands Reserve Program, and Wildlife Habitat Incentives Program. To learn more about the Farm Bill, go to www.ers.usda.gov/features/farmbill/2002farmact.pdf

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

National Park Service: The purpose of the National Park Service is "...to promote and regulate the use of the...national parks...which purpose is to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." NPS is a key 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 (PCT) so as to reflect its world-class significance for the enjoyment, education and adventure of hikers and equestrians. The

Association works to: promote the PCT 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 PCT. The PCT 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 water quality in the Linkage Design area. For more information, visit their website at http://www.swrcb.ca.gov.

Resource Conservation Districts (RCD): The Greater San Diego RCD is a non-profit agency that 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 and 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.rcdsandiego.org/.

San Diego Association of Governments (SANDAG): The 18 cities and San Diego County government are SANDAG serving as the forum for regional decision-making. SANDAG builds consensus, makes strategic plans, obtains and allocates resources, plans, engineers, and builds public transportation, and provides information on a broad range of topics pertinent to the region's quality of life. SANDAG provides the regional framework to connect our land use to our transportation systems, manage our population growth, preserve our environment, and sustain our economic prosperity. SANDAG is also engaged in the East County MSCP (http://www.sandag.org/).

San Diego Audubon Society: The Audubon Society's purpose is fostering the protection of birds and other wildlife through education and study, and advocating for a cleaner, healthier environment (http://www.sandiegoaudubon.org/).

San Diego Conservation Resources Network (CRN): Protection and management of San Diego County's open space will require substantial funding and staffing and a coordinated commitment from diverse groups, including municipalities, resource agencies, and local citizens' groups. To encourage and facilitate the participation of citizen groups, several local land conservancies are collaborating to form a nongovernmental organization, the Conservation Resources Network (CRN), which will provide information, technologies, and technical services to local land conservancies and to help mobilize and coordinate volunteers to assist with land conservation and management activities. In addition, the CRN will provide a point for coordinated contact with other organizations involved in habitat conservation, particularly local governments, state and federal resource agencies (http://www.regionalworkbench.org/).

San Diego County Farm Bureau: The mission of the Farm Bureau of San Diego County is to represent San Diego agriculture through public relations, education, and public policy advocacy in order to promote the economic viability of agriculture balanced with appropriate management of natural resources. Agriculture ranks as the fifth largest industry in San Diego County and contributes $1.4 billion to the local economy. In addition to the value to the economy, the farmers of San Diego County own and maintain vast tracts of open space. For more on their programs and activities, visit http://www.sdfarmbureau.org/.

San Diego East County Multiple Species Conservation Plan: The East County MSCP Plan is currently being developed and will address land in the linkage. The Study Area comprises over 1.5 million acres and is bounded on the west by Ramona and Palomar Mountain, on north by Riverside County, and on the east predominantly by Imperial County, and the south by Mexico. A large portion of the Study Area contains public lands, while privately owned parcels in the unincorporated area comprise approximately 418,930 acres. Since the inception of the MSCP, the County has negotiated and purchased several properties from willing sellers. Major programs are in place to manage, maintain and monitor plant and animal life on the lands once they are in the preserve in order to ensure the conservation of their unique resources. The County Department of Parks and Recreation is responsible for managing and monitoring the MSCP lands the County acquires. Management activities include but are not limited to, trash removal, passive recreation, patrol, signage, fire management, exotic plant species removal and cultural resource protection. Selected species and habitats are carefully monitored with the goal of ensuring the long-term health of populations of priority plant and animal species. The overall MSCP goal is to maintain and enhance biological diversity in the region and conserve viable populations of endangered, threatened, and key sensitive species and their habitats, thereby preventing local extirpation and ultimate extinction. Functional habitats and linkages between habitats will also be ensured through these activities. For updates on the progress of this plan, visit http://sdpublic.sdcounty.ca.gov/.

San Diego Natural History Museum: The mission of the Museum is to interpret the natural world through research, education and exhibits; to promote understanding of the evolution and diversity of southern California and the peninsula of Baja California; and to inspire in all a respect for nature and the environment. Scientists at the Museum are actively engaged in research programs (e.g., San Diego County Bird Atlas) in the planning area. The museum is also part of a consultant team that is assisting the County of San Diego with the preparation of a joint Natural Communities Conservation Plan/Habitat Conservation Plan (NCCP/HCP) and the Environmental Impact Statement/Report for the East County MSCP Plan. For more on the museum, visit them at http://www.sdnhm.org/research/index.html.

San Dieguito River Valley Conservancy: The Conservancy works as a catalyst for the establishment of a permanent open space corridor in the San Dieguito River Valley, which will maintain the natural and rural character of the valley, preserve and enhance natural and historical resources, locate and establish recreational activities appropriately, and provide a river-long system of trails to connect recreational and educational opportunities. The Conservancy purchased a key parcel in the linkage between the Volcan Mountain Preserve and Santa Ysabel Ranch East. For more information, visit http://www.sdrvc.org/conservancy.asp.

Santa Margarita River and San Luis Rey Watersheds Weed Management Area: The SMRSRLW Weed Management Area provides support, coordination and funding for management of invasive non-native plants and restoration of native riparian habitat within the Santa Margarita and San Luis Rey watersheds in San Diego and Riverside Counties. It has coordinated and carried out a multi-year removal program for invasive plant species in the San Luis Rey Watershed (http://www.smslrwma.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 SMMC is a partner in the South Coast Missing Linkages effort. For more information on SMMC, visit them at http://www.smmc.ca.gov.

Save Our Forest and Ranchlands: This organization is dedicated to the protection of the wilderness, watershed, and agricultural resources of San Diego County through proper land use planning. They believe Urban Sprawl to be the #1 threat to our natural resources and to the quality of life in San Diego. In this endeavor, they review and comment on EIRs and project proposals and speak at community forums on land use issues to educate the public and decision-makers (http://www.sofar.org).

Sierra Club's Southern California Forests Campaign: Sierra Club volunteers and staff have created the Southern California Forests Campaign to encourage public involvement in the 4 southern California Forest's Resource Management Plan revision process. The goals of the campaign are to reduce the threats to our forests and to enjoy, protect and restore them. 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's Conservation and Research for Endangered Species. For more information on this ambitious regional effort, go to http://www.scwildlands.org.

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 (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. TNC is actively acquiring land and conservation easements throughout San Diego County, and has undertaken significant conservation planning efforts in the planning area, including the protection of critical riparian and upland habitats along Santa Ysabel Creek. TNC is a partner in the South Coast Missing Linkage Project. For more information on their activities, go to http://www.tnc.org.

The Wildlands Conservancy: The Wildlands Conservancy is a non-profit, member-supported organization dedicated to land and 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, please visit their website at http://www.wildlandsconservancy.org.

Transportation Equity Act of the 21st Century (TEA-21): This Act was enacted June 9, 1998 as Public Law 105-178. TEA-21 authorizes Federal surface transportation programs for highways and highway safety The Critter Crossings Program was developed to address roadkill, habitat fragmentation, and habitat loss due to public roads. This Act provides funding for ecological infrastructure, water quality improvements, restoration of wetlands and habitat (http://www.fhwa.dot.gov/tea21).

Trust for Public Land (TPL): TPL conserves land for people to enjoy as parks, gardens and other natural places, ensuring livable communities for generations to come. TPL has undertaken significant conservation planning efforts in the planning area, including critical lands in San Felipe Valley that link Anza-Borrego with Volcan Mountain. 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 (http://www.tpl.org).

Urban Corps of San Diego: Founded in 1989 through a partnership of local elected officials and community leaders, Urban Corps began providing job training and educational opportunities for young men and women 18 to 25 years old that will help conserve our natural resources. Today, they provide job training and educational opportunities to more than 400 young people annually (http://www.urbancorpssd.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 also are engaged in watershed planning efforts that may provide opportunities for restoration of natural water flow and riparian vegetation in the linkage. For more information, go to http://www.usace.army.mil.

US Fish and Wildlife Service: The U.S. Fish and 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. 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 and 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) have recently finalized their Resource Management Plans. The Final Environmental Impact Statement and Forest Plans have identified connecting the four forests to the existing network of protected lands in the region as one of the key conservation strategies for protecting biodiversity on the forests. 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. For more information, go to http://www.biology.usgs.gov.

Volcan Mountain Preserve Foundation: The mission of the Foundation is respectful stewardship of Volcan Mountain with emphasis on maintenance and enhancement of natural habitat; protection of native plant and animal species; preservation of archaeological sites; encouragement of appropriate research and education; and provision of a unifying link connecting nearby wilderness areas, as well as, assurance that people may continue to be refreshed and inspired by the presence of wild, open space; acquisition of additional acreage to preserve all of Volcan Mountain; and encouragement of various agencies to work together (http://www.volcanmt.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. For more information on WCB, go to http://www.dfg.ca.gov/wcb.

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

Summary

A Scientifically Sound Plan for Conservation Action

In southern California, 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 once intact ecosystems. The conservation plan for the Peninsular-Borrego Connection addresses these challenges by seeking to influence regional patterns of development in a manner that best preserves landscape level processes in the region.

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. Existing conservation investments in the linkage are already extensive including lands managed by the California State Parks, US Forest Service, Bureau of Land Management, California Department of Fish and Game, County of San Diego, The Nature Conservancy, Trust for Public Land, Volcan Mountain Preserve Foundation, and other conserved lands. Each holding lies within the targeted protected 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, and urban 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 targeted 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 recreational users and 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 3D animation (Appendix C on the enclosed CD) that provides a landscape perspective of the linkage.

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 resource for existing and long-term monitoring programs.

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

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South Coast Missing Linkages Workshop Minutes
June 28, 2002 at the San Diego Zoo

Alan Dixson, Zoological Society of San Diego, Center for Reproduction of Endangered Species – *Welcome*

- Overview of Center for Reproduction of Endangered Species, San Diego Zoo and Wild Animal Park collections, and in situ conservation projects in southwest United States and at international field sites
- Central problem: recovering and enhancing the health, well-being, and reproduction of endangered species – must link species efforts in collections and laboratories with global vision of in situ conservation
- Challenged by "HIPPO" impacts to animal and plant life in the current biodiversity crisis: **H**abitat destruction, **I**nvasive species, **P**ollution, **P**opulation (more than 6 billion humans), and **O**ver-harvesting/Over-use of resources
- Programs in California and Mexico:
  1. Peninsula bighorn sheep recovery team
  2. California condor recovery team; less than 30 in 1980s - now over 180, with many returned to wild in California and Arizona (and soon in Baja California)
  3. Use of radio transmitters to track red diamond rattlesnakes and rosy boas to map home ranges and study behaviors (denning, relocation, etc.)

Scott Morrison, The Nature Conservancy - *Introductory Remarks*

- Acknowledgement of workshop organizers (South Coast Wildlands Project, The Nature Conservancy, and Conservation Biology Institute), additional project partners (Zoological Society of San Diego, The Wildlands Conservancy, State of California Resources Agency, California State Parks, San Diego State University, Santa Monica Mountains Conservancy, National Park Service, California State Parks Foundation, and U.S. Forest Service), data providers (Pronatura of Mexico, San Diego State University, and California State Parks), and special participants (representatives from CICESE, UABC, and Pronatura of Mexico, and from the La Posta, Cuyaipe, and Manzanita Bands of Mission Indians)
- A broad coalition is working to restore and protect ecological connectivity throughout California; workshop participation is instrumental to the project's ultimate success; must plan habitat linkages across borders and jurisdictional boundaries
- Project started in November 2000 at the Missing Linkages conference held at the San Diego Zoo; 232 biologists convened to identify habitat linkages necessary to conserve ecological connectivity throughout California; this is the next phase of the initiative, taking general delineation of linkages and forming focused plans for tangible conservation action; the massive social, environmental and economic transformation in the border region has made it necessary to plan for cross-border connections
- South Coast Wildlands Project will organize a series of workshops for the 15 most critical, vulnerable, and irreplaceable linkages in the South Coast Ecoregion – one of the world's most diverse landscapes, threatened by conversion of natural habitat which triggers a cascade of ecological effects that leads to loss of native diversity; innovative conceptualization of habitat linkages can maintain dynamic and functional landscape

- Presentations will cover a suite of life history attributes and landscape characteristics to factor into landscape planning; taxonomic workgroups will allow participants to identify focal species for regional conservation planning; target planning area for this workshop is a transect that runs from the coastal scrublands to the mountains and ultimately out to the desert; the goal is to maintain north/south ecological connectivity in biological regions across elevation gradients
- Considerable conservation investment north of the border; connecting these habitats will preserve the viability of native biota; must address border permeability and identify core habitat areas to conserve south of the border

Ernesto Franco, CICESE - *Where Alta and Baja Meet: An Overview of the California Border Region*

Summary: The Pacific coast border region is one of the most profound international boundaries in the world. The original ecosystems—unique in each country—have diverged due to differences in management rooted in the developing cultural, economic and political identities of American and Mexican societies during the 150 years since the international boundary was laid out. As the economic and social re-integration of the region proceeds, it has become necessary to develop conservation plans congruent with aspirations of both societies. A brief overview of the regional biogeography is presented, focused mostly on vegetation, to show the enduring similarities and developing differences in these globally significant ecosystems.

Biography: Ernesto Franco-Vizcaíno is a researcher at the Center for Scientific Research and Graduate Education of Ensenada (CICESE) who works on the shrubland, forest and desert ecosystems of the Baja California peninsula. He has helped to coordinate research and conservation efforts in Baja California for more than 15 years.

- Speaker co-authored <u>The Land of Chamise and Pines: Historical Accounts and Current Status of Northern Baja California's Vegetation</u>; CICESE is the lead organization for the reintroduction of condor to Baja California, Mexico
- Bio-geographic context for linkage areas: global biodiversity hotspot and important Mediterranean area; California and Sonoran Floristic Province vegetation types include: coastal strand, tidal marsh, coastal sage scrub, chaparral, oak woodland, riparian, grassland, vernal pool, desert scrub, mixed conifer forest, pinion juniper woodland, endemic blue fan palm oases
- Peninsula broken away about 15 million years ago; 4-6 million years ago the land was inundated forming the Gulf of California; Baja California has moved northward about 300 km and geologic faults have guided mountain development
- Exotic species constitute 8% of Baja California plant species; 30% of native plants on peninsula are endemic, especially within the cactus family
- Northern Baja: coastal sage scrub heavily impacted by development, especially near beaches (must conserve remaining areas); chamise-dominated chaparral areas more intact and common inland; riparian woodlands in fair condition
- Sharp contrast along border in stand age due to fire regimes and landscape management; wildfires in Baja California are less dangerous (occur under normal weather conditions, create diverse habitat patches, and often stop at ridgelines)
- Exotic annual grasslands common along roads where land has been grazed

- Traditional economy exists in Baja with communal land operations, but land is currently in transition; conservation and land management efforts in this region require partnership between the United States and Mexico

Tom Oberbauer, Department of Planning and Land Use, County of San Diego ***- Regional Significance of the Southern San Diego County – Northern Baja California Linkage***

Summary: The Southern San Diego County – Northern Baja California border region is one of the world's recognized hotspots for biodiversity and species endangerment. The resources of the region have evolved in a landscape characterized by variable geologic, soil, climate, and paleogeologic patterns and conditions. These unique characteristics have resulted in diverse flora and fauna that are increasingly threatened by explosive population growth in the region.

Biography: Thomas Oberbauer is a biologist in the Planning and Land Use Department of the County of San Diego. He received his Masters degree at San Diego State University for his work on the distribution and dynamics of grasslands in San Diego County. Tom has written extensively on plants in Southern California and Baja California. He is currently working on the North San Diego County Sub-area Plan for the Multiple Species Conservation Program.

- Regional biological importance: E.O. Wilson's paper on global biodiversity hotspots; Science magazine article (Jan 1997) on areas with highest probability for listing of rare and endangered species – San Diego and Santa Cruz Counties ranked highest in the country; high diversity due to multiple factors (geologic series, climatic variations, soil and vegetation diversity, paleogeologic history)
- Geologic formation map of San Diego County indicates remnants of early volcanic peaks – such meta-volcanic rock and gabbro soils support unusual plant species - indicate areas for focused endemic plant surveys
- Paleogeologic/geographic history can be inferred by current species distributions of plants and animals, unusual occurrences, and woodrat-midden information
- Precipitation, landmark, and topographic overview; regional diversity of vegetation includes chaparral types (chamise, red shank, desert transition, southern mixed), coastal sage scrub, woodlands, coniferous forests, grasslands, great basin sagebrush, cypress woodland); expansion of development and population growth (currently Tijuana municipality 1.1 million; San Diego County 2.8 million)
- Linkage areas contain many sensitive species; certain focal species need corridors; consideration of historical species ranges (grizzly bears, jaguars, condors, pronghorn)
- Issues for species movement: proposed border fence from ocean to Otay Mountain will prohibit large animal movement (bobcat, mule deer, coyote, mountain lion); highways, toll roads; expansion of urban and agricultural areas

Kathy Williams, San Diego State University ***- Connectivity & Linkages for Terrestrial Invertebrates: Considerations from a Bug's Eye View***

Summary: Insects are incredibly diverse in structure and in functions they perform in ecosystems. That diversity reflects, in part, local and regional habitat diversity. This presentation will explore cases exemplifying movement patterns and habitat requirements of some local insects. Discussion will focus on implications related to preservation of linkages and connectivity among diverse habitats of the South Coast Ecoregion.

Biography: Kathy Williams has been studying insect population ecology and insect-plant relationships since her undergraduate research on tropical butterflies at the University of Texas, Austin. She then earned her Ph.D. in Population Biology at Stanford, working on checkerspot butterflies and their host plants. She is now a faculty member in Biology at San Diego State University. Her research interests include conservation of habitats and biodiversity in the arid southwest, especially riparian, chaparral, and mountain habitats. Currently she is working on endangered butterflies in southern California, including the Laguna Mountains Skipper.

- Connectivity for invertebrates – must provide linkages among habitat types and enhance habitat diversity (natural patches, transitions and variations) to expand movement possibilities and promote invertebrate diversity (maybe 5 million species, only 1 million named – disappearing faster than they can be identified)
- Habitat diversity provides tremendous variation in ecosystem services/functions (predators, parasites, herbivores, pollinators, detritovores, scavengers, prey); habitat diversity related to insect diversity (number of species per habitat area) – larger/more abundant connected patches support more species; need heterogeneous/complex connected habitat to support invertebrate biodiversity
- Insects must move to maintain populations, between and within habitat types; with metamorphosis, adults and larvae have different resource requirements
- Case examples: monarch butterfly has wide habitat range, extremely mobile, over-winters in California and Baja – historically over-wintered on large native riparian trees, such as sycamores and cottonwoods, but with loss of habitat, now uses non-native eucalyptus groves; Quino checkerspot butterfly (federally listed since 1997 as endangered, found in Otay Mesa and San Diego County) and Chalcedon checkerspot butterfly (uses chamise chaparral and coastal sage habitat) – both inhabit fire dependent communities, and must access nutritious plants that do not occur in older age chaparral stands – must have habitat patches with different disturbance patterns; inland subspecies becoming isolated and populations declining, possibly from connectivity loss; even sedentary sub-populations require infrequent transfers of individuals
- Invertebrates need to move between and among habitats to avoid natural disturbance, find food plants, obtain suitable habitat to sustain populations
- Laguna mountain skipper, rarest butterfly in North America, found in Palomar Laguna Mountains, moves to feed on restricted host plant in mountain meadows
- Life history characteristics and movement patterns of terrestrial invertebrates must be considered in planning and preserving critical habitat linkages to maintain populations and regional biodiversity

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

Summary: Southern California and Northern Baja are home to a diverse array of amphibians and reptiles, many of which 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. The 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.

- Incredible biodiversity; corridors include rivers, valleys, ridges, dune systems – herps need variety of substrates (loose sandy alluvium for legless lizard, oak woodlands with deep leaf litter for tree-climbing salamander, continuous chamise chaparral for horned lizard, open creosote scrub for long-nosed leopard lizard, rocky habitat for black-headed snake, etc.); genetic research indicates habitat connectivity in recent evolutionary times
- Corridor design based on habitat requirements for focal species (vegetation community, range in elevation) – best to include diverse habitat types
- At Missing Linkages conference, biologists identified spadefoot toad, arroyo toad, and western pond turtle as focal species, but these were all riparian species; high elevation upland species were overlooked, such as granite night lizard that prefers microhabitats with stable exfoliating granite boulders (genetic research shows that unstable fault zones isolate sub-populations); in addition, the mountain kingsnake prefers high elevations (5000-9000 feet); linkage planning must consider connecting mountain ridges
- Arroyo toad is a good focal species for riparian habitat; prefers sandy burrowing areas in low gradient streams; status unknown in Baja region; restoration and possibly reintroduction may be necessary for linkages south of the border
- Open creosote desert scrub supports diverse snake and lizard species; dune systems support fringe-toed lizard; sandy alluvium supports sidewinder and banded gecko
- Must look at micro-habitats within corridors and encompass multiple habitat types and species of herpetofauna to maintain natural complexity and biodiversity of this region

Philip Unitt, San Diego Natural History Museum *- The Role of the International Border in California Bird Distribution*

Summary: Despite the seemingly arbitrary placement of the international border, this line corresponds to a block or bottleneck for numerous species of birds. At least 12 long-distance migrants circumvent crossing the Gulf of California by veering east before reaching Baja California. The ranges of coniferous woodland species, if not reaching their southern limit here, have a gap straddling the border. Species of oak woodland have their ranges attenuated as they approach the border. Several riparian or fresh-water species reach the southern end of their breeding distribution near the border. For two declining species, the Gray Vireo and Sage Sparrow, the extensive chaparral along the border between Otay Mountain and Jacumba likely serves as an important dispersal corridor. These factors combine to suggest that the border region is a vulnerable point along dispersal routes. Because of the limited ranges of many relevant species in Mexico, bird diversity south of the border would be more affected by habitat degradation along the border than north of it.

Biography: Philip Unitt has served as collection manager for the Department of Birds and Mammals since 1988 and as editor of Western Birds, the regional journal of ornithology for western North America, since 1986. His interests include the distribution, status, identification, subspecies, and conservation of the birds of California and Baja California, addressed most recently in a bird atlas for San Diego County, projected for publication in 2003. Previous publications address the taxonomy, distribution, and ecology of the Willow Flycatcher, Marsh Wren, Brown Creeper, Gray Vireo, and Sage Sparrow.

- Border corresponds with bottleneck for many bird species – California Floristic Province mostly located in U.S. – cross-border connectivity more critical for conservation of birds in Mexico than U.S.; migrating birds at border circumvent gulf or migrate down peninsula
- San Diego County Bird Atlas data shows that some species ranges come to abrupt end at international border due to biogeography, especially those that prefer coniferous woodlands; in addition, the mountain chickadee and dark-eyed junco are both divided into subspecies at the border
- In San Diego County near the border, oak woodland distribution narrows and becomes patchy, forming bottleneck for many species (western wood peewee, acorn woodpecker, lazuli bunting, Hutton's vireo, white-breasted nuthatch)
- Certain species are expanding their ranges southward (western flycatcher, orange ground warbler) which increases need for connectivity
- Grasshopper sparrow is grassland specialist with restricted habitat; movement is blocked by urbanization
- Tri-colored blackbird is a land bird with biology of colonial seabird, with colonies in border area and limited distribution in Baja
- Chaparral used by gray vireo, which migrates during winter to Baja in single flight
- Sage sparrow impacted by fragmentation (sedentary resident species with low dispersal)
- Coarse scale linkage planning area serves as movement corridor for many bird species

Esther Rubin, Zoological Society of San Diego, Center for Reproduction of Endangered Species *- The Role of Habitat Protection and Connectivity in the Recovery of Bighorn Sheep in the Peninsular Ranges of Southern California*

Summary: During the past quarter century, bighorn sheep in the Peninsular Ranges of southern California have declined from approximately 1100 to 400 animals. In 1998, the U.S. Fish and Wildlife Service listed this population as endangered, and a Recovery Plan was prepared to outline recovery strategies. Recovery of this population will rely heavily on habitat protection and the maintenance of habitat connectivity throughout the Peninsular Ranges. This presentation explains some of the ecological and behavioral characteristics that the Recovery Team considered when delineating the habitat of this population, and how these characteristics influence the choice of recovery strategies. In addition, the challenges of habitat protection in these mountains, and how additional research findings may help guide management decisions, will be discussed.

Biography: Esther Rubin is currently working as a postdoctoral researcher at the Zoological Society of San Diego's Center for Reproduction of Endangered Species. Her current research focuses on bighorn sheep in the Peninsular Ranges, with an emphasis on habitat use and behavior. In 2000, she completed a Ph.D. in Ecology at the University of California, Davis. Her degree has an emphasis on conservation ecology, and her dissertation was on the ecology of bighorn sheep in the Peninsular Ranges. As a member of the USFWS Recovery Team for this population, she helped identify recovery strategies for bighorn sheep, and continues to work as part of this multi-organizational group. She has a special interest in behavioral ecology and population biology, and how these two disciplines can be used to address conservation issues.

- Recovery team uses behavioral and ecological characteristics to identify land protection strategies for bighorn sheep habitat
- Threats: disease, lion predation, drought, habitat loss/modification/fragmentation, and other human impacts/disturbance (recreation, mining, etc.)
- Current estimate in U.S. peninsular ranges is 400 adults (down from 1100 in 1970s), population federally listed as endangered in 1998, and recovery plan completed in 2000
- Habitat protection and connectivity determined necessary for population recovery; habitat delineation (narrow band) based on species needs: mountains with rough rocky escape terrain, steep cliffs for lambing areas, and canyon bottoms with water source; low slopes, flat valleys and open alluvial fans important for foraging, especially during drought; distribution in peninsular ranges limited by vegetation (do not use dense habitat, such as chaparral)
- Matrilineal social structure, in which females remain in natal home range; helicopter surveys and radio collars have been used to identify eight ewe groups, with rams moving between groups; rams will move across agricultural areas
- Recovery team modeled lower elevation habitat to certain distance out from toe of slope, and combined with vegetation information from Mexican border to San Jacinto Mountains; model compared to 20,000 recorded bighorn observations to identify several chokepoints and habitat edges with high development pressure
- Low flat canyon areas have higher development pressure, impacting sheep movement
- Current studies will provide more information on how sheep utilize habitat; connectivity necessary for self-sustaining population

Ken Logan, University of California Davis, Wildlife Health Center - *Pumas, Habitat Linkages, and Conservation*

Summary: The puma is extremely sensitive to habitat loss and fragmentation. This presentation will: 1) review puma natural history that makes this so; 2) give examples of how puma life history strategies can inform planning for reserve networks that should also benefit a myriad of other life forms; and, 3) show examples of how pumas use habitats in the Peninsular Ranges of southern California.

Biography: Ken Logan has been studying pumas in the West for over 20 years. He has done research on puma population biology and puma-prey relationships in Wyoming and New Mexico. His most recently completed work was a 10-year study of puma ecology in the Chihuahua Desert, which was directed by Ken and his life partner Linda Sweanor. Presently, Ken and Linda are scientists with the U.C. Davis Wildlife Health Center studying pumas in the southern California Peninsular Ranges.

- Puma is only large wild obligate carnivore in California, and very sensitive to habitat loss/fragmentation, making it a good focal species for planning regional reserve network; serves as umbrella species because it requires large patches of wild landscapes and habitat linkages to maintain population
- Also considered a keystone species, with a tremendous impact on ecosystem energy flow, selection force on individual prey animals and modulation of prey population dynamics (which influences competitive interaction between ungulate species and indirectly impacts herbivory on vegetation communities)

- Sensitivity to habitat fragmentation based on natural life history strategy; large obligate carnivore (average male 60 kg, female 40 kg) – requires large prey to survive and reproduce; mule deer are most important regional prey source; pumas live at low population density (breeding adults 0.5-2 pumas per 100 square km; adults, sub-adults and cubs 1-5 per 100 square km); huge home ranges (average in North America for male is 290 square km; female 130 square km)
- Radio collar data shows that pumas frequently cross private unprotected lands
- Dispersal is strongly conserved trait; almost all male pumas disperse from natal areas (with 85 km average dispersal distance); only about half of females disperse (with 30 km average dispersal distance)
- 80% males and 30% females in study group were immigrants from outside population – important for numeric augmentation of population and for gene flow
- Modeling by Paul Beier has demonstrated that puma habitat patches must be very large (1000-2000 square km) to sustain population (98% probability for persistence over 100 years) and that patches must be connected to allow movement (recruitment) between populations; landscape linkages needed to maintain even small populations
- Pumas prefer mountainous terrain with vegetative cover for stalking and available prey (mule deer); often killed trying to move through developed areas or across roads – need crossing points (over/under-passes)
- Even with conservation of large wildland patches and landscape linkages in southern California, pumas must still contend with people who live and recreate in those habitats; greatest cause of recorded puma mortality in San Diego over past 20 years has been depredation control to protect "hobby animals;" second common cause of mortality is vehicle strikes on roads and highways; third cause of death is killing of pumas for public safety for recreationists in preserved areas
- Conservation of habitat patches and linkages needs to be combined with active education program to inform people on how to co-exist with large obligate carnivores

Walter Boyce, University of California Davis, Wildlife Health Center - *Cautions Concerning Connectivity*

Summary: Habitat connectivity is an important component of many conservation strategies. However, corridors can serve as conduits or pathways for undesirable migrants such as disease-causing pathogens or newly introduced exotic species. In addition, corridors can serve as portals for the spread of fire and floods across habitat patches. Careful consideration should be given to potential outcomes to reduce/mitigate for negative impacts.

Biography: Walter Boyce is Professor and Executive Director of the Wildlife Health Center's School of Veterinary Medicine at the University of California, Davis. He has worked on wildlife health and conservation in the Peninsular Ranges of southern California since 1988, with many activities focused in Anza Borrego Desert State Park and Cuyamaca Rancho State Park.

- Potential concerns for corridor/linkage planning include: connecting habitat fragments also channels and increases the flow of whatever is moving through them relative to surrounding matrix; unintended travelers include disease-causing agents (e.g. – die-off of bighorn sheep in Hells Canyon during 1990s due to spread of contact bacterial pneumonia down "ribbon" of habitat)
- Need preventive strategy or barrier to break flow, as spread of exotic/invasive species also enhanced by movement corridors

- Corridors can serve as barriers, habitat sources or sinks depending on focal species
- Edge effects include light, wind, humidity (physical) and non-native aggressive competitors or predators (biological), and are more prominent in small corridors; the shape of corridor should be based on focal species to find best relation of outer perimeter to inner area
- Establishment of linkages cannot mitigate for overall loss of habitat; some corridors are simply transit points and provide no habitat, such as underpasses; some linkages also provide habitat
- Habitat quality and selection by individuals utilizing linkages influence reproductive success and survivorship; must consider anthropogenic (human-induced) changes in landscape (e.g. – mountain lion preying on domestic animals is making selective choice that works against its survival); preserved corridors may have lower habitat quality and may not benefit certain species; cues used to select where to go may be inappropriate
- Linkage planning is a dynamic process – must incorporate available habitats and possible management practices, and consider riparian flooding, fires, vegetative succession, climate change; aim to immediately protect as much as possible, and use active adaptive management approach for linkages (preliminary inventory, predictions to achieve goals, follow-up monitoring for evaluation)

Claudia Luke, San Diego State University, Field Stations Program ***- Considerations for Connectivity & Overview of Working Groups***

Summary: This presentation describes the Santa Ana – Palomar Mountains linkage to allow workshop participants to understand purposes of the 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 U.C. Berkeley in 1989. She is 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 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 - workshops have been held to select focal species
- Global linkage role: preservation of biodiversity hotspot with concentration of endemic species (formed by gradients in elevation, lack of past glaciers, soil diversity)
- 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 parcels, considering dispersal methods of focal species, and 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 appropriate species, evaluate movement needs, draw corridor on map, 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/delivery

- Choose species sensitive to fragmentation to represent linkage areas; Crooks and Soule 1999 showed that in San Diego as fragment size decreases, multiple bird species are lost; must consider associated species in planning, including keystone species important to survival of other species (ex - *Yucca whipplei* pollinated by specific invertebrates)
- Each taxonomic working group will choose a few species, delineate movement needs, record information on natural history, distribution, habitat suitability, current land conditions, key areas for preservation and restoration; consider metapopulation dynamics so that if a species disappears due to disturbance, habitat can be re-colonized
- Focal species data will be displayed on conservation design map and used to guide planning efforts; regional approach to linkages will help the Project to gain visibility and leverage to work with multiple agencies and organizations

South Coast Wildlands is in the process of producing several flyovers or 3D visualizations of the Peninsular-Borrego Connection and other linkages throughout the South Coast Ecoregion as part of the South Coast Missing Linkages Project.

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 FLYOVER

The flyover 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).

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 flyover.

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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