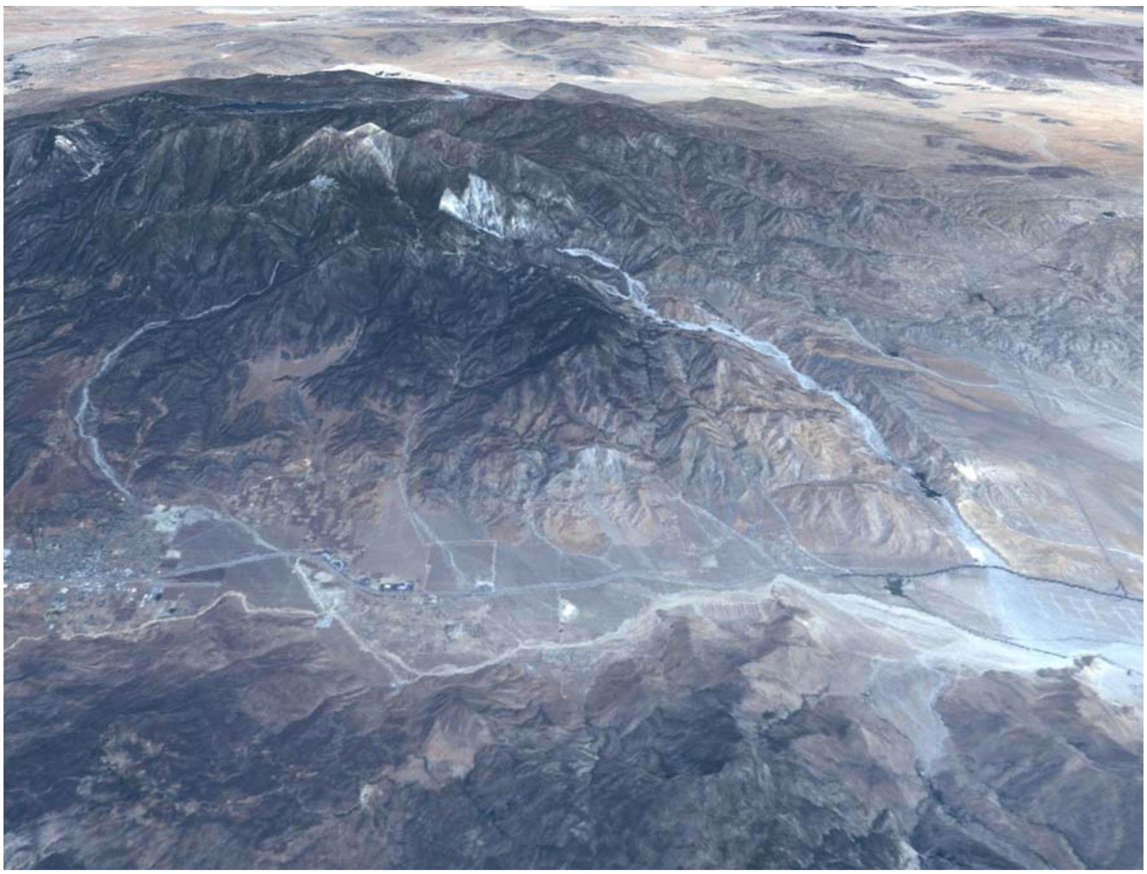
South Coast Missing Linkages Project:

A Linkage Design for the San Bernardino-San Jacinto Connection



Prepared by:

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Clint Cabañero
Dr. Paul Beier
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SOUTH COAST WILDLANDS

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September 2005

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

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Project Partners: We would like to recognize our partners on the South Coast Missing Linkages Project, including The Wildlands Conservancy, The Resources Agency, U.S. Forest Service, California State Parks, California State Parks Foundation, National Park Service, San Diego State University Field Stations Program, Environment Now, The Nature Conservancy, Conservation Biology Institute, Santa Monica Mountains Conservancy, Wetlands Recovery Project, Mountain Lion Foundation, Rivers and Mountains Conservancy, California Wilderness Coalition, Wildlands Project, Zoological Society of San Diego Center for Reproduction of Endangered Species, Pronatura, Conabio, and Universidad Autonoma de Baja California. We are committed to collaboration to secure a wildlands network for the South Coast Ecoregion and beyond and look forward to adding additional agencies and organizations to our list of partners.

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Project Steering Committee: We are extremely grateful to the following individuals, who serve on the steering committee for the South Coast Missing Linkages Project: Paul Beier (Northern Arizona University), Madelyn Glickfeld (formerly with The Resources Agency California Legacy Project), Gail Presley (California Department of Fish and Game), Therese O'Rourke (U.S. Fish & Wildlife Service, formerly with The Nature Conservancy), Kristeen Penrod (South Coast Wildlands), Rick Rayburn (California State Parks), Ray Sauvajot (National Park Service), and Tom White (U.S. Forest Service).

Executive Summary

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

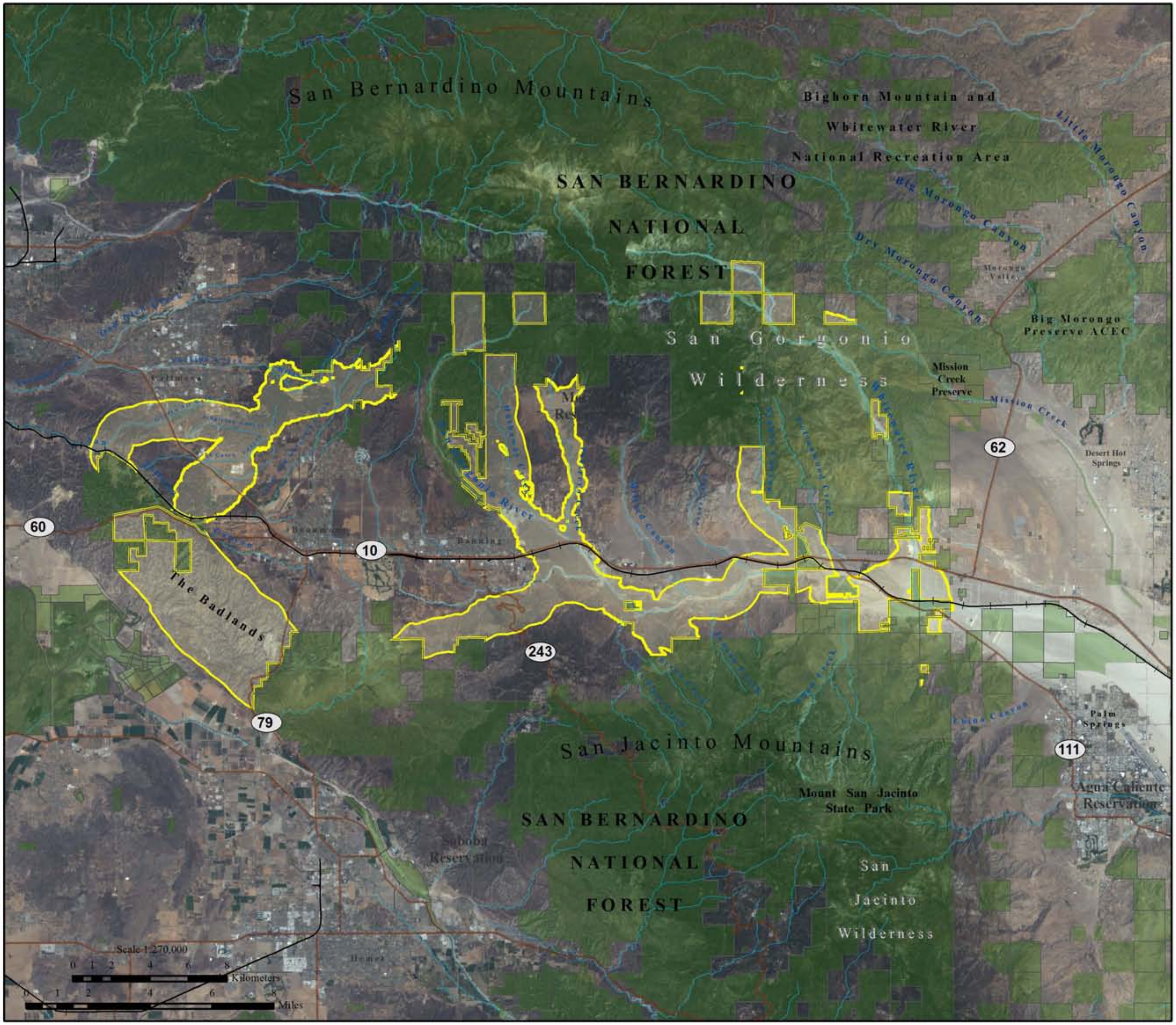
The tension between fragmentation and conservation is particularly acute in California, because our state is one of the 25 most important hotspots of biological diversity on Earth. And nowhere is the threat to connectivity more severe than in southern California—our nation's largest urban area, and still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

Although embedded in one of the world's largest metropolitan areas, southern California's archipelago of conserved wildlands is fundamentally one interconnected ecological system, and the goal of South Coast Missing Linkages is to keep it so. South Coast Missing Linkages is a collaborative effort among a dozen governmental and non-governmental organizations. Our aim is to develop Linkage Designs for 15 major landscape linkages to ensure a functioning wildland network for the South Coast Ecoregion, along with connections to neighboring ecoregions. The San Bernardino-San Jacinto Connection is situated where the Transverse and Peninsular Ranges converge and in an ecological transition zone between the South Coast and Mohave ecoregions; it is a critical landscape connection to restore and protect.

On August 7, 2002, 86 participants representing over 44 agencies, academic institutions, land managers, land planners, conservation organizations, and community groups met to establish biological foundations for planning landscape linkages in the San Bernardino-San Jacinto Connection. They identified 23 focal species that are sensitive to habitat loss and fragmentation here, including 3 plants, 4 insects, 1 amphibian, 3 reptiles, 4 birds and 8 mammals. These focal species cover a broad range of habitat and movement requirements: some are widespread but require huge tracts of land to support viable populations (e.g., mountain lion, badger); others are species with very limited spatial requirements (e.g., coast horned lizard). Many are habitat specialists (e.g., rock wren) and others require specific configurations of habitat elements (e.g. greenhairstreak butterfly that requires hilltopping habitat). 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 4 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 4 species. We then analyzed the size and configuration of suitable habitat patches within this Least Cost Union for all focal species to verify that the final Linkage Design would suit the live-in or move-through habitat needs of all. Where the Least Cost Union omitted areas essential to the needs of a particular species, we expanded the Linkage Design to accommodate that species' particular requirements to produce a final Linkage Design (Figure ES-1). We also visited priority areas in the field to identify and evaluate barriers to movement for our focal species. In this plan we suggest restoration strategies to mitigate those barriers, with special emphasis on opportunities to reduce the adverse effects of

Executive Summary - 1.
Linkage Design



Linkage Design
Protected Lands
Rivers & Streams
Roads
Railroads

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Interstate 10.

The ecological, educational, recreational, and spiritual values of protected wildlands in the South Coast Ecoregion are immense. Our Linkage Design for the San Bernardino-San Jacinto 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 permit movement of individuals and genes between desert and coastal regions and between the San Bernardino and San Jacinto Mountains and the Badlands. It will 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.

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

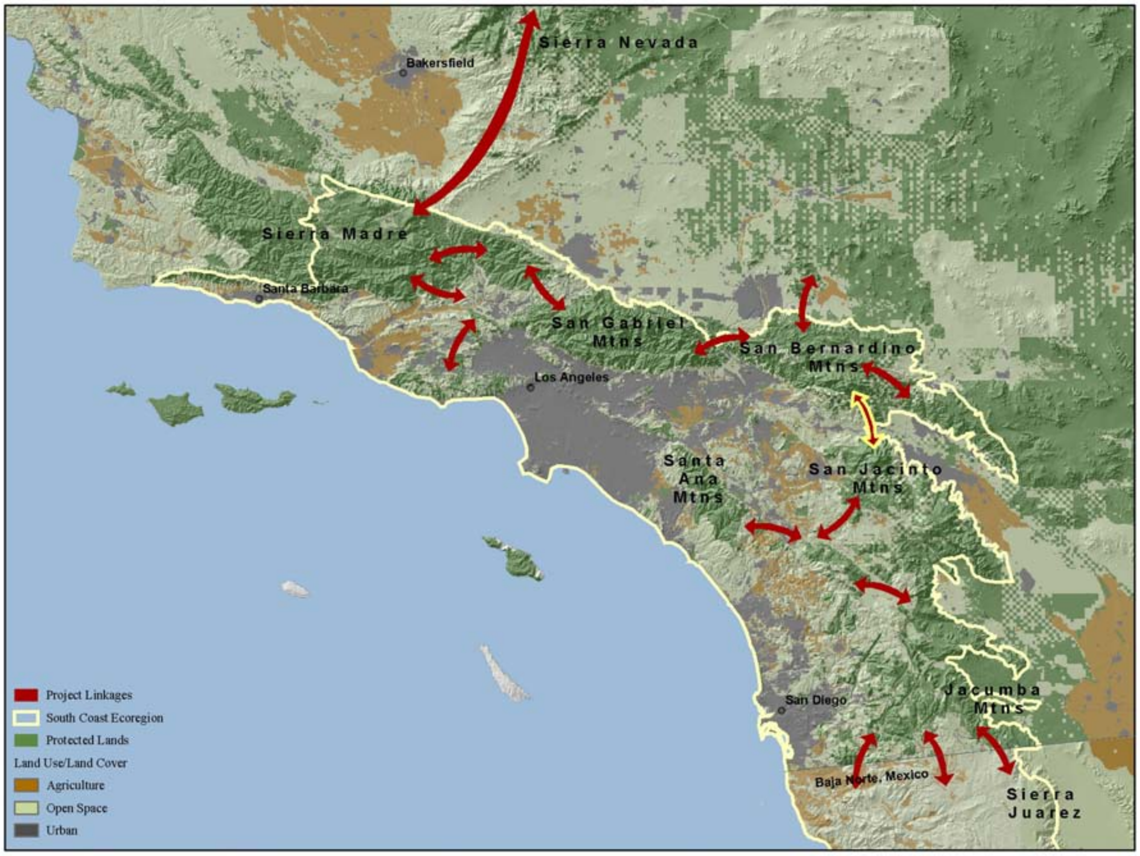


Figure 2. The South Coast Missing Linkages Project addresses habitat fragmentation at a landscape scale, and the needs of a variety of species. The San Bernardino-San Jacinto Connection is one of 15 landscape linkages identified as irreplaceable and imminently threatened.

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

Identification of these 15 priority linkages launched the South Coast Missing Linkages Project. This project is a highly collaborative effort among federal and state agencies and non-governmental organizations to identify and conserve landscape-level habitat linkages to protect essential biological and ecological processes in the South Coast Ecoregion. Partners include but are not limited to: South Coast Wildlands, The Wildlands Conservancy, The Resources Agency California Legacy Project, California State Parks, California State Parks Foundation, United States Forest Service, National Park Service, Santa Monica Mountains Conservancy, Rivers and Mountains Conservancy, Conservation Biology Institute, San Diego State University Field Stations Program, The Nature Conservancy, Southern California Wetlands Recovery Project, Environment Now, Mountain Lion Foundation, and the Zoological Society of San Diego's

Conservation and Research for 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; San Diego State University Field Station Programs, National Park Service, California State Parks, U. S. Forest Service, Santa Monica Mountains Conservancy, Conservation Biology Institute, and The Nature Conservancy have taken the lead on the other 7 linkages. The San Bernardino-San Jacinto Connection is one of these 15 linkages, whose protection is crucial to maintaining ecological and evolutionary processes among large blocks of protected habitat within the South Coast Ecoregion.

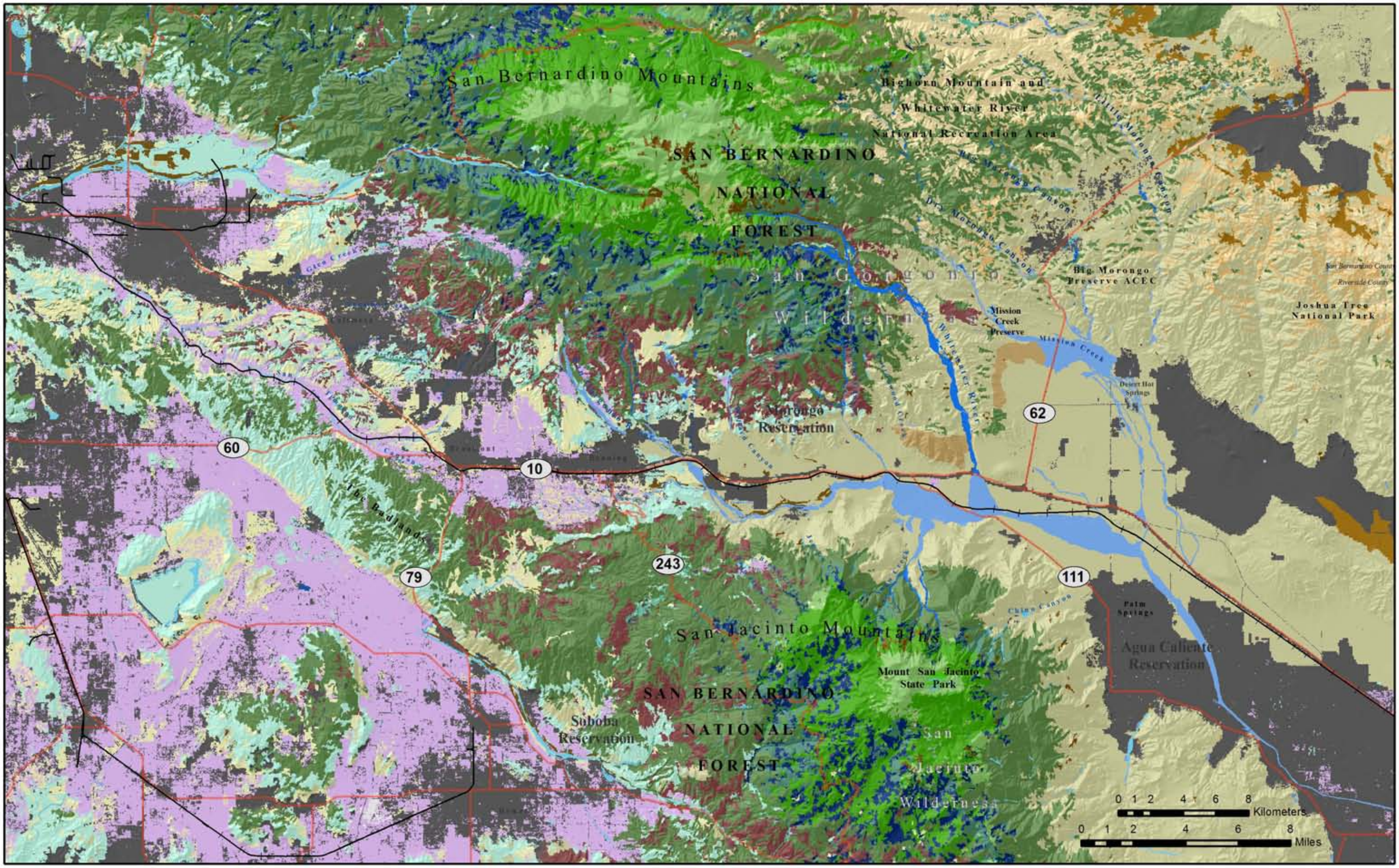
The 15 Priority Linkages

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 San Bernardino-San Jacinto Connection

The San Bernardino-San Jacinto Connection links the Transverse and Peninsular Mountain Ranges of the South Coast Ecoregion. The San Bernardino Mountains are part of the east-west trending Transverse Ranges and feature the highest peak in southern California, Mount San Gorgonio, while the San Jacinto Mountains are the highest and northernmost of the Peninsular Ranges. The Badlands are contiguous with the San Jacinto Mountains, forming a peninsula of coastal foothill habitats extending roughly 30 km (19 mi) toward the northwest.

These mountain ranges provide a rich assemblage of vegetative communities and a classic display of elevational life zones (Figure 3). The lower elevation coastal foothills are a mosaic of grassland, coastal sage, chaparral, oak savannas and woodlands, and riparian forests. At mid elevations there is a shift to montane chaparral interspersed with conifer hardwood forests dominated by Jeffrey pine (*Pinus jeffreyi*), ponderosa pine (*P. ponderosa*) and sugar pine (*P. lambertiana*) and mixed with patches of canyon live oak (*Quercus chrysolepis*) or black oak (*Q. kelloggii*). Montane riparian forests are tucked into deep canyons and montane meadows occur where the terrain is gentle and the substrate fairly impervious. At the highest elevations there is a transition to subalpine habitats, with white fir (*Abies concolor*), lodgepole pine (*P. contorta*), and limber pine (*P. flexilis*) being the most prominent species. Descending down the desert side of the



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

Alpine-Dwarf Shrub
Closed-Cone Pine-Cypress
Eastside Pine
Jeffrey Pine
Lodgepole Pine
Montane Hardwood
Montane Hardwood-Conifer
Ponderosa Pine
Sierran Mixed Conifer
Subalpine Conifer
White Fir

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

Desert Scrub
Desert Succulent Shrub
Joshua Tree
Juniper
Pinyon-Juniper
Sagebrush

Agriculture
Barren
Eucalyptus
Urban

Figure 3.
Vegetation Types
in the
Linkage Planning Area

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mountains, one passes through pinyon-juniper woodland, redshank chaparral, and desert scrub.

Both coastal and desert habitats occur in the lowlands between these mountain masses, with the San Gorgonio River marking the transition between these major vegetative zones. Coastal habitats dominate the pass to the west of the San Gorgonio River, where Noble, Little San Gorgonio, El Casco, and Wildwood creeks flow westward into San Timoteo Canyon. Desert habitats dominate to the east, with numerous alluvial plains fanning out from the canyons on the floor of the San Gorgonio Pass. The San Gorgonio and Whitewater rivers emanate from the San Bernardino Mountains to form extensive alluvial fans in concert with tributaries from the north and east sides of the San Jacinto Mountains. These rivers and streams transport and deposit sands eroded from the mountains to the desert lowlands. These sands are essential to sustaining rare dune ecosystems in the Coachella Valley. A number of sensitive natural communities occur in the planning area, including desert fan palm oasis, cottonwood willow riparian forest, and southern coast live oak riparian forest (CDFG 2005a). These include some of the rarest vegetation communities in the United States.

This variety of habitats support a diversity of organisms, including many species listed as endangered, threatened, or sensitive by government agencies (USFWS 1980, 1987, 1998, Stephenson and Calcarone 1999, USFWS 2001, Coachella Valley Association of Governments [CVAG] 2004, CDFG 2005a, 2005b). These include riparian songbirds, such as yellow warbler (*Dendroica petechia*), yellow-breasted chat (*Icteria virens*), and the endangered least Bell's vireo (*Vireo bellii pusillus*) and southwestern willow flycatcher (*Empidonax traillii traillii*). Sensitive reptiles that prefer drier habitats and sparser vegetative cover, such as the rosy boa (*Lichanura trivirgata*), coast horned lizard (*Phrynosoma coronatum blainvillei*), and the endangered Coachella Valley fringe-toad lizard (*Uma inornata*), also have the potential to occur in the linkage planning area. The threatened arroyo toad (*Bufo californicus*) occurs in the lower reaches of the Whitewater River. A number of sensitive birds of prey have been recorded in the linkage, including Cooper's hawk (*Accipiter cooperi*), golden eagle (*Aquila chrysaetos*), long-eared owl (*Asio otus*), and burrowing owl (*Athene cunicularia*). The planning area also provides habitat for a number of imperiled plant species, including slender-horned spineflower (*Dodecahema leptoceras*), Parry's spineflower (*Chorizanthe parryi* var. *parryi*), Coachella Valley milk-vetch (*Astragalus lentiginosus* var. *coachellae*), and Little San Bernardino Mountains linanthus (*Linanthus maculatus*).

In addition, because this regionally important linkage is situated where the Transverse and Peninsular Ranges converge, and in an ecological transition zone between the South Coast and Mojave ecoregions, it is considered a contact zone for many subspecies. This interchange of genetic material is most prevalent among mammals and reptiles, such as the desert woodrat (*Neotoma lepida lepida, N.l. gilva and N.l. intermedia*) (Grinnell and Swarth 1913), little pocket mouse (*Perognathus longimembris brevinasus and P.l. bangsi*) (Williams 1986), western banded gecko (*Coleonyx variegatus variegatus and C.v. abbotti*), western whiptail (*Cnemidophorus tigris tigris and C.t. multiscutatus*), rosy boa (*Lichanura trivirgata roseofusca and L.t. gracia*), and western patch-nosed snake (*Salvadora hexalepis hexalepis and S.h. virgultea*) (Stewart and Hogan 1980). The San Gorgonio Pass is situated at a unique evolutionary crossroads where genetic interactions occur at multiple temporal and spatial scales.

Finally, in addition to providing habitat for rare and endangered species and a contact zone where species intergrade along a genetic continuum, the linkage provides live-in and move-through habitat for numerous other native species that require extensive wildlands to thrive, such as American badger (*Taxidea taxus*), mule deer (*Odocoileus hemionus*), and mountain lion (*Puma concolor*).

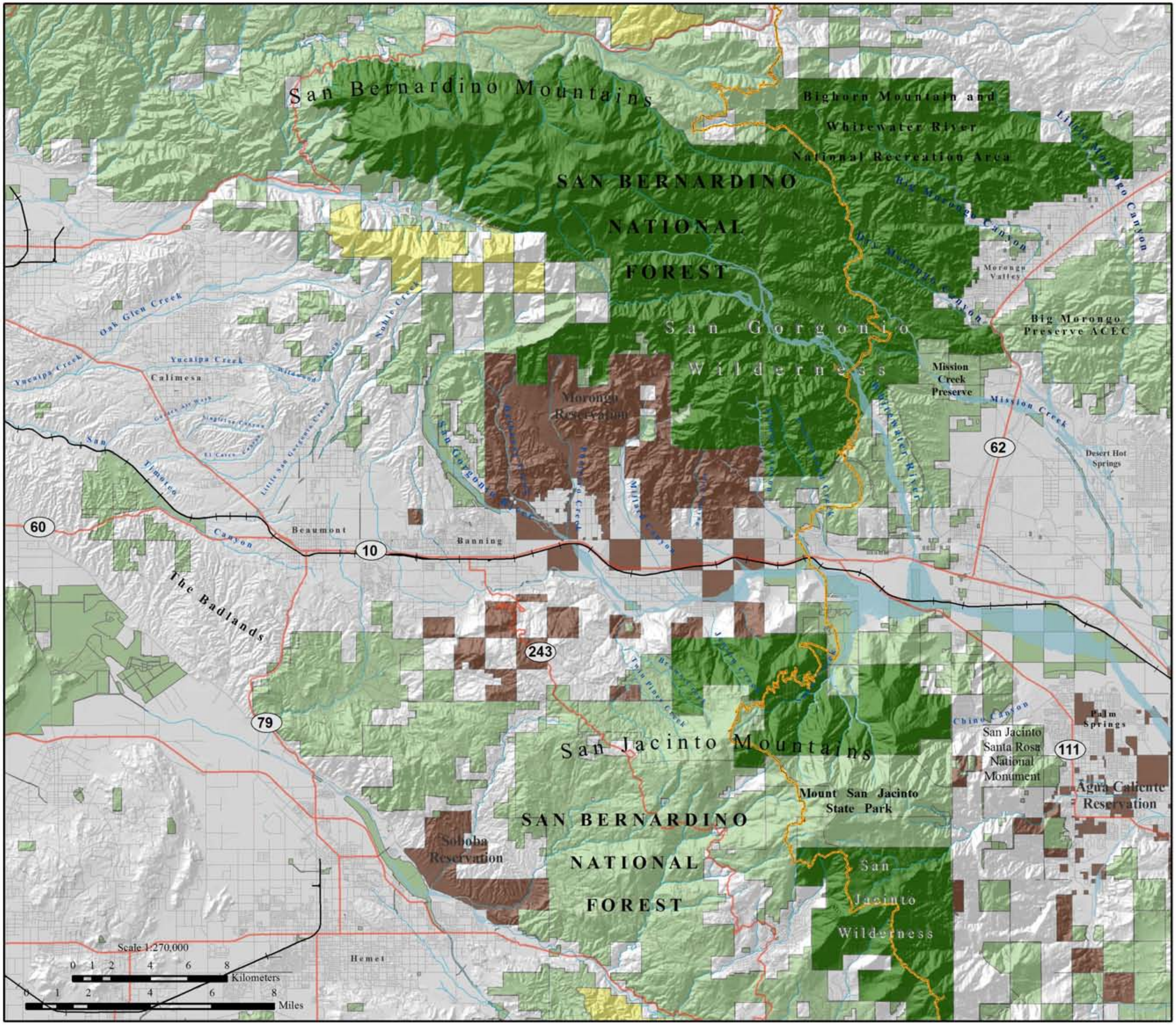
Existing Conservation Investments

Significant conservation investments already exist in the region (Figure 4), but the resource values they support could be irreparably harmed by loss of connections between them. This linkage serves to connect expansive core areas that are largely conserved within the San Bernardino and San Jacinto mountains and in the Badlands. The majority of land in the San Bernardino Mountains is protected as part of the San Bernardino National Forest and the Bighorn Mountains and Whitewater River National Recreation Area, which is administered by the Bureau of Land Management (BLM). Other significant areas protected for their conservation values include the Mission Creek Preserve, owned and stewarded by The Wildlands Conservancy, and Wildwood Canyon State Park, administered by California State Parks. In the San Jacinto Mountains, the majority of land is protected as part of the San Bernardino National Forest, Mount San Jacinto State Park, and the recently established Santa Rosa and San Jacinto Mountains National Monument. In the Badlands, land managers and conservationists have established the new San Timoteo Canyon unclassified state park unit. Wilderness Areas (WA) occur just inside the boundaries of protected areas on either side of the linkage. The Forest Service manages the San Gorgonio WA in the San Bernardino Mountains. The California Wild Heritage Campaign (www.californiawild.org) has proposed an addition to the San Gorgonio WA, and the Bighorn Mountain Wilderness additions are proposed just north of there. The San Jacinto Wilderness Area is separated into two units, one just inside the boundary of the Forest and one on the south side of Mount San Jacinto State Park. The California Wild Heritage Campaign has proposed an additional Wilderness Area along the South Fork of the San Jacinto River.

A number of key parcels in the linkage have already been protected though successful conservation planning efforts undertaken by USFS, BLM, California State Parks, The Wildlands Conservancy (TWC), Coachella Valley Mountains Conservancy, Friends of the Desert Mountains, Resources Legacy Fund Foundation (RLFF), and California Department of Fish and Game. However, significant gaps in protection remain. The Draft Environmental Impact Report and Statement for the Western Riverside Multiple Species Habitat Conservation Plan (WRMSHCP) reinforced the importance of this connection, identifying important linkage areas between the San Bernardino Mountains and the Badlands, and between the San Bernardino and San Jacinto mountains (County of Riverside 2002). Another Habitat Conservation Plan deals with the easternmost part of the linkage, the pending Coachella Valley Multiple Species Habitat Conservation Plan (CVMSHCP), which addresses Stubbe Canyon and the Whitewater River (CVAG 2004). The value of already protected land in the region for biodiversity conservation, environmental education, outdoor recreation, and scenic beauty is immense.

Another critical landowner in the linkage area is the Morongo Band of Mission Indians. The Morongo Tribe recently acquired property in Millard Canyon, “simply so that its 1,000 tribal members can traverse it with their kin and their memories.” This acquisition is part of an ambitious effort to consolidate the reservation and realize a dream of

Figure 4. Existing Conservation Investments & Other Major Landholders



- Protected Lands
- Native American Lands
- Designated Wilderness
- Proposed Wilderness
- Pacific Crest Trail
- Roads
- Rivers & Streams
- Railroads

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reclaiming their ancestral lands (Sahagun 2003). Any meaningful plan for securing this regionally important landscape linkage must also recognize the cultural significance of protecting these areas.

Southern California's remaining wildlands form an archipelago of natural open space thrust into one of the world's largest metropolitan areas 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 and restoring functional habitat connectivity to this regionally important landscape linkage is a wise investment.

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

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

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

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

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

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

Our approach has been highly collaborative and interdisciplinary (Beier et al. 2005). 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 August 7, 2002. The workshop gathered indispensable information on conservation needs and opportunities for the linkage. The workshop engaged 86 participants representing over 44 different agencies, academic

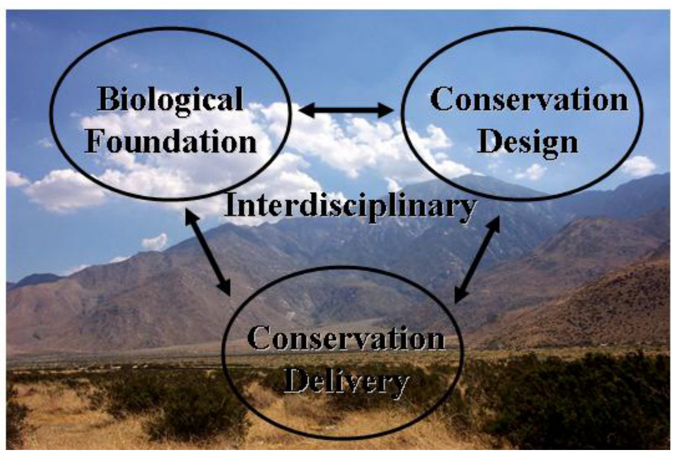


Figure 5. Successful conservation planning requires an interdisciplinary and reiterative approach among biologists, planners and activists (Baxter 2001).

institutions, conservation organizations, and community groups (Appendix A).

Focal Species Selection

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

Table 1. Regional ecologists selected 23 focal species for the San Bernardino-San Jacinto Connection

PLANTS
Dodecahema leptoceras (slender-horned spineflower)
Artemisia californica (California sagebrush)
Alnus rhombifolia (white alder)
INVERTEBRATES
Eleodes armata (desert skunk beetle)**
Apodemia mormo (metalmark butterfly)
Callophrys perplexa (green hairstreak butterfly)
Pepsis spp. (tarantula hawk)
AMPHIBIANS & REPTILES
Hyla cadaverina (California treefrog)
Phrynosoma coronatum (coast horned lizard)
Masticophis lateralis (California whipsnake)
Crotalus mitchellii (speckled rattlesnake)
BIRDS
Salpinctes obsoletus (rock wren)
Chamaea fasciata (wrentit)
Sitta pygmaea (pygmy nuthatch)
Strix occidentalis (California spotted owl)
MAMMALS
Perognathus longimembris (little pocket mouse)
Dipodomys agilis (Pacific kangaroo rat)
Dipodomys merriami (Merriam's kangaroo rat)
Neotoma macrotis (large-eared woodrat)
Ammospermophilus leucurus (Antelope ground squirrel)
Odocoileus hemionus (mule deer)
Taxidea taxus (American badger)
Puma concolor (mountain lion)
** *Indicates insufficient data to model species.*

The 23 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., coast horned lizard). They include habitat specialists (e.g., California treefrog in riparian habitats) and those requiring a specific configuration of habitat types and elements (e.g., tarantula hawks that require hilltopping habitat). Dispersal distance capability of focal species ranges from 30 m to 274 km; and modes of dispersal include flying, swimming, climbing, walking, 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). 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).

Four species were found to meet these criteria and were used in permeability analyses to identify the least-cost corridor between protected core areas: mountain lion, badger, mule deer, and Pacific kangaroo rat. Ranks and weightings adopted for each species are shown in Table 2.

The relative cost of travel was assigned for each of these 4 focal species based upon its ease of movement through a suite of landscape characteristics (land cover, 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: (Vegetation * w%) + (Road Density * x%) + (Topography * y%) + (Elevation * z%) = Cost to Movement, where w + x + y + z = 100%.

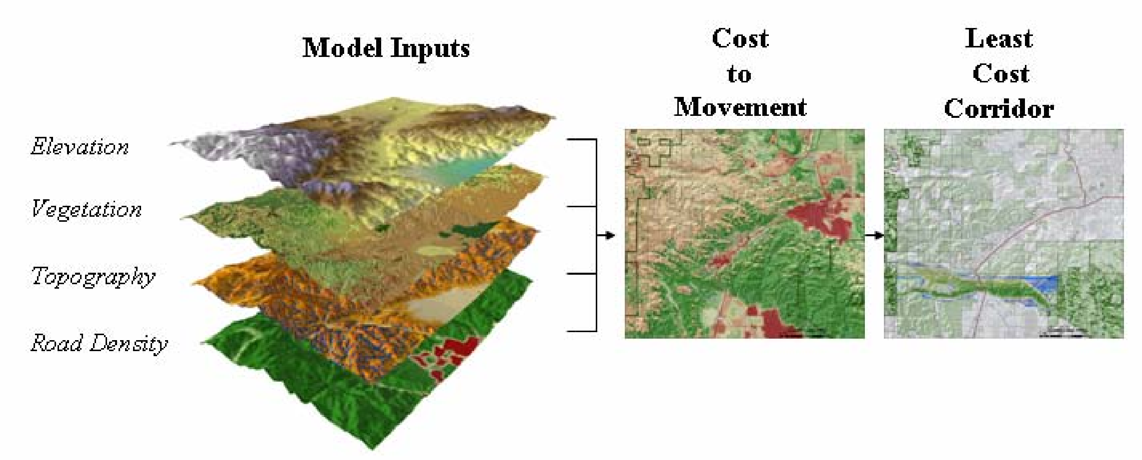


Figure 6. Permeability Model Inputs: elevation, vegetation, topography, and road density. Landscape permeability analysis models the relative cost for a species to move between core areas based on how each species is affected by various habitat characteristics.

Table 2. Model Parameters for Landscape Permeability Analyses

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

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

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

Running the permeability analysis required identifying the endpoints to be connected. Typically, targeted endpoints are selected as medium to highly suitable habitat within protected core habitat areas (e.g., National Forests, State Parks) that needed to be connected through currently unprotected lands. For this analysis, we identified areas supporting medium to highly suitable habitat for each species in the San Bernardino National Forest, Bighorn Mountain and Whitewater River National Recreation Area, Santa Rosa and San Jacinto Mountains National Monument, and protected lands in the Badlands in order to give 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 4 species was then combined to generate a Least Cost Union. The biological significance of this Union can best be described as the zone within which all 4 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 Analysis

Although the Least-Cost Union identifies the best zone available for movement based on the data layers used in the analyses, it does not address whether suitable habitat in the Union occurs in large enough patches to support viable populations and 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 coast horned 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 sizes of all suitable habitat patches in the planning area were identified as potential core areas, patches, or less than a patch. *Potential core areas* were defined as the amount of contiguous suitable habitat necessary to sustain at least 50 individuals. A *patch* was defined as the area of contiguous suitable habitat needed to support at least one male and one female, but less than the potential core area. Potential cores are probably capable of supporting the species for several 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).

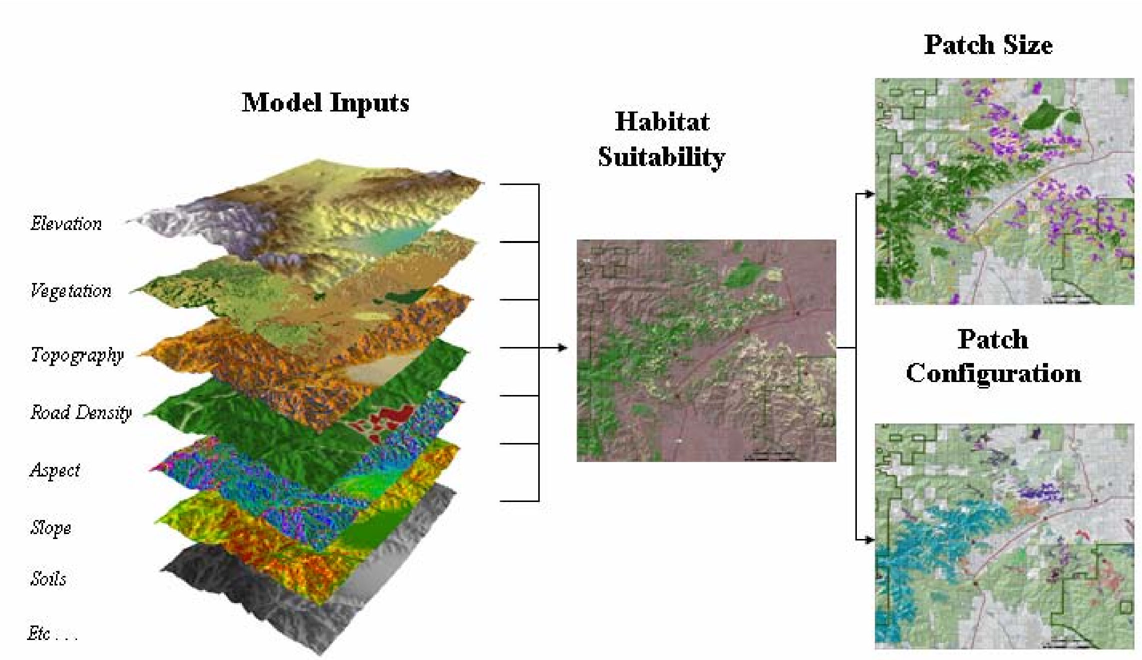


Figure 7. Model Inputs to Patch Size and Configuration Analyses vary by species. Patch size delineates cores, patches, and stepping-stones of potential habitat. Patch configuration evaluates whether suitable habitat patches and cores are within each species dispersal distance.

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 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, or culvert) 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, or natural); passageway construction (concrete, metal, or other); visibility to other side; light level; fencing; and vegetative community within and/or adjacent to the passageway. Existing highways and crossing structures are not considered permanent landscape features. In particular, crossing structures can be added or improved during projects to widen and realign highways and interchanges. Therefore, we also identified areas where crossing structures could be improved or installed, and opportunities to restore vegetation to improve road crossings and minimize roadkills.

Identify Conservation Opportunities

The Linkage Design serves as the target area for linkage conservation opportunities. We provided biological and land use summaries, and identified implementation opportunities for agencies, organizations, and individuals interested in helping conserve the San Bernardino-San Jacinto 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

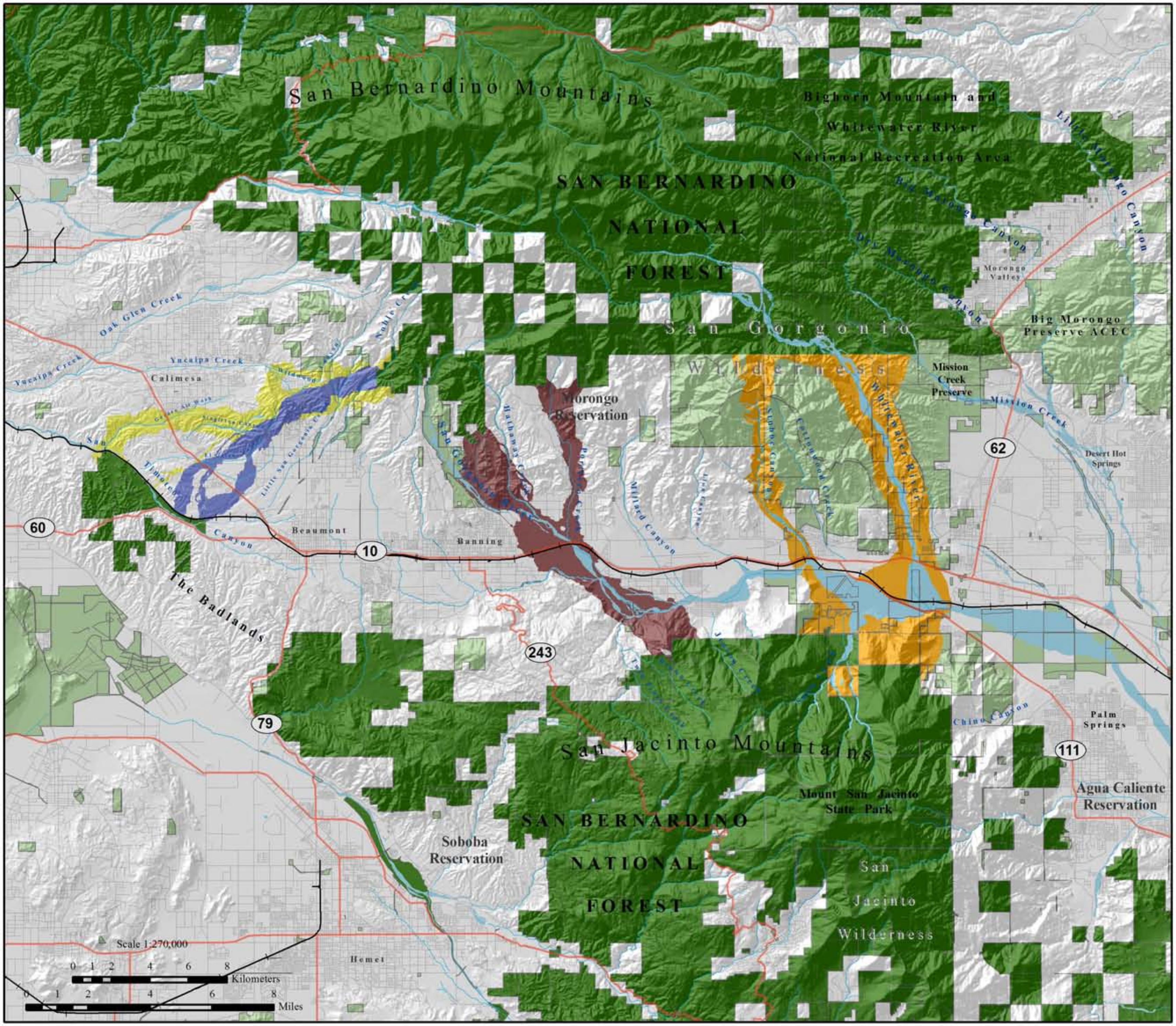
We conducted landscape permeability analyses for 4 focal species (mountain lion, American badger, mule deer, and Pacific kangaroo rat). The least cost corridors for these 4 species were quite distinct due to their diverse ecological and movement requirements (see following species accounts in this section and Table 2 in the previous section). However, there was some overlap in the western part of the linkage, with Pacific kangaroo rat following a similar, but narrower pathway as mule deer in the western part of the linkage (Figure 8).

The Least Cost Union (i.e., the union of all the least-cost corridors for each of the 4 species) stretches approximately 12 to 14 km (7.4-8.7 mi) between conserved habitats in the San Bernardino Mountains and the San Jacinto Mountains and the Badlands. It encompasses a diversity of vegetation types to account for the needs of the focal species, including coastal sage scrub, oak woodland and grassland in the western part of the Union transitioning to desert scrub communities to the east of the San Gorgonio River (Figure 9).

The several branches of the Least Cost Union indicate the distribution of the preferred habitats for these target species, encompassing a diversity of vegetation communities and topographic features. Coastal sage scrub, grassland, and mixed chaparral habitats dominate the western branch of the Union, which ranges in width from about 2 to 6 km (1.2-3.7 mi), providing a connection of coastal habitats between the San Bernardino Mountains and the Badlands. The central branch takes in portions of the San Gorgonio River, and Mias, Hathaway, and Potrero canyons north of Interstate 10 and follows the San Gorgonio River south of the freeway to enter Brown Creek Canyon in the San Jacinto Mountains. The central branch of the Union ranges in width from approximately 1 to 3 km (0.6-1.9 mi), and encompasses both coastal and desert influenced habitats. To the east, a narrow branch about 1 to 1.5 km (0.6 to 0.9 mi) wide includes Stubbe Canyon, which merges with the San Gorgonio River immediately south of Interstate 10 to enter Snow Creek Canyon in the San Jacinto Mountains. The easternmost branch of the Union follows the Whitewater River, dominated by a gallery forest of montane and valley foothill riparian habitats for much of its length, with desert wash habitat in areas of the river that are cleared by public agencies, and desert scrub and creosote scrub habitats in the uplands. This branch of the Union ranges in width from about 2 to 6 km (1.2-3.7 mi).

The next several pages summarize the permeability analyses for each of the 4-modeled species. For convenience, the narratives describe the most permeable paths from north to south, 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 latter analysis 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 with Species Overlap



- Mountain lion
- Badger
- Mule deer
- Pacific Kangaroo rat
- Target Areas*
- Protected Lands
- Roads
- Rivers & Streams
- Railroads

*This analysis was run from medium to high suitable habitat within targeted protected areas.

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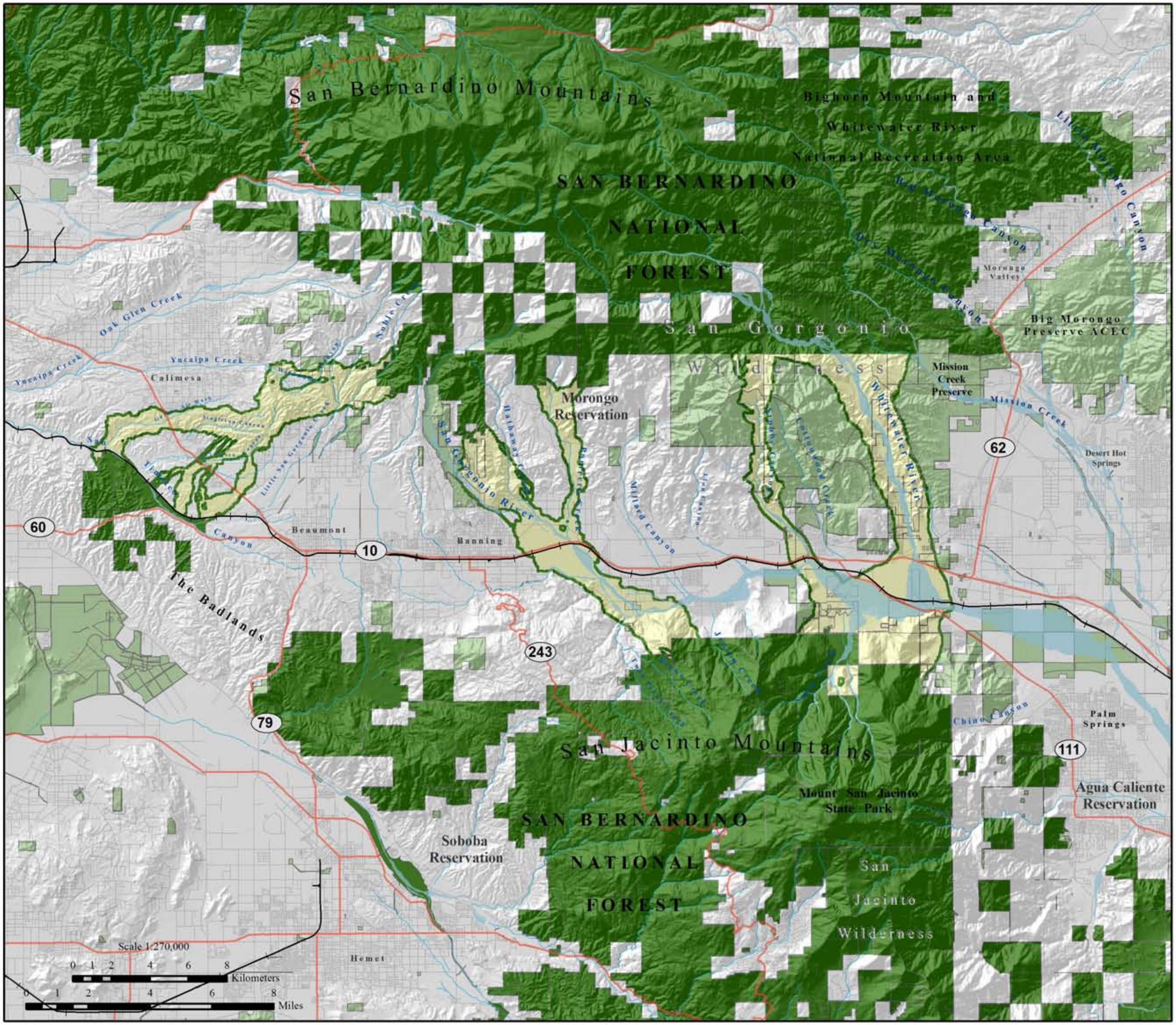
Figure 9.
Least Cost Union



- Least Cost Union
- Target Area
- Protected Lands
- Roads
- Rivers & Streams
- Railroads

*This analysis was run from medium to high suitable habitat within targeted protected areas.

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Mountain lion (*Puma concolor*)

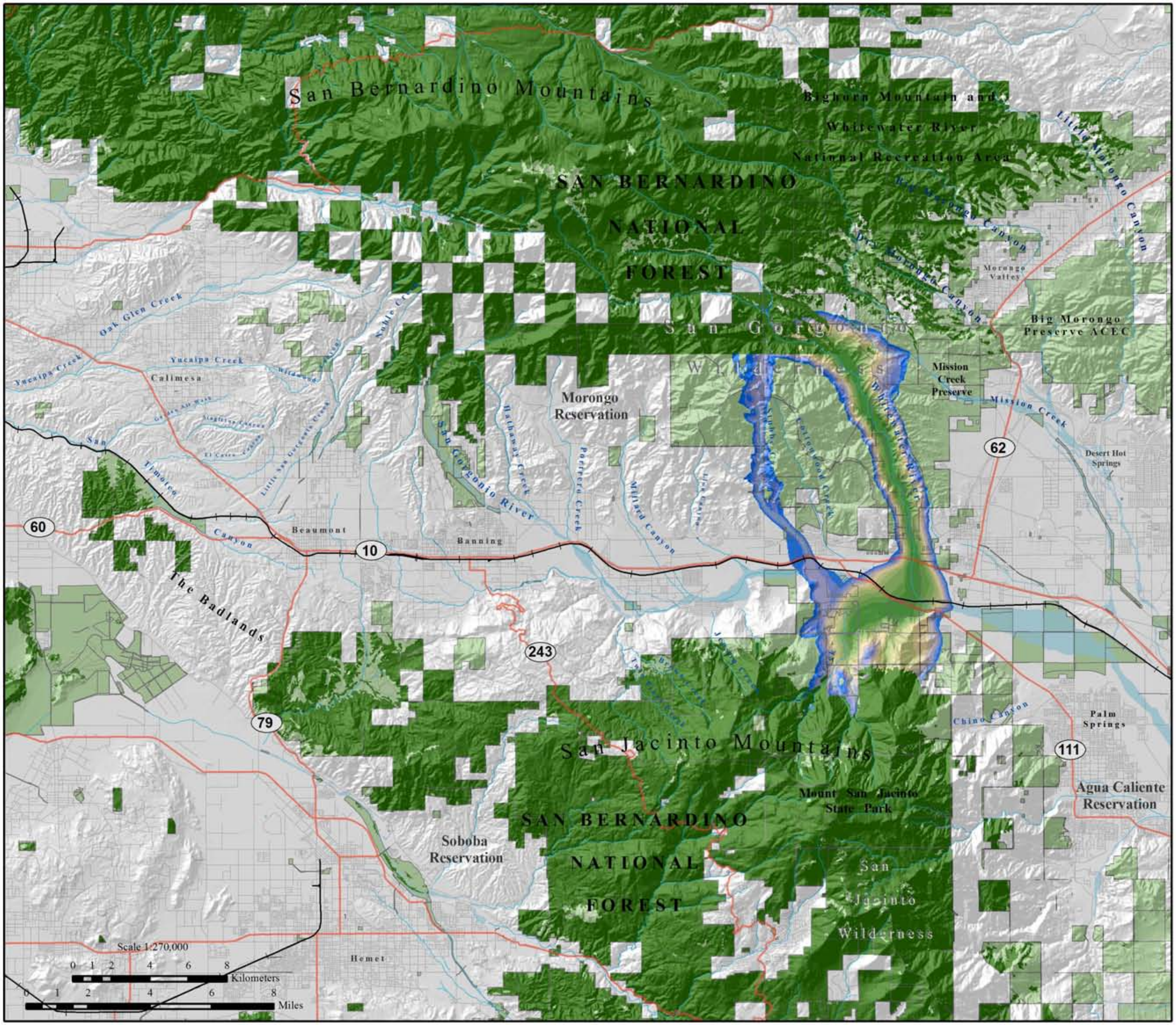
Justification for Selection: This area-sensitive species is an appropriate focal species because its naturally low densities render mountain lions highly sensitive to habitat fragmentation (Noss 1991, Noss and Cooperrider 1994), and loss of large carnivores can have adverse ripple effects through the 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 the 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 the San Bernardino Mountains and the San Jacinto Mountains is shown in Figure 10. The most permeable path emanates from the San Bernardino Mountains and follows the Whitewater River until reaching Highway 111, where the corridor widens to encompass habitats at the confluence of the San Gorgonio and Whitewater rivers, before ascending into the San Jacinto Mountains via Snow Creek Canyon and Windy Point. This route varies in width from 2 to 6 km (1.2-3.7 mi). Another much narrower route follows Stubbe Canyon and merges with the San Gorgonio River immediately south of Interstate 10 before entering Snow Creek Canyon in the San Jacinto Mountains. This corridor varies in width from about 1 to 1.5 km (0.6 to 0.9 mi). Although not identified as the most permeable path by this analysis, the San Gorgonio River provides a secondary connection for this species.

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



Least Cost Corridor

- Highly Permeable
- Less Permeable
- Suitable Habitat*
- Protected Lands
- Rivers & Streams
- Roads
- Railroads

*This analysis was run from medium to high suitable habitat within targeted protected areas.

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American badger (*Taxidea taxus*)

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

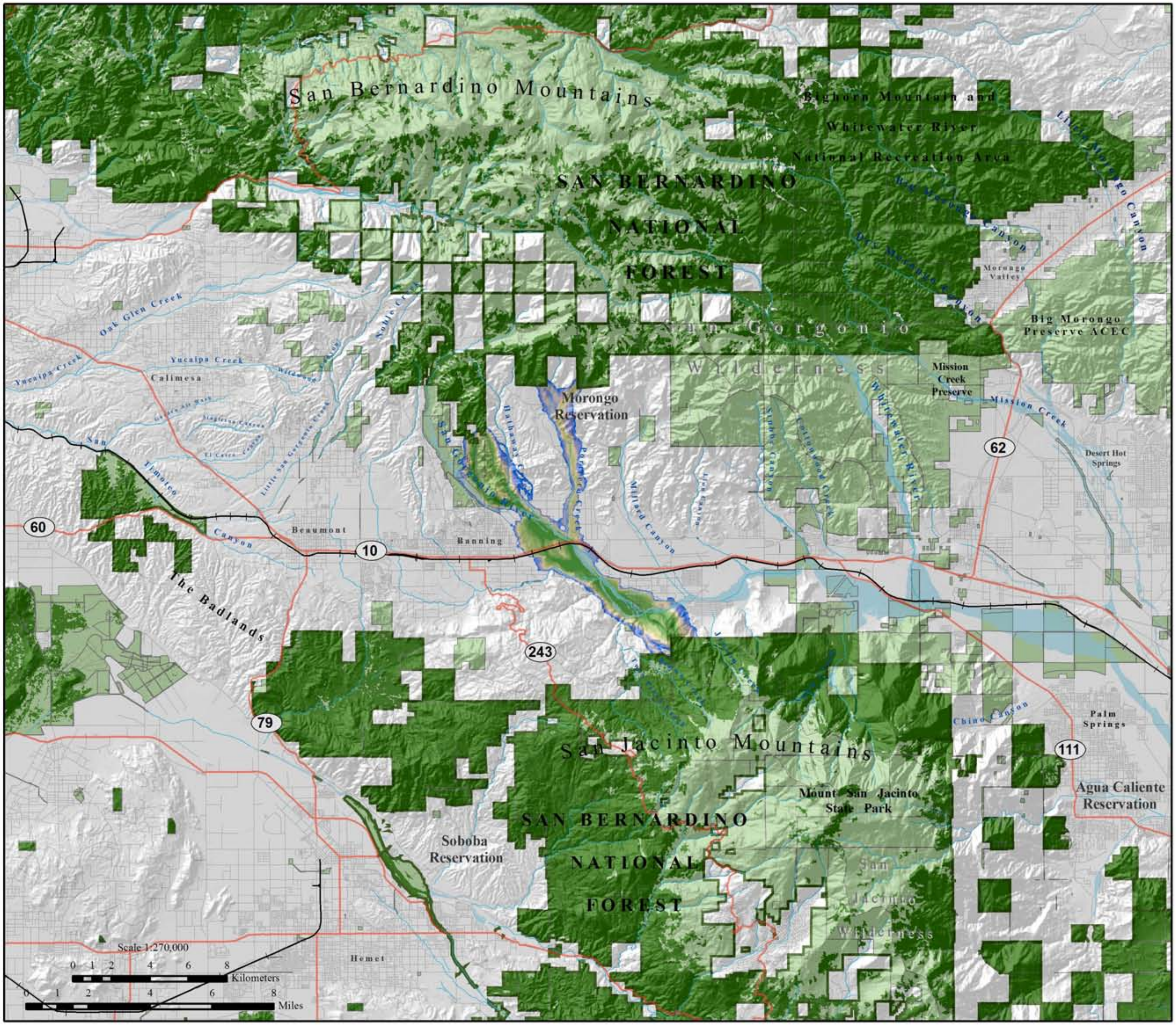
Conceptual Basis for Model Development: Badgers are associated with grasslands, prairies, and other open habitats that support abundant burrowing rodents (de Vos 1969, Banfield 1974, Sullivan 1996) but they may also be found in drier open stages of shrub and forest communities (Zeiner et al. 1990). They 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 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 least cost corridor for badger moving between targeted protected areas varies in width from 1 to 3 km (0.6-1.9 mi), and has two major branches that merge north of Interstate 10 (Figure 11). The most permeable path encompasses portions of the San Gorgonio River, and Mias and Hathaway canyons, which both flow into the San Gorgonio River north of the freeway to enter Brown Creek Canyon in the San Jacinto Mountains near Hurley Flat. The other branch extends from Burro Flats in the San Bernardino Mountains and follows Potrero Creek to the San Gorgonio River. The least cost corridor for badger basically takes in the remaining suitable habitat along Interstate 10 between the cities of Banning and Cabazon. Both movement routes contain medium to highly suitable habitat (e.g., desert scrub, desert wash, grassland, and coastal sage scrub) and the gently sloping terrain preferred by badgers. Although both movement routes encounter gravel mines in the floodplain of the San Gorgonio River, sufficient habitat is included within the linkage to facilitate movement of badgers in this area.

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



Least Cost Corridor

- Highly Permeable
- Less Permeable
- Suitable Habitat*
- Protected Lands
- Rivers & Streams
- Roads
- Railroads

*This analysis was run from medium to high suitable habitat within targeted protected areas.

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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).

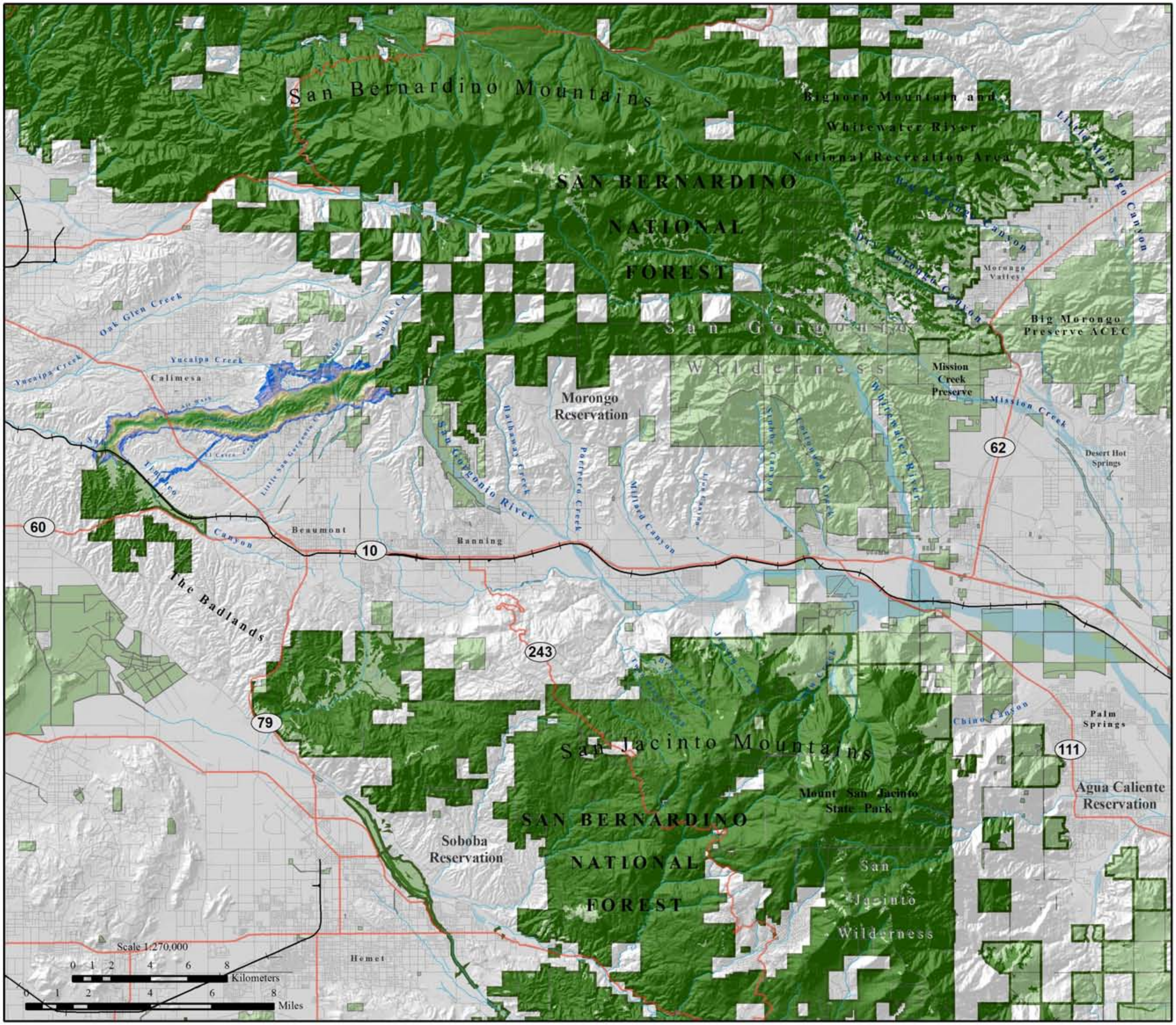
Conceptual Basis for Model Development: Mule deer use forest, woodland, brush, and meadow habitats, and reach their highest densities in oak woodlands, riparian areas, and along edges of meadows and grasslands. However, they also occur in open scrub, young chaparral, and low elevation coniferous forests (Bowyer 1986, USFS 2002). Access to a perennial water source is critical in summer. The San Bernardino Mountains population has both migratory and resident components (Nicholson et al. 1997).

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. They 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: The least cost corridor for mule deer traveling between targeted protected areas extends from the proposed San Gorgonio Wilderness addition in the San Bernardino Mountains follows Noble Creek for approximately 4 km (2.5 mi), crosses over Little San Gorgonio Creek to enter Singleton Canyon before crossing Interstate 10 using Garden Air Wash towards San Timoteo Canyon and the Badlands (Figure 12). The most permeable path takes in a broad band of medium to highly suitable habitat for mule deer, ranging in width from 1 to 3 km (0.6-1.9 mi), with other branches narrowing to less than 0.5 km (0.3 mi) wide. The least cost corridor encompasses most of the remaining natural habitats between the city of Calimesa and the community of Cherry Valley. Coastal scrub, grassland, and mixed chaparral are the dominant plant communities, with some riparian and oak woodlands interspersed.

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



Least Cost Corridor
- Highly Permeable
- Less Permeable
- Suitable Habitat*
- Protected Lands
- Rivers & Streams
- Roads
- Railroads

*This analysis was run from medium to high suitable habitat within targeted protected areas.

N

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Pacific kangaroo rat (*Dipodomys agilis*)

Justification for Selection: The Pacific kangaroo rat is sensitive to habitat loss and fragmentation. Kangaroo rats may cross some roads but have difficulty navigating wide roads and other barriers (e.g., freeways, agricultural fields and urban areas) and are highly susceptible to roadkill. Kangaroo rats may avoid areas with artificial night lighting due to elevated predation risks. This species is generally more tolerant of tree or shrub cover, and probably better able to navigate through denser vegetation than some other kangaroo rat species (W. Spencer, pers. comm.).

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

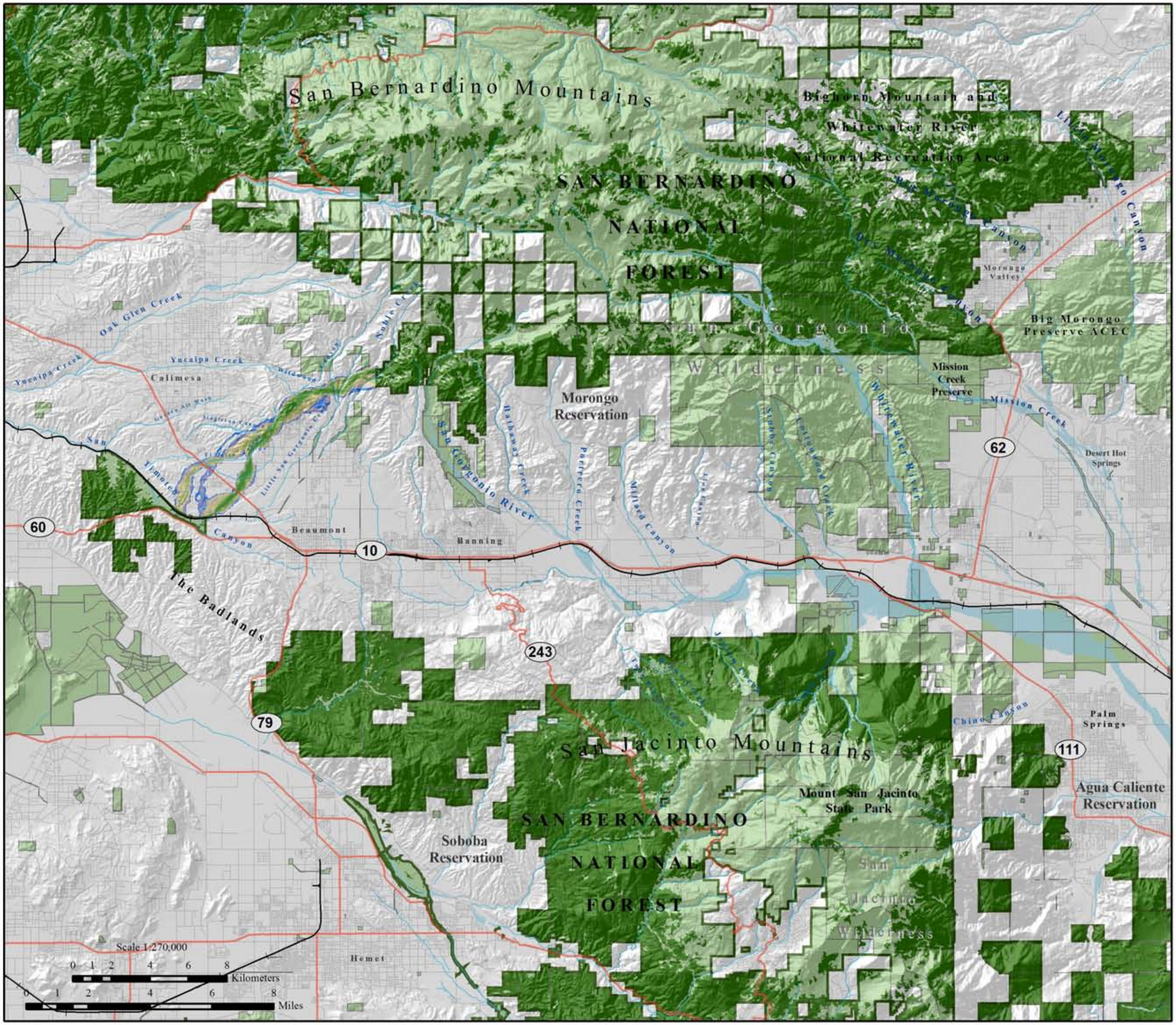
This kangaroo rat tends to be more mobile than most rodents of its size, and more so than other kangaroo rats. Most information on movements and ecology are very similar to Merriam's kangaroo rat, although with less supporting literature (W. Spencer pers. comm.). Merriam's kangaroo rat typically remains within 1-2 territories (100 m [330 ft] or so) of their birthplace, but the species is capable of longer dispersal. Zeng and Brown (1987) recorded long-distance (= dispersal) movements in adult Merriam's kangaroo rats, concluding that they are opportunistic in moving into newly available territory areas.

The Pacific kangaroo rat preferentially moves through open habitat in early successional communities. They avoid roads, densely vegetated communities, and urban areas. Please see Table 2 for model variable scorings for this species. Cost to movement for Pacific kangaroo rat was defined by weighting these inputs as follows:

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

Results & Discussion: The most permeable path for Pacific kangaroo rat closely resembles the output for mule deer (Figure 13). The least cost corridor follows the same pathway as mule deer for approximately 6 km (3.7 mi), but then branches to include El Casco Canyon and upland habitats between El Casco and Little San Gorgonio Creek before entering San Timoteo Canyon and the Badlands.

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



Least Cost Corridor

- Highly Permeable
- Less Permeable
- Suitable Habitat*
- Protected Lands
- Rivers & Streams
- Roads
- Railroads

*This analysis was run from medium to high suitable habitat within targeted protected areas.

N

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Patch Size & Configuration Analyses

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, it does not address whether suitable habitat in the Union occurs in large enough patches to support viable populations or whether patches are close enough together to allow for inter-patch dispersal; and they are based on only 4 of the 22 focal species. We therefore perform habitat suitability, patch size and configuration analyses to evaluate the configuration and extent of potentially suitable habitat in the Least Cost Union for all 22 focal species. This helps determine whether there is sufficient habitat within the 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 22 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 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 between the targeted core areas for 9 of the 22 modeled focal species: mountain lion, mule deer, badger, Pacific kangaroo rat, rock wren, speckled rattlesnake, tarantula hawk, metalmark butterfly, and green hairstreak butterfly. Model outputs suggest that the Union contains sufficient potential habitat to support populations of some species, or that patches are spaced close enough together to allow stepping-stone movement between core areas for others. The Union has little or no suitable habitat for California spotted owl and pygmy nuthatch, which are associated with montane hardwood and conifer habitats. However, these species may occasionally cross the linkage between mountain ranges. The patch configuration analyses suggest that some inter-patch distances may be too great for 4 of the focal species: large-eared woodrat, pygmy nuthatch, wrentit, and coast horned lizard. However, over many generations weather events can increase the likelihood of colonization from distant patches. Eleven focal species were determined to require habitat outside of the Least Cost Union, though there was significant overlap in the additional habitats required to meet their needs (Figure 14).

Species that require habitat outside of the Least Cost Union to protect the long term viability of populations include antelope ground squirrel, large-eared woodrat, Merriam's kangaroo rat, little pocket mouse, wrentit, chaparral whipsnake, coast horned lizard, California treefrog, California sagebrush, white alder, and the slender-horned spineflower. Habitat was added to the Union in 6 general areas to ensure that the Linkage Design accommodates each focal species (Figure 14):

San Gorgonio River & Hathaway Canyon: This habitat addition protects a key movement corridor and natural hydrological and fluvial processes, as well as preserving live-in habitat for several species. The landscape permeability analysis for badger utilized portions of the San Gorgonio River and Hathaway Canyon to move between ranges. Riparian and upland habitats were added to the Union in upper Hathaway Canyon and along the River to its confluence with the Whitewater River to meet the habitat and movement requirements of the antelope ground squirrel, little pocket mouse, Merriam's kangaroo rat, coast horned lizard, California treefrog, California sagebrush, and the endangered slender-horned spineflower. The minimum width of 2 km was imposed here to ensure that the functional processes of the linkage are protected. While this habitat addition provides an essential east-west connection for several focal species, it also helps maintain evolutionary pathways for several unique subspecies. This addition will also help to maintain the fluvial processes necessary for sustaining habitats in the linkage, which will benefit numerous species, including those not specifically addressed by our analyses, such as the endangered Coachella Valley fringe-toed lizard and the Coachella Valley milk-vetch.

Foothills of the San Jacinto Mountains: This addition was particularly important for 6 focal species associated with coastally influenced habitats: slender-horned spineflower, California sagebrush, chaparral whipsnake, coast horned lizard, large-eared woodrat, and wrentit. Many other species that utilize coastal scrub habitats (e.g., mountain lion, mule deer, rock wren, tarantula hawk, green hairstreak butterfly) will also benefit from this addition. The minimum width of 2 km makes the linkage more robust to edge effects and provides adequate configuration of suitable habitat for these species.

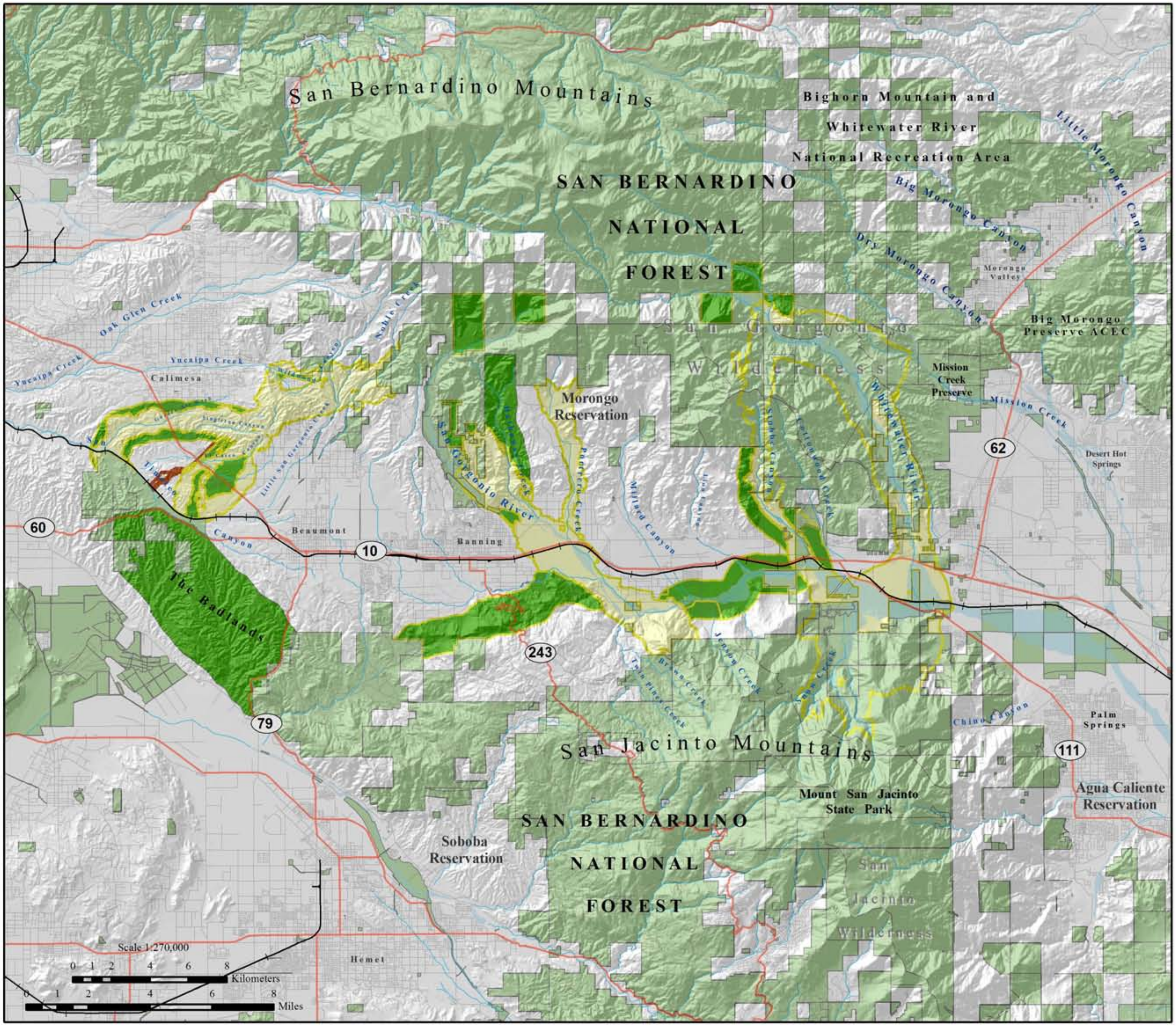
Stubbe Canyon: The Union was also modified to include upland habitats along Stubbe Canyon to meet the minimum corridor width of 2 km and to accommodate orthogonal species (i.e., species with little habitat in targeted core areas but living within the linkage), such as little pocket mouse, Merriam's kangaroo rat, and antelope ground squirrel. This addition was also necessary for 2 species with riparian movement needs (California treefrog and white alder), as it provides a secondary riparian connection between ranges in addition to the Whitewater River. This addition to the Union also provides the only suitable habitat in the linkage for California spotted owl and pygmy nuthatch. Numerous other focal species will also benefit from this addition.

Garden Air Wash & El Casco Canyon: Though most of the land outside of the western branch of the Union has largely been converted, the minimum width of 2 km was imposed here to ensure that the functional processes of the linkage are protected.

Badlands: We added a 4 km wide and 8 km long swath of natural habitats linking existing protected lands in the Badlands. This addition will benefit virtually all focal species and provides significant core areas for multiple species reliant on coastal sage scrub habitats.

Forest Service Inholdings: The Union was modified to include riparian and upland habitats in the upper watersheds of the San Gorgonio and Whitewater rivers to ensure the integrity of the targeted core habitat in the San Bernardino Mountains is protected. Several focal species will benefit from this addition including mountain lion, badger, mule deer, Pacific kangaroo rat, large-eared woodrat, spotted owl, pygmy nuthatch, and wrentit.

Figure 14.
Least Cost Union
Additions & Subtractions



Least Cost Union
Addition
Subtraction
Protected Lands
Rivers & Streams
Roads
Railroads

N

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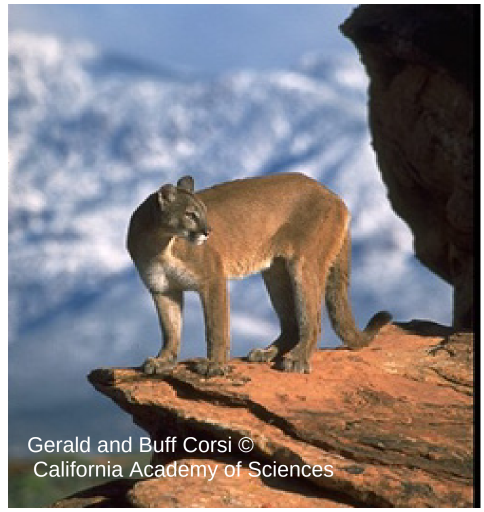
Mountain lion (*Puma concolor*)



Distribution & Status: Mountain lions (also known as puma or cougar) 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 and 5,940 ft) in elevation (Zeiner et al. 1990). 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 puma the status of a California Specially Protected species, though depredation permits are still issued (Torres 2000).

Habitat Associations: The mountain lion is a habitat generalist, utilizing many brushy or forested habitats providing good cover (Spowart and Samson 1986, Zeiner et al. 1990). They use rocky cliffs, ledges, and vegetated ridgetops that provide cover when hunting prey (Chapman and Feldhamer 1982, Spowart and Samson 1986), especially mule deer, *Odocoileus hemionus* (Lindzey 1987). Den sites may be located on cliffs, rocky outcrops, caves, in dense thickets, or under fallen logs (Ingles 1965, Chapman and Feldhamer 1982). In southern California, most cubs are reared in thick brush (Beier et al. 1995). They prefer vegetated ridgetops and stream courses as travel corridors and hunting routes (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 documented annual home range sizes between 250 and 817 km^2 (315 mi^2; Pierce et al. 1999). Home ranges in southern California averaged 93 km^2 (36 mi^2) for 12 adult females and 363 km^2 (140 mi^2) 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 and are tolerant of transients of both sexes, while the home range 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 about 1.05-1.2 adults per 100 km^2 (39 mi^2).

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) found mountain lions moved 6 km (3.7 mi) per night and dispersed 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, though they prefer not to do so (Logan and Sweanor 2001). To allow for dispersal of juveniles and the immigration of transients, lion management should be done 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 using patches $\geq$ 10,000 km^2 (3,861 mi^2). Patch size was classified as $\geq$ 200 km^2 (77 mi^2) 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*:* Extensive habitat exists for mountain lion in the San Bernardino and San Jacinto mountains and the Badlands (Figure 15). The easternmost branch of the Least Cost Union contains the most highly suitable contiguous habitat for mountain lion between protected core areas, though the western and central branches of the Union may also provide secondary connections. The least cost corridor (Figure 10) follows the Whitewater River and Stubbe Canyon, which was expected given their preference for using stream courses as travel corridors (Spowart and Samson 1986, Beier and Barrett 1993). The patch size analysis (Figure 16) emphasizes the importance of maintaining connectivity between these ranges, as neither the San Bernardino nor San Jacinto Mountains are large enough (> 10,000 km^2) to support a core population. All potential cores and patches of suitable habitat are within puma's dispersal distance (figure not shown). We conclude that the Union is likely to serve puma if habitat is added to the Union to meet the minimum corridor width of 2 km and habitat restoration efforts are undertaken in the Whitewater River.

This species requires expansive roadless areas to survive 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 lion between the targeted protected areas, we recommend that:

- Habitat restoration is initiated in Whitewater River to re-establish a gallery forest along the length of the river to its confluence with the San Gorgonio River.

- Existing road density be maintained or reduced in the Linkage Design.

- Lighting is directed away from the linkage and crossing structures. Species sensitive to human disturbance, like puma, avoid areas that are artificially lit (Beier 1995).

- Local residents are informed about: the value of carnivores to the system; the use of predator safe enclosures for domestic livestock and pets; and the habits of being thoughtful and safe stewards of the land.

Figure 15.
Habitat Suitability for Mountain lion
(Puma concolor)

Degree of Suitability
- High
- Medium to High
- Medium
- Low to Medium
- Low
- Least Cost Union
- Protected Lands
- Rivers & Streams
- Roads
- Railroads

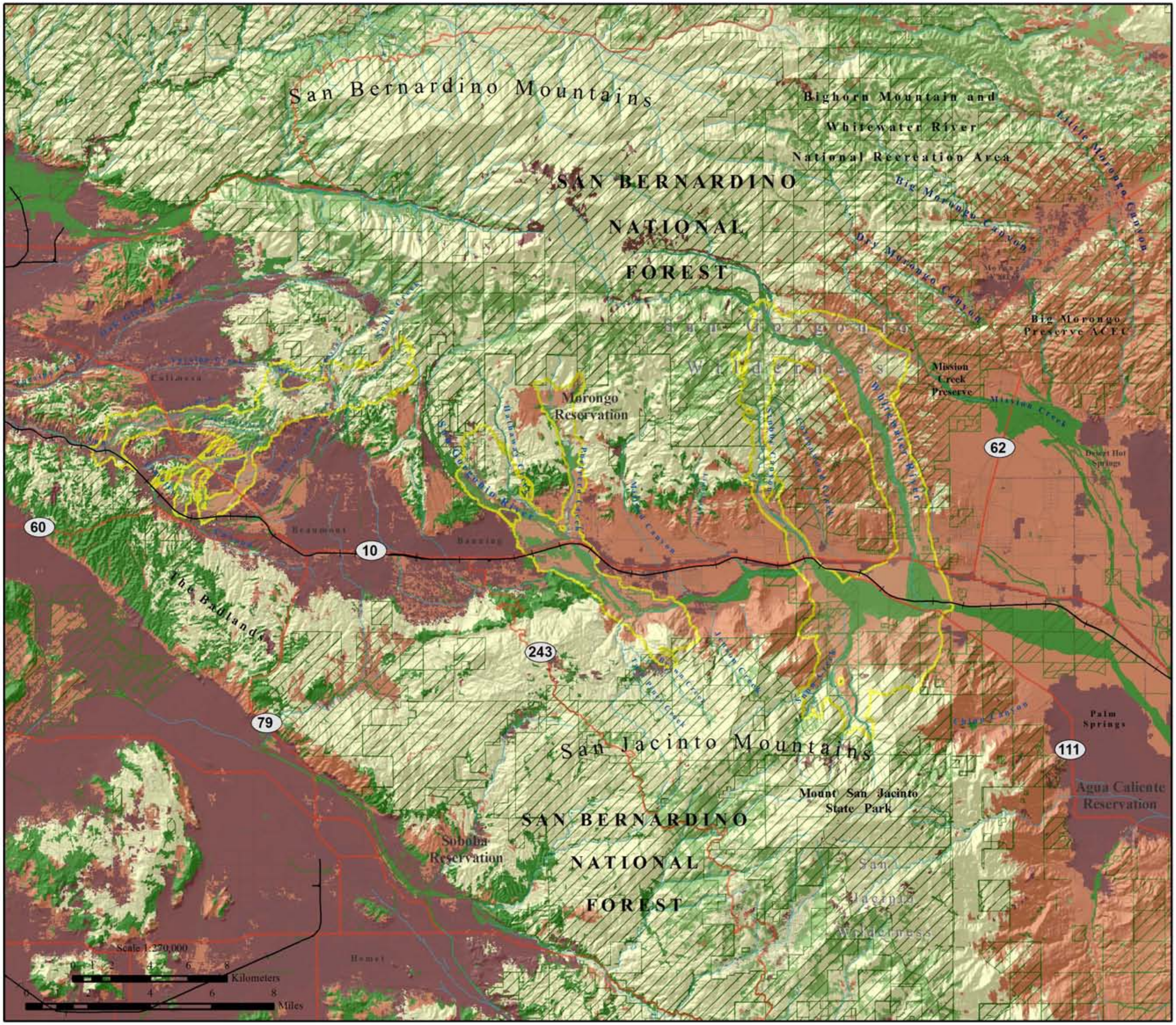


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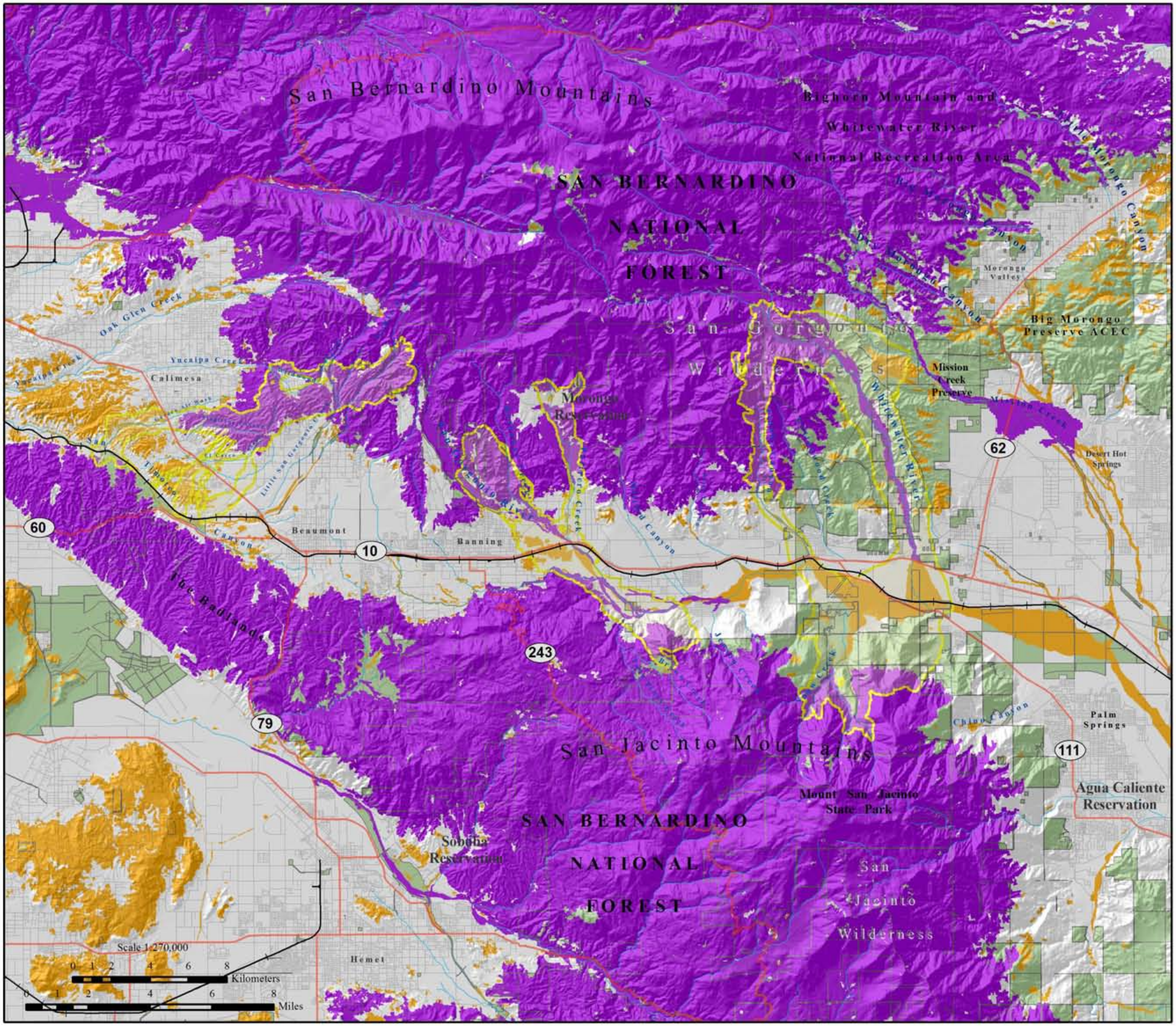
Figure 16.
Potential Cores & Patches
for
Mountain lion
(Puma concolor)



Patch
< Patch
Least Cost Union
Protected Lands
Rivers & Streams
Roads
Railroads

N

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American badger (*Taxidea taxus*)

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


Gerald and Buff Corsi © CA Academy of Sciences

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 haven't 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). The species is typically found at lower elevations (Zeiner et al. 1990) in flat, rolling, or steep terrain but it has been recorded at elevations up to 3,600 m (12,000 ft; Minta 1993).

Spatial Patterns: Home range sizes for this species vary both geographically and seasonally. Depending on location, male home ranges have been estimated to vary from 240-850 ha (593-2,100 ac) while female home ranges are from 137-725 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) found fall and winter home ranges of females varied from 137-304 ha (339-751 ac), while males varied from 537-627 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).

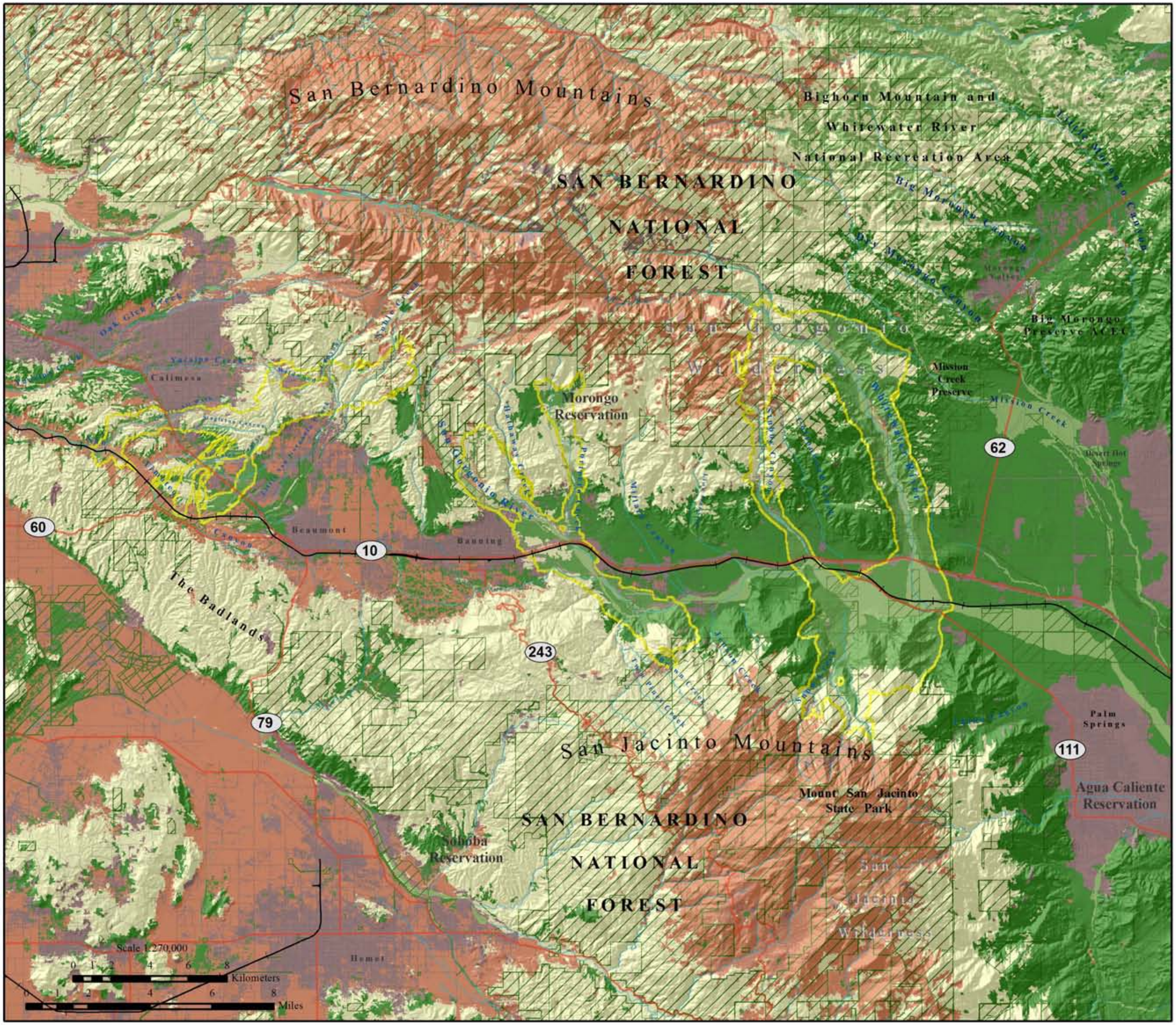
Conceptual Basis for Model Development: Badgers prefer grasslands, meadows, open scrub, desert washes, and open woodland communities. Terrain may be flat, rolling or steep, but below 3,600 m (12,000 ft) elevation. Core areas capable of supporting 50 badgers are equal to or greater than 16,000 ha (39,500 ac). Patch size is ≥ 400 ha (990 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 vast amounts of suitable badger habitat in the Least Cost Union, with the most highly suitable contiguous habitat captured in the central and eastern branches of the Union, which are dominated by desert scrub and desert wash habitats (Figure 17). The least cost corridor for badger (Figure 11) delineated the central branch of the Union. The majority of suitable habitat within the planning area is contiguous, and thus was identified as core habitat for this species (Figure 18). All potential suitable habitat patches are 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; although habitats added for other focal species will also benefit badger.

Road kill is a primary cause of death for badgers. To restore and protect habitat connections for badger, we recommend that:

- Existing road density be maintained or reduced in the Linkage Design.
- Fencing be installed along freeways to guide badgers to passageways.
- Lighting is directed away from the linkage and crossing structures.

Figure 17.
Habitat Suitability
for
American badger
(Taxidea taxus)



Degree of Suitability
- High
- Medium to High
- Medium
- Low to Medium
- Low
- Least Cost Union
- Protected Lands
- Rivers & Streams
- Roads
- Railroads

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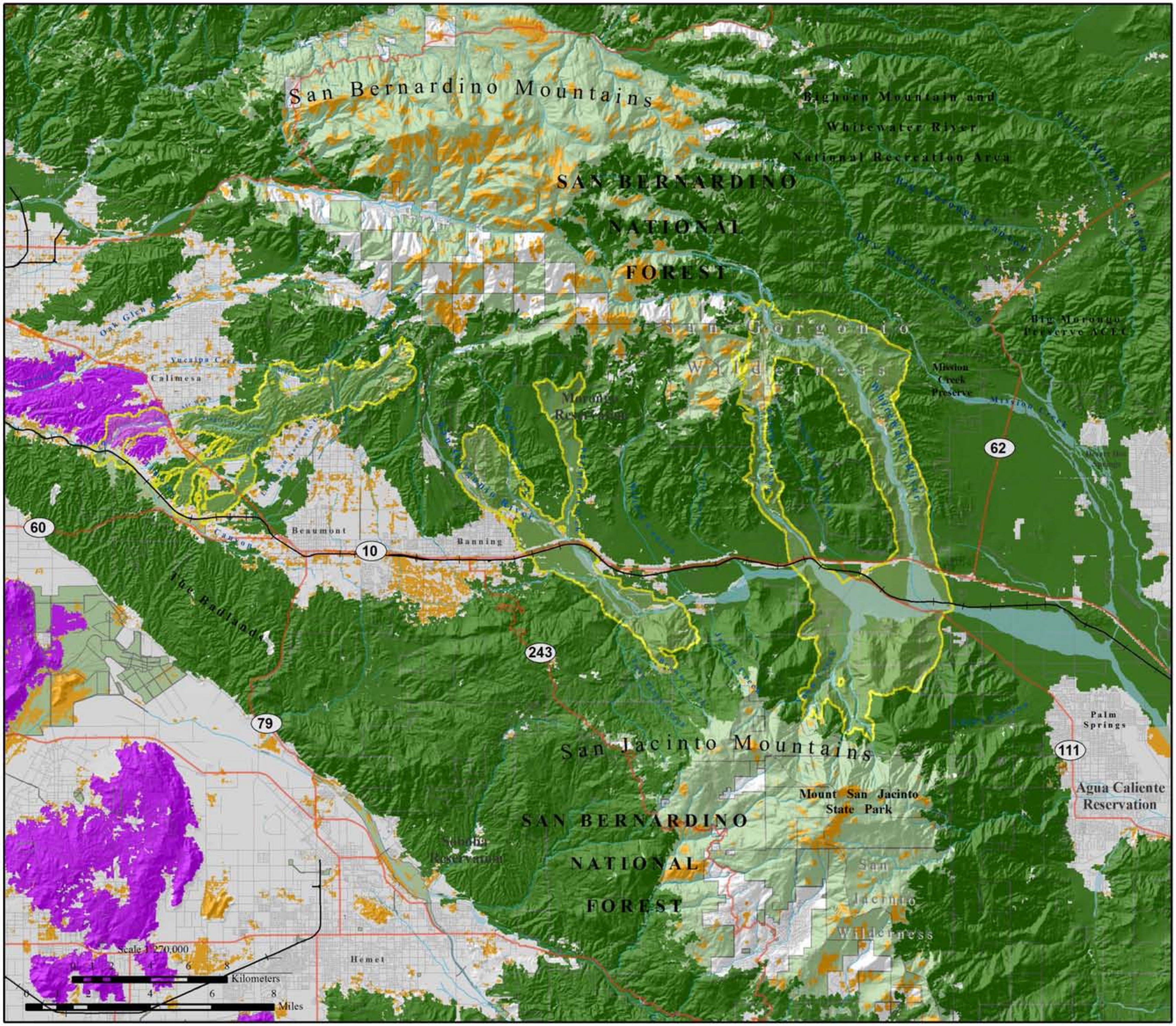
Figure 18.
Potential Cores & Patches
for
American badger
(Taxidea taxus)



Core
Patch
< Patch
Least Cost Union
Protected Lands
Rivers & Streams
Roads
Railroads

N

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Mule deer (*Odocoileus hemionus*)


Photo Courtesy of USFWS

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: This species requires a mosaic of habitat types of different age classes to meet its 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; Miller 1970) to 3,379 ha (8,350 ac; 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 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 sites throughout California 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 (Loft et al. 1998, CDFG 1983, Nicholson et al.1997, 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: The western branch of the Least Cost Union contains the most suitable habitat for mule deer and also provides the most direct connection between their preferred habitats in the targeted protected areas (Figure 19). Extensive suitable core habitat was identified for mule deer in the San Bernardino and San Jacinto mountains and in the Badlands (Figure 20), with the most highly suitable habitat at mid elevations (Figure 19). 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 western branch of the linkage will likely serve the needs of mule deer traveling through the linkage, while the central branch of the Union may provide a secondary connection for this species.

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 restore and protect habitat connections for mule deer, we recommend that:

- Road barriers be modified to accommodate mule deer movement. Though ungulates much prefer overpasses to underpasses (Gloyne and Clevenger 2001), they will utilize bridged undercrossings if they can see clearly to the other side. Gloyne and Clevenger (2001) suggest underpasses for ungulates be at least 4 m high and 8 m wide, with an openness ratio of 0.9 (where the openness ratio = height x width/length). Crossing structures for mule deer should have natural flooring and no artificial lighting (Reed et al. 1975).

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

- Existing road density be maintained or reduced in the Linkage Design.

Figure 19.
Habitat Suitability for Mule deer
(Odocoileus hemionus)

Degree of Suitability
- High
- Medium to High
- Medium
- Low to Medium
- Low
- Least Cost Union
- Protected Lands
- Rivers & Streams
- Roads
- Railroads

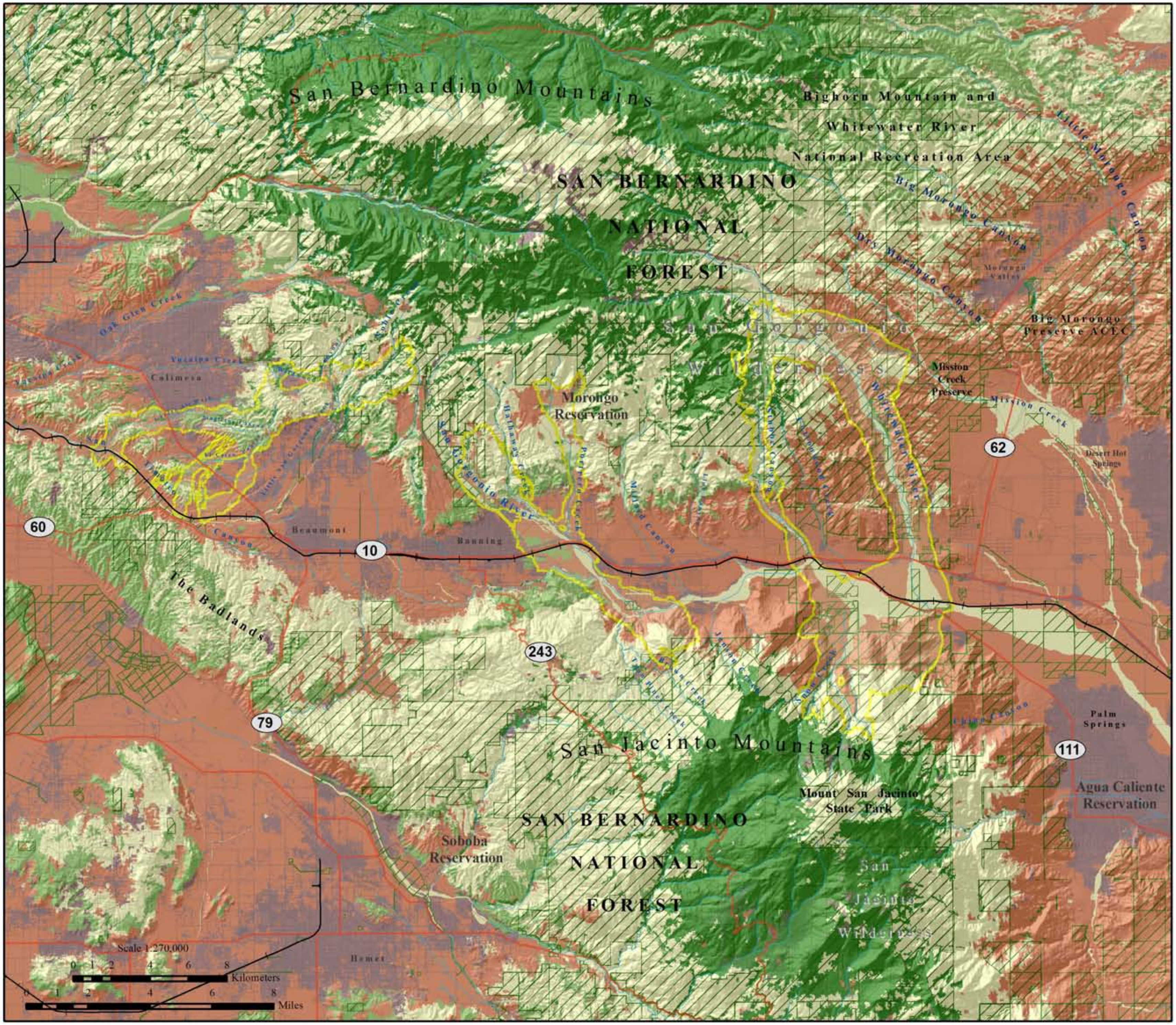

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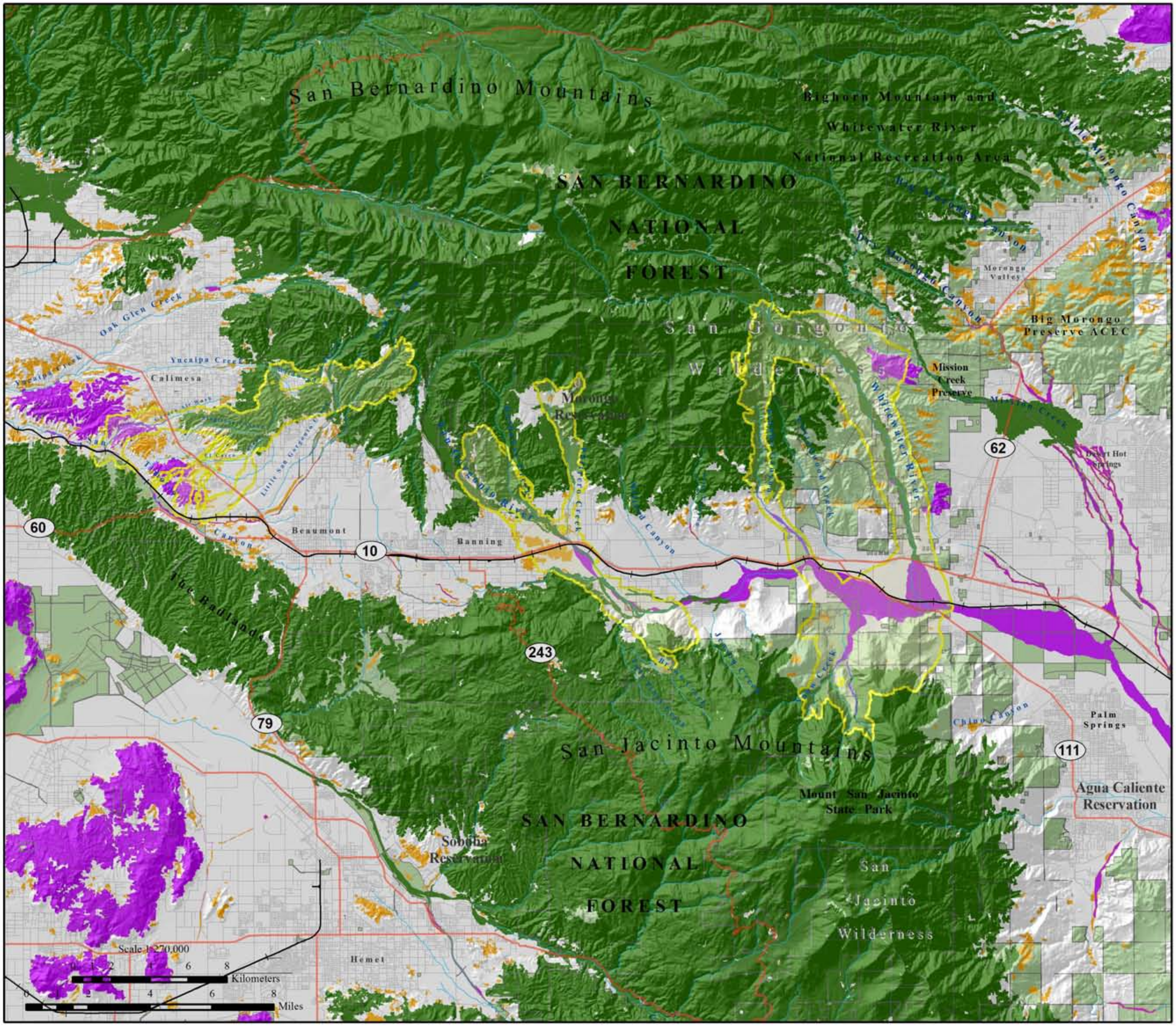
Figure 20.
Potential Cores & Patches
for
Mule deer
(Odocoileus hemionus)



Core
Patch
< Patch
Least Cost Union
Protected Lands
Rivers & Streams
Roads
Railroads

N

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Antelope ground squirrel (*Ammospermophilus leucurus*)

Justification for Selection: The antelope ground squirrel may be a keystone species because its burrows are used by a wide variety of wildlife, including reptiles, insects, and other rodents.

Distribution & Status: Members of the genus *Ammospermophilus* are found in the xeric desert habitats of the southwestern United States and northern Mexico (USFWS 1998, USFS 2002). The antelope ground squirrel is one of five species in the genus (Best et al. 1990, USFS 2002). It is common to abundant in the Great Basin, Mojave, and Colorado deserts of California south to the Mexican border (Miller and Stebbins 1964, Ingles 1965, Bradley and Mauer 1973, Honeycutt et al. 1981, Jameson and Peeters 1988, Zeiner et al. 1990).

Habitat Associations: The most favorable habitats for the antelope ground squirrel are desert scrubs, sagebrush, bitterbrush, and Joshua tree and pinyon-juniper woodlands. They may also be found in desert riparian and desert wash habitats and to a lesser extent in mixed chaparral and annual grassland (Miller and Stebbins 1964, Ingles 1965, Bradley and Mauer 1973, Honeycutt et al. 1981, Zeiner et al. 1990). This species has lower water and energy requirements than non-desert mammals of similar size. Their ability to obtain succulent plant or animal foods throughout the year appears to be their primary survival tool (Nagy 1994). Friable soil for burrowing is a habitat requisite, as burrows are used to escape predators and severe temperatures in the desert environment (Grinnell and Dixon 1919, Bartholomew and Hudson 1961, Bradley 1967, Zeiner et al. 1990). Individuals may utilize numerous burrows within their home range.

Spatial Patterns: In Nevada, home range sizes varied from 1.4-9.4 ha (3.0-20.6 ac) (Allred and Beck 1963, Bradley 1967, Zeiner et al. 1990), with an average of 6.7 ha (14.8 ac; Allred and Beck 1963, Zeiner et al. 1990). Evidently, the antelope ground squirrel is non-territorial (Fisler 1976, 1977, Zeiner et al. 1990), although they occur widely scattered and not clustered in colonies (Jameson and Peeters 1988). No dispersal estimates were found for this species in the literature, though they can home from distances up to 1.6 km (1 mi; Bradley 1968, Zeiner et al. 1990).

Conceptual Basis for Model Development: Movement in the linkage is assumed to be multigenerational. The antelope ground squirrel is restricted to arid desert habitats. Potential core areas were identified as greater than or equal to 168 ha (415 ac). Patch size was classified as $\geq$ 3 ha (7.4 ac) but less than 168 ha. Dispersal distance was defined as 3.2 km (1.9 mi).

Results & Discussion: Extensive suitable habitat was identified for this species in the San Gorgonio Pass and on the desert facing slopes of the San Bernardino and San Jacinto Mountains, with very little suitable habitat in the targeted protected areas. As such, ensuring the persistence of the antelope ground squirrel in the linkage will help maintain the ecological integrity of the linkage over time. Only the western branch of the Least Cost Union contains no potentially suitable habitat for this species, while the easternmost branch contains the most extensive contiguous highly suitable habitat (Figure 21). The majority of suitable habitat was identified as potential core areas for this species, with the Whitewater River providing a connection to extensive core habitat on the desert facing slopes of both the San Bernardino Mountains and San Jacinto Mountains (Figure 22). All potential cores and patches of suitable habitat in the eastern part of the planning area are within the presumed dispersal distance for this species (figure not shown), although barriers to movement may exist between suitable habitat patches. The linkage will likely serve the needs of antelope ground squirrels traveling through or residing in the linkage if habitat is added to the Union in Stubbe Canyon and along the San Gorgonio River.

To protect and restore habitat for antelope ground squirrel, we recommend that road barriers be modified, where necessary, to allow the antelope ground squirrel safe passage across Interstate 10 and Highway 111.

Figure 21.
Habitat Suitability
for
Antelope ground squirrel
(Ammospermophilus leucurus)

Degree of Suitability
- High
- Medium to High
- Medium
- Low to Medium
- Low
- Least Cost Union
- Protected Lands
- Rivers & Streams
- Roads
- Railroads

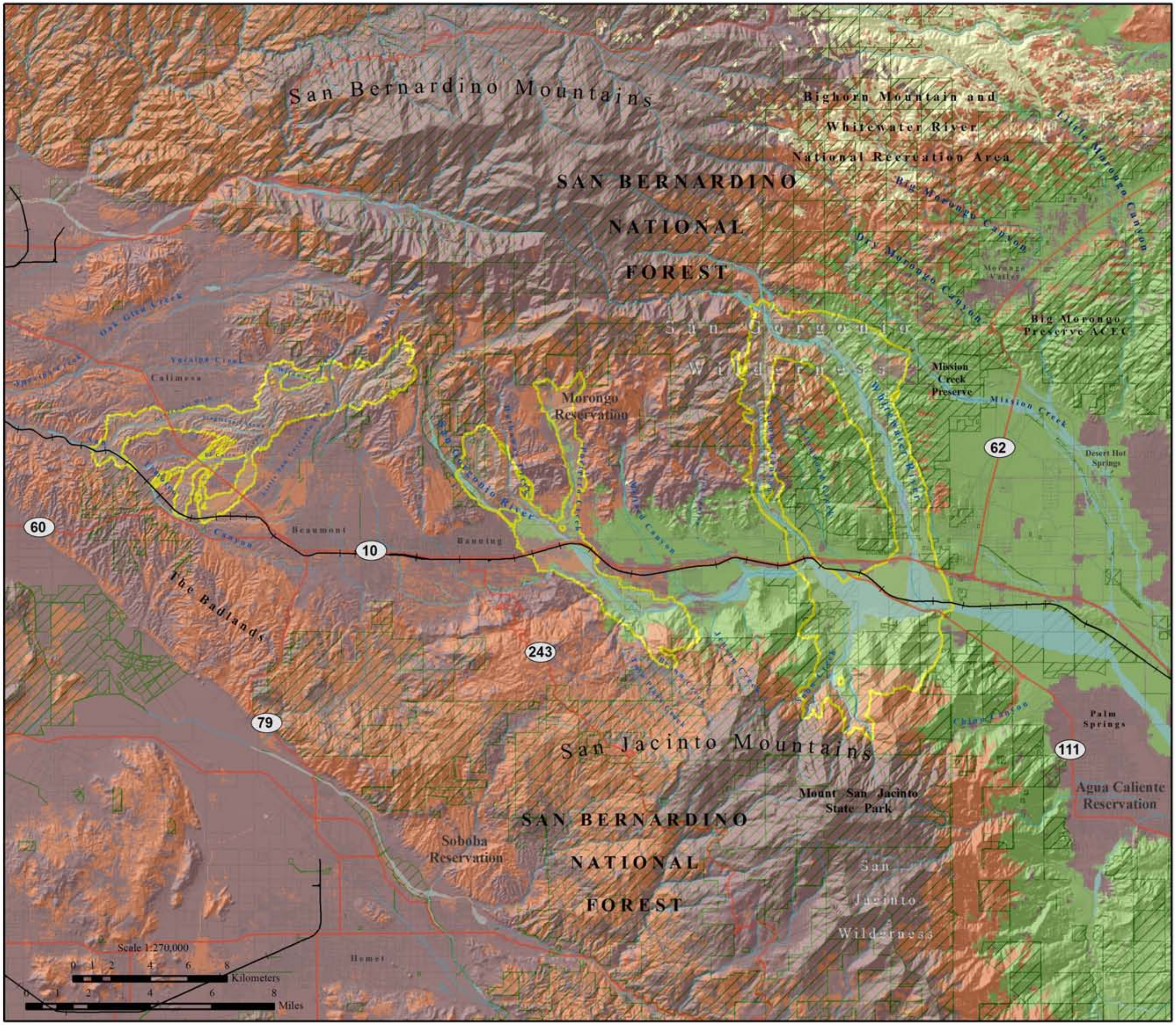

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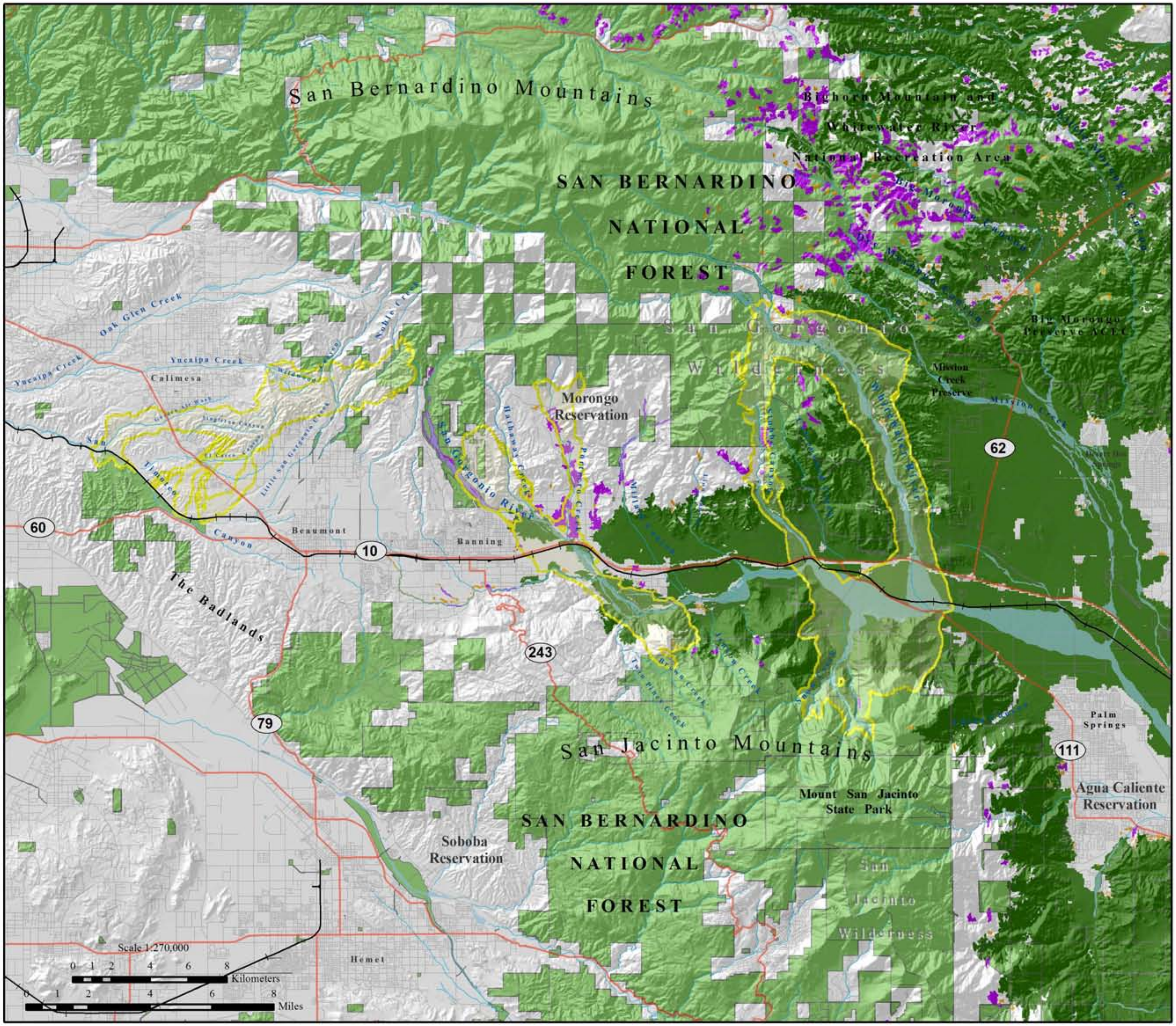
Figure 22.
Potential Cores & Patches for Antelope ground squirrel
(Ammospermophilus leucurus)



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Large-eared woodrat (*Neotoma macrotis*)

Justification for Selection: Presence of the large-eared woodrat may be correlated with high species richness (Chase et al. 2000). This species is sensitive to habitat fragmentation.

Distribution & Status: This species of large-eared woodrat (*Neotoma macrotis*), which was recently elevated to full species status from a subspecies of *Neotoma fuscipes*; Matocq 2002a) is distributed in the southern Sierra Nevada and in the coastal mountains south from about Santa Cruz, into northern Baja California (Jameson and Peeters 1988, Matocq 2002b). They are typically associated with elevations below 2,150 m (7,000 ft; Brylski 1990).

Habitat Associations: The large-eared woodrat is a nocturnal, arboreal herbivore (Lindsale and Tevis 1951, Jameson and Peeters 1988, Sakai and Noon 1993) that inhabits chaparral, oak, and riparian woodlands, and mixed coniferous forests with a well-developed understory (Murray and Barnes 1969, Jameson and Peeters 1988, Stephenson and Calcarone 1999, Matocq 2002b). Woodrats are known for their large, multichambered dwellings built of branches, which they depend upon for shelter, storing food items, and refuge from predators (Carraway and Verts 1991, Matocq 2002a). Dens are often inherited between generations (Kelly 1989, Gerber et al. 2003).

Spatial Patterns: Populations may be limited by the availability of nest-building materials (Linsdale and Tevis 1951, Brylski 1990). Population density may vary radically among sites, from greater than 80 individuals per hectare (2.5 ac) to 1.5 per hectare (Ward 1990, Sakai and Noon 1993). In Sonoma County, home range size of *Neotoma fuscipes* averaged 0.23 ha (0.58 ac) for males, and 0.19 ha (0.48 ac) for females (Brylski 1990). Cranford (1977) estimated male home range size at 2,289 m^2 (0.57 ac; Gerber et al. 2003). Sakai and Noon (1993) estimated female home range at 2,632 m^2 (0.65 ac), males at 5,338 m^2 (1.32 ac), with an average of 3,200 m^2 (0.79 ac). The largest home range recorded was 18.8 ha (46.2 ac) from Monterey (Bleich 1973, Brylski 1990). There is some overlap in home ranges during the breeding season (Jameson and Peeters 1988). Dispersal distance has been recorded at 217 m (712 ft; Sakai and Noon 1993).

Conceptual Basis for Model Development: Movement in the linkage is assumed to be multigenerational. Large-eared woodrats inhabit dense chaparral, and woodland communities, typically below 2,150 m elevation. Core areas were defined as $\geq$ 19.75 ha (49 ac). Patch size was defined as $\geq$ 0.38 ha (0.94 ac) and < 19.75 ha. Dispersal distance was defined as 434 m (1,424 ft).

Results & Discussion: Potential habitat for the large-eared woodrat largely follows the distribution of chaparral, coastal sage scrub, and oak woodland and riparian habitats in the planning area, with limited potential habitat in the San Gorgonio Pass (Figure 23).

The majority of suitable habitat was delineated as potential core areas, with most occurring in the mid to lower elevations in each of the targeted ranges (Figure 24). The western branch of the Least Cost Union provides the most contiguous habitat connection for this species, as it is the most direct route linking coastal habitats, though the central branch of the Union may offer a secondary connection for this species (Figures 23, 24). The majority of potentially suitable habitat identified for the woodrat is within the defined dispersal distance of this species, though barriers to movement may exist between suitable habitat patches (Figure 25). We conclude that the linkage is likely to serve the needs of this species for movement among populations over multiple generations if habitat is added to the Union in the foothills of the San Jacinto Mountains.

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

- Habitat restoration is initiated in Whitewater River to re-establish a gallery forest along the length of the river to its confluence with the San Gorgonio River.

- Road barriers be modified, where necessary, to allow woodrats to move along riparian corridors.

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

- Natural hydrological processes are maintained or restored.

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

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

Figure 23.
Habitat Suitability
for
Large-eared woodrat
(Neotoma marcotis)

Degree of Suitability
- High
- Medium to High
- Medium
- Low to Medium
- Low
- Least Cost Union
- Protected Lands
- Rivers & Streams
- Roads
- Railroads
- Species Occurence (CNDDB)

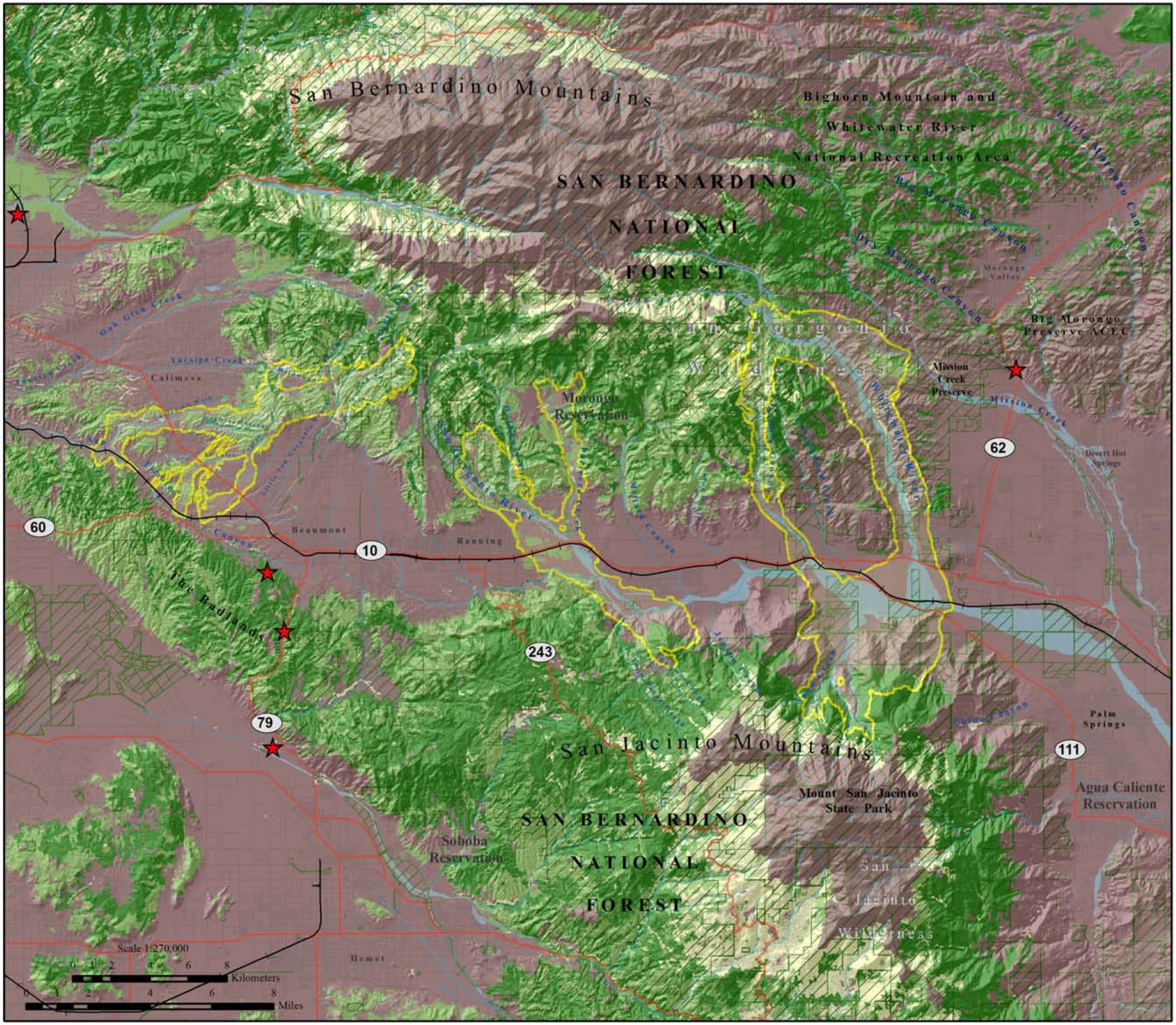

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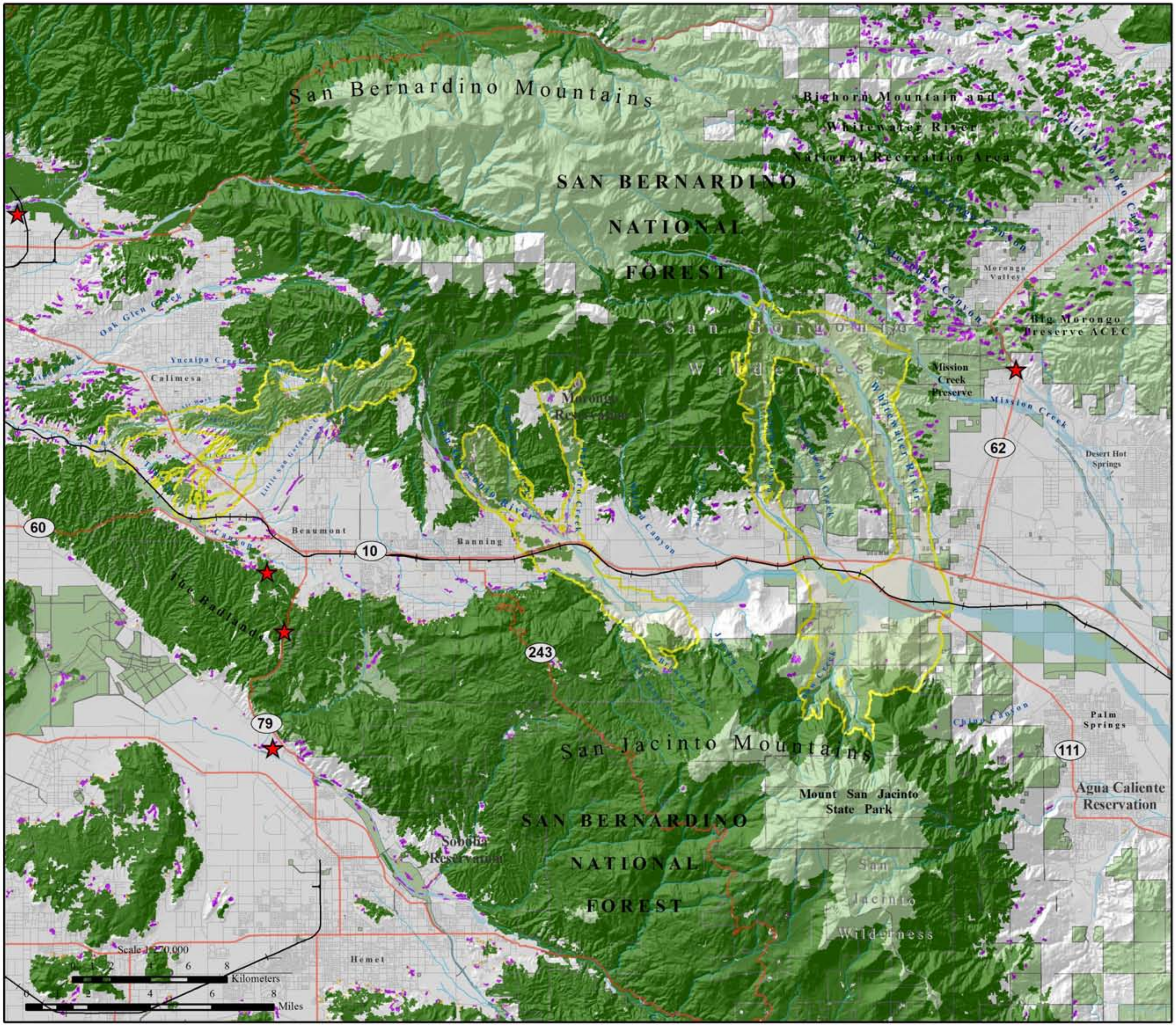
Figure 24.
Potential Cores & Patches for Large-eared woodrat
(Neotoma macrotis)



Core
Patch
< Patch
Least Cost Union
Protected Lands
Rivers & Streams
Roads
Railroads
Species Occurence (CNDDB)

N

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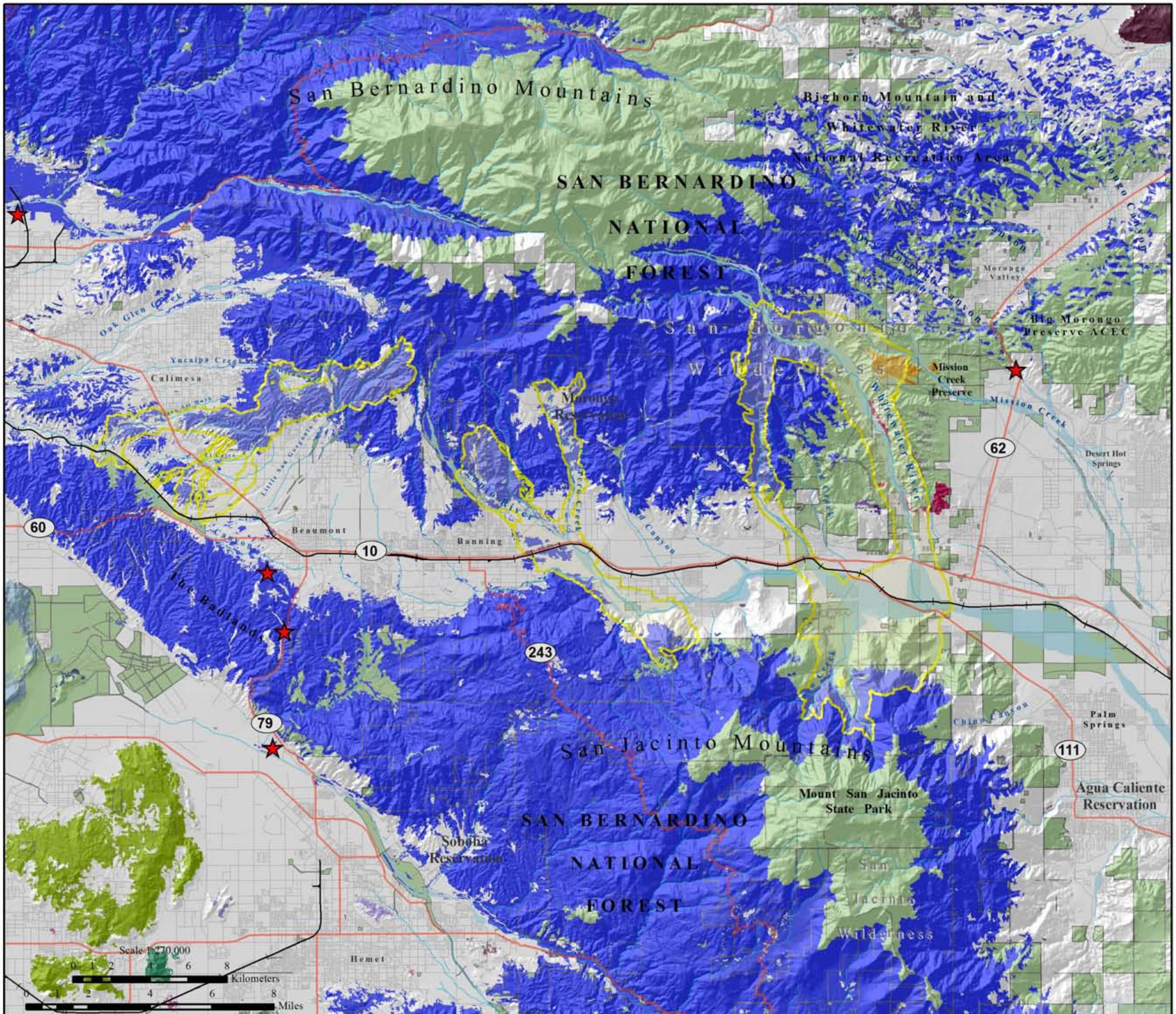
Figure 25.
Patch Configuration for Large-eared woodrat
(Neotoma macrotis)



Least Cost Union
Protected Lands
Rivers & Streams
Roads
Railroads
Species Occurence (CNDDB)

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

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Merriam's kangaroo rat (*Dipodomys merriami merriami*)

Justification for Selection: Merriam's kangaroo rat is sensitive to barriers, artificial light pollution, and dense stands of non-native annual grasses.

Distribution & Status: Merriam's kangaroo rat is a widespread species throughout arid regions of the western United States and northwestern Mexico (Hall and Kelson 1959, Williams et al. 1993, USFWS 1998). Three subspecies occur in southern California: *D. merriami merriami*, *D. m. collinus*, and *D. m. parvus*. *D. merriami merriami* occurs in the planning area; it is the most widespread kangaroo rat in California.

Merriam's kangaroo rat is not a special status species, but a subspecies not in this study area, *D. m. parvus* (San Bernardino kangaroo rat), was listed as endangered in 1998 (USFWS 1998).

Habitat Associations: Merriam's kangaroo rat occupies desert scrub habitats, sagebrush, Joshua tree, and pinyon-juniper habitats (Zeiner et al. 1990). They dwell in relatively flat or gently sloping areas with sparse to moderate vegetative cover (Zeiner et al. 1990). Merriam's kangaroo rat prefers sandy soils but they will also utilize rocky flats if they can excavate a burrow (Jameson and Peeters 1988, Zeiner et al. 1990).

Spatial Patterns: In the Palm Springs area, Merriam's kangaroo rat home range size averaged 0.33 ha (0.8 ac) for males and 0.3 ha (0.8 ac) for females (Behrends et al. 1986). Much larger home range sizes were documented for this species in New Mexico (Blair 1943), where home range size averaged 1.7 ha (4.1 ac) for males and 1.6 ha (3.8 ac) for females (USFWS 1998). Adults are territorial, defending areas surrounding their burrows (Jones 1993). Male and female home ranges overlap extensively but female home ranges rarely overlap (Jones 1989, USFWS 1998).

Merriam's kangaroo rat typically remains within 1-2 territories (approximately 100 m [328 ft]) of their birthplace, but the species is capable of longer dispersal (Jones 1989). Behrends et al. 1986 found movements of about 10 to 29 m (33-95 ft) between successive hourly radio fixes, but kangaroo rats are capable of moving much greater distances. For example, Daly et al. (1992) observed individuals moving as much as 100 m in a few minutes to obtain and cache experimentally offered seeds. Dispersal distances of up to 384 m (1,260 ft) have been recorded in Arizona (Zeng and Brown 1987).

Conceptual Basis for Model Development: Movement in the linkage is assumed to be multigenerational. Merriam's kangaroo rat prefers desert scrub, alkali desert scrub, sagebrush, creosote scrub, Joshua tree, and pinyon-juniper habitats. Within these habitats, they occupy flat and gently sloping terrain. Core areas were defined as $\geq$ 43 ha

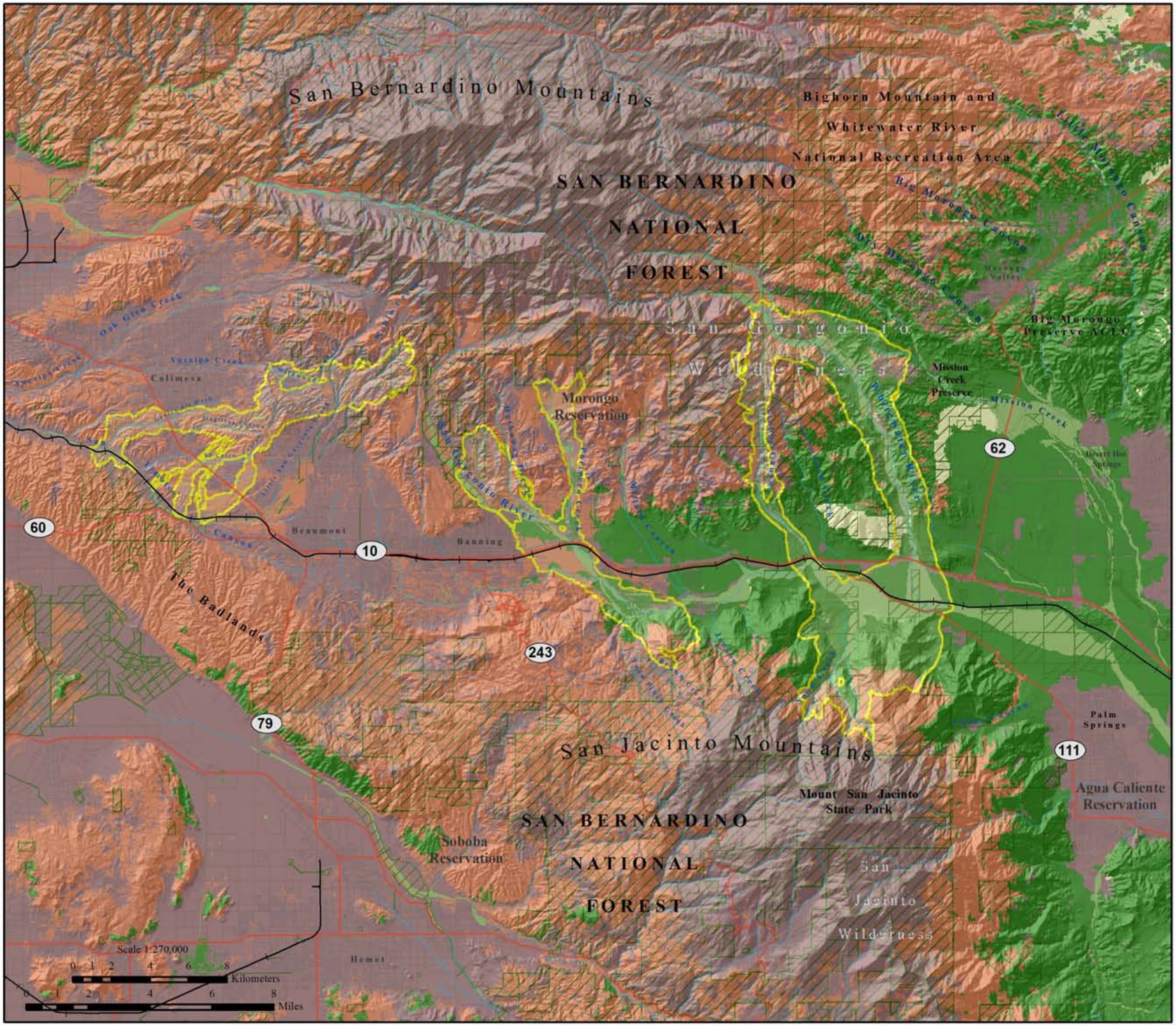
(106 ac). Patch size was defined as ≥ 0.6 ha (1.5 ac) and < 43 ha. Dispersal distance was defined as 768 m (2,520 ft), twice the recorded distance.

Results & Discussion: Merriam's kangaroo rat is limited to xeric desert habitats. As such, the most suitable habitat for this species in the planning area was identified in the San Gorgonio Pass and Coachella Valley and on the desert-facing slopes of the San Bernardino and San Jacinto Mountains (Figure 26). Highly suitable habitat for this species was identified in the central and eastern branches of the Least Cost Union, with the most contiguous highly suitable habitat identified in the easternmost branch along the Whitewater River, which encompasses the gentle terrain preferred by this species (Figure 26). The majority of suitable habitat was identified as potential core areas for this species (Figure 27). Distances among all core areas and patches in the eastern part of the planning area are within the defined dispersal distance of this species (Figure 28), although barriers to movement may exist between suitable habitat patches. We conclude that the linkage is likely to serve the habitat and movement needs of this species if habitat is added to the Union in Stubbe Canyon and along the San Gorgonio River.

Many small mammals are reluctant to cross roads or are highly susceptible to roadkill (Merriam et al. 1989, Diffendorfer et al. 1995, Brehme 2003). To restore and protect connectivity for Merriam's kangaroo rat, we recommend that:

- Crossing structures for small mammals are placed fairly frequently to facilitate movement across major transportation routes and reduce travel distance (Jackson and Griffin 2000, McDonald and St. Clair 2004).
- Short retaining walls are installed in conjunction with crossing structures along paved roads in the Linkage Design to deter small mammals, amphibians, and reptiles from accessing roadways (Jackson and Griffin 2000).
- Existing road density be maintained or reduced in the Linkage Design.
- Lighting is directed away from the linkage and crossing structures.
- Local residents are informed about the proper use of rodenticides and pesticides to reduce the likelihood of ingestion of these lethal substances on small mammals indigenous to the area.

Figure 26.
Habitat Suitability
for
Merriam's kangaroo rat
(Dipodomys merriami)



Degree of Suitability

- High
- Medium to High
- Medium
- Low to Medium
- Low
- Least Cost Union
- Protected Lands
- Rivers & Streams
- Roads
- Railroads

N

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Figure 27.
Potential Cores & Patches for Merriam's kangaroo rat
(Dipodomys merriami)

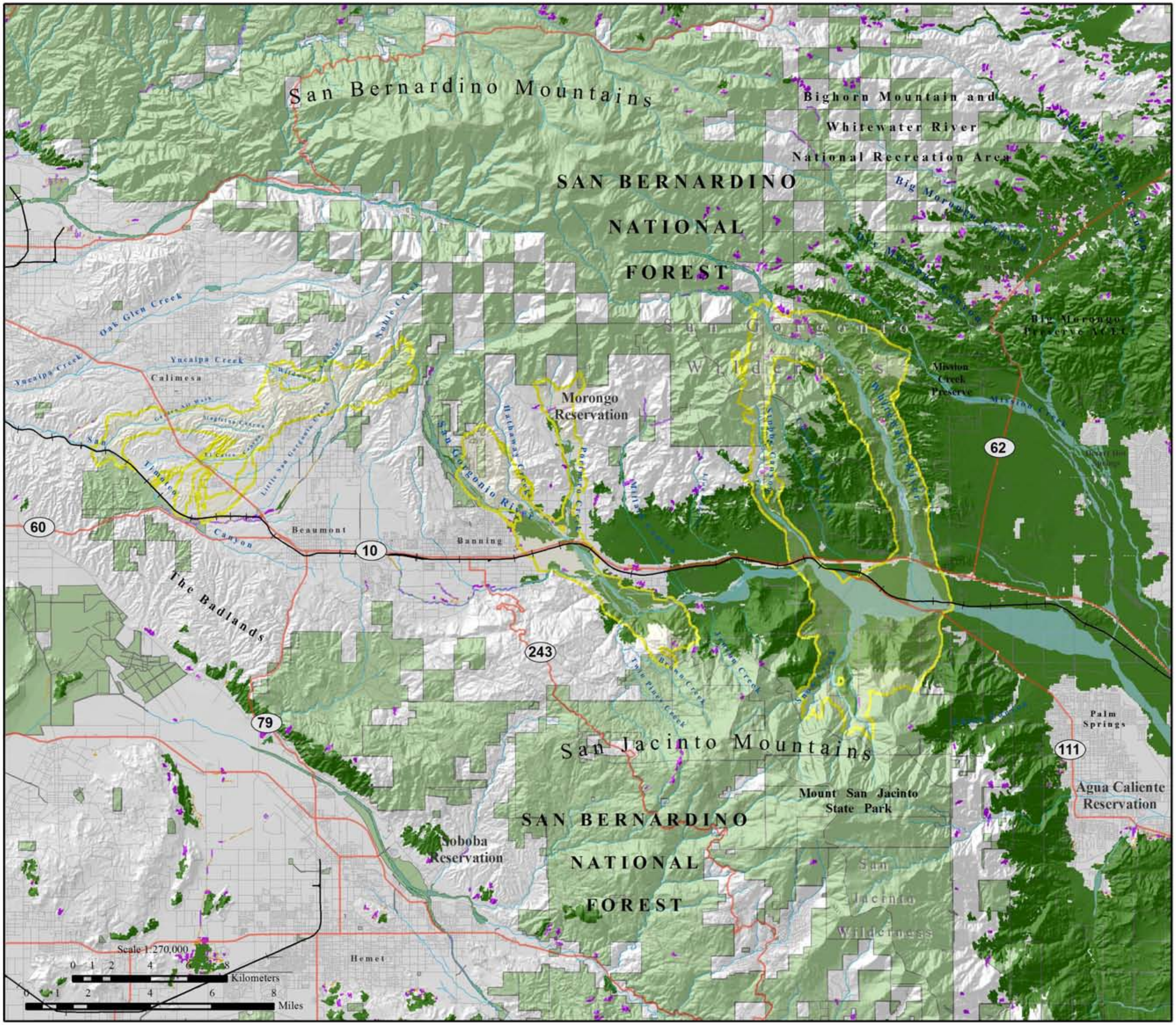

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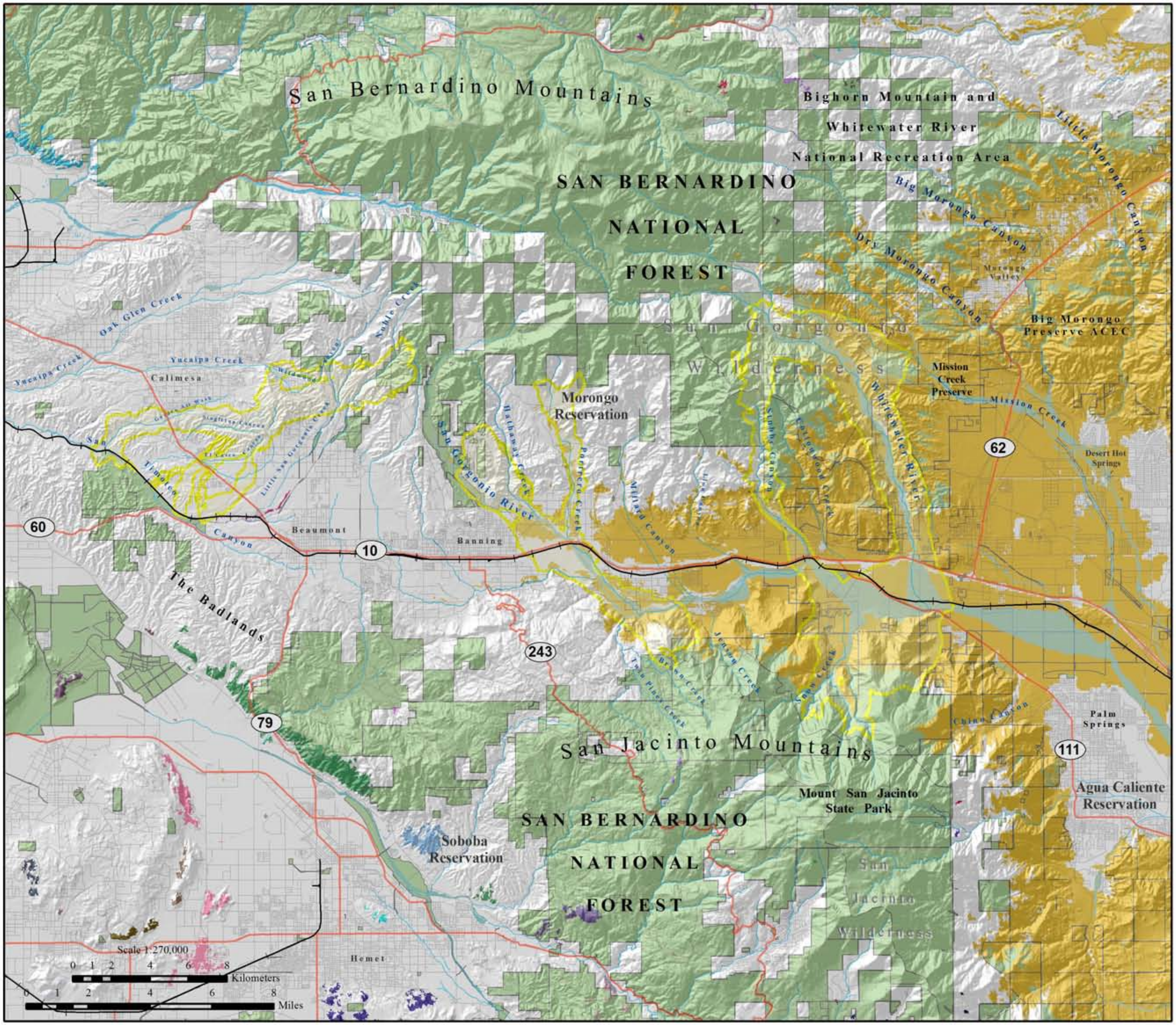
Figure 28.
Patch Configuration
for
Merriam's kangaroo rat
(Dipodomys merriami)

Least Cost Union
Protected Lands
Rivers & Streams
Roads
Railroads

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



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Pacific kangaroo rat (*Dipodomys agilis*)


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Distribution & Status: The Pacific kangaroo rat was recently split into 2 species, *D. agilis* and *D. simulans* (Dulzura kangaroo rat); *D. agilis* occurs in the planning area. The distribution of these species extends from the coastal mountains of Baja California and southern California to the Santa Barbara-San Luis Obispo county line and inland to the Tehachapi and Piute Mountains, as far north as the South Fork of the Kern River (Best 1983, Sullivan and Best 1997, Zeiner et al. 1990). They occur at elevations up to about 2,133 m (7,000 feet) in scrub and chaparral habitats (W. Spencer pers. comm.) but have been found as high as 2,250 m (7,400 ft) (Zeiner et al. 1990). The Pacific kangaroo rat is not a special status species.

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

Spatial Patterns: MacMillen (1964) estimated home range size of Pacific kangaroo rat from 0.1 to 0.6 ha (0.4 to 1.5 ac) with a mean of 0.3 ha (0.8 ac). Although fairly widespread and common, they seem to occur at somewhat lower densities than other kangaroo rats, perhaps due to the more patchy nature of their habitat (sparse or open areas within scrub and chaparral, versus more homogeneous desert or grassland habitats), which may be the result of chaparral and scrub habitats providing less food (seeds from annual forbs and grasses) than grasslands and deserts (W. Spencer pers. comm.). Christopher (1973) measured population densities of the Pacific kangaroo rat that ranged from 0.9 to 10.8 per ha (2.2-26.7 ac).

Kangaroo rat tends to be more mobile than most rodents of their size. Little specific information is available on movements of Pacific kangaroo rat, but they are probably similar to Merriam's kangaroo rat, which is better studied. Zeng and Brown (1987) recorded long-distance movements up to 384 m (1,260 ft) in adult Merriam's kangaroo rats, concluding that they are opportunistic in moving into newly available habitat. However, unlike Merriam's kangaroo rat, the Pacific kangaroo rat may disperse between adjacent mountain ranges via linkages, at least over multiple generations (W. Spencer pers. comm.).

Conceptual Basis for Model Development: Movement between protected core areas in the linkage is multigenerational. This species prefers open vegetative communities including young (post-fire) chaparral, desert scrub, annual grassland, oak woodland, pinyon-juniper woodland, and montane coniferous forests. They are primarily found between 800 and 2,250 m (2,625 to 7,382 ft) elevation (Sullivan and Best 1997). Core areas were defined as ≥ 8 ha (20 ac). Patch size was defined as ≥ 0.5 ha (1.2 ac) and < 8 ha. Dispersal distance for this species hasn't been measured, so we used twice the dispersal distance for Merriam's kangaroo rat (768 m; 2,520 ft).

Results & Discussion: Extensive suitable habitat was identified for the Pacific kangaroo rat within the analysis extent, with the most highly suitable habitat occurring in the western part of the planning area (Figure 29). All branches of the Least Cost Union contain core habitat for this species with the most contiguous highly suitable habitat identified in the western and central branches of the Union (Figure 30). The majority of cores and patches of suitable habitat are within the dispersal distance defined for this species (figure not shown), although numerous barriers to movement may exist between suitable habitat patches. We conclude that the linkage is likely to meet the needs of this species, although habitat added to the Union to support other focal species will also benefit Pacific kangaroo rat.

Many small mammals are reluctant to cross roads or are subject to roadkill (Merriam et al. 1989, Diffendorfer et al. 1995, Brehme 2003). To restore and protect connectivity for the Pacific kangaroo rat, we recommend that:

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

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

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

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

Figure 29.
Habitat Suitability for Pacific kangaroo rat
(Dipodomys agilis)

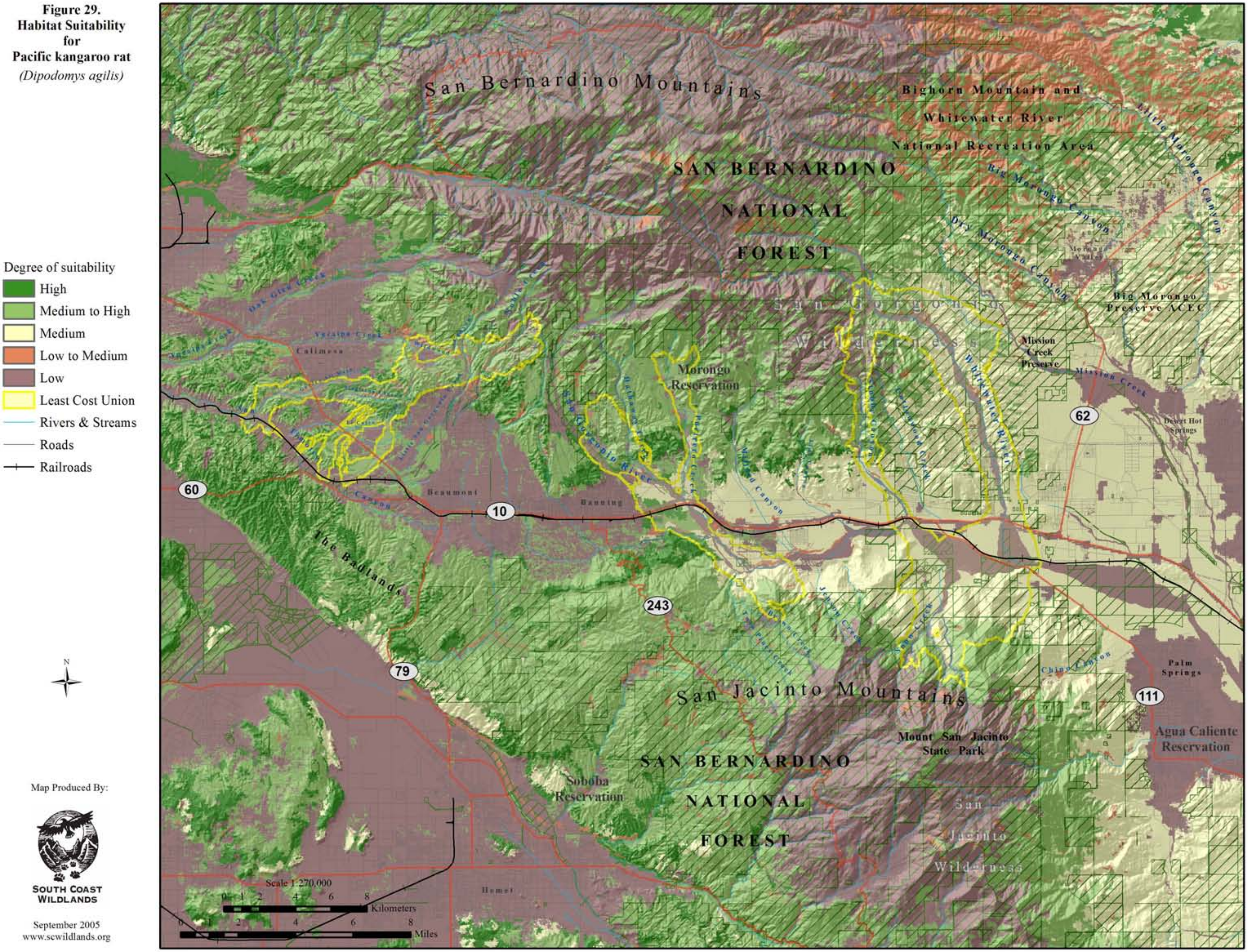

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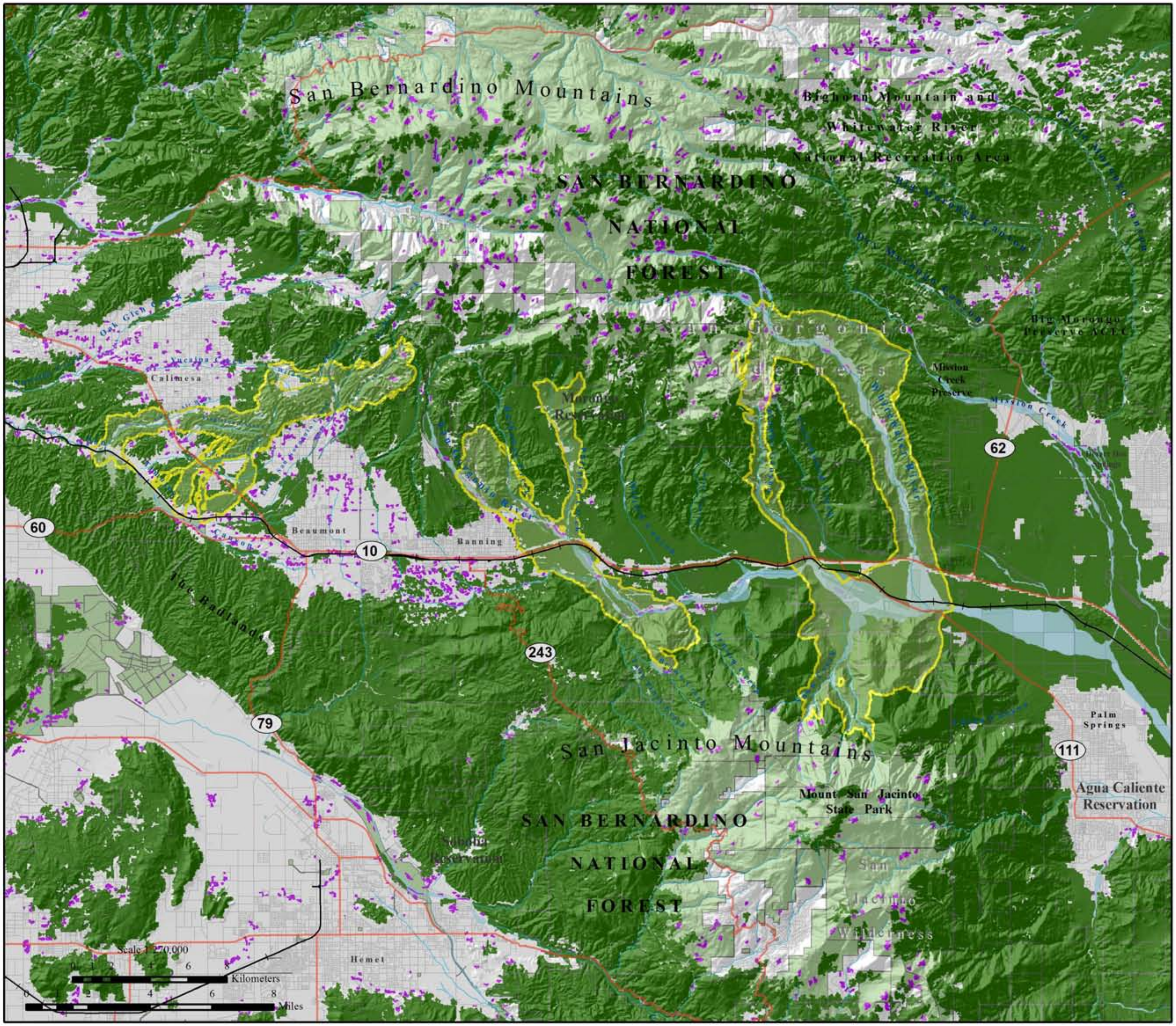
Figure 30.
Potential Cores & Patches for Pacific kangaroo rat
(Dipodomys agilis)



Core
Patch
< Patch
Least Cost Union
Protected Lands
Rivers & Streams
Roads
Railroads

N

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Little pocket mouse (*Perognathus longimembris*)

Justification for Selection: The little pocket mouse uses fine sandy soils in bajadas and river floodplains. Thus, maintaining the functionality of the sand source and transport systems is crucial to sustaining viable populations of this species (W. Spencer and T. Metcalf pers. comm., CVAG 2004).

Distribution & Status: In southern California, this species is distributed throughout the Los Angeles Basin and Mojave Desert south to Mexico, at elevations ranging from sea level to 1,700 m (5,600 ft; Zeiner et al. 1990). Five subspecies of *P. longimembris* are recognized within this region: *P. l. longimembris* (little pocket mouse), *P. l. bangsi* (Palm Springs pocket mouse), *P. l. brevinasus* (Los Angeles pocket mouse), *P. l. internationalis* (international pocket mouse), and *P. l. pacificus* (Pacific pocket mouse) (Williams et al. 1993, Swei et al. 2003). The little pocket mouse is known to hybridize with the Palm Springs pocket mouse and both are known to occur in the planning area. The Palm Springs pocket mouse has been recorded in the State Route 62/Mission Creek area (Dodd 1999, CVAG 2004) and in the extensive sandy bajada at the mouth of Snow Creek Canyon (Spencer et al. 2000ab, 2001). The two subspecies occurring in the study area are both CDFG Species of Special Concern.

Both the Palm Springs pocket mouse and the Los Angeles pocket mouse have experienced considerable population declines due to habitat loss and fragmentation (Swei et al. 2003). Threats include agricultural and urban development, transportation infrastructure, off-road vehicle use, illegal trash dumping, and domestic animal predators (CVAG 2004).

Habitat Associations: The species inhabits desert scrub, desert riparian, desert wash, sagebrush, and sparse sage scrub habitats in fine, sandy soils, which are preferred for burrowing (Hall 1946, Zeiner et al. 1990, Swei et al. 2003). They may also be encountered on gravel washes and on stony soils (Beatley 1976, Miller and Stebbins 1964, Zeiner et al. 1990). Their habitat typically consists of level to gently sloping topography (CVAG 2004).

Spatial Patterns: In Joshua Tree National Park, Chew and Butterworth (1964) found home range sizes ranged from 0.12 to 0.56 ha (0.30 to 1.4 ac; Zeiner et al. 1990). Much larger home ranges were found in Nevada, with males averaging 0.29 to 1.88 ha (0.7 to 4.7 ac) and females averaging 0.48 to 3.09 ha (1.2 to 7.6 ac; Maza et al. 1973, Zeiner et al. 1990). O'Farrell (1978) found seasonal differences in home range size, from 0.28 ha (0.69 ac) in spring to 0.80 ha (1.9 ac) in fall. Density estimates vary widely. Chew and Butterworth (1964) found maximum densities of 1.7/ha (0.7/ac) in creosote scrub (Zeiner et al. 1990). More recent studies of Palm Springs pocket mouse found much higher densities, reaching 60 to 200 individuals per hectare in creosote scrub habitat (Spencer et al. 2001, Swei et al. 2003). Movement and dispersal estimates are lacking for the local subspecies, but the Pacific pocket mouse has been observed to move up to 87 m (285 ft; Spencer et al. 2000b).

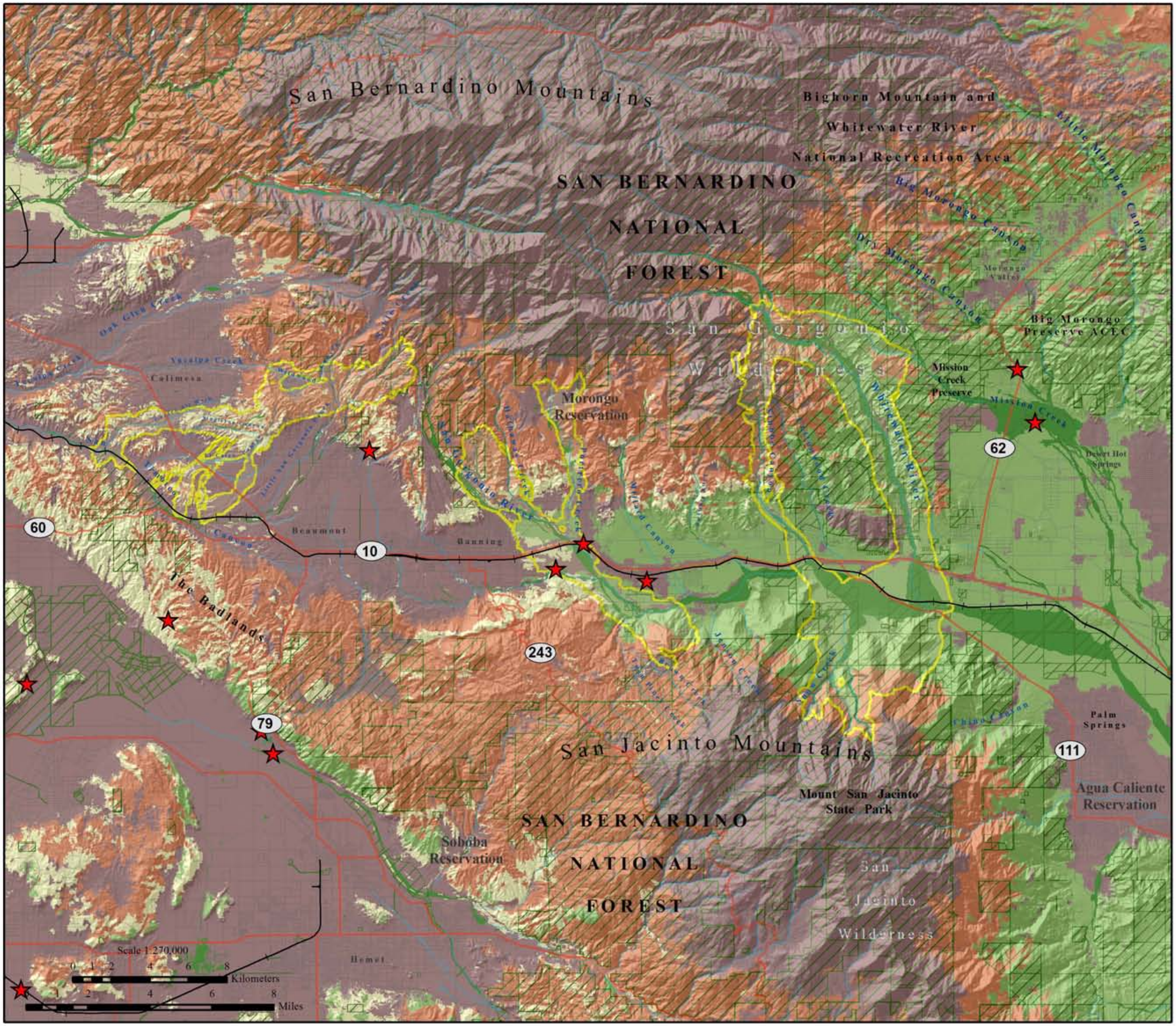
Conceptual Basis for Model Development: Movement in the linkage is multigenerational. This species prefers sparsely vegetated communities on flat to gently sloping terrain at elevations ranging from sea level to 1,700 m (5,600 ft). Potential core areas were defined as ≥ 8 ha (20 ac). Patch size was classified as ≥ 0.3 ha (0.7 ac) but less than 8 ha. Dispersal distance was defined as 174 m (571 ft), twice the recorded distance of Pacific pocket mice.

Results & Discussion: The most highly suitable habitat for the little pocket mouse is in the eastern part of the planning area (Figure 31). As such, the easternmost branch of the Least Cost Union (i.e., Whitewater River) provides the most extensive and most contiguous core habitat for this species, although core habitat was also identified in all other branches of the Union (Figure 32) and the little pocket mouse has been recorded in the central branch of the Union (Figures 31, 32). Distances among potential cores and patches of suitable habitat in the eastern part of the planning area are within the dispersal distance of this species, while potential habitat identified in the western part of the planning area and Badlands are isolated by distances too great for the species to traverse (Figure 33). We conclude that the linkage is likely to serve the habitat and movement needs of this species if habitat is added to the Union in Stubbe Canyon and along the San Gorgonio River.

Many small mammals are reluctant to cross roads (Merriam et al. 1989, Diffendorfer et al. 1995, Brehme 2003). To restore and protect connectivity for the pocket mouse, we recommend that:

- Crossing structures for small mammals are placed fairly frequently to facilitate movement across major transportation routes and reduce travel distance (Jackson and Griffin 2000, McDonald and St. Clair 2004).
- Short retaining walls are installed in conjunction with crossing structures along paved roads in the Linkage Design to deter small mammals, amphibians, and reptiles from accessing roadways (Jackson and Griffin 2000).
- Lighting is directed away from the linkage and crossing structures.
- Local residents are informed about the proper use of rodenticides and pesticides to reduce the likelihood of ingestion of these lethal substances on small mammals indigenous to the area.

Figure 31.
Habitat Suitability
for
Little pocket mouse
(Perognathus longimembris)



Degree of Suitability
- High
- Medium to High
- Medium
- Low to Medium
- Low
- Least Cost Union
- Protected Lands
- Rivers & Streams
- Roads
- Railroads
- Species Occurence (CNDDB)

N

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Figure 32.
Potential Cores & Patches
for
Little pocket mouse
(Perognathus longimembris)

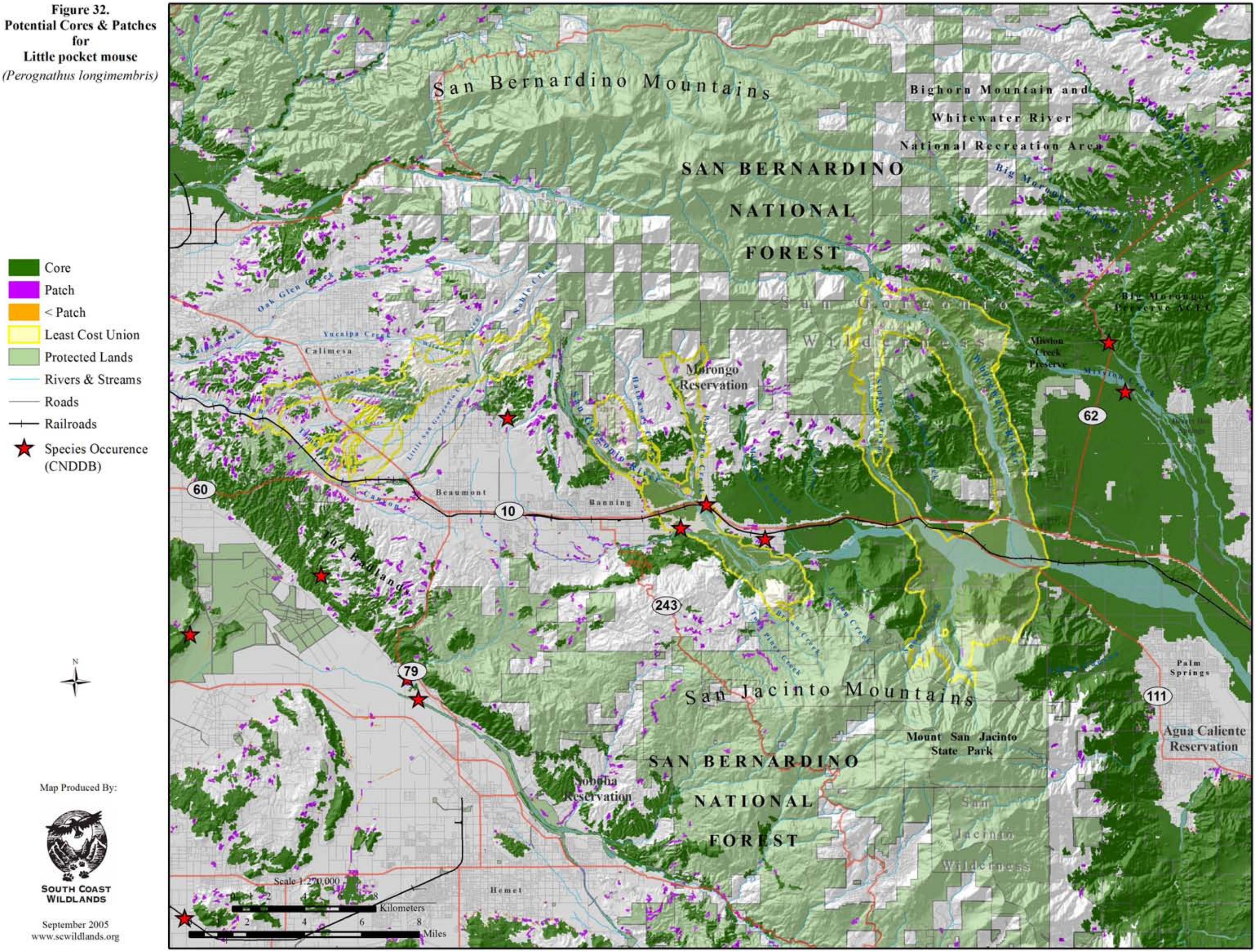
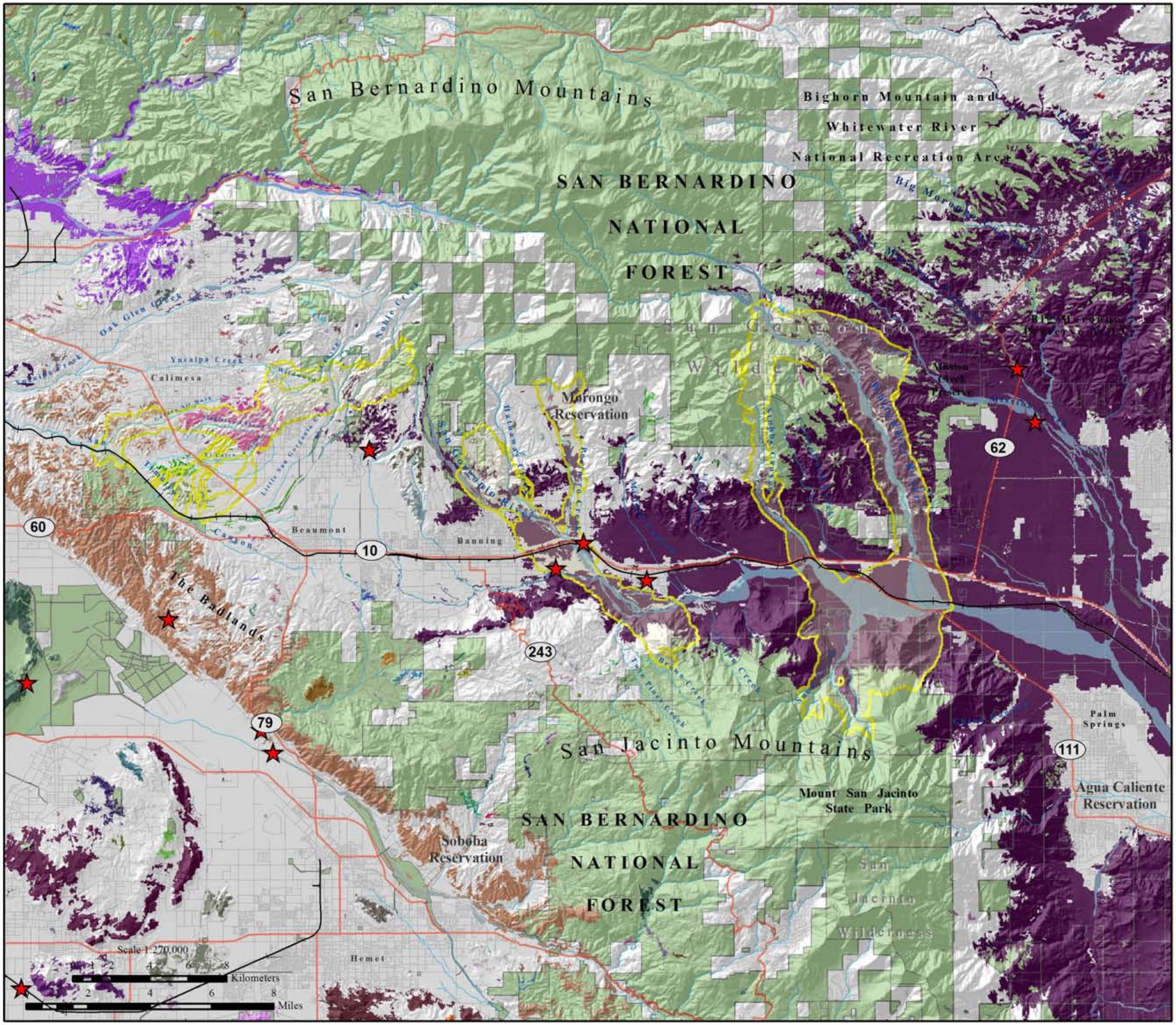


Figure 33.
Patch Configuration
for
Little pocket mouse
(Perognathus longimembris)



Least Cost Union
Protected Lands
Rivers & Streams
Roads
Railroads
Species Occurence (CNDDB)

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

N

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California spotted owl (*Strix occidentalis occidentalis*)


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

Distribution & Status: The California spotted owl is one of three subspecies of spotted owl in California. It inhabits the Sierra Nevada and the Coastal, Transverse, and Peninsular ranges (Remsen 1978, LaHaye et al. 1997). Their elevational range extends from lower than 305 m (1,000 ft) to as high as 2,591 m (8,500 ft). Southern California populations are believed to function as a metapopulation, connected by infrequent but persistent interchange of individual owls among populations (LaHaye et al. 1994, Stephenson and Calcarone 1999). The largest subpopulation is the 200 plus territories in the San Bernardino and San Gabriel Mountains. Although the San Gorgonio Pass separates the San Bernardino and San Jacinto mountains, only 16 km (10 mi) separates the southernmost San Bernardino territory from the northernmost San Jacinto territory. The California spotted owl is designated as a Federal and State Species of Special Concern (CDFG 2001).

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

Spatial Patterns: This subspecies incorporates large tracts of mature and old growth forests into its home range (LaHaye et al. 1997), requiring extensive blocks [40-240 ha (100-600 ac)] that contain suitable nesting and roosting habitat, as well as available water (Forsman et al. 1976, Zeiner et al. 1990). In the mature Douglas-fir/hemlock forests of Oregon, Forsman et al. (1977) found home range to vary between 120-240 ha (300-600 ac), and similar home range sizes have been recorded in the Sierra Nevada (Gould 1974, Zeiner et al. 1990). The distribution of prey has been found to strongly influence the size of an owl's home range (Carey et al. 1992, Zabel et al. 1995, Smith et al. 1999), and habitat use patterns (Carey et al. 1992, Carey and Peeler 1995, Zabel et al. 1995, Ward et al. 1998, Smith et al. 1999). Lower elevation habitats may be more productive due to higher prey densities in surrounding vegetative communities.

Occupied habitat at lower elevations is typically dense, mature forest on north-facing slopes and deep canyons (Stephenson and Calcarone 1999).

Home ranges are generally spaced 1.6 to 3.2 km (1-2 mi) apart in appropriate habitat (Marshall 1942, Gould 1974, Zeiner et al. 1990). Owl densities are greater in areas with a higher density of old trees in dense groves (Gutierrez et al. 1992). Smith (1996) estimated owl density for the San Bernardino population to be 0.43 per km^2 (0.4 mi^2) for oak/big-cone fir, 0.20 per km^2 for conifer/hardwood, and 0.11 owls per km^2 for mixed coniferous forests. Owl densities in Sequoia Kings Canyon National Parks have been recorded at 12.8 pairs per 100 km^2 (39 mi^2), while densities of 10.0 pairs per 100 km^2 have been estimated for the Sierra National Forest (North et al. 2000). LaHaye et al. (1997) suggested higher densities might reflect smaller territory sizes, which could result from increased prey densities.

Metapopulation analyses have estimated dispersal distances of 7-60 km (4.3-37.2 mi; LaHaye et al. 1994). However, shorter dispersal distances have been recorded. In the San Bernardino Mountain population, 67 males and 62 females dispersed 2.3-36.4 km (1.4-22.6 mi) and 0.4–35.7 km (0.3-22.2 mi) respectively (LaHaye et al. 2001). Dispersal distances for spotted owls in other populations range from 5.8 km (3.6 mi; Ganey et al. 1998) to 56 km (35 mi; Gutiérrez et al. 1996). Several radio telemetry studies have recorded even greater distances, up to 72.1 km (44 mi; Miller et al. 1997, Ganey et al. 1998, Willey and van Riper 2000, LaHaye et al. 2001).

Conceptual Basis for Model Development: This species prefers mature and old growth forests below 2,591 m (8,500 ft). Core areas potentially supporting 50 or more individuals were defined as $\geq$ 4,000 ha (10,000 ac). Patch size was classified as $\geq$ 80 ha (200 ac) but < 4,000 ha. Dispersal distance was defined as 144 km (90 mi).

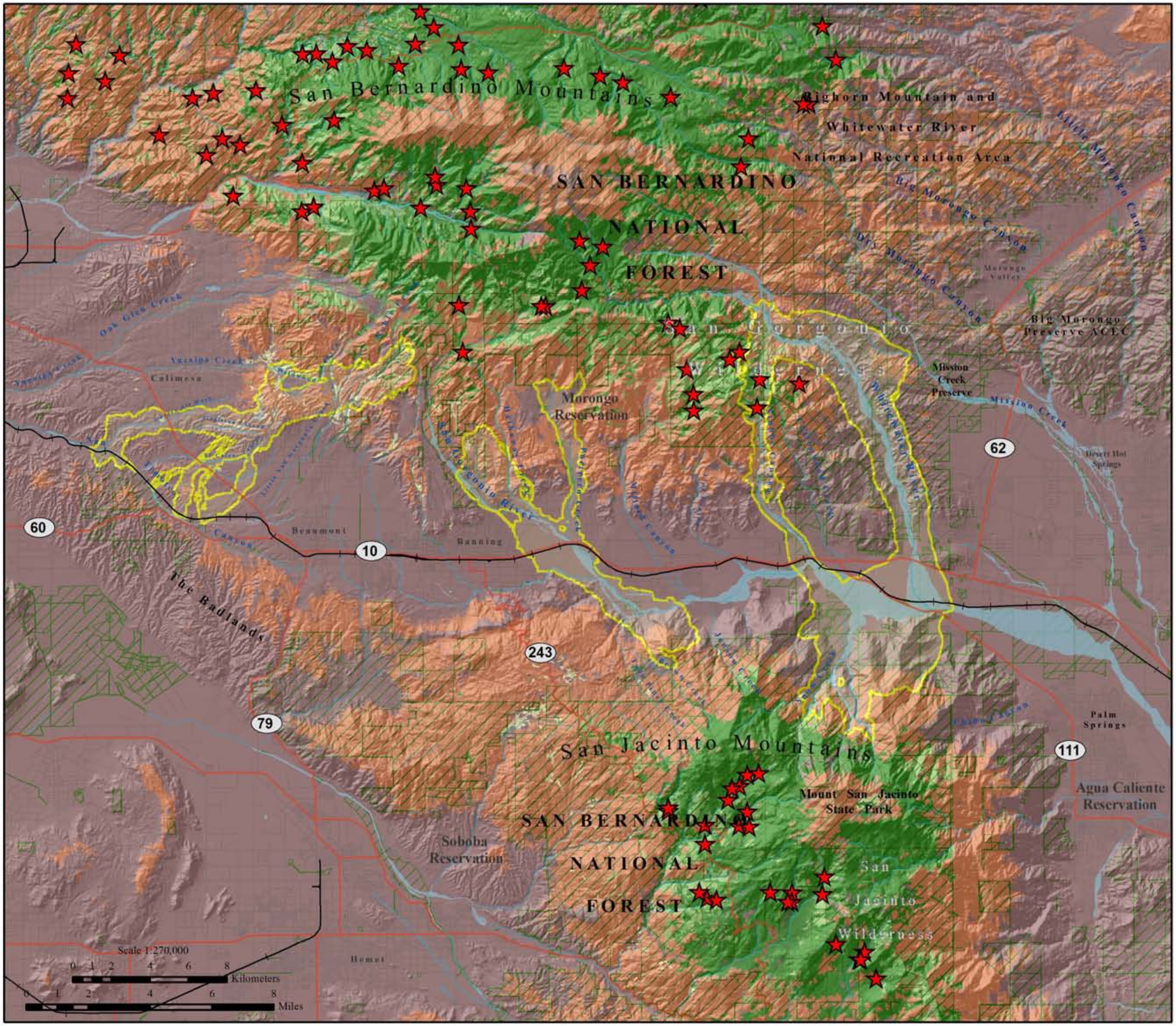
Results & Discussion: The results of the habitat suitability analysis correspond well with recorded spotted owl territories in montane hardwood and conifer habitats in both the San Bernardino and San Jacinto ranges (Figure 34). Two major core areas were identified by the patch size analysis (Figure 35). Although very little suitable habitat occurs within the Least Cost Union, the linkage is likely to accommodate infrequent spotted owl movement between these ranges if lighting is directed away from the linkage. All suitable habitat patches are well within the maximum dispersal distance of 72.1 km. We conclude that the linkage can sustain movement needs among populations of owls, serving a critical function of preserving this top predator.

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

- Lighting is directed away from the linkage to provide a dark zone for nocturnally active species. Species sensitive to human disturbance avoid areas that are artificially lit (Beier 1995, Beier et al. in press).

- Local residents are informed about the proper use of rodenticides and pesticides to reduce the likelihood of ingestion of these lethal substances by the natural predators of rodent species.

Figure 34.
Habitat Suitability
for
California spotted owl
(Strix occidentalis)



Degree of Suitability

- High
- Medium to High
- Medium
- Low to Medium
- Low
- Least Cost Union
- Protected Lands
- Rivers & Streams
- Roads
- Railroads
- Species Occurence (USFS)

N

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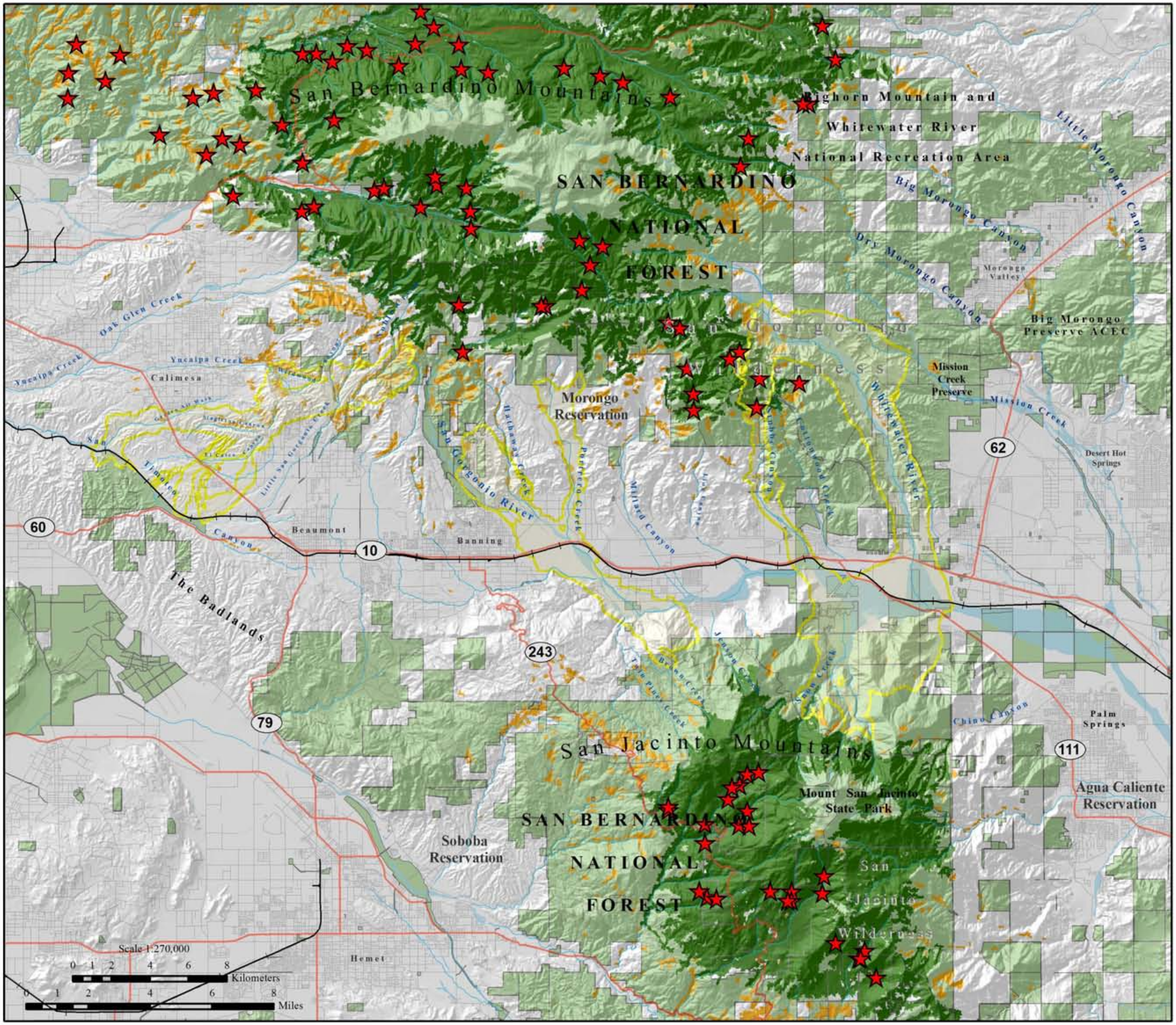
Figure 35.
Potential Cores & Patches for California spotted owl
(Strix occidentalis)



- Core
- < Patch
- Least Cost Union
- Protected Lands
- Rivers & Streams
- Roads
- Railroads
- Species Occurence (USFS)

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- Eliminate feral cattle in Stubbe Canyon to stop overgrazing which could lead to the loss of gallery cottonwood forest.

- Attempt to expand gallery forest in Stubbe Canyon and Whitewater River.

Pygmy nuthatch (*Sitta pygmaea melanotis*)

Justification for Selection: As a cavity nester dependent on large snags, the pygmy nuthatch serves as an indicator species for mature ponderosa pine forests (Ghalambor 2003). Pygmy nuthatches have limited dispersal abilities and therefore need greater connectivity between suitable habitat patches to promote genetic exchange among subpopulations (Ghalambor 2003).

Distribution & Status: *S. p. melanotis* is one of six recognized subspecies. *S. p. melanotis* has the largest and most discontinuous range of all the subspecies, occurring from southern British Columbia east to the Black Hills of South Dakota, to southern California and northern Mexico (Ghalambor 2003), up to elevations of 3,050 m (10,000 ft; Shuford and Metropulos 1996, Ghalambor 2003). Their distribution largely follows the scattered distribution of ponderosa and other yellow pines. They are found throughout the mountain ranges of southern California, including the San Jacinto and San Bernardino Mountains (Garret and Dunn 1981, Ghalambor 2003). The pygmy nuthatch has no special conservation status.

Habitat Associations: Pygmy nuthatches are residents of western yellow pine forests, preferring those dominated by ponderosa pine (*Pinus ponderosa*). In California, they favor mature stands of ponderosa and Jeffrey pines (*P. jeffreyi*), but may also be found in mixed conifer, eastside pine, and pinyon-juniper habitats (Gaines 1988, Zeiner et al. 1990, Ghalambor 2003). They've also been recorded in open stands of large lodgepole pine (*P. murrayana*) in the White Mountains (Shuford and Metropulos 1996, Ghalambor 2003). They forage on and cache pine seeds within these habitats, but also prey upon insects and spiders during the breeding season (Bent 1948).

Pygmy nuthatches are highly communal, sociable species that breed cooperatively, which is unusual for North American songbirds (Norris 1958, Ghalambor 2003). They excavate cavities in snags for nesting and roosting, relying on cavities throughout the year. The locations of communal roost cavities are largely determined by the weather, with groups changing cavities seasonally for protection from outside temperatures (Hay 1983, Ghalambor 2003).

Spatial Patterns: With such a dependence on snags, it's not surprising that pygmy nuthatches reach their highest densities in mature pine forests with plenty of snags (Ghalambor 2003). Norris (1958) evaluated 7 studies from California, Colorado and Mexico and found an average density of 19.5 males per 40 ha (100 ac), with a range between 5.3 and 33 males per 40 ha. Territory size may fluctuate depending on the density of pines, cavity availability, and the presence or absence of helpers (Norris 1958, Ghalambor 2003). Estimates of territory size vary by habitat type, ranging from 0.5 to 8.2 ha (1.3-20.1 ac; Norris 1958, Balda 1967, Storer 1977, Ghalambor 2003). In Marin County, territory size ranged from 0.8 to 1.3 ha (1.9–3.3 ac), with an average of 1.1 ha (2.7 ac; Norris 1958). Each pair occupies a foraging territory year-round. Territories may overlap, but are defended during the breeding season (Bock 1969, Ghalambor 2003).

Norris (1958) evaluated natal dispersal in pygmy nuthatches and found one male established a territory 165 m from his place of birth. Natal dispersal in females wasn't evaluated but it is expected to be further than males. First year birds established breeding sites over 4 times further from their birthplaces than the typical distance adults travel between breeding territories, with young birds moving an average of 286.5 m (940 ft) with a range of 0.6-533 m (2-1,749 ft) (Norris 1958, Ghalambor 2003).

However, more significant movements can occur during post-breeding dispersal and winter wandering, when individuals may be observed in atypical habitats (Bent 1948, Garrett and Dunn 1981, Ghalambor 2003). Pygmy nuthatches have been recorded in coastal Santa Barbara County (Lehman 1994, Ghalambor 2003), and San Diego County (Unitt 1984).

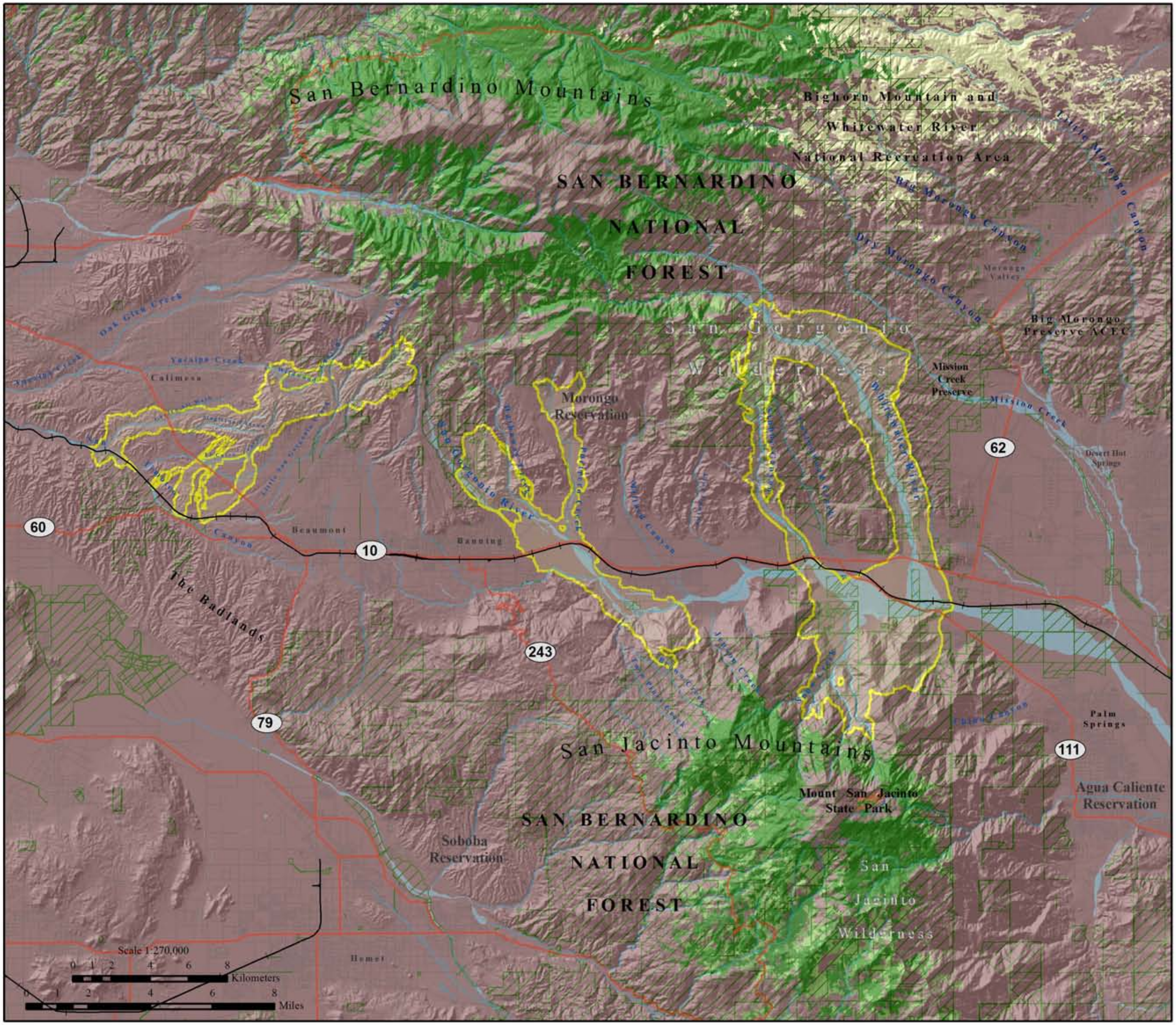
Conceptual Basis for Model Development: This species prefers high elevation mature yellow pine forests, dominated by Ponderosa or Jeffrey pines, but will also utilize mixed conifer habitats. Core areas were defined as $\geq$ 28 ha. Patch size was classified as $\geq$ 2 ha, but less than 28 ha. Dispersal distance was defined as 1,066 m (3,498 ft), twice the longest recorded movement.

Results & Discussion: The most highly suitable habitat for pygmy nuthatch was identified in the high elevation coniferous habitats in the San Bernardino and San Jacinto Mountains (Figure 36). Large core areas were identified in both ranges (Figure 37), with very little habitat identified in the Least Cost Union. The patch configuration analysis suggests that populations in the San Bernardino and San Jacinto Mountains may be functionally isolated from one another, separated by distances too great for this species to traverse (Figure 38). This species has very limited dispersal capabilities, limiting opportunities for genetic exchange among populations (Ghalambor 2003). However, since pygmy nuthatches have been recorded away from coniferous mountain habitats, movement through the linkage may still be possible (Unitt 1984, Lehman 1994, Ghalambor 2003). Where timber harvesting has reduced the number of snags, the number of breeding pairs declines (McEllin 1979, Brawn 1987, Brawn and Balda 1988, Bock and Fleck 1995, Ghalambor 2003). To protect and restore habitat for pygmy nuthatch, we recommend that:

- Snags are retained, at a range of between 5 to 12 per hectare (Balda 1975, Scott 1979, Diem and Zeveloff 1980, Clark et al. 1989, Ghalambor 2003). Clark et al. (1989) proposed snags should be relatively large in diameter.

- The natural fire regime is restored or mimicked to benefit this species (Covington and Moore 1994, Arno et al. 1995, Fule and Covington 1995, Ghalambor 2003).

**Figure 36.
Habitat Suitability
for
Pygmy nuthatch**
(Sitta pygmaea)



Degree of Suitability

- High
- Medium to High
- Medium
- Low to Medium
- Low
- Least Cost Union
- Protected Lands
- Rivers & Streams
- Roads
- Railroads

N

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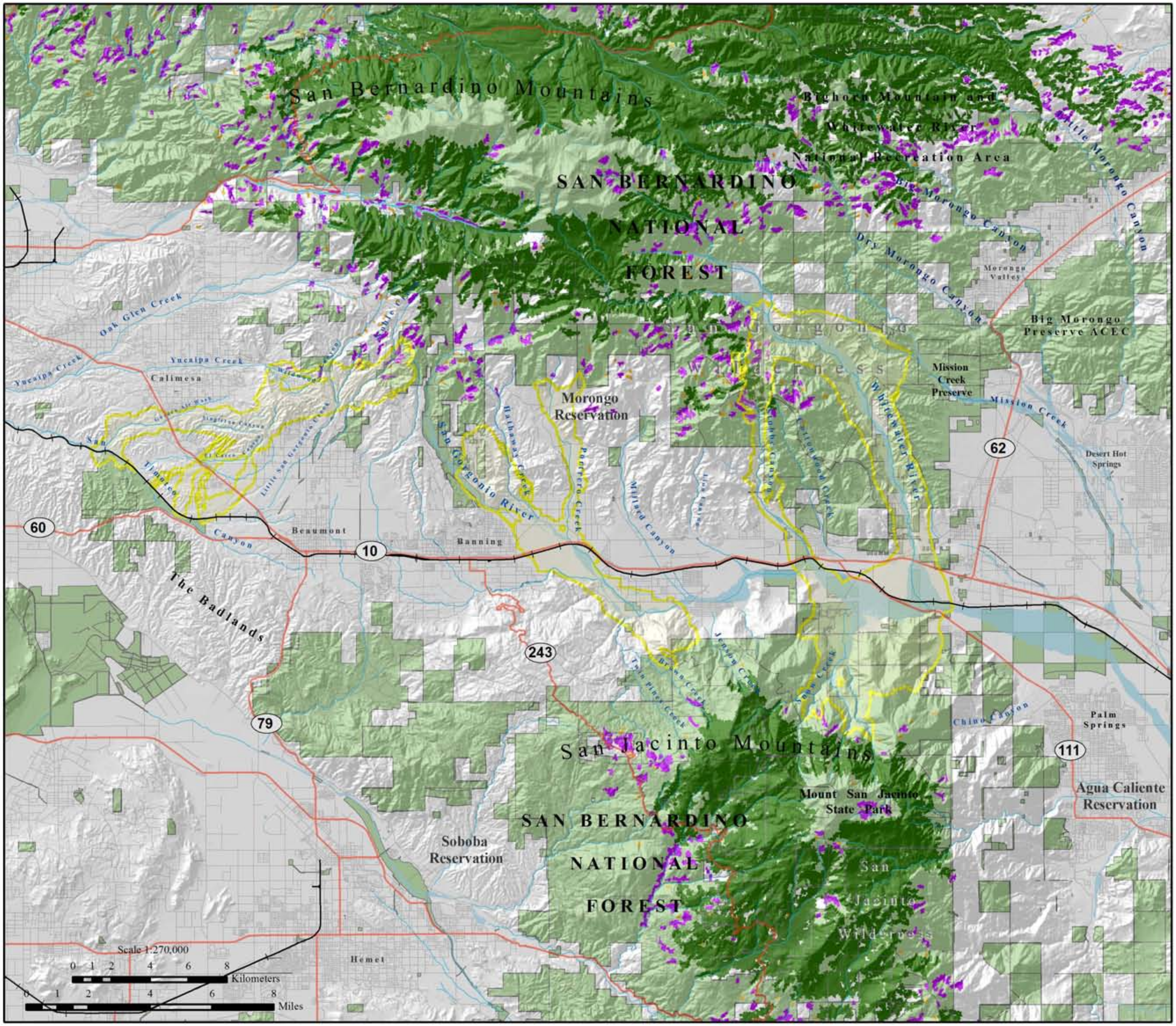
Figure 37.
Potential Cores & Patches for Pygmy nuthatch
(Sitta pygmaea)



Core
Patch
< Patch
Least Cost Union
Protected Lands
Rivers & Streams
Roads
Railroads

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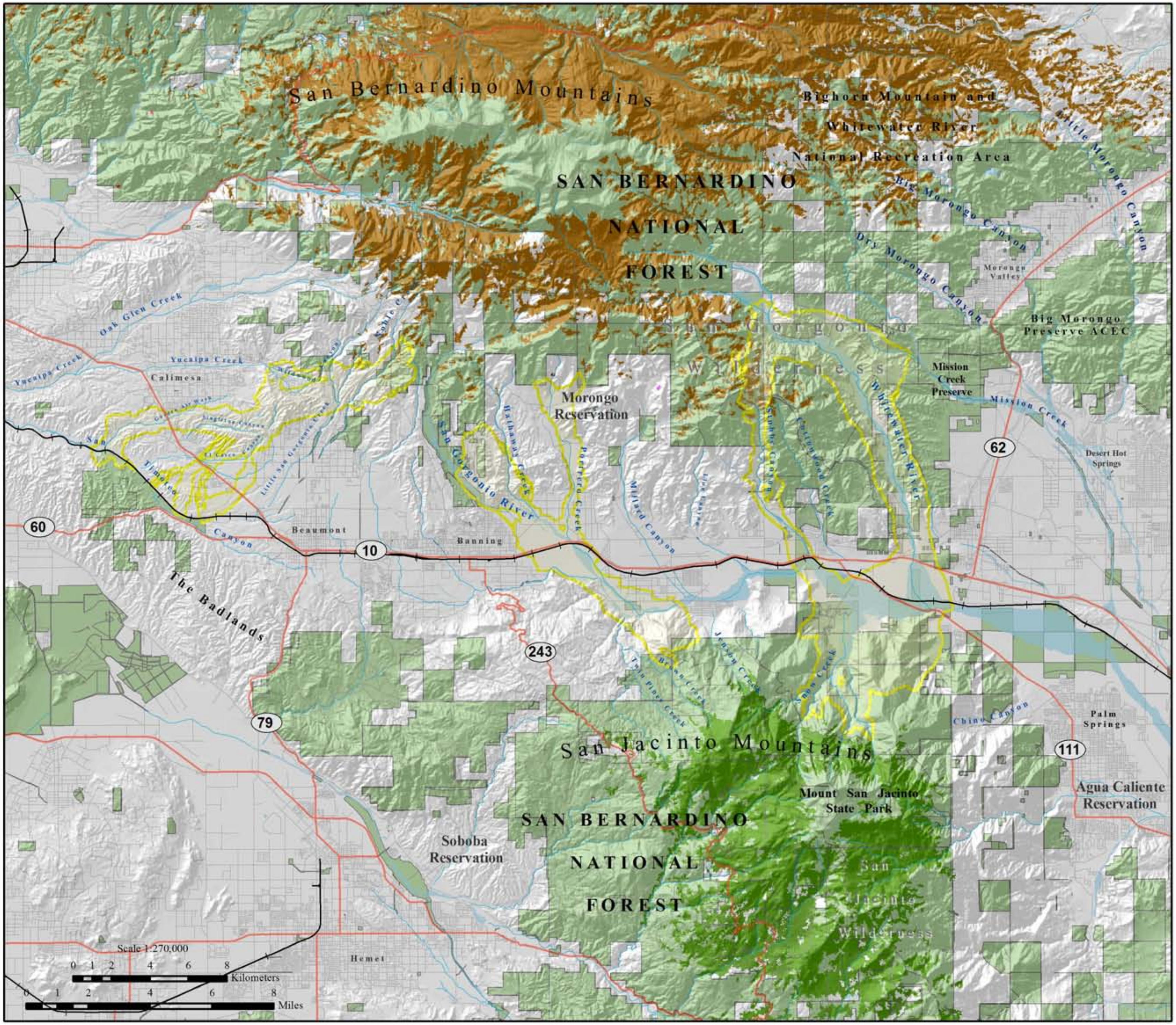
Figure 38.
Patch Configuration for Pygmy nuthatch
(Sitta pygmaea)



Least Cost Union
Protected Lands
Rivers & Streams
Roads
Railroads

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

N

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Rock wren (Salpinctes obsoletus)

Justification for Selection: The rock wren is considered a habitat specialist because of its reliance upon environments that are very patchily distributed in the landscape.

Distribution & Status: Rock wrens have a vast geographic distribution, ranging from British Columbia to Central America and from the Pacific Coast eastward to the Great Plains (American Ornithologist Union 1998, Oppenheimer and Morton 2000). In southern California, they occur from northern San Luis Obispo County south to San Diego County (Small 1994). Rock wrens have one of the broadest altitudinal ranges of any North American bird (Small 1994); nests have been discovered at 75 m (246 ft) below sea level in Death Valley and as high as 4,267 m (14,000 ft) in the Sierra Nevada and White Mountains (Grinnell and Miller 1944, Small 1994, Oppenheimer and Morton 2000). The rock wren has no special conservation status.

Habitat Associations: Although their range encompasses a huge area, they occupy a very specialized niche (Small 1994, Oppenheimer and Morton 2000). Rock wrens may be found in a variety of open vegetation communities, including Great Basin scrub, desert scrub, chaparral, deep-cut arroyos, dry gravelly washes, and perennial grassland (Grinnell and Miller 1944, Bent 1948, DeSante and Ainley 1980, Small 1994, Zeiner et al. 1990), as well as pinyon-juniper woodland and the Bristlecone-Limber Pine Zone (Morrison et al. 1993). However, within these communities, they are restricted to rocky outcrops, talus slopes, cliffs, and earthen banks, which provide refuge, foraging and breeding sites (Grinnell and Miller 1944, Bent 1948, DeSante and Ainley 1980, Zeiner et al. 1990, Oppenheimer and Morton 2000). They may also utilize small mammal burrows (Small 1994).

Spatial Patterns: No information on home range or territory size was available in the literature, though several density estimates exist (Zeiner et al. 1990). In eastern Oregon, Anderson et al. (1972) found 25 breeding males per 40 ha (100 ac) in juniper-sage habitat. In Montana, Walcheck (1970) recorded 5 pairs per 40 ha (100 ac) in pine-juniper woodland. In Arizona, Hensley (1954) observed 5-8 pairs of rock wrens per 40 ha (100 ac) in the Sonoran Desert.

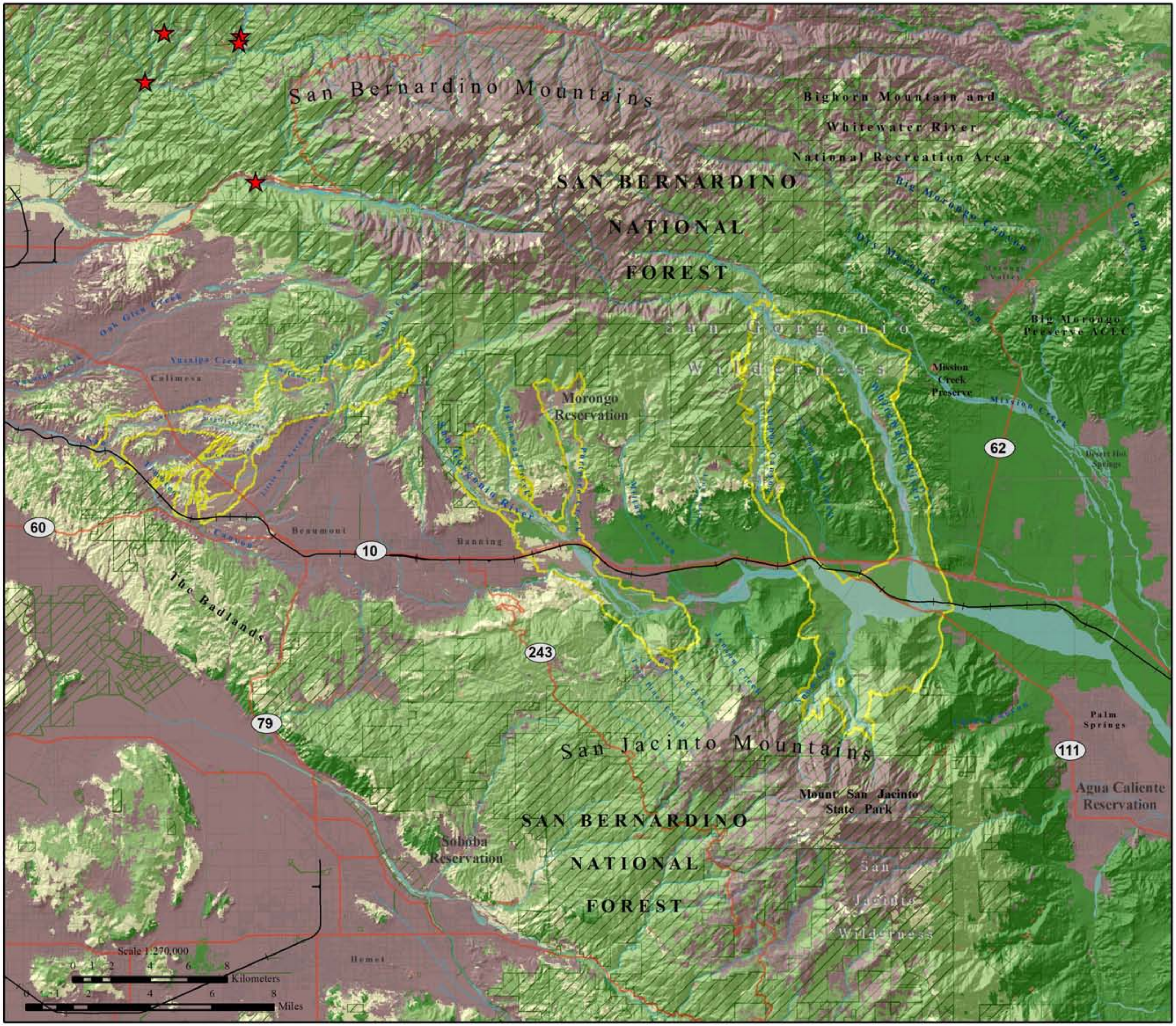
Research on the movement ecology of this species is lacking. Populations at higher elevations may move downslope in winter, while populations further north may migrate southward (Grinnell and Miller 1944, DeSante and Ainley 1980, Zeiner et al. 1990).

Conceptual Basis for Model Development: Rock wren movement in the linkage is likely multigenerational. They may utilize a variety of open habitats, including Great Basin scrub, desert scrub, pinyon-juniper woodland, deep-cut arroyos, dry gravelly washes, perennial grassland, as well as rocky outcrops and barren areas within chaparral, montane hardwood conifer and mixed coniferous forests. Core areas were defined as $\geq$ 290 ha (716 ac). Patch size was classified as $\geq$ 3.2 ha (7.9 ac) but less than 290 ha. Dispersal distance was not estimated for this species.

Results & Discussion: The habitat suitability analysis identified vast amounts of suitable habitat for rock wren, though the rocky outcrops and barren areas preferred by this species are patchily distributed in a number of vegetation communities in the planning area (Figure 39). The easternmost branch of the Union contains the most contiguous potential core habitat for this species, though all branches of the Union contain potential habitat (Figure 40). We conclude that the linkage will likely serve this species.

To protect and maintain habitat for rock wren, we recommend that inholdings that could fragment habitat and introduce non-native predators (e.g., dogs, cats; Winter 2003) be conserved through conservation easements, fee title agreements, acquisition, or other means.

Figure 39.
Habitat Suitability
for
Rock wren
(Salpinctes obsoletus)



Degree of Suitability
- High
- Medium to High
- Medium
- Low to Medium
- Low
- Protected Lands
- Least Cost Union
- Rivers & Streams
- Roads
- Railroads
- Species Occurence (USFS)

N

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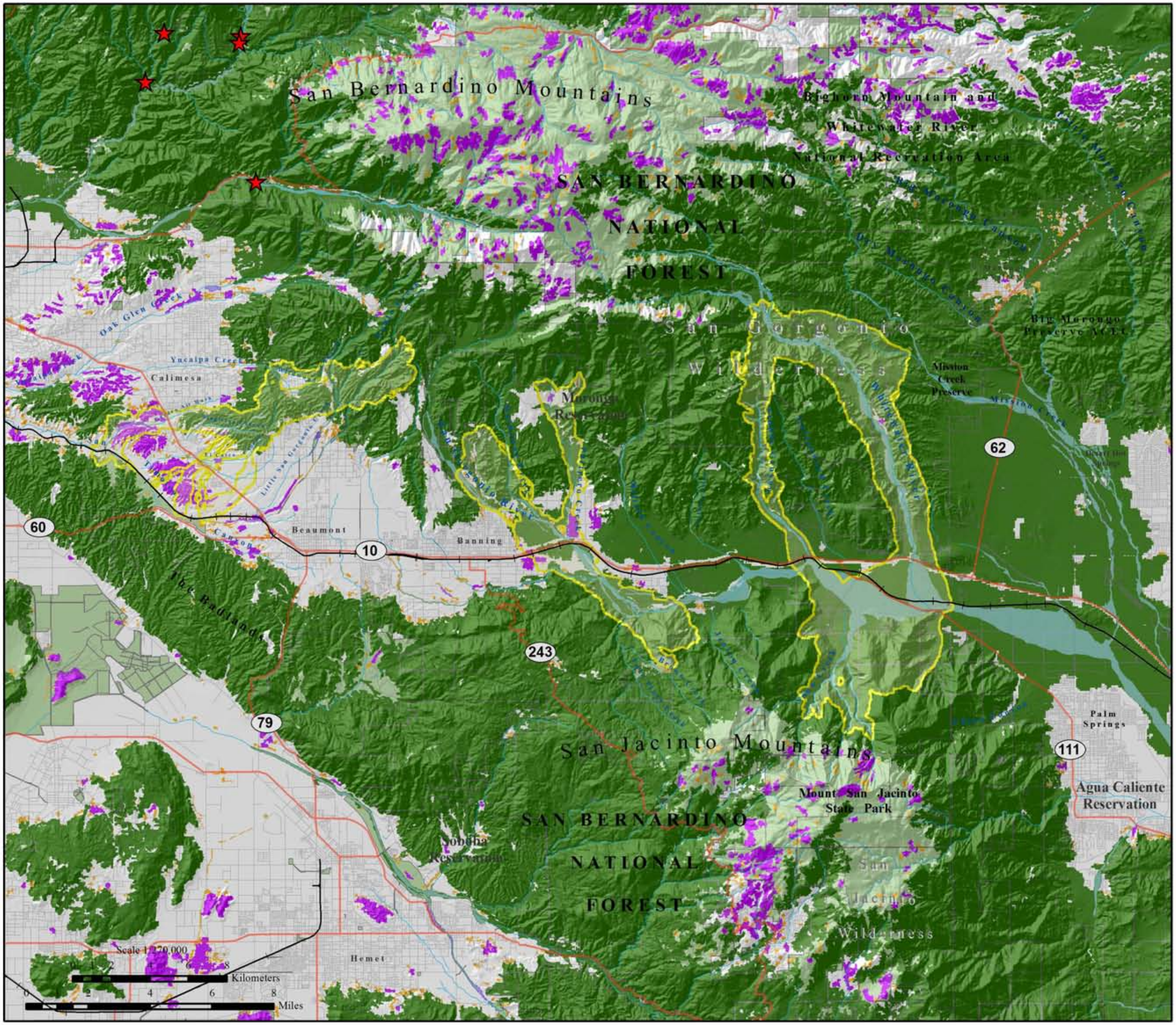
Figure 40.
Potential Cores & Patches for Rock wren
(Salpinctes obsoletus)



Core
Patch
< Patch
Least Cost Union
Protected Lands
Rivers & Streams
Roads
Railroads
Species Occurence (USFS)

N

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Wrentit (Chamaea fasciata)

Justification for Selection: The wrentit has been identified as an indicator species for Mediterranean scrub habitats, which are extremely threatened in southern California (Soulé et al. 1988, Chase et al. 2000, Crooks et al. 2001). Wrentits are highly sensitive to habitat fragmentation and are reluctant to cross roads, trails and firebreaks since they rarely venture far from cover (Small 1994). They require core habitat to persist (Crooks et al. 2001, Crooks et al. 2004).

Distribution & Status: The wrentit is virtually a California endemic, although it occurs from near the Oregon state line to the Mexican border. They are generally distributed west of the Cascades, the Sierra Nevada crest and the desert (Small 1994, Barhoum and Burns 2002). The planning area is on the eastern edge of its distribution. Wrentits typically breed from sea level to near 2,300 m (7,546 ft; Geupel et al. 2002), but have been found up to 2,500 m (8,200 feet) in the San Jacinto Mountains (Garrett and Dunn 1981, Small 1994). The wrentit is not a special status species.

Habitat Associations: Wrentits are strongly associated with chaparral and other shrubby habitats. They inhabit lowland hard and montane chaparral, coastal sage scrub, northern coastal scrub, or other habitats with a dense, structurally complex understory (Grinnell and Miller 1944, Zeiner et al. 1990, Small 1994, Geupel et al. 2002). They may also be encountered in well-developed riparian habitats that contain oaks (*Quercus* sp.), willow (*Salix* sp.) scrub, Coyote bush (*Baccharis* sp.), poison oak (*Toxicodendron* sp.), and blackberry (*Rubus* sp.) thickets (Small 1994, Geupel et al. 2002). They may also utilize shrubby understories in some conifer habitats (Grinnell and Miller 1944, Geupel et al. 2002).

Spatial Patterns: Home range size is believed to be the same as territory size (Zeiner et al. 1990). Territories are typically smaller in denser scrub communities (Erickson 1938, Geupel et al. 2002). A recent study in coastal California (Geupel et al. 2002) evaluated territories of 105 pairs that averaged 0.6 ha (1.5 ac), with a range of 0.2 to 2.2 ha (0.6 to 5.3 ac). Cogswell (1962) evaluated 361 pairs and reported smaller territories in Los Angeles County that averaged 0.5 ha (1.3 ac), with a range of 0.2 to 1.2 ha (0.5 to 3 ac). Other studies in Los Angeles County reported similar results (Mans 1961, Kingery 1962). Wrentits are likely to be extirpated from habitat fragments smaller than 10 ha (24.7 ac) in size (Soulé et al 1988, Crooks et al. 2001, Crooks et al. 2004).

Natal dispersal distances of wrentits average less than 400 m (1,312 ft) (Baker et al. 1995, Geupel et al. 2002). They typically stay within their territories, although outside of the breeding season off-territory movements of up to 500 m (1,640 ft) may occur (Geupel et al. 2002). In mountainous regions, juveniles may move upslope after the breeding season (Garrett and Dunn 1981, Small 1994).

.
Conceptual Basis for Model Development: Movement in the linkage is likely multigenerational. The wrentit requires dense habitats with plenty of cover. They prefer chaparral and coastal sage scrub, but may also be found in other habitats with dense cover. Core areas were defined as ≥14 ha (34.5 ac), while patch size was classified as ≥ 1 ha (2.47) but <14 ha. Dispersal distance was defined as 1 km (0.62 mi).

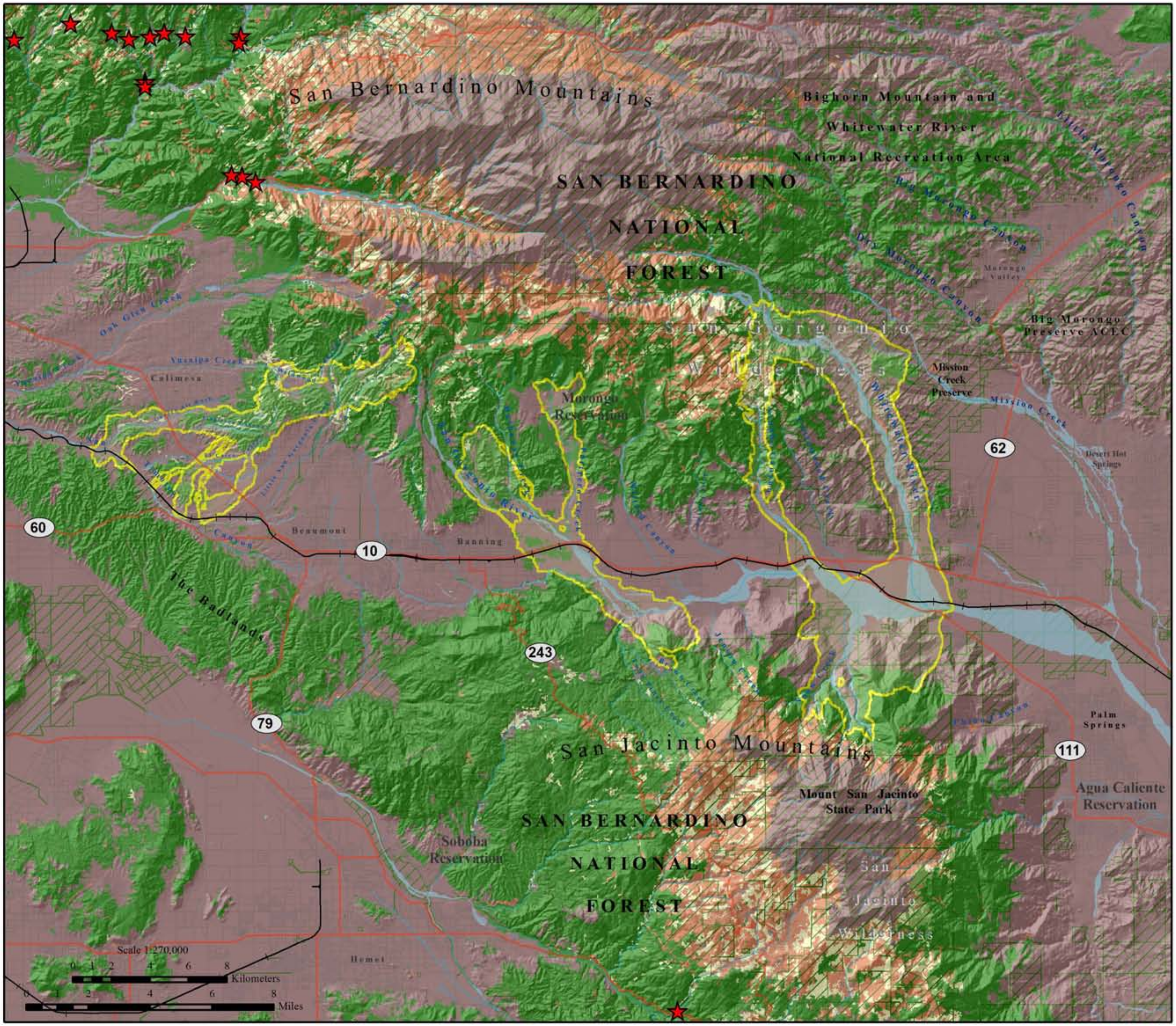
Results & Discussion: Extensive highly suitable habitat was identified for wrentit in the mid to lower elevations of the San Bernardino and San Jacinto Mountains and in the Badlands (Figure 41). The great majority of suitable habitat was delineated as potential core areas for this species (Figure 42). The western branch of the Least Cost Union provides the most direct connection between core areas and patches of suitable habitat for this chaparral specialist, while the central branch may provide a secondary connection (Figure 41, 42). The majority of cores and patches of suitable habitat are within the dispersal distance defined for this species (Figure 43), although numerous barriers to movement may exist between suitable habitat patches. We conclude that the linkage is likely to serve the needs of this species for movement among populations if habitat is added to the Union in the foothills of the San Jacinto Mountains.

Habitat loss and fragmentation is an issue for this species throughout much of their range. They are largely absent from smaller habitat patches (Soulé et al 1988, Crooks et al. 2001). To protect and restore habitat connectivity for wrentits, we recommend that:

- Inholdings that could fragment habitat and introduce non-native predators (e.g., dogs, cats; Winter 2003) be conserved through conservation easements, fee title agreements, or other means.

- Fire frequency is controlled to prevent type conversion of chaparral and scrub habitats to nonnative annual grassland (Winter 2003).

Figure 41.
Habitat Suitability
for
Wrentit
(Chamaea fasciata)



Degree of Suitability

- High
- Medium to High
- Medium
- Low to Medium
- Low
- Least Cost Union
- Protected Lands
- Rivers & Streams
- Roads
- Railroads
- Species Occurence (USFS)

N

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Figure 42.
Potential Cores & Patches for Wrentit
(Chamaea fasciata)

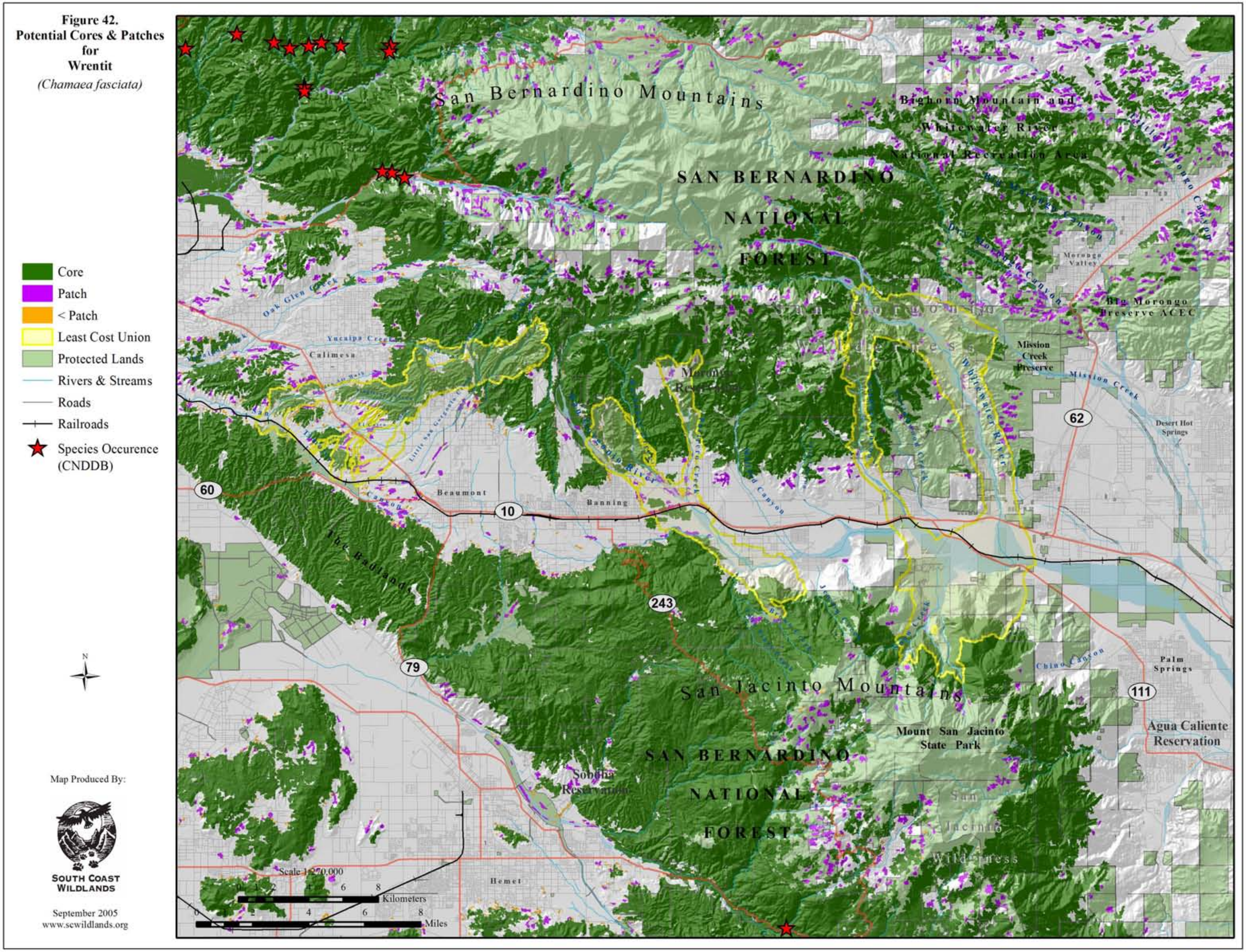
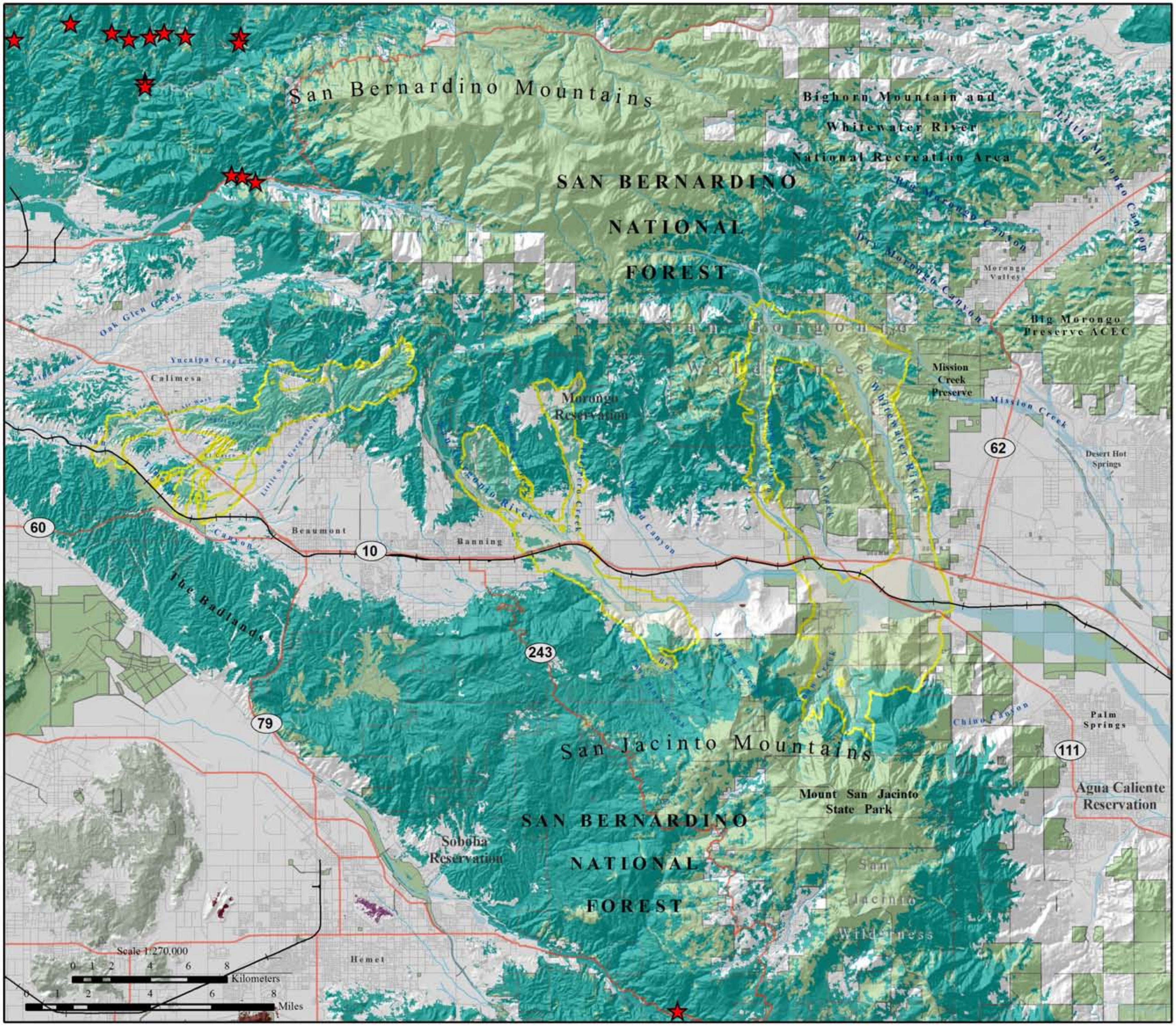


Figure 43.
Patch Configuration
for
Wrentit
(Chamaea fasciata)



Least Cost Union
Protected Lands
Rivers & Streams
Roads
Railroads
Species Occurence (CNDDB)

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

N

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Justification for Selection: California treefrogs are habitat specialists with low capacity to leave moist streamside environments.

Distribution: California treefrogs are patchily distributed from central San Luis Obispo County south to the Mexican border (Zeiner et al. 1988) and can occur at elevations up to 1,690 m (5,500 ft; Stebbins 1985).

Habitat Associations: Adults occur in deeply cut canyons with stream boulders and large, slow pools (Kay 1989). They summer under rocks, or in rock cracks at the water's edge, and spend late fall and winter inactive in deep moist crevices (Harris 1975). They breed in quiet waters of rivers and creeks, and tadpoles require standing water up to 2.5 months (Stebbins 1954).

Spatial Patterns: Frogs in Los Angeles County living along an ephemeral stream made daily movements up to 200 m (656 ft), although 83% of all movements measured were less than 25 m (82 ft; Kay 1989). Home ranges of individuals overlap.

Long-distance movements are restricted to streamside areas and vary between 34 and 506 m (112-1,660 ft; Kay 1989). Two of 9 frogs displaced 300 m (980 ft) from the point of capture were recaptured at their capture location (Kay 1989). Frogs rarely move from the streamside with winter observations occurring up to 12 m (39 ft) from streams (Harris 1975).

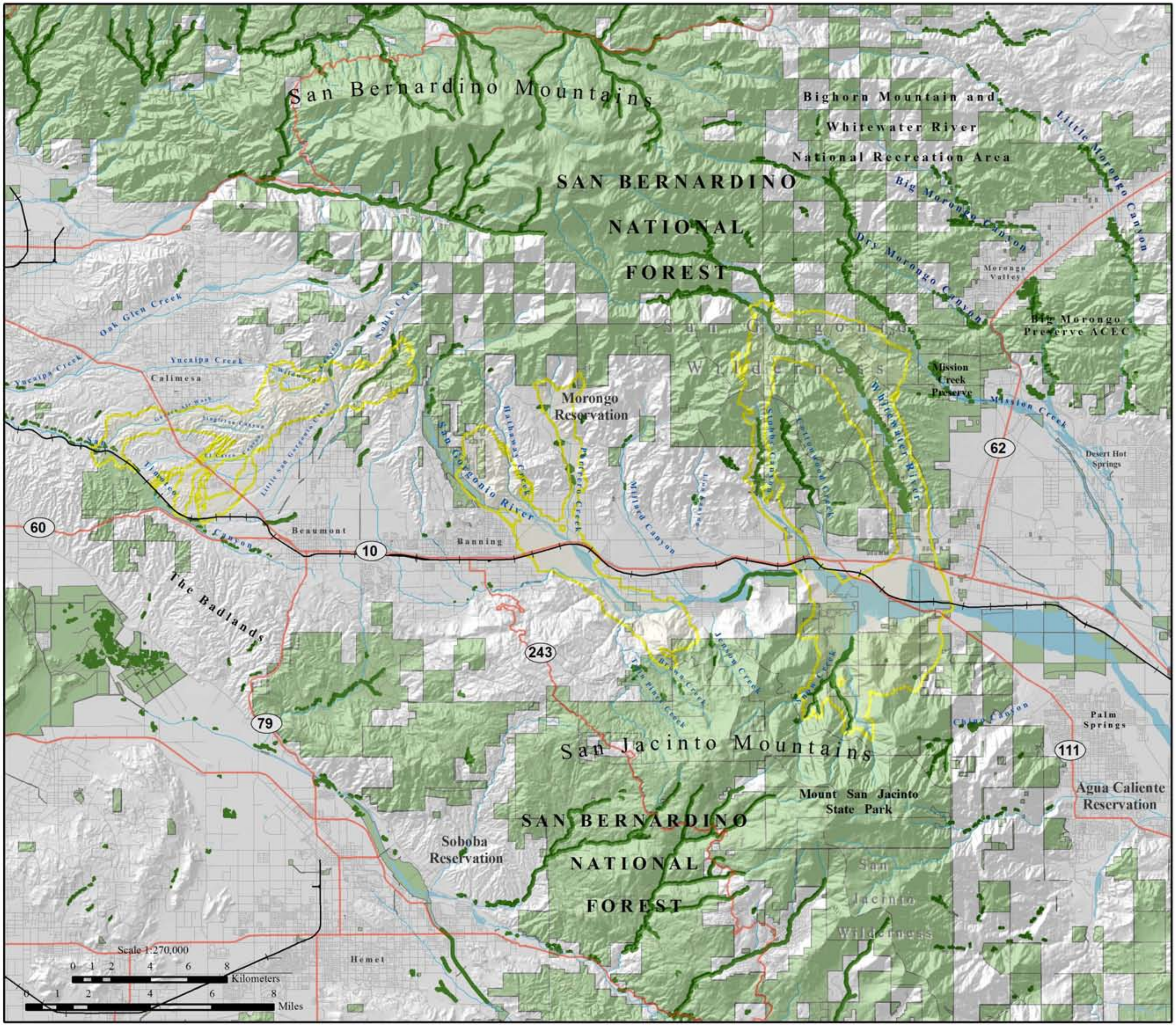
Conceptual Basis for Model Development: Treefrog movement in the linkage is likely multigenerational. Suitable habitat was identified as riparian vegetation. Because habitat quantity is a poor predictor of population density in treefrogs, we did not designate a minimum patch size, and included all suitable habitats as potential core habitat for this species.

Results and Discussion: The treefrog is restricted to riparian areas, which are fairly widespread in the targeted core areas but more limited in the vicinity of the connection (Figure 44). Potential habitat for the treefrog was identified in the Least Cost Union in the Whitewater River and in upper Stubbe Canyon. A potential riparian connection between targeted core areas is along the Whitewater River (Figure 44), especially if habitat restoration efforts are undertaken. We suggest adding habitat to the Union in Stubbe Canyon and along the San Gorgonio River. To restore and protect habitat connections for treefrogs between the San Bernardino and San Jacinto Mountains, we recommend that:

- Habitat restoration is initiated in Whitewater River to re-establish a gallery forest along the length of the river to its confluence with the San Gorgonio River.

Figure 44.
Potential Habitat
for
California tree frog
(Hyla cadaverina)

Potential Habtitat
Least Cost Union
Protected Lands
Roads
Railroads
Rivers & Streams



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- Riparian habitats needed for breeding and movement are restored.

- Invasive species be eradicated that destroy treefrog habitat (e.g., giant reed, tamarisk) and prey on tadpoles (e.g., bullfrogs and non-native fish).

- Road barriers be modified, where necessary, to allow amphibians to move along riparian corridors.

- Water quality that is compromised by runoff be restored.

- Eliminate feral cattle in Stubbe Canyon to stop overgrazing which could lead to the loss of gallery cottonwood forest.

- Attempt to expand gallery forest in Stubbe Canyon and Whitewater River.

Coast horned lizard (*Phrynosoma coronatum blainvillii)*

Justification for Selection: The coast horned lizard is highly sensitive to habitat loss and fragmentation. This species needs expansive roadless wildlands to persist.

Distribution & Status: This California endemic has 2 subspecies (*P. c. blainvillii* and *P. c. frontale*) whose ranges overlap. *P. c. blainvillii* occurs in the planning area (Stephenson and Calcarone 1999). The known elevational range for this species is from near sea level to 1,980 m (6,496 ft; Jennings and Hayes 1994).

The horned lizard has been extirpated from nearly 45% of its former range (Jennings and Hayes 1994). Agriculture, flood control, and urbanization are cited as the main reasons for its decline (Jennings and Hayes 1994). These activities promote biological invasions by Argentine ants that eliminate native ant colonies, which the horned lizard is highly dependent upon for sustenance (Pianka and Parker 1975, Montanucci 1989, Suarez et al. 2000, Suarez and Case 2002, Fisher et al. 2002). Domestic cats can also penetrate considerable distances into otherwise suitable habitat, eliminating horned lizards within a several km radius (Jennings and Hayes 1994). This species is identified as Sensitive by the federal government and is considered a California Species of Special Concern.

Habitat Associations: The horned lizard frequents several vegetative communities, including inland dunes, alluvial fans, open coastal scrub and chaparral, annual grassland with scattered perennial seepweed or saltbush, clearings in coniferous forests, broadleaf woodlands, riparian woodlands, and pine-cypress forests. However, they prefer the gravelly-sandy substrate of alluvial fans and flats dominated by alkali plants (Stebbins 1985, Zeiner et al. 1988, Jennings and Hayes 1994). Essential habitat characteristics are loose, fine sandy soils, an abundance of native ants or other invertebrates, open areas for basking, and scattered low shrubs for cover and refuge (Stebbins 1985, Fisher et al. 2002). This species may utilize small mammal burrows, or tunnel into loose soils during periods of inactivity or hibernation (Jennings and Hayes 1994).

Spatial Patterns: Little is known about home range size (Zeiner et al. 1988) or dispersal distance for this species. Fisher et al. (2002), estimated home range size of about 0.1 km^2 (10 ha or 25 ac). In a related species, *P. Solare*, males moved maximum distances of 30 m (98 ft) while females moved maximum distances of 15 m (49 ft; Zeiner et al. 1988).

Conceptual Basis for Model Development: Movement in the linkage is multigenerational. Horned lizards may use alluvial fans, alkali flats, alkali desert scrub, dunes, open coastal scrub and chaparral, annual grassland, and clearings in coniferous forests, broadleaf woodlands, and riparian woodlands. They avoid urban and agricultural developments and areas of high road density. Core areas potentially supporting 25 pairs were defined as ≥ 250 ha (618 ac). Patch size was classified as ≥ 20 ha (50 ac) but less than 250 ha. Dispersal distance was defined as 60 m (200 ft), using twice the longest recorded distance.

Results & Discussion: The most highly suitable habitat for horned lizard is in open areas within chaparral and coastal sage habitats (Figure 45). Extensive potential core areas were identified on the western slopes and foothills of the San Bernardino and San Jacinto mountains, with the largest potential core area in the planning area encompassing a contiguous block of highly suitable habitat that extends from the San Jacintos to the Badlands (Figure 46). The western branch of the Least Cost Union provides the most direct connection between core areas and patches of suitable habitat for the horned lizard, while the central and easternmost branches of the Union may provide secondary connections for this species, as the horned lizard has been recorded in each of these areas (CDFG 2005). The patch configuration analysis suggests that the majority of cores and patches of suitable habitat are within the dispersal distance defined for this species (Figure 47), although numerous barriers to movement may exist between suitable habitat patches. We conclude that the linkage is likely to serve the needs of this species if habitat is added to the Union along the San Gorgonio River and in the foothills of the San Jacinto Mountains.

Research indicates this species is more likely to persist in larger habitat patches because of its dependence on native ants, which only occur in undisturbed habitats (Suarez and Case 2002, Fisher et al. 2002). They need large patches of suitable habitat that are in close proximity to one another (Fisher et al. 2002). To protect and restore habitat connectivity for horned lizard, we recommend that:

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

- Short retaining walls are installed in conjunction with crossing structures along paved roads in the Linkage Design to deter horned lizards from accessing roadways (Jackson and Griffin 2000).

- Fire frequency is controlled to prevent type conversion of chaparral and scrub habitats to nonnative annual grassland.

- Inholdings that could fragment habitat and introduce non-native ants be conserved through conservation easements, fee title agreements, acquisition, or other means.

Figure 45.
Habitat Suitability
for
Coast horned lizard)
(Phrynosoma coronatum)

Degree of Suitability

- High
- Medium to High
- Medium
- Low to Medium
- Low
- Least Cost Union
- Protected Lands
- Rivers & Streams
- Roads
- Railroads
- Species Occurence (CNDDB)

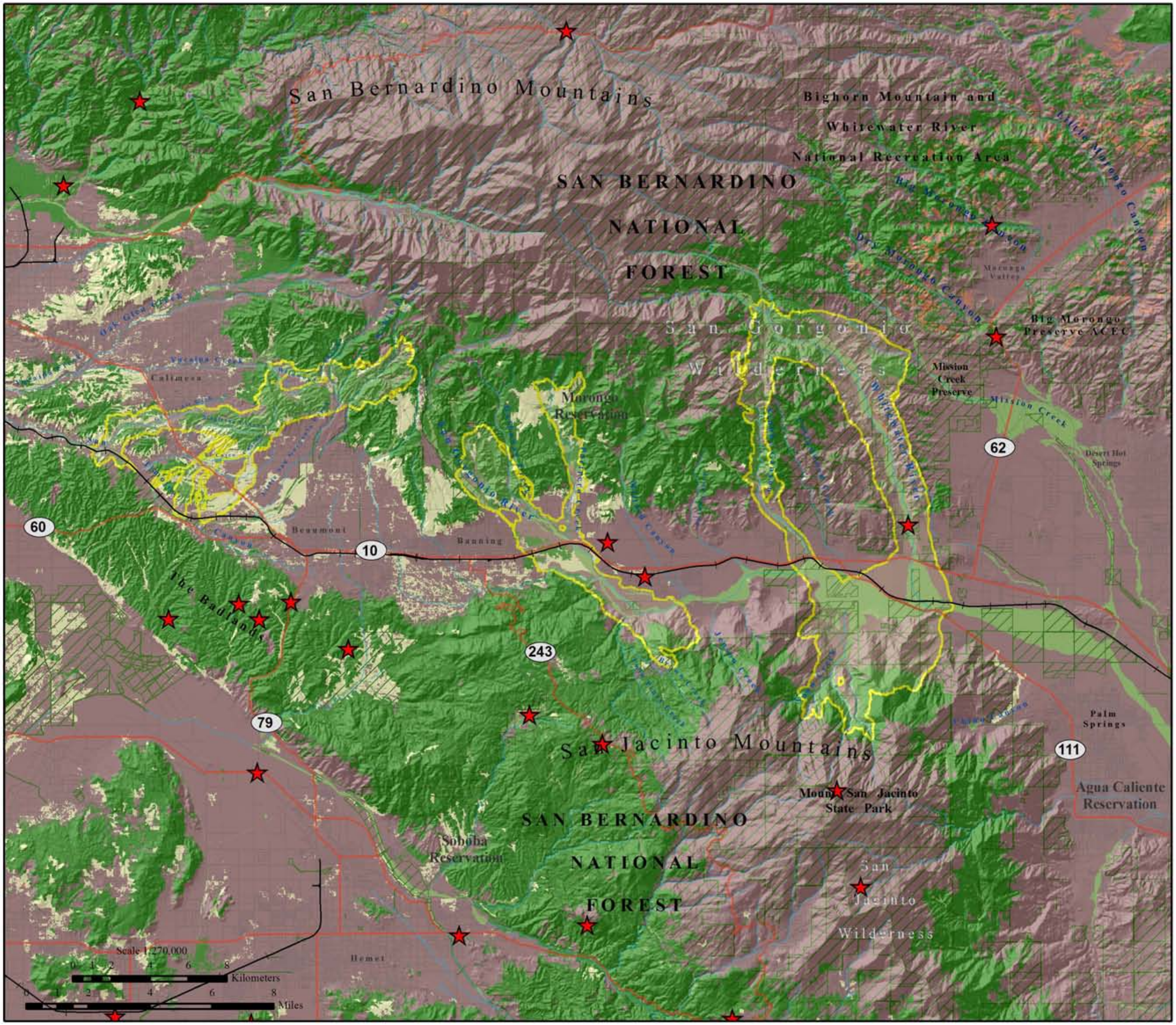

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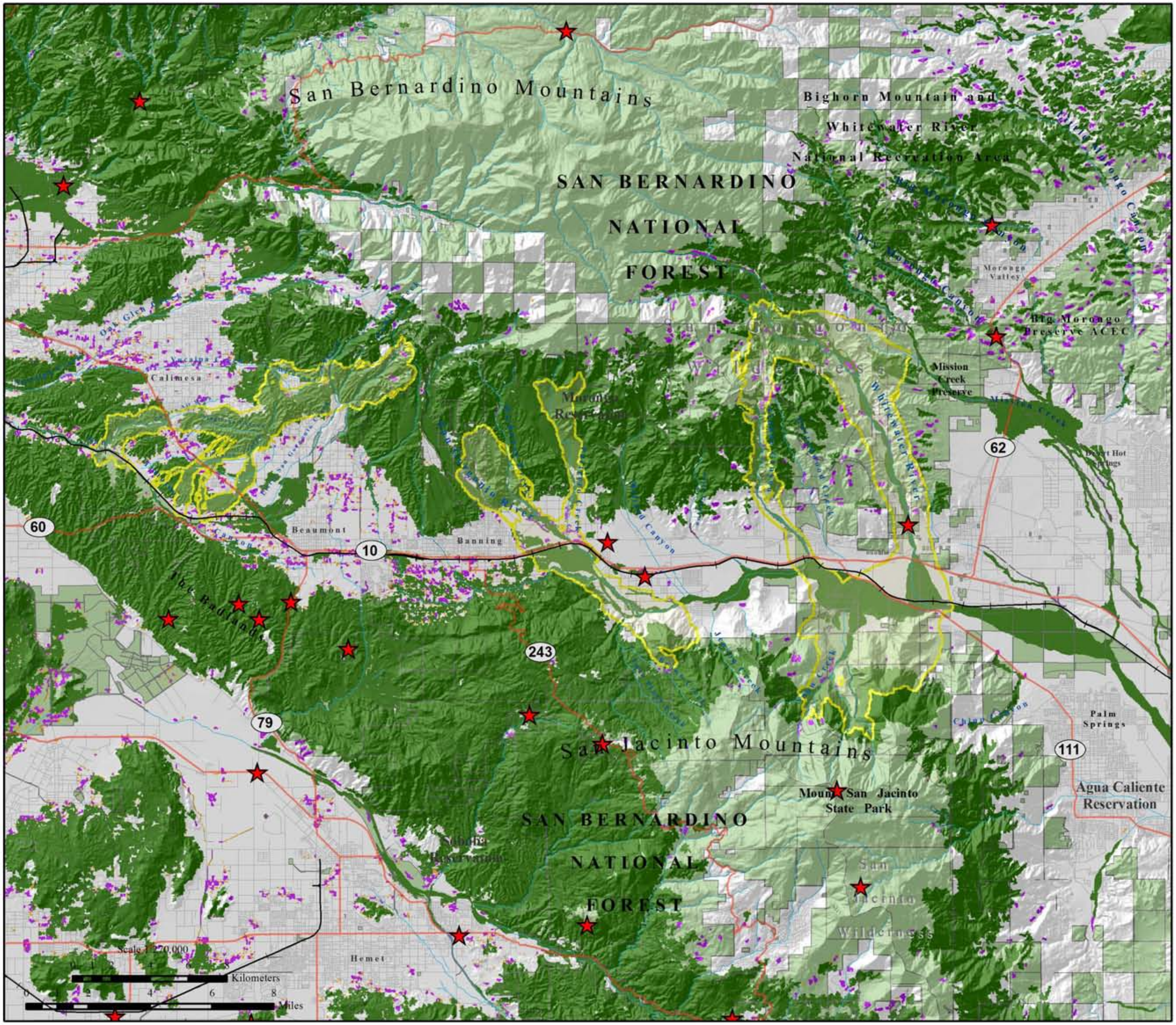
Figure 46.
Potential Cores & Patches
for
Coast horned lizard
(Phrynosoma coronatum)



Core
Patch
< Patch
Least Cost Union
Protected Lands
Rivers & Streams
Roads
Railroads
Species Occurence (CNDDB)

N

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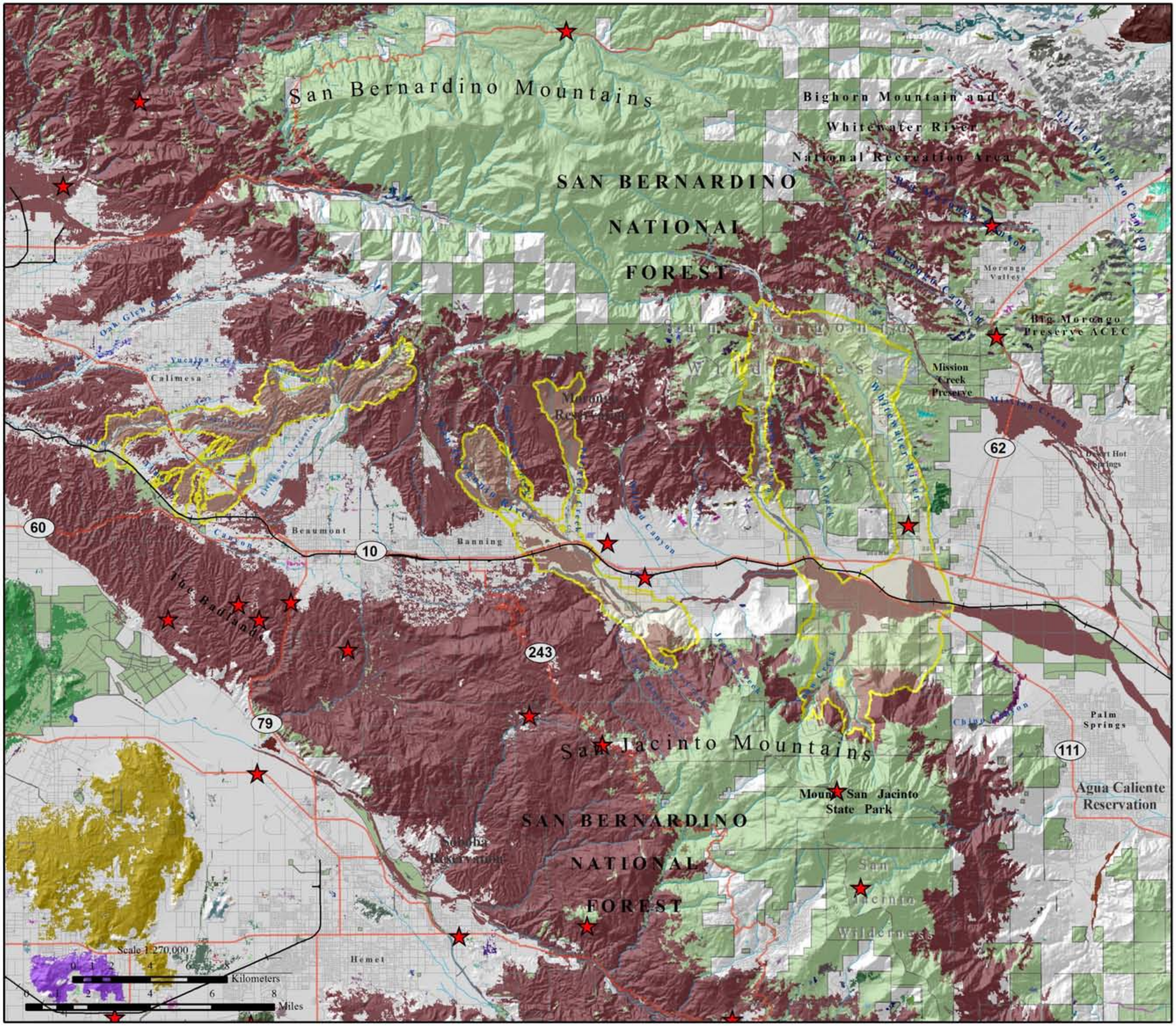
Figure 47.
Patch Configuration
for
Coast horned lizard
(Phrynosoma coronatum)

Least Cost Union
Protected Lands
Rivers & Streams
Roads
Railroads
Species Occurence (CNDDB)

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



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Chaparral whipsnake (Masticophis lateralis lateralis)

Justification for Selection: The chaparral whipsnake is particularly sensitive to habitat fragmentation. Patten and Bolger (2003) found this species to be most common in large core areas and largely absent from smaller habitat fragments, with the probability of occurrence declining steadily with fragmentation across a fragmentation gradient (Patten and Bolger 2003).

Distribution & Status: The chaparral whipsnake is one of two subspecies of the California whipsnake (*Masticophis lateralis*); the other is the endangered Alameda whipsnake (*M. l. euryxanthus*). The range of the chaparral whipsnake extends from northern California, west of the Sierran crest and desert, to central Baja California, largely coinciding with the distribution of chaparral habitats (Hammerson 1979, Jennings 1983, Stebbins 1985, USFWS 2000). The planning area is on the eastern edge of this species' distribution. The species may be found from sea level to 1,835 m (6,020 ft) in elevation (Zeiner et al. 1988).

Habitat loss and fragmentation of terrestrial and aquatic habitats are cited as the primary threats to the whipsnake (USFWS 2000, Patten and Bolger 2003). Habitat conversion and alteration, including water diversions and groundwater pumping, are likely barriers to dispersal (USFWS 2000). The chaparral whipsnake isn't considered a special status species.

Habitat Associations: The chaparral whipsnake, as its name implies, prefers mixed chaparral and chamise-redshank chaparral habitats (Zeiner et al. 1988, Swaim 1994, USFWS 2000). This species may also be encountered in valley foothill riparian, valley foothill hardwood, hardwood conifer, and various coniferous forests (Zeiner et al. 1988), as well as coastal sage scrub and coyote bush scrub habitats (Swaim 1994, USFWS 2000). Radio-telemetry studies indicate that whipsnakes regularly journey into grassland, oak savanna, and occasionally oak-bay woodland habitats (Swaim 1994, USFWS 2000). Grassland habitats may be particularly important to females for egg-laying sites (Swaim 1994, USFWS 2000).

Rock outcrops are an essential habitat component because they provide refuge and support lizard populations, the whipsnake's primary prey (Stebbins 1985, Swaim 1994, USFWS 2000). The species is known to bask in the sun prior to morning activities but avoids the direct sun at midday by retreating to cover under large rocks or fallen logs or in crevices of rock outcrops (Hammerson 1979, Zeiner et al. 1988).

Spatial Patterns: Although the home range size of the chaparral whipsnake is unknown, it is considered to be extensive for this energetic species (Zeiner et al. 1988). Male home ranges of the Alameda whipsnake, a related subspecies, have been recorded to range from 1.9 to 8.7 ha (4.7-21.5 ac), with 5.5 ha (13.6 ac) noted as the average size (Swaim 1994, USFWS 2000). Research indicates that shrub communities are the focal point of home ranges, though whipsnakes make frequent excursions into adjacent habitats (Swaim 1994, USFWS 2000). Radio-telemetry data suggest most whipsnakes are within 50 m (170 ft) of scrub habitat, though distances greater than 150 m (500 ft) have been recorded (Swaim 1994, USFWS 2000).

The whipsnake is a swift moving snake (Hammerson 1979). The striped whipsnake (*M. t. taeniatus*), an allied species, moved 3.6 km (2.2 mi) after emerging from its hibernaculum (Hirth et al. 1969), and it is likely that the chaparral whipsnake is capable of similar long distance movements (USFWS 2000).

Conceptual Basis for Model Development: The chaparral whipsnake preferentially moves through mixed chaparral and chamise-redshank chaparral habitats, but it may also be encountered in other riparian, woodland, scrub, and grassland habitats below 1,835 m (6,020 ft).

Core areas were identified as ≥137.5 ha (340 ac). Patch size was defined as ≥ 3.8 ha (9.4 ac), but less than 137.5 ha. Dispersal distance was estimated at 7.2 km (4.5 mi), or twice the longest distance recorded for an associated species.

Results & Discussion: Highly suitable habitat for the chaparral whipsnake largely follows the distribution of chaparral habitats in the planning area (Figure 48). The spatial configuration of suitable habitat is fairly extensive, with potential core areas identified in all targeted ranges (Figure 49). The western branch of the Least Cost Union provides the most direct connection between core areas and patches of suitable habitat for the whipsnake, while the central branch of the Union may provide a secondary connection for this species (Figures 48, 49). We recommend adding habitat to the Union in the foothills of the San Jacinto Mountains to serve the needs of this species. All core areas and patches of suitable habitat are within the dispersal distance of this species (figure not shown), though barriers to movement may exist between suitable habitat patches. We conclude that the linkage is likely to serve the needs of this species for movement among populations if habitat is added to the central branch of the Union in the foothills of the San Jacinto Mountains.

To protect and maintain habitat connectivity between these ranges for the whipsnake, we recommend that:

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

- Fire frequency is controlled to prevent type conversion of chaparral and scrub habitats to nonnative annual grassland.

Figure 48.
Habitat Suitability
for
Chaparral whipsnake
(Masticophis lateralis)

Degree of Suitability
- High
- Medium to High
- Medium
- Low to Medium
- Low
- Least Cost Union
- Protected Lands
- Rivers & Streams
- Roads
- Railroads

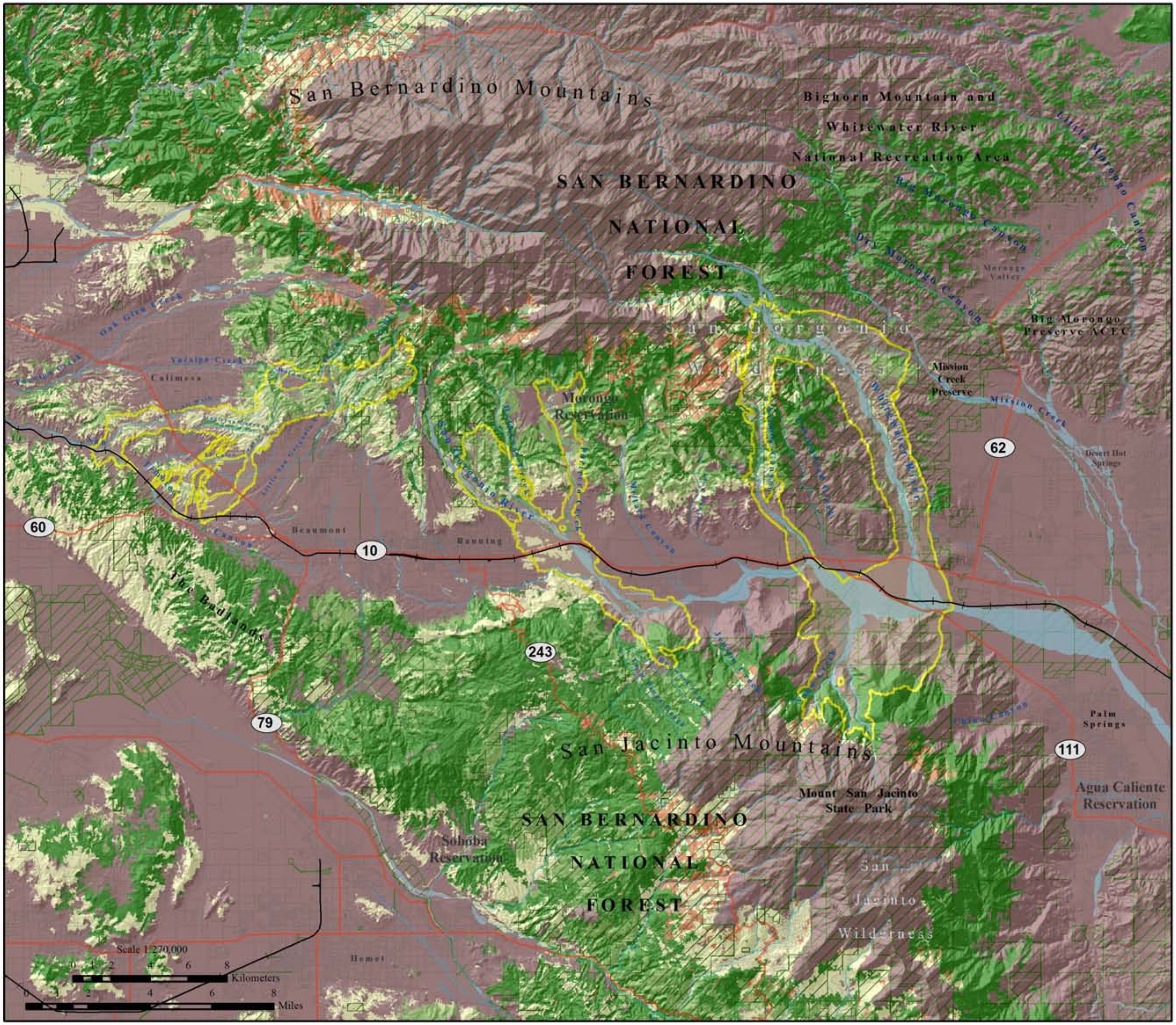

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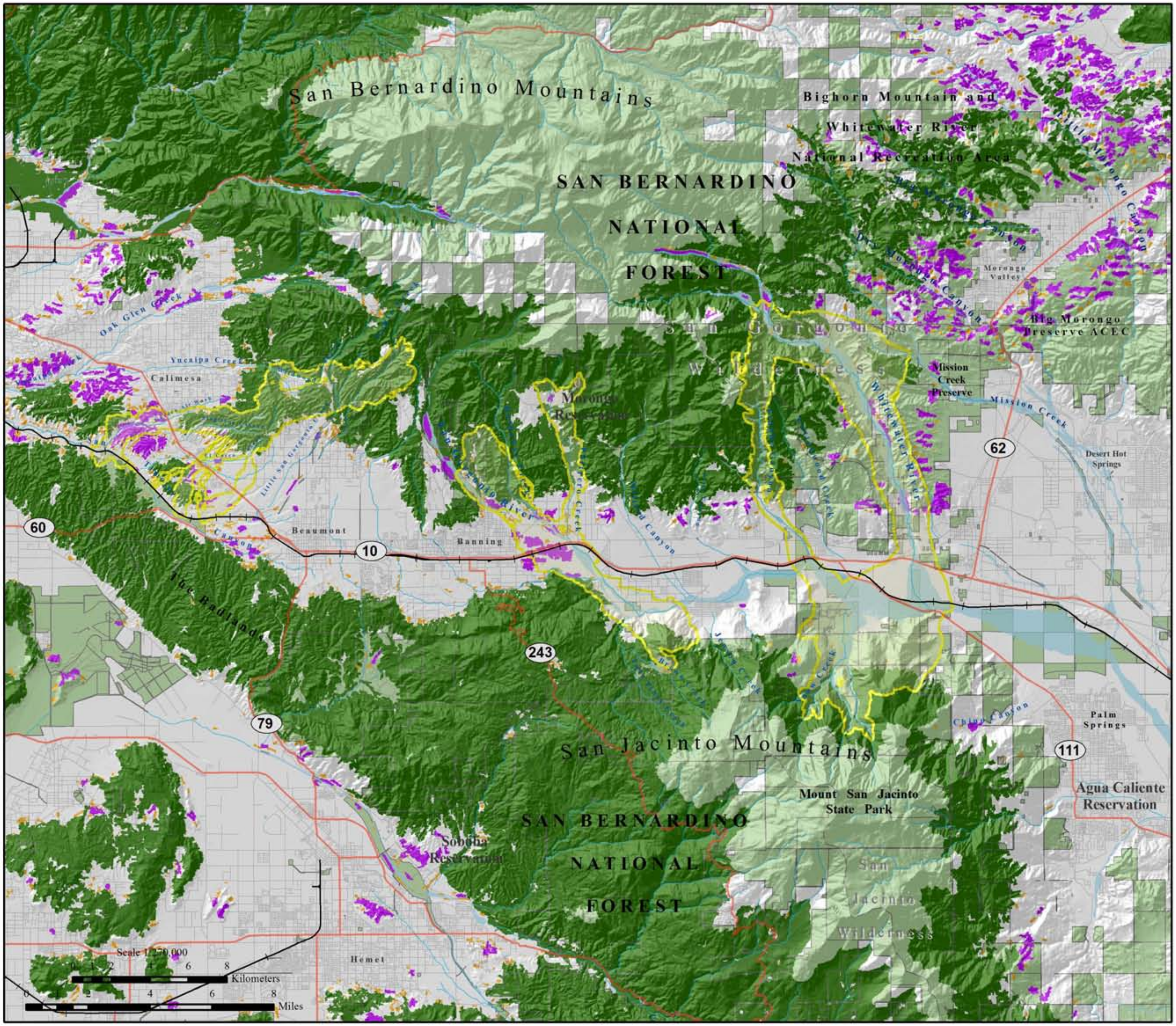
Figure 49. Potential Cores & Patches for Chaparral whipsnake

(Masticophis lateralis)



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Speckled rattlesnake (*Crotalus mitchellii*)

Justification for Selection: This reptile depends on a variety of desert and chaparral habitats. Rattlesnakes are often destroyed when encountered by humans, and are also killed while crossing roads.

Distribution & Status: The distribution of the speckled rattlesnake largely coincides with the Mojave and Sonoran Deserts, but the species may also be encountered on the southern fringes of the Great Basin Desert and in the mountains and coastal facing canyons of San Diego, Riverside, and Orange counties. It occurs from 300-2,200 m (1,000-7,300 ft) elevation (Klauber 1936, 1972, Stebbins 1954, Zeiner et al. 1988, Melli 2000).

The speckled rattlesnake is not listed as sensitive by any government entities, though more snakes are vulnerable to extinction than is currently recognized (Melli 2000).

Habitat Associations: The speckled rattlesnake inhabits a wide range of desert and chaparral habitats but may also utilize pinyon-juniper, valley foothill woodland, and conifer habitats (Klauber 1936, 1972, Stebbins 1954, Zeiner et al. 1988), as well as alluvial deposits in the desert (Melli 2000). They strongly prefer rocky habitats and may be found on steep hillsides, in deep canyons, or in other areas with adequate rocky substrate and dense vegetation. Rock formations, vegetation, and mammal burrows provide shelter (Klauber 1936, 1972, Stebbins 1954, Zeiner et al. 1988).

Spatial Patterns: No data are available on home range or dispersal for the speckled rattlesnake (Zeiner et al. 1988). However, high-elevation populations of this species are known to move considerable distances to winter hibernacula (Klauber 1972, Zeiner et al. 1988). A closely related species, the red diamond rattlesnake (*C. ruber ruber*) has been more thoroughly researched. In the red diamond rattlesnake, home range sizes of males are larger than those of females and range between 0.5 and 5 ha (1.2-12.4 ac; Tracey 2000). Home ranges of males and females can overlap (T. Brown pers. comm.).

The only reported movement distances for the red diamond rattlesnake are for adults on their home ranges: Males can move 400-700 m (1,312-2,297 ft) from den sites (Tracey 2000). Fitch and Shirer (1971) measured average daily movements for adults at 45 m (147 ft) and found that 10% percent of moves were greater than 150 m (492 ft). Juveniles are more likely to disperse long distances, but no movement data are available for this life stage (Tracey 2000).

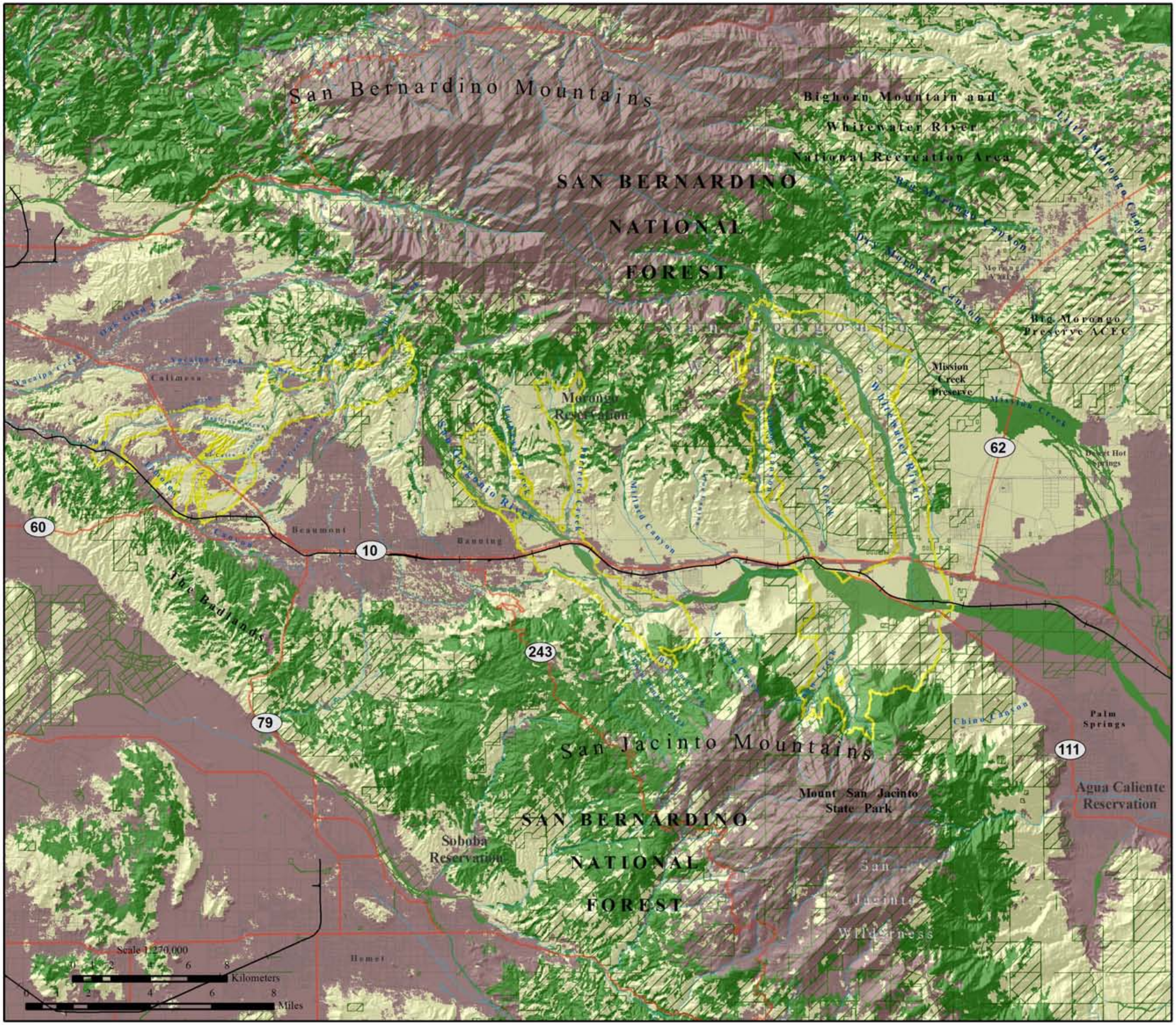
Conceptual Basis for Model Development: Suitable habitats for speckled rattlesnakes are chaparral, desert scrub, desert wash, pinyon-juniper, Joshua tree, valley foothill woodland, and conifer habitats types between 300-2,200 m elevation. Core areas were defined as greater than or equal to 2.5 km^2 (1 mi^2). Patch size was classified as ≥ 0.10 km^2 (0.04 mi^2) but < 2.5 km^2. Dispersal distance is 1,400 m (4,600 ft), or twice the maximum recorded movement for an adult red diamond rattlesnake.

Results & Discussion: The most highly suitable habitat identified for the speckled rattlesnake was mixed chaparral, redshank chaparral, riparian and desert wash habitats, while coastal sage and desert scrub habitats also ranked well (Figure 50). Almost all suitable habitat identified for this species in the planning area was designated as potential core areas, with fairly contiguous core habitat identified in all branches of the Least Cost Union (Figure 51). Despite the relatively short dispersal distance adopted for the model, rattlesnakes are able to move among habitat patches due to the relatively high levels of habitat continuity (figure not shown), though barriers to movement may exist between suitable habitat patches. We conclude the linkage is likely to serve this species, though habitats added to the Union to support the needs of other focal species will also benefit the speckled rattlesnake. To protect and restore habitat connectivity for the speckled rattlesnake, we recommend that:

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

- Fire frequency is controlled to prevent type conversion of chaparral and scrub habitats to nonnative annual grassland.

Figure 50.
Habitat Suitability
for
Speckled rattlesnake
(Crotalus mitchellii)



Degree of Suitability

- High
- Medium
- Low
- Least Cost Union
- Protected Lands
- Rivers & Streams
- Roads
- Railroads

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Figure 51.
Potential Cores & Patches for Speckled rattlesnake
(Crotalus mitchellii)

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Tarantula hawk (*Pepsis* spp.)

Justification for Selection: Tarantula hawks are sensitive to changes in habitat and highways may be impediments to their movement (Pratt and Ballmer, pers. comm.).

Distribution & Status: *Pepsis* is a New World genus with 15 species in the United States. *Pepsis formosa* and *P. thisbe* are the most common species in the southwest (Williams undated material). Tarantula hawk distributions are strongly related to the availability of their primary prey, tarantulas (*Aphonopelma* spp.; Hogue 1974, Williams undated material, Pratt and Ballmer, pers. comm.). They may be found at elevations up to 2,286 m (7,500 ft), but are typically encountered at lower elevations (Pratt and Ballmer, pers. comm.)

Habitat Associations: Tarantula hawks are associated with communities where milkweed and other nectar sources are available for adults, and host tarantulas are present (Vincent 2000, Pratt and Ballmer, pers. comm.). They may be encountered in coastal sage scrub, alluvial fan scrub, montane chaparral and high desert scrub habitats. Adults are vegetarian, using nectar from a variety of flowers, while the larvae are carnivores and feed on tarantulas (Vincent 2000). Male tarantula hawks engage in a behavior known as hilltopping, in which they stake out territories to find mates (Alcock and Bailey 1997, Williams undated material).

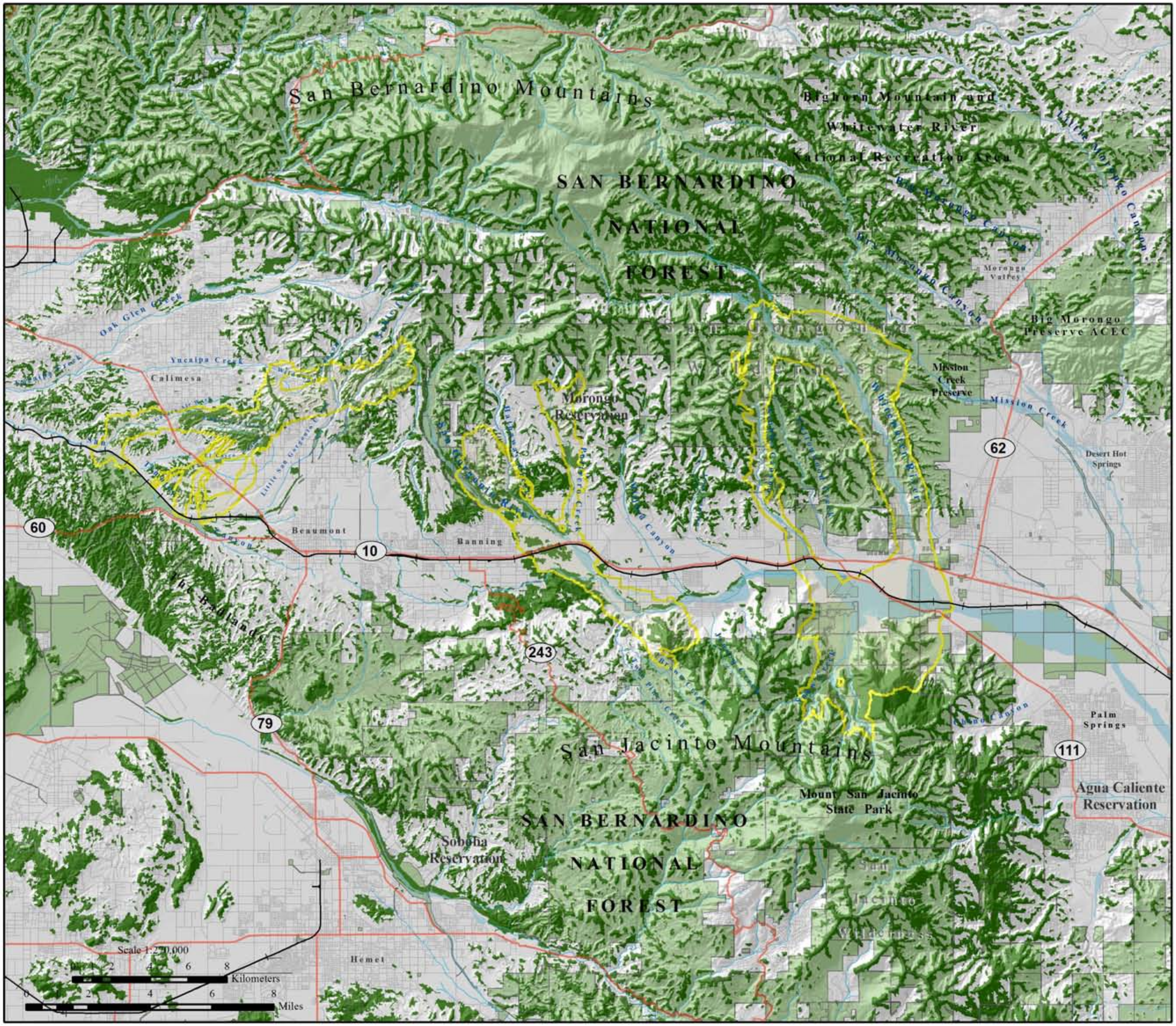
Spatial Patterns: Tarantula hawks have a fairly lengthy flight season (Alcock 1981, Alcock and Carey 1988, Alcock and Bailey 1997). Males are territorial, defending tall shrubs or small trees growing along ridges and hilltops (Alcock and Bailey 1997). Territorial defense is exhibited during the mating season. Typically there is only one resident per plant and sites are well spaced (Alcock 1981). Home range has been estimated at 3.8 km^2 (1.5 mi^2; Pratt and Ballmer, pers. comm.). No movement or dispersal estimates were available for tarantula hawks.

Conceptual Basis for Model Development: Tarantula hawks may be found in many habitats that offer nectar sources. The following vegetation communities were considered suitable: coastal sage scrub, sagebrush, mixed chaparral, montane chaparral, and chamise-redshank chaparral, below 2,286 m. Access to hilltopping habitat is critically important for population persistence, thus we identified all ridges within 2.4 km (1.5 mi) of appropriate vegetation communities to include them as potential habitat.

Results & Discussion: Extensive suitable habitat was identified for the tarantula hawk in all targeted core areas (Figure 52). The most contiguous suitable habitat for this species in the linkage was identified in the western and central branches of the Least Cost Union. Maintaining habitat quality and access to hilltopping habitat in the linkage is

Figure 52.
Potential Habitat
for
Tarantula hawk
(Pepsis spp)

- Potential Habitat
- Least Cost Union
- Protected Lands
- Roads
- Railroads
- Rivers & Streams



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critical to maintain populations of this species. We conclude that the linkage will likely serve the needs of this species, though habitat added to the Union to support other focal species will also benefit the tarantula hawk.

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

- Nectar sources and habitat quality are maintained in the linkage.
- Fire frequency is controlled to prevent type conversion of chaparral and scrub habitats to nonnative annual grassland.
- Access to hilltopping habitat in the linkage and core areas is maintained.

Justification for Selection: The metalmark butterfly was selected due to its limited dispersal capabilities and vulnerability to roadkill. Roads are significant barriers for this species (Pratt and Ballmer pers.com).

Distribution & Status: There are 9 species in the genus *Apodemia* (Powell 1975). Although the species *A. mormo* is distributed throughout the western United States and south into Baja California Mexico (Orsak 1977, Scott 1986, Struttman and Opler 2000), the subspecies *A. m. virgulti* occurs only in southern California and south into neighboring Mexico (Orsak 1977). The metalmark butterfly may occur from sea level up to 1,254 m (5,000 ft) elevation (Orsak 1977, Pratt and Ballmer pers.com).

Habitat Associations: This butterfly inhabits arid habitats, such as dry, rocky slopes in desert scrub or xeric chaparral-covered hills, but may also be found in grassland, open woodland, and dune habitats (Scott 1986, Prchal and Brock 1999, Struttman and Opler 2000), as well as coastal sage scrub (Pratt and Ballmer pers.com). Larval host plants include Wright's buckwheat (*Eriogonum wrightii*), Heerman's buckwheat (*E. heermannii;* Pratt and Ballmer 1991, Prchal and Brock 1999), and California buckwheat (*E. fasciculatum;* Orsak 1977). Young caterpillars feed on leaves, while older caterpillars consume both leaves and stems (Scott 1986, Struttman and Opler 2000). Each caterpillar undergoes five stages of growth (instars) prior to transforming into a butterfly (Ballmer and Pratt 1988). Adult nectar sources include many species of buckwheat, as well as other plants, such as Ragwort (*Senecio* sp.) and Rabbitbrush (*Chrysothamnus* sp.; Struttman and Opler 2000).

Spatial Patterns: The metalmark's flight season is from March to October (Scott 1986, Struttman and Opler 2000), with a peak in late March (Orsak 1977). They live for a little over a week, with an average lifespan of 9 days and 11 days for males and females, respectively (Scott 1986). During this time, they must feed and mate, and females have to locate a host buckwheat plant on which to deposit their eggs before they perish (Essig Museum, undated material). Most of their activities take place in the open; they prefer full sun (Scott 1986). Although density estimates are lacking, metalmarks can be quite abundant in inland areas, particularly in undisturbed foothill habitats (Orsak 1977).

Typically, metalmarks make very limited movements during their life spans, averaging 49 m (161 ft) for males and 64 m (210 ft) for females. The longest recorded movement was 617 m (2,024 ft; Scott 1986).

Conceptual Basis for Model Development: Movement in the linkage is multigenerational. The metalmark butterfly prefers dry, rocky slopes in desert scrub or chaparral, but may also be found in coastal sage scrub, grassland, open woodland, and dune habitats. Within these communities, they may be found from sea level up to 1254 m (5,000 ft) in elevation. Dispersal distance was defined as 1,234 m (4,048 ft).

Results & Discussion: Suitable habitat for the metalmark butterfly is fairly widespread in the planning area, largely following the distribution of desert scrub, coastal sage and chaparral habitats. Potentially suitable habitat was captured in all branches of the Least Cost Union (Figure 53). The most solid connection for this species is through upland habitats along the Whitewater River in the easternmost branch of the Union (Figure 53). All suitable habitat patches are within the dispersal distance of this species (figure not shown), though barriers to movement may exist between suitable habitat patches. We conclude that the linkage will likely serve the needs of this species, though habitats added to support the needs of other focal species would also benefit this species.

To protect and restore habitat and connectivity for the metalmark butterfly, we recommend that:

- Host plants and nectar sources, such as rabbitbrush, ragwort, and various species of buckwheat are maintained in the linkage.

- Fire frequency is controlled to prevent type conversion of chaparral and scrub habitats to nonnative annual grassland.

Figure 53.
Potential Habitat
for
Metalmark butterfly
(Apodemia mormo)

Potential Habitat
Least Cost Union
Protected Lands
Roads
Railroads
Rivers & Streams

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Green hairstreak butterfly (*Callophrys affinis perplexa*)

Justification for Selection: The green hairstreak butterfly was chosen as a habitat quality indicator. It is a good species for monitoring habitat health in the linkage (Pratt and Ballmer pers.com).

Distribution & Status: There are 4 recognized subspecies. *C. a. perplexa* occurs from lowland California to western Oregon, Carson Range of Nevada, and Puget Sound in Washington (Scott 1986). This butterfly is typically found below 1,254 m (5,000 ft) in elevation (Pratt and Ballmer pers.com).

Habitat Associations: The green hairstreak butterfly prefers open habitats such as coastal sage and desert scrub. It is considered an indicator species for coastal sage scrub (Pratt and Ballmer pers.com). It may also be found in woodland, chaparral, and sagebrush habitats if the canopy is sparse (Scott 1986). Larval host plants may include several buckwheat species (*Eriogonum* spp.), deerweed (*Lotus scoparius*) and other species of *Lotus*, as well as wild lilacs (*Ceanothus* spp.; Orsak 1977, Scott 1986, Heath 2004). Adults primarily use buckwheat plants as nectar sources (Heath 2004).

The larvae of this species have a symbiotic relationship with ants. Ants protect butterfly larvae and pupae from predators, even carrying them to ant nests for shelter, where they may pupate (Downey 1961, Orsak 1977). In return, the larvae exude a honey like fluid that is consumed by the tending ants (Downey 1961, Orsak 1977).

Spatial Patterns: The flight season for the green hairstreak butterfly is in spring, usually from late February to April, although populations at higher elevations may have a later season (Scott 1986, Pratt and Ballmer pers.com). Individuals may live up to 19 days in nature (Scott 1986). The hairstreak is territorial, with an average home range size of 100 m^2 (1,076 ft^2; Pratt and Ballmer pers.com).

This species is not considered a good disperser, but individuals will fly to high points where they engage in a behavior known as hilltopping to search for mates (Scott 1986, Pratt and Ballmer pers.com). They may travel along ridgetops and dry streams (Santa Barbara Museum of Natural History, undated mat.). Orsack (1977) typically encountered them along foothill ridges. Males may be found perching on overhanging branches along washes and openings in chaparral (Emmel and Emmel 1973).

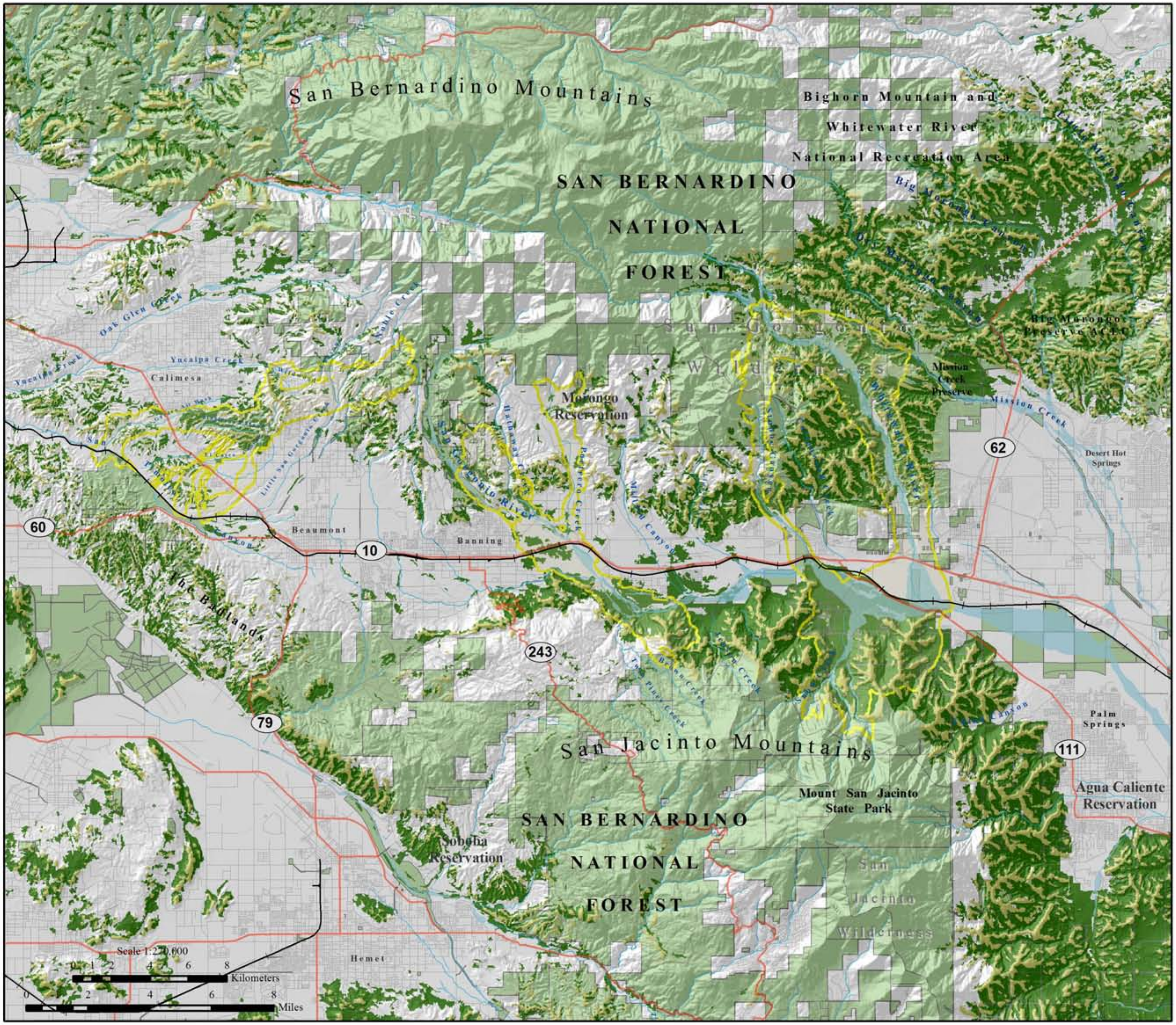
Conceptual Basis for Model Development: Movement in the linkage is multigenerational. This species is an indicator for coastal sage scrub but may also be encountered in desert scrub, sagebrush, and open woodland and chaparral habitats below 1,254 m in elevation. Access to hilltopping habitat is critically important for population persistence, thus we identified all ridges within 100 m (328 ft) of appropriate vegetation communities to include them in potential habitat.

Results & Discussion: The majority of potential habitat identified for the green hairstreak butterfly is in the desert scrub communities in the eastern part of the planning area (Figure 54). Though the hairstreak is an indicator species of coastal sage scrub, this habitat type is limited to the western foothills of the San Bernardino and San Jacinto ranges and the Badlands. All branches of the Least Cost Union provide either potentially suitable habitat or hilltopping habitat for this species, with the western and central branches of the Union providing the most direct connections among suitable habitat patches (Figure 54). We conclude that the linkage will likely serve the needs of the green hairstreak butterfly, though habitat added to the Union to support other focal species will also benefit the green hairstreak.

To protect habitat connectivity for the green hairstreak butterfly, we recommend that:

- Larval host plants and nectar sources (deerweed, ceanothus, and various species of buckwheat) are maintained in the linkage.
- Fire frequency is controlled to prevent type conversion of chaparral and scrub habitats to nonnative annual grassland.
- Access to hilltopping habitat is maintained in the linkage and core areas.
- Native ant populations are maintained in the linkage and core areas.

Figure 54.
Potential Habitat
for
Green Hairstreak butterfly
(Callophrys perplexa)



Potential Habitat
Hilltopping Habitat
Least Cost Union
Protected Lands
Roads
Railroads
Rivers & Streams

N

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Slender-horned spineflower (*Dodecahema leptoceras*)

Justification for Selection: The slender-horned spineflower was chosen to represent alluvial fan scrub habitats. This species is reliant upon natural hydrologic regimes to sustain their habitat (USFWS 2001, T. Krantz, pers. comm.).

Distribution & Status: The spineflower is an endemic species restricted to alluvial fans on the coastal side of the Transverse and Peninsular Ranges in Los Angeles, Riverside and San Bernardino counties.

The slender-horned spineflower has the distinction of being the most critically endangered plant species in southern California (Croft 1989). The species is threatened by development encroaching into the floodplain, sand and gravel mining, domestic livestock grazing, and invasion of exotic plants (USFWS 1987), as well as, flood control projects, trash dumping, trampling, and off-road vehicles (Krantz 1984, USFWS 1987, Croft 1989, Hickman 1993, Stephenson and Calcarone 1999, California Native Plant Society 2001, USFWS 2001, USFS 2002). It is believed to be vulnerable to extirpation throughout its range (California Native Plant Society 2001, USFS 2002). Even on public land, such as the San Bernardino National Forest, populations are declining (Stephenson and Calcarone 1999, USFS 2002). The spineflower was listed as a federally endangered species in 1987, and is also state listed as endangered (USFWS 1987, Croft 1989, CDFG 2003).

Habitat Associations: This species prefers alluvial fan scrub vegetation on mature sandy benches or floodplain terraces with sandy to gravelly soils surrounded by chaparral, cismontane woodland, and coastal sage scrub at elevations between 200-760 m (650-2,500 ft; Munz 1974, Croft 1989, Hickman 1993, California Native Plant Society 2001, USFS 2002). Nearly all occurrences for this species are associated with well-established alluvial scrub habitats, usually dominated by scrub oak (*Quercus berberidifolia*), coast live oak (*Q. agrifolia*), chamise (*Adenostoma fasciculatum*), and buckwheat (*Eriogonum fasciculatum*; Croft 1989, Gordon-Reedy 1997, USFS 2002). It has also been found in association with mountain mahogany (*Cercocarpus betuloides*) and yerba santa (*Eriodictyon trichocalyx*), in addition to juniper (Reveal and Krantz 1979, Krantz 1984, USFWS 1987) and in remnant riparian forests with sycamore (*Platanus racemosa*) and cottonwood (*Populus fremontii*; Croft 1989). Neel and Brown (1987) recorded this species in chaparral dominated by juniper (*Juniperus californica*), white sage (*Salvia apiana*), and Croton (*Croton californicus*; Croft 1989). Within all of these community associations, the spineflower is restricted to sparsely vegetated areas lacking canopy cover (Croft 1989), typically with undisturbed cryptogamic crusts (Reveal and Krantz 1979, Krantz 1984, USFWS 1987). The spineflower hasn't been documented on recently deposited alluvial or disturbed soil, nor is it found in areas with dense exotic annual grasses (Croft 1989, USFWS 2001, USFS 2002, T. Krantz, pers. comm.).

Spatial Patterns: The slender-horned spineflower is an annual herb that blooms from April to June (Munz 1974, Hickman 1993, California Native Plant Society 2001). As such, annual variation in the amount and timing of precipitation can greatly affect population abundance (USFWS 2001, USFS 2002). Whether seeds can be dormant for extended periods of time and still remain viable is unknown, though some believe the seed bank to be long lived (Reveal pers. com. *in* Croft1989). Dispersal mechanisms are also a mystery (Croft 1989), though it has been hypothesized that hairy mammals (e.g., coyote) may be dispersal agents or major floods may transport seeds over unknown distances (T. Krantz, pers. comm.).

Conceptual Basis for Model Development: Vegetation communities (i.e., alluvial fan sage scrub, coastal sage scrub, and barren) were queried in the GIS and then patches falling between 200-760 m elevation were delineated as potentially suitable habitat.

Results & Discussion: Although very little potentially suitable habitat was identified in the Least Cost Union, the results of the habitat suitability model correspond fairly well with recorded occurrences for this species (Figure 55). It is believed that potential habitat may exist on the Banning Bench and on the alluvial fan at the northern base of the San Jacinto Mountains (T. Krantz, pers. comm.). The central branch of the Union captured potentially suitable habitat on the alluvial fan of the San Gorgonio River (Figure 55). The linkage may serve the needs of this species if additional habitat is added to the Union at the base of the San Jacinto Mountains and along the San Gorgonio River. To protect and restore habitat for the slender-horned spineflower, we recommend that:

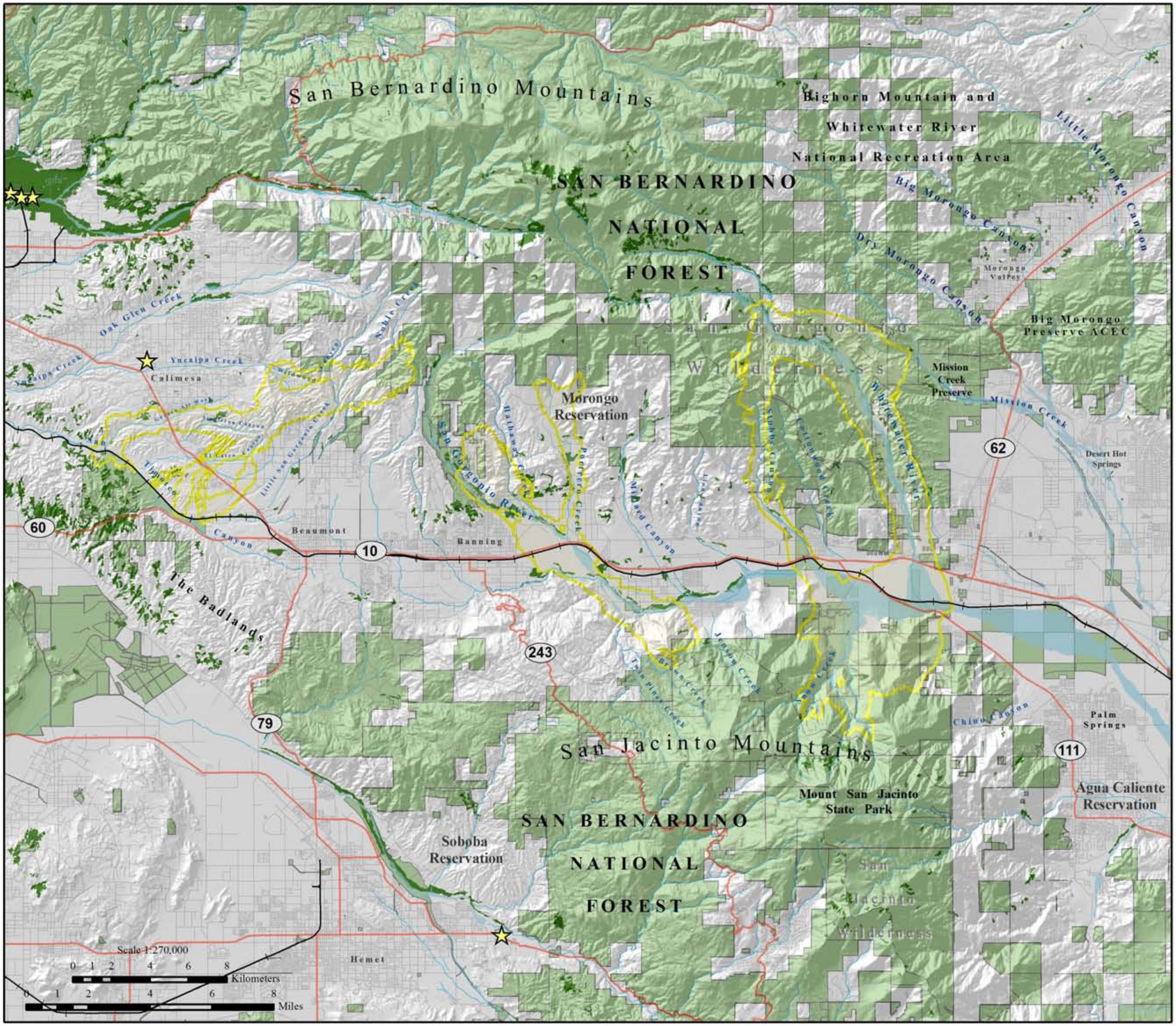
- Natural hydrological and fluvial geomorphological processes be protected and restored (USFS 2002) throughout entire drainages with occupied or suitable habitat (Croft 1989).

- Research is conducted to determine dispersal mechanisms and habitat requirements for germination and establishment (Croft 1989).

- Historical, existing, and potential habitat is protected through conservation easements and acquisitions with willing landowners to protect existing populations and sites for reintroduction (Croft 1989). The federal Endangered Species Act as amended (16 U.S.C. 1534) authorizes USFWS to acquire land for the conservation of endangered plants with Land and Water Fund Act appropriations.

- Receptive landowners work with US Fish and Wildlife Service Partners for Fish & Wildlife Program to acquire funds and technical assistance to restore and enhance alluvial fan sage habitat on their land to benefit the slender-horned spineflower and other wildlife.

Figure 55.
Potential Habitat
for
Slender-horned spineflower
(Dodecahema leptoceras)



Potential habitat
Least Cost Union
Protected Lands
Roads
Railroads
Rivers & Streams
Species Occurence (CNDDB)

N

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California sagebrush (*Artemisia californica*)

Justification for Selection: California sagebrush is declining rapidly throughout its range and was chosen as a keystone species to represent sage scrub habitat connections between the San Bernardino and San Jacinto mountains and the Badlands (T. Krantz, pers. comm.). Habitat fragmentation and loss of sagebrush (*Artemisia* spp.) habitats have imperiled these native habitats and species that depend upon them, including the coastal California gnatcatcher (Knick et al. 2003).

Distribution & Status: California sagebrush is distributed from the South Coast Ranges to cismontane southern California and Baja California Norte (Munz 1963, Hickman 1993), extending as far inland as the Cajon and San Gorgonio passes (Holland 1986). Sagebrush occurs in a fairly contiguous narrow band along the coastal base of the San Bernardino and San Jacinto foothills with a more widespread distribution in the Badlands. It is primarily found below 762 m (2,500 ft) in elevation (Munz 1963).

Historically, sagebrush habitats covered nearly 63 million ha in the west (Knick et al. 2003). Urbanization, agriculture, mining, oil and gas development, and the road network have fragmented and eliminated expansive areas once dominated by sagebrush (Schmida and Barbour 1982, Howard 1993, Noss et al. 1995, Hann et al. 1997, Knick et al. 2003). Sagebrush habitats are one of the most imperiled ecosystems in North America (Noss and Peters 1995, Mac et al. 1998, Knick et al. 2003). *Artemisia californica* is the dominant plant in several designated sensitive plant communities (Holland 1986, CDFG 2003).

Habitat Associations: California sagebrush is a dominant plant in coastal sage scrub, and is often found in association with brittlebush (*Encelia farinosa*), white sage (*Salvia apiana*), black sage (*S. mellifera*), California buckwheat (*Eriogonum fasciculatum*), deerweed (*Lotus scoparius*), and Our Lord's candle (*Yucca whipplei*) (Munz 1963, Hickman 1986). It prefers dry steep slopes and alluvial fans and is typically found on dry rocky or gravelly slopes below the chaparral (Munz 1963), though it intergrades with chaparral at slightly higher elevations (Holland 1986, Hickman 1993).

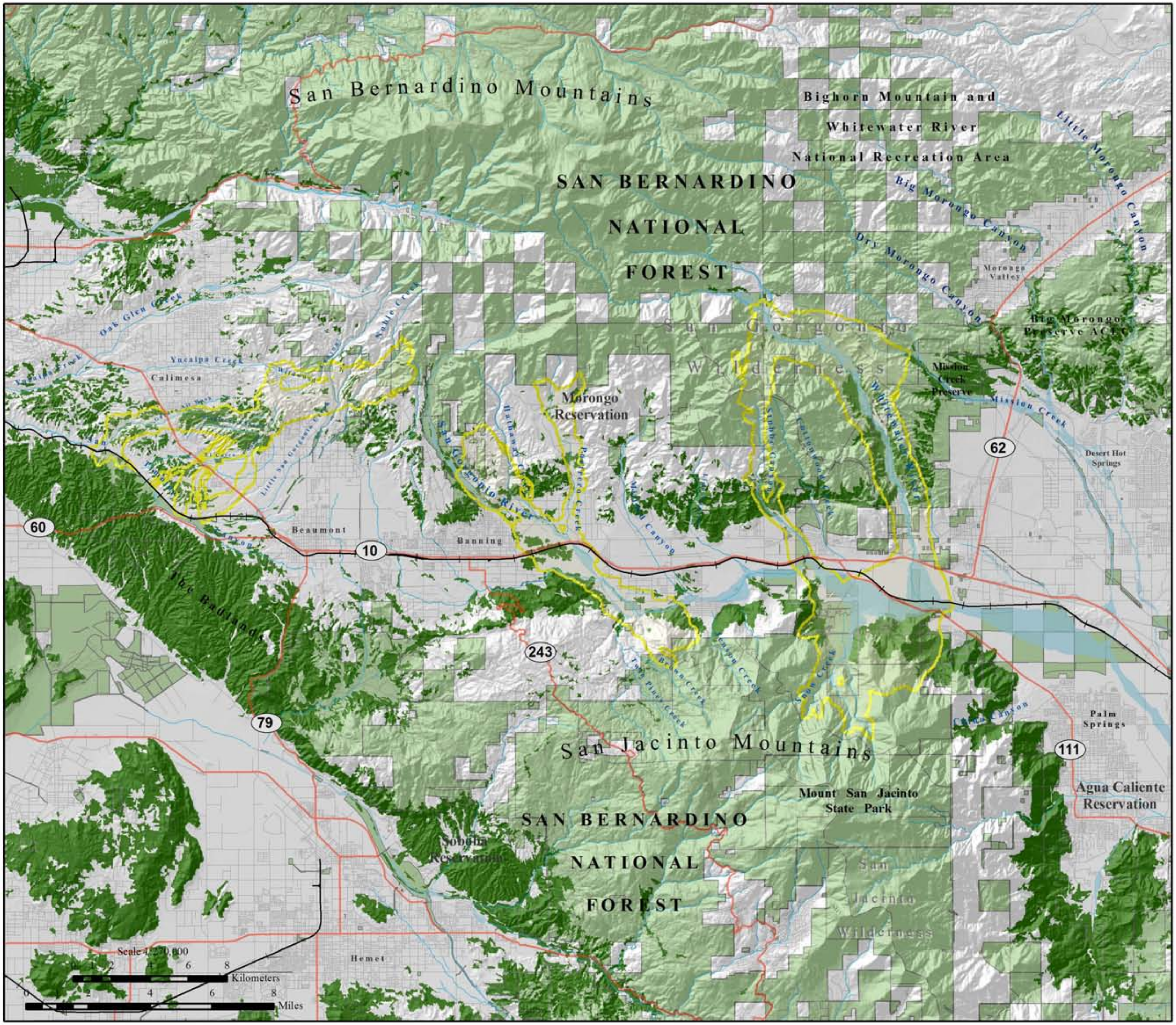
Spatial Patterns: Sweet smelling California sagebrush blooms from August to December on steep xeric slopes (Munz 1963, Holland 1986). The seeds are lightweight and believed to be wind dispersed and capable of long distance movements (Minnich 1980). During fire-free intervals, seed germination is moderate to high; crown sprouting occurs following fires (Zedler 1981).

Conceptual Basis for Model Development: Vegetation communities (i.e., California sagebrush, ceanothus mixed chaparral, lower montane mixed chaparral, scrub oak, encelia, buckwheat, sumac, and mixed soft scrub chaparral) were queried in the GIS and then patches falling below 762 m elevation were delineated as potentially suitable habitat.

Results & Discussion: Potentially suitable habitat for sagebrush was identified in the Badlands and along the base of the San Bernardino and San Jacinto mountains (Figure 56). The model likely underestimated the amount of suitable habitat, as this species intergrades with chaparral at slightly higher elevations. The western and central branches of the Least Cost Union are likely to accommodate this species if habitat is added to the Union in the foothills of the San Jacinto Mountains.

Sagebrush habitats have been severely fragmented, altering vegetation dynamics, disturbance regimes, and facilitating the spread of nonnative invasive species (Braun 1998, Brooks and Pyke 2001, Gelbard and Belnap 2003, Knick et al. 2003). To protect and restore habitat for this species, we recommend that fire frequency is controlled to prevent type conversion of sagebrush habitats to nonnative annual grassland.

Figure 56. Potential Habitat for California sagebrush *(Artemisia californica)*



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White alder (*Alnus rhombifolia*)

Justification for Selection: White alder was selected as a focal species to link riparian habitats between the San Bernardino and San Jacinto Mountains. White alder contributes to structural diversity in riparian woodlands and is an important habitat component for 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, it is found in the Coast, Transverse, and Peninsular Ranges (Holland 1986), from sea level to over 2,438 m (8,000 ft) in 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 2003).

Habitat Associations: White alder is restricted to riparian woodlands 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). 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 (Holstein 1984, Roberts et al. 1980, Uchytil 1989).

Spatial Patterns: White alders are wind pollinated. Female catkins develop into woody cones containing numerous seeds (Schopmeyer 1974, Uchytil 1989), the majority of which are viable (Schopmeyer 1974, Uchytil 1989). The seeds are transported both up and downstream by wind and water to suitably moist germination sites (Brothers 1985, Uchytil 1989, D. Woodward, pers. com.). 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 also consumed by birds, which may act as dispersal agents (USFS 1937, Uchytil 1989, D. Woodward, pers. com.).

Conceptual Basis for Model Development: Riparian vegetation communities along perennial streams were identified in the GIS and patches falling below 2,438 m (8,000 ft) were delineated as potentially suitable habitat.

Results & Discussion: Scattered patches of potential habitat were identified for white alder in the Least Cost Union, with suitable habitat more widespread in the targeted core areas (Figure 57). Potential habitat for white alder was identified in the Union in the Whitewater River and in upper Stubbe Canyon. The best riparian connection between targeted core areas is along the Whitewater River (Figure 57), especially if habitat restoration efforts are undertaken. We conclude that the linkage is likely to serve this species if habitat is added to the Union in Stubbe Canyon and along the San Gorgonio River to benefit white alder. Riparian communities are being lost at an alarming rate in the South Coast Ecoregion.

To protect and restore habitat for white alder, we recommend that:

- Habitat restoration is initiated in Whitewater River to re-establish a gallery forest along the length of the river to its confluence with the San Gorgonio River.

- Natural flood dynamics are protected, maintained, and restored.

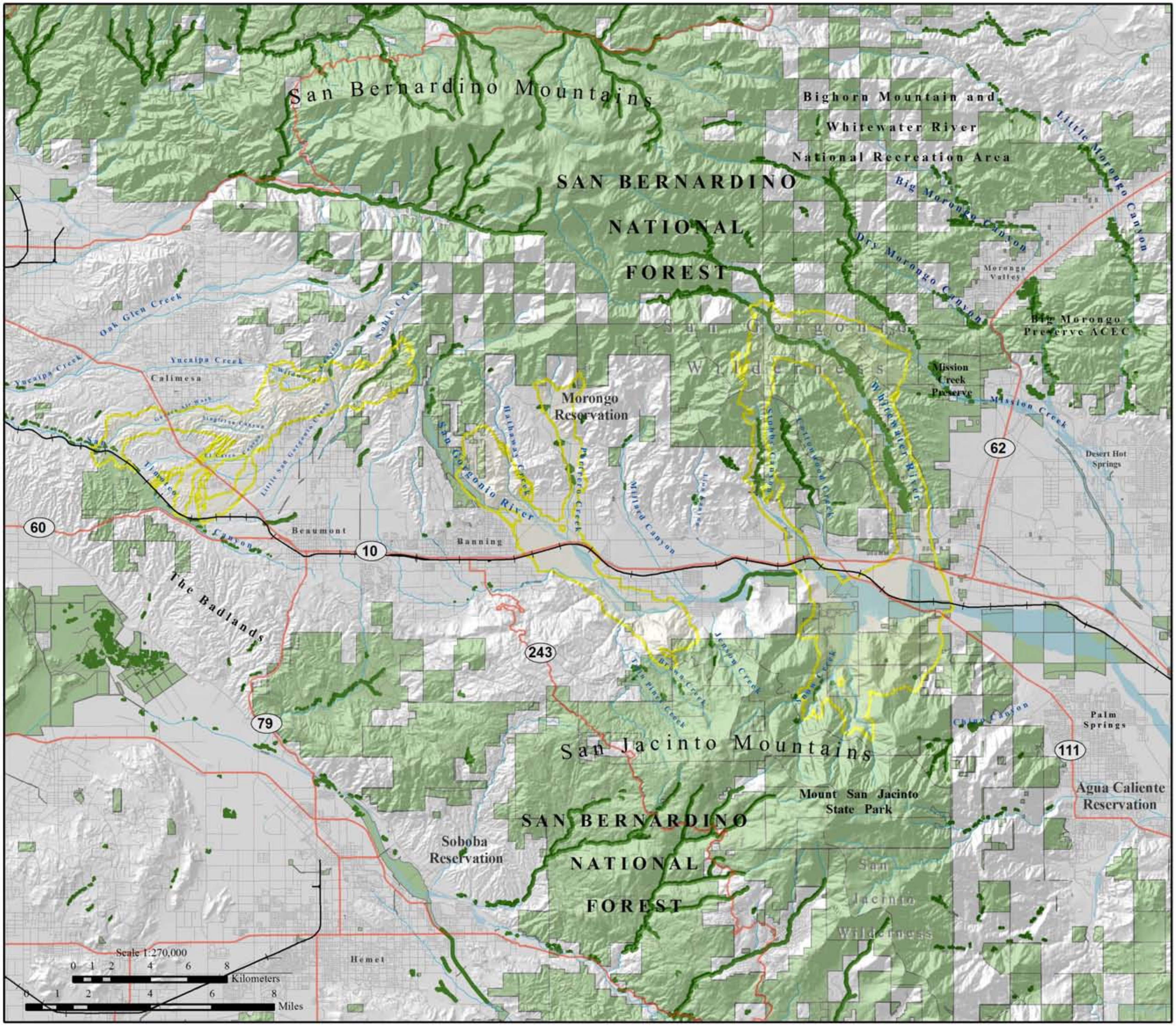
- Receptive landowners work with US Fish and Wildlife Service Partners for Fish & Wildlife Program to acquire funds and technical assistance to restore and enhance riparian habitat on their land to benefit the many species dependent on riparian systems.

- Eliminate feral cattle in Stubbe Canyon to stop overgrazing which could lead to the loss of gallery cottonwood forest.

- Attempt to expand gallery forest in Stubbe Canyon and Whitewater River.

Figure 57.
Potential Habitat
for
White alder
(Alnus rhombifolia)

Potential Habtitat
Least Cost Union
Protected Lands
Roads
Railroads
Rivers & Streams



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This chapter is the heart of the report. It summarizes the goals of the Linkage Design and presents a map (Figure 58) 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 should (1) provide live-in and move-through habitat for multiple species, (2) support metapopulations of smaller species, (3) ensure availability of key resources, (4) buffer against edge effects, (5) reduce contaminants in streams, (6) allow natural processes to operate, and (7) allow species and natural communities to respond to climatic changes. We elaborate on these goals below.

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

The Linkage Design must support metapopulations of less vagile species. Many small animals, such as horned lizards, woodrats, treefrogs, and many invertebrates, 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 some butterflies that use larval host plants in upland areas and drink from riparian 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 extend 300 m (980 ft) or more into the forest (Debinski and Holt 2000, Murcia 1995) depending on forest type, years since the edge was created, and other factors (Norton 2002). The best available data on edge effects for southern California habitats include reduction in leaf-litter and declines in populations of some species of birds and mammals up to 250 m (800 ft) in coastal scrub (Kristan et al. 2003), collapse of native plant and animals communities due 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) (Naicker et al. 2001, Maret and MacCoy 2002, Scott 2002), and fish, amphibians, and aquatic invertebrates often are more sensitive to land use at watershed scales than at the scale of narrow riparian buffers (Goforth 2000, Fitzpatrick et al. 2001, Stewart et al. 2001, Wang et al. 2001, Scott 2002, Willson and Dorcas 2003).

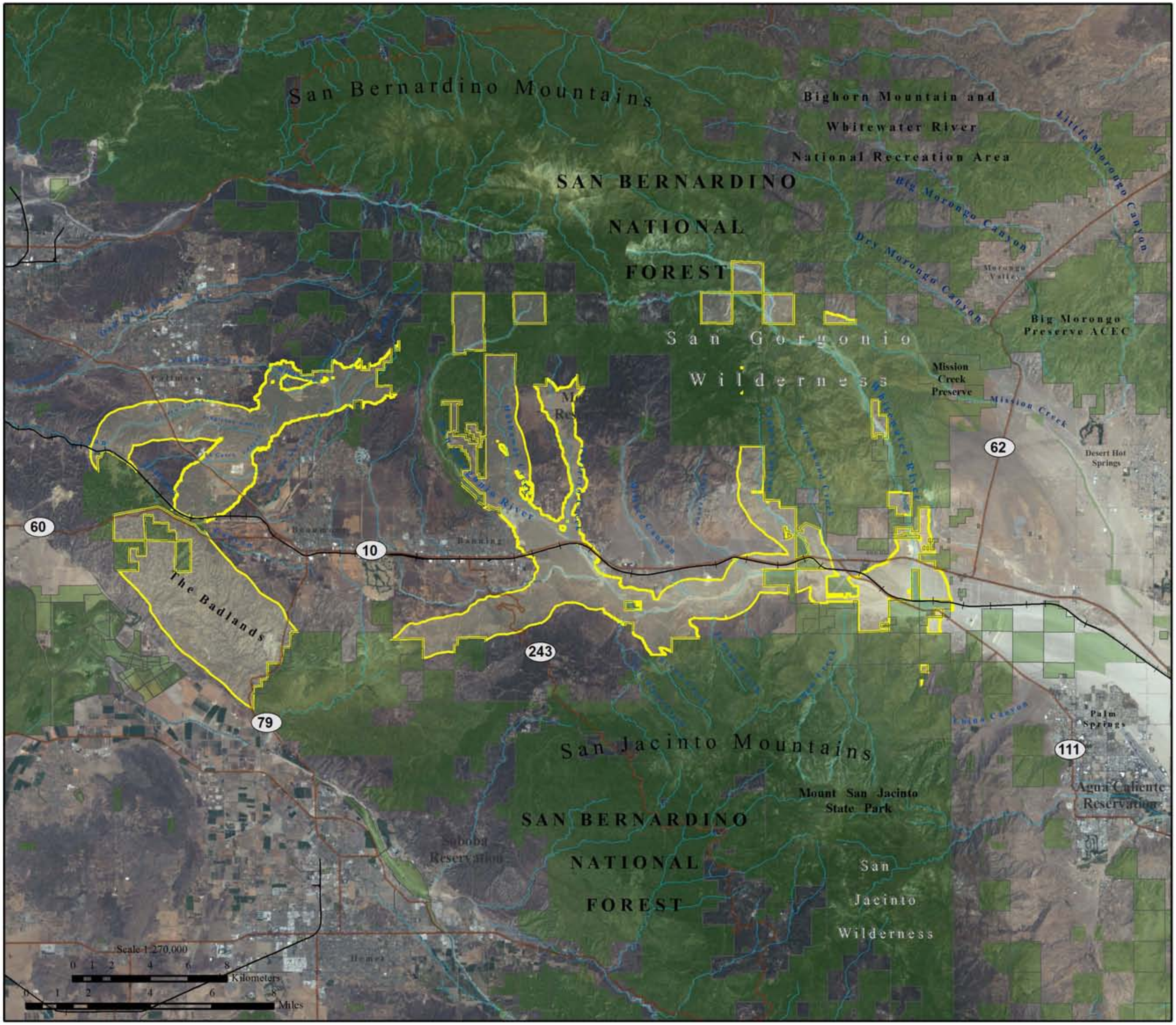
The Linkage Design must also allow natural processes of disturbance and recruitment to operate with minimal constraints from adjacent urban areas. The Linkage should be wide enough that temporary habitat impacts due to fires, floods, and other natural processes do not affect the entire linkage simultaneously. Wider linkages with broader natural communities may be more robust to changes in disturbance frequencies by human actions. 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 five routes to accommodate the diverse species and ecosystem functions it is intended to serve (Figure 58). The western branch of the Linkage Design links the San Bernardino Mountains with the Badlands via vegetation communities influenced by a more coastal climate, whereas more easterly branches cross desert vegetation (Figure 59). Dominant habitat types in the western branch include grassland, coastal sage scrub, and chaparral with oak woodland and riparian forests interspersed. This route serves such species as mule deer, large-eared woodrat, Pacific kangaroo rat, speckled rattlesnake, and coast horned lizard. It extends from Noble Creek in the San Bernardino Mountains, taking in the wide swath of natural habitats remaining between the communities of Calimesa and Cherry Valley, and entering San Timoteo Canyon in

Figure 58. Linkage Design



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the Badlands. Land in the linkage and in the Badlands has been protected through successful conservation planning efforts undertaken by California State Parks, San Timoteo Canyonlands Coalition, San Bernardino Valley Audubon, and the Center for Biological Diversity (CBD). This may be the most tenuous connection in the Linkage Design due to a few approved development projects near Calimesa, but it nevertheless is worthy of conservation. Audubon and CBD have been working with the City of Calimesa and various developers to maintain connectivity here. In addition, portions of this branch of the Linkage Design (i.e., Singleton Canyon and Garden Air Wash) are identified as lands that could be acquired as part of the Western Riverside Multiple Species Conservation Plan (County of Riverside 2002).

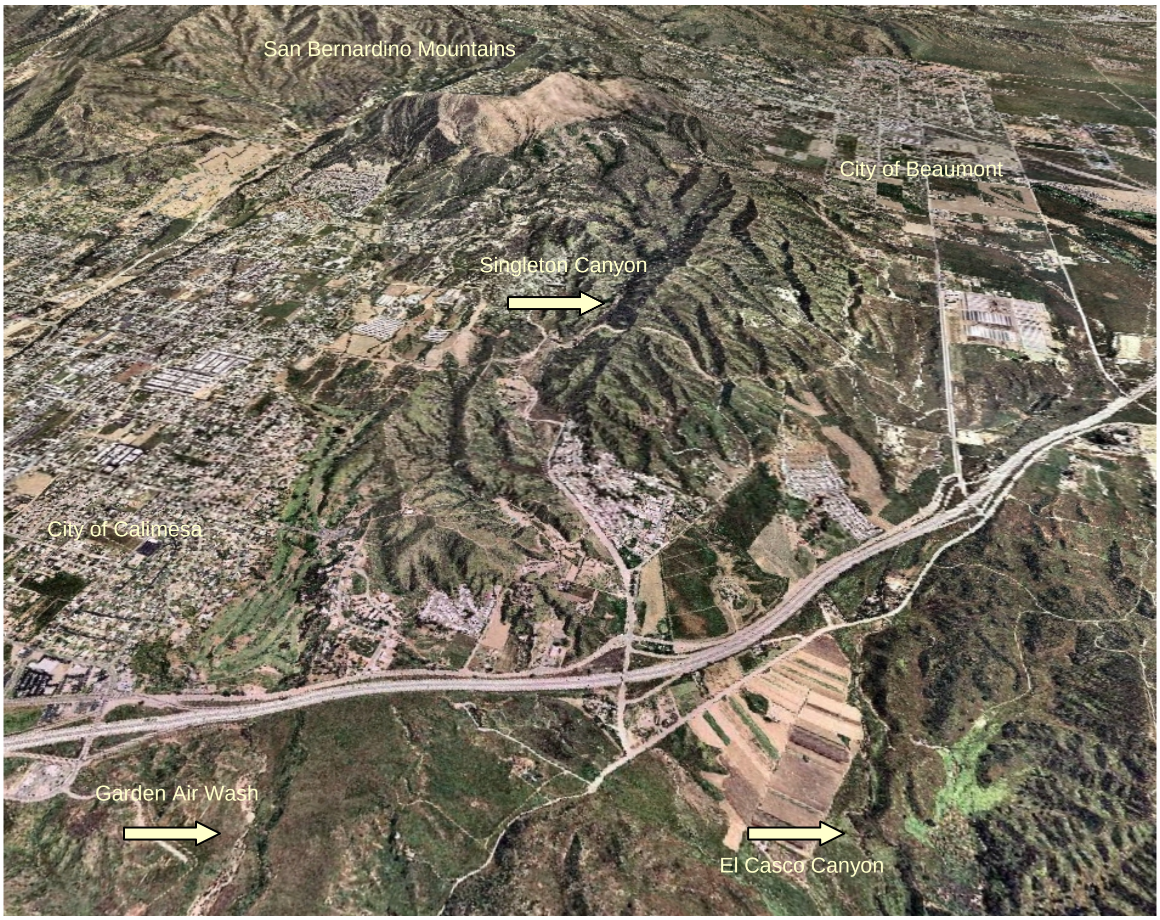


Figure 59. The western branch of the Linkage Design connects the San Bernardino Mountains to the Badlands. There are 2 feasible routes about 2 miles apart: Garden Air Wash and El Casco Canyon.

The next branch of the Linkage Design encompasses the San Gorgonio River, which forms a substantial alluvial fan through the pass to its confluence with the Whitewater River (Figure 60). The minimum corridor width of 2 km was imposed along the river south of the freeway to ensure that the functional processes of the linkage are protected. This branch of the linkage is intended to serve badger, Pacific kangaroo rat, large-eared woodrat, Merriam's kangaroo rat, and coast horned lizard. The San Gorgonio River is especially important for a number of rare endemic species associated with alluvial fans (County of Riverside 2002, CVAG 2004) that were not specifically addressed by our analyses. Black bear (introduced into the San Bernardinos in the 1920's or 1930's) have been intermittently sighted in the San Jacintos within the last 10-20 years, apparently by crossing along either the San Gorgonio or Whitewater rivers, or both. Puma have been reliably sighted in Banning, doubtless from the San Gorgonio River (S. Loe, USFS, pers. com.). Hathaway Creek is a major tributary of the San Gorgonio that joins the river north of the freeway in the Linkage Design. The creek bottom was full of small mammal tracks, a few deer tracks, and at least 2 possible puma tracks during our field visits (P. Beier personal observation 2002). Except for the close proximity of housing, Hathaway Creek looks very amenable to wildlife passage. The River also flows through the Morongo Reservation, including the main part of the river north of Interstate 10 and several half sections on the south side of the freeway, which we designated as stewardship zones in the Linkage Design.

Figure 60. The San Gorgonio River flows from the San Bernardino Mountains and crosses I-10 in two places, joining Smith Creek in the foothills of the San Jacinto Mountains, and the Whitewater River further downstream.

A branch encompassing primarily coastal sage habitat was added to the linkage in the foothills of the San Jacinto Mountains to accommodate slender-horned spineflower, California sagebrush, chaparral whipsnake, coast horned lizard, large-eared woodrat, and wrentit (Figure 60). This branch includes riparian and upland habitats at the confluence of Smith Creek and the San Gorgonio River and although the entire length of Smith Creek is not included in the Linkage Design, it ought to be conserved through restrictions on floodplain development. Many other species that utilize coastal habitats (e.g., mountain lion, mule deer, rock wren, tarantula hawk, green hairstreak butterfly) will also benefit from this connection.

The branch of the Linkage Design that includes Stubbe Canyon Wash (Figure 61) was delineated by the landscape permeability analysis for mountain lion but is also expected to serve the habitat and movement requirements of such species as badger, antelope ground squirrel, Merriam's kangaroo rat, and little pocket mouse. Numerous other species will also benefit from this addition. This connection includes a 2 km (1.2 mi) buffer (1 km to either side of the wash) to support species habitat requirements and protect water quality within the linkage and downstream. The majority of this lowland linkage is already protected, and the pending Coachella Valley MSHCP covers most of the land that has not yet been secured. The Coachella Valley Mountains Conservancy and Friends of the Desert Mountains recently secured approximately 800 acres in Stubbe Canyon that straddles the freeway. In addition to facilitating movements for several focal species, this branch of the Linkage Design provides habitat for several listed species, including the threatened desert tortoise (CVAG 2004).

Figure 61. Stubbe Canyon Wash emanates from the San Bernardino Mountains into a broad alluvial fan. It crosses Interstate 10 in two places and joins the San Gorgonio River immediately south of the freeway. There are about 12 rows of wind turbines in the floodplain of the San Gorgonio River between Lion and Stubbe Canyons.

The Whitewater River flows out of the San Bernardino Mountains through a spectacular gallery forest dominated by cottonwood and willows before emptying into a broad bajada in the San Gorgonio Pass at the base of the San Jacinto Mountains (Figure 62). This branch of the Linkage Design was delineated by the landscape permeability analysis for puma and includes both riparian and upland habitats. It would serve the habitat and movement needs of both riparian and terrestrial species (represented by California treefrog, white alder, little pocket mouse, antelope ground squirrel, and horned lizard).

Figure 62. The Whitewater River flows through the San Gorgonio Wilderness Area and empties into an expansive alluvial fan in the pass. There is a row of wind turbines on the western bank of the river and groundwater recharge basins just downstream.

The upper watershed of the Whitewater River is one of the most remote, roadless watersheds in southern California, and is eligible for Wild and Scenic River status. The pristine habitat in the upper watershed is critical for bighorn sheep, mule deer, golden eagles, and prairie falcon, and an arroyo toad population occurs in the lower elevations near the base of the mountains (Stephenson and Calcarone 1999). Other species of concern along the river include desert tortoise, willow flycatcher, and least Bell's vireo (CVAG 2004). The broad alluvial fan is also part of a dynamic sand source and sand transport area that provides habitat for sand-preferring organisms covered under the MSHCP, such as the Coachella Valley Jerusalem cricket (*Stenopelmatus cahuilaensis*), Coachella Giant Sand-treader cricket (*Macrobaenetes valgum*), and Palm Springs pocket mouse (CVAG 2004). This area offers a refugium during major flood events that could affect the adjacent Snow Creek and San Gorgonio Wash area (Noss et al. 2001, CVAG 2004).

The Whitewater River originates in the San Bernardino National Forest, flowing through the Whitewater Canyon National Recreation Area, which is administered by BLM. Most of the higher elevation habitat in the San Bernardino Mountains is within the San

Gorgonio Wilderness Area. Many wildlife agencies and conservation organizations have taken great strides in securing a linkage along the Whitewater River. The Wildlands Conservancy acquired over 1,200 acres that includes land in Whitewater Canyon, the confluence of the San Gorgonio and Whitewater Rivers, and some other key parcels south of the freeway. The Coachella Valley Mountains Conservancy, Coachella Valley Association of Governments, Friends of the Desert Mountains, and BLM are also actively purchasing land in this region that is included in the pending Coachella Valley MSHCP (CVAG 2004).

Most branches of the Linkage Design include some public ownerships that protect natural habitats from conversion to urban uses. The final Linkage Design encompasses a total of 30,114 ha (74,414 ac), of which approximately 29% (8,589 ha or 21,223 ac) currently enjoys some level of conservation protection, mostly in land owned by the Bureau of Land Management, The Wildlands Conservancy, Coachella Valley Mountains Conservancy, California State Parks, and State Lands Commission. The majority of unprotected land in the Linkage Design could be acquired through the Western Riverside Multiple Species Habitat Conservation Plan (MSHCP) and the pending Coachella Valley MSHCP (County of Riverside 2002, CVAG 2004). We delineated a stewardship zone (areas where land stewardship should be encouraged) that covers 4,695 ha (11,602 ac) of the Linkage Design that includes land owned by the Morongo Band of Mission Indians (3,195 ha or 7,895 ac) and lands already converted to urban uses (1,556 ha or 3,844 ac) that fall within the minimum corridor width of 2 km (1.2 mi).

As expected, given the geographical position of the linkage at the juncture of the Transverse and Peninsular ranges and in the transition zone between the South Coast and Desert ecoregions, the Linkage Design encompasses a diversity of natural communities that grade from Mediterranean habitats in the South Coast Ecoregion into more xeric communities within the Desert Ecoregion. The San Gorgonio River marks the transition zone where vegetation from both ecoregions intermingles. The Linkage Design includes 21 different major vegetation types (Table 3). Vegetation in the linkage is similar to that found in the two core areas, with desert scrub, mixed chaparral, and coastal sage scrub having the most widespread cover. Desert scrub is by far the most common vegetation community, covering much of the pass east of the San Gorgonio River, and extending up the steep rugged slopes on the eastern side of both the San Bernardino and San Jacinto Mountains. Coastal sage scrub makes up 13% of the total area of the Linkage Design, yet only 0.03% of the 4,006 ha (9,900 ac) included in the linkage is currently protected. Although natural vegetation comprises most of the Linkage Design, urban and agricultural lands cover roughly 7% of its area, which have been designated as stewardship zones.

A diversity of riparian habitat types occur throughout the linkage and core areas, including riparian forests, woodlands, and scrubs, oases, alluvial fans, desert washes, springs, and seeps. The Whitewater River provides the most direct connection between mountain ranges for riparian dependent species (e.g., California treefrog, white alder). Other significant riparian habitat in the Linkage Design occurs in the San Gorgonio River, Hathaway Creek, Garden Air Wash, San Timoteo Canyon, and Stubbe Canyon Wash. Despite the relatively low abundance of riparian vegetation (about 10%), riparian habitats support a disproportionately large number of species and are key movement areas for many aquatic and terrestrial organisms.

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*		
Mixed Chaparral	14,950.46	6,050.24	3,560.19	1,440.76	0.24	0.2009
Coastal Scrub	9,900.38	4,006.54	258.34	104.55	0.03	0.1330
Desert Scrub	20,343.85	8,232.87	10,798.80	4,370.12	0.53	0.2734
Chamise-Redshank Chaparral	6,848.02	2,771.29	1,229.72	497.65	0.18	0.0920
Annual Grassland	4,495.84	1,819.40	28.82	11.66	0.01	0.0604
Urban	3,843.90	1,555.57	54.41	22.02	0.01	0.0517
Desert Wash	5,176.40	2,094.81	2,119.53	857.74	0.41	0.0696
Agriculture	1,936.12	783.52	54.83	22.19	0.03	0.0260
Montane Hardwood	1,434.42	580.49	615.12	248.93	0.43	0.0193
Montane Riparian	2,108.12	853.13	1,424.60	576.51	0.68	0.0283
Montane Hardwood-Conifer	1,140.71	461.63	598.23	242.09	0.52	0.0153
Coastal Oak Woodland	552.11	223.43	14.58	5.90	0.03	0.0070
Barren	754.30	305.25	246.19	99.63	0.33	0.0101
Valley Foothill Riparian	342.09	138.44	40.92	16.56	0.12	0.0040
Sierran Mixed Conifer	209.57	84.81	28.03	11.34	0.13	0.0020
Desert Succulent Shrub	229.96	93.06	130.88	52.97	0.57	0.0030
Eastside Pine	62.27	25.20	0.00	0.00	0.00	0.0008
Desert Riparian	50.13	20.29	16.23	6.57	0.32	0.0007
Water	10.45	4.23	0.00	0.00	0.00	0.0001
White Fir	13.81	5.59	4.06	1.64	0.29	0.0002
Wet Meadow	5.34	2.16	0.00	0.00	0.00	0.00007
Eucalyptus	5.12	2.07	0.00	0.00	0.00	0.00007
Freshwater Emergent Wetland	0.63	0.25	0.00	0.00	0.00	0.000008
Sagebrush	0.43	0.17	0.00	0.00	0.00	0.000006
Total	**74,414.41**	**30,114.44**	**21,223.48**	**8,588.84**	**29%**	**100%**

Removing and Mitigating Barriers to Movement

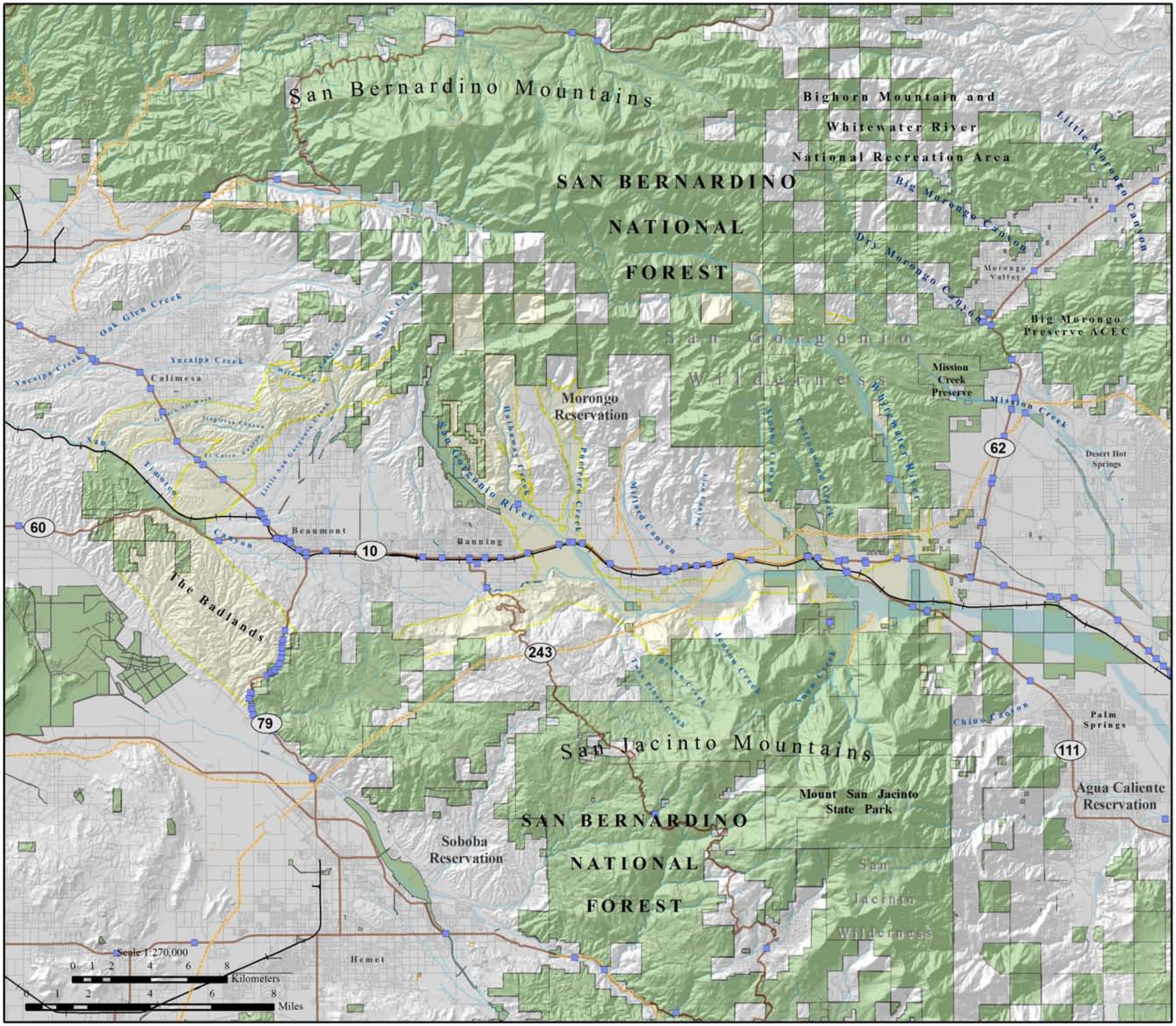
Seven types of features impede species movements through the linkage: roads, railroads, and impediments to stream flow, mining operations, wind energy developments, residential development, and recreational activities. This section describes these impediments and suggests where and how their effects may be minimized to improve linkage function.

This discussion focuses on structures to facilitate movement of terrestrial species over or under road barriers, 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. Properly designed crossing structures are a means of overcoming impediments or barriers to movement in the linkage. However, 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 Interstate 10. 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). The resulting demographic and genetic isolation increases extinction risks for populations (Gilpin and Soulé 1986). 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). Fragmentation also results in smaller populations, which are more susceptible to extinction due to demographic and environmental stochasticity.

The impact of a road on animal movement varies with species, context (vegetation and topography near the road), road type and level of traffic (Clevenger et al. 2001). For example, a road on a stream terrace can cause significant population declines in amphibians that move between uplands and breeding ponds (Stephenson and Calcarone 1999), but a similar road on a ridgeline may have negligible impact. Most

Figure 63. Existing Infrastructure in the Planning Area



Linkage Design
Protected Lands
Highways
Secondary Roads
Railroads
Pipeline (Buried)
Potential Crossing Structures

Map Produced By:

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September 2005
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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: At the time of this report, there is approximately 190 km (119 mi) of paved roads in the Linkage Design area (Table 4), most of which occur within areas designated as stewardship zones. Interstate 10, Highway 111 and Highway 79 are the major transportation routes posing the most substantial barriers to movement, while Highway 243, a 2-lane scenic route, is relatively permeable (Figure 63). A survey of these roads found a variety of existing structures (i.e., bridges, pipes, and culverts) that might be useful for implementing road-crossing mitigation projects (Figure 63).

Table 4. Major transportation routes in the Linkage Design.

Road Name	Length (km)	Length (mi)
Interstate 10	17	11
Highway 111	5	3
Highway 243	6	4
Highway 79	8	6
Other Paved Roads	154	95
Total Length of Paved Roads	**190**	**119**

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.

There are about 50 vegetated wildlife overpasses (Figure 64) in Europe, Canada, and the U.S. (Evink 2002, Forman et al. 2003). They range from 50 m (164 ft) to more than 200 m (656 ft) in width (Forman et al. 2003). Soil depths on overpasses range from 0.5 to 2 m, allowing growth of herbaceous, shrub, and tree cover (Jackson and Griffin 2000). Overpasses maintain ambient conditions of rainfall, temperature, light, vegetation, and cover, and are quieter than underpasses (Jackson and Griffin 2000). In Banff National Park, Canada, large

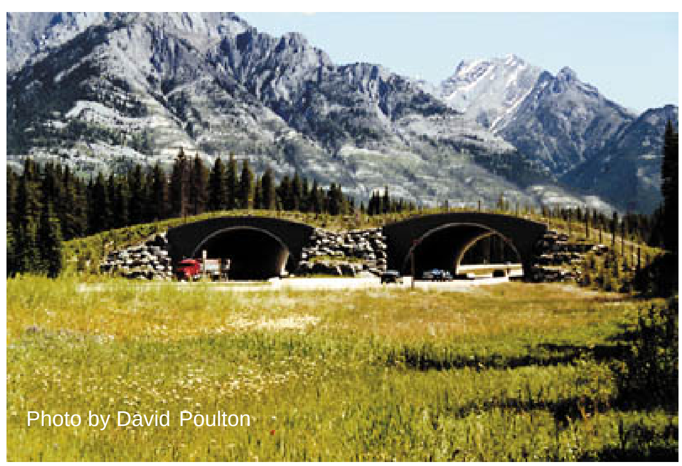

Figure 64. An example of a vegetated land bridge built to enhance movement of wildlife populations.

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).

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 65), 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 65. 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 66). Gloyne and Clevenger (2001) suggest that underpasses for ungulates should be at least 4.27 m high and 8 m wide, with an openness ratio of 0.9 (where the openness ratio = height x width/length). Earthen flooring is preferable to concrete or metal (Evink 2002).

Figure 66. Culvert on German highway, with rail for amphibians and fence for larger animals.

For rodents, pipe culverts (Figure 67), about 1 ft in diameter without standing water are superior to large, hard-bottomed culverts, apparently because the overhead cover makes small mammals 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 68). 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 67. Pipe culvert designed to accommodate small mammals.

Figure 68. 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), and noise can deter animal passage (Forman et al. 2003). Shrub or tree cover should occur near the entrance to the structure (Evink 2002). Existing structures can be substantially improved with little investment by installing wildlife fencing, earthen berms, and vegetation to direct animals to passageways (Forman et al. 2003). Regardless of crossing type, wildlife fencing is necessary to funnel animals towards road crossing structures and keep them off the road surface (Falk et al. 1978, Ludwig and Bremicker 1983, Feldhammer et al. 1986, Forman et al. 2003). Earthen one-way ramps can allow animals that wander into the right of way to escape over the fence (Bekker et al. 1995, Rosell Papes and Velasco Rivas 1999, Forman et al. 2003).

Recommended Crossing Structures on Interstate 10: Interstate 10 is the most substantial impediment to movement, bisecting the linkage for a distance of roughly 17 km (11 mi). Following standard practice (Clevenger and Wierzchowski 2005) where a road bisects a major wildland, we recommend crossing structures for large mammals at intervals of 1.5 to 2 km (0.9 to 1.25 miles), or at least one major structure per branch of the Linkage Design. Thus, we propose a total of 8 crossing structures (either bridged undercrossings or wildlife overpasses) along the 17 km of Interstate 10 through the Linkage Design. Several crossing structures adequate to accommodate wildlife movement currently exist, while others need to be improved.

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, such as lane additions or ramp remodeling in the vicinity of the Linkage Design. Open bridges (supplemented by culverts for smaller species) should be sited along natural travel routes and spaced less than 2 km (1.25 mi) apart on average, with a maximum spacing between adjacent structures not to exceed 2.8 km (1.75 mi). Excellent examples of roads retrofitted with large crossing structures at similar intervals include State Route 260 between Payson and Forest Lakes, Arizona; the Trans-Canada Highway in Banff National Park, Canada;

Interstate 75 through the Everglades in Florida; and Interstate 4 near Daytona Beach, Florida. It is also important that the entire road be fenced to funnel animals toward crossing structures.

Currently several structures along Interstate 10 accommodate various levels of animal movement (Figure 63). We recommend maintaining these structures, protecting adjacent land from development, and ensuring that future road projects do not degrade these crossing structures. These existing structures should be supplemented with major bridges or overpasses at appropriate locations and spacing, as described above.

There are two existing crossing structures under Interstate 10 in the western branch of the linkage, but neither is ideal. The existing culvert for Garden Air Wash (Figure 69) was not accessible during field visits, but is perhaps 2 m (6 ft) high and wide and about 20 m (65 ft) long. Bears were documented using this culvert in 1995 and 1998 (A. Kelley, pers. com.), and puma were killed on the road here in 1986 and 1997 (R. Fischer, CDFG, pers. com.). Caltrans is scheduled to rebuild the dangerous ramp here and is expected to make the culvert more amenable to wildlife. Development is slated to occur on the flat land above the canyon creating a choke-point for the last half-mile southwest of Interstate 10. We strongly recommend working with the developer to widen this section of the linkage to maintain the functionality of this connection over time. Wildlife movement would also be enhanced by either restoring the golf course north of the freeway to natural vegetation or adding strategic landscape vegetation.

Figure 69. Cottonwoods and willows dominate Garden Air Wash south of Interstate 10.

The culvert for El Casco Canyon (Figure 70) has 2 chambers, each about 1.5 m (4.5 ft) high and wide, and around 20 m (65 ft) long. A puma was shot near here in 1986 (R. Fischer, CDFG, pers. com.). The creek has been channelized for a stretch leading to the culvert north of the freeway, which should be restored. Though some species may currently utilize this structure, it is far from ideal due to low visibility to the other side and concrete flooring. We recommend replacing this concrete culvert with

Figure 70. The culvert for El Casco Creek looking toward the Badlands.

a bridge at the time of the next transportation improvement project in this stretch of highway. The area south of the freeway is aptly labeled "Tract between San Jacinto and San Gorgonio." Although this branch of the linkage will be restricted to mere choke-points in some areas, maintaining connectivity here will benefit multiple species.

Figure 71. First-rate bridge spanning the San Gorgonio River.

Figure 72. San Gorgonio River flowing under the road between the freeway and the railroad.

The least cost corridor for badger crosses Interstate 10 along the San Gorgonio River, and suitable habitat occurs for a number of other focal species. There are a series of crossing structures where the River flows under Interstate 10, including separate bridges for both the west and eastbound lanes (Figure 71), and for the service road between the freeway and the railroad tracks (Figure 72). Each bridge has 10 chambers, with each section measuring roughly 6 m (20 ft) wide, 3 to 5 m (10 to 15 ft) high depending on soil deposition, and roughly 20 m (65 ft) long. The 2 outer sections are shorter, about 0.9 to 1.5 m (3 to 5 ft) high. During field visits we observed an abundance of animal sign throughout this area, including deer tracks and several carnivore scats. Animals that follow washes can enter several canyons in the San Jacinto Mountains. Myers et al. (1996) recorded coyote, rabbit, mice, woodrat, and ground squirrel during tracking surveys. Just downstream, however, a low concrete dike runs almost the full width of the river, deflecting flow to the south bank to protect a mining operation that occupies almost the whole river bottom. Mining operations in the river decrease its value as a travel corridor and closing and restoring these operations would benefit this connection.

The least cost corridor for mountain lion crosses Interstate 10 using Stubbe Canyon, which has suitable habitat for several other focal species, including badger, antelope ground squirrel, little pocket mouse, and Merriam's kangaroo rat. There are a series of bridged under-crossings to accommodate Stubbe Wash, which crosses the freeway and service road in 2 places (Figures 73 and 74), roughly 30 m (90 ft) apart. Each bridge is roughly 4 to 5 m (12 to 15 ft) high, 8 to 10 m (25 to 30 ft) wide, and about 20 m (65 ft) long. Stubbe Wash joins the San Gorgonio River just south of the freeway. Coyote, rabbit, mice, woodrat, and ground squirrel were also recorded using this crossing structure (Myers et al. 1996), and many tracks were detected during recent field surveys. In addition to facilitating wildlife movement across transportation barriers, these bridges also provide passage for hikers on the Pacific Crest Trail. There is some native vegetation at the approach of these structures in both directions, but there is virtually no vegetative cover through the entire length of the actual structures themselves. We suggest planting native shrubbery in between each bridge where sunlight reaches. Signs of vehicles were also visible beneath these bridges and efforts should be made to prevent off-road vehicle use here. There are also some scattered homes on the north side of the freeway just east of the wash. We recommend maintaining the rural character of the landscape, with appropriate measures to confine light and noise pollution to home sites. Roughly 800 acres were recently purchased in Stubbe Canyon on both sides of the freeway to maintain this connection for wildlife movement and provide habitat for listed species covered by the Coachella Valley MSHCP (B. Havert and K. Barrows, pers. com.). The land in upper Stubbe Canyon should be targeted for conservation easement, purchase, or other action to maintain its wild character.

Figure 73. Looking toward the San Jacintos at the westernmost bridges over Stubbe Canyon.

Figure 74. Looking through the easternmost bridges under the freeway and service road.

The most permeable path for mountain lion crosses Interstate 10 along the Whitewater River. This area also provides habitat and connectivity for badger, Merriam’s kangaroo rat, little pocket mouse, rock wren, speckled rattlesnake, and coast horned lizard. The Whitewater River provides the most direct riparian connection between targeted protected areas, and most of the canyon is already protected. There are a series of excellent bridges, 2 for the east and westbound lanes of the freeway (Figure 75), and one for the service road (Figure 76). The freeway bridges each have 8 chambers, each measuring roughly 9 m (30 ft) high, 16 m (55 ft) wide, and 20 m (65 ft) long. The bridge for the service road has roughly the same measurements as the freeway bridges except the passageways are much shorter, at about 6 m (20 ft). The Whitewater River Bridge was found to have the highest frequency of bobcat use in the study area; and coyote, rabbit, and roadrunners were also documented using this structure (Myers et al. 1996). There is a spectacular gallery forest dominated by cottonwood and willows about 1 km north of the freeway. Public agencies bulldoze a stretch of the river just below the gallery forest to increase percolation for groundwater recharge basins. We strongly recommend initiating a riparian restoration project to improve habitat conditions (See Stream Barriers Section). Numerous species that utilize riparian or desert scrub habitats (e.g., antelope ground squirrel, Pacific kangaroo rat, large-eared woodrat, treefrog, and white alder) will benefit from re-establishing native riparian vegetation here. In addition, there is one row of windmills in the river bottom south of the freeway and many more downstream. Some of the wind farms are surrounded by chain-link fence topped with barbed wire, which should be removed to allow animals to roam the floodplain and access side canyons more easily.

Recommended Crossing Structures on Highway 111: There are two suitable bridged crossings where Highway 111 crosses the confluence of the San Gorgonio and Whitewater Rivers, one for traffic in each direction (Figure 77). Each bridge has 8 chambers, each measuring roughly 3 m (10 ft) high, 4.5 m (15 ft) wide, and roughly 9 m (30 ft) long. We investigated further downstream to look for opportunities for animals to leave the river bottom and enter the San Jacinto Mountains. There is no shortage of steep slopes to ascend, but relatively few canyon

Figure 75. Looking south toward the San Jacinto Mountains through the freeway bridge over the Whitewater River.

Figure 76. Looking up Whitewater River through the bridge built to accommodate the 2-lane service road.

Figure 77. Highway 111 bridge at the confluence of the San Gorgonio and Whitewater Rivers.

bottoms, of which Snow Canyon is by far the best (Figure 78). The small village of Snow Canyon is almost a half mile from the main wash of Snow Creek, with a broad bajada at its mouth. There is also a substantial canyon just west of the village of Snow Canyon that offers access to the San Jacintos. This small canyon has a spring about 183 m (600 ft) above the river floor. Downstream, Blaisdell Canyon looks like superb habitat, but there is some housing in the bajada at its mouth that likely impedes passage by some animals. There is a small steep canyon a bit downstream (NE of Desert Angel peak) but no underpass under Highway 111 at this point, plus chain link fencing.

Figure 78. Whitewater River flowing towards the San Jacinto Mountains with Snow Creek Canyon in the center of the photo.

We strongly recommend conservation measures to maintain the rural character in this area and attention to wildlife connectivity during any upgrading of Highway 111. There has already been significant investment in conserving the Whitewater River connection. We advise purchase or conservation easements of any large parcels in the broad alluvial fan of the river and in Snow Creek Canyon.

The area is also popular with off-road vehicle enthusiasts with heavy signs of use in the river bottom and up several side canyons. These illegal activities impact soils and vegetation and may inhibit species movement and habitat use patterns. We highly recommend preventing off-road vehicle use and enforcing closures.

Recommended Crossing Structures on Highway 79: Highway 79 or Lamb Canyon Road bisects the linkage through the Badlands. Coastal sage scrub is the dominant vegetation in the Badlands, providing habitat for a majority of the selected focal species.

There are a number of concrete pipe culverts in this stretch of the highway, sited every 300 to 500 m (0.2-0.3 mi), with average dimensions of 1.5 m (5 ft) in diameter, comparable to the one depicted in Figure 79. There is also a concrete box culvert with 2 chambers (Figure 80), each measuring about 1 m (3 ft) high and 4 m (12 ft) wide. Visibility is poor or absent through most of these structures.

None of the structures on Highway 79 is ideal for facilitating wildlife movement due to the size of the structures, limited or no visibility to the other side, and concrete flooring, and many of the structures are badly in need of maintenance. A number of the structures are clogged with weedy plant species (Figure 81), and the concrete box culvert shown in Figure 80 is practically filled with dirt. We recommend upgrading these structures to expansive bridges at least 4 m high and 8 m wide during the next transportation improvement project along this highway. We also suggest acquisition or conservation easements of any large parcels, and restoration of natural habitats that have been degraded. The Badlands provide the largest expanse of coastal sage scrub in the linkage planning area, providing habitat not only for numerous focal species but also for a number of rare and endangered species not specifically addressed by our analyses, such as the coastal California gnatcatcher. Coastal sage scrub is designated as a sensitive natural community by the state, and is underrepresented in existing protected areas.

Figure 79. Concrete pipe culvert under Highway 79, which is representative of most culverts along this highway.

Figure 80. Concrete box culvert under Highway 79, which is in need of maintenance.

Figure 81. Many structures along Highway 79 are clogged with weeds, limiting their utility for wildlife.

Other Recommendations Regarding Paved Roads within the Linkage Design:

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

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

- Install appropriate wildlife fencing along the freeway to guide animals to crossing structures and keep them off the highway. Install escape structures, such as earthen ramps, to allow animals to escape if they get trapped on the freeway.

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

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

- Move any lighted billboards that are adjacent to crossing structures at least 200 m (656 ft) away from the crossing to minimize artificial night lighting.

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 has been converted, through a partnership with CalTrans, California State Parks, and Hills for Everyone, from a vehicle interchange into a wildlife underpass to facilitate movement between the Chino Hills and the Santa Ana Mountains. About 8 wildlife underpass bridges and viaducts were installed along State Route 241 in Orange County, although urbanization near this toll road has compromised their utility (Evink 2002). Elsewhere, several crossing structures, including 3 vegetated overpasses, have been built to accommodate movement across the Trans-Canada Highway in Banff National Park (Clevenger et al. 2001). In south Florida, 24 underpasses specifically designed for wildlife were constructed along 64km (38 mi) of Interstate 75 in south Florida. 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, Land et al. 2001). 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 each of the four workshops of the South Coast Missing Linkages effort, and the agency is incorporating wildlife crossing improvements into its projects with a focus in 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.

Rail Line Barriers to Movement

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

Existing Rail Lines in the Linkage Design Area: The Union Pacific Railroad bisects the entire length of the linkage. The railroad is currently used for freight, industrial, and passenger service (County of Riverside 2003). In the western part of the linkage, the rail line runs along San Timoteo Canyon between Interstate 10 and State Route 60. Just west of Beaumont, the tracks begin to parallel Interstate 10 running just south of the freeway through much of the pass, between Little San Gorgonio and Cottonwood creeks. In the central part of the linkage area, from approximately the San Gorgonio River to Stubbe Canyon, the rail line, the freeway, and various service roads form a band of parallel impediments to animal movement between the San Bernardino and San Jacinto Mountains. Just past Stubbe Canyon and before the Interstate 10 and Highway 111 interchange in the eastern part of the linkage, the rail line begins to head southeast, crossing under Highway 111 and then running alongside the highway for roughly 4 km before heading due east to cross over the Whitewater River. For much of its length, the rail lines lie on a bed of gently-sloping gravel. For some small mammals, amphibians, and reptiles, the rails and expanse of gravel probably are moderate impediments to movement but there are multiple crossing points under the railroad tracks.

There are 3 railroad crossing structures over the San Gorgonio River. Two are box culverts (Figure 82), while the main channel is bridged (Figure 83). The box culverts each measure roughly 2 m (6.5 ft) high, 6 m (20 ft) wide, and 6 m long. The bridge over the river has 14 chambers with each section measuring about 4 m (13 ft) high, 3 m (10 ft) wide, and 6 m (20 ft) in length. There was an excellent railroad bridge over Stubbe Canyon Wash when we did field reconnaissance in spring of 2003 (Figure 84), but soon thereafter it was downgraded to a bridge with a much reduced openness ratio (Figure 85). While the new structure will still likely accommodate wildlife movement, the reconstruction effort eliminated vegetative cover in addition to reducing the size of the bridge, which now measures roughly 3 m (10 ft) high, 18 m (60 ft) wide, and 6 m (20 ft) long. The 3 railroad bridges over the Whitewater River are about a half a kilometer north of Highway 111, and 150 m (500 ft) apart. The 2 bridges to the east are about 3 m (10 ft) high, 9 m (30 ft) wide, and about 6 mi (20 ft) in length (Figure 86). The western most bridge has 4 chambers, each about 1.2 m (4 ft) high, 6 m (20 ft) wide, and roughly 6 m (20 ft) long (Figure 87).

Recommendations to Mitigate the Effects of Rail Lines in the Linkage Design: We believe that the existing rail line may present an impediment to movement of small mammals, reptiles, and amphibians. Although the railroad is probably not a complete barrier, in concert with nearby Interstate 10 and Highway 111, the railroad contributes to reduced connectivity in the linkage area.

The County of Riverside (2003) has suggested measures to reduce impacts on residents in proximity to railroads, such as installing sound walls and other noise absorbing surfaces, and eliminating at-grade crossings, which would also benefit wildlife. We recommend a policy of using any railroad realignment as an opportunity not simply to mitigate loss of wildland connectivity, but to improve it. Ameliorating the adverse affects of railroads is similar to that for roads, providing viaducts, bridged underpasses, and tunnels (Reed and Schwarzmeier 1978, Borowske and Heitlinger 1981, Forman 1995). We recommend that crossing structures should be (a) sited at least every 1.5 to 2 km, (b) aligned with crossing structures on Interstate 10 and Highway 111, (c) integrated with sound walls to reduce noise pollution, and (d) integrated with fences where beneficial to guide animals toward crossing structures. Fencing can be permeable to humans and larger animals, and would not be needed where steep cut and fill slopes already divert animals toward structures.

Implementing these recommendations will take cooperation among the rail line operators 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. A coordinated plan will ensure that, for instance, a planned crossing structure on Interstate 10 does not abut an impermeable section of the railroad for which no crossing structure is planned.

Impediments to Streams

Organisms moving through rugged landscapes often use riparian areas as travel routes. For example, many butterflies and frogs preferentially move along stream corridors (Orsack 1977, Kay 1989, USGS 2002). Even large, mobile vertebrates, such as mountain lions, have shown preferences for moving along riparian corridors (Beier 1995, Dickson et al. 2004).

For plants and animals associated with streams or riparian areas, impediments are presented by 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 convert ephemeral streams to perennial streams that support aggressive invasive species, such as bullfrogs and exotic fish that prey on native aquatic species, and giant reed (*Arundo* donax) that supplants native plant communities (Fisher and Crooks 2001).

Figure 82. Box culvert built to accommodate overflow of the San Gorgonio River, just west of the bridge to the right. Another similar structure occurs to the east of the bridge.

Figure 83. Looking south toward the San Jacinto Mountains at the railroad bridge over the main channel of the San Gorgonio River.

Figure 84. Old railroad bridge over Stubbe Canyon Wash looking toward the San Jacinto Mountains.

Figure 85. Same view as Figure 81 showing the new bridge over Stubbe Canyon Wash.

Figure 86. A railroad bridge for the Whitewater River built in 2004. ORV use is evident but there were plenty of animal tracks as well.

Figure 87. Western most railroad bridge over the Whitewater River, also built in 2004.

Impediments to Streams in the Linkage Design: The Whitewater River provides the most direct connection between targeted ranges. The San Gorgonio River emanates from the San Bernardino Mountains creating an extensive alluvial fan that provides an east west movement route through the pass, with several tributary creeks providing links to the San Jacinto Mountains. In times of high surface flows, these rivers and their tributaries may provide avenues along which riparian species journey between the San Bernardino and San Jacinto Mountains and the Badlands. Today, riparian habitats are significantly reduced in some places due to a combination of factors, including flood control, water diversions, ground and surface water extraction, the effects of which are exacerbated by drought.

The Whitewater River has a lush riparian forest until about 1.5 miles above Interstate 10 (Figure 88), and restoration would improve habitat for many species. This part of the river needs revegetation and restoration of the channel to something closer to natural form. Colorado River water is pumped into the ground just above I-10 for underground storage and transport to towns a few miles downstream. The water management agency regularly bulldozes the riparian vegetation in the river bottom with the apparent goal of increasing percolation by eliminating riparian vegetation that uses Colorado River water destined for the recharge galleries downstream (Noss et al. 2001). This practice eliminates cover that might otherwise provide meaningful habitat connectivity for both riparian and terrestrial species. Further upstream, the Whitewater Trout Farm diverts water from inside BLM Wilderness, taking 100% of the flow out of the River for several miles. Although they do return water to the river (in the floodplain, but not the main channel) below their hatchery ponds and resort, this diversion significantly impacts the gallery forest. In addition, there is also a gravel pit ½ mile above the freeway, and below that some diking to protect the Interstate 10 bridges and embankments.

Figure 88. The gallery forest in upper Whitewater River, seen along the base of the mountains, is a critical resource for wildlife in this otherwise arid landscape. Riparian restoration downstream is crucial to restore functional connectivity and should not impact groundwater recharge objectives.

The San Gorgonio River is also apparently dewatered far upstream, and would otherwise support a more substantial riparian forest. A water facility, either under construction or renovation, occurs at the northern end of Bluff Road north of Banning. Apparently this is a pump station removing water from upstream. There are also two large-scale mining operations in the floodplain of the San Gorgonio River, which likely deter wildlife movement and alter habitat use patterns (See Mining Operations section).

Surface and groundwater issues are quite complex in the linkage area and involve multiple agencies, including but not limited to the Metropolitan Water District of Southern California (MWD), Coachella Valley Municipal Water District, Desert Water Agency, City of Banning Water District, San Gorgonio Pass Water Agency, and the Beaumont-Cherry Valley Water District. In this arid landscape, it is not surprising that there has been an "imbalance between consumption and all sources of groundwater recharge" (City of Rancho Mirage 2003). Groundwater recharge is accomplished by natural percolation from perennial and intermittent surface flows that infiltrate alluvial fans and imported water. The San Gorgonio and Whitewater River subbasins are recharged by inflows from the San Gorgonio Pass area, with the San Timoteo Formation being the major water-bearing deposit in the pass (Bloyd 1971, DWR 2004). MWD's Colorado River Aqueduct cuts southwest across the Pass, and since 1973 has also been recharging the Whitewater River subbasin (County of Riverside 2003, City of Rancho Mirage 2003). With an average annual rainfall of 15 to 18 inches (Bloyd 1971, DPW 2004), and increases in the demand for limited groundwater supplies, water extraction is 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. Many rural areas in the pass have been developed with septic tanks and leachfield systems causing an increase in nitrates (City of Palm Desert 2004). Water quality has also been affected by importation of Colorado River Water, which is about 3 times higher in total dissolved solids than natural upper Whitewater River groundwater. However, no drainages in the linkage have been listed as impaired under Section 303(d) of the Clean Water Act (USEPA 2003, http://endeavor.des.ucdavis.edu/geowbs/asp/wbregion.asp). Should any drainage be listed as impaired in the future, these riparian stretches would be 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, after which an implementation plan is developed to return water quality to targeted values.

Invasive species are also an issue that needs to be addressed in the Linkage Design. Although the San Gorgonio and Whitewater rivers and other drainages in the linkage are dominated by native species, tamarisk or saltcedar (*Tamarix ramosissima*) has invaded some of these systems (e.g., Whitewater and San Gorgonio rivers). This introduced species has escaped cultivation and invaded stream courses in the arid southwest, out competing native plant species and forming monocultures that provide little value to wildlife. Tamarisk can transpire at least 200 gallons of water per plant each day and will often dry up ponds and streams (Whitson et al. 2000, Baldwin et al. 2002). Drying up of the streams, springs, and seeps in this arid landscape would be detrimental to native flora and fauna.

Riparian areas are crucial for sustaining populations of water-dependent species (e.g., California treefrog) in the Linkage Design area, and may function as steppingstones that allow movement by semi-aquatic species. They can also provide travel routes for terrestrial organisms, such as mountain lion, which are known to move along riparian corridors (Spowart and Samson 1986, Beier and Barrett 1993, Dickson et al. 2004). In addition to facilitating wildlife movement, portions of both the San Gorgonio and Whitewater rivers also provide habitat for several listed species covered by the Multiple Species Habitat Conservation Plans (Noss et al. 2001, County of Riverside 2002, CVAG 2004).

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

Continuity between upland and riparian vegetation is also important to maintaining healthy riparian communities. Many species commonly found in riparian areas depend on upland habitats during some portion of their lifecycle. Examples include butterflies that use larval host plants in upland habitat and drink water as adults and toads that 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 typically focus on establishing riparian buffer zones (Barton et al. 1985, Allan 1995, Willson 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 (Willson 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, Willson 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 (Willson and Dorcas 2003).

Recommendations to Mitigate the Effects of Streams Barriers in the Linkage Design: Since 80% of terrestrial vertebrate species depend on riparian systems (Kreuper 1992), it is critical to maintain these communities. To enhance species use of riparian habitat through the Linkage Design area, we recommend:

- Restore riparian vegetation in all drainages and upland vegetation within 1 km (0.6 mi) of streams and rivers, where feasible. This may encourage plant and animal movement and increase water quality. Non-point sources of pollution should be identified and minimized.

- Work with Coachella Valley Municipal Water District, Army Corps of Engineers (ACOE), CDFG, USFS, BLM and other relevant agencies and organizations to restore riparian vegetation in the Whitewater River.

- Work with water district staff to reorient the Whitewater basins at some time in the future to increase the rate of aeolian sand transport (Noss et al. 2001).

- Work with the USFS, CDFG, Department of Public Works, Water Districts, watershed groups and others to investigate the historic flow regime of the San Gorgonio and Whitewater Rivers and develop a surface and groundwater management program to restore and recover properly functioning aquatic/riparian conditions.

- Work with the City of Calimesa, Public Works, community residents, and others to restore riparian vegetation in Garden Air Wash and El Casco Canyon north of the freeway.

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

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

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

- Prevent off-road vehicles from driving in the creek bottom 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. Work with the Resource Conservation District to help establish use of Best Management Practices for rural communities in the Linkage Design and surrounding communities.

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

- Discourage any additional development in flood prone areas and prevent the construction of concrete-banked streams and other channelization projects.

- Support the protection of riparian and adjacent upland habitats on private lands. Pursue cooperative programs with landowners to improve conditions in riparian and upland habitats on private land in the Linkage Design.

Other Land Uses that Impede Utility of the Linkage

Land management policies in the protected areas and the linkage can have substantial impact on habitat and movements of species through the Linkage Design. It is essential that land-management and planning entities (e.g., USFS, BLM, Coachella Valley Association of Governments, Riverside County, and cities) integrate the linkage plan into their policies and regulations.

Mining Operations

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

Mining in the Linkage Design Area: There are 3 mines in the Linkage Design: Two large-scale mining operations in the floodplain of the San Gorgonio River and one small rock quarry near the Whitewater River. The two mining operations on the San Gorgonio River are about 3.5 km apart, one in northeast Banning about 1.5 km upstream from Interstate 10 (Figure 89) and the other just downstream of the freeway crossing. Here, a low concrete dike runs almost the full width of the river, deflecting flow to the south bank to protect the mining operation that occupies almost the whole river bottom.

Restoring land occupied by the mining operations in the San Gorgonio River would benefit numerous species, including badger, mule deer, little pocket mouse, Merriam's kangaroo rat, large-eared woodrat, rock wren, wrentit, chaparral whipsnake, coast horned lizard, California sagebrush, and the critically endangered slender-horned spineflower. Closing and restoring the mining operations in the San Gorgonio River would greatly enhance the conservation value of this connection.

Examples of Mitigation for Mining Operations: Mining operations can be modified with actions that reduce the affects of these industrial activities. Preventing any further mining operations in key areas of the Linkage Design through administrative withdrawals will have the greatest effect on preserving linkage function. Existing mining operations can be targeted for regulatory actions that reduce the effects of these industrial activities. These include, limiting noise from blasting, minimizing night lighting, reducing traffic in sensitive areas or constriction points, monitoring water quality and quantity, minimizing the use of harmful chemicals, and increasing enforcement of existing regulations.

Figure 89. Mining operation in the San Gorgonio River in northeast Banning, with Hathaway Creek flowing into the river just below this operation.

Recommendations to Mitigate the Effects of Mining in the Linkage Design Area: Agencies with regulatory oversight of mining operations include U.S. Fish and Wildlife Service, California Department of Fish and Game, Army Corps of Engineers, Regional Water Quality Control Board, U.S. Forest Service, Bureau of Land Management and Riverside County. The California Surface Mining and Reclamation Act (1975) requires that land used in mining operations be restored once operations have ceased. We provide the following initial recommendations regarding mining activities in the Linkage Design area:

- Implement best management practices to minimize blasting noise, night lighting, and traffic in biologically sensitive areas or corridor constriction points.
- Prohibit new mining operations in key areas of the Linkage Design. Apply for administrative withdrawals to promote recovery of listed and sensitive species and their habitats.
- Mining operations should avoid disturbance of natural waterways, rare or imperiled habitat or species, wildlife movement corridors, and other biological resources.
- Prohibit placement of mine tailings, soil and overburden, and industrial waste in riparian zones.

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

- Monitor mining operations for the presence of non-native aquatic species and implement eradication programs.

- Monitor compliance with all regulations, approved plans of operations, Habitat Conservation Plans, and with state and federal laws.

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

- When existing mining operations are completed, urge reclamation under guidelines set forth by the 1975 California Surface Mining and Reclamation Act.

Wind Turbines

Although wind-generated energy does not produce air-polluting and climate-modifying emissions, wind turbines can impact wildlife and wildlife habitats. Adverse effects can include habitat fragmentation from access roads, tower pads, above-ground power lines, and trenching for underground power lines. Birds, particularly raptors, are often killed from striking moving blades or power lines. Power lines associated with wind turbines can also be a source of mortality through electrocution if raptor-safe technology is not used. Noise generated by wind turbines may also interfere with communications in birds. An assessment of 15,000 wind turbines in the United States, estimated bird mortality in the range of 10,000 to 40,000 (mean = 33,000), with an average of 2.19 avian fatalities per turbine per year (Erickson et al. 2000, NMDFG 2004). Research has also shown that bats are highly susceptible to mortality from collisions with wind turbines (Adams 2003, NMDFG 2004).

Wind Turbines in the Linkage Design Area: The San Gorgonio Pass has the third largest concentration of wind turbines in California, with more than 3,500 located in the pass. The majority of these turbines were installed during the height of California's great *wind rush* in the early 1980s. The older wind turbines were installed much closer together, are less reliable, and operate less frequently than contemporary designs. Some of the older turbines have been replaced with tubular supported turbines, which are more bird friendly, but the majority of turbines in the Linkage Design are still lattice-supported

Figure 90. Lattice-support wind turbines downstream on the river; some are fenced limiting wildlife movement in this area.

turbines (Figure 90). There is one row of wind farms in the bottom of the Whitewater River below I-10, and about 12 rows of turbines in the floodplain of the San Gorgonio River between Stubbe Canyon and Lion Canyon. Some of the wind farms are surrounded by chain-link fence topped with barbed wire, restricting wildlife movement in the floodplain and access to side canyons.

McCrary et al. (1983, 1984, NWCC 2001) estimated that 69 million birds fly through the pass annually during migration, with 32 million in the spring and 37 million in the fall. They predicted that 6,800 birds were killed annually at the San Gorgonio wind facility based on 38 carcasses found while monitoring nocturnal migrants. A recent study in 2000 at San Gorgonio documented 42 fatalities during quarterly searches of approximately 360 turbines (Erickson et al. 2000, NWCC 2001). Additional wind energy projects have been proposed in the pass, which could increase collisions and further limit wildlife movement.

Recommendations to Mitigate the Effects of Wind Turbines in the Linkage Design Area: Considerable efforts have been made to standardize methods for siting wind plants to minimize biological impacts (NWCC 1999, NWCC 2001) and monitoring avian impacts (Anderson et al. 1999, Erickson et al. 2000, NWCC 2001). Many new wind-generating facilities have implemented site evaluation and monitoring programs that are useful for evaluating the impacts of wind plants on birds (Johnson et al. 2000, Erickson et al. 2000, Kerlinger and Curry 2000, Johnson et al. 2001, NWCC 2001). Research has shown that the smaller, faster moving, Kenetech-built, lattice-supported turbines have caused most of the bird fatalities, many of which are now being replaced with slower moving, tubular-supported turbines (Berg 1996, NMDFG 2004).

Nearly all of the following recommendations were developed by U.S. Fish and Wildlife Service and published as “Interim Guidance on Avoiding and Minimizing Wildlife Impacts from Wind Turbines” (Federal Register: July 10, 2003. Vol. 68, No. 132):

- Remove fences surrounding wind turbines in the Linkage Design to allow animals to roam the floodplain and access side canyons more easily.

- Avoid locating turbines in known migration pathways or in areas where birds are highly concentrated, such as wetlands, rookeries, roosts, and riparian areas. Avoid known daily movement flyways (e.g., between roosting and feeding areas) and areas with a high incidence of fog, mist, low cloud ceilings, and low visibility.

- Avoid placing turbines near known bat hibernation, breeding, and maternity/nursery colonies, in migration corridors, or in flight paths between colonies and feeding areas.

- Configure turbine arrays to avoid landscape features known to attract raptors, such as cliffs.

- Avoid fragmenting large, contiguous tracts of wildlife habitat by minimizing roads, fences, and other infrastructure to maintain contiguous habitat for area-sensitive species. Turbines should be sited on lands already degraded or cultivated, and away from areas of intact native habitats.

- Where feasible, place electric power lines underground (see trenching guidelines) or on the surface as insulated, shielded wire to avoid electrocution of birds. Use recommendations of the Avian Power Lines Interaction Committee (1994, 1996) for any required above-ground lines, transformers, or conductors.

- Use tubular supports with pointed tops rather than lattice supports to minimize bird perching and nesting opportunities. Avoid placing external ladders and platforms on tubular towers to minimize perching and nesting. Avoid use of guy wires for turbine or meteorological tower support. All existing guy wires should be marked with recommended bird deterrent devices (Avian Power Line Interaction Committee 1994).

- If taller turbines (top of the rotor-swept area >199 feet above ground level) require lights for aviation safety, use the minimum acceptable pilot warning and obstruction avoidance lighting specified by the Federal Aviation Administration (FAA 2000). Only white strobe lights should be used at night, and these should be the minimum number, minimum intensity, and minimum number of flashes per minute allowable by the FAA. Solid red or pulsating red incandescent lights should not be used, as they appear to attract night-migrating birds and bats at a much higher rate than white strobe lights.

- Monitor bird movements (e.g., using acoustic, radar, infrared, or observational techniques) to determine peak use dates and times for specific sites. Where feasible, turbines should be shut down during peak bird-use periods.

- Monitor wildlife mortalities at turbine sites to detect and hopefully remedy problems via upgrading, retrofitting, or relocating of turbines.

- Develop habitat restoration plans for proposed wind-farm sites.

Urban Barriers to Movement

Urban development, unlike roads or aqueducts, creates barriers that cannot be corrected by building crossing structures. Urban and suburban areas make particularly inappropriate landscapes for movements of most plants and animals (Marzluff and Ewing 2001). In addition to direct habitat removal, urban development creates edge effects that reach well beyond the development footprint. Most terrestrial mammals that move at night will avoid areas with artificial night lighting (Beier, in press). Pet cats can significantly depress populations of small vertebrates near housing (Churcher and Lawton 1987, Crooks 1999, Hall et al. 2000). Irrigation of landscapes surrounding homes encourages the spread of argentine ant populations into natural areas, where they cause a halo of local extinctions of native ant populations extending 200 m (656 ft) into native vegetation (Suarez et al. 1998, Bolger et al. 2000). Similar affects have been documented for amphibians (Demaynadier and Hunter 1998). Habitat disturbance caused by intense human activity (e.g., off-road vehicle use, dumping, camping, and gathering sites) also tends to rise in areas surrounding urban developments. Areas disturbed by human use show decreases in bird and small mammal populations (Crooks and Soulé 1999, Bolger et al. 2000, Crooks et al. 2004, Sauvajot unpubl.).

Urban Barriers in the Linkage Design Area: Urban and agricultural areas cover 8.8% of the Linkage Design and are designated as stewardship zones. The small town of

Calimesa and the rural community of Cherry Valley border the western branch of the linkage. The growing city of Banning and the town of Cabazon are on the edge of the central branch of the linkage along the San Gorgonio River. In the eastern branch of the linkage, there is some rural development near Stubbe Canyon, the village of Bonnie Bell in Whitewater Canyon, and the small community of Snow Creek at the mouth of Snow Creek Canyon. The Riverside County General Plan asserts that a considerable amount of open space within the San Gorgonio Pass would be preserved through the Rural Mountainous and Open Space Conservation land use designations, with little development outside of existing city boundaries, except the Oak Valley Specific Plan and the Cherry Valley Gateway Community (County of Riverside 2003). These two developments are adjacent to Calimesa near the western branch of the Linkage Design. The Center for Biological Diversity and the San Bernardino Valley Audubon Society took legal action against the Oak Valley project in September 2001, and settled the case in February 2002. The terms of settlement included the protection of all high-quality wetlands on-site and an additional 30 acres of wetlands off-site, a reduction in residential density, the potential for the preservation of habitat on 4,000 neighboring acres, and the protection of the Garden Air Wash, which is included in the Linkage Design (M. Bond, pers. com.). This type of cooperation is essential to the functionality of the linkage, to limit impacts of lighting, roads, domestic livestock, pets, and traffic on wildlife movement in the Linkage Design.

Steep slopes, limited water supplies, and other constraints limit opportunities for significant population growth in the Pass. In addition, land managers, planners, regulatory agencies, and stakeholders have taken great strides toward influencing the future of the Pass by engaging in the Western Riverside Multiple Species Habitat Conservation Plan (MSHCP) (County of Riverside 2002) and the pending Coachella Valley MSHCP (CVAG 2004). Since increased urbanization of currently undeveloped areas of the Linkage Design could seriously compromise wildland connectivity, we are delighted to see that these plans identify several important areas of the linkage as land that could be acquired for conservation purposes.

Recommendations for Mitigating the Effects of Urban Barriers in the Linkage Design Area: 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, maximizing outdoor water use efficient measures, encouraging the planting of locally native vegetation, minimizing the use of pesticides, poisons and other harmful chemicals, and increasing enforcement of existing regulations.

We recommend the following mitigation actions regarding urban, suburban, and rural developments in the Linkage Design area:

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

- Encourage homes abutting the linkage area to have minimal outdoor lighting, always directed toward the home and yard rather than into the linkage. Homeowners should use fences to keep dogs and domestic livestock from roaming into the linkage area. In the case of existing homes, this can best be arranged as a voluntary agreement among landowners. Residents should be encouraged to keep cats indoors at all times.

- 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, but are not limited to, living with wildlife, predator-safe enclosures for livestock and pets, landscaping, water conservation, noise and light pollution.

- Work with cites and counties to discourage new residential or urban developments in key areas of the Linkage Design.

- Encourage use of drought-tolerant landscaping to reduce water demand (City of Palm Desert 2004), and the corresponding appropriate efficient irrigation technology.

- Provide educational programs for landowners to increase their appreciation of natural communities, and to convey the importance of habitat protection and the need for connecting wild areas.

Recreation

Recreational use is not inherently incompatible with wildlife movement, although, 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: Areas currently available for recreation in the vicinity of the Linkage Design include San Bernardino National Forest, Mount San Jacinto State Park, Bighorn Mountain and Whitewater River National Recreation Area, San Jacinto/Santa Rosa National Monument, Lake Perris State Recreation Area, Wildwood Canyon State Park, and The Wildlands Conservancy's Mission Creek Preserve. These lands provide a wide range of recreational opportunities, from nature-based dispersed recreational activities (e.g., hiking, bird watching) to high-density recreation in developed sites. The majority of recreational use is concentrated in developed facilities with road access. Recreational activities in the linkage itself are primarily limited to hiking and birding along the Pacific Crest Trail, which follows Stubbe Canyon, and water play activities along Whitewater River in the National Recreation Area. Illegal recreational dams have been created in some areas that obstruct downstream flows. There is also a shooting range at the mouth of Mia Canyon on the bank of the San Gorgonio River. There are no designated off-road vehicle routes in the Linkage Design (BLM 2003, J. Sullivan, CVAG pers. com.). However, unauthorized road and trail creation (i.e., hill climbs and secondary trails up several side canyons) is an issue in areas of the Linkage Design, such as in the San Gorgonio and Whitewater rivers and near Windy Point in the foothills of the San Jacinto Mountains just east of Snow Creek. Poachers are also a serious concern, with collection for the illegal reptile trade threatening snakes, tortoise, and lizard populations (Associated Press 2005).

Recommendations to Mitigate the Effects of Recreation in the Linkage Design Area: If recreational activities are effectively planned, developed, managed, and 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.

We provide the following initial recommendations to prevent or mitigate negative effects of recreation in the Linkage Design area:

- Monitor trail development and recreational use to provide a baseline for decisions regarding levels, types, and timing of recreational use.
- Work with regional monitoring programs, such as the State's Resource Assessment Program, to collect information on special status species, species movements, and vegetation disturbance in areas of high recreational activity.
- Enforce existing regulations on recreational uses currently established.
- Work with the USFS, BLM, and non-governmental organizations to develop and conduct on-the-ground, multi-lingual outreach programs to recreational users on how to lessen impacts in sensitive riparian areas.
- 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.

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 San Bernardino – San Jacinto Linkage. This list is not exhaustive, but provides a starting point for persons interested in becoming involved in preserving and restoring linkage function.

Bureau of Land Management: BLM sustains the health, diversity and productivity of the public lands for the use and enjoyment of present and future generations. BLM administers the Whitewater River National Recreation Area in the San Bernardino Mountains and has conserved a number of key parcels in the Linkage Design. 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.

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 most important linkage areas. CalTrans recently proposed building a wildlife overpass over SR-118. In February 2003, CalTrans started removing pavement from the Coal Canyon interchange on SR 91 in Orange County and transferred the property to California State Parks expressly to allow wildlife movement between the Santa Ana Mountains of the Cleveland National Forest and Chino Hills State Park. To find out more about the innovative plans being developed by Caltrans, visit their website at http://www.dot.ca.gov.

California State Parks: California State Parks (CSP) 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 Mount San Jacinto 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 is involved in the Coal Canyon habitat connection restoration project to preserve mountain lion movement under SR 91 at the north end of the Santa Ana Mountains. CSP co-sponsored the statewide Missing Linkages conference and is a key partner in the South Coast Missing Linkages effort. CSP recently acquired land in Wildwood Canyon and the new San Timoteo Canyon unclassified state park unit in the linkage area. For more information, visit their website at http://www.parks.ca.gov.

California State Parks Foundation: The California State Parks Foundation (CSPF) is the only statewide nongovernmental 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. For more on their exciting programs, visit www.calparks.org.

California Wilderness Coalition: The California Wilderness Coalition (CWC) 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.

City of Calimesa: The City of Calimesa is a very progressive small town that is committed to protecting wildlife by establishing wildlife corridors between the San Bernardino Mountains and the Badlands. They've made significant progress towards this goal through the public planning process and by working with developers and the conservation community. For more information, go to http://www.cityofcalimesa.net.

Coachella Valley Multiple Species Habitat Conservation Plan: The mission of the CVMSHCP is to conserve adequate habitat in an unfragmented manner to provide for the protection and security of long-term viable populations of the species that are either currently listed as threatened or endangered, are proposed for listing, or are believed by the Scientific Advisory Committee, USFWS and CDFG, to have a high probability of being proposed for listing in the future if not protected by the Plan. The Plan is intended to proactively address requirements of the state and federal endangered species acts while avoiding disruption of economic development activities. The easternmost branch of the Linkage Design falls within the CVMSHCP area. For more information on the plan, go to http://www.cvmshcp.org.

Coachella Valley Mountain Conservancy: The Conservancy was established by the California Legislature in 1990 to protect the mountains surrounding the Coachella Valley, from Palm Springs to the Salton Sea. The Conservancy grew out of a community-based conservation group that believed that a partnership among the local, state, and federal governments, and the public, would be the most effective vehicle to protect the Coachella Valley's splendid natural and cultural resources. The Conservancy completed the CVMSHCP in 2004 and once approved will work to implement the plan. To learn more, go to http://www.cvmc.ca.gov.

Coachella Valley Municipal Water District: The district is involved in six water-related fields of service: irrigation water, domestic water, stormwater protection, agricultural drainage, wastewater reclamation, and water conservation. Recreation and generation of energy have become by-products of some of these services. It will be critical to work with the district to restore riparian vegetation in the Whitewater River. For more information on CVMWD, go to http://www.cvwd.org.

Desert Protective Council: The Desert Protective Council's mission is the protection, appreciation, and enjoyment of some of nature's most marvelous bounty: our deserts. The Council has spearheaded many hard-won successes that have resulted in the preservation of wildlife habitats and natural resources of the four great deserts of the southwest. For more information, go to http://www.dpcinc.org.

Desert Tortoise Council: The Council is a private, nonprofit organization that promotes conservation of the desert tortoise in the wild in a variety of ways. They hold an annual symposium to bring together scientists, managers, and concerned people to share the latest information available on the desert tortoise and its management. For more information, go to http://www.deserttortoise.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

Friends of the Desert Mountains: The Friends are working to provide conservation resources for landowners and to acquire land. They recently helped acquire 800 acres of land in Stubbe Canyon in the Linkage Design. For more information visit http://www.privatelandownernetwork.org.

Morongo Band of Mission Indians: The Morongo Band of Mission Indians is a sovereign nation that owns a substantial amount of land designated as stewardship zones in the Linkage Design. We look forward to working with the Morongo Community and Tribal Council to protect part of their cultural heritage by maintaining habitat connectivity between the San Bernardino and San Jacinto Mountains. For more information, visit their website at lhttp://www.morongonation.org.

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

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

Resource Conservation District: This non-profit agency supports conservation of natural ecosystems through programs that reduce the effects of on-going land-use practices on the environment. They 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. The federal district has 1 office with responsibilities in this area, the Inland Empire West RCD. To find out more about their programs, go to http://www.carcd.org.

San Bernardino Mountains Land Trust: SBMLT grew out of heightened conservation concerns in the early 1990s, when the San Bernardino National Forest faced multiple threats to its ecological integrity. This group has been involved in several successful land acquisition efforts for conservation. SBMLT has an advisory committee that assists in several areas of expertise, including legal, real estate, forestry, biology, journalism, and publications. Land trusts are critical to implementing the Linkage Design, and the SBMLT is working diligently to keep the forest intact. For more information, see http://www.lta.org/findlandtrust/CA.htm.

San Bernardino Valley Audubon: Audubon members are dedicated to protecting birds, wildlife, and our shared environment. They work with policymakers in Washington, D.C., state legislatures, and local governments across the country to restore and protect our natural legacy, secure funds for vital conservation programs, and preserve key natural areas. The San Bernardino Valley Audubon Chapter has over 1600 members in San Bernardino and Riverside Counties and is actively engaged in conservation activities in the Linkage Design and surrounding areas. For more information, go to www.sbvas.org.

Santa Monica Mountains Conservancy: This state agency was created by the Legislature in 1979 and is charged with 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.

San Timoteo Canyonlands Coalition: The Coalition is dedicated to preserving the natural, cultural, historic and recreational resources of the San Timoteo Canyon and Badlands area. Their current focus is to support the creation of the new State Park in San Timoteo Canyon. In the initial phase, land is being acquired for the park from private land donations and land purchases from willing sellers. Existing public lands such as the Norton Younglove Reserve will be incorporated into the park, and future plans include the creation of a network of hiking trails and wildlife corridors linking other conserved areas. For more information, go to http://www.santimcan.org.

Save our Forest Association, Inc.: The Save Our Forest Association, Inc. (SOFA) was formed to stop inappropriate land exchanges within the San Bernardino National Forest, though now they work on a variety of other critical conservation issues. SOFA monitors and comments on any large development projects that affect the long term health and vitality of the forest ecosystem in the San Bernardino Mountains, including large subdivisions, water extraction, etc. They also closely monitor commercial logging, cattle grazing, and off-road vehicle use. To find out more about the association, visit their website at www.saveourforestassoc.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 high-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.

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 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 has acquired thousands of acres in the Linkage Design and owns and manages Pipes Canyon and Mission Creek Preserves. TWC is a vital partner in the South Coast Missing Linkages project. For more information, please visit their website at http://www.wildlandsconservancy.org.

US Army Corps of Engineers: The mission of the ACOE is to provide quality, responsive engineering services for planning, designing, building and operating water resources and other civil works projects (Navigation, Flood Control, Environmental Protection, Disaster Response, etc.). They 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.

Western Riverside Multiple Species Habitat Conservation Plan: The County of Riverside is involved in regional planning in the Linkage Design area for its Riverside County Integrated Plan (RCIP). The plan incorporates NCCP conservation planning efforts and establishes zoning and transportation goals to the year 2020. The preferred alternative of the Administrative Draft of the Western Riverside MSHCP recognized the value of connecting natural areas within the planning area and the NCCP process will make these lands available for purchase from willing sellers using mitigation dollars from regional developments.

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

Humans are significant agents of biogeographic change in southern California by converting native habitats 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 that support one of the world's greatest warehouses of species diversity.

This interaction between human development and 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 massive changes to once intact ecosystems. The conservation plan for the San Bernardino-San Jacinto Connection addresses these challenges by seeking to influence regional patterns of development in a manner that best preserves natural landscape-level processes in the region.

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

Next Steps

The San Bernardino to San Jacinto Mountains Linkage Design is a scientifically sound starting point for conservation implementation and evaluation. This plan can be used as a resource by regional land managers to assist them in their critical role in sustaining biodiversity and ecosystem processes. Existing conservation investments in the region are already extensive, including lands managed by the US Forest Service, Bureau of Land Management, California State Parks, California Department of Fish and Game, and the State Lands Commission. Each public property within existing protected core areas as well as the linkage itself 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 transportation 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 agencies, organizations, and individuals interested in preserving and restoring linkage function. We urge the reader to 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 and improving linkage function. To this end, we provided a list of organizations, agencies, and regional projects that provide opportunities for collaborative 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 support for 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 in 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 to address the habitat needs of species in the Linkage Design area and their movements (of individuals and genes). The suite of predictions generated by the GIS analyses conducted in this planning effort represent hypotheses to be tested and refined by 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 ensure the greatest protection for our precious 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
Wednesday August 7, 2002 at the University of Redlands

8:30	*Welcome Address* Geary Hund, California State Parks
8:40	*Where Linkage Planning and MSCPs Meet* Tom Scott, University of California Riverside
9:00	*Connectivity Planning for Plants* Tim Krantz, University of Redlands
9:20	*The Role of Arthropods in Wildlife Linkages* Greg Ballmer, Tri-County Conservation League
9:40	*Reptiles and Amphibians in the Transition and Foothill Regions of the San Bernardino Mountains* Chris Brown, U.S. Geological Survey Biological Resources Division
10:00	Break
10:15	*Ornithological Considerations for Habitat Connectivity Planning* Chet McGaugh & John Green, AMEC
10:35	*Distribution, Biology, Dispersal, and Habitat Connectivity Issues Affecting the Spotted Owl in Southern California* William S. La Haye, Department of Fisheries, Wildlife, and Conservation Biology, University of Minnesota, St. Paul
10:55	*Considering Small Mammals in Linkage Planning for the South Coast Ecoregion* Wayne Spencer, Conservation Biology Institute
11:15	*Cougars, Corridors, and Conservation* Paul Beier, Northern Arizona University
11:45	*Considerations for Connectivity & Overview of Working Groups* Claudia Luke, San Diego State University Field Station Programs
12:10	Lunch – *Vouchers will be issued to all participants for use in the Commons*
1:00	Working Group Session

<u>Taxonomic Group Leaders</u>

Plants:	Tim Krantz
Invertebrates:	Gordon Pratt
Herps/Fish:	Chris Brown & Claudia Luke
Birds:	Bill La Haye
Mammals:	Paul Beier

4:45 *Closing Remarks* by Kristeen Penrod, South Coast Wildlands Project

5:00 Adjourn; Please join us for a Beer & Wine Social

Workshop Summary

Geary Hund, California State Parks – *Welcome*

- Missing Linkages initiative identified 232 statewide linkages; 69 are associated with the South Coast Ecoregion; 15 most crucial are focus of collaborative planning effort coordinated by South Coast Wildlands Project; this workshop will lay the biological foundation for corridor planning between the San Bernardino Mountains and surrounding ranges (San Gabriel, Granite, Little San Bernardino, and San Jacinto Mountains)
- Preservation of biodiversity in southern California will require connectivity
- Linkage between Santa Ana Mountains and Chino Hills was established across 91 freeway at Coal Canyon, where mountain lion established home range on both sides of freeway as documented by Paul Beier; private properties purchased and protected, and CalTrans will close the exit, remove pavement, and restore the underpass
- California Floristic Province is one of 25 global biodiversity hotspots; South Coast Ecoregion is considered a “hotspot within a hotspot” deserving special attention
- Scientific investigation combined with environmental advocacy can achieve landscape-level connectivity needed for nature to adapt to changes over time

Tom Scott, University of California, Riverside - *Where Linkage Planning and MSCPs Meet*

Summary: The focus of my current research is examining biologically diverse hot spots within the Riverside and Coachella Valley Multiple Species Conservation Plans (MSCPs). Some of the linkage areas we will be considering today are located within these MSCPs. My discussion will highlight some of the diverse species that occur in these linkage areas, and some considerations for habitat corridor planning in areas with high biological diversity.

Biography: Dr. Scott is an Adjunct Associate Professor in the Department of Earth Sciences at the University of California, Riverside. He received his PhD at the University of California in 1987. His research focuses on wildlife conservation in fragmented and altered landscapes, including studies of wildlife movement, habitat use, and population biology in oak woodland, sage scrub, and riparian habitats; behavioral changes and adjustments in habitat use of woodland bird species in response to human activities; the conservation and management of island bird species through captive propagation, predator control, and habitat restoration.

- Political mentality against southern California exists due to intense level of development and high representation in Congress; this is land of geologic, climatic, and human superlatives; regional single family housing is worth up to $27 billion per year
- Landscape disturbance began in 1940s with water availability; urban sprawl/suburbia expansion occurring in developed areas around the world; educated, politically active individuals living in Wildland-Urban Interface (WUI); can achieve conservation with local support (residents dislike rapid landscape change); about 38-48% of landscape will be converted; 100 km WUI edge in San Diego County, 2300 km in Riverside County

- One acre of natural habitat in southern California more valuable for global biodiversity preservation than acre of lowland tropical rainforest; tropics are diverse, but southern California's high level of endemism reveals unique suite of species at each location
- California contains 30% of entire country's endemic taxa, and has semitropical influence; endemics have narrow distributions due to range contraction or isolation
- Multiple edges of distributions (species margins) meet in southern California, which has resulted in abundance of endemic species
- High level of endemism at Baldwin Lake/ Pebble Plains, Otay Mesa, Del Mar, Vail Lake, Sierra Madre/Occidental; geologic calliope ranges from "brand new" to 9 million years old, with mountains still rising (11,000 feet but less than 2 million years old) as Pacific and North American Plates slide past each other; San Jacinto Peak is greatest vertical climb in North America (800 to 3200 m over less than seven km); incredible spatial diversity, but landscape variation is a challenge for functional linkage planning
- Multiple Species Conservation Plans (MSCPs) direct land use and resource management planning; Riverside County and Western Mojave plans are being developed, and include habitat linkages between preserves; important for biologists to get involved in MSCP process, the political solution to Endangered Species Act issues; even with plans, landscape will suffer from air pollution, recreational use, and urban drool (excess runoff often supporting harmful exotic species, such as bullfrogs)
- Linkages must be functional, with stated goals and measurable benefits

Tim Krantz, University of Redlands – *Connecting Rare Plant Communities*

Summary: People don't think of plants as migrating, but they certainly do—not as individuals, but over the span of generations. Montane plant communities migrate up and down in elevation over time between glacial and interglacial episodes, while valley species move through passes and along flood plains. Most of Southern California's rare plant communities are characterized by restricted suitable habitats and/or limited dispersal capability. Compounding those natural limitations, habitat fragmentation, flood control measures, invasive exotic species and other developments constrain the remaining opportunities to provide connections between rare plant populations and communities.

Biography: Dr. Krantz is an Assistant Professor of Environmental Studies at the University of Redlands; and is Director of the Salton Sea Database Program. He is a recognized authority on the flora of the San Bernardino, San Gabriel and San Jacinto Mountains and has worked extensively on endemic plants and plant communities of the region. He has worked for many years, first as an employee and later as a consultant to the Southern California National Forests, mapping endemic plant distributions; and served for six years on the San Bernardino County Planning Commission.

- Rare plant communities move over long-term (hundreds to thousands of years) between glacial and interglacial episodes (fossil evidence of conifer species found in Santa Ana and San Jacinto washes); usually restricted to specific ecological conditions; poor dispersal abilities, as movement away from favorable habitat would be disadvantageous
- Linkages contain montane communities (San Bernardino, San Gabriel, San Jacinto) separated by barriers/corridors (Cajon Wash, Banning Pass and Santa Ana River)
- Big Bear region has extremely diverse endemic flora; plant communities include pebble plains (relic from ice age) as "islands in a sea of conifers" restricted to dense clay soils; mapped using indicator species (Bear Valley sandwort and Kennedy's

buckwheat, an alpine plant found at 7000 ft – nearest relatives located at nearby 11,500 ft summit)

- Sub-alpine meadow: clay soil with more water; associated with several endangered plants (Big Bear checkerbloom, slender-petal mustard, California dandelion)
- Mapped extant locations of plant communities, forming network of preserves to protect best remnants of these unique communities; corridors over long-term provide genetic resources for plant communities to make necessary connections
- Another community restricted to carbonate resources/limestone soils (includes cushion berry buckwheat and Parish's daisy); nearest relatives in desert communities; concentrations of endemic species threatened by limestone mining, but less than 30% of mineral resource actually valuable for mining – great opportunity for conservation
- Linkage areas also contain southern rubber boa, spotted owl, bald eagle, unarmored three-spine stickleback, Andrew's marble butterfly; plant communities are animal communities, and so habitat connectivity will benefit both flora and fauna
- Lowland passes/washes may act as barriers for montane species
- San Jacinto slender-horned spineflower and Santa Ana River woolly star are restricted to alluvial fan sage scrub, found between mountain ranges
- Seven Oaks Dam on upper Santa Ana River currently prevents natural flood scour events that maintain dynamic ecosystem; sand/gravel mining, flood control and development are fragmenting community
- Shortest route not necessarily best route; easier for most species to cross fewer life zones between mountain ranges (San Timoteo Canyon, Wildwood Canyon, and Crafton Hills may link San Jacinto and San Bernardino Mountains better than Banning Pass)

Greg Ballmer, Tri-County Conservation League - *The Role of Arthropods in Wildlife Linkages*

Summary: Arthropods are ubiquitous in all habitats and are largely responsible for maintaining habitat quality and productivity. For arthropods, habitat fragmentation frequently leads to speciation rather than extinction. Most arthropods, by virtue of their small size, ecological specialization, high reproductive rate, and small home ranges, do not benefit directly from habitat linkages. Exceptions include arthropod species having a metapopulation structure. Also, arthropod communities benefit indirectly from habitat linkages when those linkages help to maintain populations of vertebrates, whose presence is critical to maintaining overall community structure.

Biography: Greg Ballmer earned a B.S. degree in Entomology at UCR in 1967, he then spent three years in Thailand as a Peace Corps Volunteer entomologist in the Thai National Malaria Eradication Project. Greg returned to UCR in 1971, where he completed his M.S. degree in Entomology in 1973. Currently, Greg lives in Riverside and works as a Staff Research Associate in the Entomology Department at University of California, Riverside. Although his professional experience is primarily with agricultural pest control, Greg's private interests include butterfly biology and systematics, arthropod habitat conservation, and overall preservation of native California habitats and biotic communities. In 1989 Greg Ballmer petitioned the US Fish and Wildlife Service to list *Rhaphiomidas terminatus abdominalis* (Delhi Sands Flower-loving Fly) as an Endangered Species; it received that status in 1993.

- Invertebrates are primary intermediate between plant and animal biomass, and provide vital ecosystem services (food for invertebrates and small vertebrates, breakdown of organic wastes/nutrient recycling, soil aeration, pollination, vector for seed dispersal)
- Habitat is combination of biotic and abiotic factors with which an organism interacts to support its growth and reproduction; organism is integral part of its habitat
- Linkages allow long-term gene flow which increases functional genetic diversity of population; this helps overcome stochastic events and long-term environmental changes
- Linkages allow short-term movement to escape catastrophic events, use accessory habitat and re-colonize after disturbance; arthropods occupy diversity of habitats and community types at different points in life cycles, and therefore need connectivity
- Arthropods maintain habitat quality within linkage areas; habitat loss or conversion can form serious barrier to insect movement; must link small invertebrate populations to maintain gene pool and metapopulation structure
- Certain arthropods may not need linkages (those that have high reproductive rate, occupy restricted or widely spaced geographic areas, are highly migratory or wind dispersed); rapid evolution/speciation can occur when populations are isolated
- Vernal blue butterfly subspecies – in southern California only occurs on somewhat barren ridgetop in San Bernardino Mountains with specific buckwheat host plant – linkages will not benefit such Pleistocene relics with spotty distribution – not found in nearby appropriate locations that contain the host plant
- Migratory painted lady butterfly has ephemeral populations and does not need linkages
- Delhi Sands flower-loving fly, an endemic arthropod threatened by habitat fragmentation, inhabits scattered sand patches; endemic Jerusalem cricket also utilizes sandy habitat; both are capable of re-colonizing habitat from source population after disturbance

Chris Brown, USGS Biological Resources Division - ***Reptiles and Amphibians in the Transition and Foothill Regions of the San Bernardino Mountains***

Summary: The transition and foothill regions of the San Bernardino Mountains are biological hotspots in San Bernardino County, having a unique mixture of coastal, mountain and desert herpetofauna. These areas are also important connections between the Transverse Ranges. Although much of this habitat still exists, development is encroaching on the San Bernardino Mountains, weakening these linkages, and several barriers already exist in a setting that was historically wide open. We have been studying the herpetofauna of the transverse ranges since 1995 in order to better understand the distribution and needs of the sensitive reptiles and amphibians throughout this region. Successful management of the diverse herpetofauna within these historical corridors of the Transverse Ranges must take into consideration the heterogeneous and expansive nature of the transition zones and foothills that connect the San Bernardino Mountains with outlying ranges.

Biography: Chris Brown is a biologist for the US Geological Survey, Western Ecological Research Center. Since 1995, he has been studying the herpetofauna of southern California to support research needs of UC San Diego, San Diego State University, National Biological Survey and the USGS. His interests in herpetology have focused on distribution, status and natural history of the mountain and coastal herpetofauna of southern and Baja California.

- Linkage area contains wide range of habitats; linkages from San Bernardino Mountains to surrounding ranges include coastal and desert influences, transitional belt of habitat around mountains, and montane habitats, resulting in phenomenal diversity; working group must select multiple species to represent the four different linkages - horned lizard, speckled rattlesnake, and western spadefoot toad recommended as focal species
- 1 turtle, 13 lizards, 19 snakes, 4 salamanders, and 7 frogs and toads inhabit planning area; (SB = San Bernardino Mountains, SG = San Gabriel Mountains, SJ = San Jacinto Mountains, LSB = Little San Bernardino Mountains, GM = Granite Mountains)
- Salamanders demonstrate limited connectivity between these mountain ranges; garden slender salamander (south-facing coastal slopes; SB – SG, SJ); San Gabriel Mountain slender salamander (SB – SG); large blotch salamander (SB – SJ); Monterrey ensantina best example for species movement (gene flow) between all these ranges
- Frogs and toads: western toad (SB – SG, LSB); arroyo toad (SB – SG, SJ); red spotted toad (desert slopes); spadefoot toad (little known about distribution, but recently found in foothill transition zones around SB – SG, SJ); California treefrog (fairly common in all ranges); mountain yellow-legged frog (most historical habitat lost in Santa Ana wash)
- Desert tortoise on desert slopes (SB – GM, SJ); tortoises reside within linkage areas
- Fish: speckled dace (SB – SG), found in Cajon wash and Lytle Creek, but rather isolated
- Lizards: zebra-tailed lizard (SB - SJ); coast horned lizard (SB – SJ, SG, LSB); long-nosed leopard lizard (desert transition zone; SB – SJ, SG, LSB); Gilbert skink (possibly SB – GM); western whiptail (all ranges; species variety may be result of isolation)
- Snakes: glossy snake (resides within linkage areas; SB – GM, recommended focal species); ringneck snake (SB – SG); distribution largely unknown for: red racer, patch-nosed snake, lyre snake, and rosy boa (which does not like to cross even dirt roads); southwestern speckled rattlesnake (easily detectable, found throughout linkage areas, recommended as focal species, good barometer for snake movement)
- Amphibian visual encounter surveys; targeted species for San Bernardino area include arroyo toad, western toad, California treefrog, Pacific treefrog, spadefoot toad; field biologists noting movement barriers (roads and dams), impacts of recreation (ATV use and illegal dumping), development impacts (light pollution, habitat and connectivity loss)
- Herpetofauna biodiversity data (starting in 1999): pitfall trap arrays at 51 study sites throughout southern California; over 630 arrays (4400 buckets, 1800 snake traps, 28 km fencing); captured 46 species in 18 families; study sites have between 9-33 species
- Historical perspective must consider natural history of desert and coastal species, as different forms intergrade (ex – gopher snakes at Silverwood Lake); natural gene flow should be conserved; 5 different forms of red racer in California

Chet McGaugh & John Green, AMEC – *Ornithological Considerations for Habitat Connectivity*

Summary: The power of flight, and the amazing dispersal and migratory abilities of birds enable them to traverse huge expanses of unsuitable habitat. Habitat connectivity at the landscape level is not an issue for most birds. Birds resident within the linkages, or living in similar habitats adjacent to the linkages, would benefit most from the connectivity of large habitat patches. Sensitive species and ecological specialists would benefit more from conservation measures within their various habitats than from an attempt to establish linkages.

Biography: Chet McGaugh is a wildlife biologist specializing in ornithological studies. As a consultant (currently with AMEC Earth and Environmental in Riverside) and as an avid birdwatcher, he has studied the distribution and ecology of birds in this ecoregion for 25 years. He participated in the U.S. Fish and Wildlife Service's life history study of the California Gnatcatcher, and has conducted hundreds of surveys for sensitive bird species, including the Least Bell's Vireo, Southwestern Willow Flycatcher, and the California Gnatcatcher. He is the compiler of the Salton Sea – North Christmas Bird Count.

Biography: John Green is a wildlife biologist specializing in ornithological studies. As a consultant with AMEC Earth and Environmental, John specializes in the monitoring of sensitive bird populations such as the Least Bell's Vireo. John's many contributions to the ornithological community in this ecoregion include his acclaimed Southeastern California Rare Bird Alert, which is the Internet clearing-house for bird sightings in the region, and his participation in a valley-wide survey of Mountain Plovers in the Imperial Valley in 2002.

- Many bird species are capable of easily dispersing between suitable habitats
- Flightless birds and those that can only fly limited distances need connectivity; California gnatcatcher is weak flyer with poor dispersal over unsuitable habitat, and therefore is susceptible to impacts from habitat fragmentation
- Diversity in flying ability and movement patterns between species
- No need to consider water birds or migratory species for connectivity planning
- Sedentary birds and birds unlikely or unwilling to disperse over large areas of unsuitable habitat will benefit from linkages; ex – cactus wren, rock wren, scrub jay, California thrasher, wrentit, Bewick's wren, bushtit; gene flow occurs if populations are not isolated; many birds would utilize habitat available within linkage areas, but montane species have characteristics and habitat needs distinct from birds inhabiting most of the lower elevation linkage areas; unknown whether many mountain species cross washes and desert habitat to move between the ranges
- Acorn woodpecker shows seasonal movements to hospitable resource areas
- Band-tailed pigeon probably crosses between ranges, which allows gene flow
- Sensitive species that would utilize linkages include Le Conte's thrasher, sage sparrow, rufous-crowned sparrow, burrowing owl, and loggerhead shrike

Bill LaHaye, University of Minnesota, St. Paul – *Distribution, Biology, Dispersal, and habitat connectivity issues affecting the Spotted Owl in southern California.*

Summary: The Spotted Owl is a large avian predator that primarily inhabits older forests in western North America. This owl is an interior forest species whose flight adaptations have been driven by the need for maneuverability in densely wooded environments. Thus in spite of having a wingspan exceeding one meter, the Spotted Owl is a weak flyer in open terrain. This may restrict the dispersal of this owl in regions lacking contiguous forest. Here I present the pertinent results of a 12-year demographic study on this species in the San Bernardino Mountains. Information will be presented on general biology, current and historic distribution, dispersal, and metapopulation aspects of the Spotted Owl in southern California.

Biography: Bill LaHaye received a Master of Science degree from Humboldt State University in 1989 and has been studying the Spotted Owl for 20 years. While he has worked on various projects studying this species in California, Arizona and New Mexico, the majority of Bill's efforts have been in southern California. The topics of Bill's published works include natural history, diet, demography, dispersal, and metapopulation dynamics.

- Spotted owl demography research conducted in San Bernardino Mountains; owls inhabit interior forests with dense canopy and ambush prey; live in continuous forest at higher elevations, with distribution more patchy and linear at lower elevations; may have historically utilized oak woodlands; current distribution in southern California includes islands of mountaintop habitat with metapopulation becoming fragmented
- Owls studied for 12 years in San Bernardino Mountains and 6 years in San Jacinto Mountains; over 95% of encountered owls were banded; no movement between mountain ranges has been documented during this study
- About 850 owls banded in San Bernardino Mountains (over 300 adults and over 500 juveniles); researchers were surprised that no juvenile dispersal was observed

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

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

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

- Most linkages designed for large mammals that must move between large habitat areas to survive and reproduce; many smaller species will not use inter-montane linkages for movement, but rather will benefit from the protected habitat
- Small mammals (especially rodents and lagomorphs) are prey for larger mammals; small mammals are more dispersal limited and habitat specialized than larger mammals
- Keystone species include burrowing rodents (pocket gophers, ground squirrels and kangaroo rats) that modify soil, impact plant distribution, create habitat for other species
- Micro-habitat specialists; pocket mouse subspecies adapted to slices of vegetation community or geological substrate; genetic differentiation due to geographic isolation
- Conservation planning recognizes irreplaceability and vulnerability (incorporating and connecting habitat for rare endemic species with limited distributions)
- For most taxa (including small mammals), linkages are not designed to move individuals of various species from one mountain range to another (many have not moved between ranges for tens of thousands of years), but rather to provide for long-term genetic exchange and adaptation; species will benefit from preserved habitat in linkages
- Orthogonal linkage concept: for small mammals distributed in elevational bands in particular vegetation communities or soil strata, breadth of linkage is important; habitat located at right angle to general linkage arrows; connect both across and along linkages
- Inhabitants of pinyon juniper, oak woodland, chaparral, and other lower elevation areas of linkages may be planned for (western gray squirrel, dusky-footed woodrat, chipmunk)
- Different suite of species needed for each linkage; species that should be considered for planning: round-tailed ground squirrel, Mojave ground squirrel, western gray squirrel, chipmunk, San Bernardino kangaroo rat, little pocket mouse, long-tailed weasel, spotted skunk, ringtail, badger (fragmentation-affected grassland species), kit fox, dusky-footed woodrat, pinyon mouse, pocket gopher (keystone burrowing species, dispersal limited)
- Plans for bat roosting structures can be incorporated into bridge and overpass structures
- Linkages for large mammals must provide habitat for prey base (unless function is simply to move species across and away from roads); also, consider location of rare and endemic species to compliment linkage design
- With climate change, expect upslope migration resulting from global warming; linkages should be broad enough to accommodate natural processes (flood scour and deposition, fire); capture whole environmental gradients to protect multiple specialized species

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

Summary: Because the puma or cougar lives at low density and requires large habitat areas, it is an appropriate umbrella species for landscape connectivity in the South Coast Ecoregion. A crucial issue, however, is whether connectivity is provided by narrow corridors through urban areas (an artificial substitute for natural landscape connectivity). In particular, corridors decrease extinction risk only if they facilitate dispersal of juveniles between mountain ranges. To address this issue, we conducted fieldwork on pumas in the Santa Ana Mountain Range, a landscape containing 3 corridors (1.5, 6, and 8 km long). Each of the 3

corridors was used by 2 or more dispersing juvenile puma. Five of 9 radio-tagged dispersers successfully found and used a corridor. The corridors in this landscape were relict strips of habitat, not designed to facilitate animal movement. Puma doubtless would be even more likely to use well-designed linkages. Puma will use corridors that lie along natural travel routes, have < 1 dwelling unit per 50 acres, have ample woody cover, lack artificial outdoor lighting, and include an overpass or underpass integrated with roadside fencing at high-speed road crossings. "If we build it, they will come."

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

- Pumas exist at low density; functional connectivity needed for movement and dispersal
- Santa Ana Mountains study: 9 radio-collared juvenile dispersers tracked; three corridors/habitat constrictions present, but not designed for habitat connectivity:
  1. Coal Canyon (short freeway undercrossing near railroad tracks, stables, and golf course); 3 lions attempted to cross (2 successful); M6 was premier user of corridor, crossing under freeway more than 22 times in 18 months; home range included habitat on both sides of freeway; after completion of study, surrounding properties were preserved, and CalTrans agreed to close underpass to traffic, remove asphalt, and turn over to California State Parks for restoration and use as wildlife linkage
  2. Santa Ana – Palomar (longer, I15 is major impediment, patchwork of land ownership); 2 lions attempted to cross (1 successful); one lion crossed Santa Ana – Palomar linkage by walking across I15 rather than finding a safer route underneath; point of crossing was just north of border patrol/INS checkpoint; several lions were killed crossing at this same site – multiple lions are demonstrating preferred crossing site, which should be focus of planning for vegetated freeway overpass
  3. Arroyo Trabuco (protected from urban areas by tall bluffs, contains dense riparian vegetation, resident deer population, darkness, water); 3 lions attempted to cross (3 successful); comfortable corridor – lions spent 2-7 days traveling through corridor
- 5 of 9 study animals found and successfully used one of the three corridors; sites were not designed for animal movement, which explains unsuccessful attempts
- Photographic overview of potential linkage areas from field reconnaissance to demonstrate habitat opportunities; USGS map used to show the location for each photo:
  1. SB-GM linkage area: one-mile-wide band with virtually no housing – great opportunity; Grapevine Canyon has perennial water; Joshua tree woodland and creosote scrub
  2. SB-SG linkage area: Cajon Wash; I15 impediment; National Forest property on both sides; potential riparian and upland connections; old route 66, railroad tracks; bridged and culvert undercrossings for I15 at four main drainages (best bridge is at Cleghorn Creek with perennial water and direct route into Lone Pine Canyon); vegetation scorched by recent wildfire; SG-Baldy Mesa secondary linkage important
  3. SB-SJ linkage area: low elevation connection across San Gorgonio Pass; possible upland connection through badlands and San Timoteo Canyon; I10 and SR111 are impediments; Morongo Reservation includes upper San Gorgonio River; massive sand and gravel mining operation; development along I10 increasing impediment; many drainages/canyons in lower San Jacinto Mountains; The Wildlands Conservancy recently protected portion of Whitewater River; windfarms near I10

4. SB-LSB linkage area: SR62 main impediment; several drainages cut through Morongo Valley; Mission Creek – good bridges for movement – The Wildlands Conservancy owns portion; desert wash connectivity possible across freeway; possible need for crossing over highway; large band of undeveloped land; natural wetlands in Big and Little Morongo Wash

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

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

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

- At the 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, mid-sized carnivores increase (mesopredator release), and multiple bird species are lost; must consider associated species in planning, including keystone species important for 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 project to gain visibility and leverage to work with multiple agencies and organizations

Appendix C: 3D Visualization

The South Coast Wildlands is in the process of producing several flyovers or 3D visualizations of the San Bernardino-San Jacinto 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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