# South Coast Missing Linkages Project

*A Linkage Design for the Tehachapi Connection*

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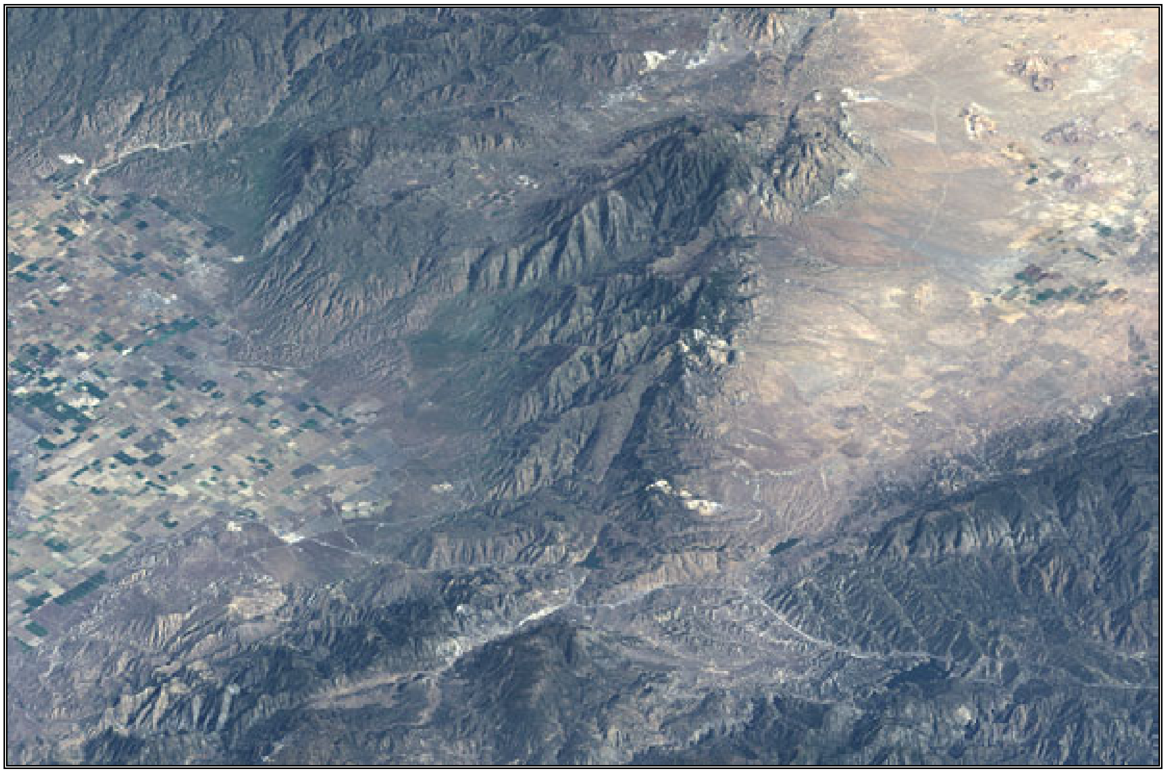

**South Coast Wildlands Project**

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***In order to make this document servable over the web, the resolution of all maps has been drastically reduced. The original version is available at no cost, by contacting South Coast Wildlands Project at info@scwildlands.org. For more information on the South Coast Missing Linkages Project, visit our website at www.scwildlands.org.**

# South Coast Missing Linkages Project

## *A Linkage Design for the Tehachapi Connection*

SOUTH COAST
WILDLANDS
PROJECT

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**September 2003**

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Produced by South Coast Wildlands Project: 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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# 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 Tehachapi Connection is perhaps our most important linkage in that it is the sole wildland connection between two major mountain systems—the Sierra Nevada and the Sierra Madre.

On September 30, 2002, 90 participants representing over 40 agencies, academic institutions, land managers, land planners, conservation organizations, and community groups met to establish biological foundations for planning landscape linkages in the Tehachapi region. They identified 34 focal species that are sensitive to habitat loss and fragmentation here, including 9 plants, 7 insects, 1 amphibian, 5 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, California spotted owl); others are endemic species, narrowly restricted within the linkage planning area (e.g., yellow-blotched salamander). Many are habitat specialists (e.g., pond turtle in riparian habitat, or acorn woodpecker in oak woodlands) and others require specific configurations of habitat elements (e.g. California quail or western toad). Together, these 34 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.

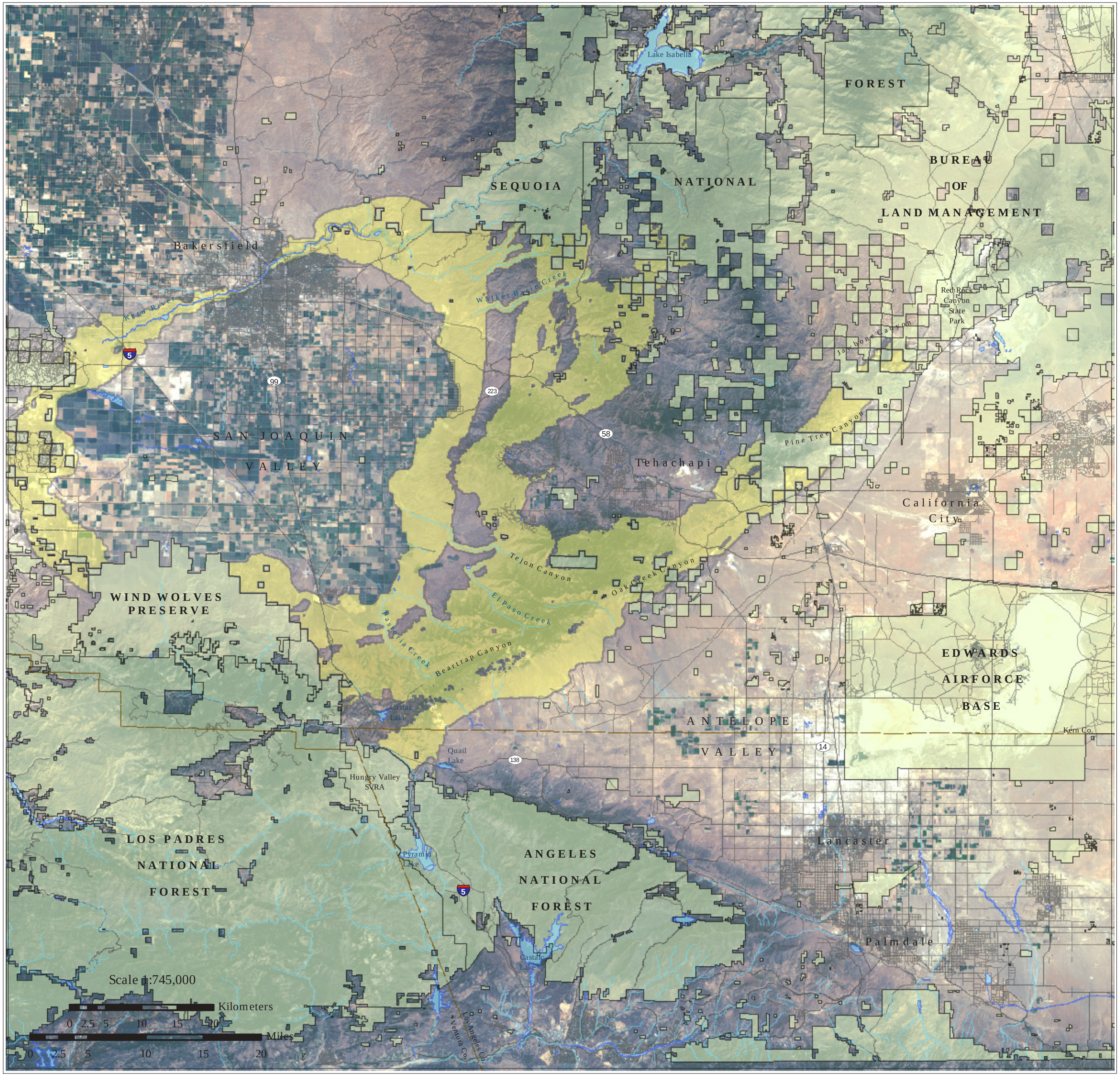
To identify potential routes between existing protected areas we conducted landscape permeability analyses for 9 focal species for which appropriate data were available. Permeability analyses model the relative cost for a species to move between protected core habitat or population areas. We defined a least-cost corridor—or best potential route—for each species, and then combined these into a Least Cost Union covering all 9 species. We then analyzed the size and configuration of suitable habitat patches within this Least Cost Union for all 34 focal species to verify that the final Linkage Design would suit the live-in or move-through habitat needs of all. Where the Least Cost Union omitted areas essential to the needs of a particular species, we expanded the Linkage Design to accommodate that species' particular requirements to produce a final Linkage Design (Figure ES-1).

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

# Figure. ES-1
# Linkage Design for the Tehachapi Connection

**Legend**

- Linkage Design
- Ownership Boundaries
- Paved Roads
- County Lines
- Waterbodies
- Perennial Rivers & Creeks

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focal species. In this plan we suggest restoration strategies to mitigate those barriers, with special emphasis on opportunities to reduce the adverse effects of Interstate-5, State Route 58, and the California Aqueduct.

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

## Nature Needs Room to Move

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

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

Southern California's remaining wildlands form an archipelago of natural open space thrust into one of the world's largest metropolitan area within a global hotspot of biological diversity. These wild areas are naturally interconnected; indeed, they historically functioned as one ecological system. However, recent intensive and unsustainable activities threaten to sever these 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. The value of already protected land in the region for biodiversity conservation, environmental education, outdoor recreation, and scenic beauty is immense, but it can be irrevocably degraded if these remaining wildlands become disconnected. A relatively modest investment in connective habitats now can help ensure the integrity of these sites in perpetuity.

## Patterns of Habitat Conversion

As a consequence of rapid habitat conversion to urban and agricultural uses, California has become a hotspot for species at risk of extinction. California has the greatest number of threatened and endangered species in the continental U.S, representing nearly every taxonomic group, from plants and invertebrates to birds, mammals, fish, amphibians, and reptiles (Wilcove et al. 1998). In an analysis that identified "irreplaceable" places for preventing species extinctions (Stein et al. 2000), Southern California 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, which is the only one of the 25 most threatened global hotspots of biodiversity that lies in North America (http://www.biodiversityhotspots.org/xp/Hotspots).

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

**Missing Linkages: A Statewide Vision**

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

**South Coast Missing Linkages: A Vision for the Ecoregion**

Following the statewide Missing Linkages conference, the South Coast Wildlands Project (SCWP), a non-profit organization established to pursue habitat connectivity planning in the South Coast Ecoregion, brought together regional ecologists to conduct a formal evaluation of these 69 linkages. The evaluation was designed to assess the biological irreplaceability and vulnerability of each linkage (*sensu* Noss et al. 2002). Irreplaceability assessed the relative biological value of each linkage, including both terrestrial and aquatic criteria: 1) size of habitat blocks served by the linkage; 2) quality of existing habitat in the smaller habitat block; 3) quality and amount of existing habitat in the proposed linkage; 4) linkage to other ecoregions or key to movement through ecoregion; 5) facilitation of seasonal movement and climatic change; and 6) addition of value for aquatic ecosystems. Vulnerability was evaluated using recent high-resolution aerial photographs, local planning documents, and other data. This process identified 15 linkages of crucial biological value that are likely to be irretrievably compromised by development projects over the next decade unless immediate conservation action occurs (Figure 1). The biological integrity of several thousand square miles of the very best Southern California wildlands would be irreversibly jeopardized if these linkages were lost.

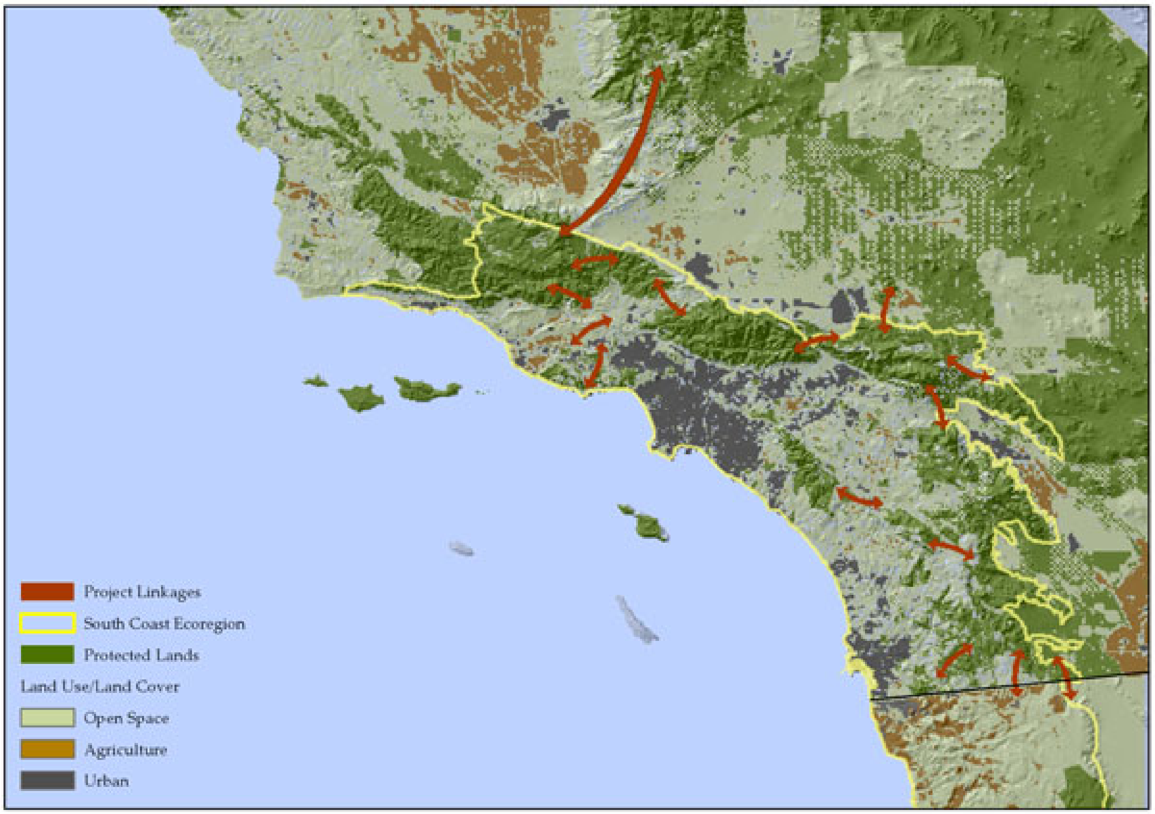



Figure 1. The South Coast Missing Linkages Project addresses habitat fragmentation at a landscape scale, and the needs of a variety of species. It identified 15 landscape linkages as irreplaceable and imminently threatened.

> **South Coast Missing Linkages** is collaboration 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.

Identification of these 15 priority linkages launched the South Coast Missing Linkages Project – an ecoregional effort that supports the statewide vision of the Missing Linkages Conference. The primary goal of this highly collaborative effort is to quickly secure a network of the largest wildlands that will conserve ecosystem processes within the Ecoregion, and between the South Coast and other ecoregions in the state. 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. Partners 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 Stations Program, The Nature Conservancy, Environment Now, The Wildlands Project, California Wilderness Coalition, and the Zoological Society of San Diego Center for Reproduction of Endangered Species. It is our hope that the South Coast Missing Linkages effort will serve as a catalyst for directing funds and attention toward the protection of ecological connectivity for the South Coast Ecoregion and beyond.

To this end, SCWP is coordinating and hosting regional workshops, providing resources to partnering organizations, conducting systematic GIS analyses for all 15 linkages, compiling and distributing the final report, and helping to raise public awareness regarding connectivity needs in the ecoregion. SCWP has taken the lead in researching and planning for 7 of the 15 linkages; San Diego State University Field Station Programs, National Park Service, California State Parks, U. S. Forest Service, Santa Monica Mountains Conservancy, Conservation Biology Institute, and The Nature Conservancy have taken the lead on the other 8 linkages. The Sierra Madre to Sierra Nevada Mountains Linkage (i.e., the Tehachapi 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 as well as adjoining ecoregions.

**The other 14 priority linkages are:**

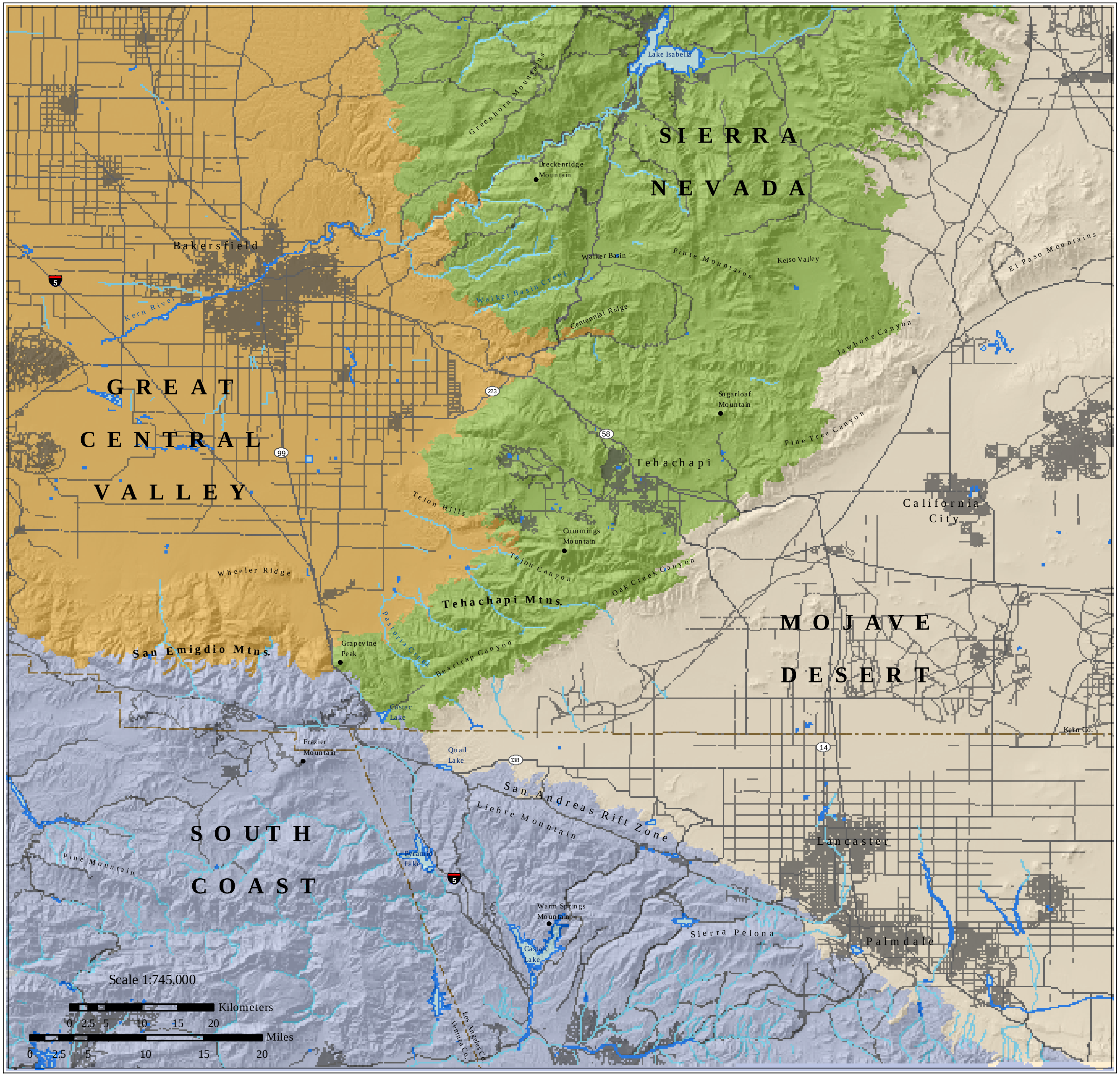
- Santa Monica Mountains-Santa Susana Mountains
- Santa Susana Mountains-Sierra Madre Mountains
- E. Sierra Madre Mountains-W. Sierra Madre Mountains
- San Gabriel Mountains-Sierra Madre Mountains
- San Bernardino Mountains-San Gabriel Mountains
- San Bernardino Mountains-San Jacinto Mountains
- San Bernardino Mountains-Little San Bernardino Mountains
- San Bernardino Mountains-Granite Mountains
- Santa Ana Mountains-Palomar Ranges
- Otay Mountains-Laguna Mountains
- Campo Valley-Laguna Mountains
- Otay Mountains-Northern Baja
- Peninsular Ranges-Anza Borrego
- Jacumba Mountains-Sierra Juarez Mountains

## Ecological Significance of the Tehachapi Connection

The Tehachapi Mountains lie at the remarkable confluence of 5 major biogeographic regions, and have been described as a "biogeographic crossroads" and "crucible of evolution" (White et al. 2003). Perhaps most significantly, *the Tehachapis provide the only remaining wildland connection between two major mountain systems*. The Sierra-Cascade uplands form a major wildland system that stretches for over 2000 miles from southern Kern County into northern British Columbia. The southern tip of this cordillera reaches toward the center of the 800-mile-long upland system comprised of the Sierra Madre (the coastal ranges from San Francisco to Los Angeles), Transverse (San Gabriel, San Bernardino, and San Jacintos Mountains), and Peninsular ranges (Santa Ana, Palomar, and Laguna Mountains of San Diego County, and the Sierra Juarez of Baja California). The Tehachapi Mountains connect these major ranges by virtue of their geographic position between the Sierra Madre, Castaic, and Sierra Nevada Ranges. This largely intact landscape linkage is biogeographically unique because it is situated at the juncture of several major ecoregions, including the Sierra Nevada, South Coast, Great Central Valley, and the Mojave Desert (Figure 2). Thus, the Tehachapis provide connectivity not only for montane species, but also for species associated with the San Joaquin Valley foothills and grasslands, and for desert species along the southeastern slopes of the Tehachapi Mountains.

The area is geologically active, with several major fault zones converging here, which helped create a remarkable montage of ecological communities. Vegetation communities here include a variety of oak woodlands, coniferous forests, mixed hardwood coniferous forests, wet meadows, desert scrub, pinyon-juniper woodland, grasslands, and coastal riparian and scrub habitats (Figure 3). The vegetation is quite distinct where ecoregions meet, for instance, Joshua tree woodlands intermix with oak, juniper and pine in a transition zone on the Mojave side of the mountains.

## Figure 2. Convergence of Ecoregions




### Legend

- Great Central Valley
- Mojave Desert
- Sierra Nevada
- South Coast
- County Lines
- Paved Roads
- Waterbodies
- Perennial Rivers & Creeks

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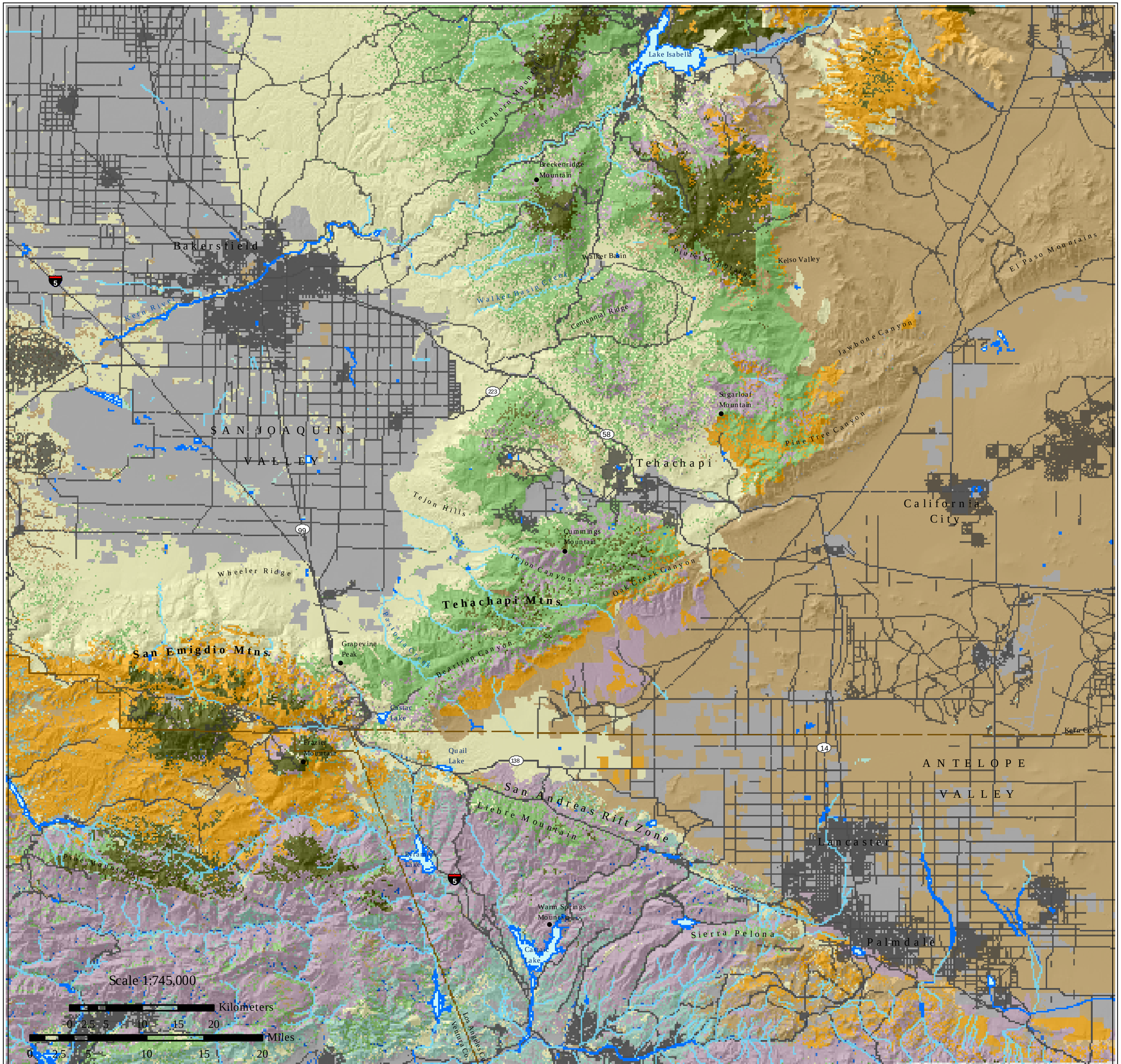
**Figure 3.**
**Aggregated Vegetation Types in the Planning Area**




**Legend**

- Urban/Agriculture
- Grassland
- Desert scrub/shrub
- Coastal scrub
- Oak woodland
- Coniferous forest
- Chaparral
- Riparian
- Joshua tree
- Pinyon-Juniper
- Water
- Perennial Rivers & Creeks
- County Lines
- Paved Roads

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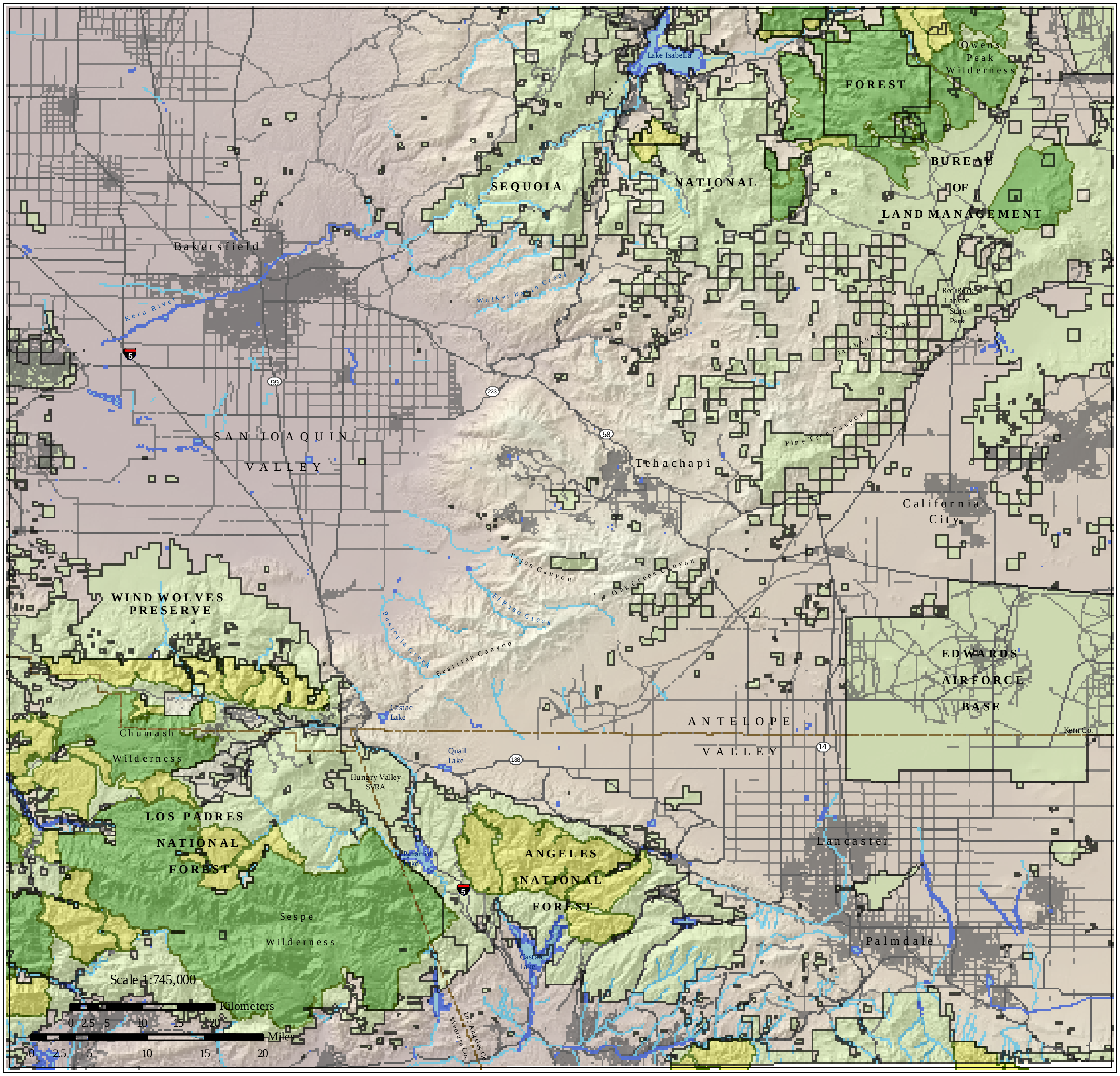
Numerous imperiled plant and animal species are known from the vicinity, including Bakersfield cactus, arroyo toad, red-legged frog, blunt-nosed leopard lizard, San Joaquin kit fox, Tule elk, Tipton kangaroo rat, Tehachapi pocket mouse, and Mohave ground squirrel. The area includes habitat designated as critical to the survival of the endangered California condor and supports significant populations of other birds of prey such as California spotted owl, golden eagle and burrowing owl. Of the approximately 100 focal species identified for the 15 linkages in the Ecoregion, over 30 are associated with this linkage because of its unique biogeography. Many of these species need extensive wildlands to thrive, such as California spotted owl, American badger, mule deer, and mountain lion.

**Existing Conservation Investments**

Significant conservation investments already exist in the region (Figure 4), but the resource values they support could be irreparably harmed by loss of connections between them. The majority of all three surrounding ranges are included in the National Forest system as Los Padres, Angeles, and Sequoia National Forests. The Los Padres, west of Interstate 5, has several roadless areas, including the Chumash Wilderness and several areas north of it that are proposed for wilderness status as part of the California Wild Heritage Act: San Emigdio, Antimony, Pleito, and Tecuya. These are contiguous with the 97,000-acre Wind Wolves Preserve, the largest privately owned nature preserve on the west coast, which was established in the mid 1990's. Other Wilderness areas have been proposed to the south, which would connect these areas to the Sespe Wilderness Area (Penrod et al. 2002). The Castaic Range of the Angeles National Forest lies east of Interstate 5 and south of State Route 138. Roadless areas proposed for Wilderness status here include Salt Creek, Fish Canyon, Tule, and Red Mountain, while the Liebre Mountain area has been proposed as a Special Interest Area because of its unique plant associations (Penrod et al. 2002). Sequoia National Forest covers over a million acres with extensive roadless wildlands in the southern Sierra Nevada, much of which is included in the Dome Land, Golden Trout, and Bright Star Wilderness Areas. The California Wild Heritage Act would secure additional roadless habitat that is contiguous with these areas and designate the Lower Kern River as Wild and Scenic.

The Bureau of Land Management administers extensive land in the northeast portion of the linkage, encompassing Pine Tree Canyon, sections to the south of Cummings Mountain, and along Oak Creek Canyon. Other BLM lands occur in the Jawbone Canyon area, which was established to protect the Sierra/Mojave/Tehachapi ecotone. The Piute Mountains of Sequoia National Forest lie just west of Jawbone Canyon. California State Parks also administers land in the vicinity, including Red Rock Canyon State Park to the east of Jawbone Canyon and Fort Tejon Historic State Park and Hungry Valley Off Road Vehicle State Recreation Area in the southern part of the linkage.

**Figure 4.**
**Existing Conservation Investments in the Planning Area**




**Legend**

- Ownership Boundaries
- Designated Wilderness
- Proposed Wilderness
- County Lines
- Paved Roads
- Waterbodies
- Perennial Rivers & Creeks

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

1) Select focal species from diverse taxonomic groups to represent a diversity of habitat requirements and movement needs.
2) 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) Use patch size and configuration analyses to identify the priority areas needed to maintain linkage function.
4) Conduct field investigations to ground-truth results of prioritization analyses and document conservation needs.
5) Compile results of analyses and fieldwork into a detailed comprehensive report.
6) Develop an information resource on conservation needs and activities in the priority movement areas for project collaborators to protect and restore habitat connectivity.

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

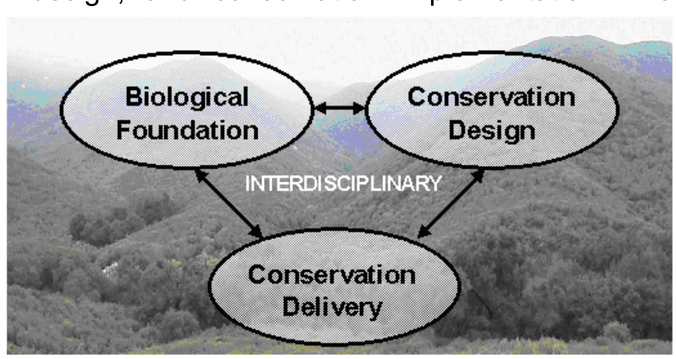



Figure 5. Successful conservation planning requires an interdisciplinary and reiterative approach among biologists, planners and activists (Baxter 2001).

## Focal Species Selection

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

The 34 focal species identified at the workshop included 9 plants, 7 insects, 1 amphibian, 5 reptiles, 4 birds and 8 mammals. These species capture a diversity of movement needs and ecological requirements, from species that require large tracts of land (e.g., mountain lion, badger, California spotted owl) to those with distributions restricted to the linkage planning area (e.g., yellow-blotched salamander). They include habitat specialists (e.g., acorn woodpecker in oak woodlands) and those requiring a specific configuration of habitat types and elements (e.g., pond turtles that require aquatic and upland habitats). Dispersal distance capability of focal species varies from 30 m to 110 km, and the modes of dispersal include flying, floating, swimming, climbing, and walking.

| Table 1. Focal Species Selected |
|---|
| **Plants** |
| *Eschscholzia lemmonii kernensis* (Tejon poppy) |
| *Opuntia basilaris* var. *treleasei* (Bakersfield cactus) |
| *Quercus douglasii* (Blue oak) |
| *Quercus kelloggii* (California black oak) |
| *Alnus rhombifolia* (White alder) |
| *Abies concolor* (White fir) |
| *Aesculus californica* (California buckeye) |
| *Pinus jeffreyi* (Jeffrey pine) |
| *Pinus monophylla* (Singleleaf pinyon) |
| **Invertebrates** |
| *Pleocoma linsleyi* (Linsley's Rain beetle) |
| *Brachysomida vittigera* (Lined Lomatium Longhorned borer) |
| *Crossidius coralinus tejonicus* (Tejon Longhorned borer) |
| *Lycaena heteronea clara* (Bright blue copper butterfly) |
| *Plebulina emigdionis* (San Emigdio blue butterfly) |
| *Speyeria callippe macaria* (Callippe fritillary) |
| *Arctonotus lucidus* (Bear sphinx moth) |
| **Amphibians & Reptiles** |
| *Ensatina eschscholtzii* (Yellow-blotched salamander) |
| *Clemmys marmorata* (Western pond turtle) |
| *Phrynosoma coronatum* (Coast horned lizard) |
| *Gamelia sila* (Blunt-nosed leopard lizard) |
| *Gambelia wislizenii* (Long-nosed leopard lizard) |
| *Lampropeltis zonata* (California mountain kingsnake) * |
| **Birds** |
| *Toxostoma redivivum* (California thrasher) |
| *Melanerpes formicivorus* (Acorn woodpecker) |
| *Athene cunicularia* (Burrowing owl) |
| *Strix occidentalis occidentalis* (California Spotted owl) |
| **Mammals** |
| *Perognathus alticola inexpectatus* (Tehachapi pocket mouse) |
| *Dipodomys nitratoides nitratoides* (Tipton kangaroo rat) |
| *Dipodomys heermanni* (Heerman's kangaroo rat) |
| *Sciurus griseus* (Western gray squirrel) |
| *Odocoileus hemionus* (Mule deer) |
| *Vulpes macrotis mutica* (San Joaquin kit fox) |
| *Taxidea taxus* (Badger) |
| *Puma concolor* (Mountain lion) |

* This species was not modeled.

## 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 can identify a least-cost corridor, or the best potential route for each species between protected core areas (Walker and Craighead 1997, Craighead et al. 2001, Singleton et al. 2002). The purpose of the analysis was to identify which land areas would best accommodate all focal species living in or moving through the linkage.

Species used in landscape permeability analysis must be carefully chosen, and were included in this analysis only if:

- We know enough about the movement of the species to reasonably estimate the cost-weighted distance using the data layers available to our analysis.
- The data layers in the analysis reflect the species ability to move.
- The species occurs in both cores (or historically did so and could be restored) and can potentially move between cores, at least over multiple generations.
- The time scale of gene flow between core areas is shorter than, or not much longer than, the time scale at which currently mapped vegetation is likely to change due to disturbance events and environmental variation (e.g. climatic changes).

Nine species were found to meet these criteria and were used in permeability analyses to identify the least-cost corridor between the core areas, for each: mountain lion, badger, San Joaquin kit fox, mule deer, western gray squirrel, Tipton kangaroo rat, Tehachapi pocket mouse, California spotted owl, and blunt-nosed leopard lizard. Ranks and weightings adopted for each species are shown in Table 2.

The relative cost of travel was assigned for each of these 9 focal species based upon its ease of movement through a suite of landscape characteristics (e.g., vegetation type, road density, and topographic features). The following spatial data layers were assembled at 100-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 km. 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

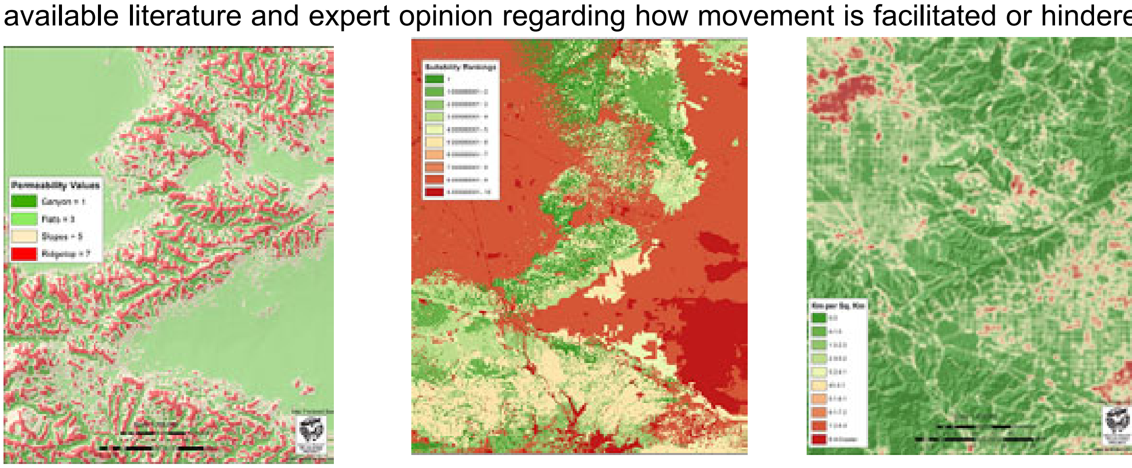


Figure 6. Model Inputs: Topographical features, vegetation, and road density.

Table 2. Focal Species Movement Criteria. Values in this table were used as input for the Landscape Permeability analyses.

| Variable | Blunt-nosed leopard lizard | California Spotted owl | Tehachapi pocket mouse | Tipton kangaroo rat | Western gray squirrel | Mule Deer | San Joaquin Kit fox | American Badger | Mountain Lion |
|---|---|---|---|---|---|---|---|---|---|
| **Dispersal Distance** | | | | | | | | | |
| Normal or Average | 1186 m | 7 km | 100 m | 384 m | | 97 km | 7.8 km | 51 km | 65 km |
| Maximum | 2372 m | 72.1 km | 200 m | 768 m | | 217 km | 60 mi | 110 km | 274 km |
| **Cost Raster** | | | | | | | | | |
| Land cover | 0.60 | 0.75 | 0.70 | 0.70 | 0.80 | 0.65 | 0.80 | 0.65 | 0.40 |
| Road density | 0.10 | 0.25 | 0.10 | 0.10 | 0.20 | 0.15 | 0.10 | 0.00 | 0.30 |
| Topography | 0.20 | 0.00 | 0.10 | 0.10 | 0.00 | 0.20 | 0.10 | 0.25 | 0.30 |
| Elevation | 0.10 | 0.00 | 0.10 | 0.10 | 0.00 | 0.00 | 0.00 | 0.10 | 0.00 |
| **Vegetation** | | | | | | | | | |
| Agriculture | 10 | 10 | 10 | 8 | 10 | 9 | 9 | 7 | 10 |
| Alkali Desert Scrub | 1 | 10 | 5 | 1 | 10 | 10 | 8 | 2 | 7 |
| Alpine-Dwarf Shrub | 10 | 6 | 10 | 10 | 10 | 9 | 10 | 3 | 4 |
| Annual Grassland | 1 | 10 | 3 | 3 | 10 | 9 | 3 | 1 | 7 |
| Barren | 6 | 10 | 10 | 8 | 10 | 10 | 5 | 9 | 10 |
| Bitterbrush | 1 | 10 | 6 | 10 | 10 | 3 | 10 | 3 | 2 |
| Blue Oak Woodland | 6 | 3 | 9 | 10 | 1 | 1 | 10 | 5 | 2 |
| Blue Oak-Foothill Pine | 6 | 3 | 9 | 10 | 1 | 1 | 10 | 5 | 3 |
| Chamise-Redshank Chaparral | 10 | 6 | 9 | 8 | 10 | 6 | 10 | 4 | 5 |
| Closed-Cone Pine-Cypress | 10 | 10 | 10 | 10 | 4 | 3 | 10 | 6 | 5 |
| Coastal Oak Woodland | 10 | 3 | 9 | 10 | 1 | 1 | 8 | 5 | 2 |
| Coastal Scrub | 10 | 10 | 5 | 10 | 10 | 3 | 10 | 4 | 2 |
| Desert Riparian | 1 | 10 | 5 | 10 | 10 | 4 | 9 | 3 | 1 |
| Desert Scrub | 1 | 10 | 3 | 10 | 10 | 9 | 1 | 2 | 7 |
| Desert Succulent Shrub | 10 | 10 | 4 | 10 | 10 | 8 | 10 | 2 | 7 |
| Desert Wash | 10 | 10 | 5 | 10 | 10 | 5 | 5 | 3 | 2 |
| Eastside Pine | 10 | 1 | 5 | 10 | 2 | 1 | 10 | 5 | 5 |
| Estuarine | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 5 |
| Eucalyptus | 10 | 10 | 10 | 10 | 8 | 7 | 10 | 6 | 6 |
| Freshwater Emergent Wetland | 10 | 10 | 10 | 10 | 10 | 9 | 10 | 9 | 2 |
| Jeffrey Pine | 10 | 1 | 5 | 10 | 2 | 2 | 10 | 5 | 5 |
| Joshua Tree | 10 | 10 | 3 | 10 | 10 | 8 | 10 | 2 | 4 |
| Juniper | 10 | 10 | 3 | 10 | 9 | 5 | 9 | 3 | 3 |
| Lacustrine | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 9 | 10 |
| Lodgepole Pine | 10 | 3 | 10 | 10 | 4 | 5 | 10 | 6 | 5 |
| Mixed Chaparral | 10 | 6 | 9 | 8 | 3 | 6 | 10 | 4 | 5 |
| Montane Chaparral | 10 | 6 | 10 | 10 | 9 | 5 | 10 | 4 | 5 |
| Montane Hardwood | 10 | 2 | 10 | 10 | 1 | 1 | 10 | 6 | 3 |
| Montane Hardwood-Conifer | 10 | 1 | 10 | 10 | 1 | 1 | 10 | 6 | 3 |
| Montane Riparian | 10 | 1 | 10 | 10 | 3 | 2 | 10 | 6 | 1 |
| Other/Unknown Conifer | 10 | 1 | 10 | 10 | 4 | 3 | 10 | 6 | 5 |
| Palm Oasis | 10 | 10 | 9 | 10 | 10 | 7 | 10 | 6 | 3 |
| Perennial Grassland | 10 | 10 | 4 | 3 | 10 | 7 | 2 | 1 | 6 |
| Pinyon-Juniper | 10 | 10 | 3 | 10 | 8 | 4 | 10 | 3 | 3 |
| Ponderosa Pine | 10 | 1 | 5 | 10 | 2 | 2 | 10 | 5 | 5 |

| Variable | Blunt-nosed leopard lizard | California Spotted owl | Tehachapi pocket mouse | Tipton kangaroo rat | Western gray squirrel | Mule Deer | San Joaquin Kit fox | American Badger | Mountain Lion |
|---|---|---|---|---|---|---|---|---|---|
| Red Fir | 10 | 1 | 10 | 10 | 4 | 4 | 10 | 6 | 5 |
| Riverine | 10 | 10 | 10 | 10 | 10 | 9 | 10 | 9 | 1 |
| Sagebrush | 8 | 10 | 9 | 10 | 10 | 5 | 10 | 3 | 7 |
| Saline Emergent Wetland | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 6 |
| Sierran Mixed Conifer | 10 | 1 | 10 | 10 | 1 | 2 | 10 | 6 | 5 |
| Subalpine Conifer | 10 | 6 | 10 | 10 | 8 | 6 | 10 | 6 | 5 |
| Urban | 10 | 10 | 10 | 10 | 10 | 10 | 5 | 10 | 10 |
| Valley Foothill Riparian | 4 | 1 | 10 | 10 | 1 | 1 | 10 | 4 | 1 |
| Valley Oak Woodland | 8 | 3 | 9 | 10 | 1 | 1 | 8 | 4 | 2 |
| Water | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 9 |
| Wet Meadow | 10 | 8 | 10 | 10 | 10 | 5 | 10 | 4 | 6 |
| White Fir | 10 | 1 | 10 | 10 | 4 | 2 | 10 | 6 | 5 |
| **Road Density** | | | | | | | | | |
| 0-0.5 km per square km | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 0.5-1 km per square km | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 |
| 1-2 km per square km | 6 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 4 |
| 2-4 km per square km | 8 | 3 | 3 | 3 | 2 | 5 | 3 | 1 | 6 |
| 4-6 km per square km | 9 | 3 | 3 | 5 | 5 | 7 | 3 | 1 | 9 |
| 6-8 km per square km | 10 | 10 | 9 | 8 | 8 | 10 | 5 | 1 | 10 |
| 8-10 km per square km | 10 | 10 | 10 | 10 | 10 | 10 | 8 | 10 | 10 |
| 10 or more km per square km | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| **Topographic Features** | | | | | | | | | |
| Canyon bottoms | 2 | 1 | 3 | 3 | 1 | 5 | 10 | 2 | 1 |
| Ridgetops | 10 | 10 | 3 | 8 | 1 | 2 | 8 | 7 | 7 |
| Flats | 1 | 5 | 1 | 1 | 1 | 8 | 1 | 1 | 3 |
| Slopes | 8 | 1 | 8 | 5 | 1 | 1 | 3 | 9 | 5 |
| **Elevation** | | | | | | | | | |
| -260 to 0 feet | 1 | 10 | 3 | 2 | | 6 | 10 | 1 | |
| 0-500 feet | 1 | 10 | 3 | 1 | | 4 | 10 | 1 | |
| 500-750 feet | 1 | 10 | 3 | 2 | | 3 | 10 | 1 | |
| 750-1000 feet | 1 | 10 | 3 | 2 | | 3 | 10 | 2 | |
| 1000-3000 feet | 1 | 1 | 3 | 10 | | 3 | 10 | 2 | |
| 3,000-5000 feet | 10 | 1 | 1 | 10 | | 3 | 10 | 3 | |
| 5000-7000 feet | 10 | 1 | 2 | 10 | | 3 | 1 | 3 | |
| 7000-8000 feet | 10 | 1 | 3 | 10 | | 5 | 10 | 5 | |
| 8000-9000 feet | 10 | 1 | 10 | 10 | | 5 | 10 | 5 | |
| 9000-11500 feet | 10 | 10 | 10 | 10 | | 5 | 10 | 5 | |
| >11500 feet | 10 | 10 | 10 | 10 | | 8 | 10 | 8 | |

by natural and urban landscape characteristics. These data layers were then used to create a cost surface; each input category was ranked and weighted, such that:

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

Weighting allowed the model to capture variation in the influence of each input (e.g., vegetation, road density, topography, elevation) on focal species movements. A unique cost surface was developed for each species. A corridor function was then used to generate a data layer showing the relative degree of permeability between two core areas. For each focal species, the top 1% was designated as the least-cost corridor.

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

**Patch Size & Configuration Analysis**

Patch size and configuration analyses were conducted for all focal species, including those for which we could not conduct landscape permeability analysis, to evaluate whether each species' needs were adequately accommodated by the Least Cost Union. Habitat suitability models were developed using the literature and expert opinion. Spatial data layers used in the analysis varied by species and included: vegetation, elevation, topographic features, slope, aspect, and hydrography. 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. We then identified each area of contiguous suitable habitat larger than 50 times the recorded minimum home range size as a *potential core* and each area of contiguous suitable habitat 2 to 49 times the minimum recorded home range as a *patch*. Potential cores are probably capable of supporting the species for several decades (although with erosion of genetic material if isolated). Patches can support at least one breeding pair of animals (perhaps more if home ranges overlap greatly) and are probably useful to the species if the patch can be linked via dispersal to other patches and core areas. Because most attempts to document dispersal distances are underestimated (LaHaye et al. 2001), we assumed each species could disperse twice as far as the longest documented dispersal distance. For each species we compared the configuration and extent of potential cores and patches, relative to the species dispersal ability, to evaluate whether the Least Cost Union was likely to serve the species. If necessary we added additional habitat to help ensure that the linkage provides sufficient live-in habitat and/or "move-thru" habitat in perpetuity for the species' needs.

**Minimum Linkage Width**

Many species exhibit metapopulation dynamics, whereby the long-term persistence of a local population requires connection to other populations (Hanski and Gilpin 1991).

Distributional patterns of plants and animals vary spatially and temporally at different biogeographic scales (Ligon and Stacey 1996). For relatively sedentary species like salamanders and terrestrial insects, gene flow will occur over decades by gene flow through a metapopulation. Thus the linkage must be large enough to support metapopulations of these species. To accommodate this need, we imposed a 2-mile (3 km) minimum width throughout upland habitat in the linkage. Riparian and upland routes were considered separately when applying the minimum width rule. The widest estimate provided in the literature, a 1-km upland buffer used by the Western pond turtle (*Clemmys marmorata*) (Holland unpubl.), was used as minimum width for all aquatic species. For a variety of species, including those we did not formally analyze, a wide linkage helps ensure availability of appropriate habitat, host plants (e.g., for butterflies), pollinators, and areas with low predation risk. In addition, fire is part of the natural disturbance regime and a wide linkage allows for a semblance of a natural fire regime to operate with minimal constraints from adjacent urban areas. A wide linkage also enhances the ability of the biota to respond to climate change, and buffers against edge effects.

**Field Investigations**

We conducted field surveys to ground-truth existing habitat conditions, document existing barriers and potential passageways, and describe restoration opportunities. All location data were recorded using a mobile GIS/GPS with ESRI's ArcPad.

Because paved roads present the most formidable potential barriers, surveyors drove or walked each accessible section of road that transected the linkage. All types of potential crossing structures (e.g., bridge, underpass, overpass, culvert, pipe) were photo documented and measured. Data taken for each crossing included: shape; height, width, and length of the passageway; stream type, if applicable (perennial or intermittent); floor type (metal, dirt, concrete, natural); passageway construction (concrete, metal, other); visibility to other side; light level; fencing; vegetative community within and/or adjacent to the passageway.

Existing highways and crossing structures are not permanent features of the landscape. In particular, crossing structures can be improved during projects to widen and realign highways and interchanges. Therefore, we also identified areas where crossing structures could be improved or installed, and opportunities to restore vegetation to improve road crossings and minimize roadkills.

**Identify Conservation Opportunities**

The Linkage Design serves as the target area for linkage conservation opportunities. We provided biological and land use summaries, and implementation opportunities for agencies, organizations, and individuals interested in participating in conservation activities in the Tehachapi 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 provide a visualization of the linkage from a landscape perspective (Appendix C).

# Landscape Permeability Analysis

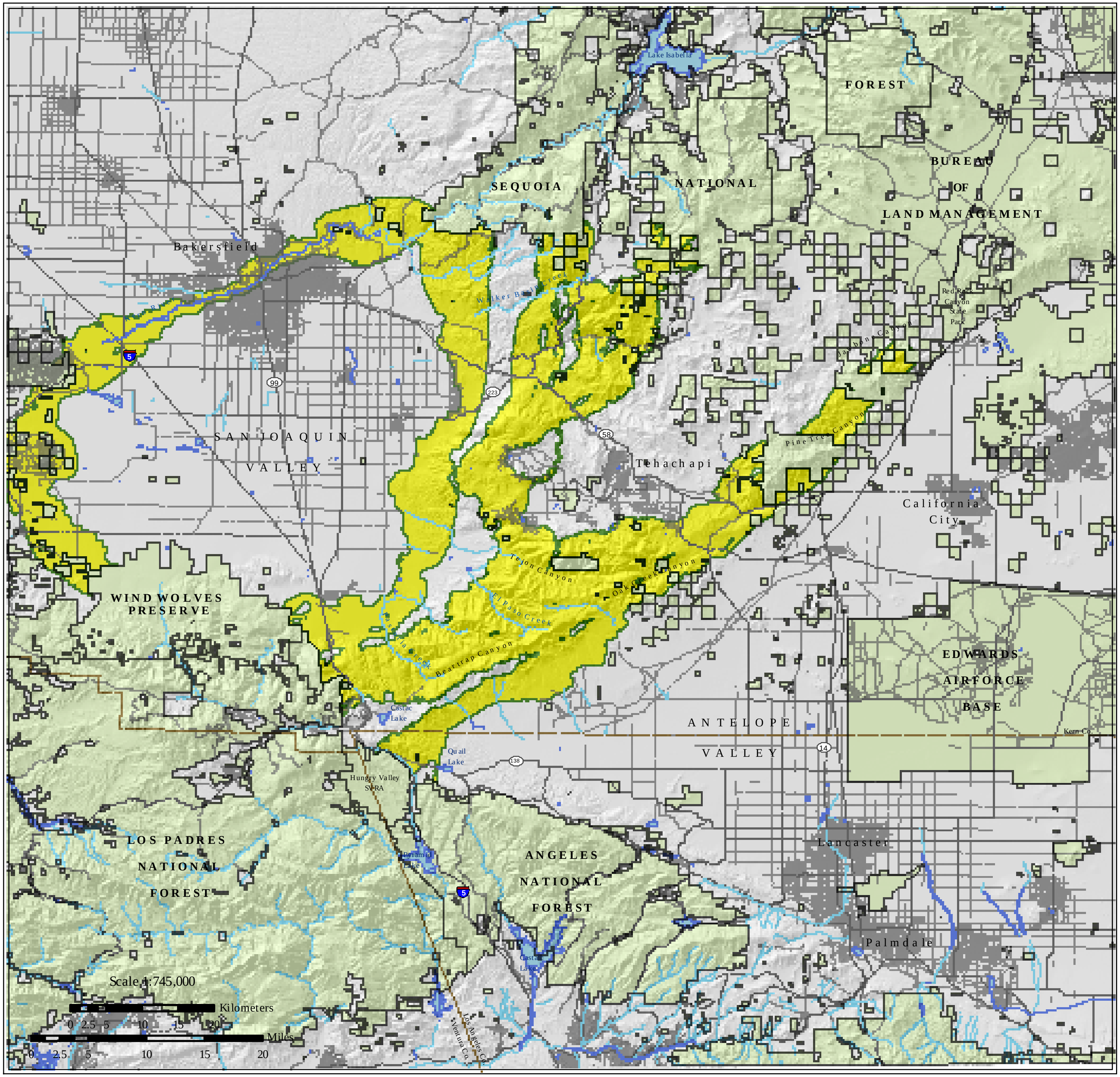
We conducted landscape permeability analyses for 9 species as described in the following several pages. The Least Cost Union (i.e., the union of the top 1% for all 9 species) demonstrates the need for habitat connectivity in several major vegetation and physiographic zones, including foothill grasslands of the southern San Joaquin Valley, high-elevation hardwood and coniferous forests, the foothill transition into the Mojave Desert along the base of the southern Tehachapi, and northern Liebre and Sawmill mountains (Figure 7). The most permeable paths for most focal species converged and overlapped considerably in the southern part of the linkage and diverged in the northern part of the linkage (Figure 8). High permeability areas are sites where focal species encounter the fewest obstacles or hazards, and have the greatest chance of finding food and shelter between protected core areas.

The Linkage Union runs in a southwest to northeasterly direction from Wind Wolves Preserve, Los Padres National Forest, Hungry Valley State Park, and Angeles National Forest to the Sequoia National Forest and Jawbone-Butterbredt-Kelso Valley area managed by the Bureau of Land Management. It includes a band of habitat that extends from 5-10 km wide along the arc of the San Joaquin Valley floor; an upland connection from 10-20 km wide through Beartrap Canyon to Tejon Canyon, where it branches around the city of Tehachapi, heading either toward Bear Mountain, up Centennial Ridge to the Piute or Breckenridge mountains of the Sequoia Core Area, or toward Oak Creek Canyon, through Pine Tree Canyon to the Jawbone Canyon Core Area; and a 3-5 km band of habitat along the southeastern slopes of the Tehachapi Mountains that expands to an approximate width of 7-10 km between Oak Creek and Jawbone canyons.

Native vegetation accounts for 95% of land cover in the Least Cost Union, which encompasses over thirty distinct vegetation communities. Grassland covers the greatest area; other dominant natural communities include desert scrub, blue oak woodland, mixed chaparral, valley oak woodland, pinyon juniper, montane hardwood and blue oak foothill pine. The Least Cost Union spans a distance of roughly 60 miles, and encompasses 254,840 ha (629,723 ac). Existing protected habitat (mostly in disjunct BLM parcels) covers 31,709 ha (78,355 ac) of the Least Cost Union.

The next several pages summarize the permeability analyses for each of the 9 modeled species. For convenience, the narratives describe the most permeable paths from south to north; our analyses, however gave equal weight to movements in both directions. The following section (Patch Size and Configuration Analysis) describes our procedure to evaluate how well the Least Cost Union would likely serve the needs of all focal species, including those for which we could not conduct permeability analysis. The latter analysis expanded the Least Cost Union to provide for critical live-in or move-through habitat for particular focal species.

# Figure 7.
# Least Cost Union




## Legend

- Least Cost Union
- Ownership Boundaries
- County Lines
- Paved Roads
- Waterbodies
- Perennial Rivers & Creeks

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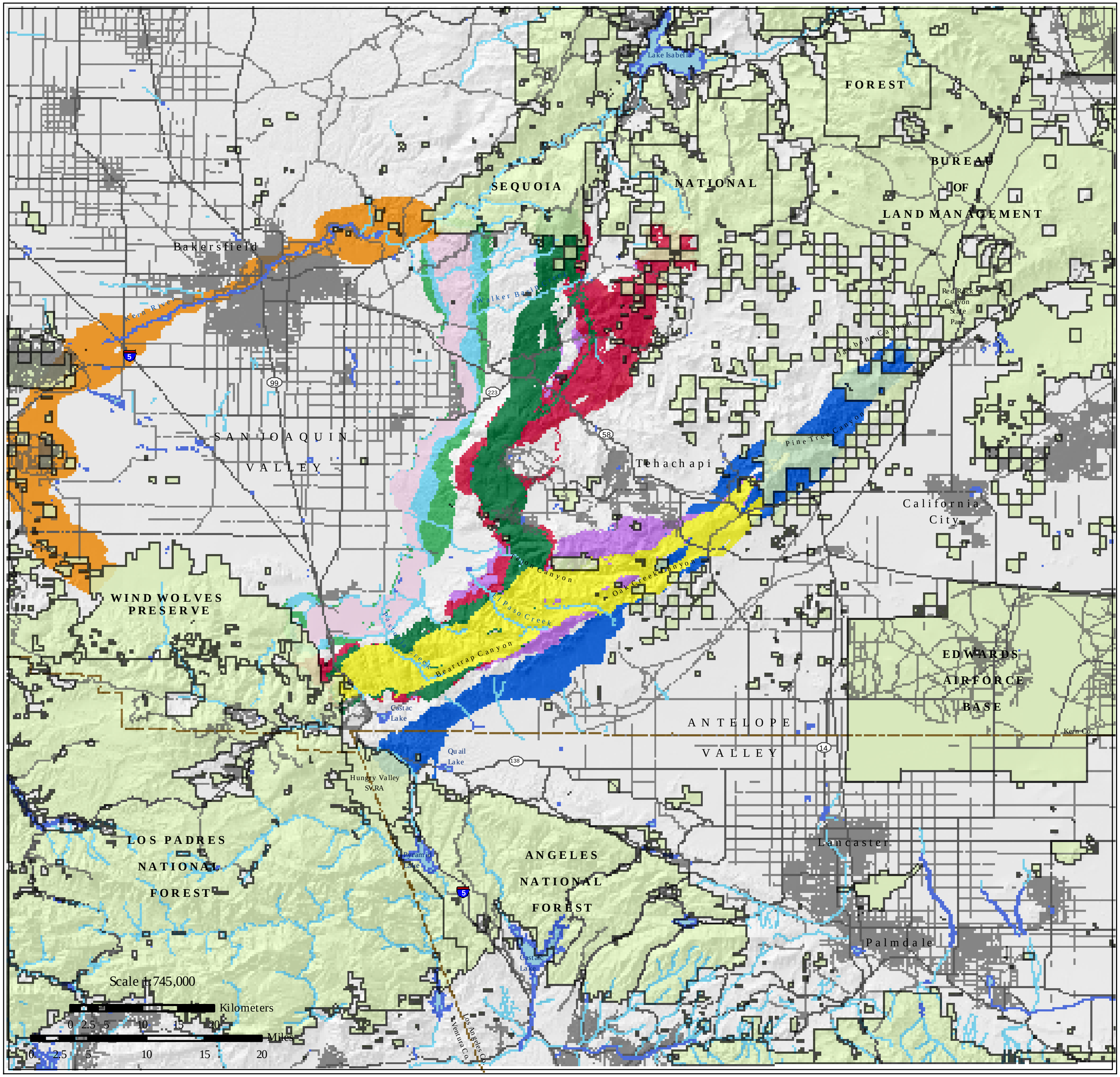
## Figure 8.
## Least Cost Union (Species Overlap)




### Legend

- Tipton kangaroo rat
- American badger
- Blunt-nosed leopard lizard
- San Joaquin kit fox
- Mountain lion
- California spotted owl
- W. gray squirrel
- Mule deer
- Tehachapi pocket mouse
- County Lines
- Ownership Boundaries
- Paved Roads
- Waterbodies
- Perennial Rivers & Creeks

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## Mountain Lion (*Felis concolor*)


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

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

(Vegetation * 40%) + (Road Density * 30%) + (Topography * 30%) = cost surface

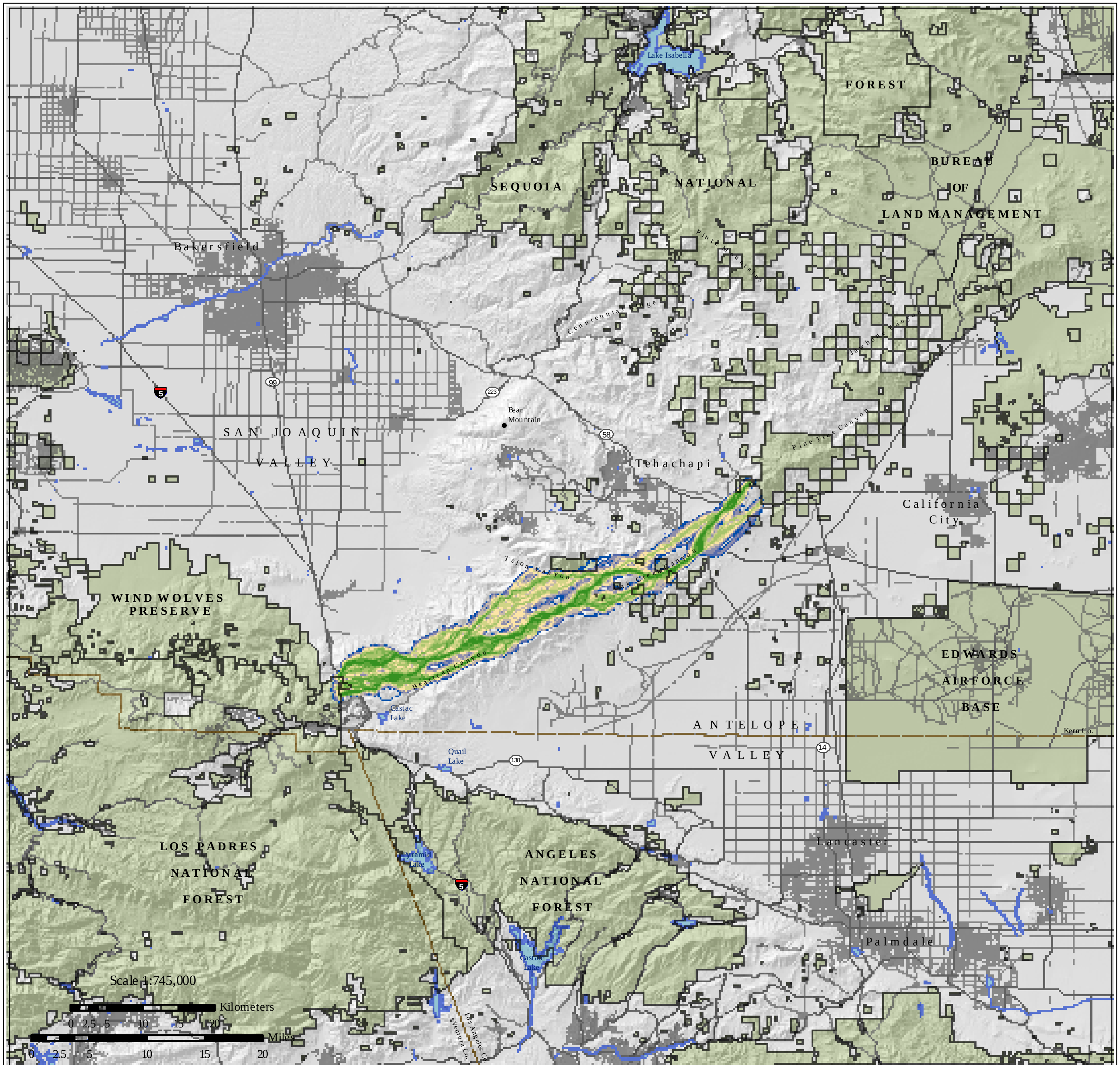
**Results & Discussion:** Figure 9 delineates the most permeable area (top 1%) for mountain lion movement between the Sierra Madre and Sierra Nevada protected core areas. It encompasses the riparian habitat of Pastoria Creek, the oak woodland, coniferous forests and chaparral habitat of Beartrap, Oak Creek and Cameron canyons, and the pinyon juniper woodland in Sand Canyon and Pine Tree Canyon. Another route with high potential, although not included in the top 1%, runs from Pastoria Creek, Tunis Creek, and Beartrap Canyon towards Tejon or Live Oak canyon, skirts Bear Valley over to Bear Mountain, through a Blue oak and foothill pine association, then crosses SR 58 west of the community of Keene through scattered oak woodlands and scrub communities on Centennial Ridge and down Harper Canyon to the Piute Mountains. Brite Creek was also identified as another route for mountain lion moving from Tehachapi Mountain to Black Mountain and Keller Valley, though the area is somewhat constrained between the Tehachapi and Cummings valleys.

**Figure 9.**
**Least Cost Corridor**
**for**
**Mountain lion**
***(Puma concolor)***

**Legend**

- Paved Roads
- Ownership Boundaries
- County Lines
- Highly Permeable
- Less Permeable

N

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## American Badger (*Taxidea taxus*)


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

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

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

([Vegetation] * 0.65) + ([Elevation] * 0.10) + ([Topographic features] * 0.25)

**Results & Discussion:** Figure 10 delineates the most permeable route (top 1%) for badgers moving between the Sierra Madre and Sierra Nevada protected core areas. The contiguous belt of grassland and foothill habitat around the southern arc of the San Joaquin Valley, from the San Emigdio Ranges on Wind Wolves Preserve toward the Kern River area on Sequoia National Forest, was identified as the most permeable to badger movement. Badgers may use all low elevation grasslands and major canyons and drainages between protected areas, including Cottonwood, Walker Basin, Caliente, Sycamore and Little Sycamore, Comanche, Tejon, El Paso, Pastoria, and Grapevine canyons.

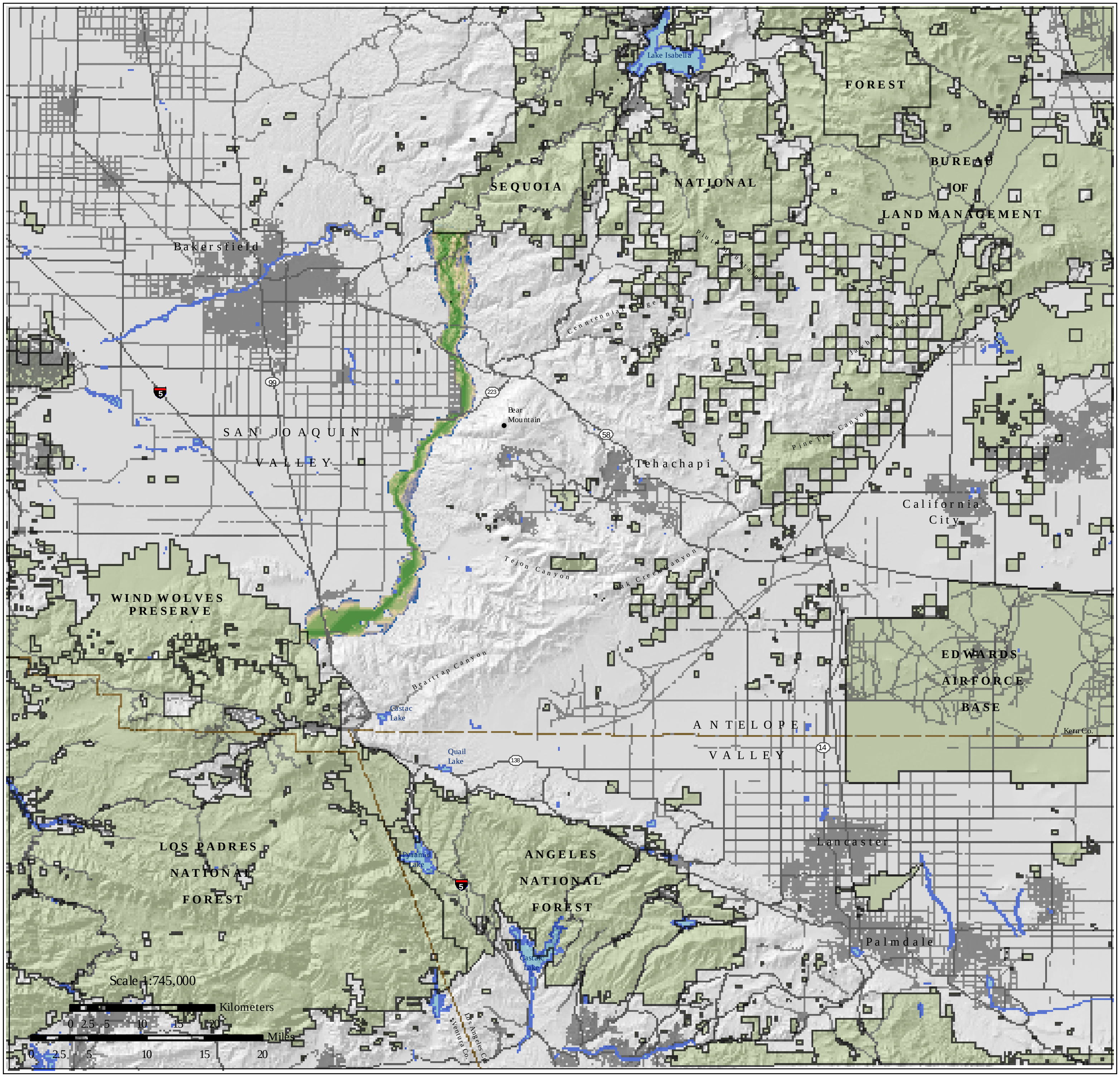
Another potentially key area for badger movement, not included in the top 1%, was identified between Liebre Mountain in the Angeles National Forest and the Cameron Canyon area administered by the Bureau of Land Management. This potential route encompasses grassland, desert scrub and pinyon-juniper communities on the Antelope Valley floor and along the eastern slopes of the Tehachapi Mountains.

**Figure 10.**
**Least Cost Corridor**
**for**
**American badger**
***(Taxidea taxus)***

**Legend**

- Paved Roads
- Ownership Boundaries
- County Lines
- Highly Permeable
- Less Permeable

N

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## San Joaquin Kit Fox (*Vulpes macrotis mutica*)


**Justification for Selection:** Principal reasons for this species' decline are habitat loss, fragmentation, and degradation by agriculture, residential, commercial, and industrial development, and associated roads (USFWS 1998, Koopman et al. 1998, CDFG 2000, USFS 2002). Barriers to movement such as aqueducts and busy highways limit dispersal (USFS 2002). However, pups and adults are known to move through disturbed habitat, including agricultural fields, oil fields and rangelands, and across highways and aqueducts (Haight et al. 2002). However, vehicle collisions are probably the greatest source of mortality (Cypher et al. 2000 *in* USFS 2002).

**Conceptual Basis for Model Development:** This small mammalian carnivore primarily inhabits native or annual grasslands and sparsely vegetated scrub habitats with abundant rodent populations, such as alkali sink scrub, saltbush scrub, and chenopod scrub, though oak woodlands, vernal pools, alkali meadows and playas also provide habitat (USFWS 1998, Brown et al. undated mat.). They prefer annual and perennial grasslands and open scrub habitats. They can move through other habitats (e.g., some agricultural fields) though they prefer not to do so Major highways and heavily traveled roads present obstacles to movement (Cypher et al. 2000 *in* USFS 2002). Juveniles may disperse up to 60 miles from their natal dens (Thelander 1994). Please see Table 2 for specific rankings for this species; cost to movement for kit fox was defined by weighting various inputs, such that:

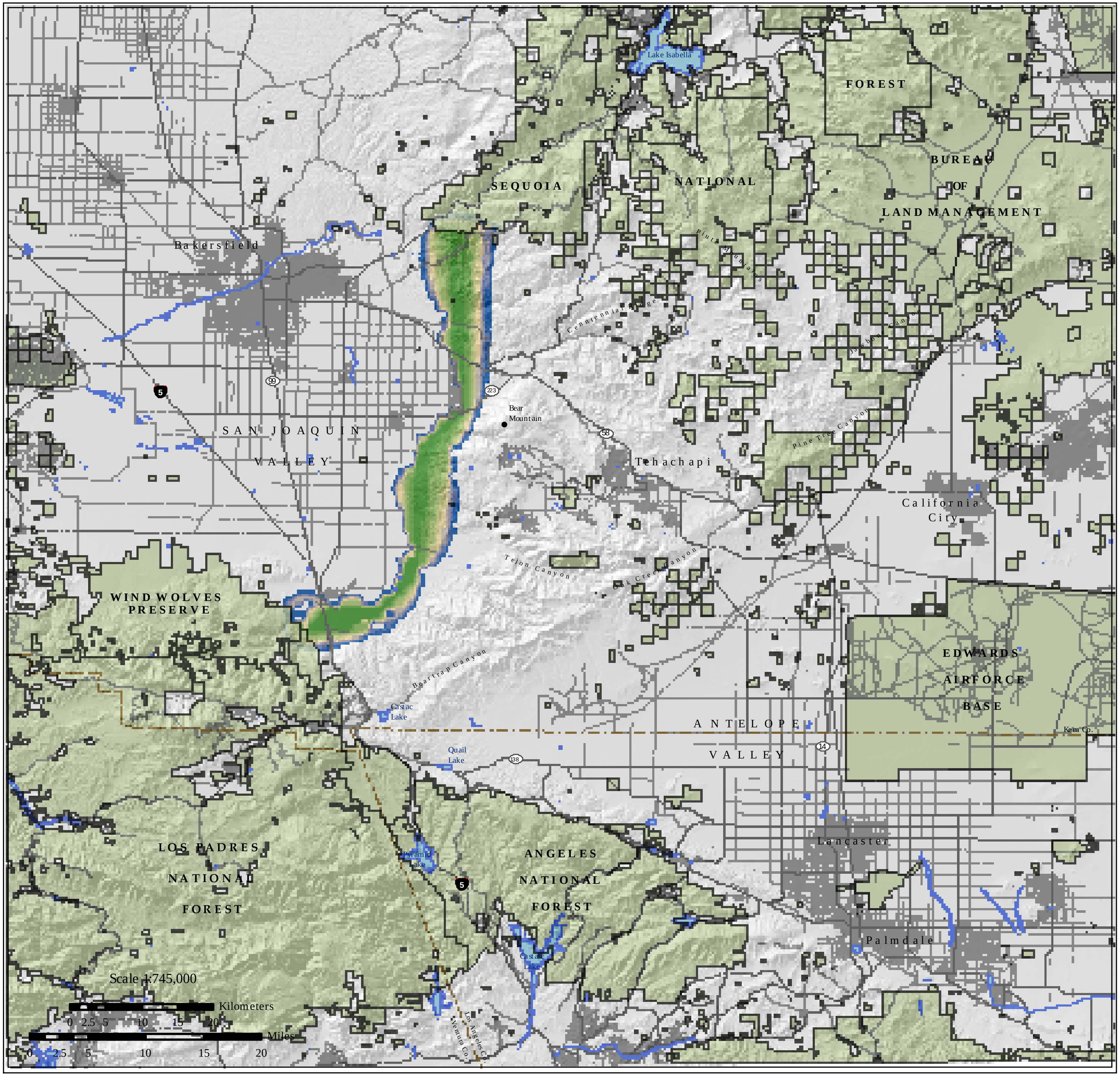
(Vegetation * 80%) + (Road Density * 10%) + (Topography * 10%) = cost

**Results & Discussion:** The permeability model output (top 1%) identified the contiguous belt of grassland and foothill habitat around the southern end of the San Joaquin Valley as the best potential route for kit fox moving between protected core areas (Figure11). The species may use all low elevation grasslands and major canyons and drainages between protected areas, from the San Emigdio Ranges on Wind Wolves Preserve to the Kern River area on Sequoia National Forest. The output provided by the landscape permeability analysis corresponds nicely with the movement corridor identified in the recovery plan for kit foxes and several other species (USFWS 1998), which called for the maintenance and enhancement of "habitat and movement corridors around the south end of the Valley between the Maricopa area on the west and Poso Creek area on the northeast." Recovery Task 5.3.8 specifically addresses the importance of maintaining compatible land uses in the southwest, southern, and southeastern Valley edge for kit fox, from McKittrick south to Maricopa, and then east and north to the Kern River (USFWS 1998). Another highly permeable route, not included in the top 1% of the landscape permeability results, utilizes the Kern River to move between protected core areas on either side of the Valley. The Kern River Alluvial Fan Element was also identified as an important dispersal corridor for this species in the recovery plan (USFWS 1998).

**Figure 11.**
**Least Cost Corridor**
**for**
**San Joaquin kit fox**
***(Vulpes macrotis mutica)***

**Legend**

- Paved Roads
- Ownership Boundaries
- County Lines
- Highly Permeable
- Less Permeable

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## Mule Deer (*Odocoileus hemionus*)

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


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

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

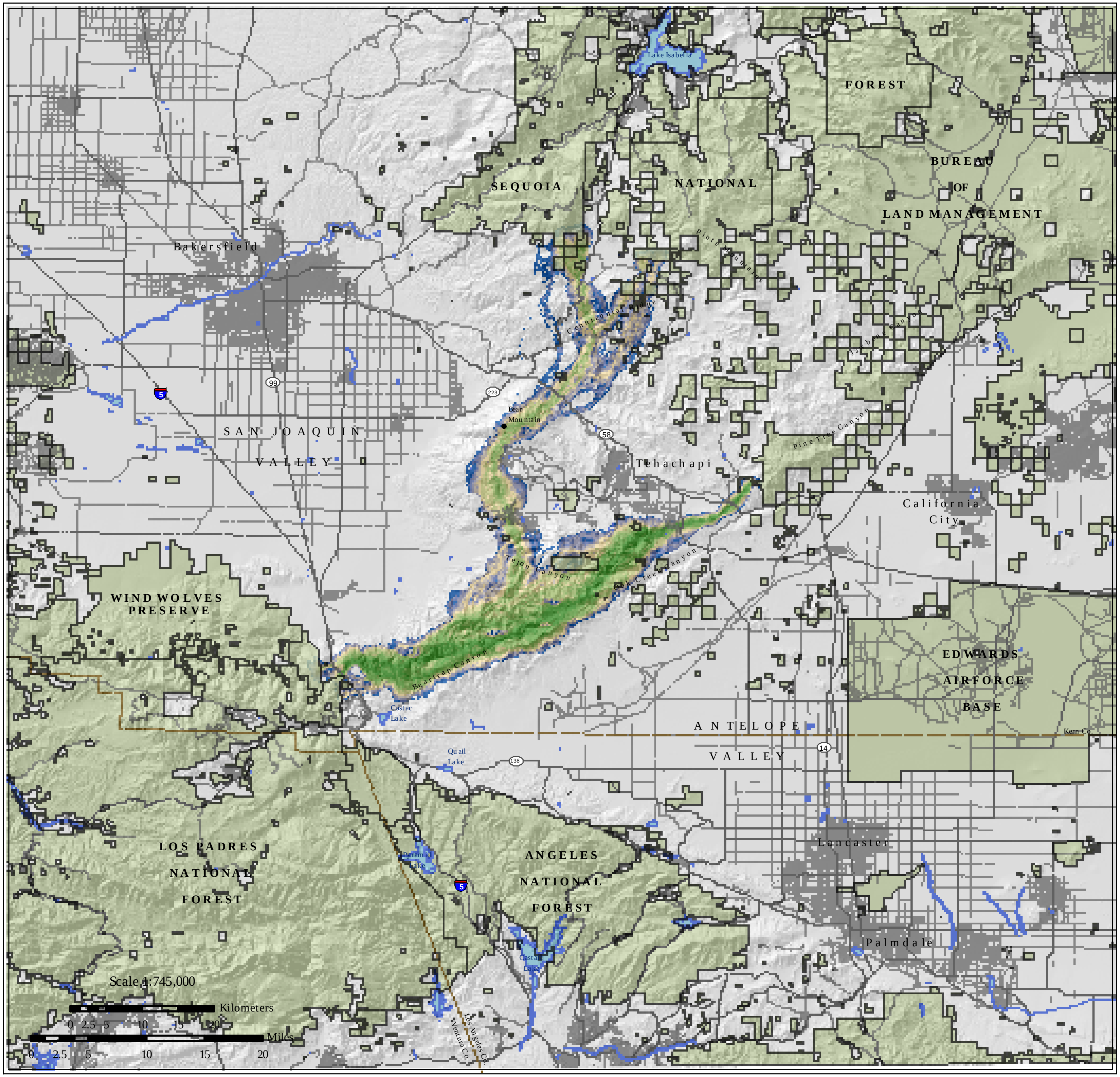
(Vegetation * 65%) + (Topography * 20%) + (Road Density * 15%) = cost

**Results & Discussion:** Figure 12 delineates the most permeable area (top 1%) for mule deer moving between the Sierra Madre and Sierra Nevada protected core areas. The results of the analysis for mule deer also support the need to conserve the complex mosaic of diverse habitats that occur in the Tehachapi Mountains, particularly Valley oak and Blue oak woodlands, Mixed coniferous forests with an understory of Black oak, and Valley foothill riparian habitats. The area delineated as the best potential route for this species encompasses Beartrap Canyon, Pastoria Creek, Tunis Creek, and Stratton Canyon. The linkage branches near Tejon Canyon, with the preferred route heading through Oak Creek Pass, funneling animals towards Sand Canyon in the direction of Sugarloaf Mountain or the Pine Tree Canyon area managed by the Bureau of Land Management. The other highly permeable route continues from Tejon Canyon continues Oak Flat, over to Bear Mountain, and crossing SR 58 west of the community of Keene through scattered oak woodlands and scrub communities into the Sequoia National Forest, either over Centennial Ridge to Breckenridge Mountain or down Harper Canyon to the Piute Mountains.

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

**Legend**

- Paved Roads
- Ownership Boundaries
- County Lines
- Highly Permeable
- Less Permeable

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## Western Gray Squirrel (*Sciurus griseus*)


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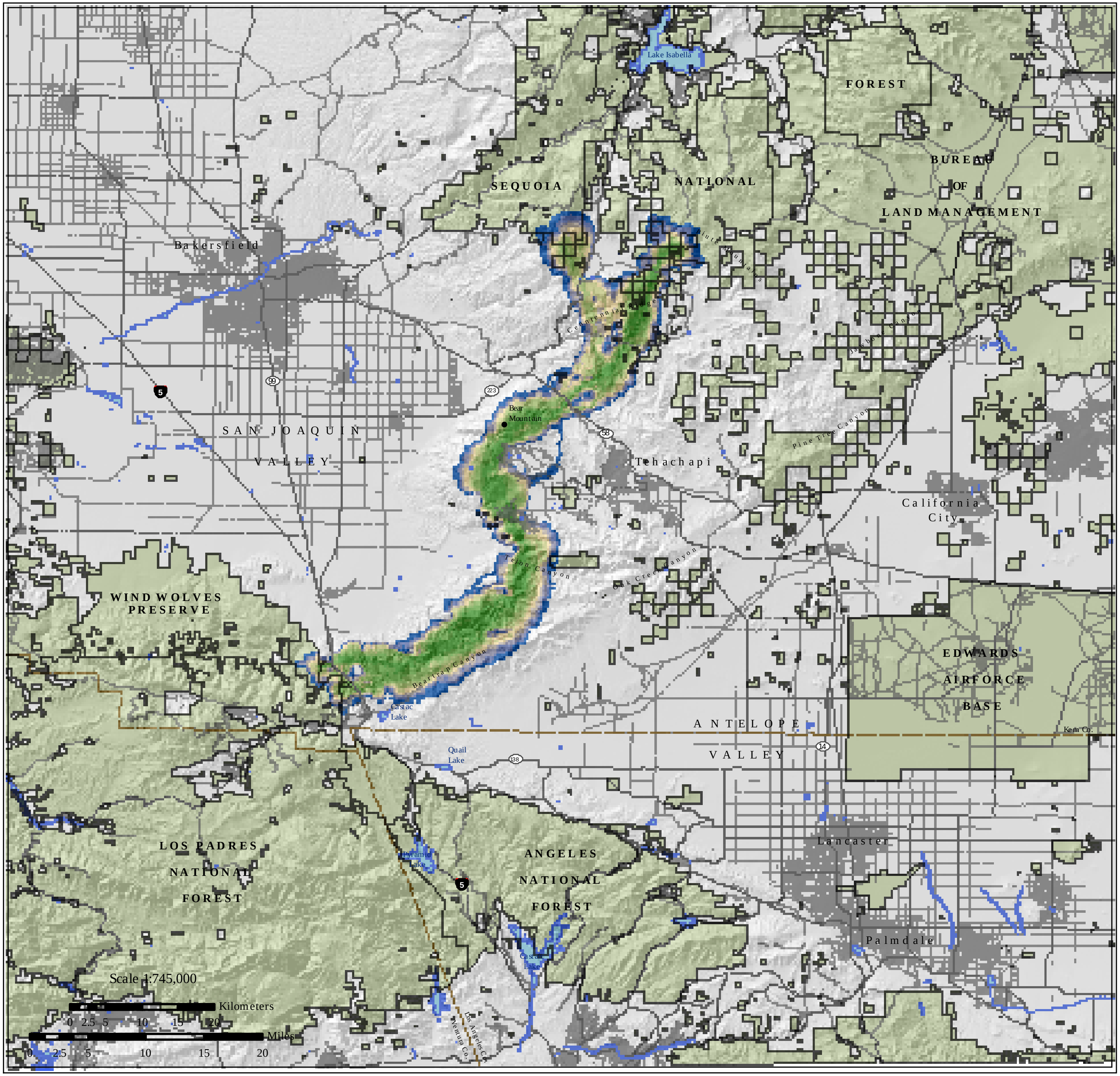
**Justification for Selection:** The Western gray squirrel is considered susceptible to fragmentation, is probably dispersal limited, and suffers from roadkill. Ryan and Carey (1995) found 25% of the 318 individuals documented in their study were recorded as roadkill, with most roadkilled squirrels being females or juveniles. The species is also impacted by the removal of snags, duff, slash, or oak trees (CDFG 1990).

**Conceptual Basis for Model Development:** This species prefers mature stands of moist conifer, hardwood, and mixed hardwood-conifer habitats (Ingles 1995 *in* CDFG 1990). These arboreal squirrels preferentially move through woodland and forested habitats, rarely touching the ground and avoiding open habitats, agricultural and urban land cover. Abundance is strongly associated with oak species diversity as acorns are their primary food source. They often attempt crossing roads at grade but aren't too successful. Movement between protected core areas in the linkage is multigenerational. Please see Table 2 for specific rankings for this species; cost to movement for Western gray squirrel was defined by weighting various inputs, such that:

(Vegetation * 80%) + (Road Density * 20%)

**Results & Discussion**: Figure 13 delineates the most permeable area (top 1%) for Western gray squirrel moving between the Sierra Madre and Sierra Nevada protected core areas. The output echoes the importance of conserving the complex mosaic of diverse hardwood and coniferous forests that occur at mid to high elevations in the Tehachapi Mountains. The model suggests the best potential route for this species is through woodland and forested habitat in Beartrap Canyon, Pastoria Creek, and Tunis Creek down Tejon or Live Oak Canyon, around Bear Valley and over to Bear Mountain, through a Blue oak and foothill pine association. The squirrel also utilizes the large expanse of upland habitat west of the community of Keene to cross SR 58 and then heads toward Centennial Ridge. From here to the Sequoia protected core area, the linkage splits in two, with the most permeable route heading toward the southern Piute Mountains and another highly likely route over to Breckenridge Mountain.

**Figure 13.**
**Least Cost Corridor**
**for**
**Western gray squirrel**
***(Sciurus griseus)***




**Legend**

- Paved Roads
- Ownership Boundaries
- County Lines
- Highly Permeable
- Less Permeable

N

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## Tipton Kangaroo Rat (*Dipodomys nitratoides nitratoides*)

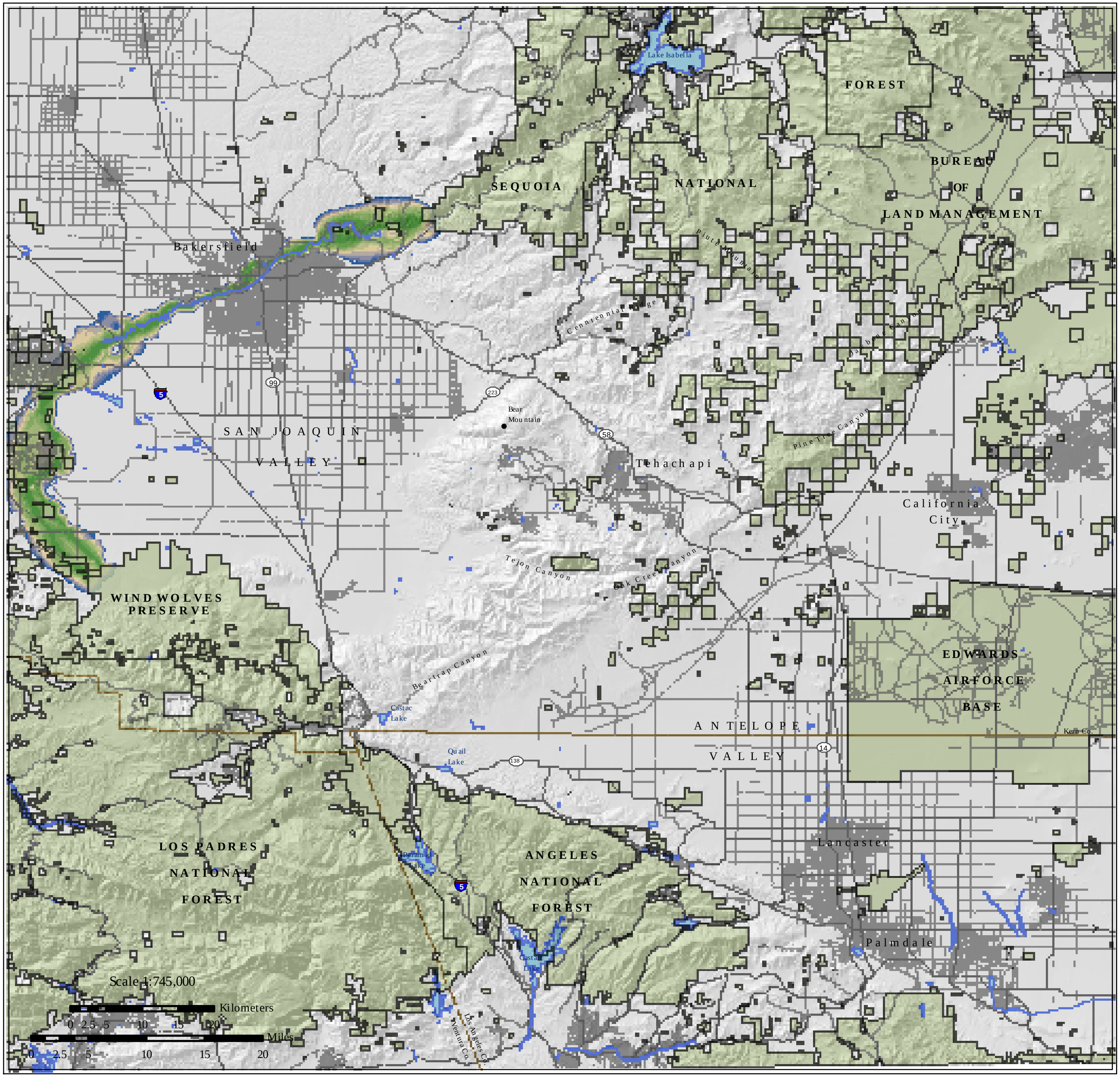

**Justification for Selection:** Habitat conversion and fragmentation by agriculture are cited as the primary causes of their precipitous declines (Williams and Germano 1993), although urban and industrial development has also contributed significantly (USFWS 1998). Construction of dams and canals has also taken its toll: the California Aqueduct has effectively isolated Tipton kangaroo rat from historically occupied habitat along the southern and western edges of the valley floor (Hafner 1979, Williams 1985 *in* Williams 1986, USFWS 1998). Uptain et al. (1998) observed substantial declines of the Tipton kangaroo rat that approached 100 percent at four separate study sites, due largely to the highly fragmented and isolated condition of populations.

**Conceptual Basis for Model Development:** Tipton kangaroo rats are restricted to arid vegetation communities occupying the valley floor in alluvial fan and floodplain soils, on level or nearly level terrain, at an elevation of 200 to 300 ft (Williams 1986). Individuals are known to move through scattered shrubs with an understory of native and introduced annual grasses associated with valley sink scrub, valley saltbush scrub, and terrace grassland communities. They avoid urban and intense agricultural areas, and probably areas of dense grasses and thatch. Their movements may be strongly influenced by physical barriers, such as canals, steep slopes, or roads. Kangaroo rats are often seen crossing roads at night, but they suffer significant road kill, with reduced population levels resulting in the vicinity of paved roads (W. Spencer and C. Brehme pers. comms.). Light pollution might also reduce movements and habitat suitability: Robin Kobaly (BLM; pers. comm.) reported reduced trap success for Merriam's kangaroo rats adjacent to new ball field lighting at Morongo Reserve. Dispersal distances have not been recorded for this species. However, the congener *D. merriami* has been found to disperse up to 384 m (Zeng and Brown 1987), which was therefore assumed a reasonable dispersal distance for the similar-sized Tipton kangaroo rat. See Table 2 for specific rankings for this species. Cost to movement for Tipton kangaroo rat was defined by weighting various inputs, such that:

([Vegetation] * 0.70) + ([Road Density] * 0.10) +([Elev.] * 0.10) + ([Topography] * 0.10)

**Results & Discussion:** The landscape permeability analysis identified the rich alluvial fan of the Kern River as the best potential movement route (Top 1%) for intergenerational movement of Tipton kangaroo rat between protected core areas on either side of the San Joaquin Valley (Figure 14). The output provided by the landscape permeability analysis is consistent with areas identified as conservation targets for Tipton kangaroo rat in the recovery plan (USFWS 1998), which calls for the development of a "protection plan to connect and expand Kern River alluvial fan area including the Kern Fan Element, Cole's Levee Ecosystem Preserve, and other mitigation parcels" (i.e., Recovery Task 5.1.6). Another highly permeable route, not included in the top 1%, includes the extensive grassland and valley sink scrub habitat that exists in a contiguous belt along the fringes of the southern San Joaquin Valley. Population viability studies on other kangaroo rat species suggest that reserves should be at least several thousand acres to maintain viable populations over the long term (Goldingay et al. 1997).

**F i g u r e 14.**
**Least Cost Corridor**
**for**
**Tipton kangaroo rat**
***(Dipodomys nitratoides nitratoides)***




**L e g e n d**

Paved Roads
Ownership Boundaries
County Lines
Highly Permeable
Less Permeable

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## Tehachapi Pocket Mouse (*Perognathus alticola inexpectatus*)

**Justification for Selection:** Populations of the Tehachapi pocket mouse are thought to be small, scattered, and vulnerable to extinction from anthropogenic-induced land changes (Huey 1926 *in* Sullentich 1983, Williams 1986). The linkage is probably critical to maintaining genetic vigor for this highly restricted species (W. Spencer, pers. comm.). Livestock grazing is the dominant land use within the species range, but wind farms, mines, urban development and off-road vehicles have converted and fragmented historically suitable habitat (Laabs 1989). The species may also be adversely affected by fire-type conversion of desert scrub and Joshua tree scrub to grassland. Potential barriers to movement include roads, canals, and dense grasslands (W. Spencer, pers. comm.).

**Conceptual Basis for Model Development:** This species is known to utilize coastal sage, chaparral, desert scrub, pinyon-pine woodland, Joshua tree woodland, arid grasslands, grassy flats among scattered Jeffrey or Ponderosa pine, and oak savanna habitats (Williams et al. 1993, Best 1994 *in* Labbs 1989); it has also been recorded in fallow grain fields (Williams 1986). It is primarily associated with fine sandy soils on flats or in gently sloping terrain; steep slopes may act as barriers (W. Spencer, pers. com.).

Movement between core areas in the linkage is multigenerational. Tehachapi pocket mouse may disperse up to 100 m (W. Spencer pers. comm.), and preferentially move through open scrub and woodland habitats. Denser scrub and woodland habitats are avoided, as are urban and intense agricultural areas. Roads are difficult to navigate safely. Please see Table 2 for specific rankings for this species; cost to movement for the Tehachapi pocket mouse was defined by weighting various inputs, such that:

([Vegetation] * 0.65) + ([Elevation] * 0.10) + ([Topographic features] * 0.25)

**Results & Discussion:** The landscape permeability analysis identified the southeastern flank of the Tehachapi Mountains as the best potential movement corridor (Top 1%) for intergenerational movement of Tehachapi pocket mouse (Figure 15). The model output corresponds closely with suitable habitat and the known locations of this species, along the desert-side foothills of the Tehachapis. The area of highest permeability extends from Peace Valley along the foothills of the Tehachapis to Oak Creek Canyon, through Oak Creek Pass to Pine Canyon and on to the Jawbone Canyon area managed by the Bureau of Land Management. Vegetation within the area of highest permeability includes hardwood and coniferous forests, chaparral, pinyon-juniper woodland, desert scrub, and arid grassland habitats.

**Figure 15.**
**Least Cost Corridor**
**for**
**Tehachapi pocket mouse**
***(Dipodomys alticola inexpectatus)***

**Legend**

- Paved Roads
- Ownership Boundaries
- County Lines
- Highly Permeable
- Less Permeable

N

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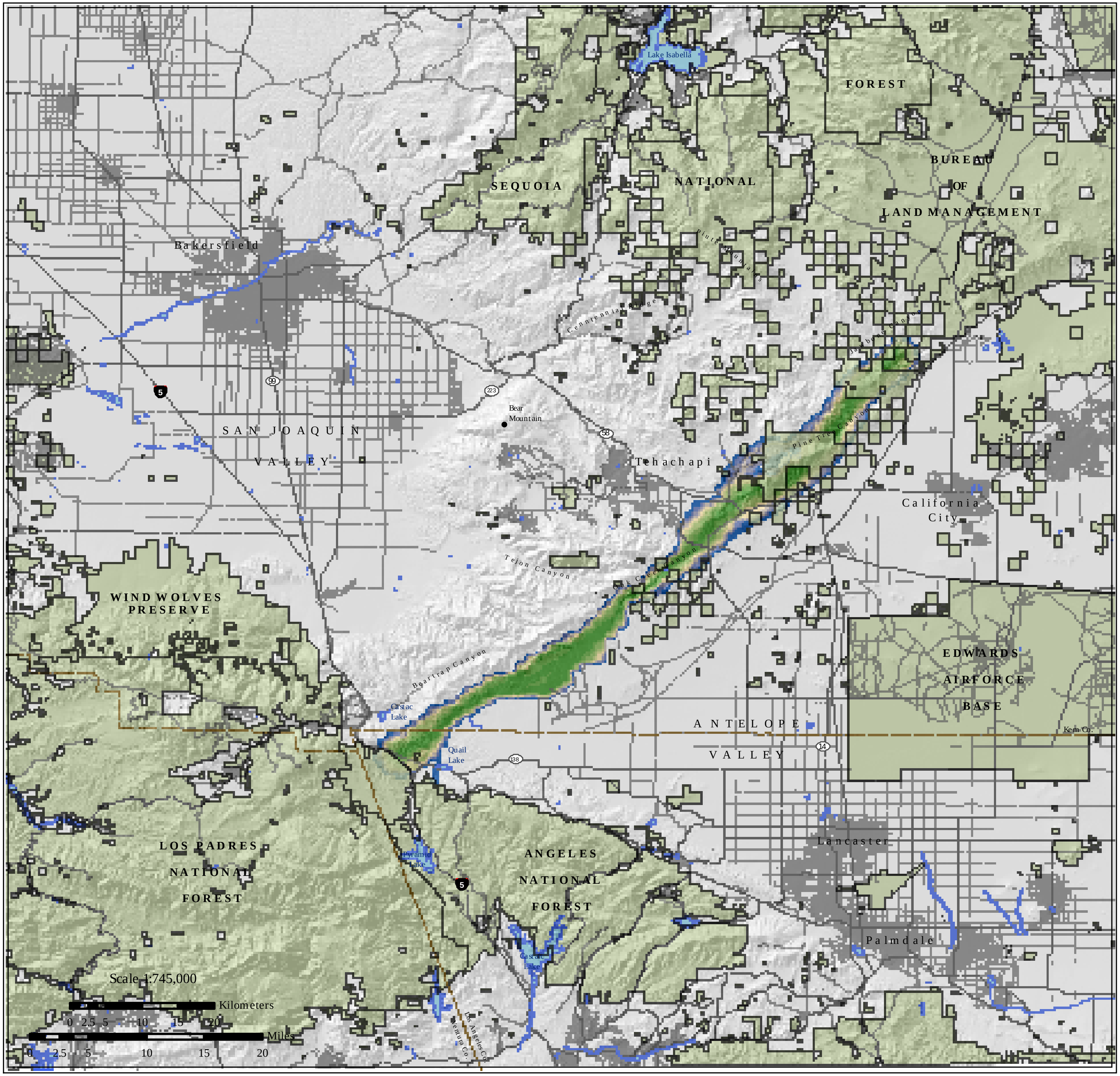

## California Spotted Owl (*Strix occidentalis occidentalis*)


**Justification for Selection:** The California spotted owl depends on extensive blocks of mature and old growth forests. Owl demography is strongly affected by forest fragmentation because successful juvenile dispersal depends on the proportion of the landscape that is forested (Harrison et al. 1993).

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

Spotted owls can disperse up to 72.1 km (LaHaye et al. 2001), and preferentially move through mature wooded and forested habitats. They occasionally hunt in more open habitats but prefer the forest interior; they avoid urban and agricultural areas. Please see Table 2 for specific rankings for this species; cost to movement for California spotted owl was defined by weighting various inputs, such that:

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

**Results & Discussion:** Figure 16 delineates the most permeable area (top 1%) for spotted owl moving between the Sierra Madre and Sierra Nevada core areas. The results for this analysis illustrate the importance of conserving the mature montane hardwood and coniferous forests that occur in the Tehachapi Mountains. The best potential route for this species encompasses Beartrap Canyon, Pastoria Creek, Tunis Creek, and Tejon Canyon. The route then heads toward Live Oak Canyon, skirts Bear Valley over to Bear Mountain, through a Blue oak and foothill pine association, then crosses SR 58 west of the community of Keene through scattered oak woodlands and scrub communities over Centennial Ridge to Breckenridge Mountain and the Greenhorn Range in the Sequoia protected core area.

**Figure 16.**
**Least Cost Corridor**
**for**
**California spotted owl**
***(Strix occidentalis occidentalis)***

**Legend**

- Paved Roads
- Ownership Boundaries
- County Lines
- Highly Permeable
- Less Permeable

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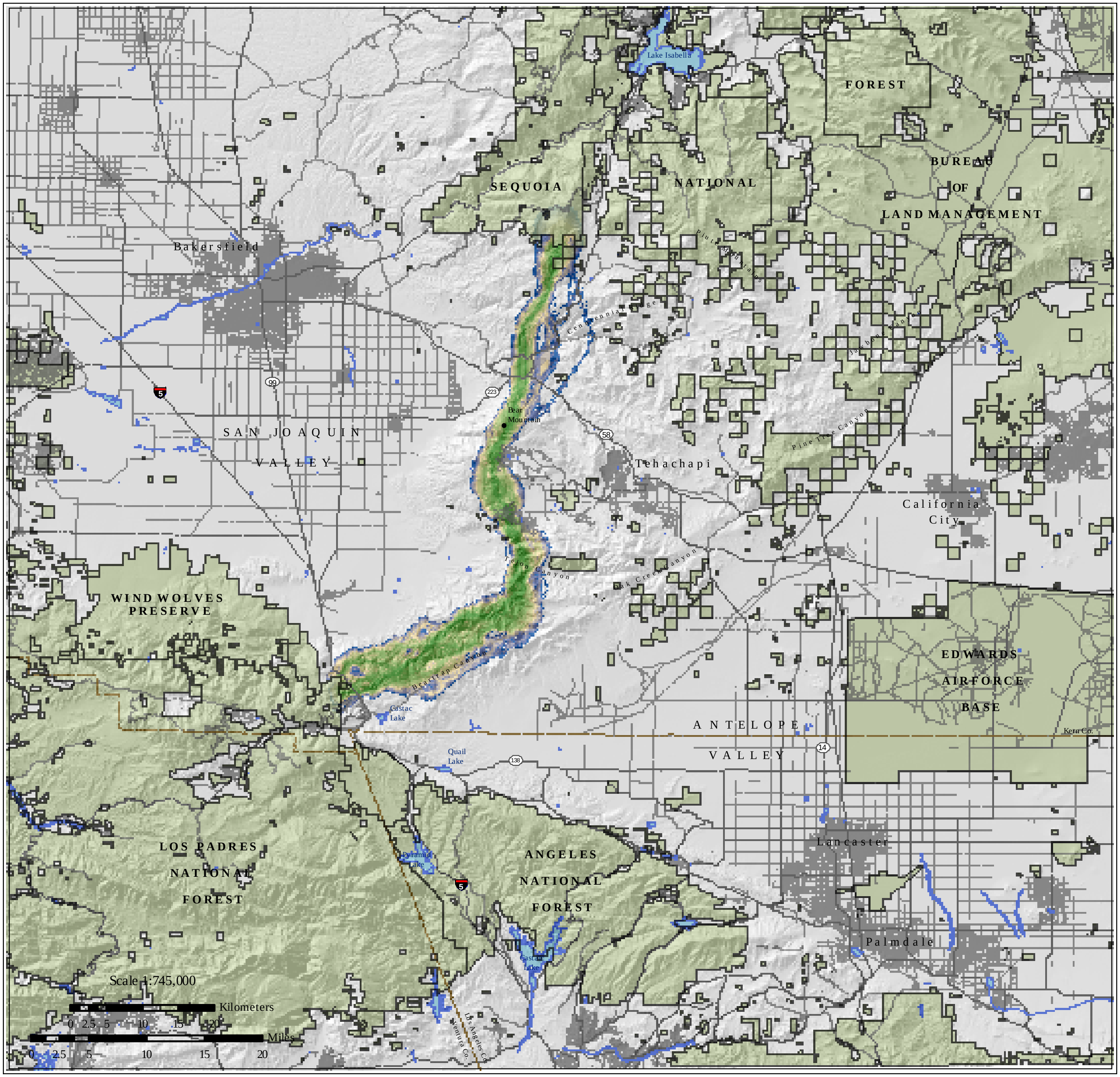


## Blunt-Nosed Leopard Lizard (*Gambelia silus*)


**Justification for Selection:** The blunt-nosed leopard lizard is threatened by habitat degradation and fragmentation by urban development, grazing, mining, road and pipeline construction, agricultural conversion and associated pest control, and off-road vehicles (USFWS 1980). Habitat fragmentation by roads and development is cited as the greatest threat to species persistence (USFWS 1998). Automobiles and off road vehicles are significant causes of mortality (Tollestrup 1979, Uptain et al. 1985, Williams and Tordoff 1988 *in* USFWS 1998).

**Conceptual Basis for Model Development:** The blunt-nosed leopard lizard inhabits semiarid grasslands or sparsely vegetated plains, in low foothills, on canyon floors, and in large washes and arroyos (USFWS 1980). It uses a variety of communities, including annual and perennial grassland, alkali playa, Valley sink scrub and Valley saltbush scrub, Sierra Tehachapi Saltbush scrub, Upper Sonoran Subshrub scrub and serpentine bunchgrass (USFWS 1998). The elevational range of this species extends from about 30 to 900 m (100 to 3000 ft) (Stebbins 1985, CDFG 1988). It prefers relatively flat terrain (Warrick et al. 1998), and is typically absent from areas of steep slope, dense vegetation, or areas that are seasonally inundated (USFWS 1998).

Movement between core areas in the linkage is multigenerational. This species preferentially moves through scattered shrubs in grassland, alkali scrub and wash communities in flats and canyon bottoms. They avoid urban and intense agricultural areas. Roads are difficult to navigate safely. Please see Table 2 for specific rankings for this species; cost to movement for blunt-nosed leopard lizard was defined by weighting various inputs, such that:

([Vegetation] * 0.60) + ([Elev.] * 0.10) + ([Road density] * 10) + ([Topography] * 0.20)

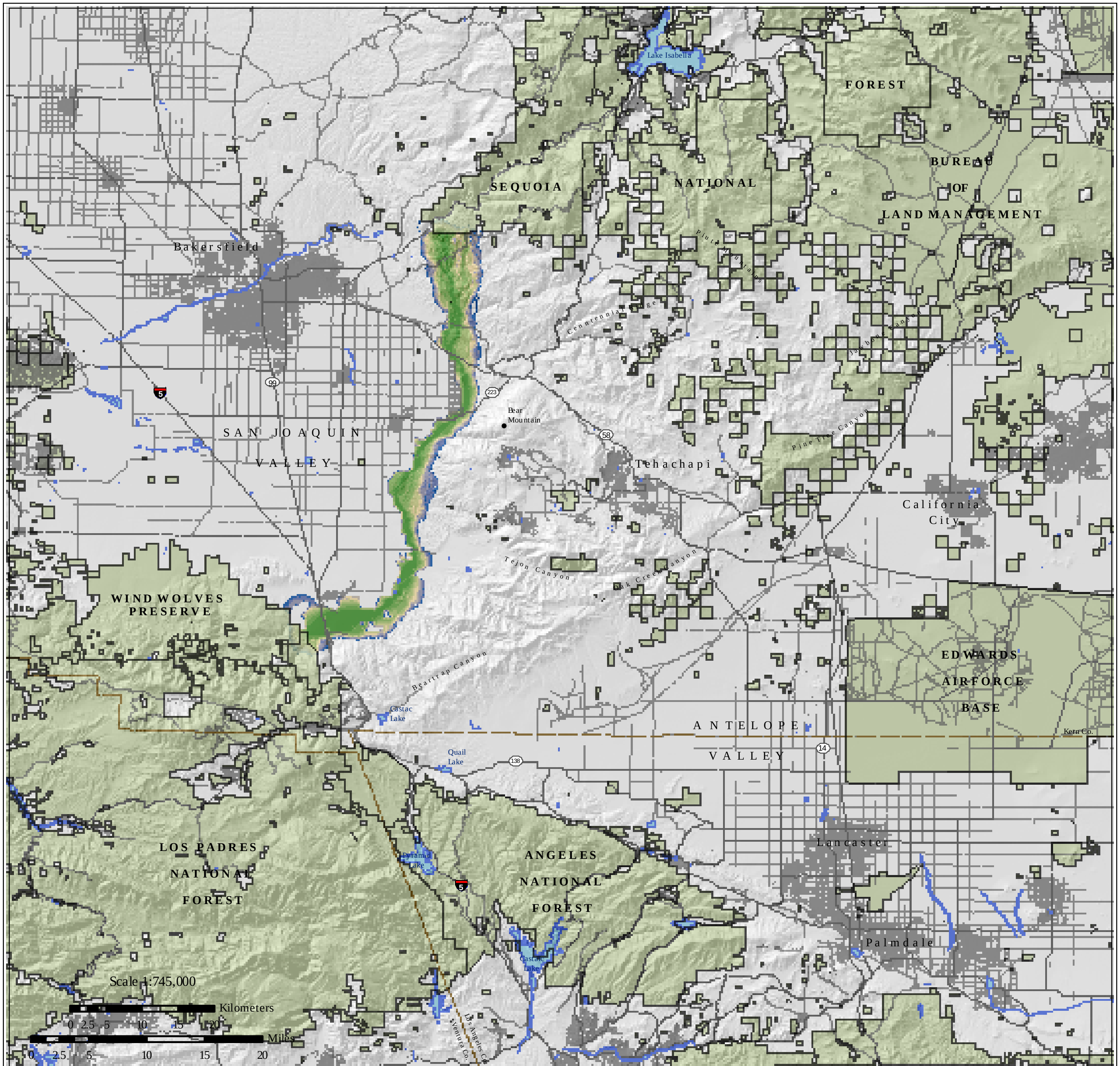
**Results & Discussion:** The landscape permeability analysis identified the arc of the San Joaquin Valley floor as the best potential travel route (Top 1%) for intergenerational movement of blunt-nosed leopard lizard between core areas (Figure 17). The output provided by the landscape permeability analysis corresponds with areas identified as conservation targets (Recovery Task # 5.3.8) for this species in the recovery plan for upland species of the Valley (USFWS 1998).

**Figure 17.**
**Least Cost Corridor**
**for**
**Blunt-nosed leopard lizard**
***(Gambelia sila)***

**Legend**

- Paved Roads
- Ownership Boundaries
- County Lines
- Highly Permeable
- Less Permeable

N

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## Patch Size & Configuration Analysis

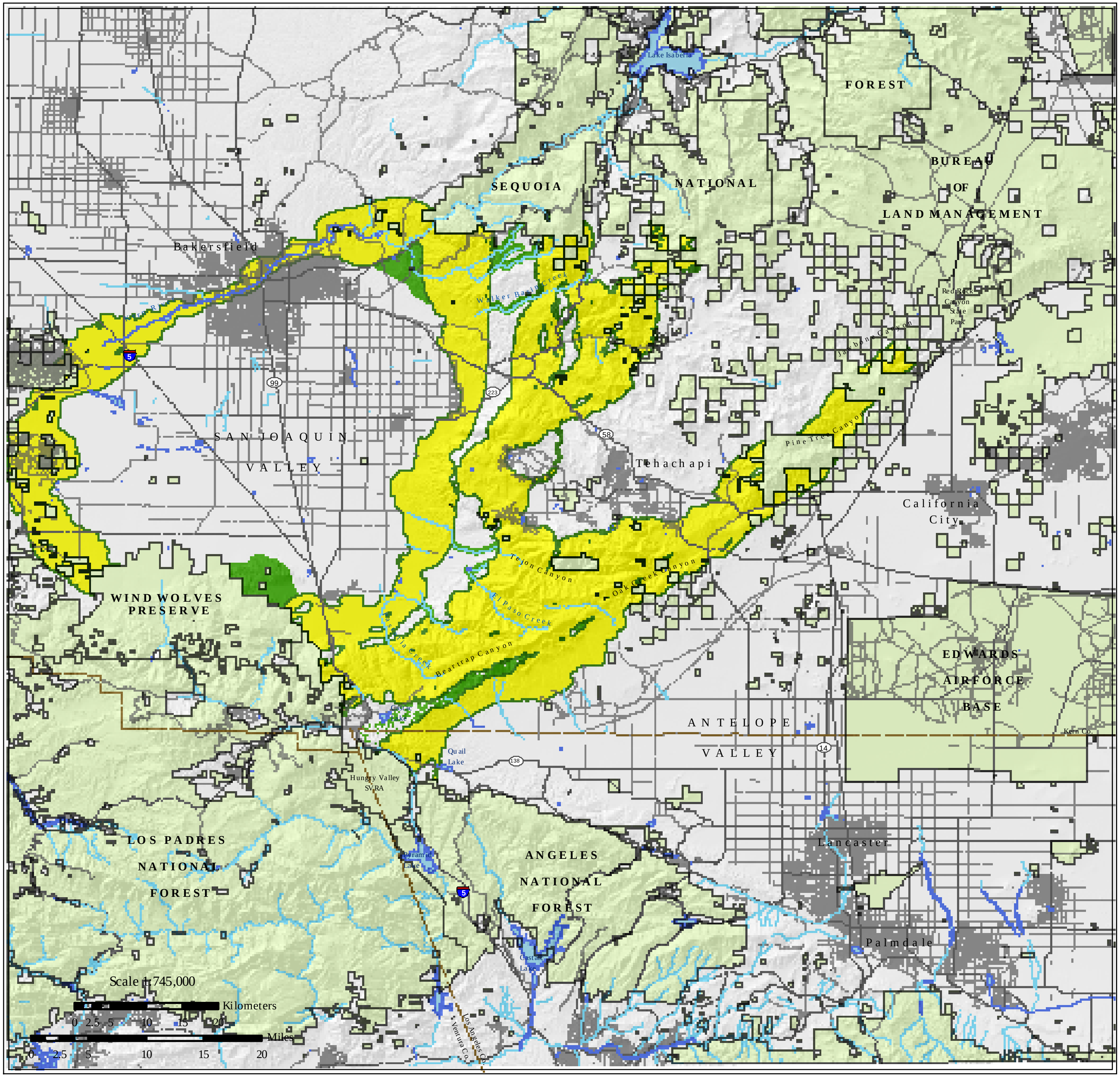
Patch size and configuration analyses were used to evaluate the configuration and extent of potentially suitable habitat for all focal species in relation to the Least Cost Union to determine whether each species is likely to be served by the linkage. We used conservation biology principles to identify any additional habitats not captured by the Least Cost Union that are necessary to maintain linkage function. For each species we evaluated whether 1) core areas and patches are within the dispersal distance of the species; 2) the distribution of potentially suitable habitat is natural or because of disturbances; 3) the Least Cost Union is likely to provide the species with sufficient live-in and or move-through habitat; and 4) if a species was not served by the Least Cost Union, whether the species would be accommodated if additional habitat was added. Because of the diversity of habitat preferences among focal species in the same taxonomic group, the majority of focal species appear to be well served by the Least Cost Union. Only 6 of the 34 focal species were determined to require habitat outside of the Least Cost Union, and there was significant overlap in the additional habitats required to meet their needs (Figure 18).

The focal species with the least amount of suitable habitat in the Least Cost Union is Western pond turtle, a species that has a very spotty distribution within the linkage but significant populations occur within the core areas. Potential core areas identified in the analyses for this species include the following perennial streams: Pastoria, Los Alamos, Tunis, El Paso, Tejon, Walk Basin, Rattlesnake, and the North and South Forks of Cottonwood creeks. Portions of these potential population centers not captured in the Least Cost Union were added to meet the needs of this species.

The Least Cost Union was also modified to include portions of Wheeler Ridge and the area south of the Kern River just east of Bakersfield to include the habitat necessary to meet the needs of Blunt-nosed leopard lizard, Tipton kangaroo rat, and Heerman's kangaroo rat. Three other endangered species (Tejon poppy, Bakersfield cactus, and San Joaquin kit fox) will also benefit from these additions. The grassland, scrubland, and wetland communities that once dominated the valley floor have been largely transformed by agricultural, urban and industrial development. Only remnants of these once vast and biologically diverse natural communities remain on the valley's perimeter (Haight et al. 2002). As of 1998, 75 species of plants and animals dependent on habitats in the San Joaquin Valley were federally listed as endangered, threatened or candidate species. The additions included for these species correspond with habitats identified as critical to the survival of many species addressed in the Recovery Plan for Upland Species of the San Joaquin Valley (USFWS 1998).

The long narrow gap in the Least Cost Union boundary on the southeastern slope of the Tehachapis was included to accommodate the California thrasher and Blue Copper butterfly, though many other species that utilize chaparral habitats will also benefit from this addition. The California thrasher is a habitat specialist strongly associated with dense chaparral. The Blue copper butterfly has limited dispersal capabilities (i.e., average dispersal distance of 1 km) and is dependent on various species of buckwheat (*Eriogonum* spp.) that occur in chaparral habitats.

**Figure 18.**
**Least Cost Union Additions**




## Legend

- Least Cost Union
- Additions
- County Lines
- Paved Roads
- Waterbodies
- Perennial Rivers & Creeks

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The final Linkage Design for the Tehachapi Connection includes the habitat additions described above, as well as deletions of the highly urbanized areas bordering the Kern River. The Least Cost Union originally covered 223,131 ha (551,368 ac), excluding protected areas. The collective results of these analyses identified 13,571 ha (33,534 ac) of additional land that was necessary to help ensure that each species is served by the Linkage Design.

The next several pages summarize the patch size and configuration analyses performed for the 6 species that added habitat to the Least Cost Union (i.e., Western pond turtle, blunt-nosed leopard lizard, Tipton kangaroo rat, Heerman's kangaroo rat, California thrasher, and blue copper butterfly). All other focal species appear to be well served by the Linkage Design. **Note:** Please see Appendix D for more detailed information on the results of the focal species patch size and configuration analyses not included in the body of this report.

## Western Pond turtle (*Clemmys marmorata*)

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

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

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

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

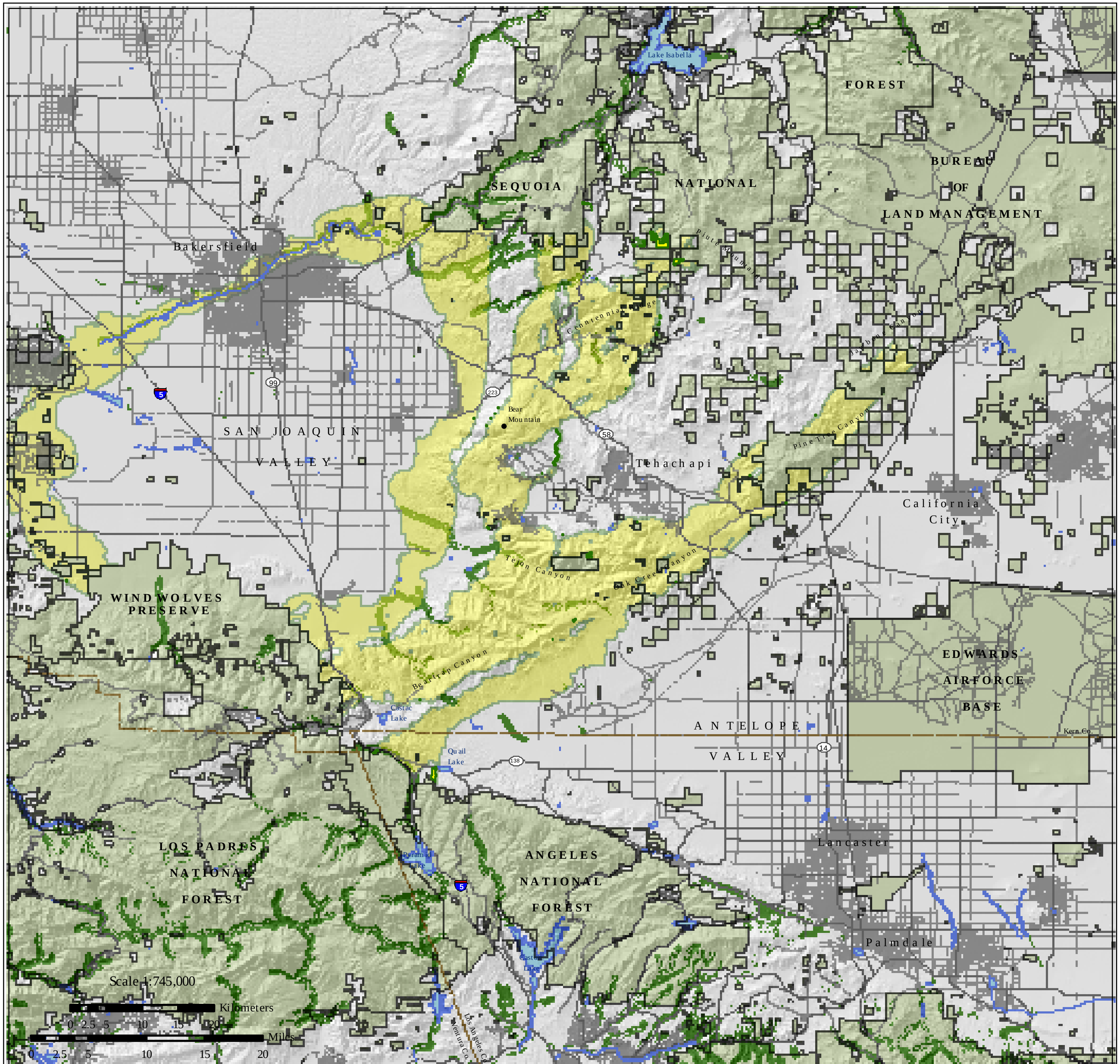
Males and females can travel long dispersal distances along watercourses and overland. Males tend to move greater average and total distances than females or juveniles and can move over 1.5 km along watercourses (Bury 1972). Both males and females can move overland 0.5 km from nearest watercourse (Holland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

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

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

**Results & Discussion:** The linkage may not adequately serve this species, primarily due to the gap in the Least Cost Union boundary (Figure 19). Riparian and aquatic habitats in the Tehachapis historically contained large populations of pond turtles, but changes to these habitats through time have eliminated pond turtles from much of their historic range. For this reason, the linkage is an incredibly important block of habitat to the long-term conservation of this species. Potential core areas not captured in the Least Cost Union include portions of the perennial stream habitat of Tejon, Pastoria, Tunis, Walker Basin, and Cottonwood creeks. These and other perennial creeks included in the Least Cost Union would allow for a wealth of habitat restoration opportunities to enhance existing populations of pond turtles, and possibly re-introduce them into watersheds from which they have been eliminated. Pond turtles can move significant distances from water, and can cross ridges from one watershed to another under certain conditions. For these reasons, the linkage is likely to provide suitable habitat if core areas currently outside of the Least Cost Union were added to the design.

**Figure 19.**
**Potential Cores**
**for**
**Western pond turtle**
***(Clemmys marmorata)***




**Legend**

- Least Cost Union
- Potential Cores
- Paved Roads
- Ownership Boundaries
- County Lines

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## Blunt-nosed leopard lizard (*Gambelia silus*)

**Distribution & Status:** This species was historically distributed throughout the arid lands of the San Joaquin Valley and the adjacent foothills (USFWS 1980). Extant populations are known from Kern and Pixley National Wildlife Refuges, Liberty Farms, Allensworth, Antelope Plains, Buttonwillow, Elk Hills, Tupman Essential Habitat Areas, on the Carrizo and Elkhorn Plains, north of Bakersfield around Poso Creek, and around the towns of Maricopa, McKittrick and Taft (Byrne 1987, R.L. Anderson pers. Comm., L.K. Speigel pers. comm. *in* USFWS 1998, USFWS 2001). The species has also been documented near the Kern Front oil field, at the base of the Tehachapis and west of the California Aqueduct on Tejon Ranch, and on Wind Wolves Preserve in the San Emigdio Range (USFWS 1998). The blunt-nosed leopard lizard was federally listed as threatened in 1967 and state listed as endangered in 1971.

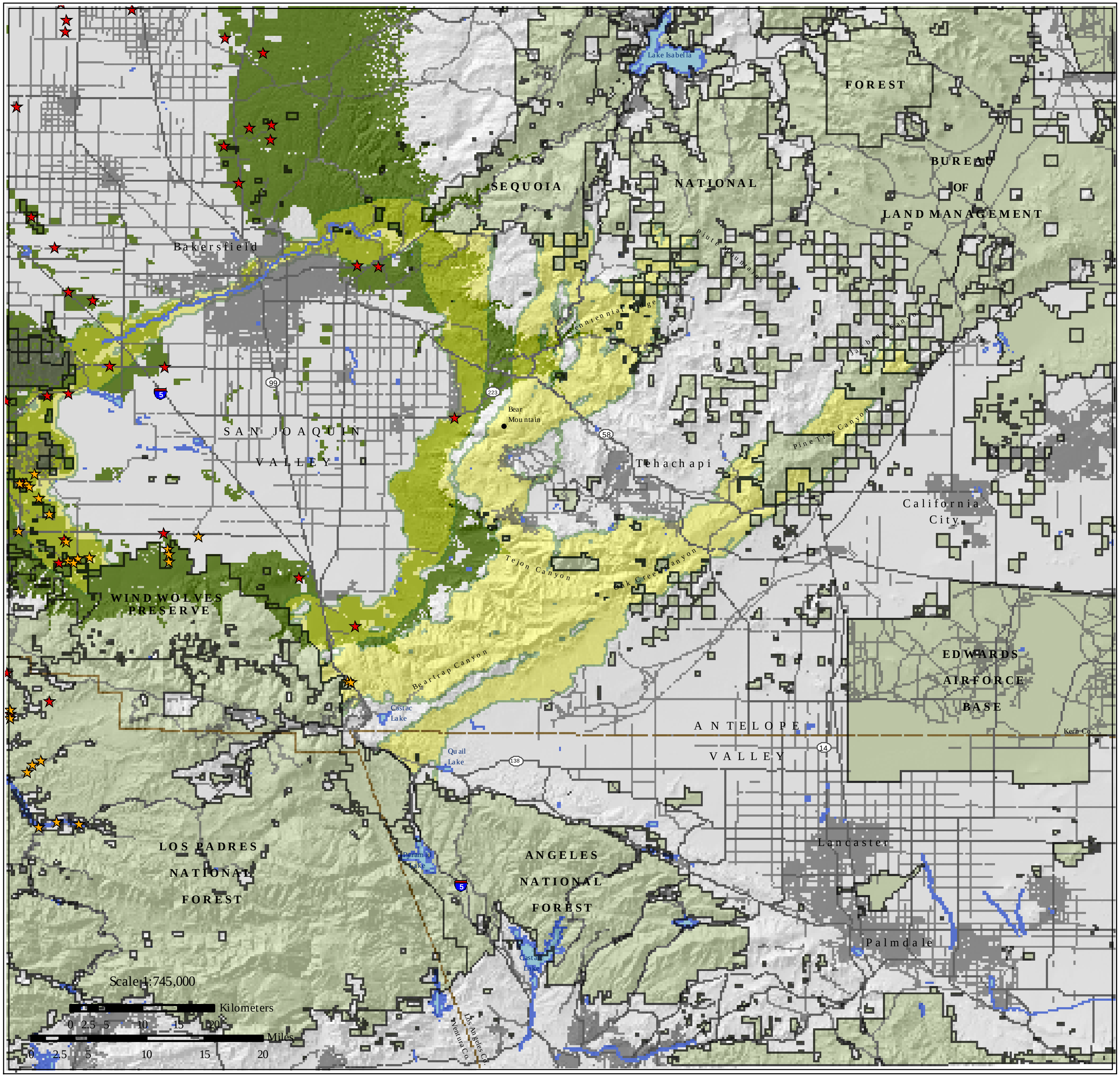
**Habitat Associations:** This species inhabits low foothills, canyon floors, and large washes and arroyos (USFWS 1980) in annual and perennial grassland, alkali playa, Valley sink scrub and Valley saltbush scrub, Sierra Tehachapi Saltbush scrub, Upper Sonoran Subshrub scrub and serpentine bunchgrass habitats (USFWS 1998). They seek refuge in small mammal burrows, under exposed rocks or along banks (CDFG 1988) in sandy, gravelly, or loamy substrates (Stebbins 1985).

**Spatial Patterns:** Recorded home range sizes vary, with an average home range size 0.1 to 1.09 ha for females and 0.21 to 1.7 ha for males (Tollestrup 1983, USFWS 1998). Warrick et al. (1998) recorded much larger home range sizes at the Naval Petroleum Reserves, 5.64 ha for males and 2.42 ha for females. Males are territorial and aggressive (USFWS 1980) but male and female home ranges often overlap. No estimates for dispersal distance were found for this species. Parker and Pianka (1976) report long-range natal dispersal of up to 1186 m for long-nosed leopard lizard (*in* Dudek and Associates, undated mat.).

**Conceptual Basis for Model Development:** This species may be found in grassland, alkali scrub, washes, and foothill riparian habitats between 30-900 meters in the San Joaquin Valley (Stebbins 1985, CDFG 1988). Minimum patch size is less than the minimum mapping unit of 1 ha, thus patch size was defined as $\geq$ than 1 ha but < than 50 ha. Core areas were defined as $\geq$ 50 ha. Dispersal distance was defined based on movements of long-nosed leopard lizard, using twice the recorded distance of 2372 m (1186 m x 2).

**Results & Discussion:** The linkage will likely serve this species, since both sufficient live-in and move-through habitat has been incorporated into the conservation design. There is a fairly contiguous band of remnant grassland habitat along the perimeter of the southern San Joaquin Valley that may function as core habitat for this species and allow intergenerational movement between core areas (Figure 20). The model also identified important core habitat in the Elk Hills, North Coles Levee, and in the lower Kern River. The majority of potentially suitable habitat identified for this species between protected lands in the planning area was captured in the Least Cost Union. Additional habitat exists outside of the Least Cost Union, on Wheeler Ridge, in Tejon Canyon, west of Centennial Ridge, south of the Kern River just east of Bakersfield, and in the foothills of

**Figure 20.**
**Potential Cores**
**for**
**Blunt-nosed leopard lizard**
***(Gambelia sila)***




**Legend**

- Least Cost Union
- Potential Cores
- SERP Occurences*
- CNDDB Observation
- Paved Roads
- Ownership Boundaries
- County Lines

*Data courtesy of CSUS Endangered Species Recovery Program, 1998.

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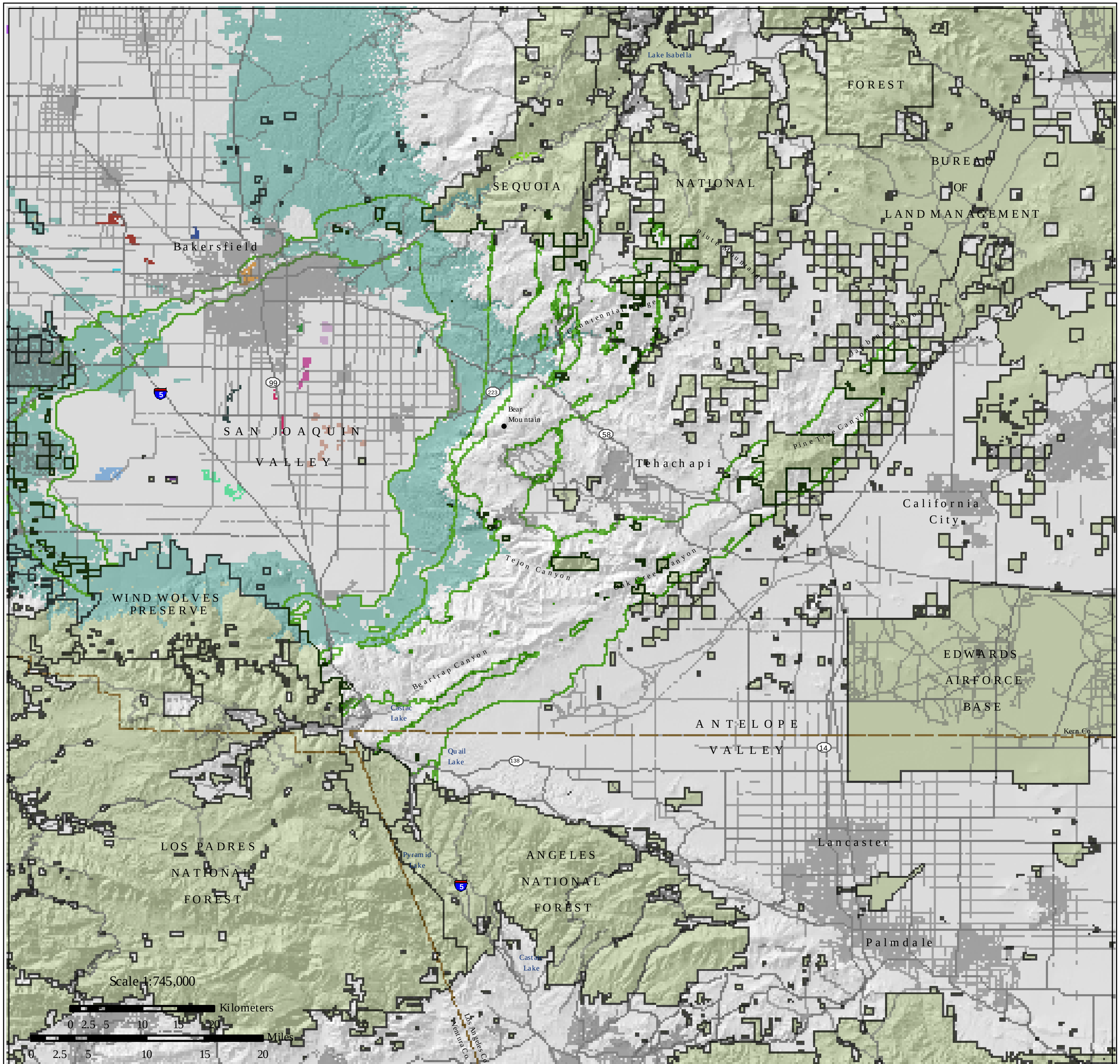
the Sierra Nevada. All potential core areas of potentially suitable habitat are fairly contiguous, and are within the dispersal distance of this species (Figure 21). The present distribution of the species is a natural artifact of a once wider distribution and the potential for enhancement of previously occupied areas is likely available within the linkage.

**Figure 21**
**Patch Configuration**
**for**
**Blunt-nosed leopard lizard**

***(Gambelia sila)***




## Legend

- Least Cost Union
- Paved Roads
- Ownership Boundaries
- County Lines

Colors signify patches of suitable habitat that are within twice the dispersal distance (2,372 m).

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## Tipton Kangaroo Rat (*Dipodomys nitratoides nitratoides*)

**Distribution & Status:** Williams (1985 *in* Williams 1986) estimated this species historically occupied 695,174 ha (1,716,480 ac) of valley floor habitat that extended from Tulare Lake Basin in the north to the southern and western extent of their range in the foothills of the Tehachapi Mountains and the marshes and open water channels of the Kern River alluvial fan. By 1985, Tipton kangaroo rats had been reduced to about 25,000 ha (63,000 ac) or only 3.7% of their historic range. Populations still persist west of Tipton, Pixley, and Earlimart around Pixley National Wildlife Refuge, Allensworth Ecological Reserve, and Allensworth State Historical Park, Tulare County; between the Kern National Wildlife Refuge, Delano, and natural lands surrounding Lamont (southeast of Bakersfield), at the Coles Levee Ecosystem Preserve; and other scattered locales in Kern County (USFWS 1998).

**Habitat Association:** Tipton kangaroo rats are restricted to the arid vegetation communities occupying the valley floor in alluvial fan and floodplain soils in level or nearly level terrain at an elevation of 200 to 300 ft (Williams 1986). Populations were historically most abundant in relictual interior dune grassland and Sierra Tehachapi saltbush scrub communities (USFWS 1998). Today, occupied habitats consist of scattered shrubs with an understory of native and introduced annual grasses associated with valley sink scrub, valley saltbush scrub, and terrace grassland communities. Woody shrubs usually present include saltbush, arrowscale, quailbush, pale-leaf goldenbush, honey mesquite, and seepweed. The species may also be associated with vernal pools and alkaline playas (Williams 1985 *in* USFWS 1998).

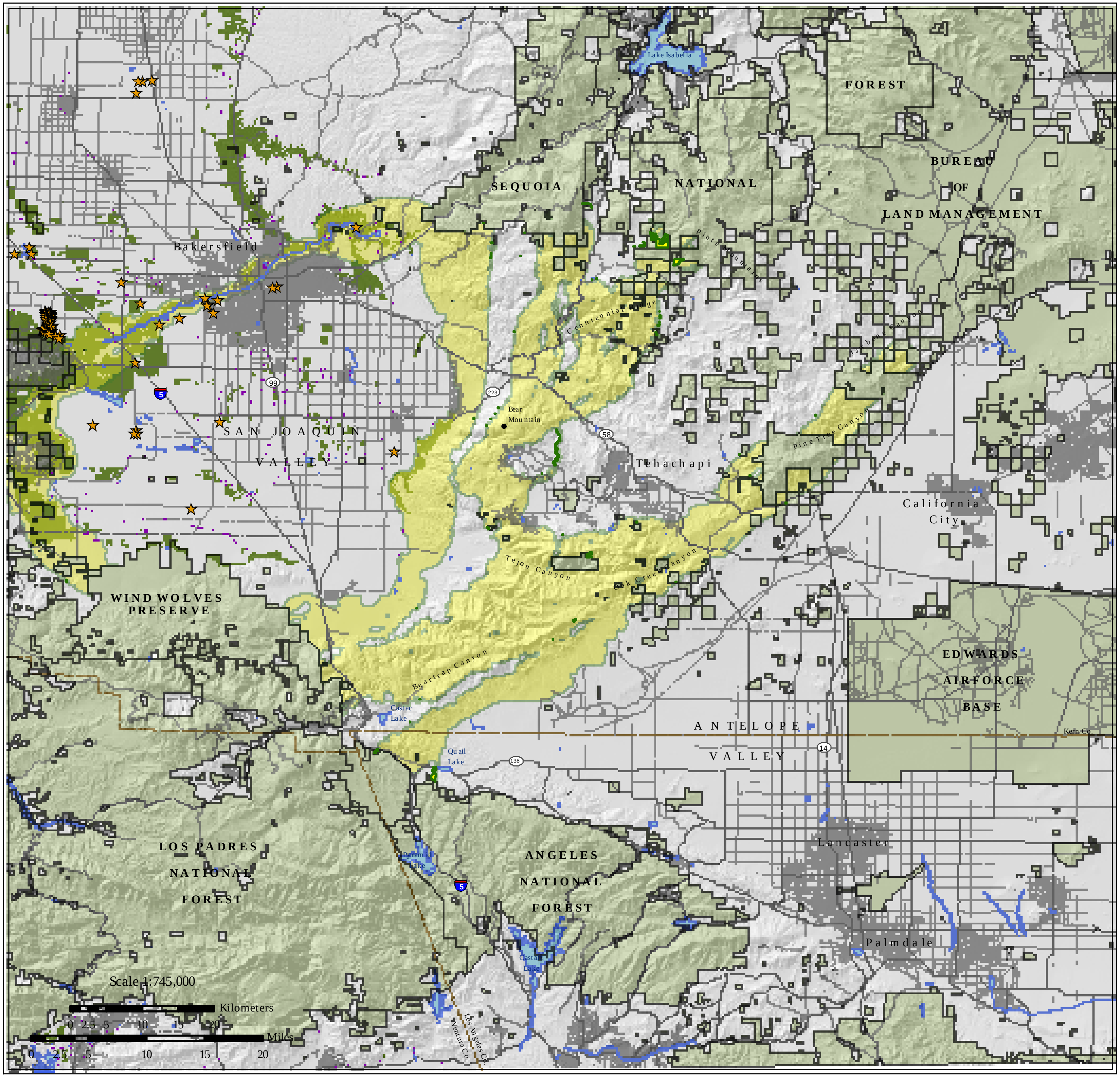
**Spatial Patterns:** No information was found in the literature on home range or dispersal distances for this subspecies. The home range of the closely related Fresno kangaroo rat (*D. n. exilis*) was estimated by Warner (1976) at only about 566 square meters, but this is considered a likely under-estimate (*in* USFWS 1998). A more likely estimate might be based on the closely related (and similar-sized) Merriam's kangaroo rat (*D. merriami*), which has recorded home ranges of about 1.65 ha for males and 1.57 ha for females (Blair 1943).

**Conceptual Basis for Model Development:** No home range or dispersal estimates for this species could be located, so we used the statistics for Merriam's kangaroo rat, an equivalent-sized congener. Home range estimates for *D. merriami* range from about 0.26 ha to 1.65 ha, depending on location, season, and sex. We used 1 ha as the minimum patch size for Tipton kangaroo rat because that is the minimum mapping unit for the GIS and approximates an average to large home range for these small kangaroo rats. Patch size was thus defined as $\geq$ 1 ha and < 16 ha. Core areas were defined as $\geq$ 16 ha. Dispersal distance was defined as 768 m, twice the recorded distance for Merriam's kangaroo rats (384 m) (Zeng and Brown 1987).

**Results & Discussion:** The Least Cost Union may not completely serve the needs of this species unless some habitat restoration in undertaken (Figure 22). Habitat for this species has been significantly fragmented and reduced in the planning area, though 2 considerable core areas remain (Figure 23). One that encompasses the Maricopa Flats, Buena Vista Hills and Valley, Elk Hills, the North Coles Levee, and up the Kern River to

**Figure 22.**
**Potential Cores and Patches**
**for**
**Tipton kangaroo rat**

***(Dipodomys nitratoides nitratoides)***




## Legend

- Least Cost Union
- Potential Cores
- Patches
- ESRP Occurences*
- Paved Roads
- Ownership Boundaries
- County Lines

*Data courtesy of CSUS Endangered Species Recovery Program, 1998.

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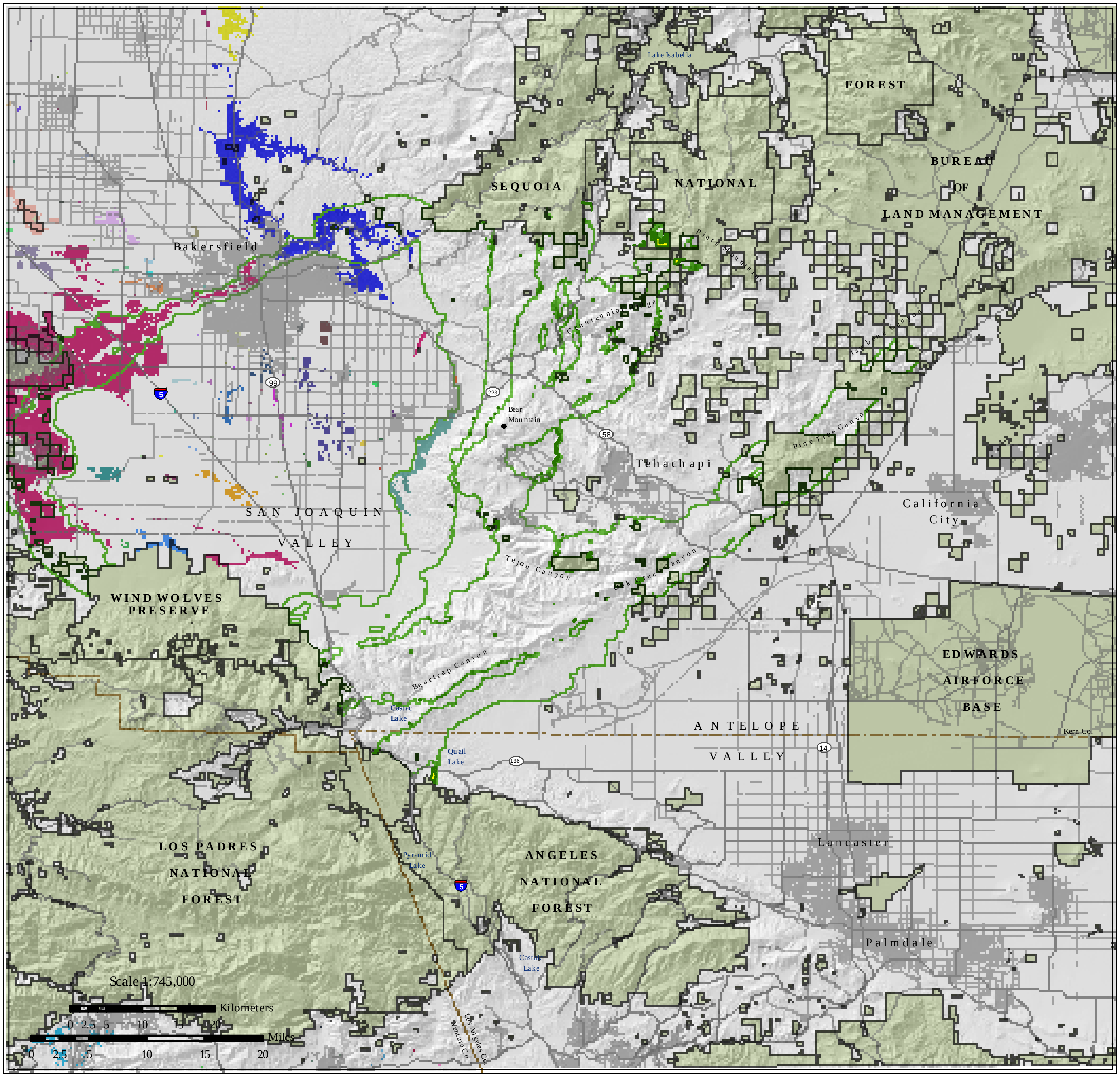
**Figure 23.**
**Patch Configuration**
**for**
**Tipton kangaroo rat**
***(Dipodomys nitratoides nitratoides)***




**Legend**

- Least Cost Union
- Paved Roads
- Ownership Boundaries
- County Lines

Colors signify patches of suitable habitat that are within twice the dispersal distance (768 m).

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where State Routes 99 and 204 cross the River. The other significant core area includes the upper Kern River, Cottonwood Creek, and Sharktooth and Kern River Oil Fields. The Kern River alluvial fan area could serve as a linkage across the San Joaquin Valley between occupied habitats on either side. Ensuring an adequate linkage here would likely require some restoration of agricultural lands that might be retired due to drainage problems (USFWS 1998) and perhaps active management to favor Tipton kangaroo rat populations over the larger, habitat generalist Heerman's kangaroo rat. Another fairly good-sized habitat block that was captured in the Least Cost Union occurs along the southern San Joaquin Valley, at the base of the Tejon Hills. Other important habitat not included in the Least Cost Union occurs along the base of Wheeler Ridge, at the northern most fringes of the Wind Wolves Preserve, south of the Kern River just east of Bakersfield, and in the Sharktooth and Kern River Oil fields.

The output provided by the analysis corresponds with important habitat areas identified in the recovery plan for this species (USFWS 1998). Preliminary studies indicate that expansive core areas will be required to maintain or restore viable metapopulation dynamics for kangaroo rats (Goldingay et al. 1997). The recovery plan suggests core habitat areas of several thousand acres 2,000 ha (about 5,000 ac) are necessary to restore functional metapopulation structure (USFWS 1998).

## Heermann's Kangaroo Rat (*Dipodomys heermanni)*

**Justification for Selection:** There are 7 recognized subspecies (Thelander et al. 1994), several of which are either extinct or highly endangered due to habitat loss and isolation (Goldingay et al. 1997).

**Distribution & Status:** Heermann's kangaroo rat is distributed in the foothills of the Sierra Nevada from Fresno to El Dorado cos., in the San Joaquin Valley to the Tehachapi Mountains, and in the Coast Ranges south of San Francisco Bay to Point Conception (Thelander et al. 1994, CDFG 1999), below about 3,000 feet (Williams et al. 1993).

**Habitat Associations:** This species may inhabit annual grassland, coastal scrub, mixed and montane chaparral, and open stages of valley foothill hardwood and valley foothill hardwood-conifer habitats (CDFG 1999). It is known to utilize dry, grassy plains with friable soils, but it also occurs on hillsides, knolls, and ridges with sparse to moderate chaparral cover (Grinnell 1933, Fitch 1948 *in* CDFG 1999).

**Spatial Patterns:** Home ranges of a half-acre in size have been documented for this species (Thelander et al. 1994). Densities of up to 17 individuals per hectare have been reported in the San Joaquin Valley, but annual fluctuations were significant. Fitch (1948) found most marked individuals to remain fairly close to their burrows, typically within 30-120 m (*in* CDFG 1999).

**Conceptual Basis for Model Development:** This species can inhabit a variety of vegetation communities on generally well-drained soils, including grasslands, scrublands, and open chaparral. It is known from elevations up to about 3,000 feet in the foothills surrounding the San Joaquin Valley (Williams et al. 1993). Home range for this species is 0.31 to 0.33 ha. The minimum patch size is less than the minimum mapping unit of 1 ha, thus patch size was defined as $\geq$ than 1 ha but < 16 ha. Core areas were defined as $\geq$ 16 ha, or 50 times the minimum defined home range of 0.31 ha. No dispersal distance estimates for this species were found in the literature, so we used twice the dispersal distance recorded for Merriam's kangaroo rat 768 m (384 m x 2); movement in the linkage is multigenerational.

**Results & Discussion:** The Least Cost Union includes the North Coles Levee, Elk Hills, Buena Vista Hills and Valley, and Maricopa Flats, around the arc of the southern valley, and then up towards Pixley National Wildlife Refuge (Figure 24). The Kern River alluvial fan area may also serve as a linkage across the San Joaquin Valley between habitats on either side (Figure 25). All potentially suitable habitats identified as core areas are within the dispersal distance of the species. Other important habitat not included in the Least Cost Union occurs along the base of Wheeler Ridge, at the northern most fringes of the Wind Wolves Preserve, south of the Kern River just east of Bakersfield, and in the Sharktooth and Kern River Oil fields. This species' geographic range resembles a donut, with the highly modified floor of the San Joaquin Valley representing the donut hole. The thin rim of remnant habitats around the southern edge of the San Joaquin Valley appears to be the only remaining habitat connection for this species between core habitat areas on either side of the Valley.

**Figure 24.**
**Potential Cores & Patches**
**for**
**Heermann's kangaroo rat**

***(Dipodomys heermanni)***

**Legend**

- Least Cost Union
- Potential Cores
- Patches
- Paved Roads
- Ownership Boundaries
- County Lines

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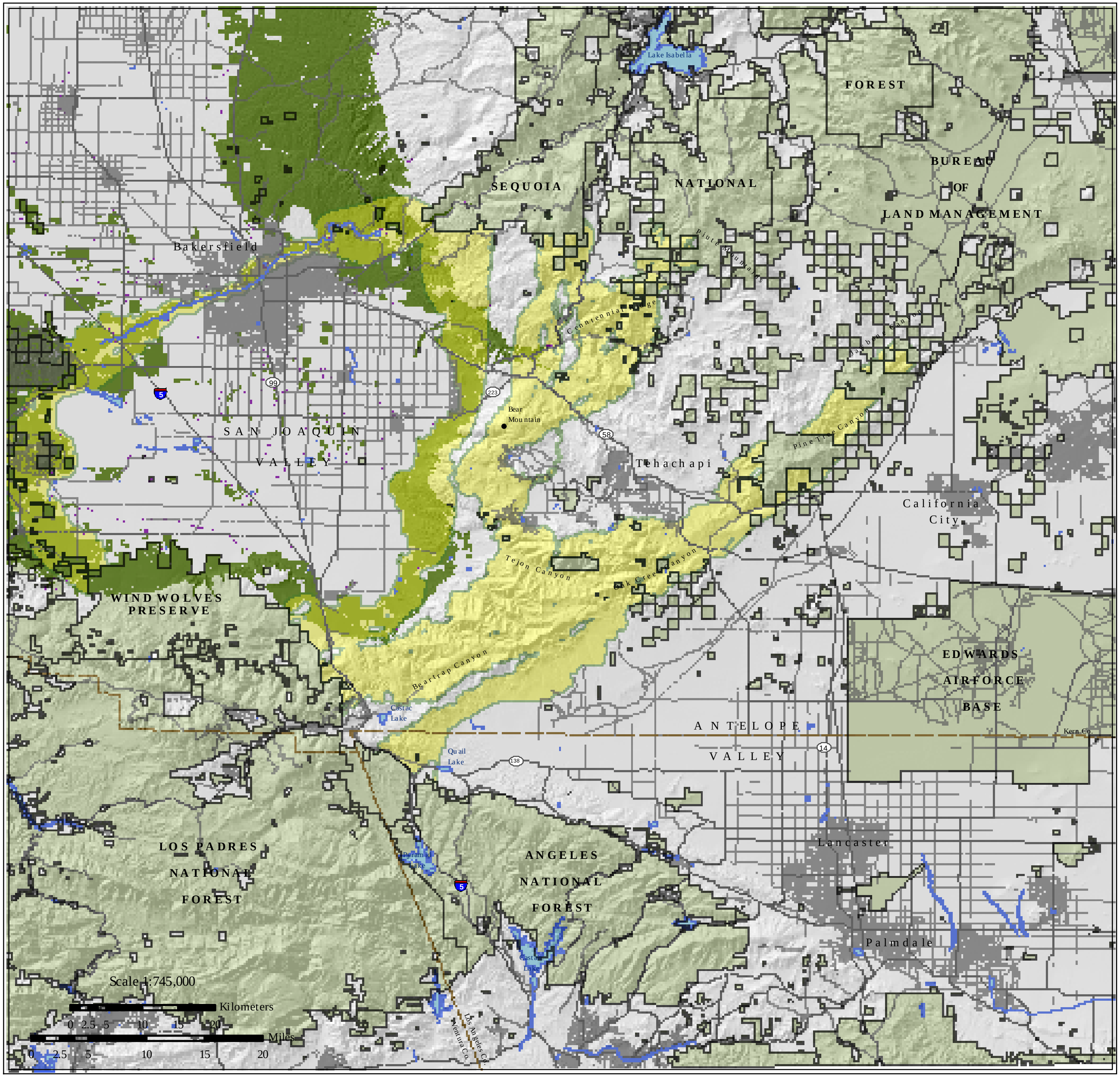
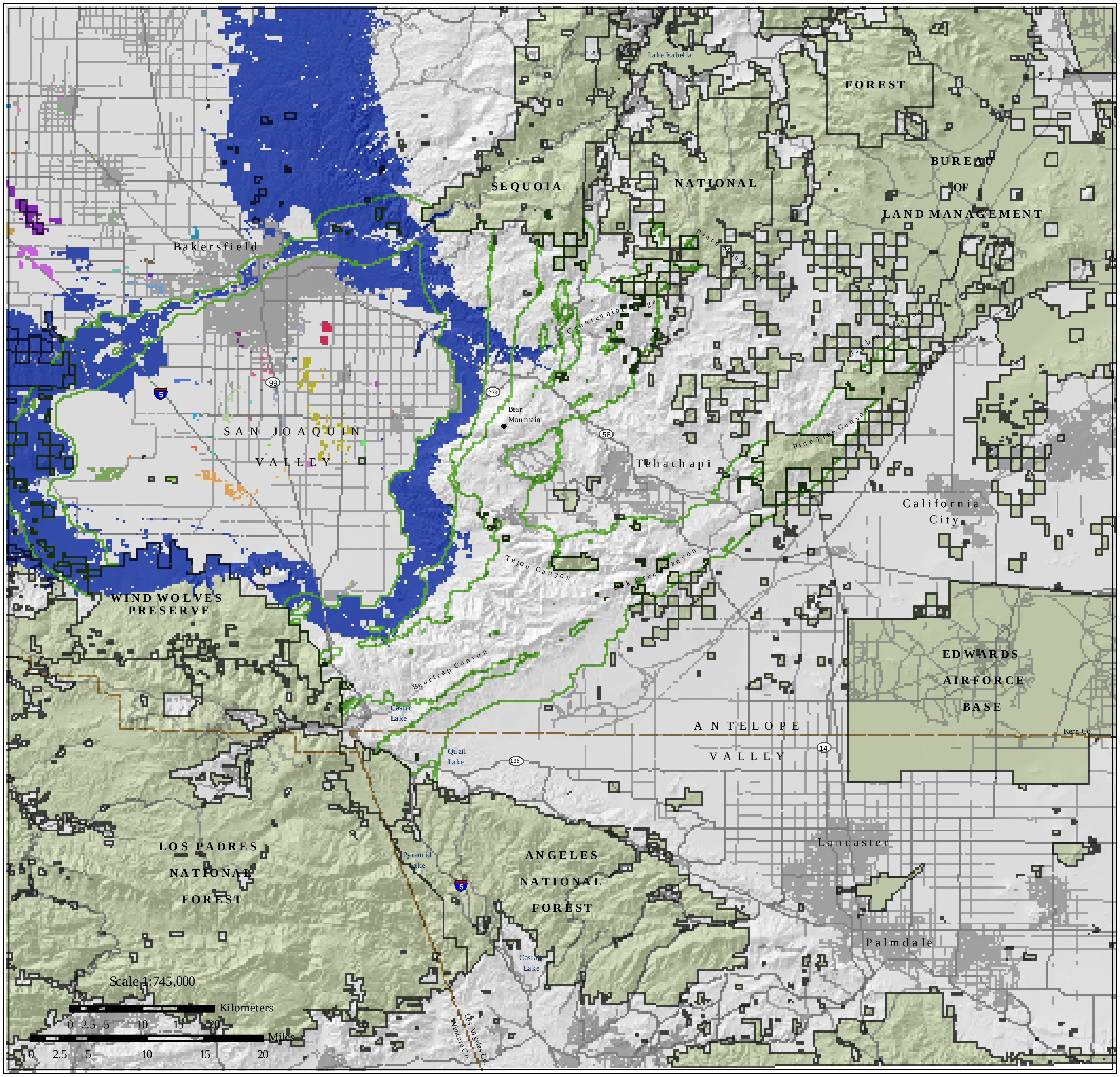


**F i g u r e 25.**
**Patch Configuration**
**for**
**Heermann's kangaroo rat**

***(Dipodomys heermanni)***




## L e g e n d

Least Cost Union

Paved Roads

Ownership Boundaries

County Lines

Colors signify patches of suitable habitat that are within twice the dispersal distance (768 m).

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## California thrasher (*Toxostoma redivivum*)


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

**Distribution & Status:** California thrasher is endemic to the coastal and foothill areas of the California Floristic Province into adjacent areas of northwest Baja California (Cody 1998). In southern California, it occurs in montane chaparral up to 2000 m (6000 ft) (CDFG 1990).

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

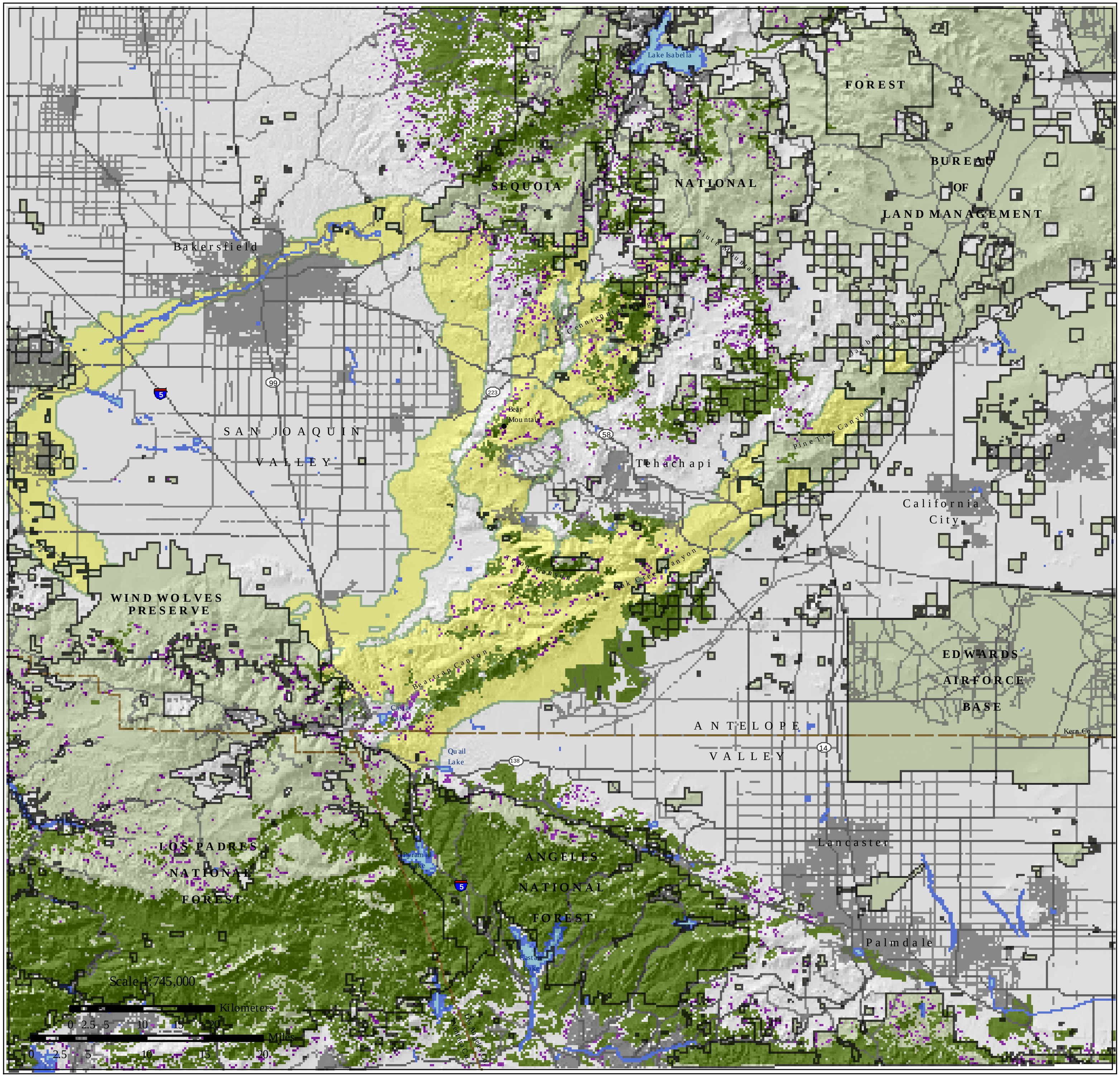
**Spatial Patterns:** Home range size may be up to 20 ha (50 ac) in scrub oak desert habitat (Jehl 1978 *in* CDFG 1990). In the Santa Monica Mountains, territories averaged 1.4 ha (3.5 ac) (Kingery 1962 *in* CDFG 1990). California thrasher is mostly a sedentary resident species, although there may be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

**Conceptual Basis for Model Development:** This species has a strong preference for chaparral vegetation, though it may also be found in riparian, open oak woodlands, or desert scrub habitats. Home ranges sizes have been recorded between 1.4-20 ha. The minimum patch size was defined as 3 ha, using just over twice the smallest recorded territory (1.4 ha x 2). Patch size was classified as $\geq$ 3 ha but < 70 ha. Core areas potentially supporting 50 or more individuals was defined as $\geq$ 70 ha (1.4 ha x 50). No dispersal distances were found for this species in the literature, thus only habitat suitability and patch size analyses were performed.

**Results & Discussion:** Extensive core habitat exists for this species in the Castaic, Sierra Madre, and Sierra Nevada protected areas, as well as in multiple BLM parcels that cover much of Sugarloaf Mountain and Bean Canyon (Figure 26). The Least Cost Union captured potential core areas of Tejon Canyon, Cummings Mountain, Bear Mountain, and Centennial Ridge. Other core areas not included in the Least Cost Union are distributed along the southeastern slopes of the Tehachapis from Castac Lake to Liebre Twins; and on the desert slopes from Canyon del Gato-Montes to Tylerhorse Canyon. Several minimum patches ($\geq$ 3 ha but < 70 ha) are situated between core areas.

**F i g u r e 26.**
**Potential Cores & Patches**
**for**
**California thrasher**

***(Toxostoma redivivum)***




**L e g e n d**

- Least Cost Union
- Potential Cores
- Patches
- Paved Roads
- Ownership Boundaries
- County Lines

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The spatial configuration of suitable habitat within the Least Cost Union may not allow for intergenerational movement between existing protected areas because the core habitats along the southeastern slopes of the Tehachapis are excluded. Though dispersal estimates are lacking for this species, this particular core area extends roughly half the length of the linkage, from near the Los Padres and Angeles National Forest to Oak Creek Canyon, varying in width from approximately 1-2.5 km. The inclusion of this core area is likely essential for any chaparral specialist to facilitate genetic exchange among populations.

## Bright Blue Copper Butterfly (*Lycaena heteronea*)

**Justification for Selection:** This species is vulnerable to extinction throughout its range and was selected because of its sensitivity to habitat loss and fragmentation.

**Distribution & Status:** The species ranges from British Columbia south and east through south central California, northern Arizona, and northern New Mexico. The subspecies that occurs in California (*L. h. clara*) is scarce and very local and is the southern race of a Sierran and Great Basin species (Emmel and Emmel 1973). It occurs in scattered colonies in the vicinity of Mt. Pinos, the Tehachapi, and Piute mountains (Garth and Tilden 1986 and Emmel and Emmel 1973) at elevations between 4,000-10,500 ft (K. Osborne, G. Pratt, and K. Davenport pers. comm.). This species has been proposed for federally endangered status.

**Habitat Associations:** This species occurs in low to middle elevation mountain canyons, in sagebrush scrub, open woodland and forest, mountain meadows, and on river flats (Scott 1986, Struttmann undated mat.). The larvae feed on the leaves of various species of buckwheat (*Eriogonum* spp.) and adults sip the nectar of flowers (Scott 1986). Females stay close to their food plant, various species of buckwheat (*Eriogonum* spp.), which are known to occur in the planning area. *E. umbellatum* occurs through the Piute Mountains and on Breckenridge Mountain, from the pinyon woodland through the Jeffrey pine forest (Twisselman 1967). *E. microthecum* occurs on dry ridges and washes in pinyon woodland south to Jawbone Canyon. *E. latifolium auriculatum* occurs in the Temblor Range; *E. l. nudum* occurs in the grasslands of the Temblor Range south to the Mt. Pinos area and in the foothills of the Greenhorn Range; *E. l. pauciflorum* occurs in the red fir forest on Sunday Peak; *E. l. saxicola* occurs at mid elevations around Mt. Pinos and in Jeffrey pine forests, sometimes in desert facing canyons (Twisselman 1967). Males often perch on and hold territories in tall sagebrush scrub particularly *Artemesia tridentate* (Emmel and Emmel 1973), which may occur on valleys and slopes in sagebrush scrub, Jeffrey pine, pinyon woodland, Douglas oak woodland, chaparral, dry meadows, and Great Basin scrub (Twisselman 1967).

**Spatial Patterns:** They have one flight from late June to early August. The bright blue copper typically travels a distance of 1 km, although it may occasionally journey long distance of up to 10 km (K. Osborne, G. Pratt, and K. Davenport pers. Comm.). Males may patrol in search of females or perch while awaiting females.

**Conceptual Basis for Model Development:** Movement between Core Areas in the linkage is multigenerational, though the species may disperse up to 1 km and may occasionally travel up to 10 km. No home range or density estimates were found in the literature, therefore only potentially suitable habitat was delineated. They are associated with valleys and slopes in sagebrush scrub, Jeffrey pine, pinyon woodland, Douglas oak woodland, chaparral, dry meadows, and Great Basin scrub with *Artemisia tridentate* and various species of buckwheat. Good nectar sources will aid in the movement of this species (K. Osborne, G. Pratt, and K. Davenport pers. comm.). Dispersal distance was defined as 2 km for the patch configuration analysis, double the estimated dispersal distance.

**Results & Discussion:** The Least Cost Union captured potentially suitable habitat for this species on the lower southeastern slopes of the Tehachapis, in Oak Creek Canyon, Cummings Mountain, Pine Tree Canyon, and Bear Mountain. Important habitat not captured in the Least Cost Union includes the gap in the boundary along the southeastern flank of the Tehachapis, and the Sugarloaf Mountain area (Figure 27). The patch configuration analysis identified significant core areas for this species in the Sierra Madre, Tehachapi, and Sierra Nevada Ranges that are within twice the dispersal distance of this species (Figure 28). The area on the southeastern slopes of the Tehachapis not captured in the Least Cost Union is essential for this species because of the spatial configuration of suitable habitat and the species limited dispersal capabilities (2 km).

**Figure 27.**
**Potential Cores for**
**Bright blue copper butterfly**
***(Lycaena heteronea clara)***

**Legend**

- Least Cost Union
- Potential Cores
- Paved Roads
- Ownership Boundaries
- County Lines

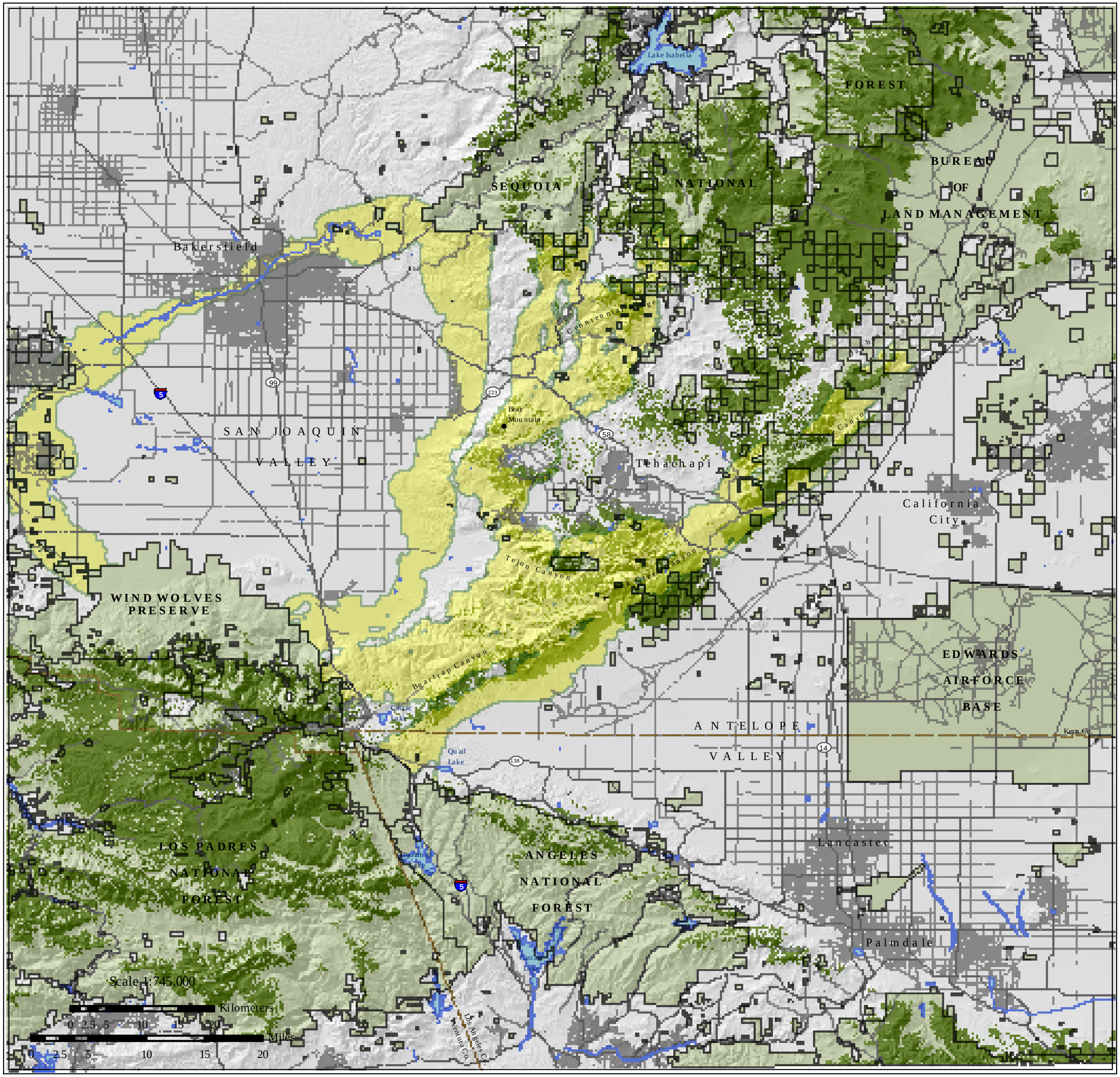


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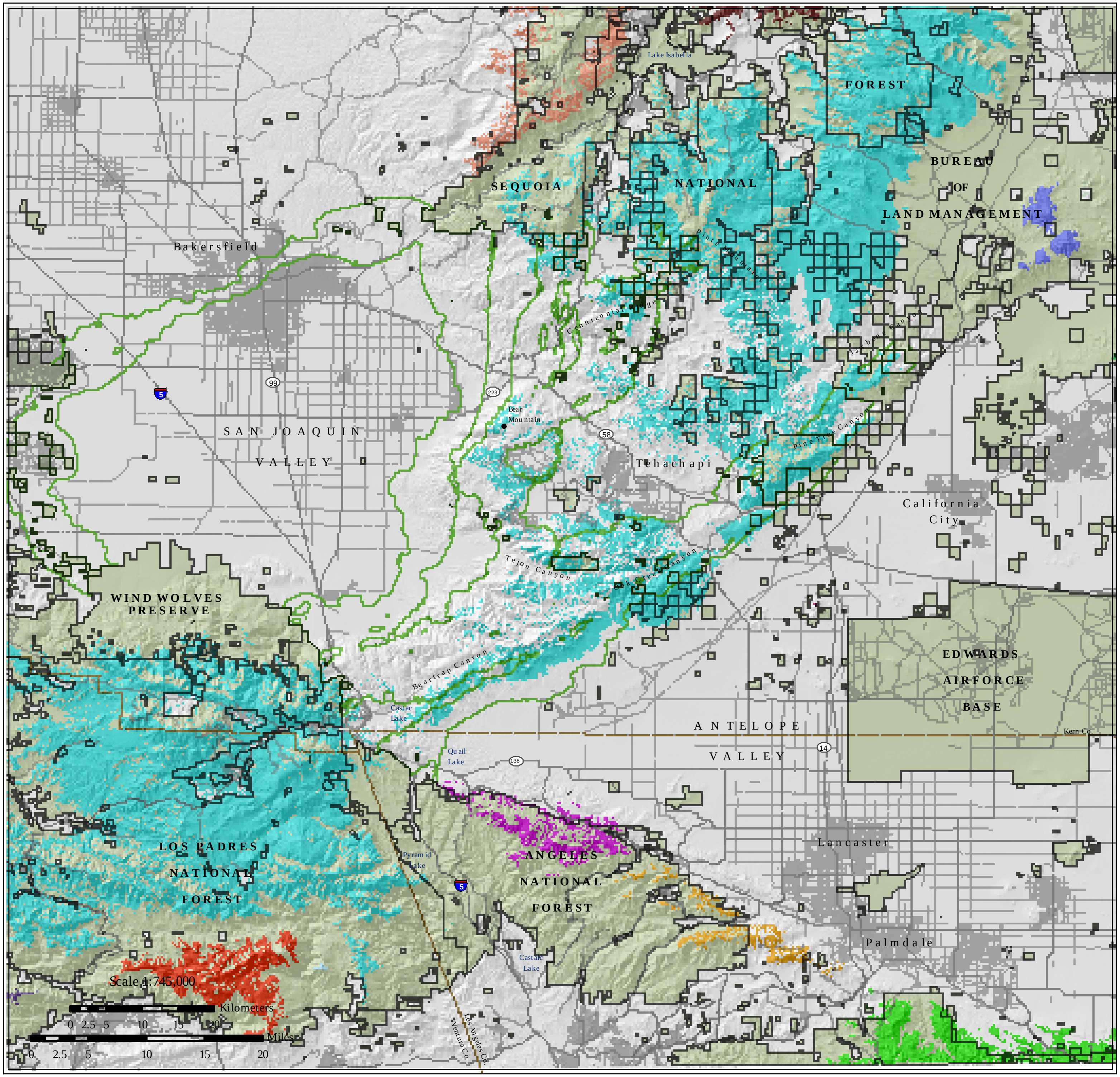
**Figure 28.**
**Patch Configuration for Bright blue copper butterfly**
***(Lycaena heteronea clara)***




**Legend**

- Least Cost Union
- Paved Roads
- Ownership Boundaries
- County Lines

Colors signify patches of suitable habitat that are within twice the dispersal distance (2 km).

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## Description of the Linkage

The final Linkage Design is multi-pronged to accommodate the range of species and ecosystem functions it serves (Figure 29). The four main prongs tend to follow elevational contours and thereby connect along areas of similar ecological conditions. One prong includes a swath of grassland and foothill habitats along the southern rim of the San Joaquin Valley to serve the suite of grassland-dependent species clinging to existence there, such as the endangered San Joaquin kit fox, blunt-nosed leopard lizard, badger, and Tejon poppy. A second prong connects a series of higher elevation forest and shrubland habitats serving numerous species, including puma, California spotted owl, western gray squirrel, and mule deer. A third prong follows the desert-side slopes of the Tehachapis, thereby connecting habitats for species, such as the Tehachapi pocket mouse, that are restricted to the unique conditions of this biogeographic contact zone.

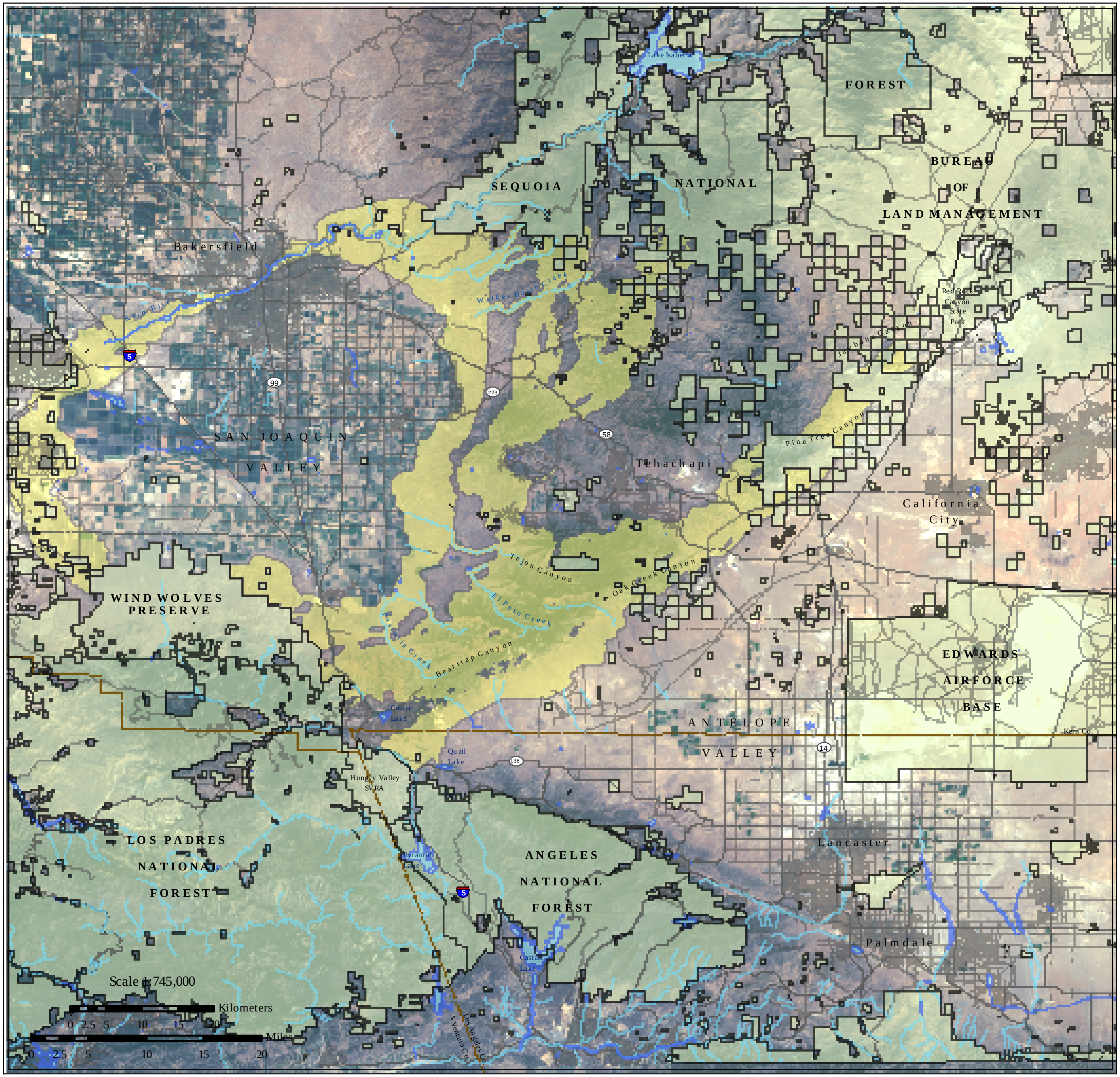
These first three major prongs, or linkages, are clearly separated in the northeastern portion of the study region where each connects into the Sierra Nevada, but they tend to fuse in the more geographically constrained southwestern portion of the study area, in the western Tehachapis. Some cross connections were added between these prongs to serve the movement needs of species, such as the western pond turtle, that require aquatic and riparian habitats running orthogonal to the main contour-following linkages.

Although the three main elevational prongs described above resulted from our objective modeling efforts, their existence was largely anticipated by participants in the September 30, 2002, Biological Foundations Workshop. It was a common perception amongst biologists familiar with this region that the needs of the valley floor, montane, and desert species would be met by different linkages in these distinct geographic bands, which has been substantiated by our analyses. However, a forth prong was a somewhat unexpected result of our permeability models. This linkage follows alluvial habitats along the Kern River directly across the San Joaquin Valley to connect alluvial grasslands and rare alkali habitats required by various valley-floor species, such as the endangered Tipton kangaroo rat. In retrospect, we should have anticipated this linkage despite the highly altered nature of the valley floor it passes through. In fact, the importance of this linkage was documented in the recovery plan for the Valley (USFWS 1998).

## Natural Communities in the Linkage

As might be expected in this remarkable “biogeographic crossroads” (White et al. 2003) the Linkage Conservation Design encompasses a tremendous diversity of natural communities, including over 30 distinct vegetation communities (Table 3). Although natural vegetation comprises most of the Linkage Design (about 95%) agriculture and urban development cover roughly 5% of its area. Unfortunately, only about 12% (78,355 out of 663,257 total acres) of the Linkage Design currently enjoys some level of conservation protection (Figure 29), mostly in BLM parcels.

**Figure 29.**
**Linkage Design**
**for the**
**Tehachapi Connection**




**Legend**

- Linkage Design
- Ownership Boundaries
- Paved Roads
- County Lines
- Waterbodies
- Perennial Rivers & Creeks

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| Table 3. Approximate Vegetation and Land Cover in the Linkage | | |
|---|---|---|
| **Vegetation Type** | **Hectares** | **Acres** |
| Annual Grassland | 111,228 | 274,850 |
| Unknown Shrub Type | 26,714 | 66,011 |
| Blue Oak Woodland | 21,418 | 52,925 |
| Desert Scrub | 20,206 | 49,930 |
| Mixed Chaparral | 15,778 | 38,987 |
| Valley Oak Woodland | 11,994 | 29,638 |
| Pinyon-Juniper | 11,631 | 28,110 |
| Agriculture | 9,313 | 23,013 |
| Montane Hardwood | 8,514 | 21,039 |
| Blue Oak-Foothill Pine | 7,990 | 19,743 |
| Alkali Desert Scrub | 5,576 | 13,778 |
| Urban | 3,890 | 9,612 |
| Unknown Conifer Type | 2,266 | 5,599 |
| Coastal Oak Woodland | 1,755 | 4,337 |
| Sierran Mixed Conifer | 1,662 | 4,107 |
| Jeffrey Pine | 1,390 | 3,435 |
| Sagebrush | 1,290 | 3,188 |
| Chamise-Redshank Chaparral | 1,008 | 2,491 |
| Bitterbrush | 978 | 2,417 |
| Ponderosa Pine | 796 | 1,968 |
| Juniper | 726 | 1,794 |
| Montane Chaparral | 511 | 1,263 |
| Perennial Grassland | 486 | 1,200 |
| Coastal Scrub | 374 | 924 |
| White Fir | 347 | 857 |
| Montane Hardwood-Conifer | 225 | 556 |
| Riverine | 213 | 526 |
| Water | 158 | 390 |
| Barren | 127 | 314 |
| Valley Foothill Riparian | 68 | 168 |
| Freshwater Emergent Wetland | 28 | 69 |
| Wet Meadow | 4 | 10 |
| Lacustrine | 3 | 7 |
| **Total** | **268,411** | **663,257** |

Habitats within the linkage are similar to those found in the two Core Areas, with grasslands, oak woodlands, coniferous forests, desert scrub, and pinyon-juniper woodland communities predominant (Figure 3). Grasslands are distributed in a contiguous arc around the San Joaquin Valley floor for the entire extent of the planning area, extending through Tehachapi Pass and the Quail Lake area and into the Tehachapi Valley. Grassland is the most common habitat in the Linkage Design, accounting for 42% of its natural vegetative cover. Oak woodlands predominate above the grasslands, covering 19% of the Linkage Design, mostly at mid-elevations in the

Tehachapis. Blue oak woodland comprises roughly 40% of oak woodlands in the Tehachapi Mountains, though Valley oak woodlands are also abundant. Desert scrub and woodland community connections occur from the San Emigdio Mountains and Frazier Mountain area, along the southeastern slopes of the Tehachapi Mountains, to Pine Tree and Jawbone canyons. Chaparral communities are distributed along the northwest facing slopes in Beartrap Canyon, on its ridges, on the southeastern flank of the Tehachapis both above and below the pinyon juniper association, and on the slopes of Cummings and Sugarloaf mountains.

Mixed coniferous forests occupy roughly 2% of the Linkage Design at mid to upper elevations. The pine associations in the Tehachapis differ somewhat from those found at higher elevations in the core areas on either end of the Linkage Design. However, affinities between high-elevation plant assemblages in the Sierra Madre and Sierra Nevada suggest that under moister climatic conditions, the linkage may have allowed dispersal of plant species from the Sierra Nevada into the Sierra Madre. Valley foothill riparian vegetation occurs along the Kern River and numerous drainages flowing from the mountain ranges into the San Joaquin Valley.

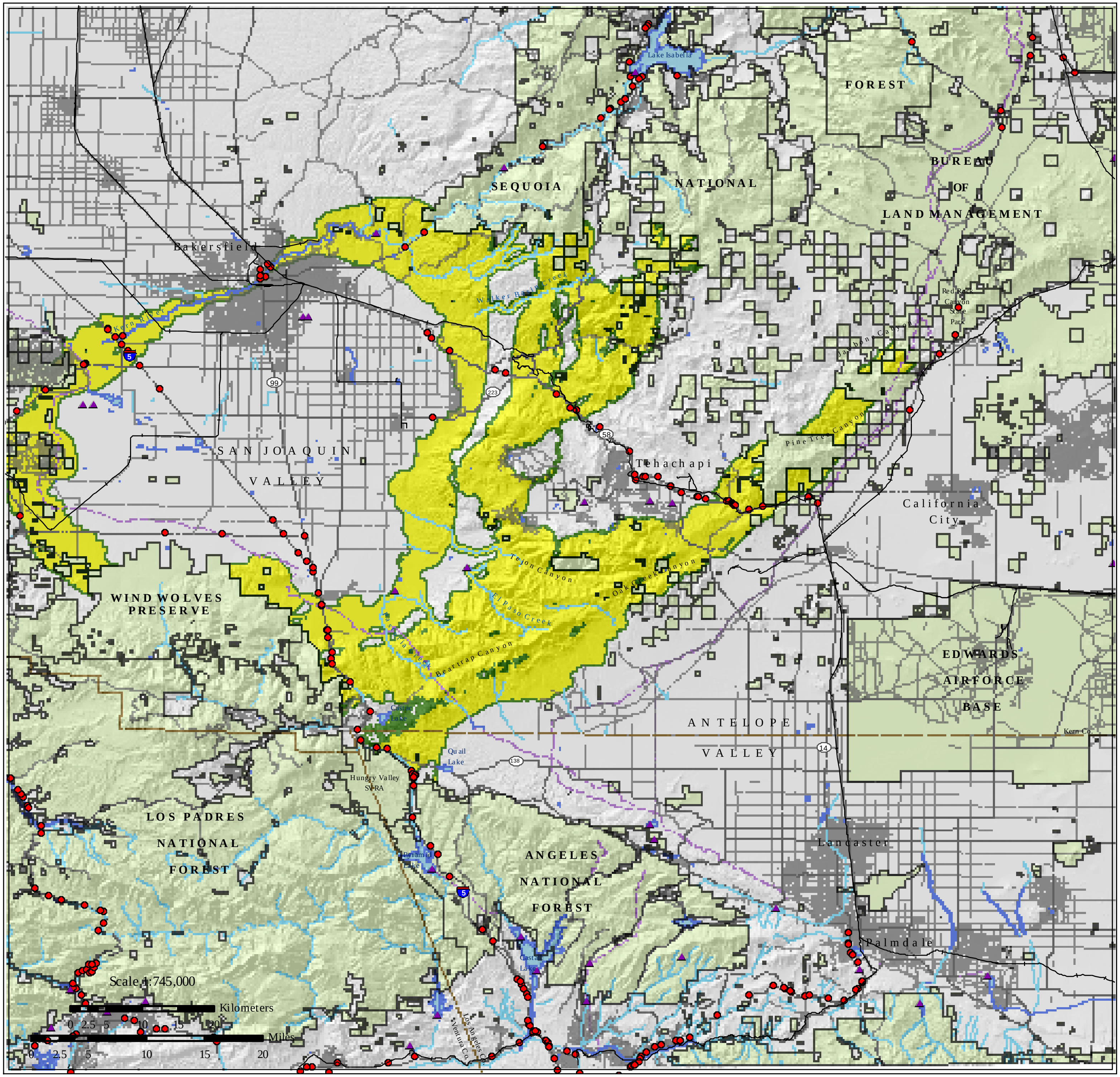
**Removing and Mitigating Barriers to Movement**

Five types of features impede species movements through the Linkage to varying degrees: roads, the California Aqueduct, dams or other impediments to stream flow, urban development, and agriculture (Figure 30). Although these comprise only a small portion of the Linkage Design area, their adverse effects on species movements are disproportionately large, and ameliorating them is essential to maintain or restore functional linkages. This section describes these impediments and suggests where and how their effects may be mitigated to improve linkage function.

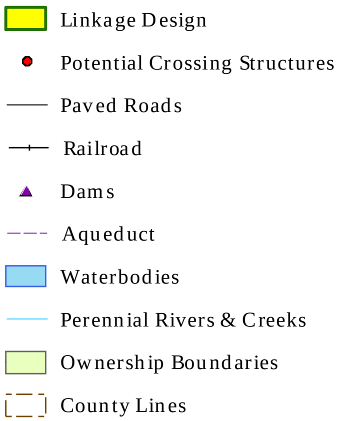
This discussion focuses on structures to facilitate movement of terrestrial species across roads or aqueducts, and on structures to facilitate stream flow under roads. Although some documents refer to such structures as “corridors” or even “linkages,” we use these terms in their original sense to describe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

**Roads as Barriers to Upland Movement:** Wildland fragmentation by roads is increasingly recognized as one of the greatest threats to biodiversity (Trombulak and Frissell 2000, Forman and Deblinger 2000, Jones et al. 2000, Reijnen et al. 1997, Noss 1983, Harris 1984, Wilcox and Murphy 1985, Wilcove et al. 1986, Noss 1987). Roads cause fragmentation by killing animals in vehicle collisions, by creating discontinuities in natural vegetation (the road itself and induced urbanization), by altering animal behavior (noise, artificial light, human activity), by promoting invasion of exotic species, and by

# Figure 30. Existing Infrastructure in the Planning Area




## Legend




South Coast Wildlands Project

Map Produced By:
South Coast Wildlands Project
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degrading the chemical environment (Lyon 1983, Noss and Cooperrider 1994, Forman 1998). Roads present semi-permeable barriers for non-flying animals (e.g., insects, fish, amphibians, reptiles, and mammals) and even some flying species (e.g., butterflies and low-flying birds). The genetic isolation of populations caused by roads is an increasing cause of concern. For example, Ernest (2003) documented little flow of mountain lion genes between the Santa Ana and Palomar ranges (where I-15 is the most obvious barrier), and between the Sierra Madre and Sierra Nevada (where I-5, and urbanization along SR-58, are the most obvious barriers). Fragmentation by roads increases inbreeding and genetic drift, potentially contributing to extinction of local populations.

The impact of a road on animal movement varies with species (e.g., the same freeway would have different impact on ground beetles, coyotes, or birds), context (vegetation and topography near the road), and road type and level of traffic (Clevenger 2001). For example, a road on a stream terrace can cause significant population declines in slow-moving amphibians approaching breeding ponds (Stephenson and Calcarone 1999), but a similar road on a ridgeline would have negligible impact on the population. Virtually all documented impacts of roads on animal movement concern paved roads; low-speed dirt roads are of much less concern, and may even facilitate movement of focal species such as mountain lions (Dickson et al. 2004).

**Types of Mitigation for Roads:** Forman et al. (2003) suggest several ways to mitigate the ecological impact of roads on landscape linkages by creating wildlife crossing structures and reducing traffic noise and light, especially at entrances to crossing structures. Wildlife crossing structures have been successful both in the United States and in other countries (DOT 2000, 2002), and include underpasses, culverts, bridges, and bridged overcrossings. Most structures were built to accommodate streamflow, but have been documented to be useful for wildlife movement. Research and monitoring have confirmed the value of these structures in facilitating wildlife movement. The main types of structures, from most to least effective, are vegetated land-bridges, bridges, and culverts.

There are about 50 vegetated wildlife overpasses, or vegetated land bridges in Europe, Canada, Florida, Hawaii, New Jersey, and Utah (Evink 2002, Forman et al. 2003). They range in width from 50 m (164 ft) to more than 200 m wide (656 ft) (Forman et al. 2003). Soil depth ranges from 0.5 to 2 m, allowing for the development of herbaceous, shrub and tree cover (Jackson and Griffin 2000). Wildlife fencing is necessary to funnel animals towards passageways and away from roads (Falk et al. 1978, Ludwig and Bremicker 1983, Feldhammer et al. 1986 *in* 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 *in* Forman et al. 2003). Habitat connectivity can be enhanced for small ground-dwelling animals by ensuring contiguous vegetation, or by placing branches, logs, and other cover along the overpass (Forman et al. 2003). Overpasses maintain ambient conditions of rainfall, temperature, light, vegetation, and cover, and are quieter than underpasses (Jackson and Griffin 2000). In Banff, large mammals preferred overpasses to other crossing structures (Forman et al. 2003). Similarly, birds associated with woodland habitats used overpasses significantly more than they did open areas without an overpass. Other research indicates overpasses may encourage birds and butterflies to cross roads (Forman et al. 2003).

Bridges over waterways should be long enough to permit growth of both riparian and upland vegetation along both stream banks (Forman et al. 2003, Evink 2002, Jackson and Griffin 2000). The extended bridge is the most successful and cost-effective means of providing connectivity (Evink 2002). Bridges with greater openness ratios are generally more successful than low bridges and culverts (Veenbaas and Brandjes 1999 *in* Jackson and Griffin 2000). The best bridges, sometimes termed *viaducts*, are elevated roadways that span entire wetlands, valleys, or gorges (Jackson and Griffin 2000), but are cost-effective only where topographic relief is sufficient to accommodate the structure (Evink 2002).

Although inferior to bridges for most species, culverts are also effective (Jackson and Griffin 2000). For carnivores and other large mammals, large box culverts are most effective, and natural earthen substrate flooring is preferable to concrete or metal (Evink 2002). For rodents, pipe culverts 1 ft in diameter without standing water are superior to large, hard-bottomed culverts, apparently because the overhead cover makes them feel secure against predators (Forman et al. 2003, Clevenger 2001). In places where a bridged, vegetated undercrossing or overcrossing is not feasible, placing pipe culverts alongside box culverts can help serve movement needs of both small and large animals.

Noise, artificial night lighting, and other human activity can deter animal use of a passageway (Yanes et al. 1995, Pfister et al. 1997, Clevenger and Waltho 2000 *in* Forman et al. 2003), and noise can deter animal passage (Forman et al. 2003). Shrub or tree cover should occur near the entrance to the crossing structure (Evink 2002). Existing structures can be substantially improved with little investment by installing wildlife fencing, earthen berms, and vegetation to direct animals to passageways (Forman et al. 2003).

**Recommended Locations for Crossing Structures on Interstate 5:** Interstate 5 is probably the most substantial impediment to plants and terrestrial animals within the Linkage Design (Figure 30). It bisects the southern part of the linkage and currently lacks adequate crossing structures. Given the continental importance of this linkage, we have identified three locations at which first-class crossing structures should be located. At each of these three locations, we recommend either a vegetated landbridge, or an ample bridged undercrossing large enough to allow natural vegetation to grow throughout the structure.

The top priority for a crossing structure on I-5 is where Grapevine Creek crosses I-5 just south of Ft. Tejon State Park and the Tejon Ranch Corporate Headquarters. (Grapevine Creek also crosses I-5 in four other locations). The 1% least cost corridors for puma, mule deer, and western gray squirrel cross the freeway here, and appropriate habitats for badger and California thrasher occur along this part of freeway. Natural habitat abuts the freeway for several kilometers in most of this area. Potential habitat for California spotted owl habitat is also least fragmented in this area. Finally, this area offers maximum continuity for oak woodlands along I-5, and thus would best serve the needs of most species associated with oak woodlands, including salamanders and reptiles that were not used in our permeability analyses.

Grapevine Creek now crosses I-5 here in a small concrete box culvert, which should be replaced with a large bridged undercrossing. To maximize the utility of Grapevine Creek as a movement area, we recommend removal of several buildings that now house the

Tejon Ranch Headquarters (two administrative buildings, about a dozen homes, and an old school building), and removing the associated mile of Lebec Road. The area vacated by these buildings should be restored to native vegetation.

Less than half a mile north of the Grapevine Creek undercrossing, there is a freeway interchange for Ft Tejon State Historic Park and Tejon Ranch Headquarters. This interchange is unsafe, below federal Interstate standards, and doubtless will be replaced when CalTrans next works in the area. The interchange also encroaches on Grapevine Creek within Ft Tejon State Park, reducing its utility for animal movement. Therefore, replacement of the interchange by the transportation agencies provides an opportunity to (a) build the Grapevine Creek Bridge and (b) move the interchange about ½ mile north, to the mouth of Johnson Canyon.

Another top priority for a first-class crossing structure on I-5 is a 2-mile-long stretch of grasslands north of the commercial development known as Grapevine and south of the California aqueduct. Least cost paths of American badger and San Joaquin kit fox cross I-5 in this area, which also provides the best habitat connectivity for blunt-nosed leopard lizard and Heerman's kangaroo rat. The extensive grasslands in this area suggest it would be useful for all grassland specialist species whose needs we did not analyze. We suggest a vegetated land bridge in this area. Besides the freeway itself, the only significant infrastructure in this area is a weigh station for southbound trucks that lies in approximately the center of the 2-mile stretch of I-5. With appropriate measures to confine light and noise pollution to the vicinity of the weigh station, there should be no need to move the station. The land on either side of the freeway is entirely in private ownership here.


Figure 31. Culvert on Interstate-5 for Gorman Creek with Hungry Valley State Park in the foreground. Note steep degraded slopes on far side of I-5.

Although less important than the previous two locations, a third priority for a greatly improved crossing structure along I-5 is a 3-mile stretch of freeway south of the village of Gorman and north of the interchange with SR138. The least cost path of the Tehachapi pocket mouse crosses I-5 here, and suitable habitat for several other focal species, such as badger, occurs in this area. The western freeway frontage is Hungry Valley State Park, and the eastern side is private property. East of the freeway, there are about 8-12 homes along the old Gorman Post Road. Most of these are probably compatible with linkage function. However, much of the vegetation on the steep slopes appears to have been overgrazed and now lacks woody cover except in drainage bottoms (Figure 31). Thus restoration or cessation of grazing domestic livestock would be needed. Four concrete box culverts about 5 feet tall and wide are spaced one-half to 1 mile apart, and suggest locations for bridged undercrossings. Each culvert opens directly into Hungry Valley State Park on the west end of the culvert, and into Gorman Valley on the east end (Figure 31). Alternatively, a vegetated land bridge may also be feasible in this stretch of road. Steep slopes, poorly consolidated soils, and seismic constraints may limit the development potential of the private property in this area.


Figure 32: Fill slope along SR-58 that should be replaced with a bridge.

**Recommended Locations for Crossing Structures on State Route 58:** State Route 58 is a 4-lane divided road with heavy traffic volumes (Figure 30). A concrete center divider runs almost continuously from the western foothills all the way east to the Tehachapi Creek Bridge at Keene, and again for another mile near Tehachapi. This barrier is about 5 ft tall from its west end to Bealville Road; elsewhere it is about 2.5 ft tall. The major feeder road to SR58 in the western part of the linkage area (Bear Mountain Road SR223) is a quiet country lane that is not a major impediment today. However, if lanes are added to SR233, wildlife passage should be accommodated. Further east, SR202 runs eastward from the city of Tehachapi into the agricultural but increasingly urban Cummings Valley and nearby residential developments of Stallion Springs and Bear Valley.

Figure 33: View south from the culvert shown in Figure 32, showing oak woodland habitat.

We recommend first-class highway crossing structures (canyon-spanning bridges, or vegetated overcrossings) in three areas along SR-58. The first area is in the grasslands near the San Joaquin Valley floor, between the 900-ft and 1400-ft elevation contours. The 1% Least Cost Corridors for blunt-nosed leopard lizard, San Joaquin kit fox, and American badger all lie in this 2.5-mile wide stretch of SR-58. The best habitat for Heerman's and Tipton kangaroo rats also occurs here. Within this 2.5 miles, probably the best location for an underpass is at the 1020-ft elevation contour, where the freeway now sits on a 40-ft deep layer of fill that spans a small canyon. Replacing this fill slope with a bridge 40 ft above the canyon bottom and about 500 ft long would provide an excellent crossing opportunity. At the 1280-ft contour, there is a similar fill slope that provides an alternate location for a bridge of similar dimensions. The lower elevation fill slope lies in the area modeled as the best habitat for focal species, but habitat quality is high at both sites. The adjacent land is private property, but there are no dwellings or significant infrastructure (besides the highway) in the area.

The second area for which we propose an improved crossing structure is in the oak woodlands between the Hart Flat Road interchange with SR-58 and the village of Keene. There are no homes in the 1.5 miles between Keene and a few dwellings near the Hart Flat Road interchange. The 1% least cost corridors for mule deer and western gray squirrel cross SR-58 here, and the entire area is excellent mountain lion habitat. An excellent location for an underpass is at the 2440-ft contour, where the highway now sits on a 20-ft fill slope that should be replaced with a bridge (Figure 32, Figure 33). Alternatively, it may well be possible to construct a vegetated overcrossing here.

In addition, we recommend maintaining the rural character of the landscape at the bridge over Tehachapi Creek east of the main part of the village of Keene and west of the Keene Post Office (Figure 34). There is about a quarter-mile of wildlands (oak woodland) here, within the village of Keene, disturbed only by a rail line and a 2-lane road connecting the east and west portions of the village. Although this bridge is an excellent crossing structure, it is not sufficient as the sole crossing structure in the oak woodland belt for several reasons. First, it lies on the periphery of the Linkage Design. Second, the crossing structure contains a railroad and a 2-lane paved road. Although the paved road receives little traffic today, we cannot rely on that in the future. Finally, the wildland approaches to the underpass are steep slopes on both sides of the freeway. To the extent that animals tend to follow streams, an animal that descended the steep slope to reach the underpass would be tempted to follow Tehachapi Creek east or west (village of Keene in both directions) rather than ascend the steep slope on the other side.

The third area we recommend for a crossing structure is in the transition zone among Mohave desert, grassland, and woodland west of Tehachapi, where two bridges now span Sand Creek. The 1% least cost paths of Tehachapi pocket mouse, mule deer, and mountain lion all cross SR-58 at these bridge sites. In this case, excellent bridges already exist (Figure 35) and the main task is to ensure that they are not replaced by less-permeable structures when SR-58 is next widened. We also recommend enhancement of riparian vegetation underneath the bridges and approaching them.

Figure 34. SR-58 bridge over Tehachapi Creek. The paved road connects the east and west portions of Keene.

Figure 35. The north side of SR 58 at Sand Creek.

**Other Recommendations Regarding Paved Roads Within the Linkage Area:**

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

- Encourage the transportation agencies to use each road improvement project as an opportunity to replace fill slopes and pipe culverts with box culverts (large enough to allow a clear view to the other side) or bridges (large enough to allow vegetation to grow). Culverts should be a minimum of 5 feet tall and wide for a 2-lane road, 8 feet for a 4-lane road. Promote the use of earthen substrate flooring. In locations where a bridge is not feasible and only a culvert can be provided, install a pipe culvert (designed to remain free of water) parallel to the box culvert to provide for passage of small mammals, amphibians, and reptiles.

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

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

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

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

**Roads as Ephemeral Barriers:** Structures designed for wildlife movement are increasingly common. In southern California, 26 wildlife crossing structures were installed along 22-miles of State Route 58 in the Mohave Desert specifically for desert tortoise movement (Evink 2002). In the South Coast Ecoregion, the Coal Canyon interchange on State Route 91 is now being converted, through a partnership with CalTrans, California State Parks, and Hills for Everyone, from a vehicle interchange into a wildlife underpass to facilitate movement between the Chino Hills and the Santa Ana Mountains. About 8 wildlife underpass bridges and viaducts were installed along State Route 241 in Orange County, although urbanization near this toll road has compromised their utility (Evink 2002). Elsewhere, several crossing structures, including 3 vegetated overpasses, have been built to accommodate movement across the Trans-Canada Highway in Banff National Park (Clevenger 2001). In south Florida, 24 underpasses specifically designed for wildlife were constructed along 64km of Interstate 75 in south Florida in about 1985. The structures are readily used by endangered Florida panthers and bears, and have reduced panther and bear roadkill to zero on that route. Smaller wildlife crossings on State Route 29 in south Florida have proved nearly as effective (Lotz et al. 1996).

Almost all of these structures were designed specifically for wildlife movement along existing highways and were not part of the original road design. This fact demonstrates that the existing low permeability across Interstate 5 should not be accepted as irreversible. Most importantly, the current lack of permeability should not be used as an excuse to develop lands adjacent to the freeway on the grounds that the freeway is a permanent and absolute barrier. Indeed, at least 2 pumas crossed bustling Interstate-15 near Temecula in the early 1990's (Beier 1996, and unpublished data), and another crossed SR-118 near Simi Valley in 2003 (Ray Sauvajot, National Park Service, unpublished data)." In contrast to a road, an urban development creates a barrier that cannot be corrected by building crossing structures. Urban and suburban areas make particularly inappropriate landscapes for movement of all large carnivores, most reptiles and amphibians, and many nocturnal small mammals. Thus development along freeways creates significant new and more permanent obstacles to landscape connectivity, above and beyond that presented by a freeway alone.

Representatives from CalTrans have attended each of the four workshops of the South Coast Missing Linkages effort, and the agency is eager to spend its mitigation dollars in the most important linkage areas. For example, CalTrans recently proposed building a wildlife overpass over SR-118, and in February 2003 CalTrans started removing pavement from the Coal Canyon interchange in Orange County and transferred the property to California State Parks expressly to allow wildlife movement between Cleveland National Forest and Chino Hills State Park. In the case of I-5, improvements may not occur during the next 10-20 years, during which gene flow will continue to be disrupted. However, once connectivity is restored, genomes of all affected species should rapidly recover.

**The California Aqueduct**

On the southwest slopes of the Tehachapi Mountains, the California Aqueduct emerges from a tunnel and divides into two branches (Figure 30). One branch runs east to Lancaster, the other west to Quail Lake, and continuing for another two miles beyond Quail Lake until it enters a buried penstock to Pyramid Lake. The 10-mile-long stretch of above-ground structures present a formidable barrier for the 10 miles of this for most terrestrial animals, with a 50-m wide expanse of water and paved bank slopes of about 100% (45°) slope. Fortunately, most of the aqueduct lies outside of the Linkage Design, with the exception of the 2-miles of aqueduct west of Quail Lake and the concrete overflow canal that extends another mile west. This overflow canal sits atop the buried penstock and approximately follows the border of Angeles NF. It is 6 to 7 feet deep, sheer-sided, 8 ft wide, and bordered on each side with 6-ft chain link topped by 3 strands of barbs. We recommend a vegetated land bridge, at least 300-ft wide, over some portion of the aqueduct west of Quail Lake.

**Impediments to Streams**

For animals associated with streams or riparian areas, impediments are presented by road crossings, exotic species, scouring of native vegetation by increased runoff, water recharge basins, dams, dumping of soil and agricultural waste in streambeds, farming in streambeds, gravel mining, and concrete structures to stabilize stream banks and streambeds. Increased urban and runoff also can create permanent streams in areas that were formerly ephemeral streams; permanent waters can support aggressive invasive species such as bullfrogs and giant Reed, displacing native species. Bullfrogs in particular are known to make waters unsuitable for native amphibians.

To lessen the impact of such impediments within the Linkage Design footprint, we recommend: (a) aggressive enforcement of existing regulations restricting dumping of soil and agricultural wastes in streams, and of regulations restricting farming, gravel mining, and building in streams and floodplains, (b) removal of exotic aquatic species and vegetation from stream and river channels, (c) no additional discharge of urban or agricultural runoff into streamcourses, (d) reduction of existing urban and agricultural runoff, and (e) returning to or mimicking the natural flow regime wherever possible. Three dams occur within the Linkage Design footprint (Figure 30). One on the Kern River managed by the Kern County Department of Parks and Recreation, and 2 owned by Tejon Ranch, on El Paso and Tejon creeks. Three other dams or major diversions occur along the Kern River outside of the Linkage Design footprint, the Buena Vista Dam which is also managed by the Department of Parks and Recreation, a diversion by Southern California Edison to generate electricity, and further up the River the dam that created Lake Isabella. Three others occur in the Tehachapi Valley on Chanac, Blackburn and Antelope creeks. Each of these are owned and administered by the Tehachapi-Cummings Water District which was formed to import water to the area, encouraging residential communities to expand in Tehachapi, especially Bear Valley, Golden Hills, and Stallion Springs. We are not aware of significant concrete-banked streams in the Linkage Design footprint; such structures should not be built in the Linkage.

**Urbanization**

As mentioned above, urban development, unlike a road or an aqueduct, creates a barrier that cannot be corrected by building crossing structures. Urban, industrial and suburban areas make particularly inappropriate landscapes for movement of all large carnivores, most reptiles, and many nocturnal small mammals. Most terrestrial mammals that move at night will avoid areas that have artificial night lighting (Beier, in Press).

Throughout the oak woodlands of the Tehachapi Mountains, most homes on lots larger than 5 acres retain most of the native oak woodland, and avoid chain-link fences. Relatively small expanses of such developments, such as much of the south frontage of SR-58 between Keene and Tehachapi, probably cause minimal impediment to animal movement. Larger expanses, such as Bear Valley and Stallion Springs, likely are nearly impermeable due to increased traffic volume, higher traffic speed, increased numbers of pets (predators on small wildlife, prey of large carnivores), increased lighting and noise and other impacts presenting a serious threat to connectivity. West of the city of Tehachapi, the large residential developments of Bear Valley northwest of Cummings Valley and Stallion Springs southwest of Cummings Valley span almost the entire width of the oak woodland belt in this area. We strongly recommend a public education campaign, such as the On The Edge program developed by the Mountain Lion Foundation, which encourages residents at the urban wildland interface to become active stewards of the land. Such voluntary cooperation is essential to functioning of the linkage, to limit impacts of lighting, roads, domestic livestock, pets, and traffic on wildlife movement in the Linkage Design area.

We recommend no major new residential or urban developments in the Linkage Design area. Where development of single residences or small subdivisions do occur, we recommend no street lighting on new roads, except for flashing yellow or red lights to warn of dangerous curves, flood hazards, or similar risks. A few estates on large lots (such as 50 acres or larger) may be compatible with the linkage. However, the total extent of any development should be limited. As a condition of such new subdivisions, the developer should develop a mechanism whereby purchasers of lots accept loss of pets and livestock to wild predators without demanding compensation or a depredation permit. The Mountain Lion Foundation has also worked to develop predator safe domestic livestock enclosures and works with several ranchers and farmers to help keep livestock safe, with the ultimate goal of reducing the number of depredation permits issued for mountain lions.

We recommend that homes abutting the linkage area should have minimal outdoor lighting, always directed toward the home and yard rather than into the linkage. Homeowners should use fences to keep dogs and domestic livestock from roaming into the linkage area. In the case of existing homes, this can best be arranged as a voluntary agreement among landowners.

**Agriculture and Livestock Grazing**

Row-crop agriculture occurs in the Cummings Valley area west of Tehachapi, thus impacting the least cost paths of most focal species. Row crops also impinge on the least-cost path of the Tipton kangaroo rat in the San Joaquin Valley. The removal of native grasslands and woody vegetation reduces the permeability of areas used for agriculture. We recommend working with farmers, or purchasing strips of agricultural land, to restore native plant communities to some or all of the agricultural lands in the Linkage Design.

Livestock are grazed in many parts of the Linkage Design area. We recommend stocking levels that do not degrade native vegetation or increase prevalence of invasive exotic species. We also recommend monitoring to ensure that grazing improves or maintains the condition of the natural vegetation. We encourage partnerships with livestock operators to adopt predator-friendly operations.

The Tehachapi Mountains contain over 500 springs and seeps. Most springs in areas grazed by cattle have been heavily trampled to the point that little or no vegetation remains within 20 feet of the springs. These conditions likely decrease the value of these springs for all wildlife, especially amphibians and turtles. We recommend that livestock operators and landowners keep livestock out of riparian areas and springs, to allow for the regeneration of vegetation to these areas.

**Other Land Uses**

A number of cement aggregate companies, several wind energy facilities, and two airports also occur in the vicinity. The California Portland Cement Company lays on the western edge of the Mojave Desert, near Oak Creek Canyon. National Cement Company leases land from Tejon, off the 138 just north of Quail Lake; their lease goes for another 70 years, and the site will likely remain severely degraded after any restoration. In the Tehachapi Pass, the Wind Industry has installed over 5,000 wind turbines, sited mostly on ridgelines and plateaus; these wind farms are also typically used for cattle grazing.

**Land Protection & Stewardship Opportunities**

Agencies or organizations actively involved in land protection and stewardship in this area include, but are not limited to, California Department of Fish and Game, U.S. Fish and Wildlife Service, U.S. Forest Service, Bureau of Land Management, California State Parks, The Wildlands Conservancy, The Nature Conservancy, Tehachapi Resource Conservation District, and Trust for Public Land. The Trust for Public Land is working with the Tejon Ranch Company to secure at least 100,000 acres of their property but the configuration of the set aside is not yet known. The Resources Legacy Fund has also identified Tejon Ranch as a special opportunity area for their Preserving Wild California program. The Pacific Crest Trail also crosses through this area and may be helpful in directing federal funds to secure land in the linkage.

A variety of planning efforts addressing the conservation and use of natural resources are currently underway in the region. The South Coast Missing Linkages Project supports and enhances existing efforts by providing information on regional linkages critical to achieving the conservation goals of each planning effort. Since the South Coast Missing Linkages Project addresses connectivity needs for the major linkages associated with the South Coast Ecoregion, it can provide a landscape context to localized planning efforts to assist them in achieving their conservation goals. This Project is deeply committed to collaboration and coordination to achieve the vision of a wildlands network for the South Coast Ecoregion and beyond. Existing planning efforts in the study area include, but are not limited to the following.

**USFWS Recovery Plans and Critical Habitat for Threatened and Endangered Species**: The Recovery Plan for Upland Species of the San Joaquin Valley (USFWS 1998) deals with a number of federally listed species, including 5 focal species addressed by this planning effort (San Joaquin kit fox, Tipton kangaroo rat, blunt-nosed leopard lizard, Bakersfield cactus, Tejon poppy). Linkages and important habitat areas identified in the Recovery Plan correspond well with the Linkage Design. Recovery Task 5.1.6 addresses the Kern River Alluvial Fan Area, which was identified as important for both San Joaquin kit fox and Tipton kangaroo rat. Recovery Task 5.3.8 addresses the Southwest, Southern, and Southeastern Valley edge, from McKittrick south to Maricopa, and east and north to the Kern River, which was identified as critical to the recovery of San Joaquin kit fox, blunt-nosed leopard lizard, Bakersfield cactus, and Tejon Poppy.

Designated or proposed critical habitat for 4 threatened or endangered species and 1 endangered plant community has been identified by US Fish and Wildlife Service in the planning area: California condor (*Gymnogyps californianus*) arroyo toad (*Bufo* microscaphus), California gnatcatcher (*Polioptila californica californica*), least Bell's vireo (*Vireo belli pusillus*), and vernal pools. The added protection provided by the Endangered Species Act may be helpful for protecting habitat in the linkage.

**Kern Valley Floor Habitat Conservation Plan:** The KVFHCP, which has yet to be approved, covers 3,110 square miles of the southern portion of the San Joaquin Valley. The Preferred Alternative of the Draft Plan (April 2001) identifies 3 Habitat Zones in order of importance, these are: Red, Green, and White. The Draft calls for minimum-width connections of 1-mile to be maintained throughout all areas in the Red and Green Zones and includes incentives to protect habitat in large contiguous blocks.

The majority of the Linkage Design in the KVFHCP boundary falls within the Green and Red Zones, though some areas are within the White Zone. Three of our focal species (San Joaquin kit fox, blunt-nosed leopard lizard, and Tipton kangaroo rat) are identified as Umbrella Species in the KVFHCP. Provisions for 2 other focal species, Bakersfield cactus and American badger, are also provided in the KVFHCP.

**Metropolitan Bakersfield Habitat Conservation Plan:** The MBHCP was approved in 1994 and covers the 405 square miles of the Metropolitan Bakersfield General Plan (2010) area. Since it's approval, over 4,000 acres have been acquired. Four of our focal species (San Joaquin kit fox, Tipton kangaroo rat, blunt-nosed leopard lizard, and Bakersfield cactus) are covered by the MBHCP. The portion of the Linkage Design within the boundary of the MBHCP includes the Kern River Corridor, which is identified as a priority for protection.

**West Mojave Habitat Conservation Plan:** The Draft WMHCP EIS would amend the California Desert Conservation Area, which has yet to be approved. The WMHCP covers 6.4 million acres, some of which is within the boundary of the Linkage Design. The Preferred Alternative includes two specific areas that would benefit the linkage, the Kelso Creek Monkeyflower and Middle Knob Conservation Areas, both of which are above SR58. However, no conservation targets were identified in the portion of the Linkage Design on the desert slopes of the Tehachapi Mountains that fall within the WMHCP boundary, which is important for species such as the Tehachapi pocket mouse and badger.

**U.S. Forest Service Resource Management Plan Revisions:** The four southern California Forests (Los Padres, Angeles, San Bernardino, and Cleveland) are in the process of jointly revising their Resource Management Plans; Los Padre and the Angeles are both within the planning area. The biological importance and feasibility of connecting these forests to the existing network of protected lands in the region is being evaluated in the Draft Environmental Impact Statement. The Forest Service is taking a proactive role in habitat connectivity planning in the region, which is a key component of their plan. Land and Water Conservation Funds 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.

**Department of Parks and Recreation:** The Department is actively engaged in the preservation of the State's rich biological diversity through their acquisition and restoration programs. Ensuring connections between State Park System wildlands and other protected areas is one of their highest priorities.

**Wildlife Conservation Board:** The Wildlife Conservation Board administers capital outlay for wildlife conservation and related public recreation for the State of California and is within the Department of Fish and Game (DFG). Conceptual Area Protection Plans are internal DFG documents used to help determine acquisition priorities, several of which occur within the planning area.

**Los Angeles County Significant Ecological Areas (SEA):** Los Angeles County is currently engaged in a 2020 General Plan update, which will likely include proposed revisions and expansions to existing SEAs. The segment of the Linkage Design that falls within Los Angeles County has been proposed as part of the San Andres Rift Zone SEA

(PCR 2000), which includes several important wildlife movement areas, including a connection between the San Gabriel and Tehachapi Mountains. Two focal species (southwestern pond turtle, Tehachapi pocket mouse) were identified in the report and have been observed or are expected to occur in the SEA (PCR 2000).