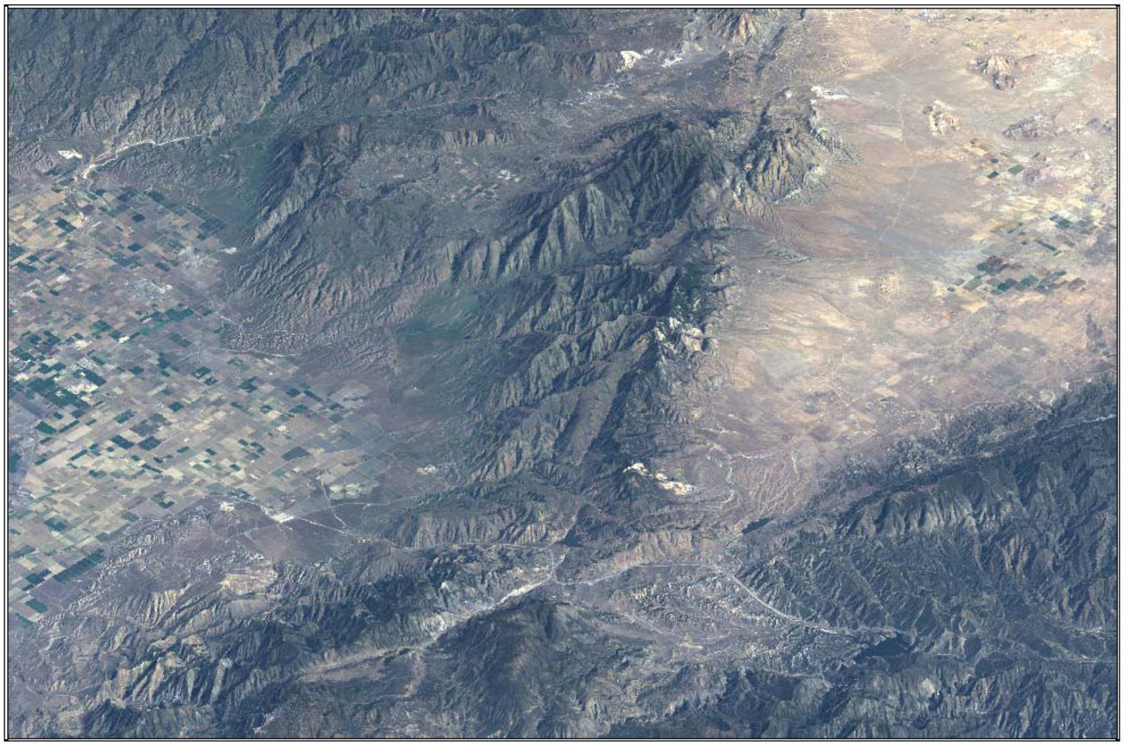
South Coast Missing Linkages Project:

A Linkage Design for the Tehachapi Connection



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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 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.

Introduction

Nature Needs Room to Move

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

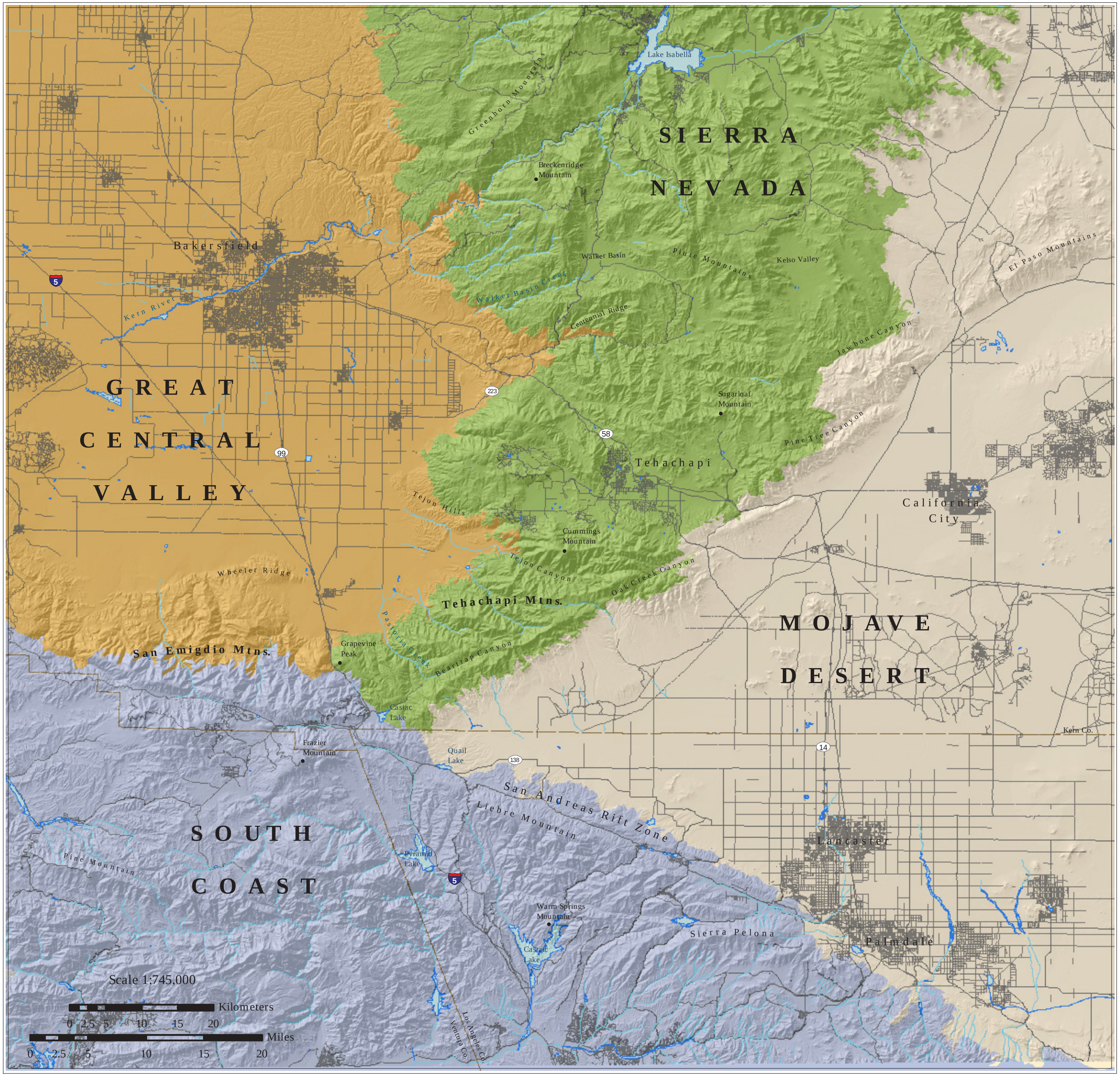
The other 14 priority linkages are:
Santa Monica Mountains-Santa Susana Mountains
Santa Susana Mountains-Sierra Madre Mountains
E. Sierra Madre Mountains-W. Sierra Madre Mountains
San Gabriel Mountains-Sierra Madre Mountains
San Bernardino Mountains-San Gabriel Mountains
San Bernardino Mountains-San 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.

Figure2. Convergence of Ecoregions



Legend

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

N

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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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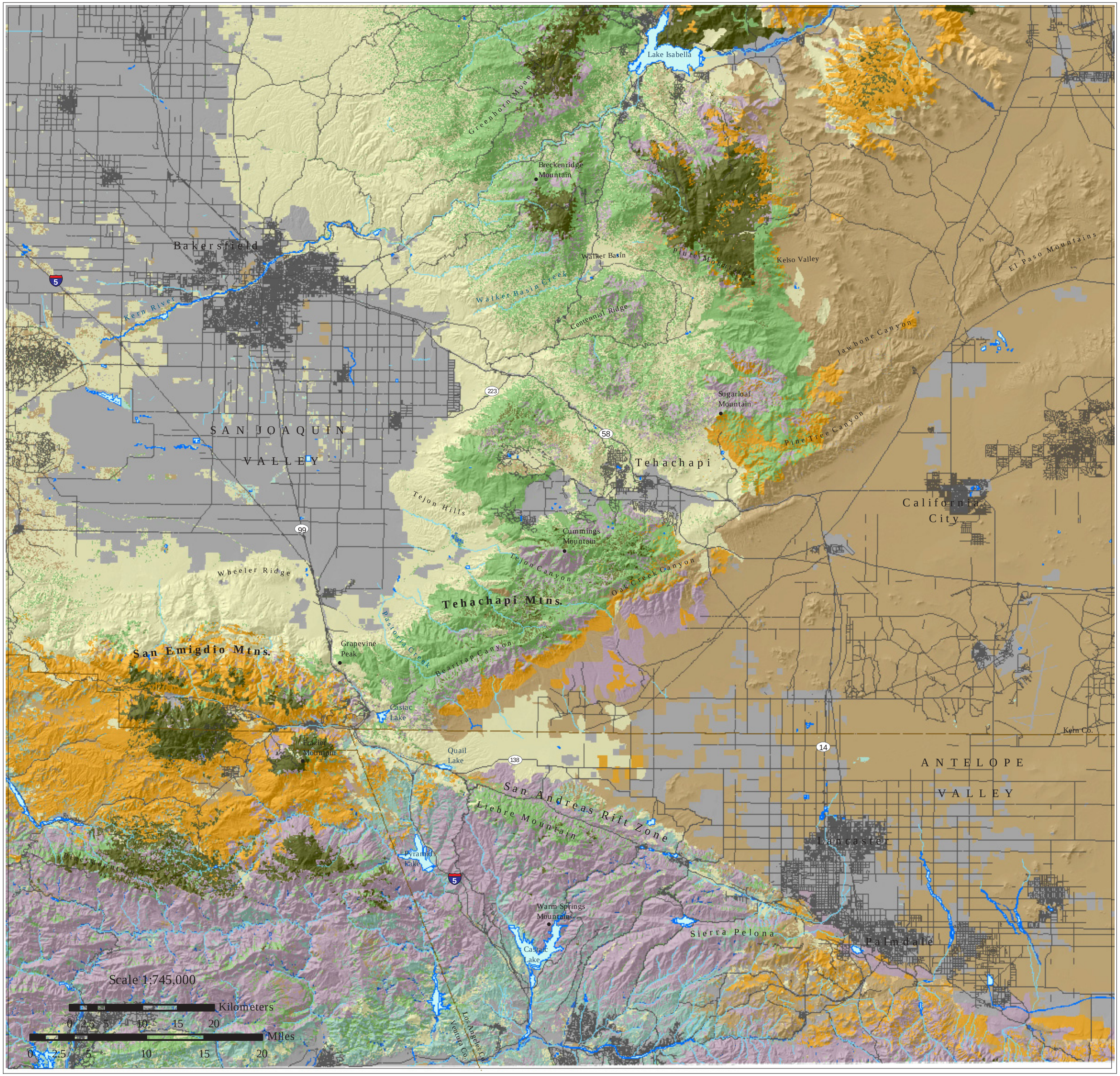

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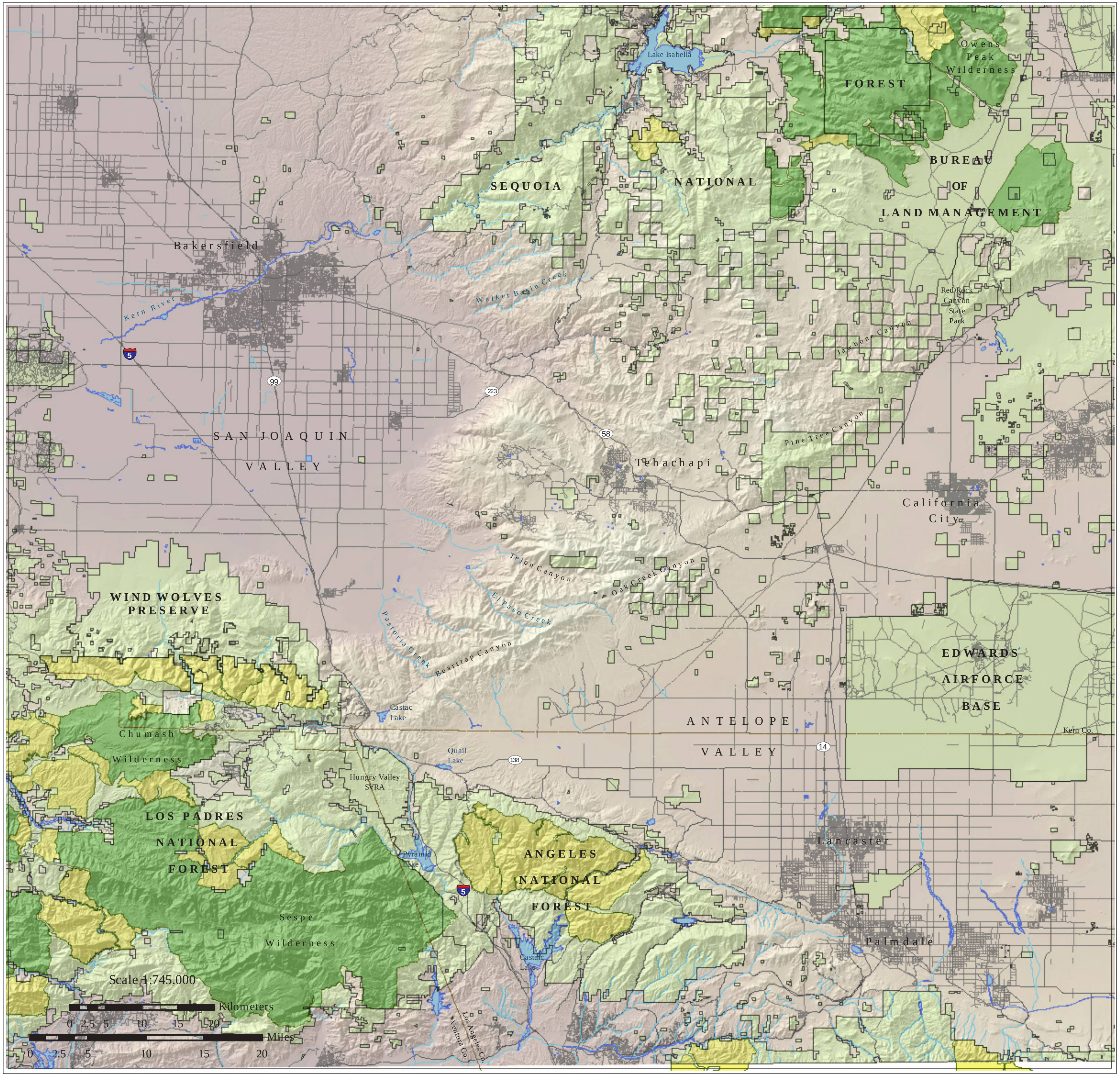
Numerous imperiled plant and animal species are known from the vicinity, including Bakersfield cactus, arroyo toad, red-legged frog, blunt-nosed leopard lizard, San Joaquin kit fox, Tule elk, Tipton kangaroo rat, Tehachapi pocket mouse, and Mohave ground squirrel. The area includes habitat designated 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).

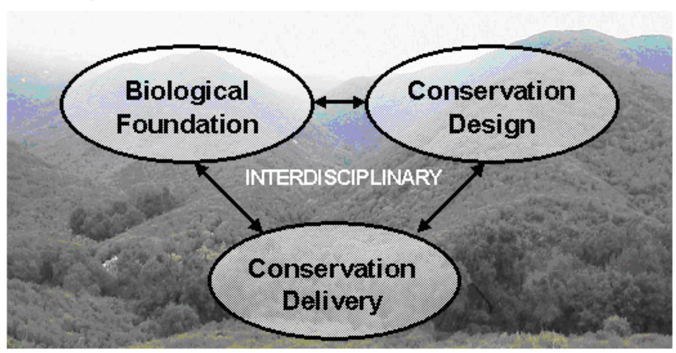


Figure 5. Successful conservation planning requires an interdisciplinary and reiterative approach among biologists, planners and activists (Baxter 2001).

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

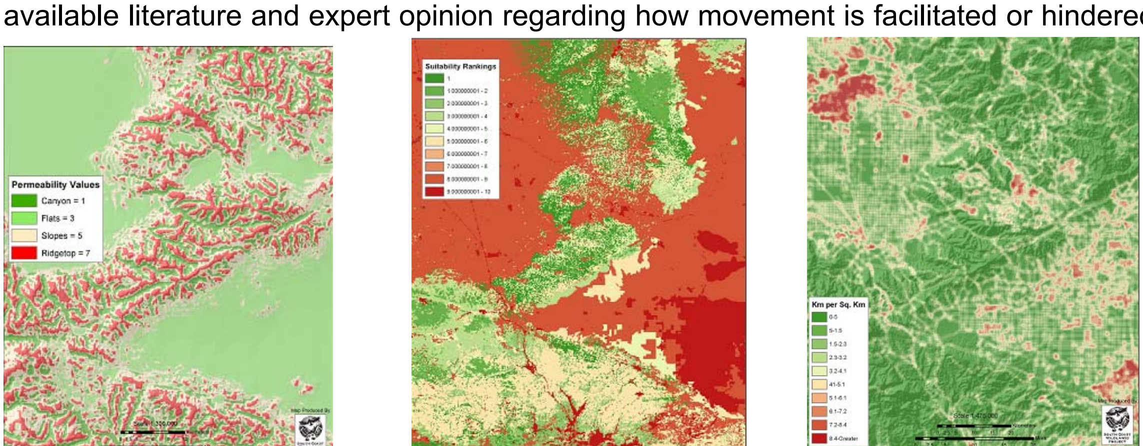


Figure 6. Model Inputs: Topographical features, vegetation, and road density.

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

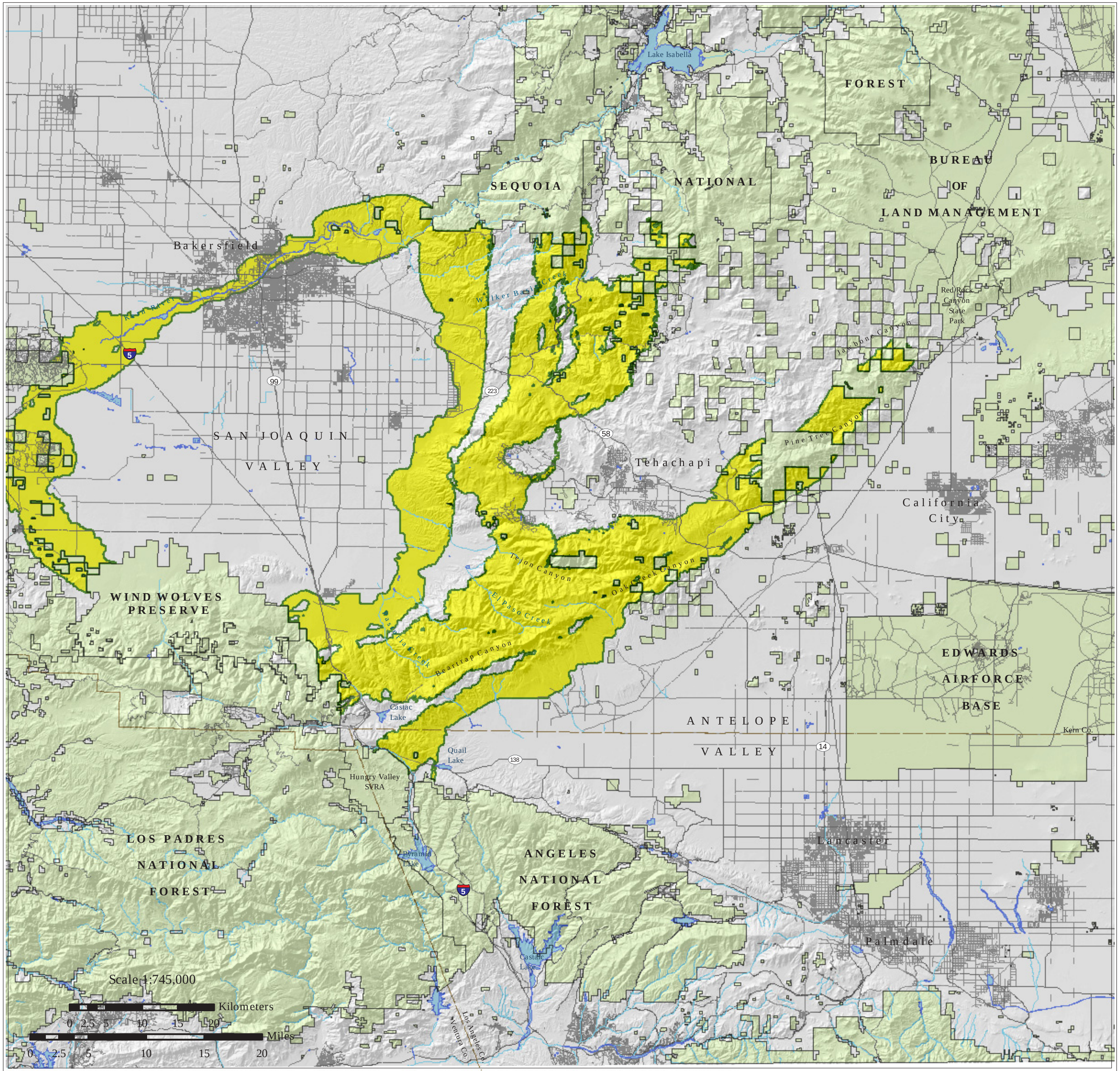
We conducted landscape permeability analyses for 9 species as described in the following several pages. The Least Cost Union (i.e., the union of the top 1% for all 9 species) demonstrates the need for habitat connectivity in several major vegetation and physiographic zones, including foothill grasslands 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

N

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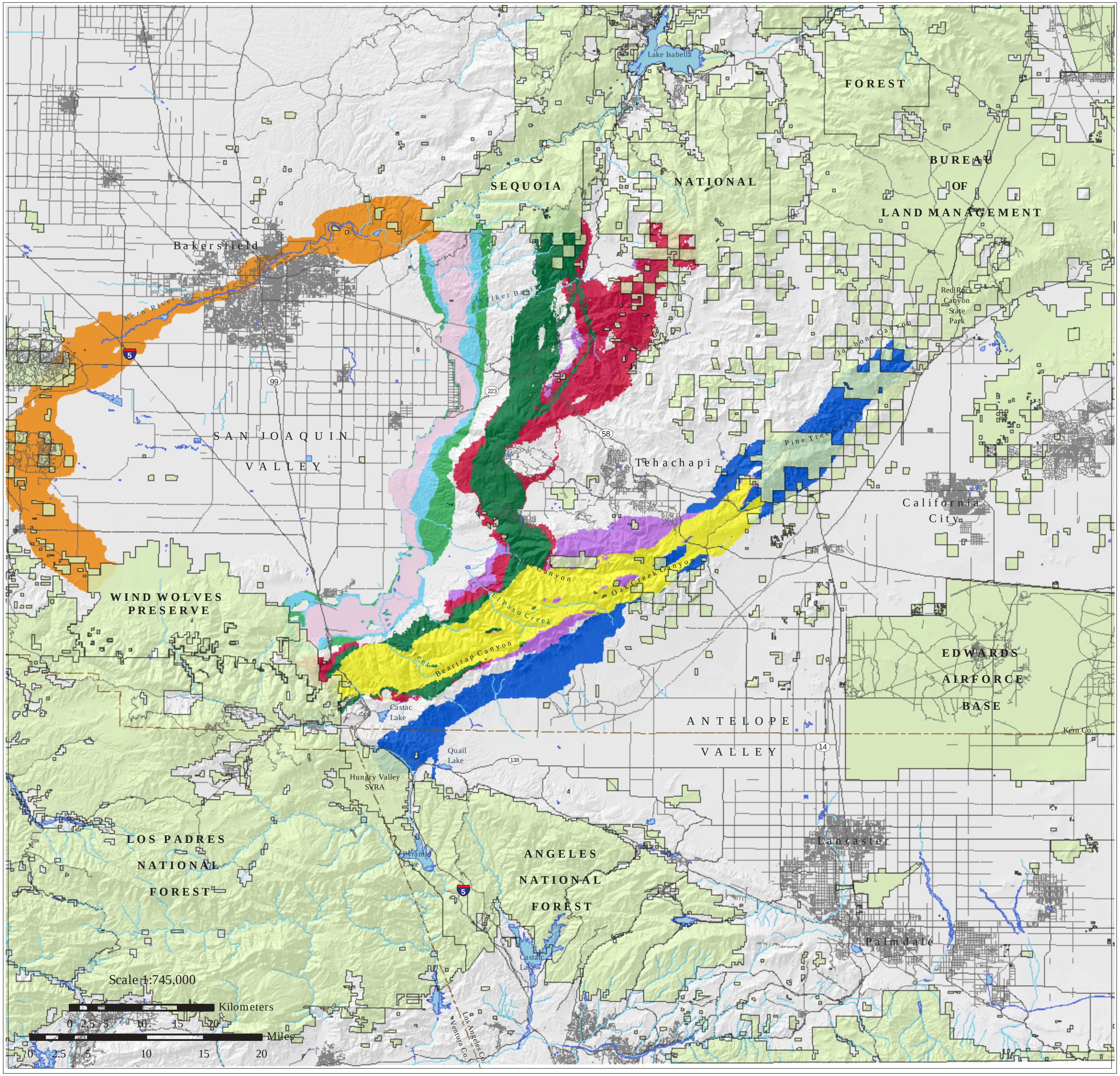
Figure 8.
Least Cost Union (Species Overlap)



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

N

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Mountain Lion (*Felis concolor*)

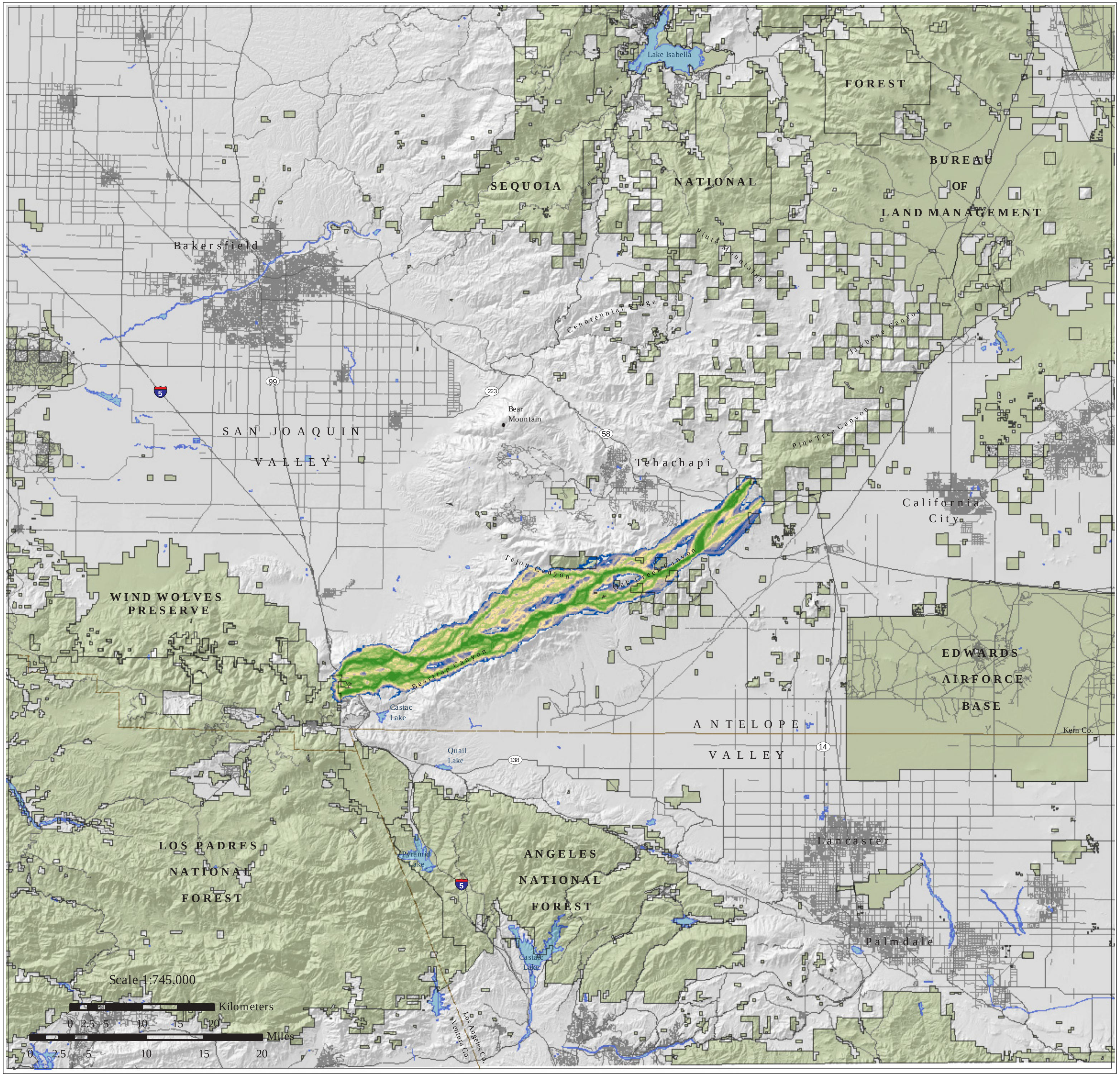
Justification for Selection: These area-sensitive species are appropriate focal species (Noss 1991) because their naturally low densities render them highly sensitive to habitat fragmentation, and loss of large carnivores can have adverse ripple effects through the entire ecosystem (Soule and Terborgh 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)

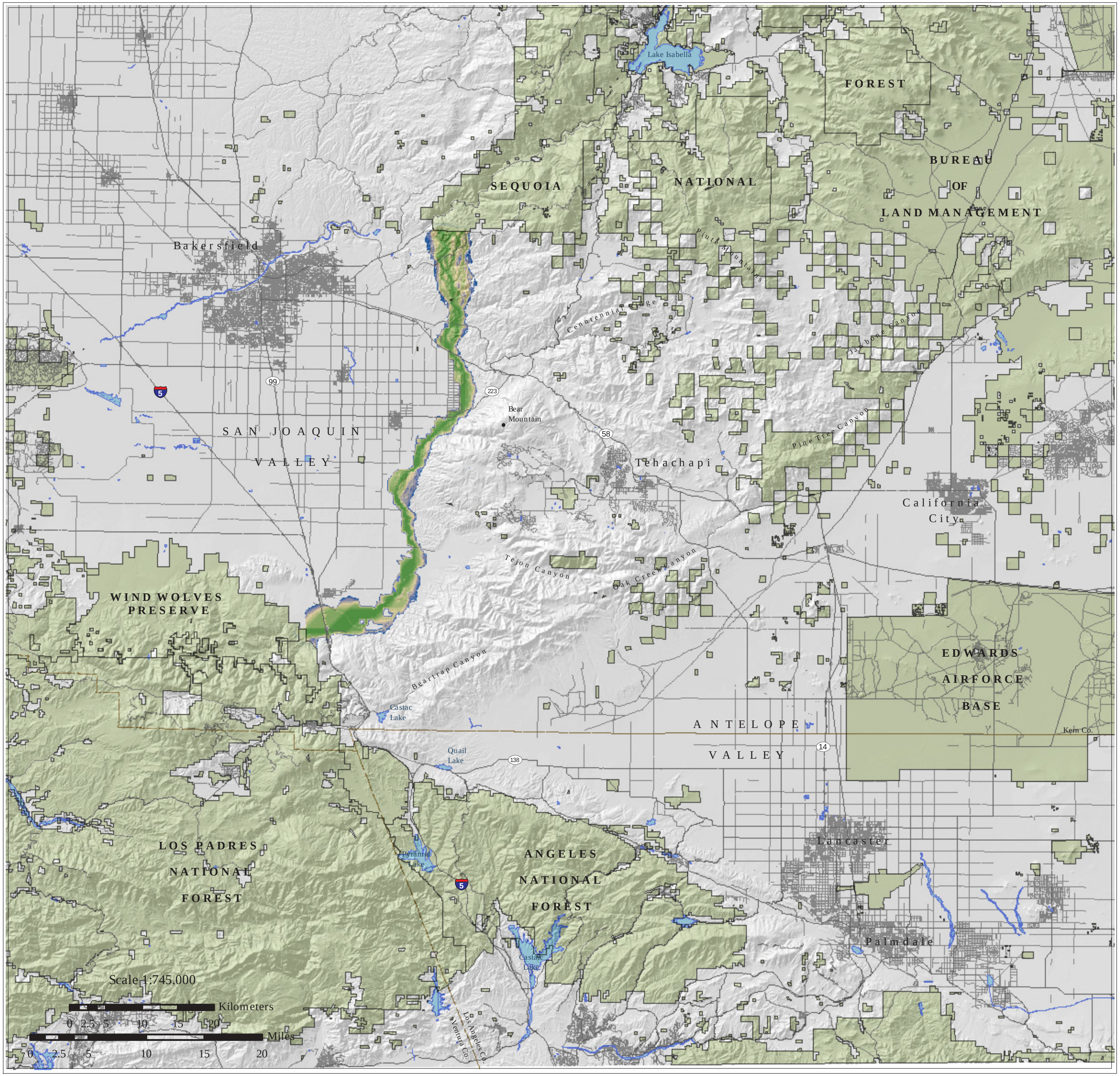
Results & Discussion: Figure 10 delineates the most permeable route (top 1%) for badgers moving between the Sierra Madre and Sierra Nevada protected core areas. The contiguous belt of grassland and foothill habitat around the southern arc of the San Joaquin Valley, from the San Emigdio Ranges on Wind 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



Scale 1:745,000

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San Joaquin Kit Fox (*Vulpes macrotis mutica*)

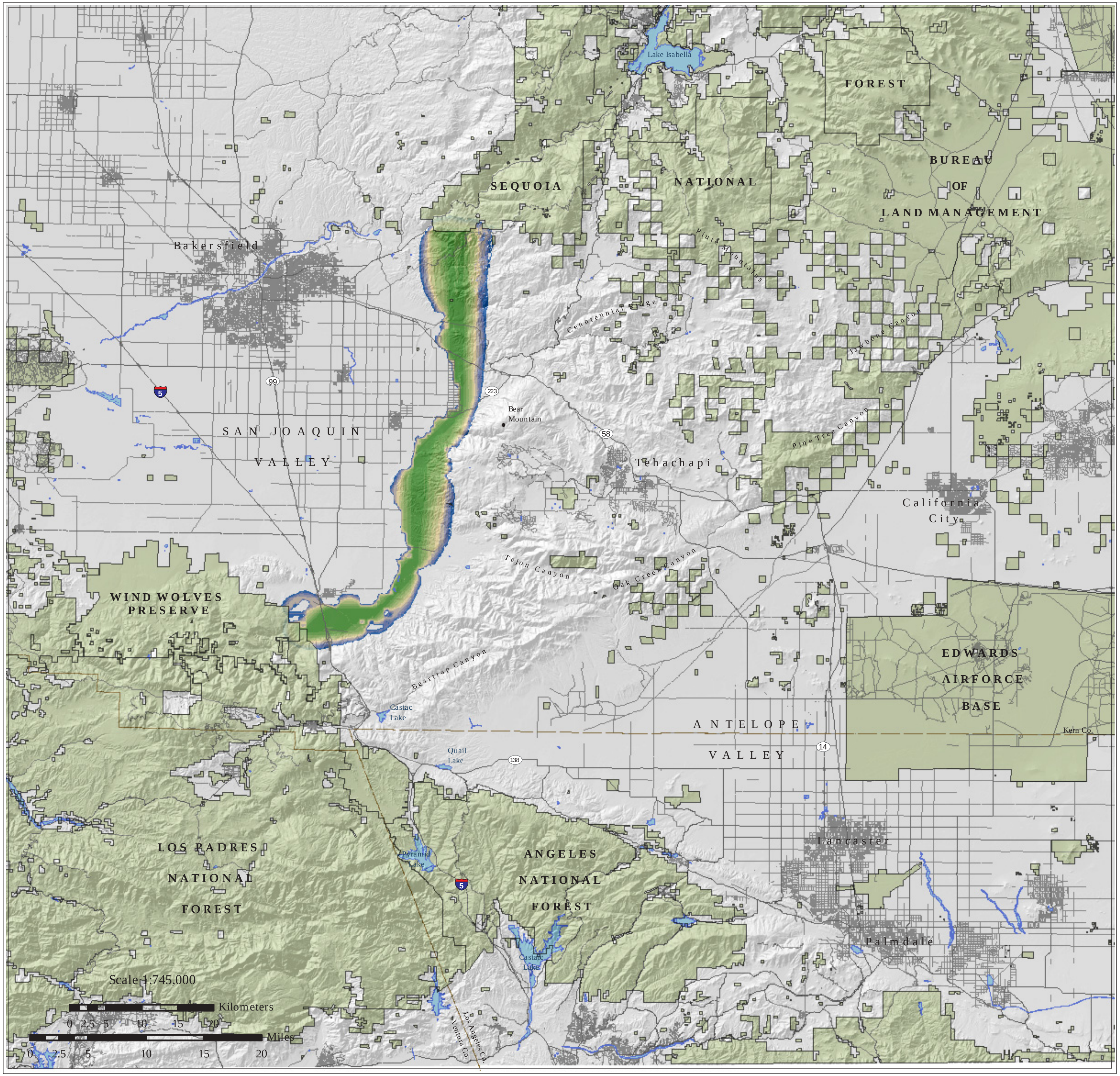
Justification for Selection: Principal reasons for this species' decline are habitat loss, fragmentation, and degradation by agriculture, residential, commercial, and industrial development, and associated roads (USFWS 1998, Koopman et al. 1998, CDFG 2000, USFS 2002). Barriers to movement such as aqueducts 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

N

SOUTH COAST WILDLANDS PROJECT

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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

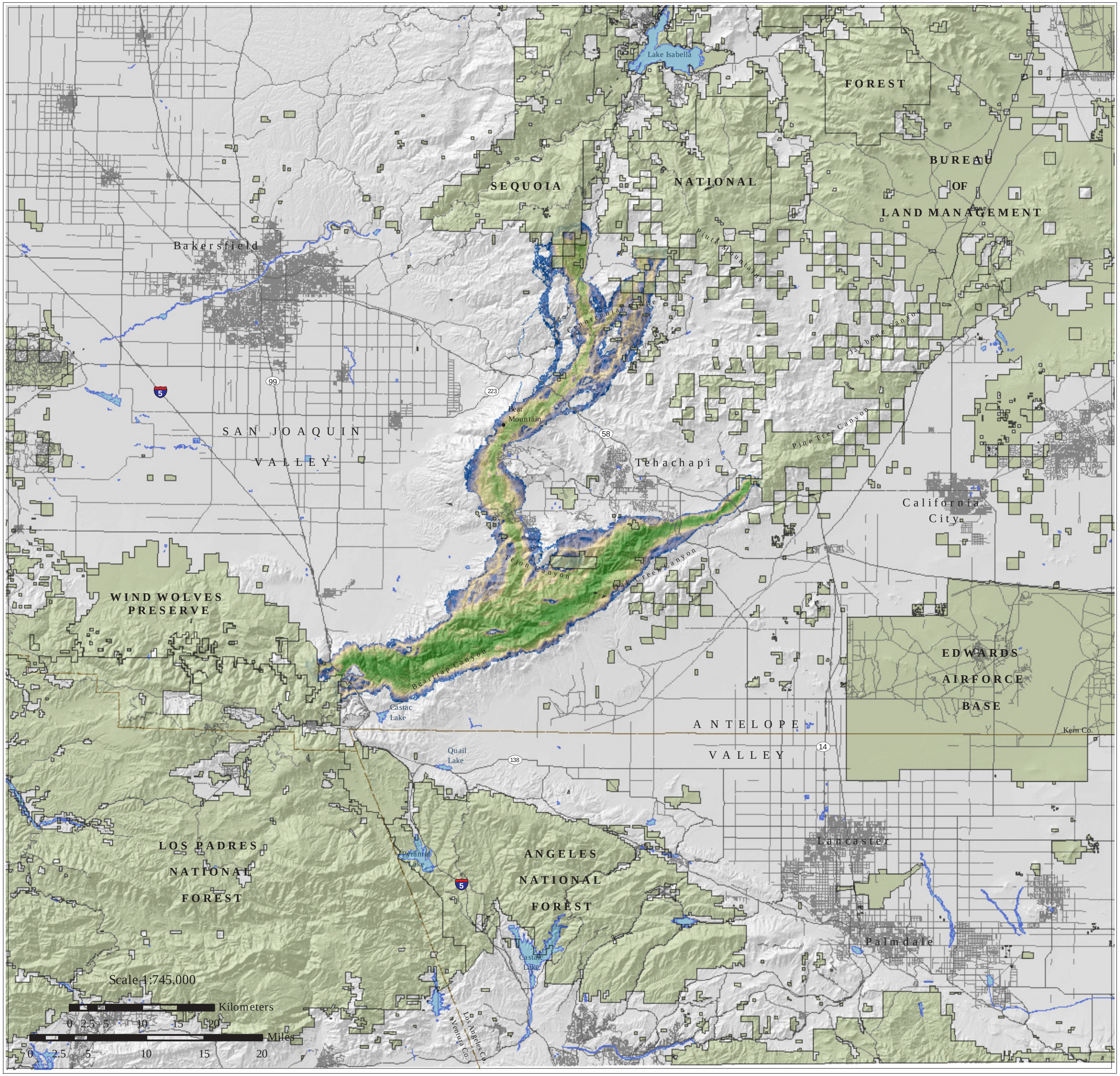
Results & Discussion: Figure 12 delineates the most permeable area (top 1%) for mule deer moving between the Sierra Madre and Sierra Nevada protected core areas. The results of the analysis for mule deer also support the need to conserve the complex mosaic of diverse habitats that occur in the Tehachapi 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

N



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Western Gray Squirrel (*Sciurus griseus*)

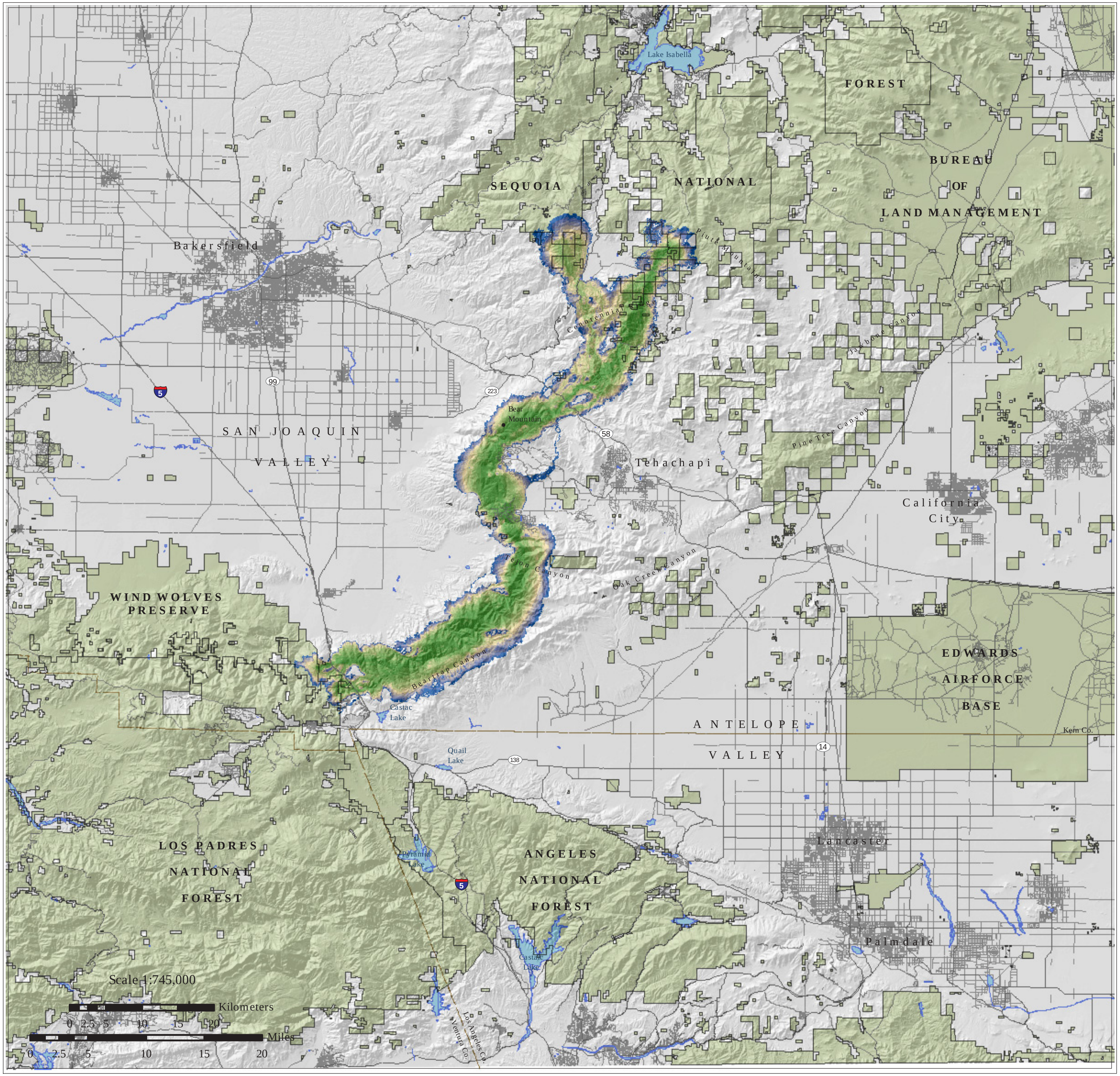
Justification for Selection: The Western gray squirrel is considered susceptible to fragmentation, is probably dispersal limited, and suffers from roadkill. Ryan and Carey (1995) found 25% of the 318 individuals documented in their study were recorded as roadkill, with most roadkilled squirrels being 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*)

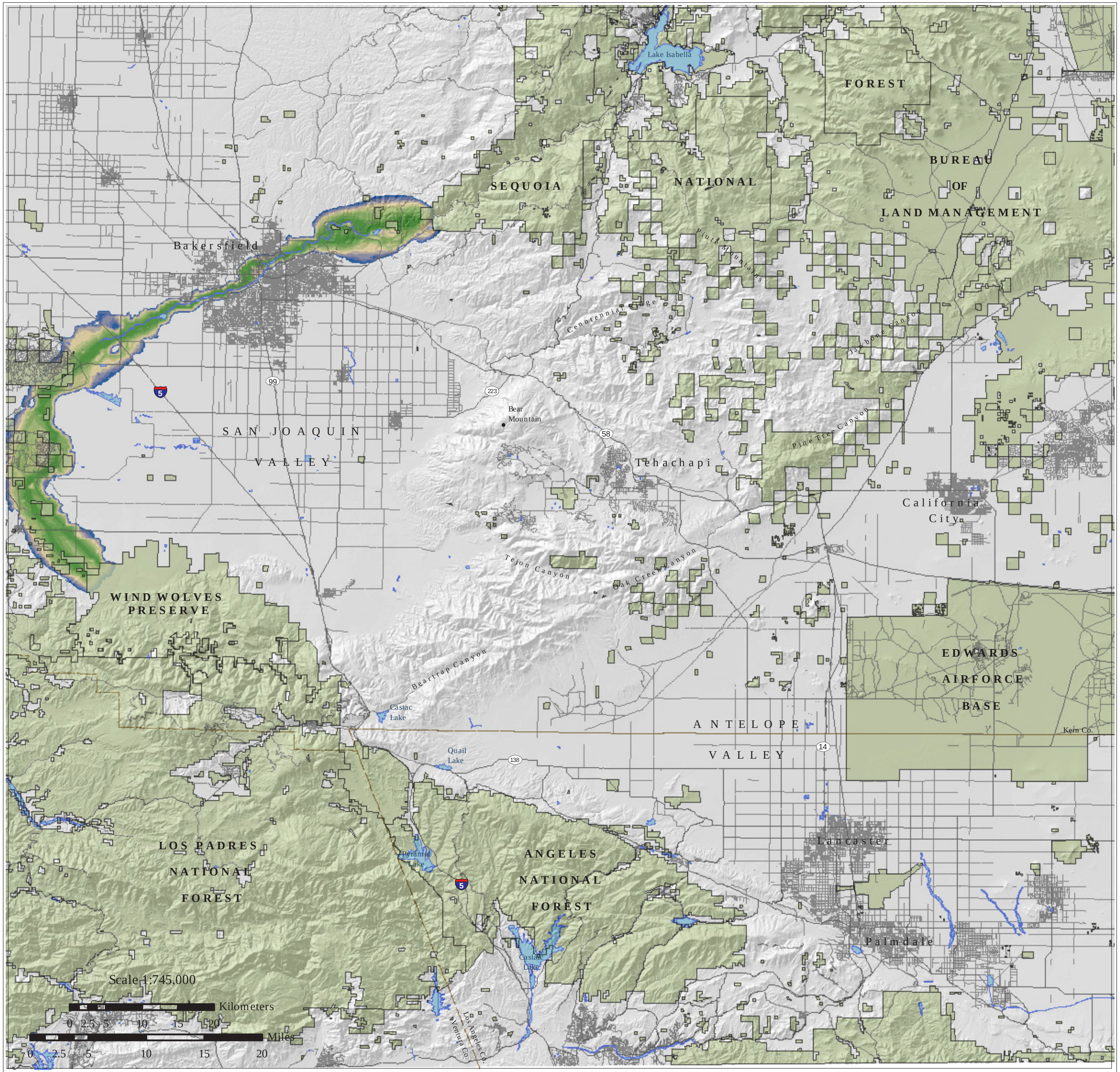
Justification for Selection: Habitat conversion and fragmentation by agriculture are cited as the primary causes of their precipitous declines (Williams and Germano 1993), although urban and industrial development has also contributed significantly (USFWS 1998). Construction of dams and canals has also 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).

Figure 14.
Least Cost Corridor
for
Tipton kangaroo rat
(Dipodomys nitratoides nitratoides)



Legend

- 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.).

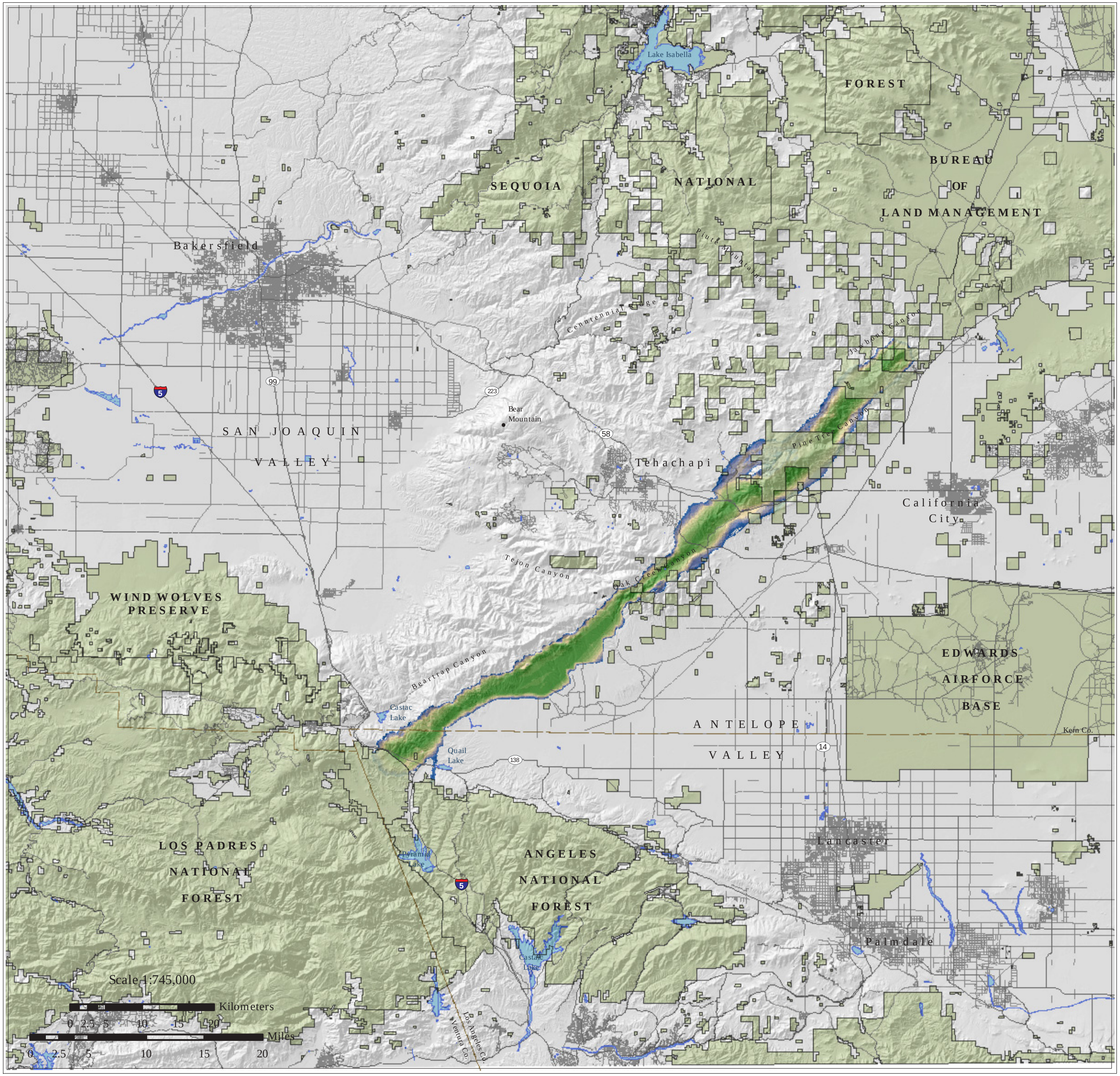
Conceptual Basis for Model Development: This species is known to utilize coastal sage, chaparral, desert scrub, pinyon-pine woodland, Joshua tree woodland, arid grasslands, grassy flats among scattered Jeffrey or Ponderosa pine, and oak savanna habitats (Williams et al. 1993, Best 1994 *in* Labbs 1989); 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

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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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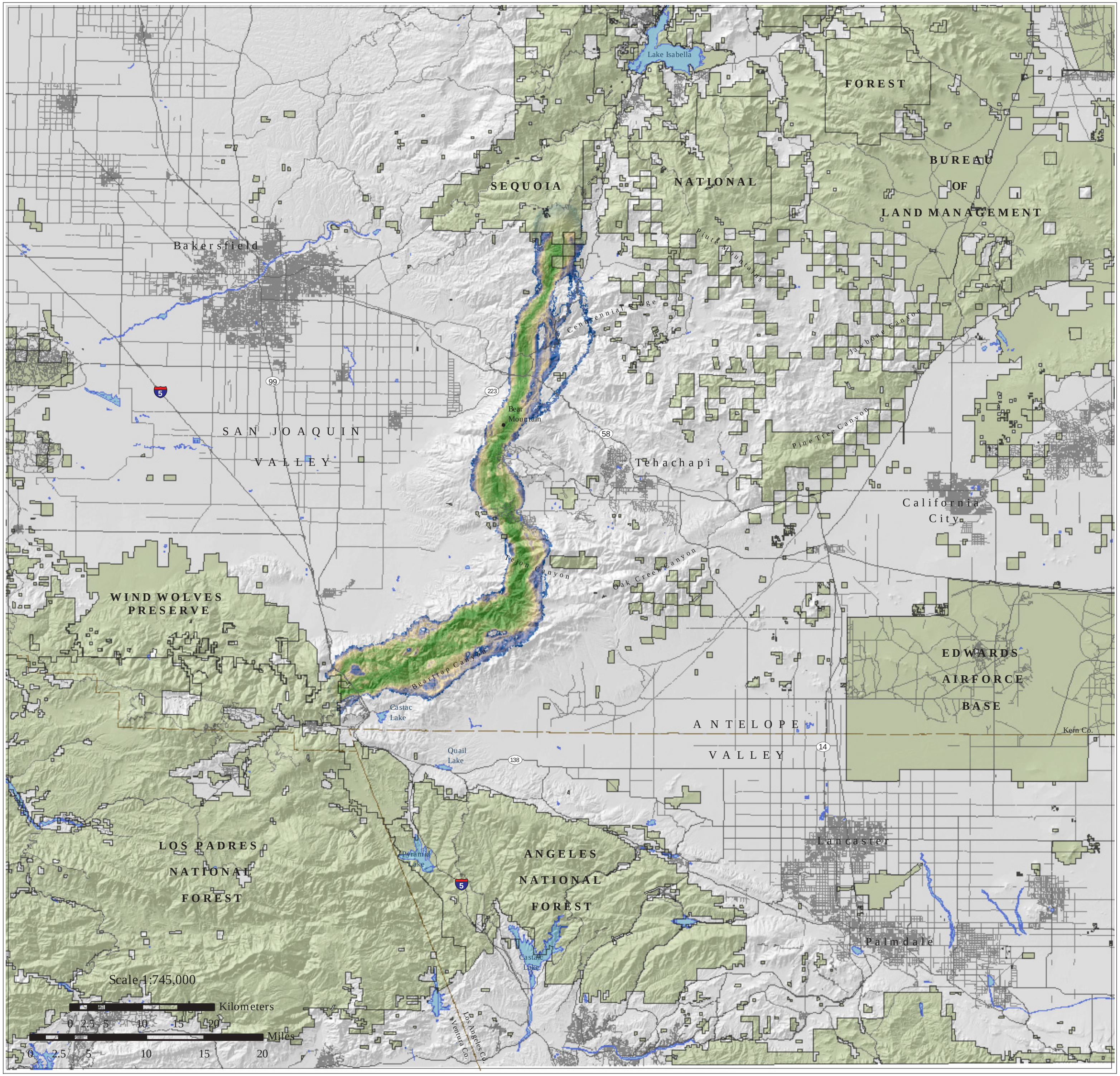


Blunt-Nosed Leopard Lizard (*Gambelia silus*)

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).

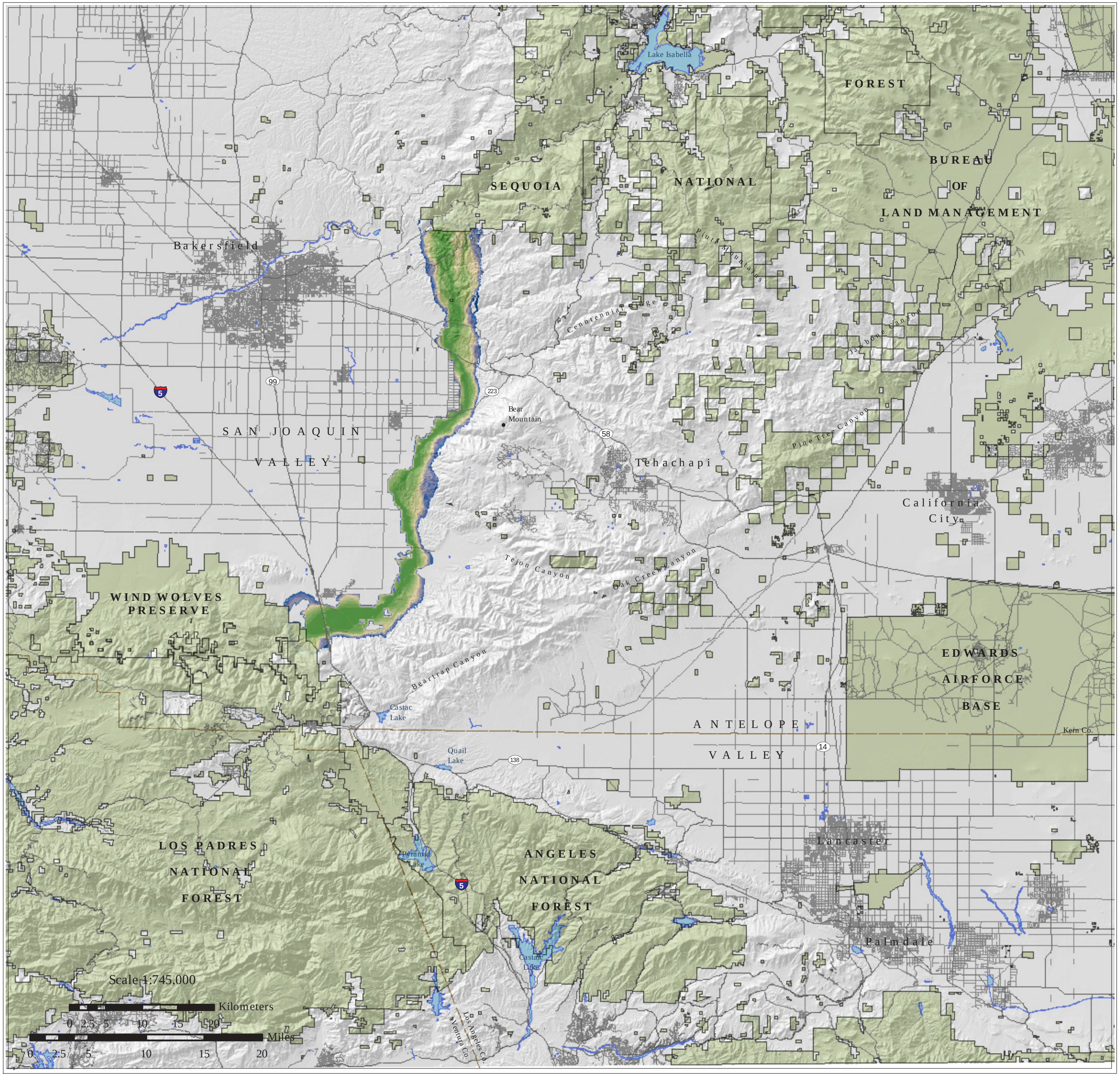
Conceptual Basis for Model Development: The blunt-nosed leopard lizard inhabits semiarid grasslands or sparsely vegetated plains, in low foothills, on canyon floors, and in large washes and arroyos (USFWS 1980). It uses a variety of communities, including annual and perennial grassland, alkali playa, 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

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Patch Size & Configuration Analysis

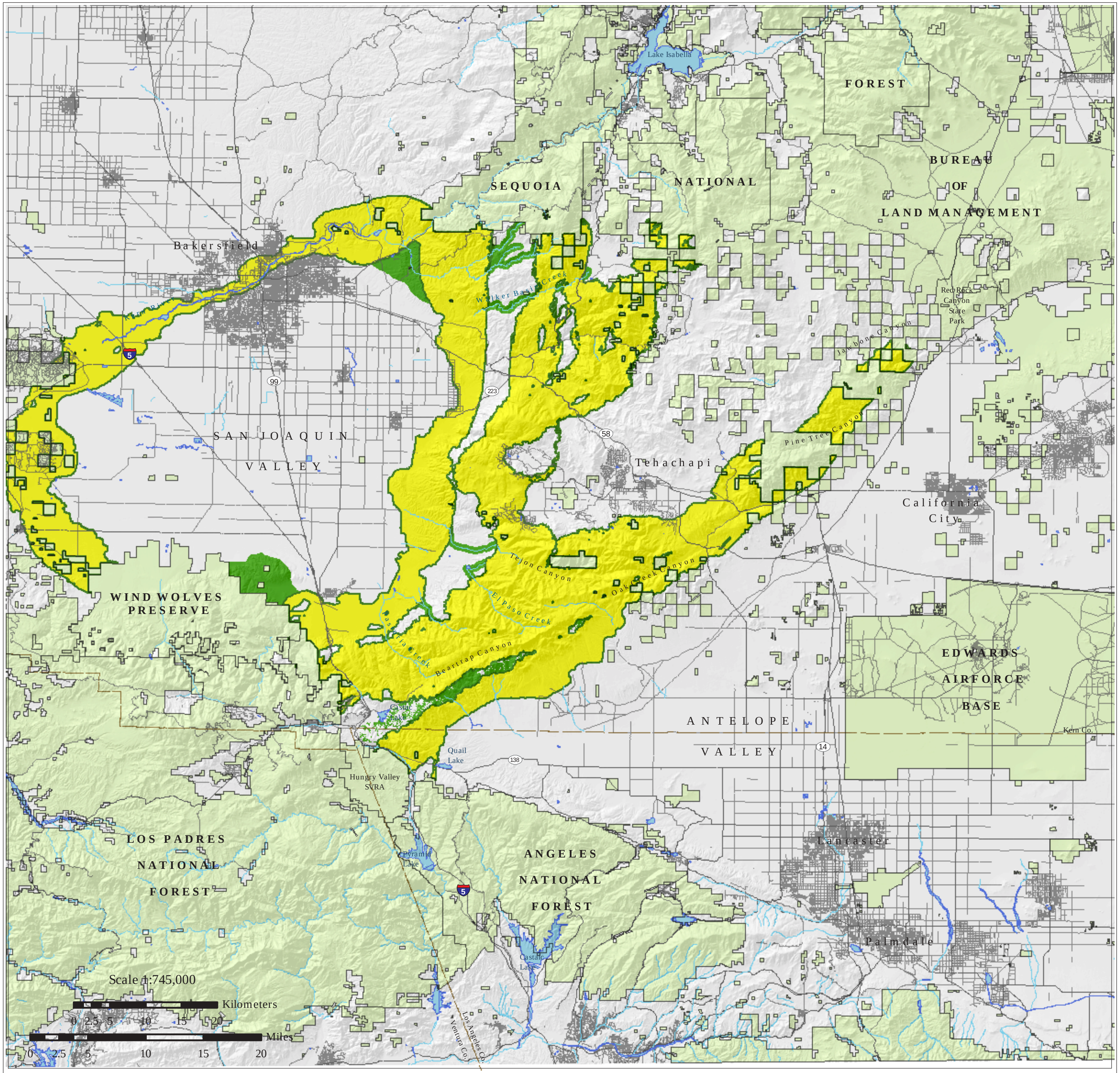
Patch size and configuration analyses were used to evaluate the configuration and extent of potentially suitable habitat for all focal species in relation to the Least Cost Union to determine whether each species is likely to be served by the linkage. We used conservation biology principles to identify 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



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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.).

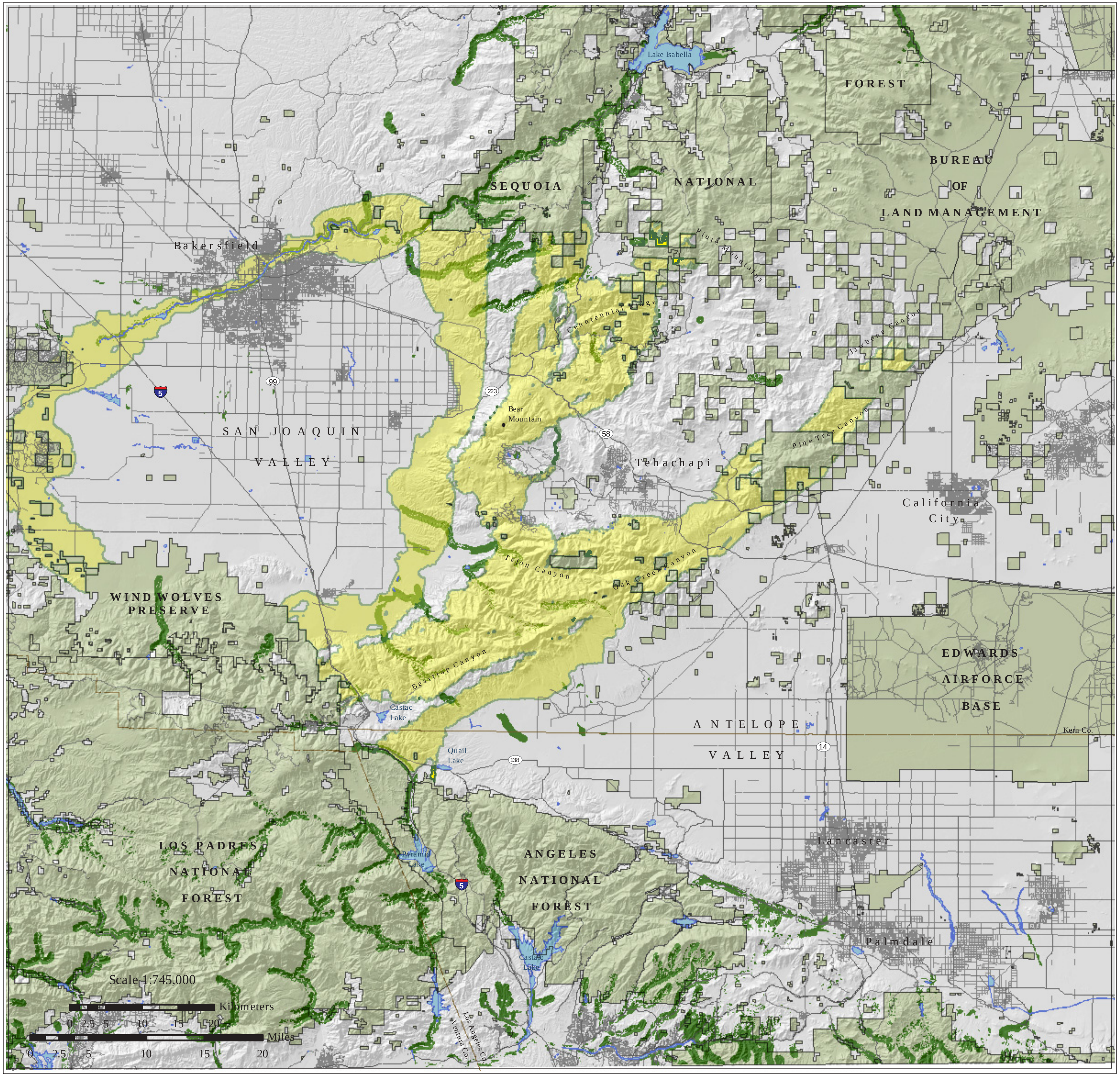
Males and females can travel long dispersal distances along watercourses and overland. Males tend to move greater average and total distances than females or juveniles and can move over 1.5 km along watercourses (Bury 1972). Both males and females can move overland 0.5 km from nearest watercourse (Holland 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.).

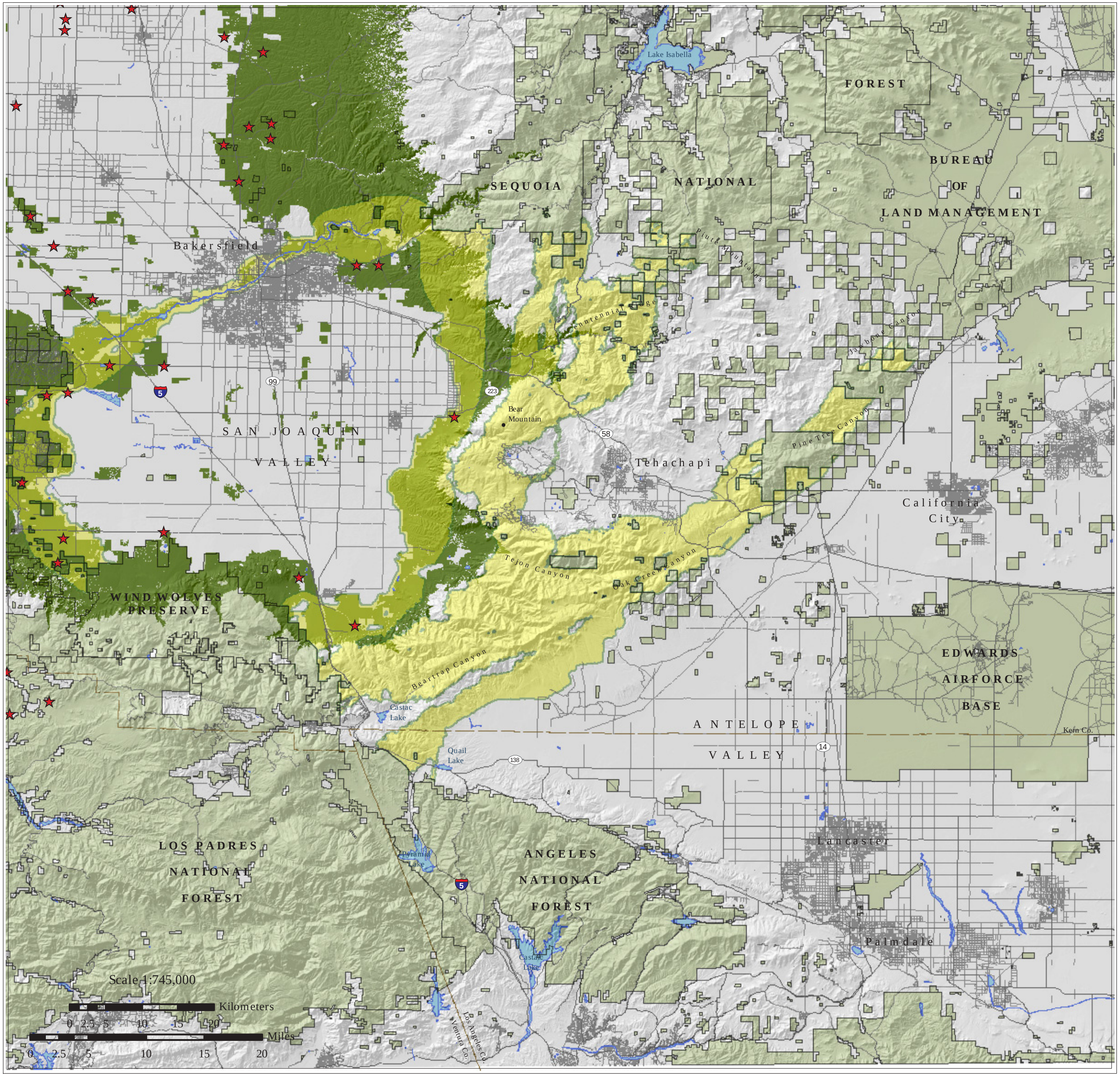
Conceptual Basis for Model Development: This species may be found in grassland, alkali scrub, washes, and foothill riparian habitats between 30-900 meters in the San Joaquin Valley (Stebbins 1985, CDFG 1988). Minimum patch size is less than the minimum mapping unit of 1 ha, thus patch size was defined 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
- CNDDB Observation
- Paved Roads
- Ownership Boundaries
- County Lines



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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.

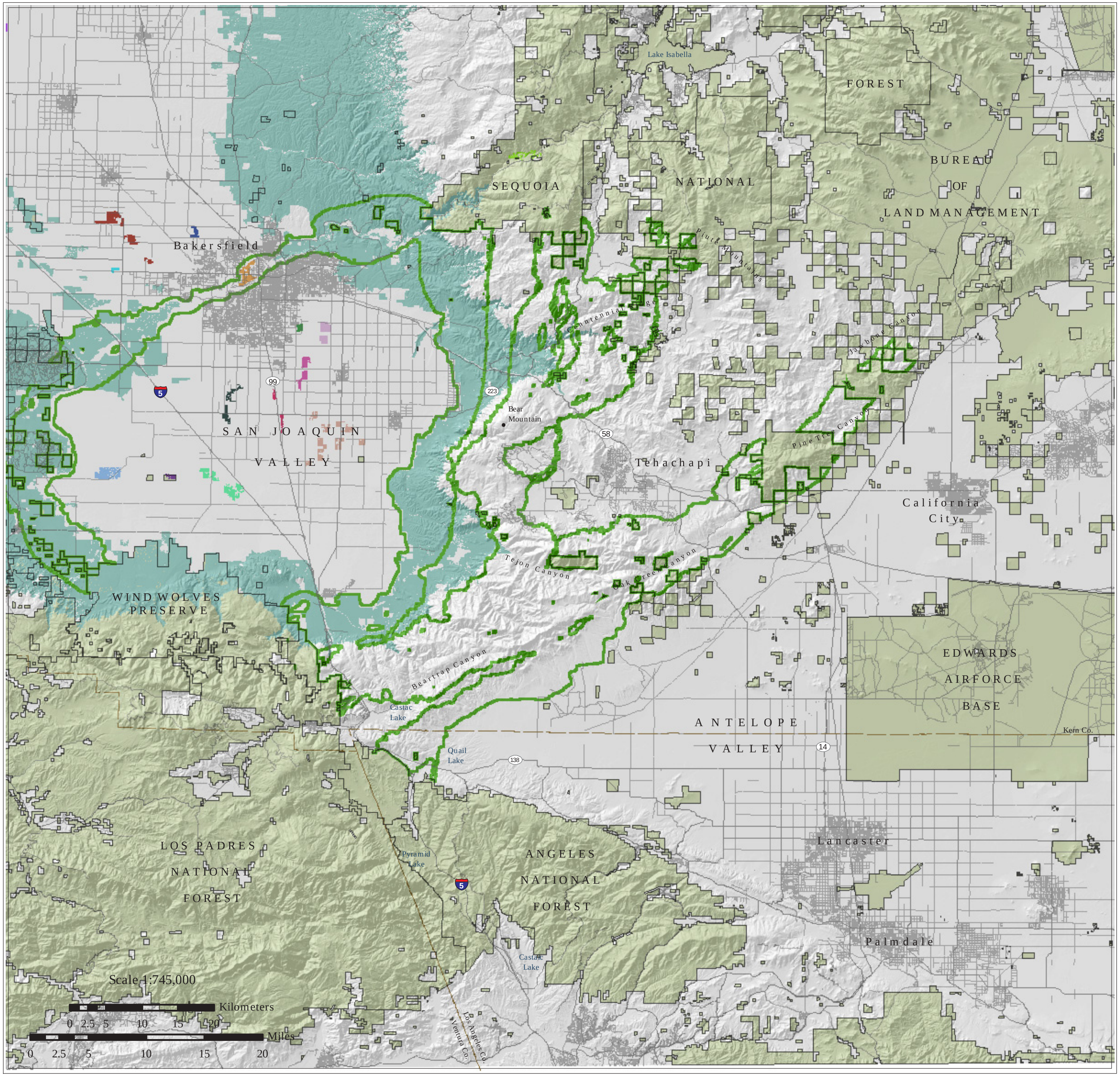
Figure 21
Patch Configuration
for
Blunt-nosed leopard lizard

(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).

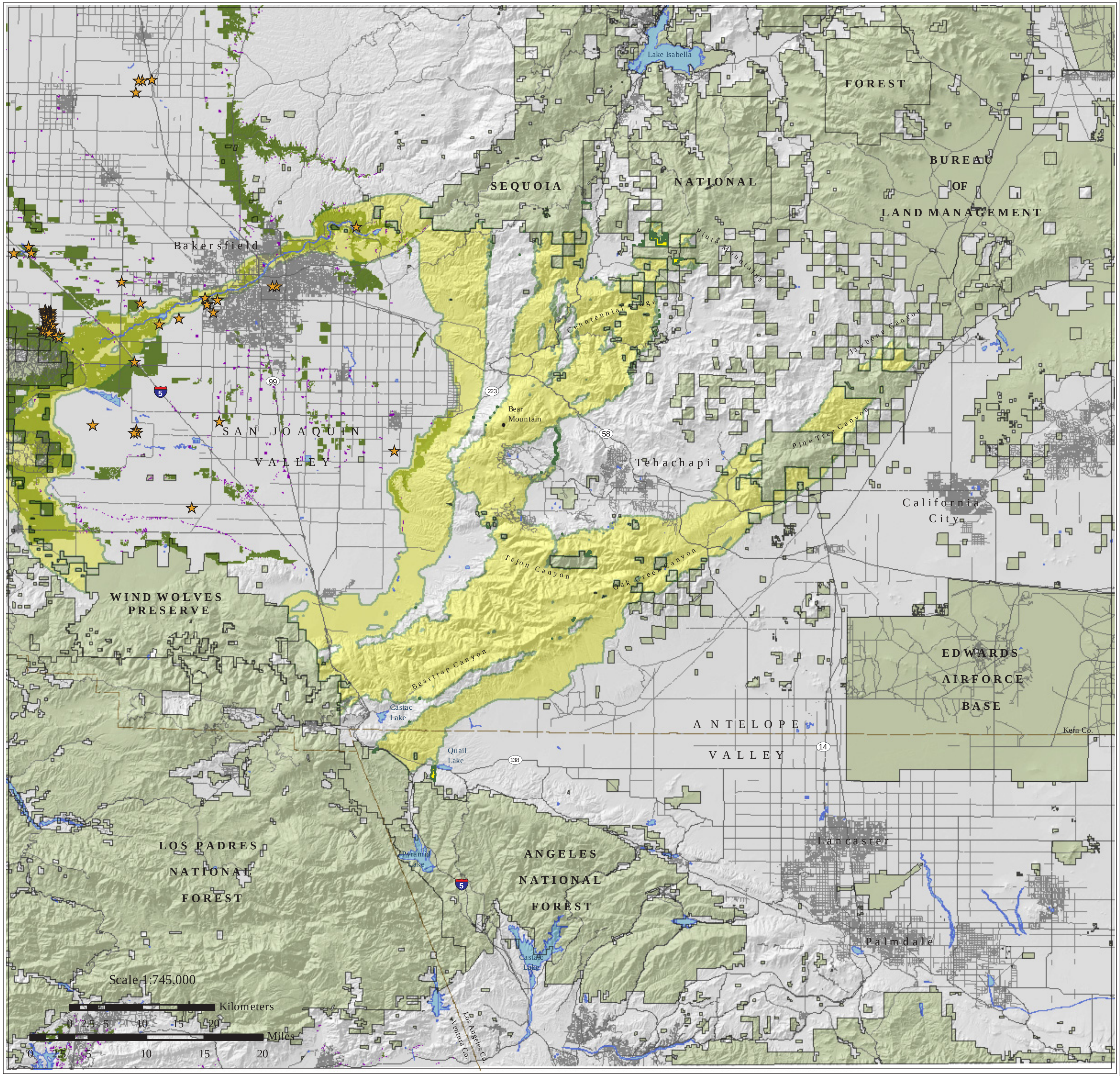
Spatial Patterns: No information was found in the literature on home range or dispersal distances for this subspecies. The home range of the closely related Fresno kangaroo rat (*D. n. exilis*) was estimated by Warner (1976) at only about 566 square meters, but this is considered a likely under-estimate (*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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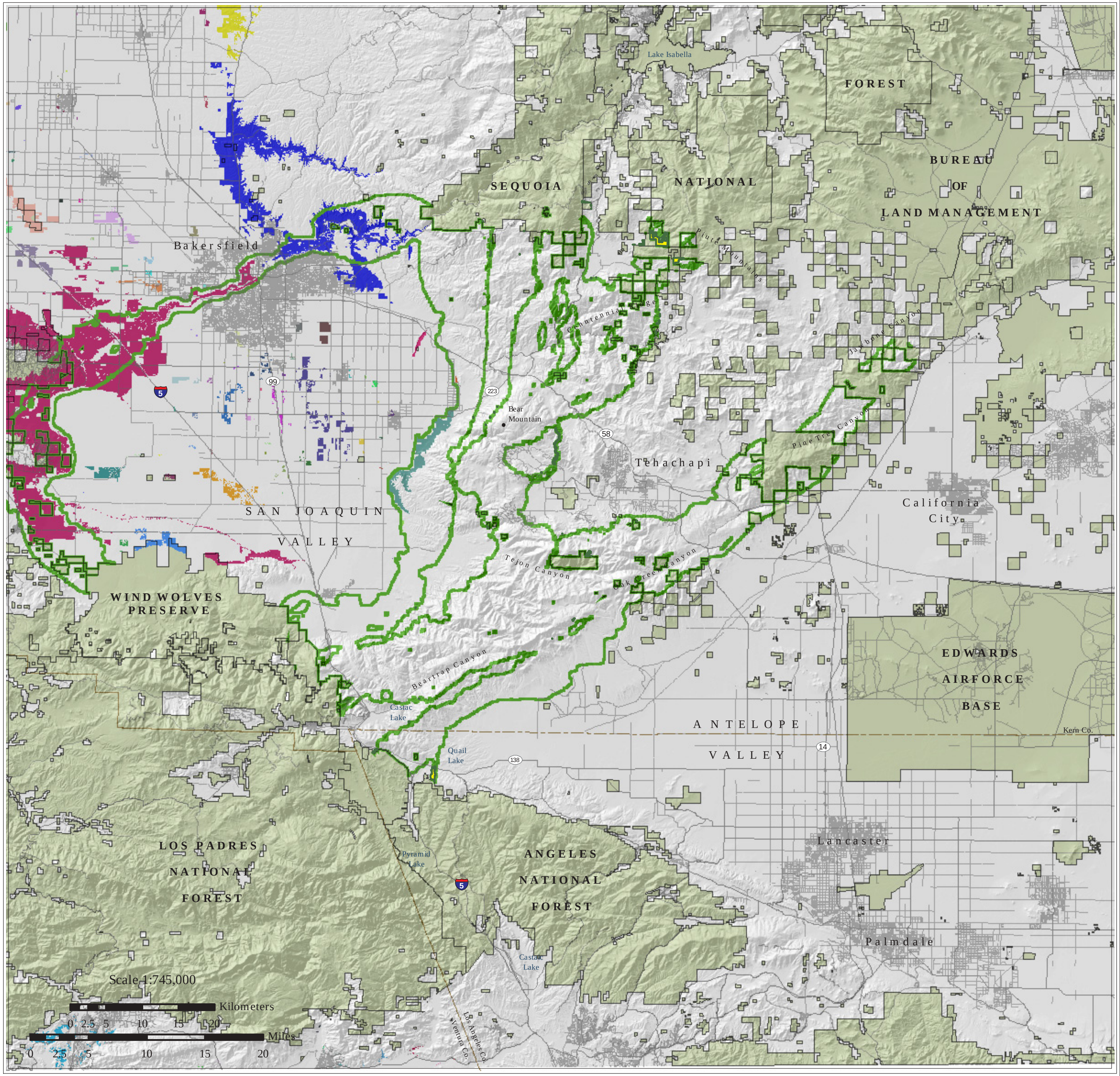
Figure 23.
Patch Configuration
for
Tipton kangaroo rat
(Dipodomys nitratoides nitratoides)



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).

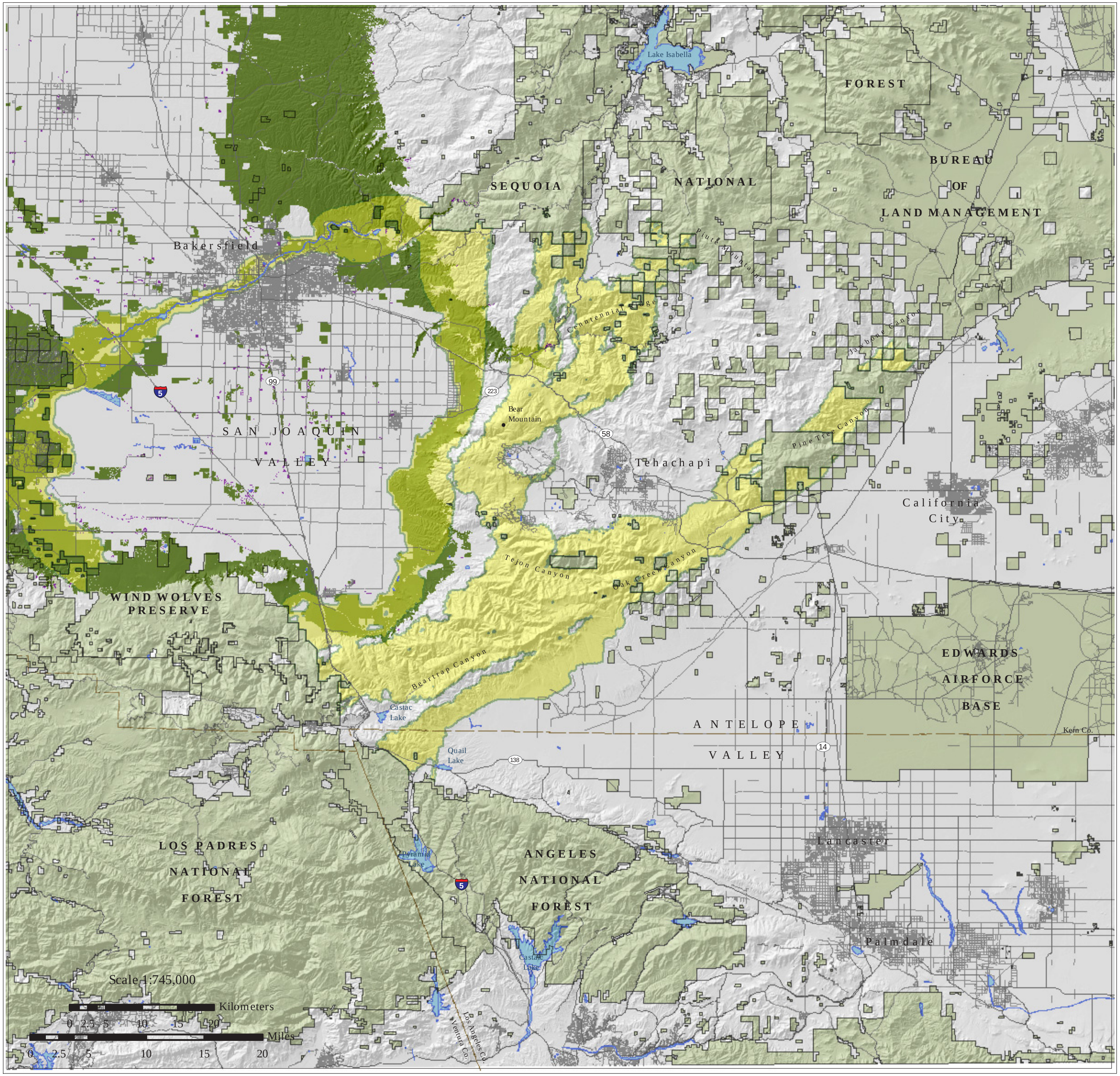
Spatial Patterns: Home ranges of a half-acre in size have been documented for this species (Thelander et al. 1994). Densities of up to 17 individuals per hectare have been reported in the San Joaquin Valley, but annual fluctuations were significant. Fitch (1948) found most marked individuals to remain 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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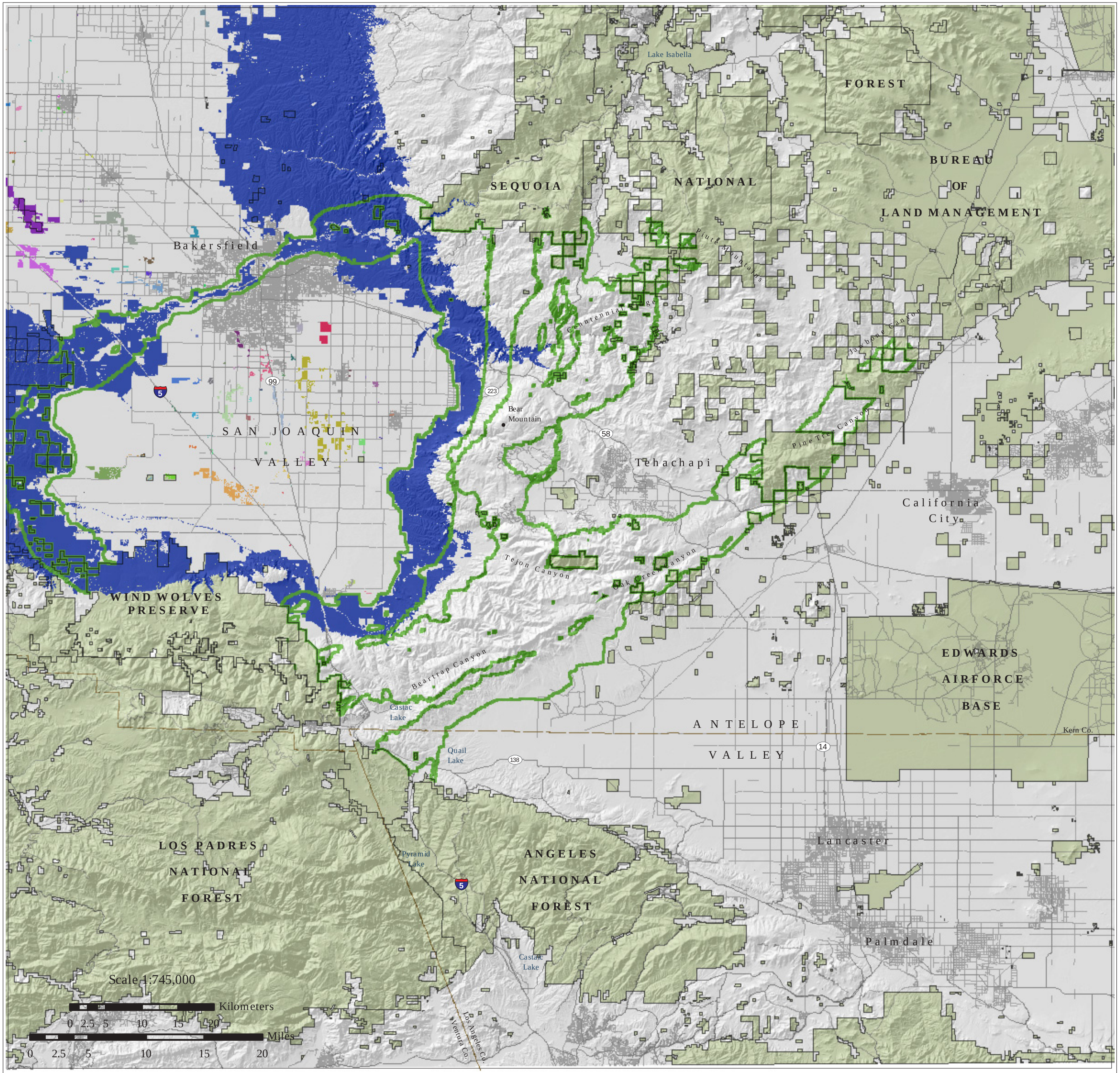
F i g u r e 25.
Patch Configuration
for
Heermann's kangaroo rat

(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).

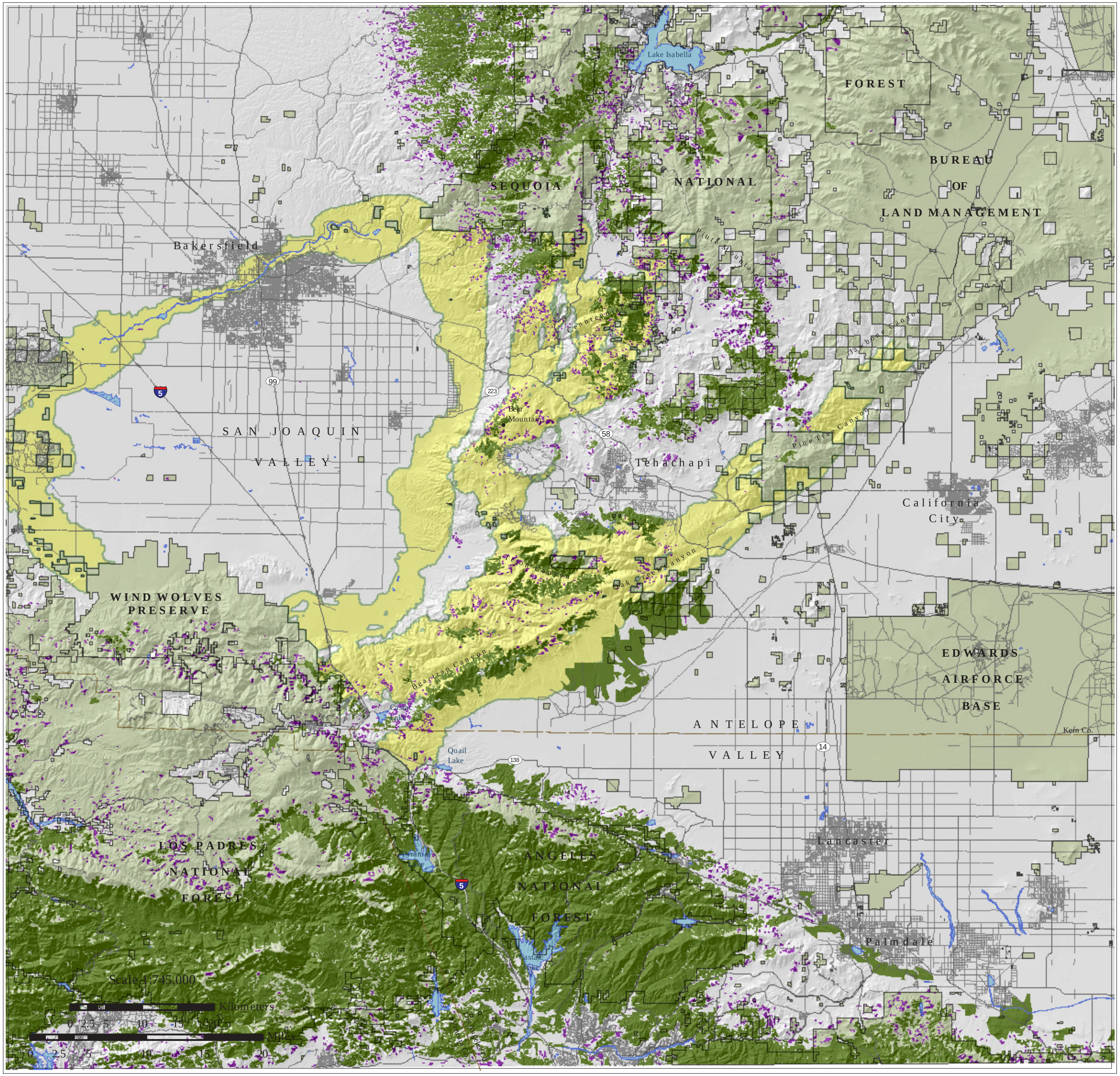
Habitat Associations: California thrasher is primarily associated with dense chaparral though it may also occur in adjacent oak woodland and riparian habitats (Cody 1998). This species avoids oak woodland devoid of understory (Robertson and Tenney 1993), although it may use these habitats outside the 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.

Figure 26.
Potential Cores & Patches
for
California thrasher
(Toxostoma redivivum)



Legend

- 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.

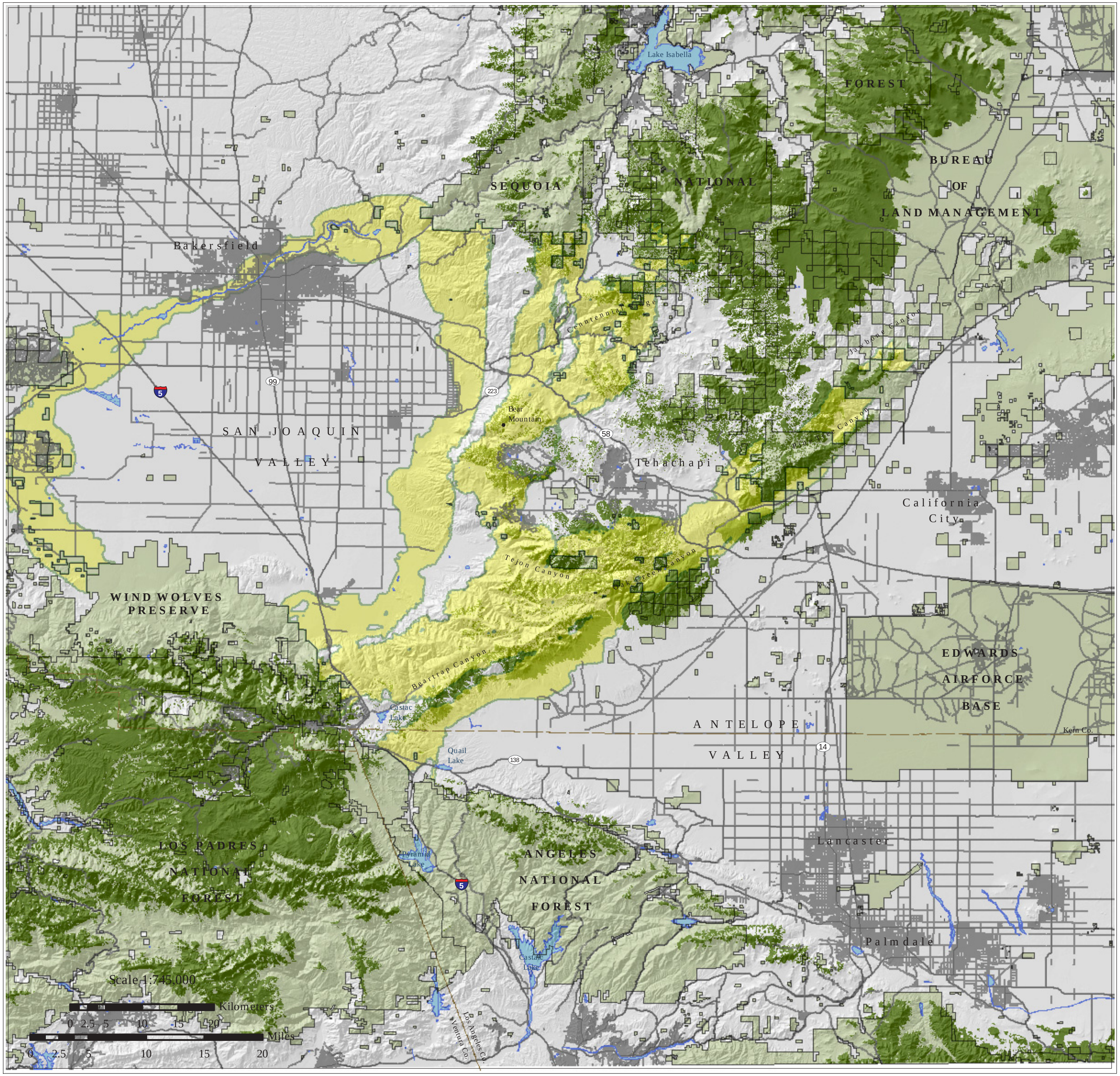
Habitat Associations: This species occurs in low to middle elevation mountain canyons, in sagebrush scrub, open woodland and forest, mountain meadows, and on river flats (Scott 1986, Struttmann undated mat.). The larvae feed on the leaves of various species of buckwheat (*Eriogonum* spp.) and adults 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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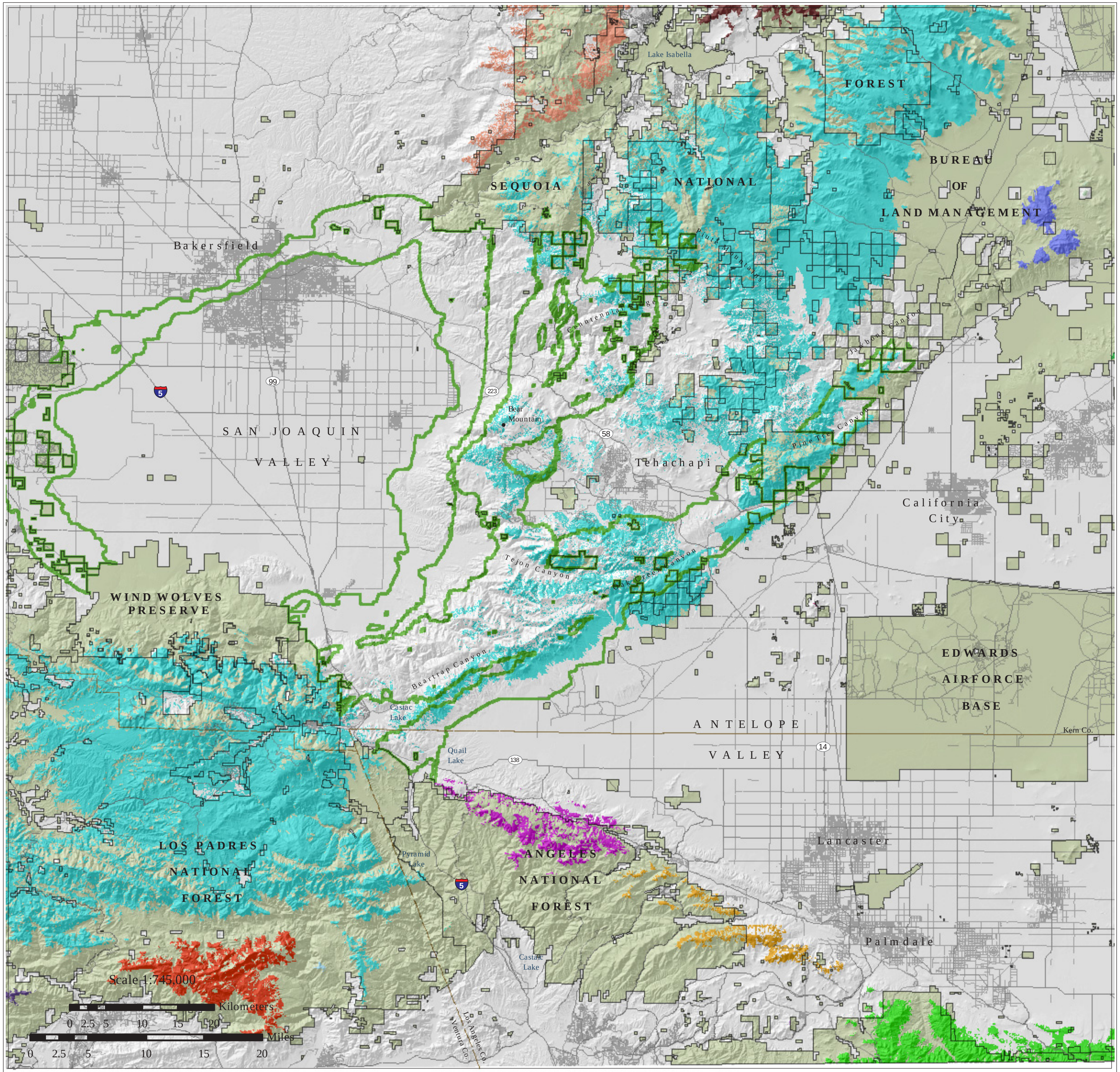
Figure 28.
Patch Configuration for Bright blue copper butterfly
(Lycaena heteronea clara)

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.

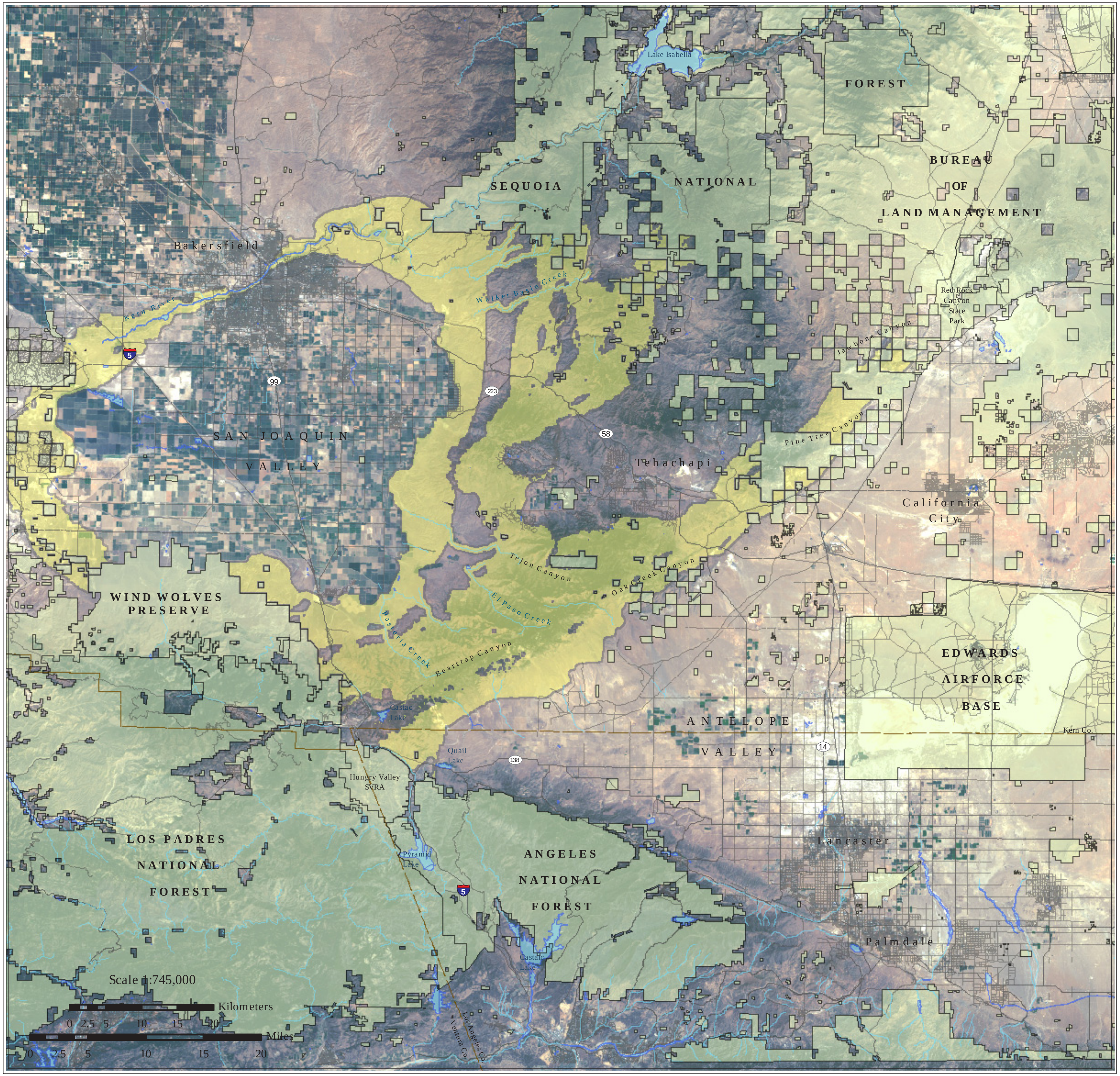
These first three major prongs, or linkages, are clearly separated in the northeastern portion of the study region where each connects into the Sierra Nevada, but they tend to fuse in the more geographically constrained southwestern portion of the study area, in the western Tehachapis. Some cross connections 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.

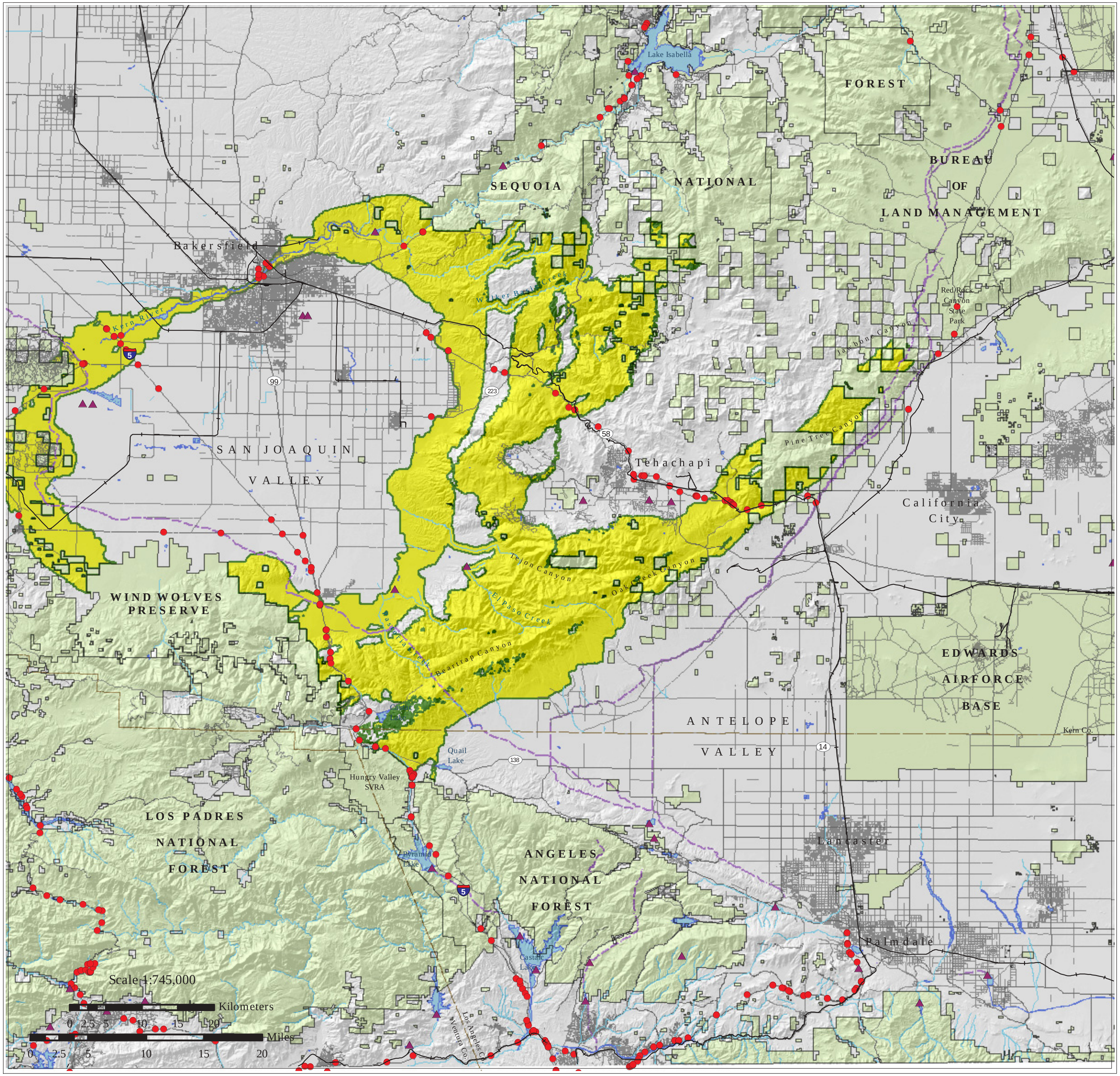
This discussion focuses on structures to facilitate movement of terrestrial species across roads or aqueducts, and on structures to facilitate stream flow under roads. Although some documents refer to such structures as “corridors” or even “linkages,” we use these terms in their original sense to describe 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

- Linkage Design
- Potential Crossing Structures
- Paved Roads
- Railroad
- Dams
- Aqueduct
- Waterbodies
- Perennial Rivers & Creeks
- Ownership Boundaries
- County Lines



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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.

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

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.

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.

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

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).

Appendix A: Workshop Participants

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

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

8:00 Check-in

8:30 *Welcome and Opening Remarks*
Rick Rayburn, California State Parks

8:40 *Regional Overview*
Paul Beier, Northern Arizona University

9:00 *Linkages From a Plant Perspective*
Ileene Anderson, California Native Plant Society

9:20 *Connecting Arthropods in the Southern Sierra Nevada Area*
Gordon Pratt, University of Riverside California

9:45 *Herpetofaunal Biodiversity in the Southeastern Sierra Nevada Mountains*
Dave Morafka, California State University, Dominguez Hills

10:15 Break

10:30 *Hop, Crawl or Slither? Contrasting Corridors for Herpetofauna*
Rob Lovich, AC/S Environmental Security Marine Corps Base, Camp Pendleton

10:50 *Birds Can Fly: An Overview of the Conservation Challenges in the Southern San Joaquin Valley*
David Clendenen, Preserve Manager for The Wildlands Conservancy at Wind Wolves Preserve

11:10 *Blue Grouse, Exit Stage Right*
James Bland, Santa Monica College

11:30 *Considering Small Mammals in Linkage Planning for the South Coast Ecoregion*
Wayne Spencer, Conservation Biology Institute

11:50 *Cougars, Corridors, and Conservation*
Paul Beier, Northern Arizona University

12:10 *Considerations for Connectivity and Overview of Working Group Session*
Claudia Luke, San Diego State University Field Station Programs

12:30 Lunch - a Mediterranean mezza will be served

1:15 Working Group Session

<u>Taxonomic Group Leaders</u>:

Plants	-	Tim Thomas
Invertebrates	-	Gordon Pratt
Herps/Fish	-	Claudia Luke
Birds	-	Michael White
Mammals	-	Paul Beier

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

5:00 Adjourn: Please join us for a Beer & Wine Social here at the Frazier Park Recreation Building.

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

Rick Rayburn, California State Parks – *Welcome*

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

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

- This project will also help agencies enforce laws to avoid subdivision and land conversion in priority connectivity areas to allow wildlife movement
- Thank you to David Myers of The Wildlands Conservancy (for supporting this project and protecting the Wind Wolves Preserve), Kristeen Penrod, and SCWP board members
- September 2002 Discover Magazine article highlighted and publicized this effort

Paul Beier, Northern Arizona University – *Regional Overview*

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

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

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

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

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

- Photographs shown: great basin sagebrush, California juniper association (threatened by increasing human activity and fire occurrence), San Gabriel Mountains, desert scrub, Joshua tree woodland (not adapted to fire - causes type conversion to desert scrub)
- In southern Sierra Mountains, hydrology and soils dictate naturally occurring fragments of mountain meadows in pinyon forest; alluvial processes provide opportunity for movement of plant propagules
- Botanically exciting area with localized populations of possible undescribed species (such as new onion found on pebble-based soils with no exotic weed competition); substrate-specific rare plants present
- Linkages encouraging plant movement may also allow spread of exotic weeds; corridors with disturbed habitats may allow invasive plants to exploit resources
- Some plant communities require fire for persistence (such as chaparral); desert plants not adapted to fire, and may type convert to support invasive species
- In San Gabriel Mountains and Great Valley, nitrogen deposition from poor air quality may effect vegetation by supporting exotic species over native vegetation

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

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

Biography: Pratt began his academic career with a bachelor's of science in biology at Northeastern University in Boston, Massachusetts. He finished a master's degree in Molecular Biology isolating and identifying mRNAs for specific proteins of the blowfly at Queen's University in Kingston, Ontario Canada. Pratt then did a Ph.D. on the evolution of the *Euphilotes enoptes* and the *E. battoides* complexes (small blue butterflies adapted to buckwheats) at the University of California at Riverside, California. Afterwards he did a post-doctorate on the sympatric evolution of treehoppers at the University of Delaware. Presently Pratt is a researcher at the University of California at Riverside working on endangered butterflies and the diversity of insects in various desert areas. He coteaches a course on the ecology of butterflies of southern California through extension at UCR. Pratt has authored and coauthored 36 papers on insects, most of which are on different aspects of butterfly evolution and biology.

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

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

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

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

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

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

- Panamint canyons contain perennial snow-fed streams and waterfalls, chain ferns and orchids, and diverse riparian vegetation, although very close to Death Valley; endemic rattlesnake, slender salamander and alligator lizard found in Panamint sky islands
- There may be more undescribed salamanders in this region of California than in tropical Guatemala; one salamander species lives in ice-melt under rock crevices and dies of heatstroke at temperatures over 60 deg F; many unique endemic herpetofauna must be described to properly manage habitats in southern and central Sierra Nevada Mountains
- California's Sierra ranges are national hotspot of amphibian and reptile endemism; some species (such as western fence lizard) are ice age relics that occur in almost every range of the southwest U.S.; others are unique endemics not closely related to regional species, but morphologically similar to fossils from Mio-Pliocene and have existed on certain ranges for 5-10 million years or longer in relative isolation; Panamint alligator lizard is between these two extremes, with several partially differentiated populations

  Herpetofauna diversity based on:
  - Large size of ranges located in huge basins with available surface water
  - Old age of tectonic events forming these ranges (12-15 million years old)
  - Tremendous topographic relief and wide variety of habitats
  - Important wetlands between ranges with temporary connections during wet years
  - Insulation against change to some extent; "buffered bench" hypothesis says that ranges rise up like benches with steep ridge on one side and rolling plateaus on other side; snow-melt from high peaks feeds lower plateau streams to sustain surface water year-round at buffered latitude and altitude, conditions which can sustain populations in relatively mesic habitats for millions of years rather than thousands of years; creates treasure of relic herpetofauna in a "Miocene Park"

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

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

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

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

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

Summary: On the face of it, birds … because they can fly, would seem to be less susceptible to the negative effects of habitat fragmentation than other more terrestrially bound vertebrates. In reality, as a group, birds display a high degree of variance with regard to their susceptibility to habitat fragmentation. Adaptable generalists such as the common raven are thriving in the southern San Joaquin Valley ecoregion. Specialists, such as the Yellow-

billed cuckoo and the southwest willow flycatcher are endangered. Other species, such as the purple martin and Lewis' woodpecker embody issues that go beyond habitat fragmentation. The Wildlands Conservancy's Wind Wolves Preserve and Stubblefield Ranch property, together with the Los Padres National Forest, the Bitter Creek National Wildlife Refuge, and the Carrizo Plain National Monument, create a vast block of connected habitats. However, great challenges remain. The San Joaquin Valley has largely been converted to monoculture farming. Recently proposed and expected future development projects on Tejon Ranch represent a tremendous threat to habitat connectivity. Aggressive and creative conservation action, combined with delicate politics will be required to maintain and re-create functioning habitat connectivity in the San Joaquin ecoregion.

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

- San Joaquin Valley is highly altered ecosystem; habitat fragmentation, degradation, and loss is most severe on valley floor; 272,000-acre Tejon Ranch is currently proposed for development of 23,000-house Centennial community, a 1,450-acre warehouse complex, and ranchettes at Tejon Lake, creating an immediate threat to regional habitat continuity
- American crows and various blackbirds utilize crops, but use of pesticides impacts avian populations; it seems that crow and blackbird populations have dramatically declined
- Historic population trends for most birds in this region have not been documented
- Rim of valley floor has potential for maintaining connectivity; foothills on eastern side are relatively intact through Tehachapi and Sierra Nevada Mountains
- The Wildlands Conservancy has conserved nearly 100,000 acres, including Wind Wolves Preserve, near the Stubblefield property, Los Padres National Forest, Bitter Creek National Wildlife Refuge, and Carrizo Plain National Monument, which together create a vast, contiguous block of connected habitats
- Region is ecologically unique at convergence of Transverse Ranges, Coast Ranges, Sierra Nevada Mountains, western Mojave Desert, and San Joaquin Valley; elevation range of over 8,000 feet; impressive mosaic of habitats and biodiversity
- Diverse avifauna found here with variance in reaction to fragmentation; for example, common raven is flourishing to point that it negatively impacts other native species
- American kestrels found even near agriculture; white-tail kite is nomadic predator; turkey vultures capitalize on road kill, livestock mortality, and garbage; golden eagles found in foothills, and require undisturbed habitat (hazards posed by highways and power lines)
- Tricolor blackbird population is less than 200,000 and declining; nesting habitat in valley is mostly gone, and breeding attempts in agricultural fields often obliterated by harvest
- Captive breeding process and sub-optimal rearing and release methodologies have dramatically changed behavior of re-introduced California condors
- In general, sedentary habitat specialists are good focal species for linkage planning; participants should focus on habitat types to highlight species with special significance
- Grasslands, although altered by exotic annual grasses, should be preserved and managed to maintain biodiversity; they provide wintering habitat for long-billed curlew, mountain plover, and ferruginous hawk; possible focal species: ground nesting birds (horned larks, lark sparrows, and meadowlarks), savanna sparrow, burrowing owl
- Saltbush scrub focal species: sage sparrow, LeContes thrasher, and loggerhead shrike

- Riparian habitats need restoration (such as removal of salt cedar); possible focal species: willow flycatcher, least Bell's vireo, yellow warbler, and yellow-breasted chat
- Oak savanna requires conservation and management; must provide habitat for cavity nesters and excavators such as acorn woodpecker; also important are western bluebirds and purple martins; need to control European starlings and restore oak recruitment
- Montane areas are less threatened, except for fragmentation caused by logging in Sierra Nevada Mountains; obvious focal species for this habitat is the spotted owl

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

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

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

- Blue grouse inhabit coniferous forests of western North America; Mount Pinos blue grouse subspecies occurs at southwest limit of species distribution; most of planning area considered marginal habitat; limited scientific knowledge; recognized as gamebird
- Population declining since 1930s; 1928 Mount Pinos description estimated maximum of 50 pairs; 1978 was last documented sighting; no longer occur in Kern County; range contraction probably caused by habitat degradation related to logging industry
- Blue grouse more abundant in old growth forests; hooting males found in massive firs; habitat requirements in central Sierra Nevada Mountains have 3 seasonal components:
    - Spring courtship: males vocalize (hoot) to attract females in mixed mature conifer forests from 6,000-9,000 feet; require open glades with patchy mosaic of woody shrubs and herbs, and massive firs; usually group of about five males return to specific site until canopy closes over, which rarely happens in California
    - After hatching, females move chicks to summer brood-rearing habitat, a moist montane meadow with lush herbaceous growth in walking vicinity of hooting site
    - Over-wintering site (this site may be same as hooting habitat)
- More grouse found in protected mature forests (with firs over one meter in diameter and well over 100 years old) than in cleared or selectively harvested areas

- Fire suppression allows open glades needed for hooting to fill in with shrubs and young firs; also, catastrophic fires can kill the massive firs and also reduce grouse habitat
- Reforestation after clear-cut or burn: blue grouse need mixed conifers, but many areas have been planted as pine plantations / monocultures lacking firs and canopy openings
- Grazing livestock degrade soil, change hydrology, cause erosion, and trample herbaceous layer in brood-rearing habitat; blue grouse also impacted by encroachment of meadows for residential development and campgrounds, and ATV disturbance
- Linkages may restore blue grouse to southern California; protected mixed conifer "stepping stones" needed from Sierra Nevada Mountains into Tehachapi area, which has been used for timber production; protect mountain meadows; restore natural fire regime

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

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

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

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

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

Summary: Because the puma or cougar lives at low density and requires large habitat areas, it is an appropriate umbrella species for landscape connectivity in the South Coast Ecoregion. A crucial issue, however, is whether connectivity is provided by narrow corridors through urban areas (an artificial substitute for natural landscape connectivity). In particular,

corridors decrease extinction risk only if they facilitate dispersal of juveniles between mountain ranges. To address this issue, we conducted field work on pumas in the Santa Ana Mountain Range, a landscape containing 3 corridors (1.5, 6, and 8 km long). Each of the 3 corridors was used by 2 or more dispersing juvenile puma. Five of 9 radio-tagged dispersers successfully found and used a corridor. The corridors in this landscape were relict strips of habitat, not designed to facilitate animal movement. Puma doubtless would be even more likely to use well-designed linkages. Puma will use corridors that lie along natural travel routes, have < 1 dwelling unit per 50 acres, have ample woody cover, lack artificial outdoor lighting, and include an overpass or underpass integrated with roadside fencing at high-speed road crossings. "If we build it, they will come."

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

- Pumas exist at low density; functional connectivity needed for movement and dispersal
- Santa Ana Mountains study: 9 radio-collared juvenile dispersers were tracked; three corridors / habitat constrictions present, but not designed for habitat connectivity:
  1. Coal Canyon (short freeway undercrossing near railroad tracks, stables, and golf course); 3 lions attempted to cross (2 successful); M6 was premier user of corridor, crossing under freeway more than 22 times in 18 months - home range included habitat on both sides of freeway; after completion of study, surrounding properties were preserved, and CalTrans agreed to close underpass to traffic, remove asphalt, and turn over to California State Parks for restoration and use as wildlife linkage
  2. Santa Ana – Palomar (longer, I-15 is major impediment, patchwork of land ownership); 2 lions attempted to cross (1 successful); one lion crossed Santa Ana – Palomar linkage by walking across I-15 rather than finding a safer route underneath; point of crossing was just north of border patrol / INS checkpoint; four un-tagged lions were killed crossing at this site – multiple lions are demonstrating preferred crossing site, which should be focus of planning for vegetated freeway overpass
  3. Arroyo Trabuco (protected from urban areas by tall bluffs, contains dense riparian vegetation, resident deer population, darkness, water); 3 lions attempted to cross (3 successful); lions spent 2-7 days traveling through this "comfortable" corridor
- Mountain lions do use narrow corridors and artificial linkages; 5 of 9 study animals found and successfully used at least one of the three corridors; these "accidental corridors" were not designed for animal movement, which explains some unsuccessful attempts

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

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

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

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

Appendix C: 3D Animation

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

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

The fly-over provides a virtual landscape perspective of the local geography and land use in the Tehachapi connection. 2002 USGS LANDSAT Thematic Mapper data was used to build a natural color composite image of this study area.

INSTRUCTIONS ON VIEWING FLY OVER

Simply download the .avi file "Tehachapi_flyover.avi" from the CD onto your computer's hardrive. Putting the file on your computer before viewing, rather than playing it directly from the CD, will provide you with a better viewing experience since it is a large file.

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

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

Please direct any comments or problems to:

Clint Cabañero
GIS Analyst
South Coast Wildlands Project
clint@scwildlands.org

Appendix D: Patch Size & Configuration

Mountain Lion (*Puma concolor*)

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

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

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

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

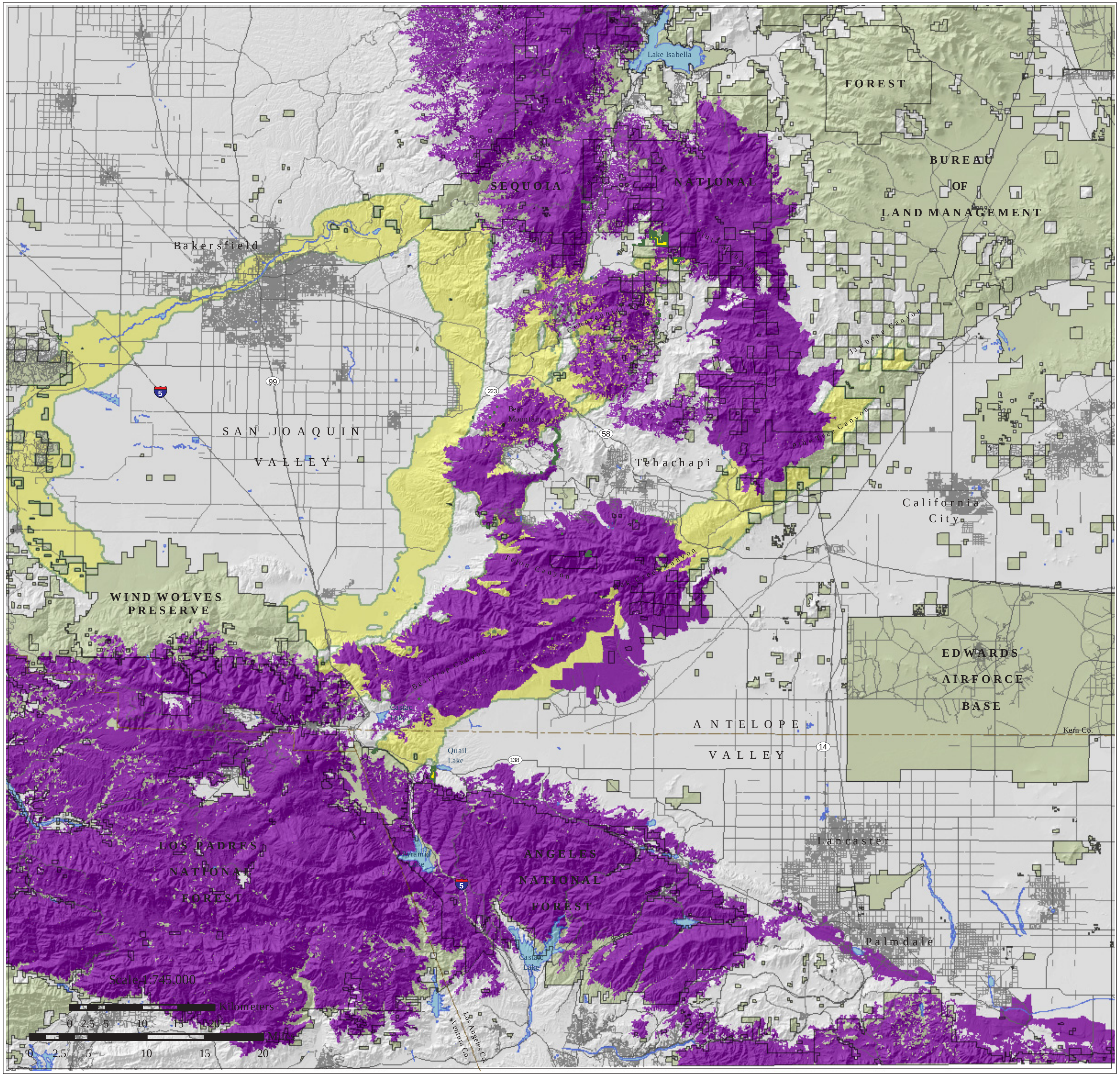
Conceptual Basis for Model Development: Puma will utilize most habitats above 590 m in elevation, provided they have cover. Road density is also a significant factor in habitat suitability for mountain lions. The minimum patch size was defined as 186 km^2, using twice the home range size of 93 km^2. Patch size was classified as $\geq$ 186 km^2 but

< 4,650 km^2. Core areas potentially supporting 50 or more individuals were modeled using patches $\geq$ 4650 km^2 (93 km^2 x 50). Dispersal distance for Puma was defined as 65 km.

Results & Discussion*:* The Least Cost Union is likely to serve this species as sufficient move through habitat was captured in the analysis (Figure 36). The model identified all upland habitat in the Tehachapi Mountains as one contiguous potentially suitable habitat patch ($\geq$ 186 km^2 but < 4,650 km^2), the majority of which was captured in the Least Cost Union. However, no contiguous patches $\geq$ 4,650 km^2 (i.e., core areas capable of potentially supporting 50 individuals) occur within the analysis window, illustrating the importance of maintaining connectivity through the Tehachapis. Extensive habitat exists in the Sierra Madre and Castaic Ranges of the Los Padre and Angeles National Forests, and in the Piute and Greenhorn mountains of the Sequoia National Forest. All habitat patches are well within the dispersal distance of this species. Individual adults may even traverse the entire length of the linkage over a matter of days. This species requires expansive roadless areas to survive and functional connectivity between subpopulations in the existing protected areas.

Figure 36. Habitat Patches for Mountain lion

(Puma concolor)



Legend

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

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SOUTH COAST WILDLANDS PROJECT

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South Coast Wildlands Project
August 2003

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American Badger (*Taxidea taxus*)

Distribution & Status: Once a fairly widespread resident throughout open habitats of California, badger is now uncommon throughout the state and is considered a California Species of Special Concern (CDFG 1995, CDFG 1999). There have been 2 recent sightings of badger in the linkage planning area, one in the vicinity of Quail Lake and another just south of the California Aqueduct near Maricopa Flat (CDFG 1999).

Habitat Associations: Badgers are largely considered habitat specialists, associated with grasslands, prairies, and other open habitats (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). They are occasionally found in open chaparral (< 50% cover) but haven't been documented in mature stands (Quinn 1990 *in* CDFG 1999). They prefer friable soils for excavating burrows and require abundant rodent populations (Banfield 1974; de Vos 1969 *in* Sullivan 1996). The species is typically found at lower elevations (CDFG 1999) in flat, rolling or steep terrain but it has been recorded at elevations up to 3,600 m (12,000 ft) (Minta 1993).

Spatial Patterns: Home range sizes for this non-migratory species vary both geographically and seasonally. Male home ranges have been estimated between 240-850 ha and females at 137-725 ha (Long 1973, Lindzey 1978, Messick and Hornocker 1981, CDFG 1999). Though, in northwestern Wyoming, home ranges up to 2100 ha have been reported (Minta 1993). In Idaho, home ranges of adult females and males averaged 160 ha and 240 ha respectively (Messick and Hornocker 1981). Badgers may exhibit seasonal changes in home range size, being more restricted in winter (CDFG 1999). In Minnesota, Sargeant and Warner (1972) radio-collared a female badger, whose overall home range encompassed 850 ha; range was restricted to 725 ha in summer, 53 ha in autumn, and to a mere 2 ha area in winter. In Utah, Lindsey (1978) found fall and winter home ranges of females varied from 137-304 ha, while males varied from 537-627 ha (Lindzey 1978). Males may double movement rates and expand their home ranges during the breeding season to maximize encounters with females (Minta 1993). Lindzey (1978) documented natal dispersal distance for one male (110 km) and one female (51 km).

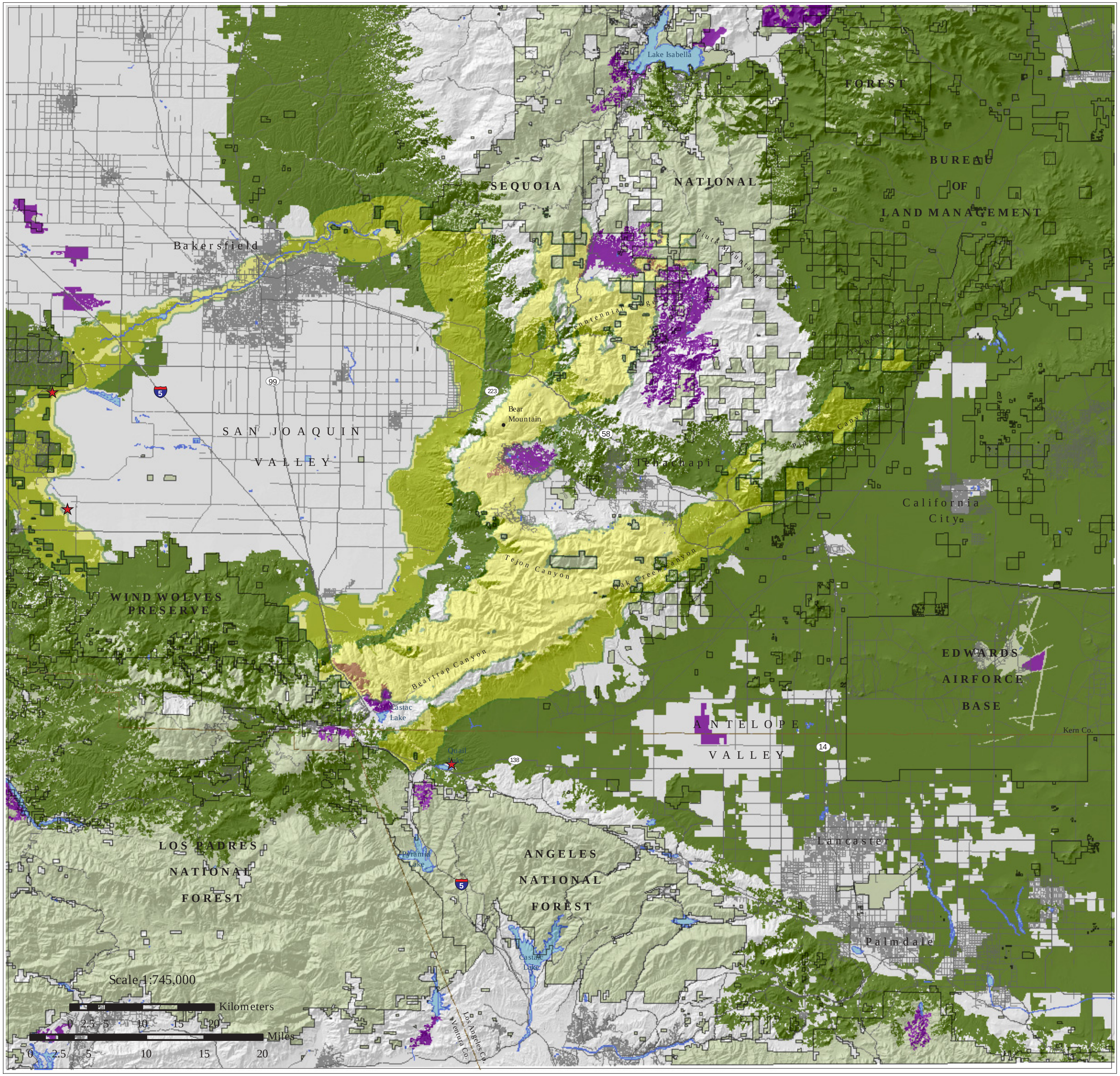
Conceptual Basis for Model Development: Prefers grasslands, meadows, scrubs, riparian, desert washes and open woodland communities. Terrain may be flat, rolling or steep but below 3,600 m (12,000 ft) in elevation. The minimum patch size was defined as 2 home ranges (480 ha), using the smallest recorded range (240 ha x 2). Core Areas containing fifty badgers are equal to or greater than 12,000 ha in size (240 ha x 50). Patch size is $\geq$ 480 ha but < 12,000 ha. Maximum dispersal distance for male badgers is 110 km, while the longest recorded distance for females is 51 km; both distances were evaluated.

Results & Discussion: The linkage will likely serve this species since sufficient live in and move through habitat was captured in the Least Cost Union (Figure 37). The model identified extensive core areas in the grassland and foothill habitat that exists in a contiguous belt along the fringe of the southern San Joaquin Valley, from Wind Wolves

Figure 37.
Potential Cores & Patches for American badger
(Taxidea taxus)

Legend

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



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SOUTH COAST WILDLANDS PROJECT

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Preserve and Los Padres National Forest, along the base of the Tehachapi Mountains, to the southwestern portion of Sequoia National Forest. The Least Cost Union also encompasses a fairly contiguous block of potential core habitat for this species in the grassland, desert scrub and woodland communities of the Antelope Valley, from protected core areas in the Sierra Madre, San Emigdio, and Castaic Ranges, along the southeastern slopes of the Tehachapi Mountains, to the Jawbone Canyon area managed by the Bureau of Land Management. Extensive core habitat areas also exist outside of the Least Cost Union, near Wheeler Ridge, in Tejon Canyon, around Quail Lake, in the Tehachapi Valley, in the foothills of the Sierras north and south of the Kern River, and in desert scrub habitats of the Antelope Valley. All potentially suitable habitat patches captured within the Least Cost Union that will support at least two individuals are within the 51 km dispersal distance of this species.

San Joaquin kit fox (*Vulpes macrotis mutica*)

Distribution & Status: Historically, the San Joaquin kit fox was widely distributed on the valley floor and adjacent low foothills of the San Joaquin Valley, from the vicinity of Byron in Contra Costa County, extending southward to the foothills of the Tehachapi Mountains. By 1930, its range had already been reduced by half, with the largest remaining populations in the southern and western portions of the valley (USFS 2002). The species was federally listed as endangered in 1967 and state-listed as threatened in 1971 (USFWS 1998). No comprehensive surveys have been conducted of the entire historical range, but experts believe the fox inhabits remaining suitable habitat on the San Joaquin Valley floor and in the surrounding foothills and valleys of the coastal ranges, Sierra Nevada and Tehachapi Mountains (Thelander 1994; USFWS 1998).

Habitat Associations: Topography and vegetative cover strongly influence the distribution of kit fox, but prey availability and predator avoidance also have an effect on habitat use by this species (Grinnell et al. 1937, Egoscue 1962, Daneke et al. 1984, Zoellick et al. 1989 *in* Warrick and Cypher 1998). 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 material). They prefer open environments so they can more easily detect predators (Warrick and Cypher 1998). Research has also shown high capture rates in recently burned areas, which was attributed to the openness of the habitat and its affect on predator evasion (Zoellick et al. 1989 *in* Warrick and Cypher 1998). The species can also persist in and adjacent to some kinds of agriculture (row crops, irrigated pastures, orchards, vineyards) and urban areas (USFWS 1998); though these are indisputably sub optimal environments to maintain native wildlife or recover populations of endangered species (Cypher and Frost 1999).

Spatial Patterns: The species is typically associated with lower elevations, though it has been recorded just east of Fort Tejon at 363 m (1,200 ft) (Grinnell et al. 1937, USFWS 1983 *in* USFWS 1998) and up to 473 m (1319 ft) (B. Cypher pers. comm.). They are mainly associated with gently sloping and flat terrain. The literature suggests slopes of 0-5% are ideal, slopes of 5-10% provide fair habitat, and places with slopes >10% are largely unsuitable for kit fox (Haight et al. 2002). Warrick and Cypher (1998) found the spatial distribution of kit fox in the Elk and Buena Vista hills of the Temblor Range to be consistently affected by topography (Warrick and Cypher 1998, Zoellick et al. 2002).

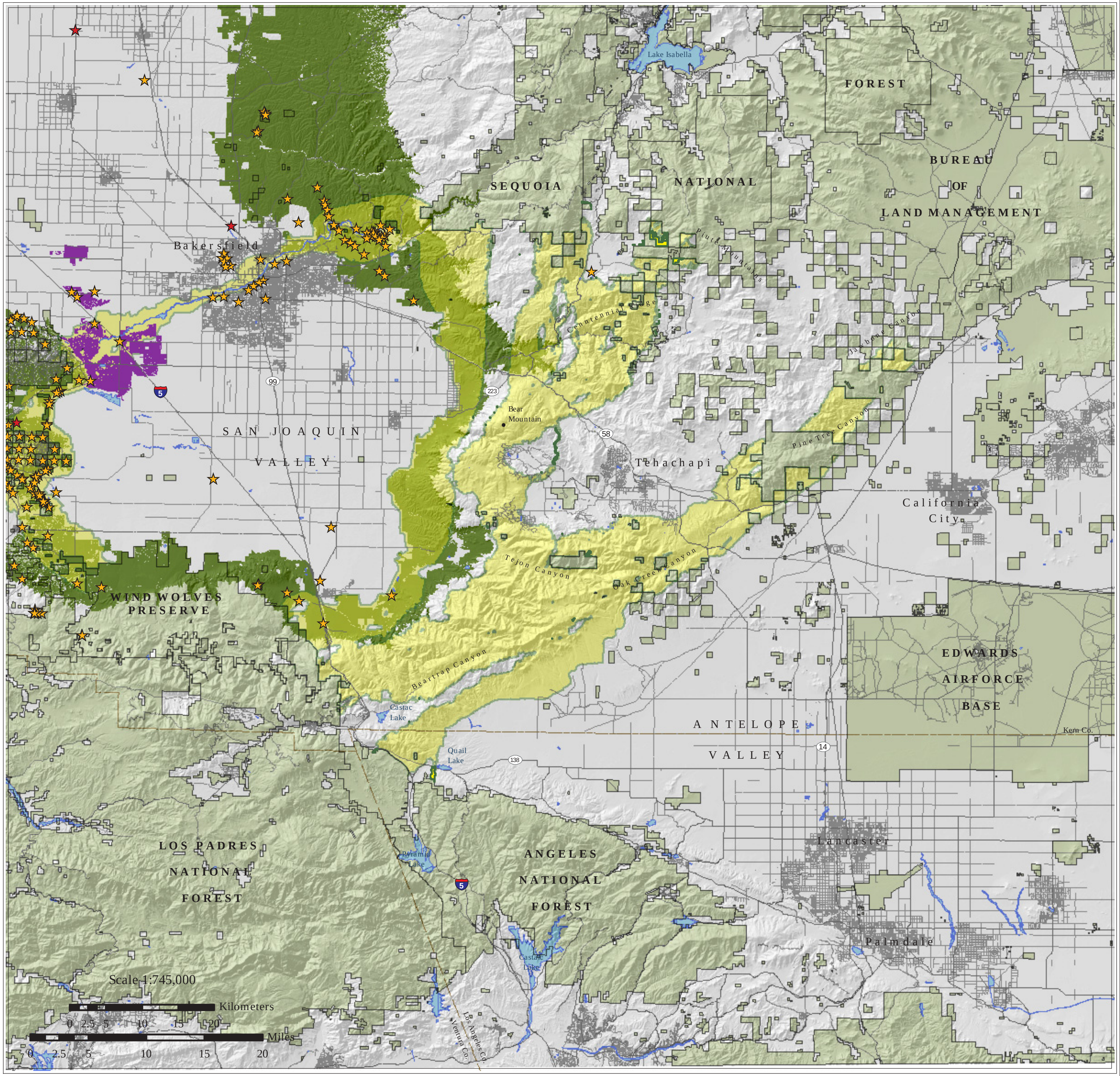
Home range estimates vary from less than 1 mi^2 (2.59 km^2) up to approximately 12 mi^2 (31.08 km^2)(Morrell 1972, Knapp 1978, Zoellick et al. 1987, Spiegel and Bradbury 1992, White and Ralls 1993 *in* USFS 2002). Home range size is largely dependent on prey availability, which can vary annually (Haight et al. 2002). In 2000, home range sizes at the Naval Petroleum Reserve averaged 5.2 km^2 (Koopman et al.), while in 2002 the mean was 4.6 km^2 (Zoellick et al. 2002). In the Carrizo Plain, home range size averaged 11.6 km^2 (White and Ralls 1993 in Zoellick et al. 2002). Haight et al (2002) assumed 2 kit foxes per home range, which they estimated averaged 3.9 km^2 in good habitat and 7.8 km^2 in fair habitat (Haight et al. 2002). Studies indicate that a density of one kit fox per square mile is a reasonable figure to use to estimate populations based on known acreage of habitat (CDFG 2000).

Juvenile dispersal can be less than 5 miles or up to 60 miles from their natal dens (Thelander 1994). Koopman et al. (2000) found that 33% dispersed from their natal territory, significantly more males (49%) than females (24%). Dispersal distances vary widely, with male foxes known to travel over 40 km (Haight et al. 2002). Average length of nightly movements during the breeding period (14.6 $\pm$ 1.1 km) was greater than during pup-rearing (10.7 $\pm$ 1.0 km), and pup dispersal periods (9.4 $\pm$ 1.1 km) (Zoellick et al. 2002). Mean dispersal distance of kit foxes at the Naval Petroleum Reserves was 7.8 $\pm$ 1.1 km (n=48) and didn't differ between sexes (Scrivner et al. 1987 *in* Koopman et al. 2000).

Conceptual Basis for Model Development: This species prefers grasslands and sparsely vegetated scrub habitats in the San Joaquin Valley and surrounding foothills below 473 m in elevation. The minimum patch size was defined as 2 home ranges (517.8 ha), using the smallest recorded range (258.9 ha x 2). Patch size was classified as $\geq$ 517.8 ha but < 12,945 ha. Core areas potentially supporting 50 or more kit fox are $\geq$ 12,945 ha (258.9 ha x 50). Dispersal distance was defined as 60 miles.

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 (Figure 38). The model identified the fairly contiguous band of remnant grassland habitat along the perimeter of the southern San Joaquin Valley as core habitat for this species. All core areas and patches are well within the species maximum dispersal distance of 60 miles. Other important habitat identified outside of the Least Cost Union exists on Wheeler Ridge, in the Tejon Canyon area, in the Elk Hills, and around Bakersfield south of the Kern River. This species will also benefit from the habitat added to the Least Cost Union.

Figure 38.
Potential Cores & Patches for San Joaquin kit fox
(Vulpes macrotis mutica)



Legend

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

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

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Mule Deer (*Odocoileus hemionus*)

Distribution & Status: Mule deer have a widespread distribution in California and are common to abundant in appropriate habitat; they are absent from areas with no cover, such as desert communities or agricultural areas (Longhurst et al. 1952, Ingles 1965 *in* CDFG 1990). Mule deer are classified by the California Department of Fish & Game as a big game animal.

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

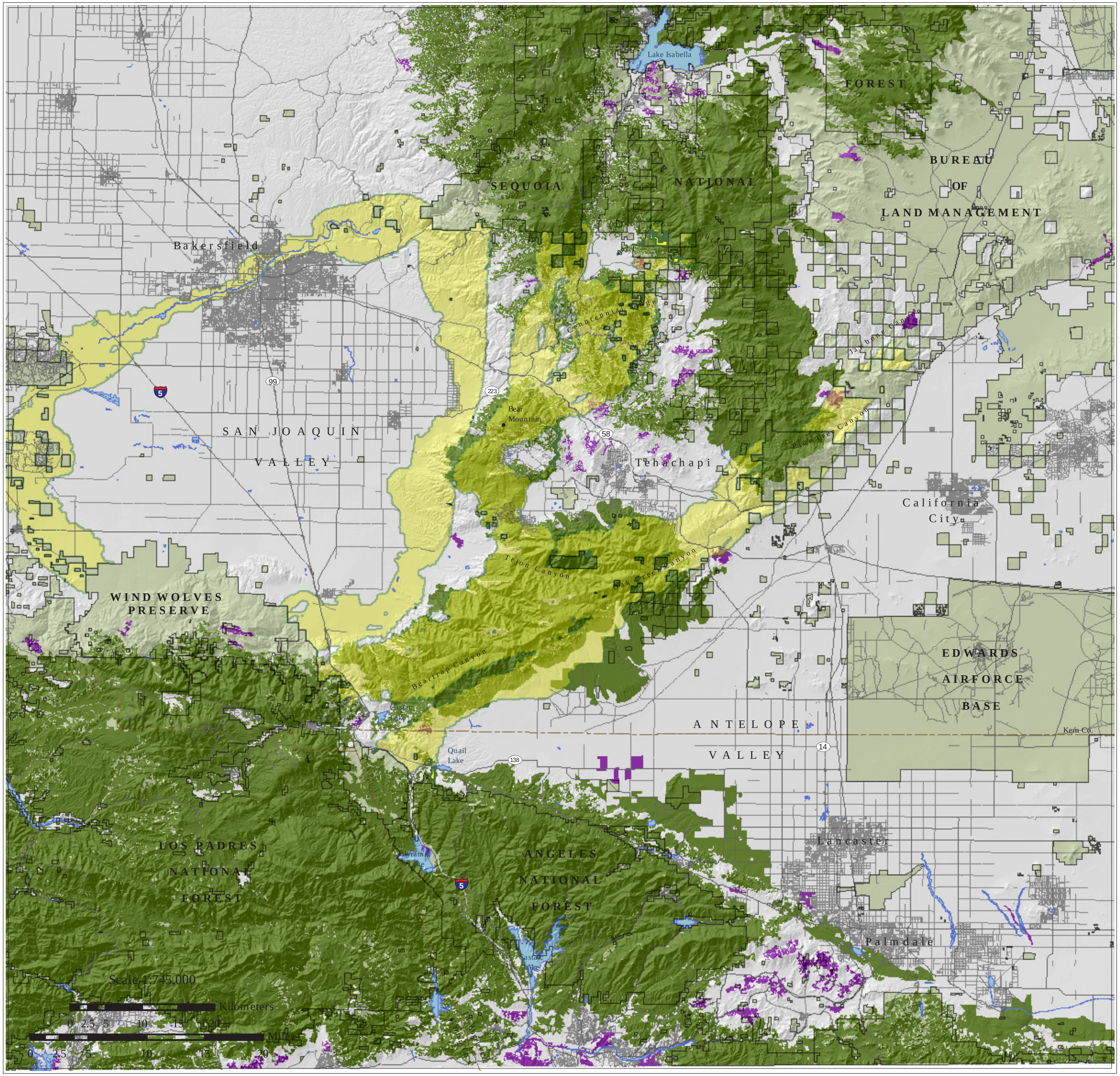
Spatial Patterns: Home ranges typically comprise a mosaic of habitat types that provide deer with various life history requirements. Several home range estimates exist in the literature, ranging from 39 ha (Miller 1970) to 3,379 ha (Severson and Carter 1978 *in* Anderson and Wallmo 1984, Nicholson et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

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

Conceptual Basis for Model Development: They utilize grassland, and meadow habitats, reaching their highest densities in oak woodland. Requires access to perennial water. The minimum patch size was defined as 2 home ranges (78ha), using the smallest recorded range (39 ha x 2). Patch size was classified as $\geq$ 78 ha but < 1950 ha. Core areas potentially supporting 50 or more deer are equal to and greater than 1950 ha (78 ha x50). Dispersal distance was defined as 97 km.

Results & Discussion: The Least Cost Union will also likely serve the needs of Mule deer living in or moving through the linkage (Figure 39). A fairly contiguous block of potentially suitable core habitat occurs throughout the hardwood and coniferous forest belt of the Tehachapi Mountains, from Castac Lake to Bear Mountain. Other core areas included in the Least Cost Union include Centennial Ridge and Sugarloaf Mountain. All core areas and patches (min size to core size) are within the dispersal distance of this species.

Figure 39.
Potential Cores & Patches for Mule deer
(Odocoileus hemionus)



Legend

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

N

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Western Gray Squirrel (*Sciurus griseus*)

Distribution & Status: Western gray squirrels are found in Washington, Oregon, California, and Nevada (Ryan and Carey 1995). In California they occur in the Klamath, Cascade, Sierra Nevada, Coast, Tehachapi, Little San Bernardino, Santa Rosa, and Laguna mountains (Ingles 1995 *in* CDFG 1990, USFWS 2002). The species is designated as a federal species of concern.

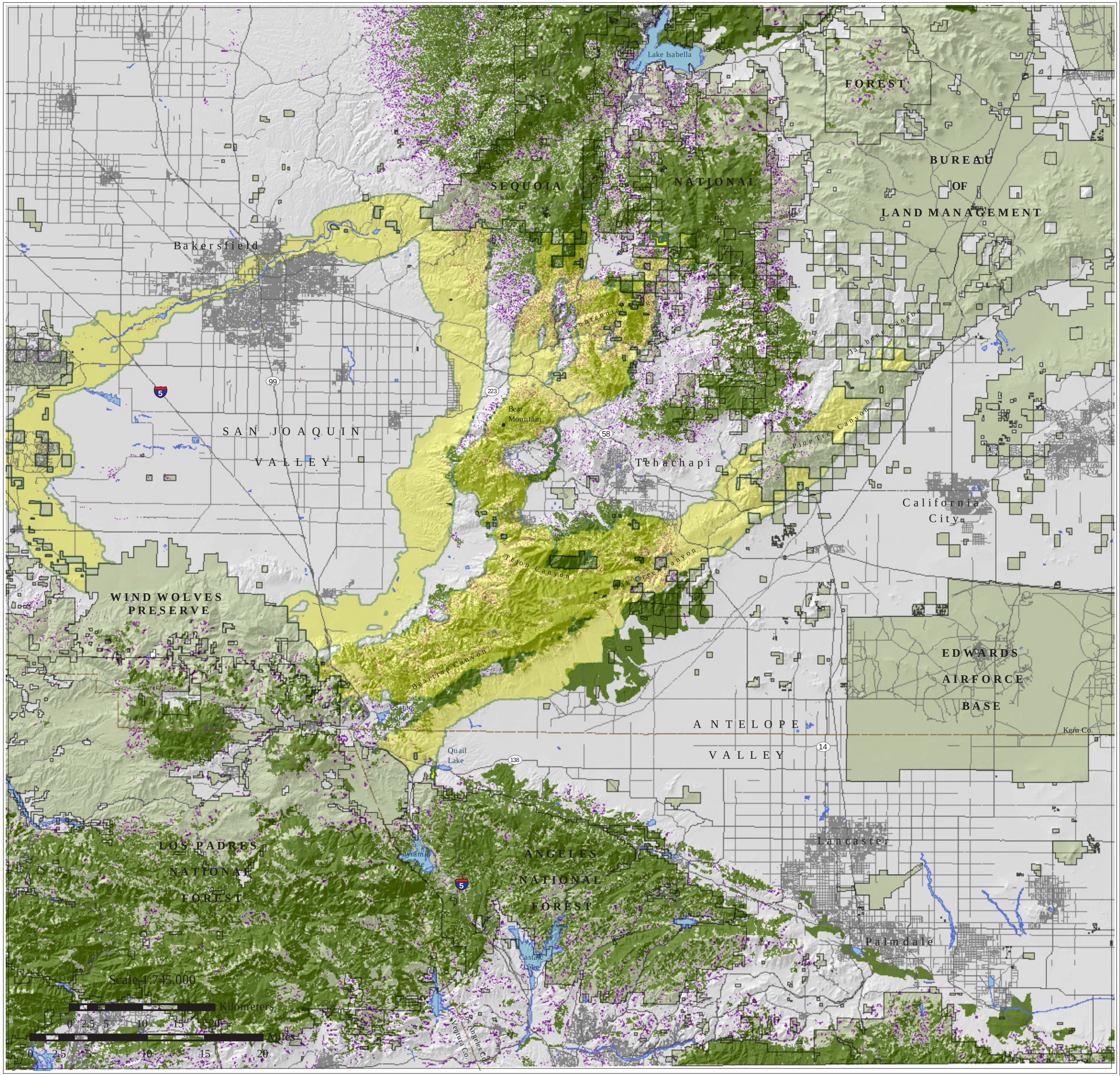
Habitat Association: Prefers mature stands of moist conifer, hardwood, and mixed hardwood-conifer habitats (Ingles 1995 *in* CDFG 1990). Closely associated with oak species abundance and diversity, they rely mostly on acorns, though pinecones, and other nuts, some fungi, berries and insects are also consumed. They are classic scatter hoarders with caches buried throughout their home range, using olfaction and memory to retrieve their stashes (Halloran 1999). These cavity nesters require diverse oak woodlands and stands of mixed conifer with heritage oaks and snags for cover, foraging and nesting habitat (CDFG 1990)

Spatial Patterns: The distribution of squirrels in the landscape is dependent on the size of the oak stand and adjacency to other forests and to water. Patch size must be diverse enough to provide adequate resources throughout the year and large enough for occupancy of multiple individuals, providing a greater chance of persistence (Ryan and Carey 1995); home range size is negatively associated with food resources and population density (Halloran 1999). Western gray squirrels aren't territorial, exhibiting small overlapping home ranges; typically 3 hectares in size, but can vary from 0.5 hectares to greater than 7 hectares (Halloran 1999). In Washington, it was found to prefer stands > 8 ha and < 0.6 km from water, with an average summer range between 2.6 and 4.2 ha, but this study was based on a total of 38 squirrel observations in 30 of 169 forest stands at Ft. Lewis, WA, where the species has been proposed for federal listing as endangered (Gilman 1986, Asserson 1974, Foster 1992, *in* Ryan and Carey 1995). Adjacency of oak stands to other forested habitats provides additional food and may provide connections to other patches of core oak woodlands and forested habitats (Ryan and Carey 1995). No dispersal or movement distances were mentioned in the literature for this species

Conceptual Basis for Model Development: This species occurs in moist conifer, hardwood, and mixed hardwood-conifer habitats (Ingles 1995), typically between 1,600 and 7,000 ft (Vaughan 1954 *in* CDFG 1990). The minimum patch size was defined as 2 home ranges 1 ha, using the smallest recorded range (0.5 ha x 2). Core areas potentially supporting 50 or more Western gray squirrel are $\geq$ to 25 ha (0.5 ha x 50). Patch size is defined as $\geq$ 1 ha but < 25 ha. No dispersal or movement distances were cited in the available literature.

Results & Discussion: The Least Cost Union analysis encompasses the majority of areas identified as important for the Western gray squirrel to live in or make intergenerational movements between core areas (Figure 40). Potentially suitable core habitat for this species is distributed almost continuously from the Castaic and Sierra Madre Ranges, through the montane hardwood and coniferous forests of the Tehachapi Mountains to the Sierra Nevada.

Figure 40.
Potential Cores & Patches
for
Western gray squirrel
(Sciurus griseus)



Legend

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

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Tehachapi Pocket Mouse (*Perognathus alticola inexpectatus*)

Distribution & Status: This endemic species ranges from as far west as Cuddy Valley near Mount Pinos, east along the southeastern flank of the Tehachapis to Sand Canyon, and southeast along the northern slope of the San Gabriels to Elizabeth Lake (Williams et al. 1993). The first specimen was collected west of Lebec at an elevation of 6,000 ft; it has since been recorded as low as 3,500 ft (CDFG 1986). It has been documented from Gorman, Mt. Pinos, Lebec, Cuddy Valley, and the Tehachapi Pass area, from Tehachapi Peak, Oak Creek Canyon, Cameron Canyon, and Sand Canyon, and around Elizabeth Lake, Quail Lake, and Lake Hughes (Williams 1978 *in* CDFG 1986, Laabs 1989, Sulentich 1983). Habitat for this species appears to be nearly continuous along the desert slopes of the southern Sierra Nevada, Tehachapi Mountains, and San Gabriel Mountains (CDFG 1986, Stephenson and Calcarone 1999). The majority of suitable habitat for this species occurs on private land, most notably Tejon Ranch, which hasn't been extensively sampled.

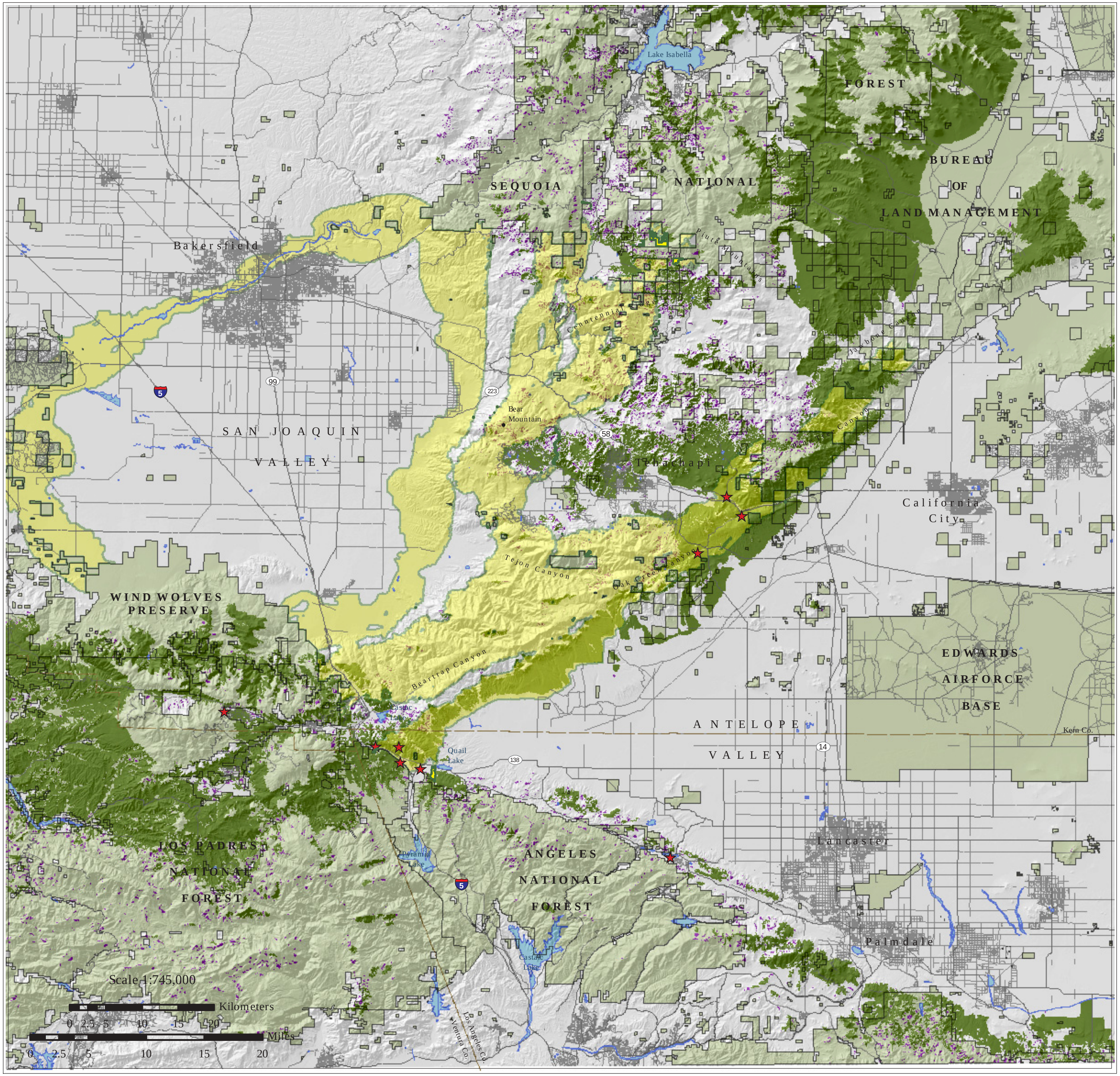
Habitat Associations: This species is known to utilize coastal sage, chaparral, desert scrub, pinyon-pine woodland, Joshua tree woodland, arid grasslands, grassy flats among scattered Jeffrey or Ponderosa pine, and oak savanna habitats (Williams et al. 1993, Best 1994 *in* Labbs, undated mat.); it has also been recorded in fallow grain fields (CDFG 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.).

Spatial Patterns: Because of the rarity of this species, and the fact that the majority of its range is on private land, the spatial requirements of this species are largely unknown. Movements are thought to be very limited; dispersal may be about 100 meters or so (W. Spencer, pers. comm.).

Conceptual Basis for Model Development: This species inhabits desert scrub, Joshua tree woodland, pinyon-juniper, perennial and annual grasslands, desert wash and open coniferous forests between 3500 to 6000 feet. Presently no home range or dispersal distance data exists on Tehachapi pocket mouse, so values were used for Little Pocket Mouse (*P. longimembris*), a similar sized congener. Female home range varies from 0.48 to 3.09 ha (Maza et al. 1973). The minimum patch size was defined as 1 ha, since that is the minimum mapping unit. Patch size was defined as $\geq$ 1 ha but < 24 ha. Core Areas potentially containing fifty individuals were defined as $\geq$ 24 ha in size (0.48 ha x 50). Maximum dispersal distance was defined as 100 m.

Results & Discussion: It appears that the modeled linkage would adequately serve the species, with sufficient live-in habitat to support interconnected populations along the desert-facing slopes of the Tehachapis (Figure 41). The patch size and configuration analyses identified these extensive core areas to be within the dispersal distance of the species (Figure 42). However, uncertainties remain due to the lack of sufficient survey data within the species' range, and concerns about habitat type-conversion of desert communities to nonnative grasslands, as exacerbated by frequent fire. Climate change could also result in upslope migration of suitable habitats, potentially fragmenting this apparently continuous distribution. Although this portion of the study area is relatively free of roads, the degree to which roads, canals, or other features may limit movements along the linkage are unknown.

Figure 41.
Potential Cores & Patches
for
Tehachapi pocket mouse
(Perognathus alticola inexpectatus)



Legend

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

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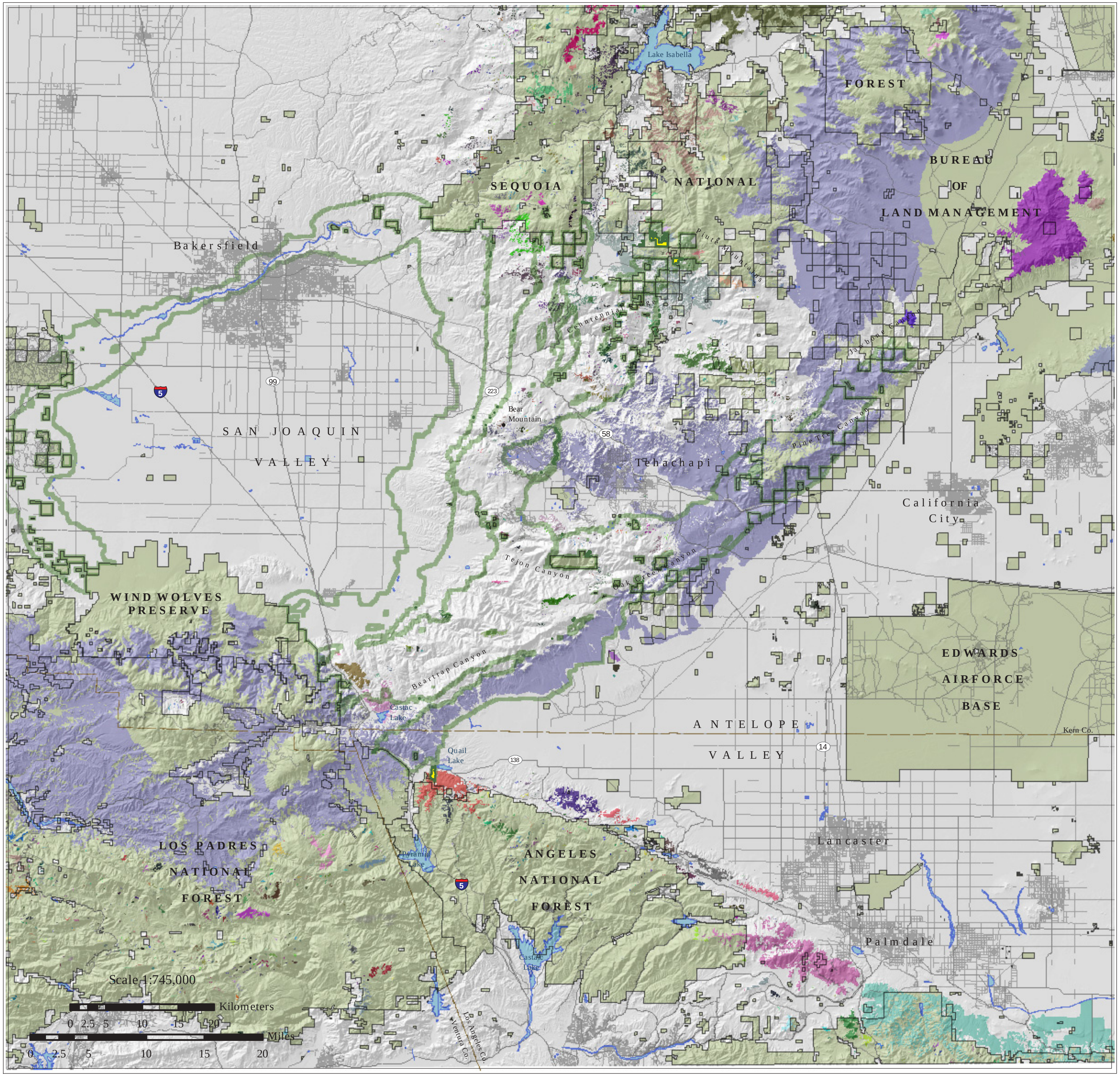
Figure 42.
Patch Configuration
for
Tehachapi pocket mouse
(Perognathus alticola inexpectatus)



Legend

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

Colors signify patches of suitable habitat that are within a dispersal distance of 120 m.

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California Spotted Owl (*Strix occidentalis occidentalis*)

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

Habitat Associations: This species is associated with structurally complex mature or old growth hardwood, riparian-hardwood, hardwood-conifer, mixed and pure conifer habitats with substantial canopy cover (>70%) and majestic long-standing trees and snags (Verner et al. 1992, Gutiérrez et al. 1992, LaHaye et al. 1994, Moen and Gutiérrez 1997). Nest trees are typically the largest in the stand (Gutiérrez et al. 1992), which usually contains an accumulation of down woody debris with a well-developed soil layer (Verner et al. 1992). Foraging habitat for this subspecies can be more variable than its northern relative, sometimes hunting in relatively open terrain (Gutierrez et al. 1992).

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

Home ranges are generally spaced 1.6 to 3.2 km (1-2 mi) apart in appropriate habitat (Marshall 1942, Gould 1974 *in* CDFG 1990). Owl densities are greater in areas with a higher density of old trees in dense groves (Gutierrez et al. 1992). Smith (1995) estimated owl density for the San Bernardino population to be 0.43 per km^2 for oak/big-cone fir, 0.20 per km^2 for conifer/hardwood, and 0.11 owls per km^2 for mixed coniferous forests (*in* LaHaye et al. 1997). Owl densities in Sequoia Kings Canyon National Parks have been recorded at 12.8 pairs per 100 km^2, while densities of 10.0 pairs per 100 km^2 have been estimated for the Sierra National Forest (North et al. 2000). LaHaye et al. (1997) suggested higher densities might reflect smaller territory sizes, which could result from increased prey densities.

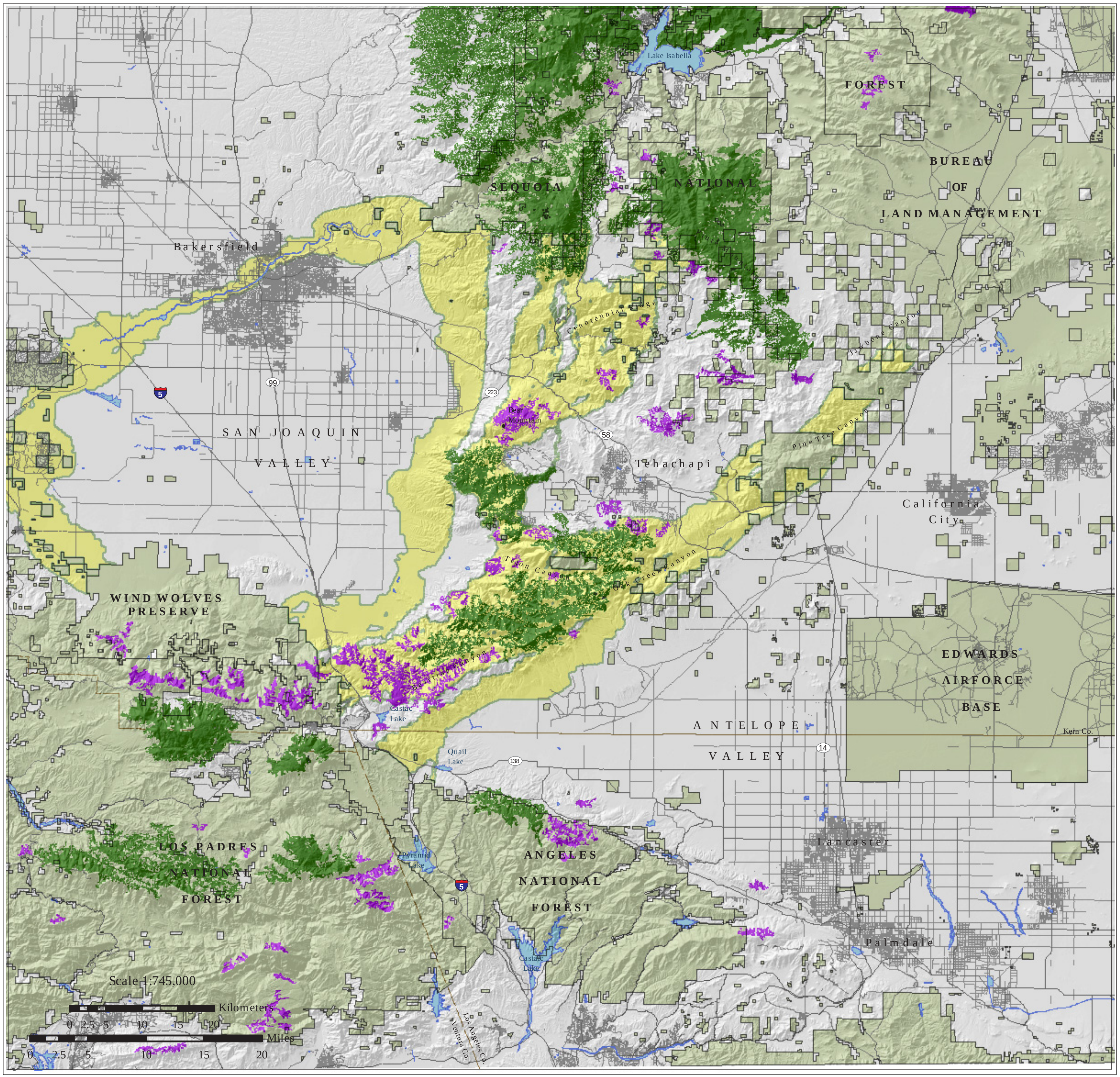
Metapopulation analyses have estimated dispersal distances of 7-60 km (LaHaye et al. 1994). However, shorter dispersal distances have been recorded. In the San Bernardino Mountain population, 67 males and 62 females dispersed 2.3-36.4 km and 0.4 –35.7 respectively (LaHaye et al. 2001). Dispersal distances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

Several radio telemetry studies have been conducted (Miller et al. 1997, Ganey et al. 1998, Willey and van Riper 2000) that recorded even greater distances, up to 72.1 km (in LaHaye et al. 2001).

Conceptual Basis for Model Development: This species prefers mature and old growth forests below 8,500 feet in elevation. Home range sizes have been recorded from 40-240 ha. The minimum patch size was defined as 2 home ranges (80 ha), using the smallest recorded range (40 ha x 2). Patch size was classified as ≥ 80 ha but < 2,000 ha. Core areas potentially supporting 50 or more individuals was defined as ≥ 2,000 ha (40 ha x 50). A number of dispersal distances have been recorded for California spotted owl (i.e. 2.3 km, 3.2 km, 5.8 km, and 7km), with a maximum dispersal distance of 72.1 km recorded using radio telemetry data.

Results & Discussion: The Least Cost Union will also likely serve the needs of the California spotted owl, since both sufficient live in and move through habitat has been incorporated into the conservation design (Figure 43). Extensive potentially suitable habitat was captured within the Least Cost Union for this species, including 2 major core areas in the Tehachapi Mountains. One core area extends from Bear Trap Canyon to just south of the city of Tehachapi, the other includes the area to the south of Bear Mountain. A number of minimum patches (≥ 80 ha but < 2,000 ha) of suitable habitat also occur within the Least Cost Union in between core areas. All suitable habitat patches are within 7 km of each other, way below the maximum dispersal distance of 72.1 km recorded for the species.

Figure 43.
Potential Cores & Patches for California spotted owl
(Strix occidentalis occidentalis)



Legend

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

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Burrowing owl (*Athene cunicularia*)

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

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

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

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

Conceptual Basis for Model Development: This species prefers the open terrain of grassland and desert scrub communities below 1615 m in elevation. Minimum patch size is less than the minimum mapping unit of 1 ha, thus patch size was defined as $\geq$ than 1 ha but < 8 ha. Core areas were defined as $\geq$ 8 ha, or 50 times the minimum defined home range of 0.16 ha. Dispersal distance was defined by using twice the recorded distance of 60 km (30 km x 2).

Results & Discussion: The Least Cost Union will also likely serve burrowing owl, providing both live-in and move-through habitat. Potentially suitable core habitat captured within the Least Cost Union for this species, includes a 2-10 km wide band of habitat stretching from the Wind Wolves Preserve boundary, along the foothills and slopes of the Tehachapi and Sierra Nevada mountains up to the Kern River; scattered patches of habitat exist along the Kern River to the Elk Hills potential core area (Figure 44). Other likely core habitat areas exist along the southeastern slopes of the Tehachapi Mountains, though not all of this was captured in the Least Cost Union. All potentially suitable habitat patches are within the 30 km dispersal distance of this species.

Figure 44. Potential Cores & Patches for Burrowing owl
(Athene cunicularia)

Legend

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

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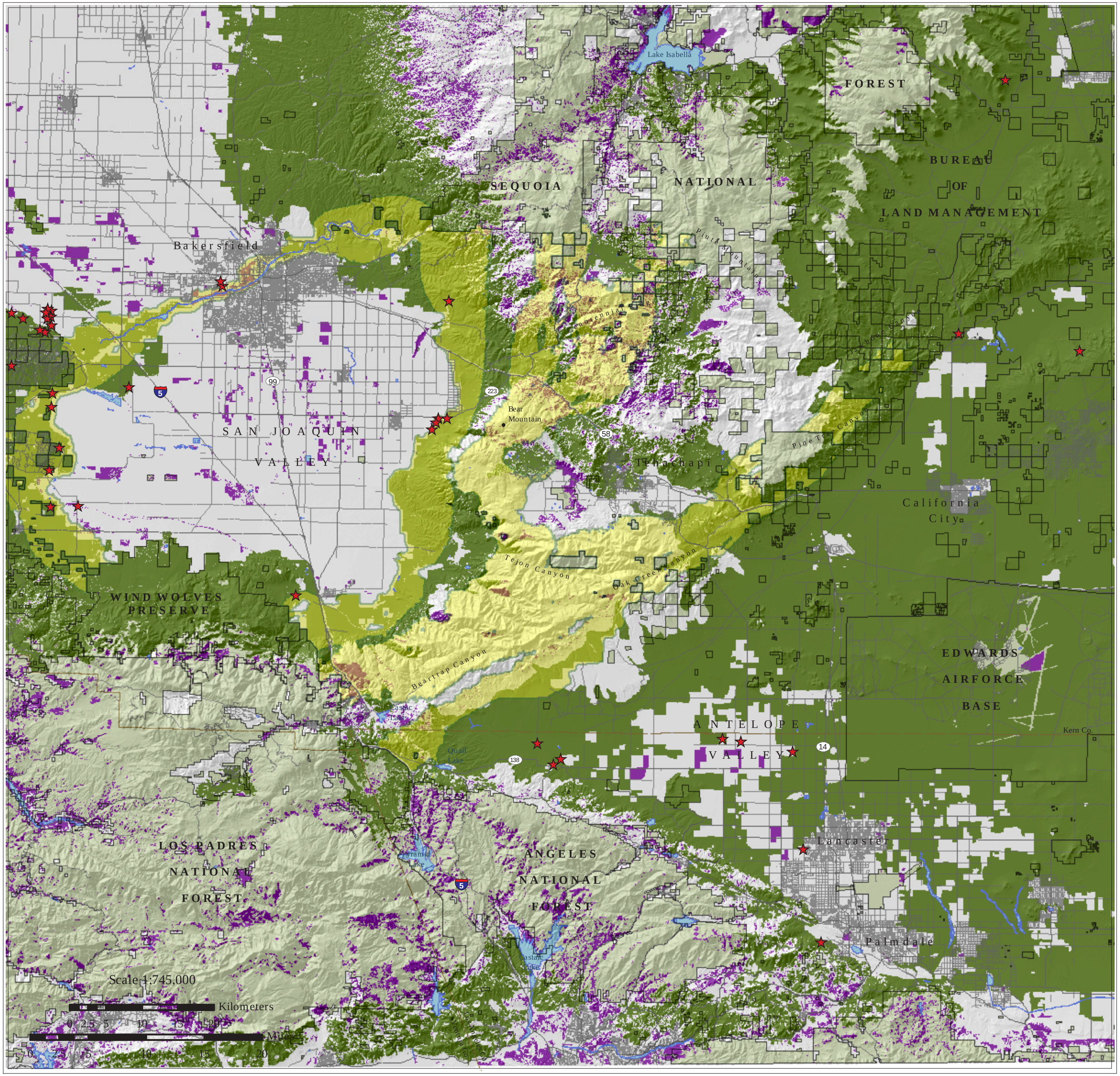


Acorn woodpecker (*Melanerpes formicivorus*)

Justification for Selection: The continued elimination of oaks is a threat to the existence of this species in California (Verner and Boss 1980 *in* CDFG 1990). Overgrazing causes reduced regeneration of oaks.

Distribution & Status: Acorn woodpeckers occur from northwestern Oregon, California, the American Southwest, and western Mexico through the highlands of Central America, as far south as northern Columbia (Koenig et al. 1999). They are typically found below 2100 m, though most good habitats are below 915 m in elevation (CDFG 1990).

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

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

On the western slope of the Sierras, upslope movement occurs in fall to mixed conifer habitat with black oak (Verner and Boss 1980 *in* CDFG 1990). Dispersal distances of 0.22 $\pm$ 0.48 km for males and 0.53 $\pm$ 0.52 km for females have been recorded. The usual avian pattern of greater dispersal distance by females holds true for acorn woodpeckers (Koenig et al. 2000). The maximum-recorded dispersal distance for this species is 4.3 km (Baker et al. 1995 *in* Koenig et al. 2000).

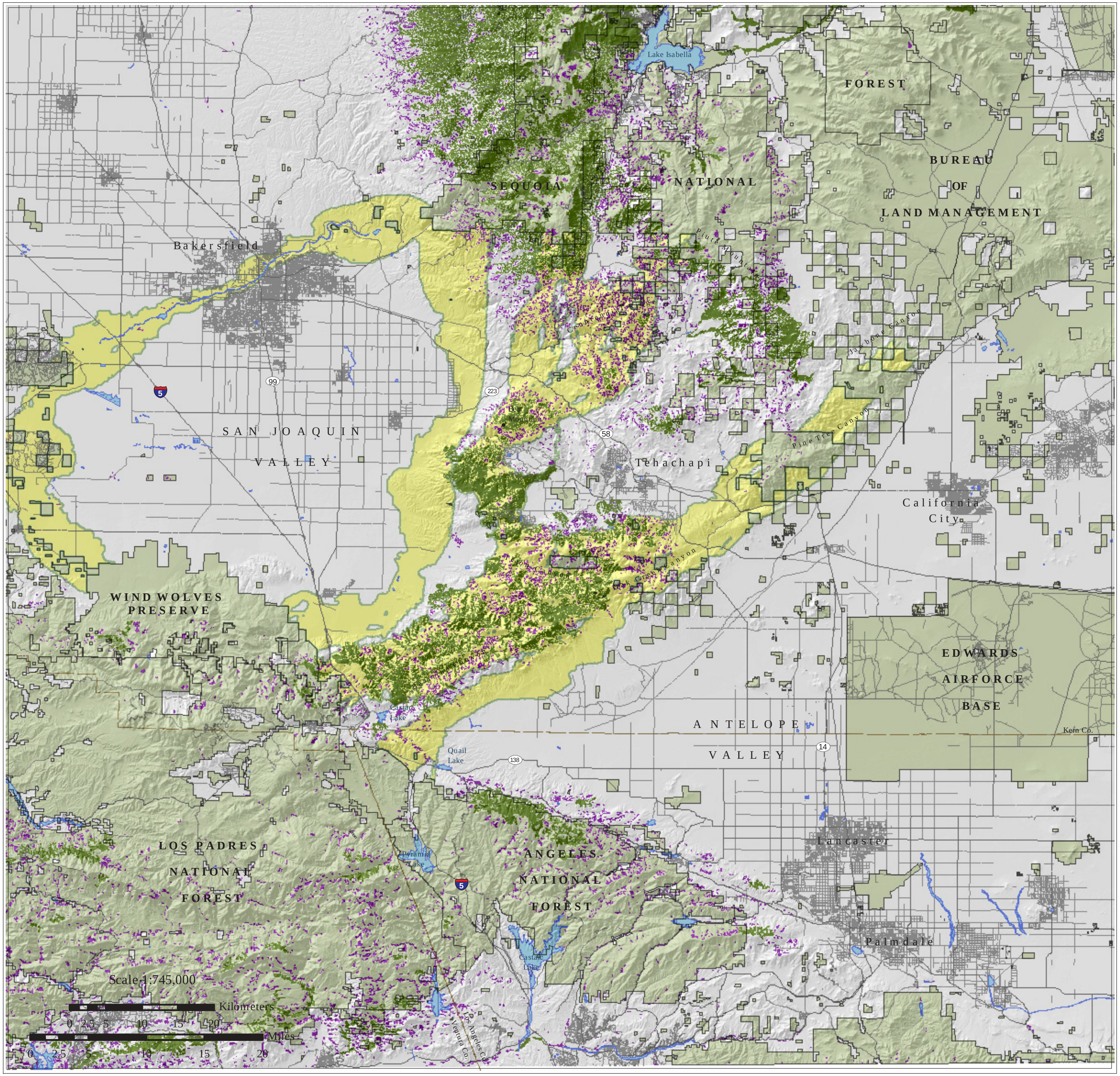
Conceptual Basis for Model Development: This species prefers mature oak woodlands and hardwood coniferous forest below 2100 m in elevation. Home ranges sizes have been recorded between 1.5-9 ha. The minimum patch size was defined as 2 home ranges (3 ha), using the smallest recorded range (1.5 ha x 2). Patch size was classified as $\geq$ 3 ha but < 75 ha. Core areas potentially supporting 50 or more individuals was defined as $\geq$ 75 ha (1.5 ha x 50). Dispersal distance was defined using twice the maximum distance (8.6 km), or 4.3 km x 2.

Results & Discussion: This species needs appear to be well accommodated by the Least Cost Union (Figure 45). The results of the analysis for acorn woodpecker also support the need to conserve the complex mosaic of hardwood and conifer habitats that occur in the Tehachapi Mountains. The spectacular diversity of oak species within the Least Cost Union provides a dependable food supply for this species. Potentially suitable core habitat for this species is distributed almost continuously from Beartrap Canyon to Cummings Mountain, including Pastorio Creek, Tunis Creek, Tejon Canyon, and Bear Mountain, virtually all potentially suitable habitat for this species was encompassed in the Least Cost Union. Another potential core area occurs in the lower Piute Mountains that wasn't captured in the Least Cost Union; there are currently scattered parcels in this area managed by the Bureau of Land Management.

Figure 45.
Potential Cores & Patches
for
Acorn Woodpecker
(Melanerpes formicivorus)

Legend

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



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Coast horned lizard (*Phrynosoma coronatum)*

Justification for Selection: Coast horned lizard is highly sensitive to habitat loss and fragmentation, with agriculture, flood control, and urbanization cited as the main reasons for its decline (Jennings and Hayes 1994). These activities promote biological invasions by Argentine ants that eliminate native ant colonies, which the coast horned lizard is highly dependent on for sustenance (Pianka and Parker 1975, Montanucci 1989, Suarez et al. 2000 *in* Suarez and Case 2002, Fisher et al. 2002). Domestic cats can also penetrate considerable distances into otherwise suitable habitat, eliminating horned lizards within a several km² radius (Jennings and Hayes 1994). This species needs expansive roadless wildland to persist.

Distribution & Status: This California endemic has 2 subspecies whose ranges overlap; the Coast horned lizard (*P. c. frontale*) occurs on both the coastal and San Joaquin sides of the mountains and intergrades with the San Diego horned lizard (*P. c. blainvillii*) in southern Kern County and much of northern Santa Barbara, Ventura, and Los Angeles counties (Stephenson and Calcarone 1999). The known elevational range for this species is from near sea level to 1980 m at Breckenridge Mountain in Kern County (Van Denburgh 1922 *in* Jennings and Hayes 1994). The coast horned lizard was historically recorded from scattered locales from Shasta County south along the edges of the Sacramento Valley into the South Coast Ranges, San Joaquin Valley, and Sierra Nevada foothills to northern Los Angeles, Santa Barbara and Ventura counties, California (CDFG 1988, Jennings and Hayes 1994), reaching its highest densities in the relict lake sand dunes and alluvial fans of the San Joaquin Valley (Bryant 1911, Van Denburgh 1922 *in* Jennings and Hayes 1994). It has disappeared from about 35% of its historical extent, while the San Diego horned lizard is gone from nearly 45% of its former range (Jennings and Hayes 1994). The species is identified as Sensitive by the federal government and is considered a California Species of Special Concern.

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

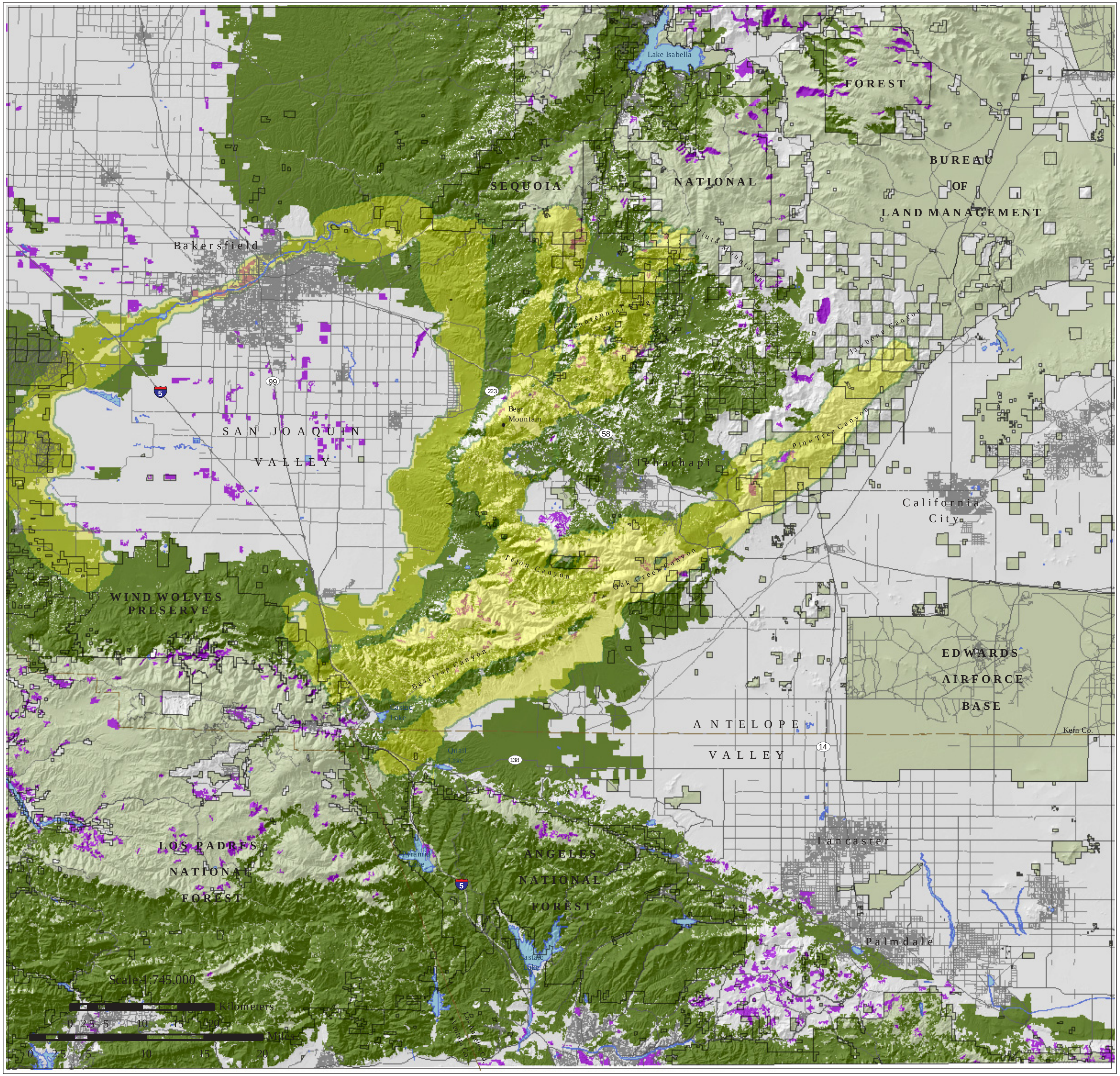
Spatial Patterns: Not much is known about home range size (CDFG 1988) or dispersal distance for this species. A recent study in 2002 however estimated home ranges size of about 0.1km^2 (Fisher et al.). Males of an associated species, P. solare, moved further than females, maximum distance for males was 30m (98 ft), while females moved a maximum distance of 15 m (49 ft) (Baharav 1975 *in* CDFG 1988).

Conceptual Basis for Model Development: Movement between Core Areas in the linkage is multigenerational. They may utilize several habitat types including alluvial fans, alkali flats, dunes, open coastal scrub and chaparral, annual grassland, and clearings in coniferous forests, broadleaf woodlands, and riparian woodlands. They avoid urban and agricultural developments and areas of high road density. The only home range estimate found in the literature was 0.1 km^2, or 10 ha. The minimum patch size was defined as 2 home ranges (20 ha), using the smallest recorded range (10 ha x 2). Patch size was classified as $\geq$ 20 ha but < 500 ha. Core areas potentially supporting 50 or more coast horned lizards are $\geq$ 500 ha (10 ha x 50). Dispersal distance was defined as 60 m, using twice the recorded distance.

Results & Discussion: This species needs appear to be well accommodated by the Least Cost Union (Figure 46). Extensive potentially suitable core habitat was captured in the Least Cost Union, contiguous habitat on the San Joaquin Valley floor, into the foothills and upland habitats of the Tehachapi Mountains (e.g. Beartrap Canyon, Tejon Canyon), to Bear Mountain, and Centennial Ridge, and in the chaparral habitats on the southeastern slopes of the Tehachapis up to Oak Creek Canyon. Other important potential core areas, not included in the Least Cost Union include Wheeler Ridge, around Quail Lake, and Emerald and Sugarloaf mountains, as well as in between both gaps in the Least Cost Union boundary.

With a dispersal distance of only 60 m, the patch configuration analysis yielded interesting results (Figure 47). Three potential interactive core areas emerged (i.e. where suitable habitat patches are within the dispersal distance); 1) Castaic, Tehachapi, Sierra Nevada, 2) Sierra Madre, and 3) the San Emigdio Ranges and Elk Hills, with the first and last being the most relevant to the linkage. Research indicates this species is more likely to persist in larger habitat patches because of its dependence on native ants, which only occur in undisturbed habitats (Suarez and Case 2002, Fisher et al. 2002). The spatial configuration of suitable habitat is also of concern because of the limited movement and dispersal capability of the species; they need large patches of suitable habitat that are in close proximity to one another (Fisher et al. 2002).

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



Legend

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

N

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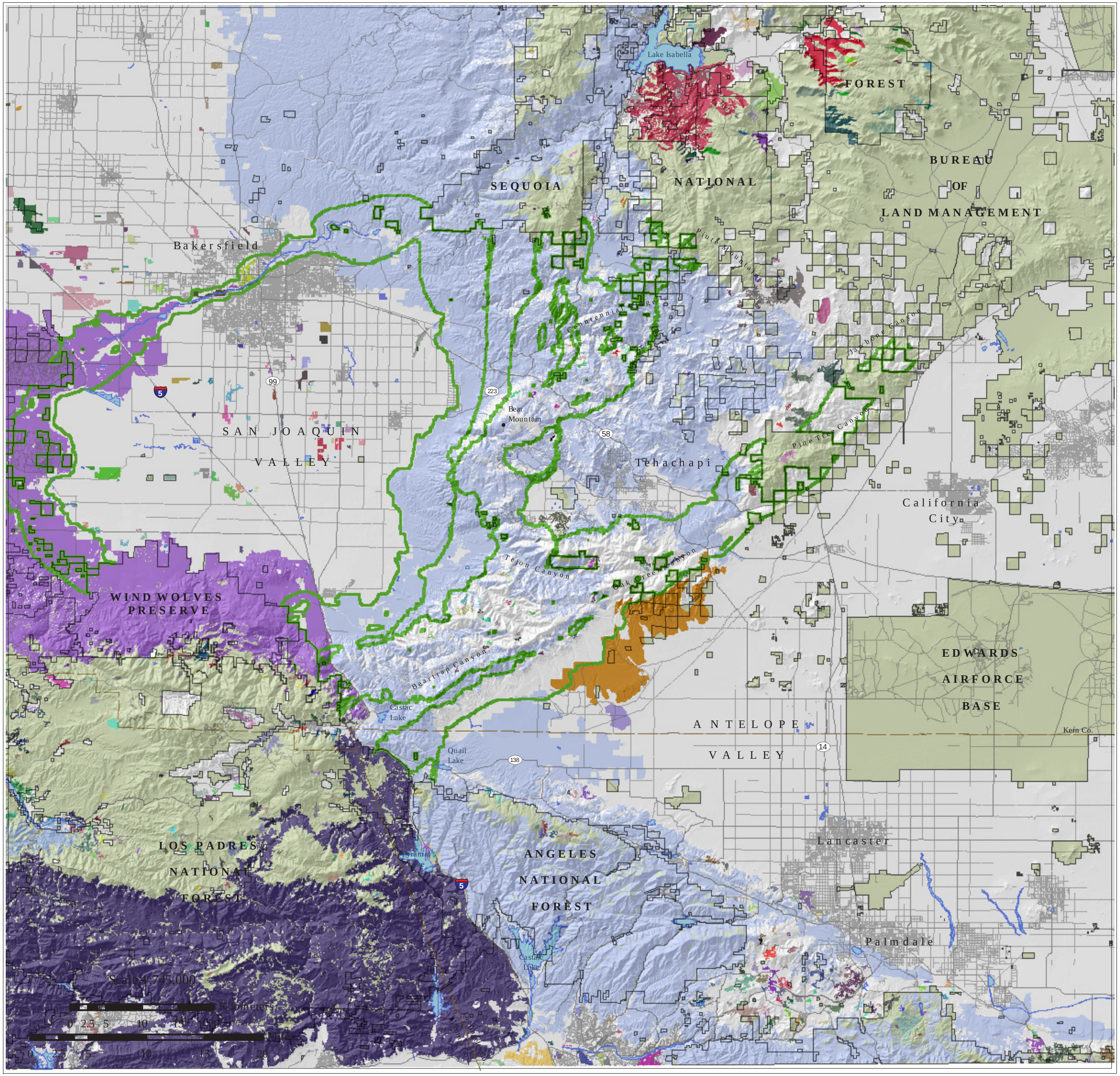
Figure 47.
Patch Configuration
for
Coast horned lizard
(Phrynosoma coronatum)



Legend

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

Colors signify patches of suitable habitat that are within twice the dispersal distance (60 m).

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Yellow-blotched Salamander (*Ensatina eschscholtzii croceater*)

Justification for Selection: Salamanders play an important role in forest ecosystems, and can be the most abundant vertebrates in their habitat (Burton and Likens 1975, Pough et al. 1987, Bury 1988 *in* Grialou et al. 2000). Logging and other land use changes may inhibit movement and dispersal capabilities of this species (Ovaska 1988, *in* Grialou et al. 2000, Stebbins 1954). Suitable habitat is needed for movement during the rainy season. Primary barriers to movement include major roads, aqueducts and large agricultural lands (M. Long, pers. comm.).

Distribution & Status: Blotched salamanders are found from southwestern British Columbia to southern California along the Pacific coast inland to the Cascades and Sierra Nevada (Rosenberg et al. 1998), at elevations ranging from sea level to around 3050 m (10,000 ft) (CDFG 1988). The yellow-blotched salamander (*E. e. croceater*) is one of 7 subspecies; it is restricted to Kern and Ventura Counties ranging from the Piute Mountains southwestward through the Tehachapi Mountains extending to the vicinity of Mount Pinos and Frazier Mountain in the Sierra Madre Range (Jennings and Hayes 1994). The Tehachapi Mountains make up a significant portion of this species range (USFS 2002) and are a contact zone between *E. e. croceater* and *E. e. klauberi*, both of which are found in oak-pine woodlands.

Habitat Association: This species occurs under downed wood and branches in montane hardwood, hardwood conifer and mixed coniferous forests (Jennings and Hayes 1994) and typically reach their highest densities in forests with deep organic soils and abundant woody debris (Rosenberg et al. 1998). In the Sierra Nevada, they have been recorded in habitats with an overstory of ponderosa pine, sugar pine, incense cedar, white fir, and black oak (Staub et al. 1995). Suitable habitat in the Sierra foothills is dominated by blue oak, interior live oak, foothill pine, California black oak, valley oak, and ponderosa pine with an understory of buckbrush, coffeeberry, toyon, and poison oak, annual and perennial grasses (Block and Morrison1998). In the Tehachapi Mountains, suitable habitat occurs in oak woodlands on north-facing slopes which may be comprised of blue oak, interior live oak, canyon live oak, California black oak, valley oak, and Brewer's oak with an understory of buckbrush, redberry, chamise, bigberry manzanita, mountain mahogany, and annual and perennial grasslands (Block and Morrison 1998). Block and Morrison (1998) found occupied habitat for this species to be highly correlated with canyon live oak and blue oak woodlands on Tejon Ranch.

Spatial Patterns: Block and Morrison (1998) placed 452 traps on Tejon Ranch in the Tehachapi Mountains at elevations ranging from 1100 to 1700 m. This species occurred in 13% of the traps, comprising roughly 39% of the individuals captured, and greater than 95% of them were found under downed logs or branches.

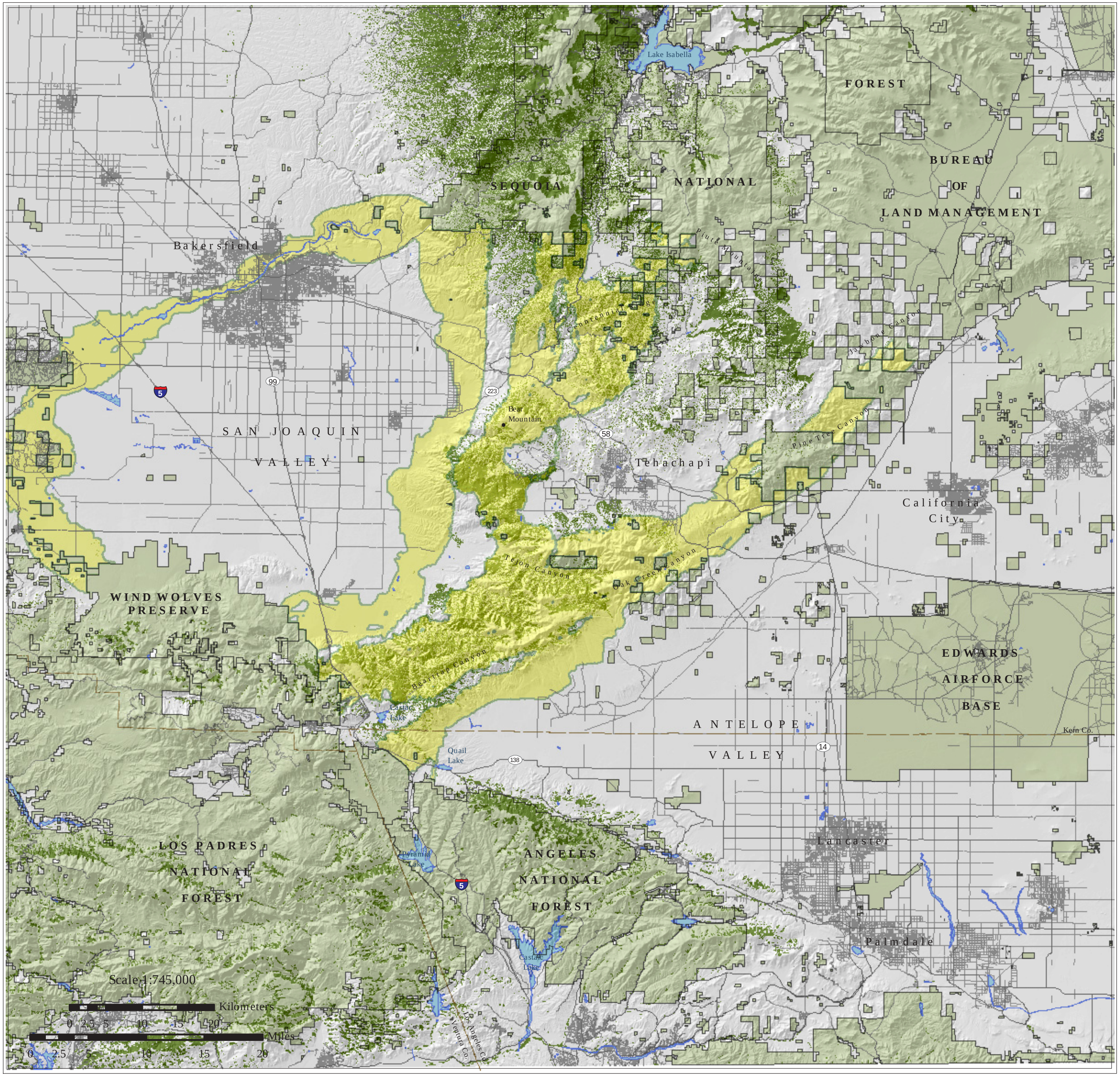
Estimated mean home ranges of 10.0 m^2 for females and 19.5 m^2 for males (Rosenberg et al. 1998). Much larger ranges were found in 1995, with females ranging up to 23 m^2 and males up to 41m^2 (USFS 2002). This species may be the most abundant vertebrate in the community, reaching densities of up to 1300 individuals per hectare in high quality habitat (Stebbins 1954, Rosenberg et al. 1998).

Movements have been estimated to average 20 m (65 ft) for mature males and 10 m (33 ft) for females (USFS 2002), though Staub et al. (1995) documented movements of up to 120.4 m for males and 60.6 m for females in the Sierra Nevada. Staub et al. (1995) found animals achieve higher rates of movement and survival in suitable habitat than in the unsuitable habitat of the matrix.

Conceptual Basis for Model Development: This species has the potential to occur in montane hardwood, hardwood conifer and mixed coniferous habitats on north-facing slopes between 200-1700 m in elevation. Home range sizes for this species have been recorded between .0006 ha and .0041 ha. Thus, estimates for minimum core area capable of potentially supporting 50 or more individuals would be 0.03 ha to 0.205 ha (minimum home range x 50). However, 1 ha is the minimum mapping unit, so all pixels of suitable habitat were defined as cores. We then evaluated which cores are within the maximum-recorded dispersal distance (120 m), and within twice the recorded distance (240 m).

Results & Discussion: The Least Cost Union is likely to serve this species. Extensive amounts of core montane hardwood and coniferous forest habitat were included in the design (Figure 48). Long-term habitat connectivity for the yellow-blotched salamander between the Sierra, Tehachapi, and Transverse Ranges depends in large part on preservation of the habitats within Tejon Ranch. This species range in this area is natural, and disturbance/development of occupied habitats could jeopardize dispersal ability of this species by fragmentation. Through both evolutionary and ecological time this area has been a major connection for dispersal of this and many other species. The patch size and configuration analysis for this species indicates there are 3 extensive core areas in the planning area, one in the Sierra Nevada, one in the Tehachapis and another along the desert slopes of the Castaic Ranges (Figure 49). All available museum records and observations of this species indicate a nearly even distribution through the Tejon Ranch lands (Jennings and Hayes 1994).

Figure 48.
Potential Cores & Patches
for
Yellow-blotched salamander
(Ensatina eschscholtzii croceater)



Legend

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

N

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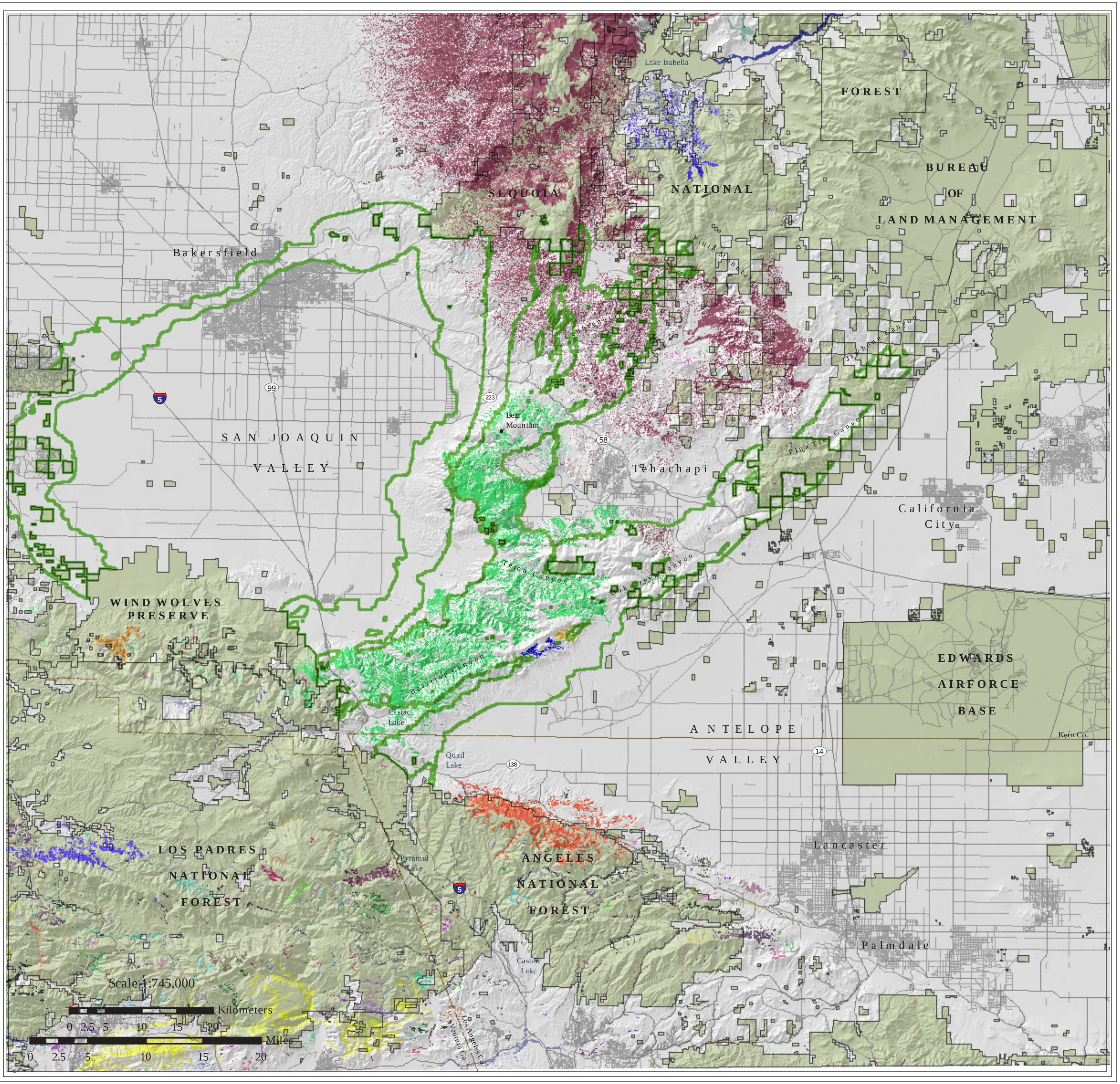
Figure 49.
Patch Configuration
for
Yellow-blotched salamander
(Ensatina eschscholtzii croceater)

Legend

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

Colors signify patches of suitable habitat that are within twice the dispersal distance (240 m).



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Long-nosed leopard lizard (*Gambelia wislizenni*)

Justification for Selection: The long-nosed leopard lizard was chosen as a representative species of desert scrub and woodland communities on the Antelope Valley side of the linkage, while the blunt-nosed leopard lizard (*G. sila*), an associated species was selected to capture habitats on the San Joaquin Valley side of the connection.

Distribution & Status: The long-nosed leopard lizard is widely distributed in the Great Basin, Mojave and Colorado deserts of California south to Baja, and west at the southern end of the Central Valley into Santa Barbara County and eastern Kern County (Stebbins 1985, CDFG 1988). This species can be found near sea level to around 1800 m (5905 ft) (Stebbins 1985, CDFG 1988).

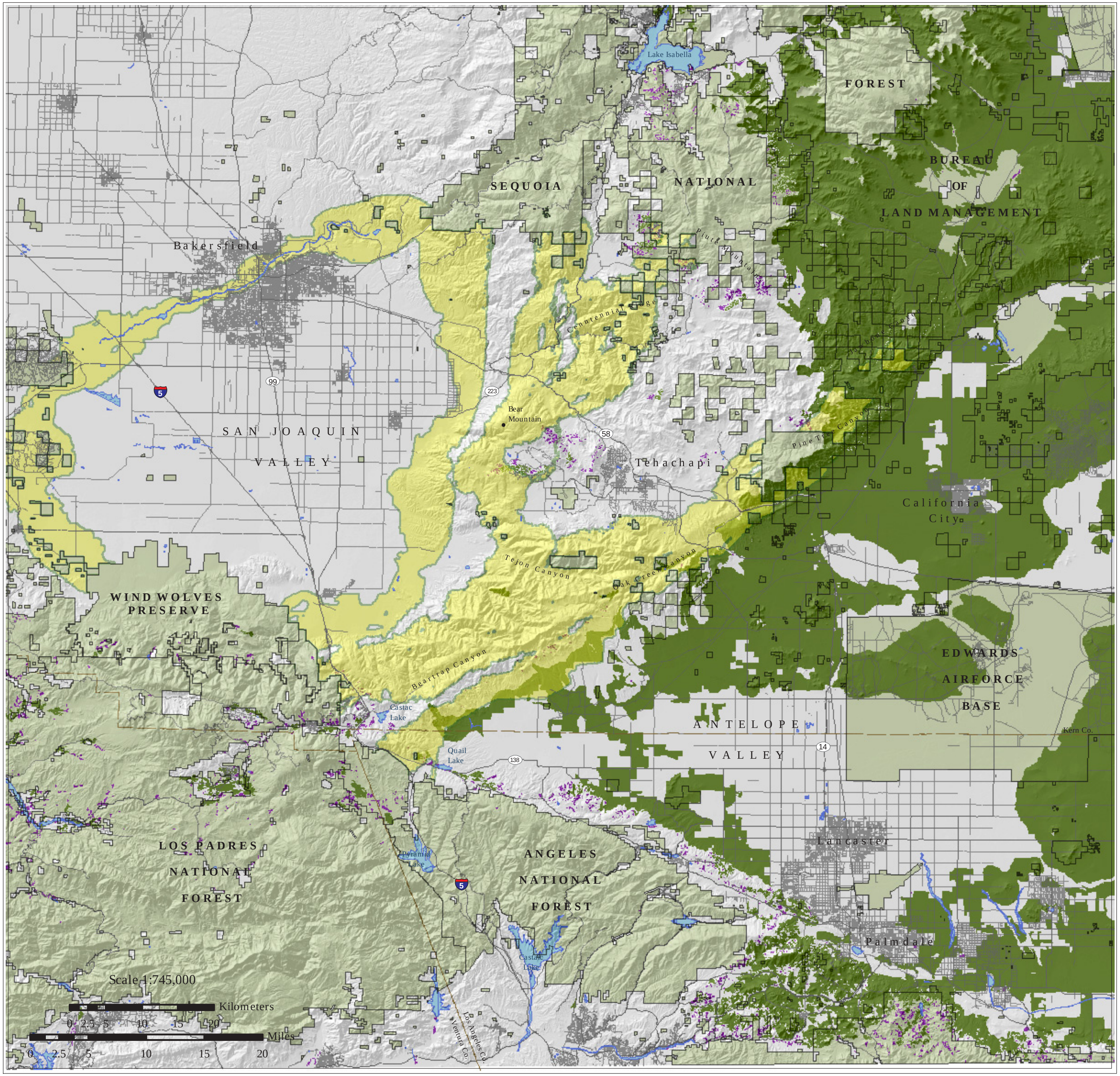
Habitat Associations: It frequents a variety of desert woodland and scrub habitats, including semiarid grasslands, alkali bush, sagebrush, and creosote bush (Stebbins 1985, CDFG 1988, Dudek and Associates undated mat.). They avoid areas with dense grass and brush (Stebbins 1985). Requires sand and friable soils to excavate burrows, preferring sandy or gravelly flats and plains; it is less common in rocky areas (CDFG 1988).

Spatial Patterns: This species is a wide-ranging predatory lizard of the desert flatlands (McCoy 1967 *in* Dudek and Associates), whose home range can be as large as several hectares (CDFG 1988). Densities vary from 5 to 19 individuals per hectare (Parker and Pianka 1976 *in* Dudek and Associates), with the greatest densities recorded in creosote flats (CDFG 1988). There is little information on dispersal or movement for this species. Parker and Pianka (1976) report long-range natal dispersal of up to 1186 m (*in* Dudek and Associates).

Conceptual Basis for Model Development: This species is associated with desert scrub, desert wash, Joshua tree and juniper woodlands, and sagebrush below 1800 m (5905 ft). Home range sizes for this species have been estimated at several hectares; we used a conservative estimate of 1 ha for home range. Minimum patch size was defined as $\geq$ 2 ha but < 50 ha. Thus, estimates for a core area capable of potentially supporting 50 or more individuals would be $\geq$ 50 ha (1 ha x 50). However, 1 ha is the minimum mapping unit, so all pixels of suitable habitat were defined as cores. We then evaluated which patches and cores are within the maximum-recorded dispersal distance (1,186 m), and within twice the recorded distance (2,372 m).

Results & Discussion: The linkage is on the edge of this species distribution, yet based on the output from the patch size and configuration analyses; it appears that this species is at least marginally accommodated by the Least Cost Union (Figure 50). The desert scrub and pinyon-juniper habitat on the southeastern slopes of the Tehachapi Mountains, extending from the Quail Lake area to Oak Creek, Pine Tree and Jawbone canyons, was captured in the Least Cost Union. Extensive potentially suitable habitat occurs outside of the Least Cost Union in the desert scrub communities of the Antelope Valley.

Figure 50.
Potential Cores & Patches
for
Long-nosed leopard lizard
(Gambelia wislizenii)



Legend

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

N

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Callippe fritillary (*Speyeria callippe*)

Justification for Selection: Callippe fritillary is sensitive to habitat alteration from urban development (Orsak 1977).

Distribution & Status: There are a number of different subspecies, 3 of which occur in Kern County (K. Davenport and G. Pratt pers. comm.). This subspecies (*S. c. macaria*) occurs from the Mt. Pinos area through the Tehachapi Mountains to the Greenhorn and Piute mountains at the southern end of the Sierra Nevada Range, and south to Bouquet Canyon (Emmel and Emmel 1973).

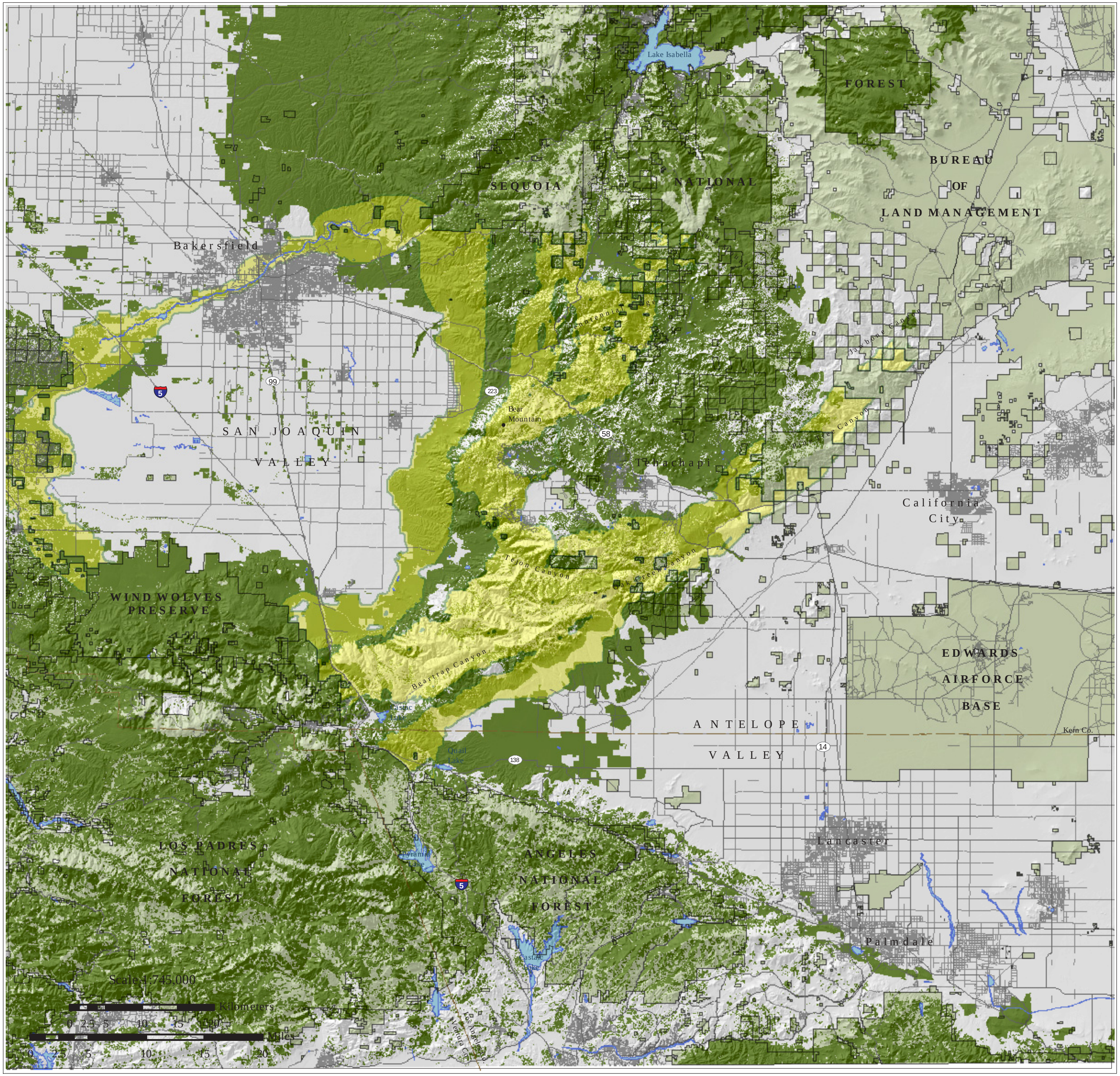
Habitat Associations: This subspecies has one flight from late May to July and emerges earlier than other *Speyeria* species occurring in the same locality (Emmel and Emmel 1973). It has been recorded in open pine and oak woodlands, sagebrush, chaparral, and grassland habitats and may be found on hillsides, in canyons and meadows (Emmel and Emmel 1973). They may fly in mixed coniferous forests at up to 8,000 feet but they don't oviposit above 6500 feet. They ovideposit in spring and larvae are dormant until the following winter (K. Davenport and G. Pratt pers. comm.). Larvae hostplants are members of the genus *Viola* spp. that occur in moist places. Females deposit eggs under shrubs where *Viola* will come up the next spring for larvae to feed on the leaves (Scott 1986). Adults visit violets in spring, but also utilize wallflower and yerba santa as nectar sources (K. Davenport and G. Pratt pers. comm.). Males seek hilltops and ridges to await unmated females (Orsak 1977, Scott 1986).

Spatial Patterns: No density estimates exist for this species but in three other members of the genus, abundance was positively correlated with abundance of the *Viola* host plant (Fleishman et al. 2002). Rapid increases on host plants in wet years (Emmel and Emmel 1973) suggest that individuals are good dispersers and quickly colonize host plant populations. Other species in this genus also show this propensity where density is best modeled as a consequence of habitat quality rather than patch area or degree of isolation (Fleishman et al. 2002). Other habitat specialists in the genus have also been observed to preferentially avoid crossing habitat edges into other habitat types, including crops and roads (Ries and Debinki 2001). Adults are low but fast flyers (Emmel and Emmel 1973) capable of 30-mile movements (K. Davenport and G. Pratt pers. comm.).

Conceptual Basis for Model Development: No home range or density estimates were found in the literature; therefore only potentially suitable habitat was delineated. Movement between protected core areas in the linkage is multigenerational. This butterfly regularly disperses up to 10 km and potentially up to 30 km and prefers to move through open habitats (open oak and riparian woodlands, chaparral, coastal sage, and grasslands). It will disperse through other native habitats, but avoids agricultural and urban landscapes. Extensive developed areas, even wide freeways, are likely barriers since this species avoids leaving suitable habitats.

Results & Discussion: Callippe fritillary appears to be well served by the Least Cost Union. The model output suggests that highly suitable for this species occurs primarily on the northwest and southeast slopes of the Tehachapi Mountains, likely providing both live-in and move through habitat between protected habitat in the Sierra Nevada and Sierra Madre ranges (Figure 51).

Figure 51.
Potential Cores for Callippe Fritillary
(Speyeria callippe macaria)



Legend

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

N

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San Emigdio Blue Butterfly (*Plebejus emigdionis*)

Justification for Selection: This species is sensitive to habitat loss and fragmentation from urban development and roads. Roads are likely barriers for this species.

Distribution & Status: The San Emigdio blue butterfly is a very local and rare species in southern California from Inyo County south through the Mojave Desert, San Joaquin Valley, in isolated scattered colonies in the lower portion of Owens Valley, and in Bouquet and Mint Canyons in the Castaic Range (USGS undated mat.). There are known to occur in canyons along the north side of the San Gabriel Mountains near the desert's edge, and in arid areas south of Mount Abel near San Emigdio Mesa (Emmel and Emmel 1973, Murry 1990). In the planning area, the species has been documented in Cache Creek and Sand Canyon in the Tehachapis, Soledad Canyon, Hungry Valley, 9 mile Canyon, and on Wind Wolves Preserve (K. Davenport and G. Pratt pers. Comm.). This species isn't afforded any special status.

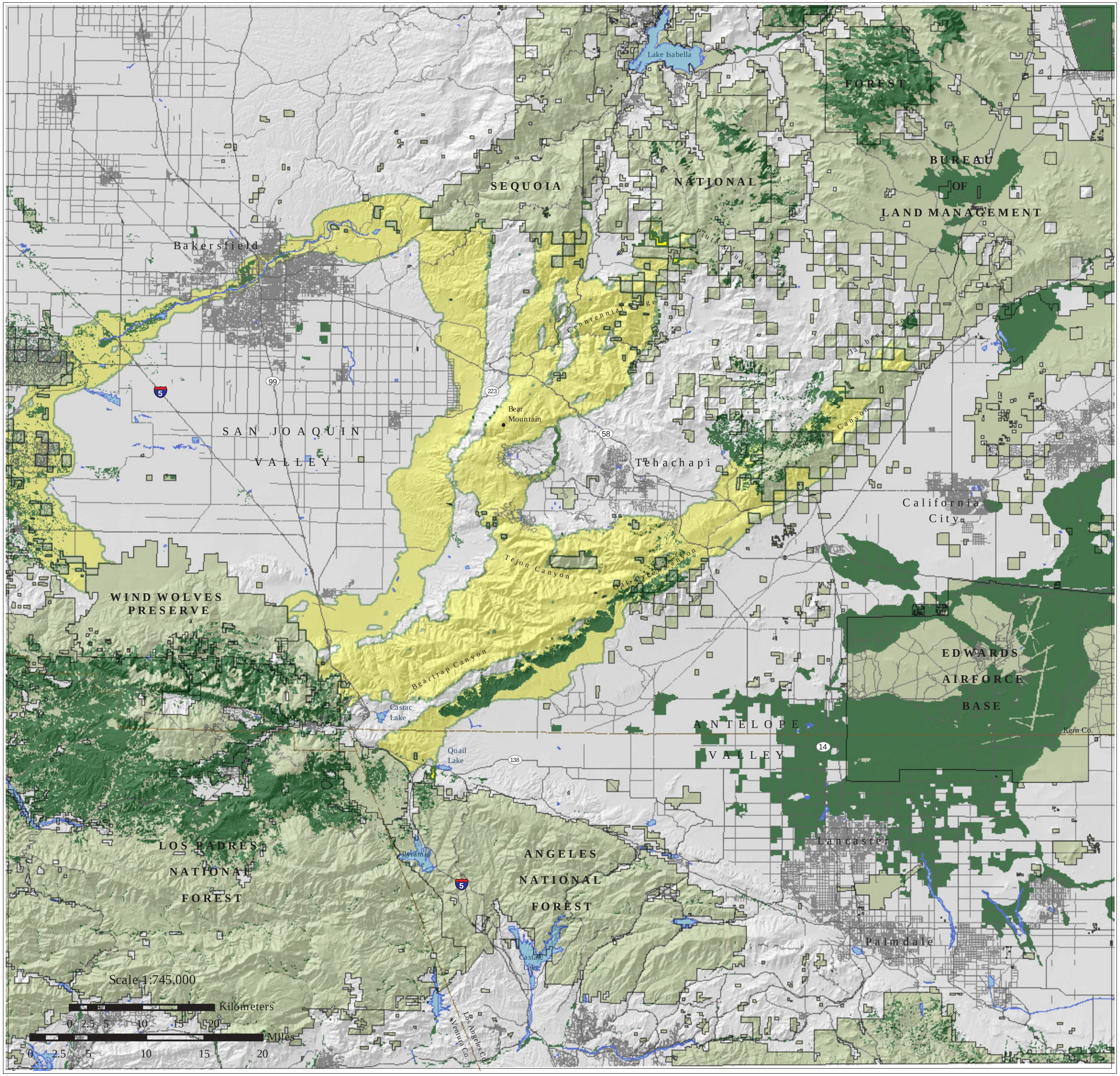
Habitat Associations: This species occurs in shadscale scrub in desert canyons, near washes, and riparian areas. It is closely associated with the widespread saltbush *Atriplex canescens* in alkali sink areas and mostly intermittent streams (Murry 1990, Garth and Tilden 1986). The butterfly's distribution is more localized than the host plant, suggesting other factors may determine habitat suitability. One limiting factor lies in the fact that a particular species of ant tends the larvae of the San Emigdio blue butterfly, the ant benefiting from honeydue produced by the larvae, and the larvae benefiting when ants ward off predators and parasitoids (Osborne pers. Comm.). The host plant *Atriplex canescens* leaves are fed on by the larvae and adults on the nectar (USFS 2002).

Spatial Patterns: This small blue butterfly has been known to reach distances of 1km, although data on dispersal is inconsistent (K. Davenport and G. Pratt pers. Comm. However, species in the same genus, P. icarioides (Lupine blue) have been recorded flying an average distance of 27 m for males, and 32 m for females, longest distance recorded 162 m over their 8 day life span (Scott 1986). Most males in this genus patrol areas with high concentrations of their host plant all day to seek females (Scott 1986).

Conceptual Basis for Model Development: Movement between protected core areas in the linkage is multigenerational. The host plant may occur in alkali desert scrub, bitterbrush, desert and montane riparian, desert wash, and pinyon juniper woodland. This butterfly regularly visits river and creek beds, making for good corridors. Good nectar plants and yellow flowers may help this species to move between patches. Roads are likely barriers since this species flies low to the ground. Dispersal distance was defined as 1 km.

Results & Discussion: The model identified several large patches of potentially suitable habitat for this species in the planning area. The Least Cost Union captured 2 significant blocks of habitat for this species, on the southeastern slopes of the Tehachapi Mountains, and on the lower slopes of Sugarloaf Mountain (Figure 52). However, these two patches were determined to be beyond the dispersal distance for this species. Nevertheless, the linkage is likely to provide this species with live-in habitat.

Figure 52.
Potential Cores for
San Emigdio blue butterfly
(Plebulina emigdionis)



Legend

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

N

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Bear Sphinx moth (*Arctonotus lucidus*)

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

Distribution & Status: In California this moth can be found locally in foothill regions of the San Gabriel, Western Sierra Madre, Coast Ranges, and the Tehachapi Mountains (K. Osborne pers.comm.). Populations of this species occur in and around the Central Valley rim between 500 ft and 4500 ft in elevation (K. Osborne pers.comm.). They have been recorded from the bottom of the Grapvine in Central Valley, and in the vicinity of Fort Tejon, Lebec, and Gorman (K. Osborne pers.comm.). This species isn't afforded any special status.

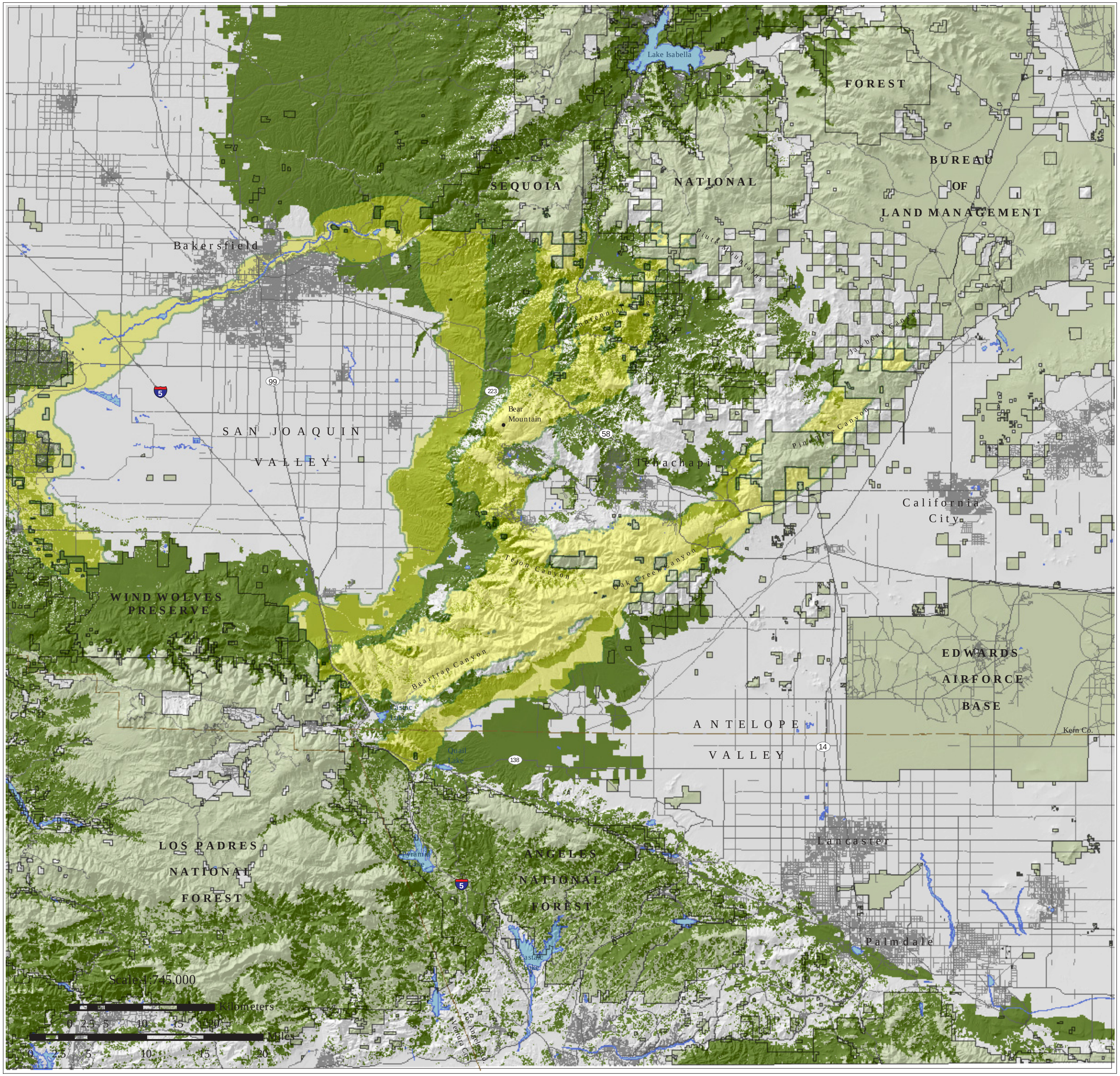
Habitat Associations: Oak woodlands and grasslands are typical habitats of this species, which is found in broad and undeveloped woodlands, hills, and canyons (K. Osborne pers.comm.). Larvae feed on plants of the evening primrose family (Comstock and Henne 1942) such as *Clarkia* and *Camissonia* species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

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

Conceptual Basis for Model Development: This species prefers oak woodland and grassland communities but may also utilize other habitats where food plants occur in abundance, including open coniferous forests, chaparral, and desert scrub and woodland communities, between 500-4500 feet in elevation. Urban and agricultural areas may be important impediments due both to habitat alteration and adult attraction to artificial light sources. Since no home range estimates were found in the literature, all patches of suitable habitat 1 ha or greater were used in the analysis. Dispersal distance was defined as 2 km.

Results & Discussion: The linkage is likely to serve this species since extensive blocks of potentially suitable habitat were incorporated into the linkage design (Figure 53). Wide linkages are important to allow free dispersal and gene flow across populations. Bear sphinx appears generally distributed through the Grapevine Canyon, Gorman pass, and valleys to the east and west, due to an abundance of Clarkia host plants in this area. All potentially suitable habitat patches are within twice the dispersal distance of this species. This is a species of wide open landscapes. Small "core" areas of a few square kilometers linked by thin "corridors" would likely not suffice in maintaining this species (K. Osborne pers. comm.).

Figure 53.
Potential Cores for Bear sphinx moth
(Arctonotus lucidus)



Legend

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

N

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Linsley's rain beetle (*Pleocoma linsleyi*)

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

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

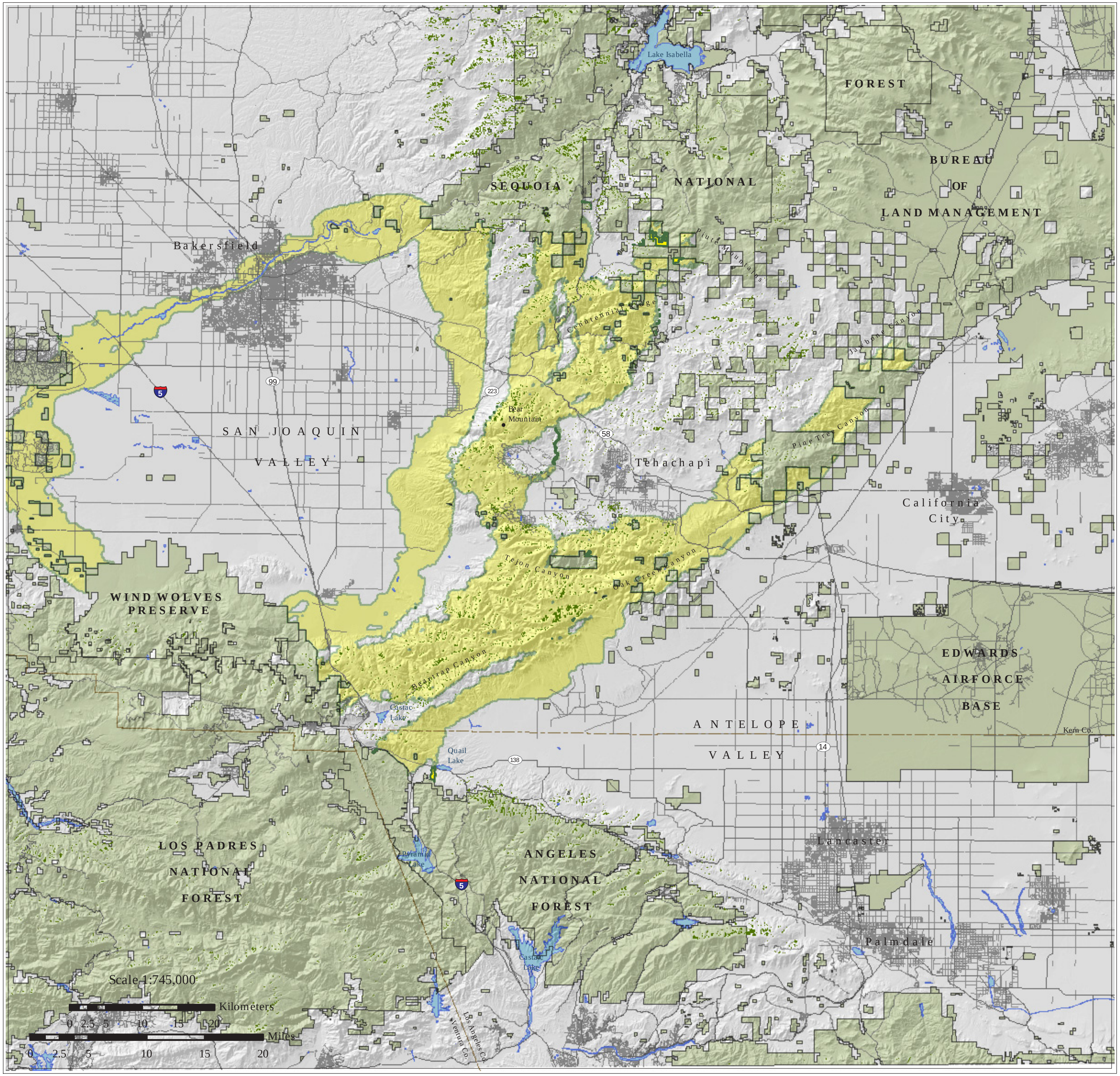
Habitat Associations: Larvae of *Pleocoma* live within the soil, usually within bands with heavy clay content, and feed upon roots of a variety of plants. *Pleocoma linsleyi* larvae appear to favor canyon oak (Quercus chrysolepis) as the primary host, where available, but are not necessarily restricted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

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

Conceptual Basis for Model Development: No home range estimates have been developed for this species; therefore only potentially suitable habitat was delineated. Movement in the linkage would be by males flying between habitat areas, which probably occur only rarely, and females of this species are unable to disperse across any sort of unnatural barrier. Major landform breaks (deep canyons, exposed rock, rivers, lakes, etc.) are significant barriers to *Pleocoma* movement, as would be freeways, concrete channels, aqueducts, etc. (F. Hovore, pers. comm.).

Results & Discussion: The species would likely be served by the Least Cost Union since the distribution is relictual, and probably entirely natural (Figure 54). There is no way of determining the potential for population maintenance via linkages *a priori*, but male dispersal probably would occur occasionally between the patches. Minor surface changes likely do not extirpate *Pleocoma*, but excavation and creation of hardscape

**Figure 54.
Potential Cores for
Linsley's rain beetle
*(Pleocoma linsleyi)***



Legend

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

N

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barriers would be significant to population dispersal and persistence. This species probably can persist locally within a sequence of relatively small habitat patches, provided that the overall linkage is “tight” enough to provide regular gene exchange between patches (F. Hovore, pers. comm.).

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Tejon rabbitbrush longhorned borer (*Crossidius coralinus tejonicus*)

Justification for Selection: This subspecies is restricted to a small area of suitable habitat in the Tejon Pass, and is susceptible to land use changes such as urban development, late-season wildfire, or agriculture.

Distribution & Status: *Crossidius coralinus* is distributed across the western U.S. in two separate population groups, one raning through the desert areas of the Great Basin, and the other confined to the Central Valley and northern Transverse Ranges of California (Linsley & Chemsak, 1961; Linsley, 1962). There are 13 described subspecies, three of which occur in Kern County: *Crossidius coralinus ascendens* ranges through the western Antelope Valley; *C.c. ruficollis* is confined to the lowlands of the southern San Joaquin Valley; and *C.c. tejonicus*, which is known only from the Tejon Pass (Lebec, Frazier Park) to nearby portions of Cuddy Creek valley. This species is afforded no special status.

Habitat Associations: The larval host is *Chrysothamnus nauseosus mojavensis*, a shrubby species of rabbitbrush; the larvae bore within the living root systems. The subspecies in the Antelope Valley also uses this larval host, but the *ruficollis* subspecies utilizes several different species of *Isocoma* as it larval host (Linsley & Chemsak, 1961; F.Hovore file data). Rabbitbrush tends to colonize recently-disturbed substrates, and so is most often found on low-gradient alluvial fans, in association with sage scrub formations, but it also may be common around the periphery of agricultural areas, along roadsides, and in pastures. The longhorned borers are closely-linked ecologically to their larval host plants, and generally occur with them over a range of substrate conditions, but usually are not present in seasonally inundated soils (F.Hovore file data).

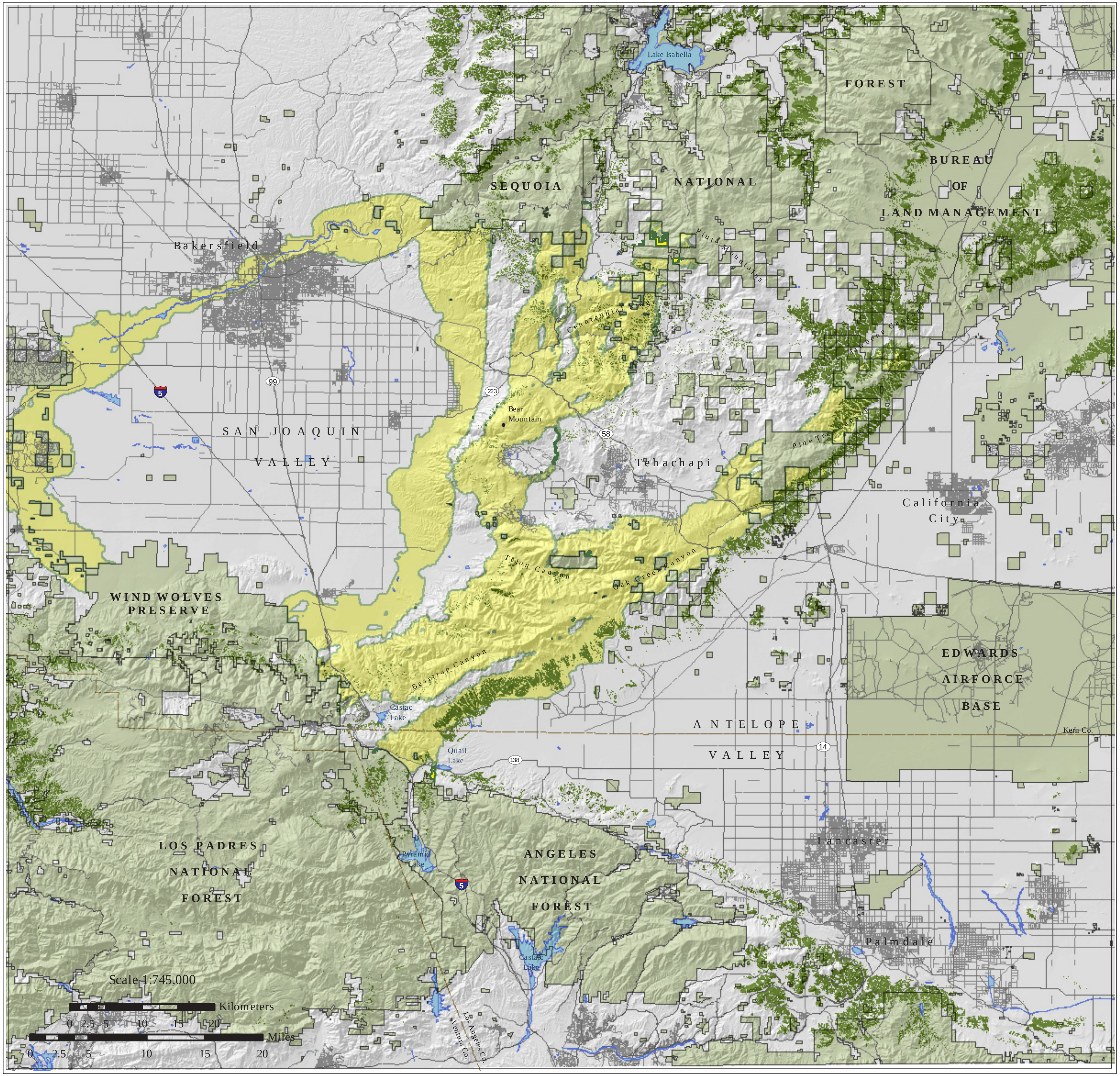
Spatial Patterns: No density studies have been conducted, but the ratio of beetles to host plants observed in the field has ranged from 1:1 to perhaps as many as 6:1. The age and root stock size of the host plants likely influences the density of individuals within any host patch. Dispersal distances have not been measured, but the adult beetles are strong fliers, and wary of approaching predators, and likely can cross distances of many miles in search of new host plant resources.

Conceptual Basis for Model Development: No home range or density estimates have been developed for this species; therefore only potentially suitable habitat was delineated. Movement through the linkage would have to be multigenerational, but it is unlikely that this species would disperse beyond its present known distributional parameters because of shifts in host plant availability. If it were to move east across the rift zone, it would encounter the subspecies *ascendens* in the Antelope Valley, on the same host, and if it co-mingled with that taxon to any extent, subspecies identity likely would break down. Movement to the north would take it into the range of the subspecies *ruficollis*, on a different host genus, and it likely would not successfully colonize and compete with that taxon. The present array of discreet, geographically segregated subspecies in *Crossidius coralinus* strongly suggests that the described populations do not interact genetically to any significant extent.

Results & Discussion: Given the evidence that these subspecies do not ebb and flow significantly within short time frames, the linkages appear to be sufficient for their persistence (Figure 55). Because the larval host plant shifts demographically with disturbance, it would seem that the linkage would provide sufficient opportunity for persistence (F. Hovore, pers. comm.). The probable dispersal distance, with help from wind, likely is sufficient to move between any and all patches.

The presumption is that this species was distributed over more of the landscape prior to pre-historic isolation of the habitats around the San Joaquin Valley, which have lead to separation of the species into isolated populations. Its specific distribution follows its host, which follows disturbance, but its overall distribution is relictual within the upper valleys of the Tejon Pass. Disturbance on a small scale, and not followed by land use changes which restrict its host plant from colonizing the substrates, would favor it; large-scale change likely would not.

Figure 55.
Potential Cores for
Tejon rabbitbrush longhorned borer
(Crossidius coralinus tejonicus)



Legend

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

N

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Lined *Lomatium* longhorned borer (*Brachysomida vittigera*)

Justification for Selection: This species is presently is known from only a few scattered localities along the western foothills of the San Joaquin Valley, in association with its putative larval host plant, a small, dark-flowered species of *Lomatium*.

Distribution & Status: *Brachsomida vittigera* was described (Linsley & Chemsak, 1972) from four total specimens, one from Lebec, Tejon Pass; one from 15 mi SW Havilah, Kern Co.; and two badly preserved specimens from "Colony Road, Tulare Co." [probably near Kaweah] Since that time, it has been taken in only one other reported site, approximately 1 mile E of Fountain Springs, in association with an undetermined species of *Lomatium* (F.Hovore file data). The probable overall range of the species is from the north slope of Tecuya Ridge and Tejon Pass across the low foothills of the Tehachapi and southern Sierra Nevada to the Fresno County (or perhaps even further north). This species is not afforded any special status.

Habitat Associations: The presumed larval host plant (Lomatium sp.) and the beetle have been found together on north-facing slopes of low knolls in open grassland – rangeland, just below the limit of valley oak savannah on the eastern foothills of the San Joaquin Valley. Soils are heavy, dark clays, densely overgrown in most areas with non-native grasses, and the beetles tend to be distributed only where native wildflowers are able to form small stands within the grasses. Males fly in search of females, which are much heavier-bodied, and apparently unable to fly (F. Hovore, pers. comm.).

Spatial Patterns: No density studies have been conducted, but the beetles can be fairly common within even small patches of the Lomatium, suggesting that the larvae likely feed externally upon roots and rootlets, and not within the main root or stem. A patch of only a few hundred plants, covering approximately $100m_2$ may yield several dozen adult beetles at any given time, suggesting that over the entire period of adult emergence several hundred beetles may be present therein. If females cannot fly, though, genetic dispersal would be by males flying between patches, but metapopulation movement would occur incrementally over longer periods of time (F. Hovore, pers. comm.).

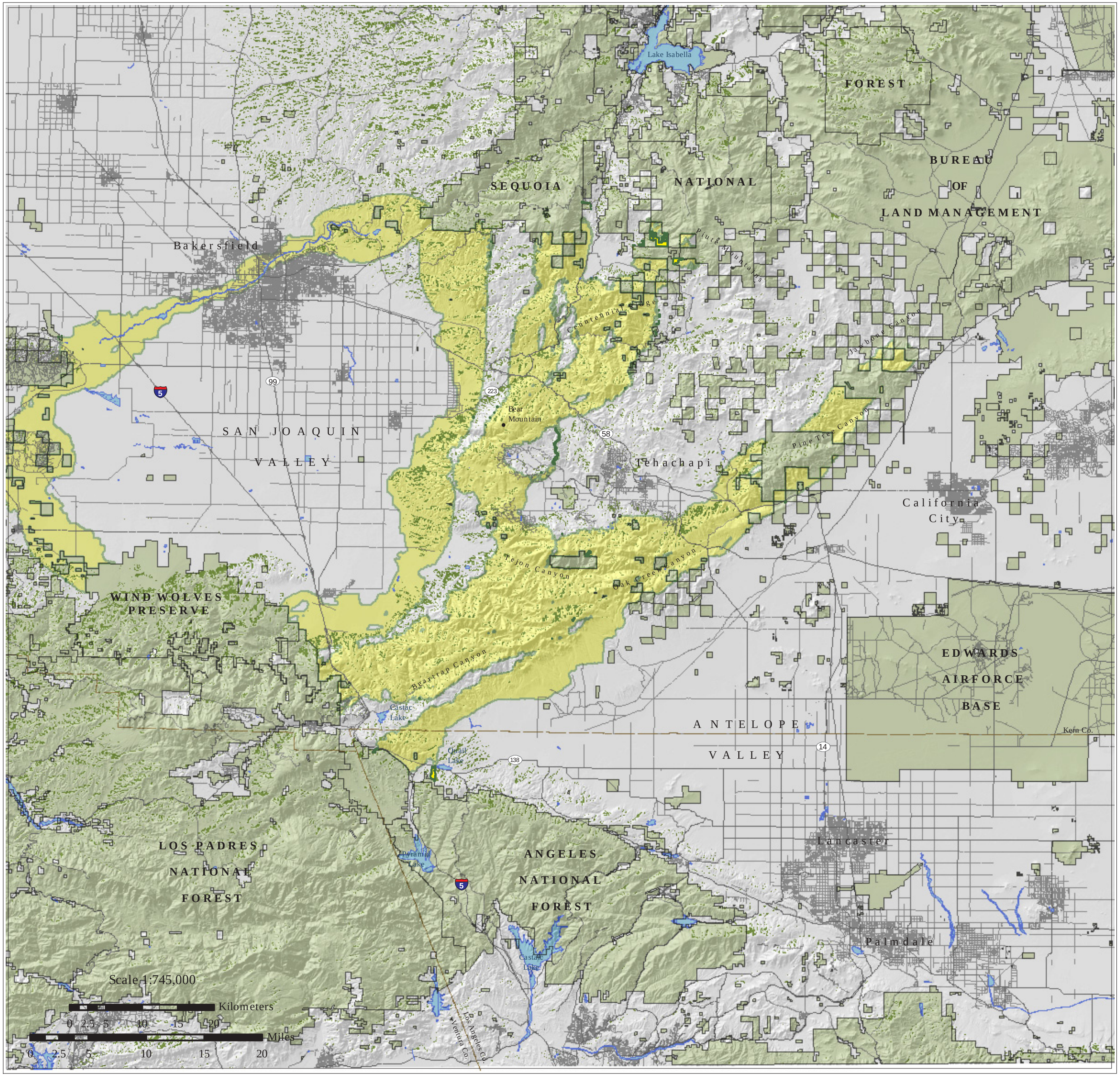
Conceptual Basis for Model Development: Movement in the linkage would be by males flying between habitat areas, which may not occur with any frequency, and it is unlikely that females of this species are able to disperse across any sort of unnatural barrier. The overall distribution, however, suggests that it must be capable of moving through areas of unsuitable habitat to find the larval host plant, or that it utlizes host other than the observed species of *Lomatium* (F. Hovore, pers. comm.).
.
Results & Discussion: The linkages appear to be sufficient for their persistence, provided that major breaks in natural habitat do not occur (Figure 56). It is likely that this species can persist locally in relatively small habitat patches, provided that the linkage is "tight" enough to provide regular gene exchange between patches. The distribution appears to be relictual, probably around ancient shoreline gradients, and more recently fragmented by land use changes (grazing, fire frequencies, introduction of non-native grasses, etc.). It is unlikely that this species would persist through substrate or habitat disturbance, except that which models natural phenomena (F. Hovore, pers. comm.).

Figure 56.
Potential Cores for
Lined Lomatium longhorned borer
(Brachysomida vittigera)

Legend

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

N



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White Fir (*Abies concolor*)

Justification for Selection: Barriers to animal movement may hinder the dispersal abilities of this species (H. Safford pers. comm.).

Distribution & Status: The species reaches its best development and maximum size in the central Sierra Nevada (American Forestry Association 1978 *in* Laacke 1992). Elevations range from a minimum of 600 m (1,970 ft) to a maximum of almost 3400 m (11,150 ft) east of the continental divide in central Colorado. In the Sierra Nevada it is primarily found at elevations between 1200 and 2100 m (3,900 and 6,900 ft). In the Tehachapi Mountains, it may be found on high ridges or in canyon bottoms, on protected north facing slopes and in deep canyon bottoms (Twisselman 1967). This species is not afforded any special status.

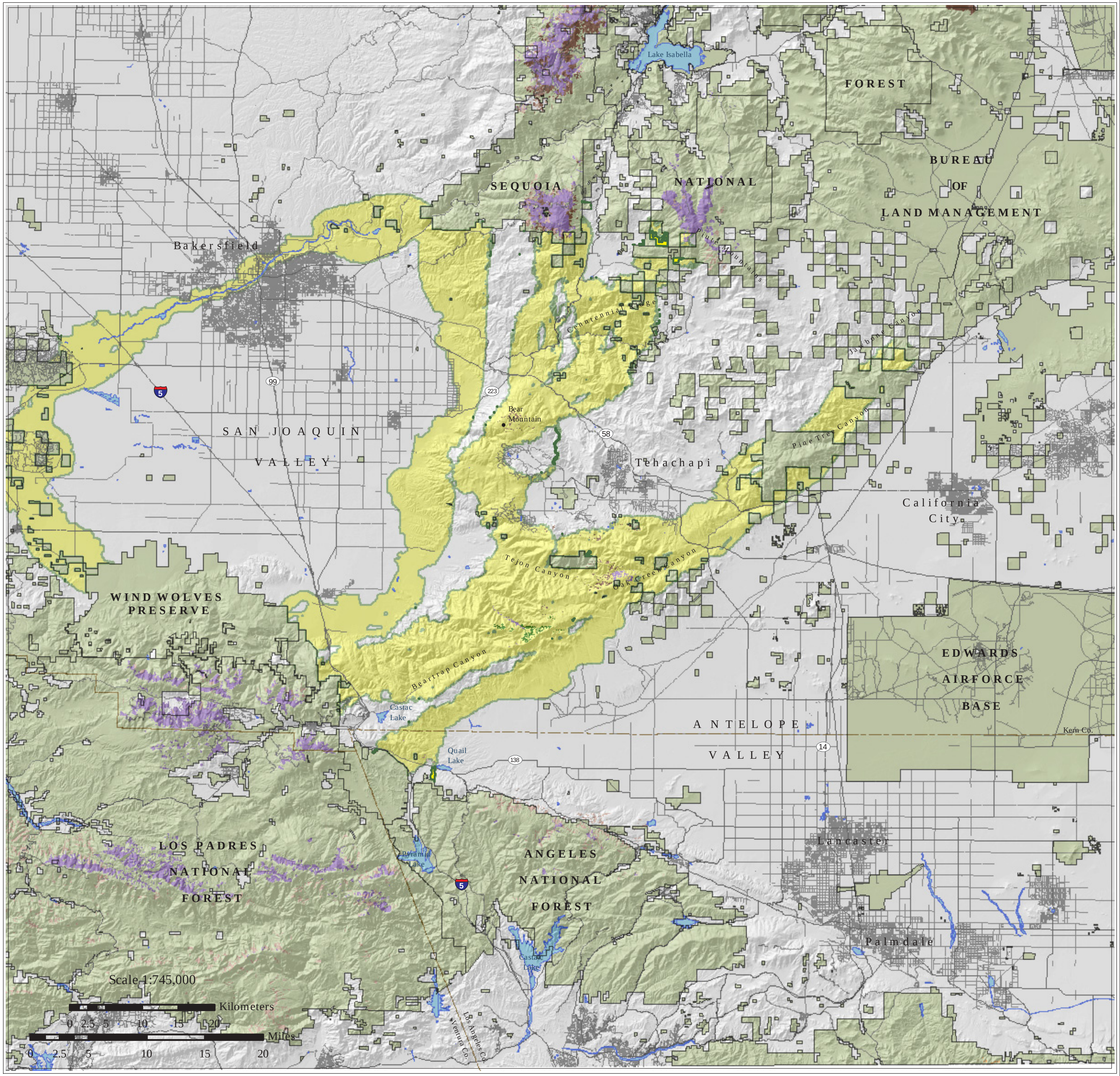
Habitat Associations: California white fir is a climax community. At higher elevations it may form pure stands. In the southern Sierra Nevada, white fir in this transition zone generally tolerates canopy closure better and dominates on nutrient-rich sites (Parker 1986 *in* Laacke 1992). The most common associates in mixed coniferous forests are incense-cedar, ponderosa pine, sugar pine, Jeffrey pine, Douglas-fir, and California black oak (Fowells 1965, Parker and Matyas 1980 *in* Laacke 1992). In the central Sierra Nevada, white fir is associated with giant sequoia (Fowells 1965 *in* Laacke 1992). In the Tehachapi Mountains, it is common in the Jeffrey pine forests.

Spatial Patterns: The species grows on various types of terrain, including extremely steep and unstable slopes, though it prefers gentle slopes and level ground. Seeds can lie dormant for up to 300 years, waiting to germinate in areas opened up by fire or harvesting where they may quickly establish dominance (Conard and Radosevich 1981, Fowells 1965, McNeil and Zobel 1980 *in* Laacke 1992). California white fir flowers in May or June, fertilization occurs soon after and seeds germinate in the spring immediately following snowmelt (Jones 1974 *in* Laacke 1992).

Habitat Suitability, Patch Size & Configuration Analyses: White fir is dispersed by birds, small mammals, and gravity ranging in distance from 1 m to 10 km (Safford pers. comm.). It is estimated that about 123 species of birds occur in the white fir habitats of California, 50 of which are associated primarily with mature forests. There are 33 species of mammals associated with White fir, with 7 of these dependent on mature stands. Reptiles are represented by 17 species, with 8 reliant on mature forests (Verner et al. 1980 *in* Laacke 1992). We did not attempt to model animal dispersers but instead identified potentially suitable habitat.

Results & Discussion: White fir currently has a limited distribution in the Tehachapi Mountains, while large populations of white fir exist in the Greenhorn Range of the Sequoia National Forest and in the Sierra Madre Range. Clusters of potentially suitable habitat were identified in upper Beartrap Canyon, and in Oak Creek Canyon within the Least Cost Union (Figure 57). White fir forests have been logged or degraded in parts of the Tehachapi Mountains, affecting habitat use and movements of blue grouse (*Dendragapus ocscurus*) between the Sierra Nevada and Sierra Madre ranges (J. Bland, pers. comm.).

Figure 57.
Potential Habitat for White fir
(Abies concolor)



Legend

- Least Cost Union
- Eastside pine
- Montane hardwood-conifer
- Ponderosa pine
- Sierran mixed conifer
- White fir
- Paved Roads
- Ownership Boundaries
- County Lines

N

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Blue oak (*Quercus douglasii*)

Justification for Selection: Continued clearing of blue oak for rangeland improvement resulted in the loss of 1 million acres (0.4 million ha) of blue oak woodland (Bolsinger 1988, U.S. Department of Agriculture 1959 *in* Howard 1992). Other factors contributing to species decline are road construction, residential, and commercial development (Vogl 1977 *in* Howard 1992). Use of blue oak for fuelwood is also an issue (Burns and Honkala 1990 *in* Howard 1992). Seedlings and young trees are uncommon in many regions due to the combination of drought cattle grazing, and the inability of very young seedlings to compete with nonnatives (Twisselman 1967).

Distribution & Status: Blue oak is a California endemic, which covers 8 percent of state's total land area (Adams et al. 1992, Barbour 1987 *in* Howard 1992). It occurs in valleys and lower slopes of the Coast Ranges and in lower foothills of the Sierra Nevada. Its distribution almost completely encircles the Central Valley (Holland 1986; Munz 1973). Blue oak ranges in elevation from 165 feet (50 m) at the northern Central Valley floor to 5,900 feet (1,800 m) in its southernmost distributional limits (Burns and Honkala, 1990 *in* Howard 1992). Blue oak is also found east of the crest of the mountains, especially in the canyons of the Tehachapi Range and the other desert-facing canyons north to Jawbone Canyon and the west side of Kelso Valley (Twisselman 1967). An extensive blue oak woodland exists in the Greenhorn foothills.

Habitat Associations: Blue oak is often found with gray pine but may also occur with several other oak species, including interior live and valley oaks. The blue oak can may form dense woodlands or occur on open savannas. It merges or forms a mosaic with annual grassland at low elevation and with chaparral, other oak woodland phases, or singleleaf pinyon-California juniper woodland at higher elevation (Griffin 1977 *in* Howard 1992). They may also be found in association with Coulter pine and California buckeye (Howard 1992). Soil substrates range from gravelly loam to gravelly clay-loam (Burns and Honkala 1990 *in* Howard 1992).

Spatial Patterns: Abundant acorn crops are produced every 2 to 3 years, with larger crops every 5 to 8 years (Olson 1974 *in* Howard 1992). The acorns are capable of immediate germination. A 3-year study in the central Sierra Nevada foothills showed that blue oak woodland is utilized by 92 species of birds, 7 species of rodents, 3 lizards, 4 snakes, and the state-endangered foothill yellow-legged frog (Block and Morrison 1987 *in* Howard 1992).

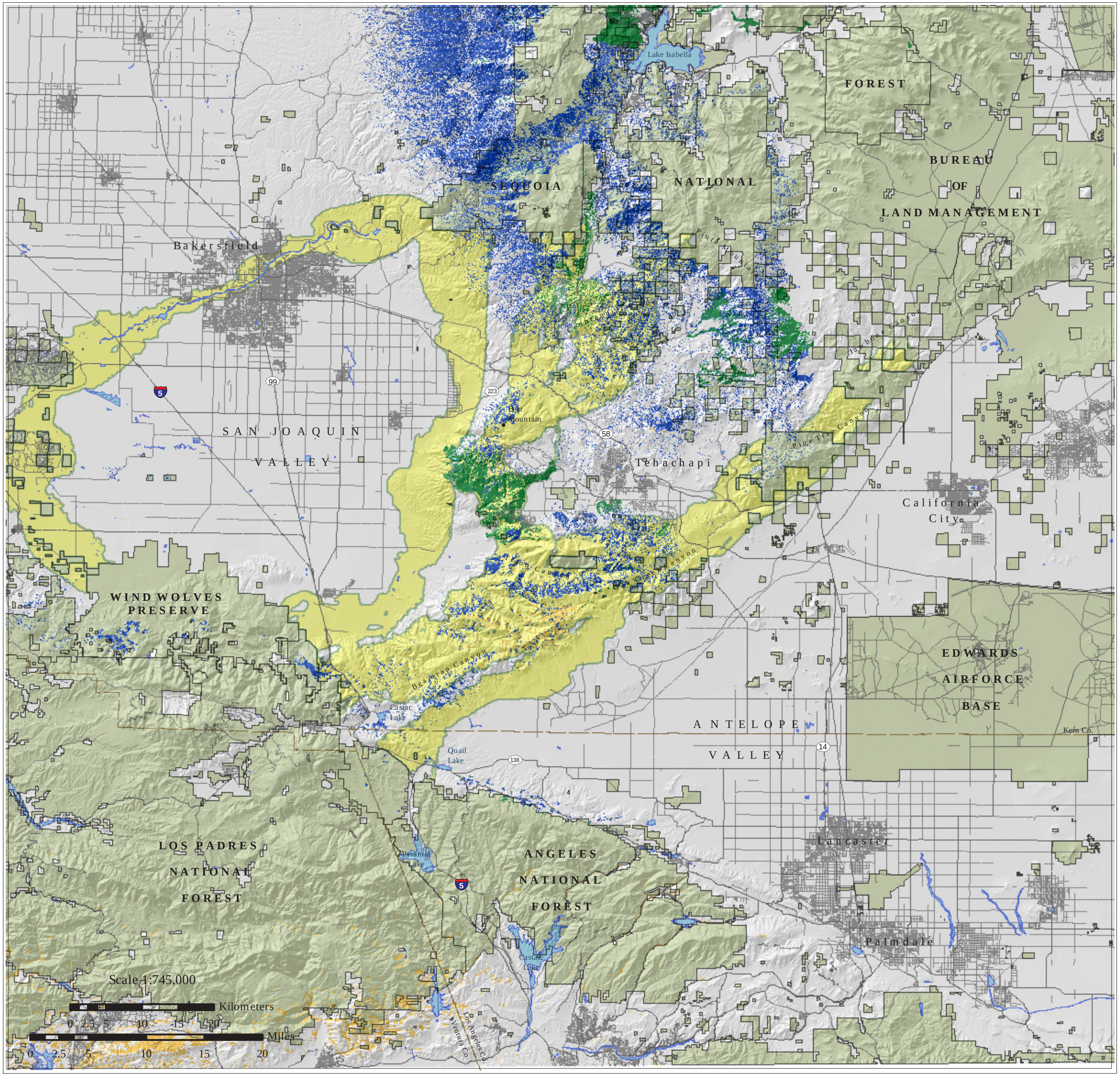
Conceptual Basis for Model Development: Vegetative communities in which the species is likely to occur (i.e., blue oak woodland and blue oak foothill pine) were queried in a GIS to evaluate general distribution and potential suitable habitat.

Results & Discussion: This species appears to be well represented in the Least Cost Union (Figure 58), and represents roughly 40% of the oak diversity in the final Linkage Design. The Blue oak woodland community is seriously underrepresented in existing protected areas, 75% is in private ownership, 14% is in the National Forest System, and 11% is in various other public ownerships (Bolsinger 1988 *in* Howard 1992). This is clearly a species that needs the linkage and it provides valuable foraging and nesting habitat for a variety of wildlife species.

Figure 58.
Potential Habitat for Blue oak
(Quercus douglasii)

Legend

- Least Cost Union
- Blue Oak-Foothill Pine
- Blue Oak Woodland
- Coastal Oak Woodland
- Paved Roads
- Ownership Boundaries
- County Lines



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California Black Oak (*Quercus kelloggii*)

Justification for Selection: Oaks (Quercus spp.) may be the single most important genus used by wildlife for food and cover in California forests and rangelands (Edelbrock 1991 *in* Howard 1992), and California black oak occupies more total area in California than any other hardwood species (Bolsinger 1988 *in* Howard 1992).

Distribution & Status: California black oak is distributed along foothills and lower mountains of California and southern Oregon. It is found from Lane County, Oregon south through the Cascade Range, the Sierra Nevada, and the Coast, Transverse, and Peninsular ranges to San Diego County, California (Munz 1973). California black oak can live up to 500 years of age (Burns and Honkala 1990 *in* Howard 1992. In California, the elevational range varies from 200 to 8,000 feet (60-2,440 m) (Burns and Honkala 1990 *in* Howard 1992).

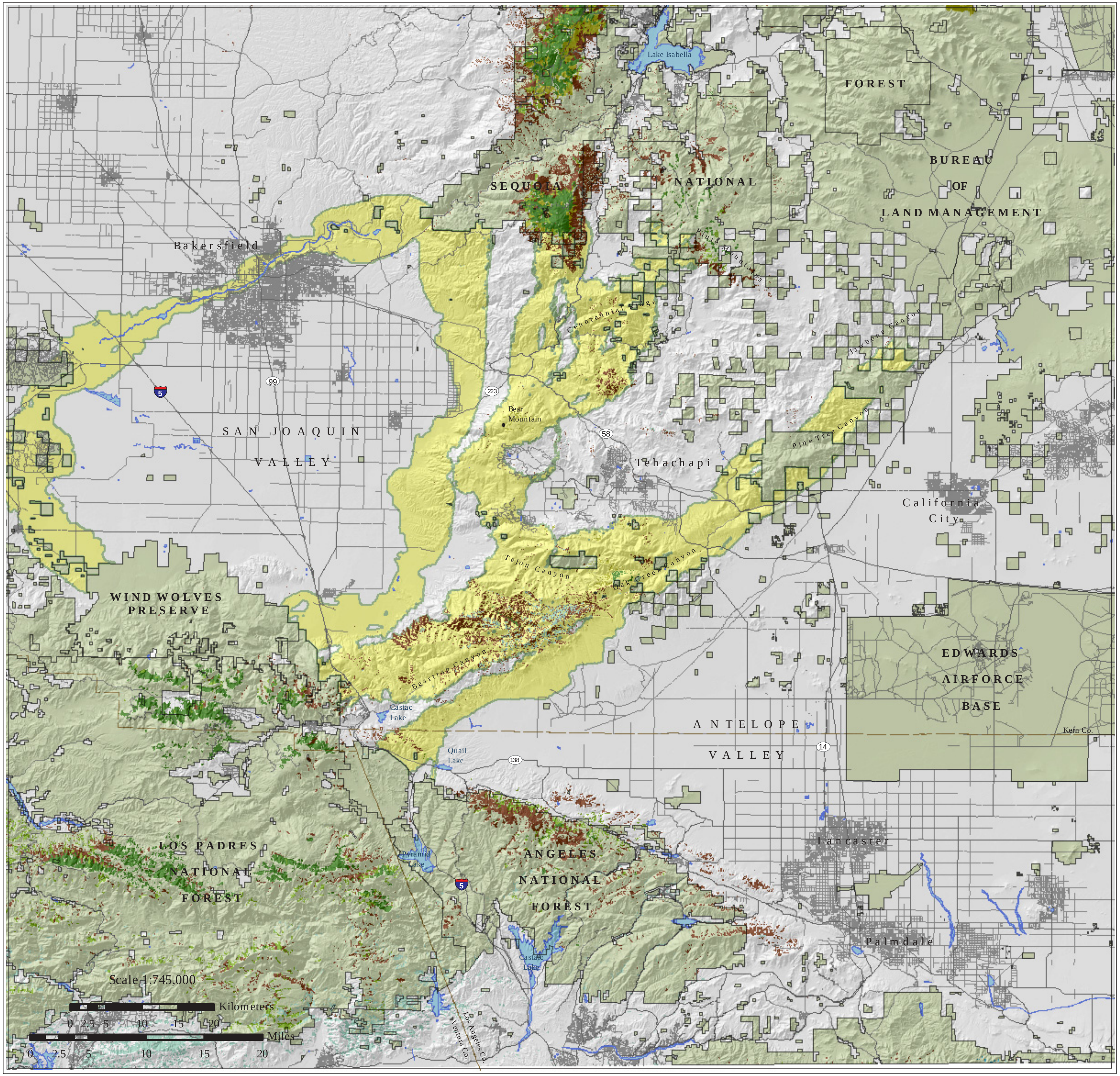
Habitat Associations: California black oak occurs in pure or mixed coniferous forest stands (Twisselman 1967). Commonly associated species include incense-cedar, tanoak, interior live oak, Pacific dogwood, and bigleaf maple (Burns and Honkala 1990 *in* Howard 1992). Common understory shrubs include various species of manzanita, Brewer oak, Sierra gooseberry, poison-oak, and Sierra mountain misery (Burns and Honkala 1990 *in* Howard 1992).

Spatial Patterns: California black oak is wind pollinated. Acorns may be dispersed by by gravity or animals (Burns and Honkala 1990 *in* Howard 1992). Acorn viability varies greatly. Seedling establishment rates are best in acorns buried by seed-caching rodents or birds. The California ground squirrel and the Stellar's jay are important for seed dispersal. Seedlings cannot establish on heavy clay soils or soils compacted by logging (Howard 1992).

Conceptual Basis for Model Development: Vegetative communities in which the species is likely to occur (i.e., montane hardwood, mixed coniferous forests) were queried in a GIS to evaluate general distribution and potential suitable habitat.

Results: California black oak appears to be well represented in the Least Cost Union (Figure 59). It has a similar distribution to blue oak in the linkage, mainly in the middle prong of the Linkage Design. It also occurs on the northern slopes of the San Gabriel, in the Sierra Madre and Sierra Nevada ranges.

Figure 59.
Potential Habitat for
California black oak
(Quercus kelloggii)



Legend

- Least Cost Union
- Coastal oak woodland
- Eastside pine
- Montane hardwood-conifer
- Montane hardwood
- Ponderosa pine
- Sierran mixed conifer
- Paved Roads
- Ownership Boundaries
- County Lines

N

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California Buckeye (*Aesculus californica*)

Justification for Selection: California buckeye is valuable for habitat restoration of stream or riverbanks and on steep slopes (Goldner 1984, Katibah 1984, Stromberg and Katibah 1984 *in* Howard 1992). The species ability to disperse can be hindered by barriers to animal dispersal and lack of appropriate habitat to germinate and survival of plants (H. Safford, pers. comm.).

Distribution & Status: California buckeye is an endemic plant of California. It occurs in the Klamath and Coast Ranges from Siskiyou County south to Los Angeles County. In the Cascade Range and the foothills of the Sierra Nevada, it occurs from Shasta County south to Kern County. California buckeye is occasionally found in the Central Valley in Yolo, Colusa, and Stanislaus Counties (Holmer et al 1994 *in* Howard 1992). California buckeye occurs below 4,000 feet (1,219 m) (Munz 1973).

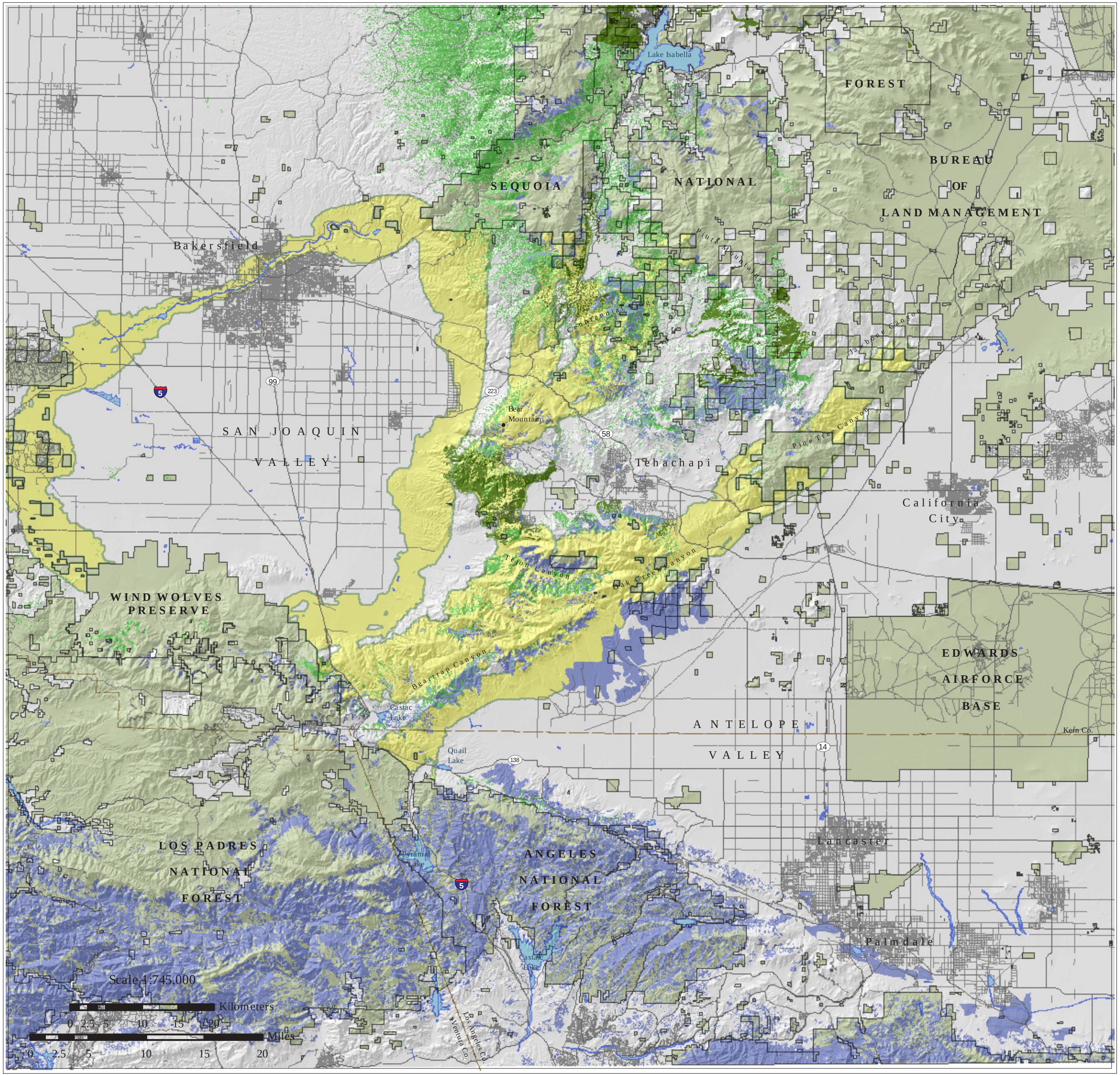
Habitat Associations: California buckeye grows on dry slopes, in canyons, and along waterways (Munz 1973). In the Central Valley it occurs along stream and riverbanks (Holmer et al 1994, Mirov and Kraebel 1937 *in* Howard 1992). It occurs as widely scattered individuals in open grasslands. It also occurs as an understory shrub in mixed evergreen forest (Baker et al. 1981 *in* Howard 1992). California buckeye occurs below 4,000 feet (1,219 m) (Munz 1973). It is an indicator species of climax chaparral and mixed oak communities (Allen et al. 1991 *in* Howard 1992) and in California buckeye woodlands (Buckman 1964 *in* Howard 1992). California Buckeye will move up the slopes with warming (H. Safford, pers. comm.). California buckeye is generally common in the mountains southwest to Lebec where it can form a mixed woodland with Douglas oak and digger pine. It is most commonly found in Kern Canyon on the steep canyon sides while being rather rare in Pleito Canyon of the Emigdio Range (Twisselman 1967). Its distribution is very common on North facing slopes (H. Safford, pers. comm.).

Spatial Patterns: Seed dispersal is poor and is accomplished mainly by gravity or water; dispersal by animals is rare (Halverson and Clark 1989 *in* Howard 1992). California buckeye can sprout from the stump or root crown (Baker et al. 1982, Van Dersal 1938 *in* Howard 1992). The dispersal of seeds ranges from meters to hundreds of meters (H. Safford, pers. comm.).

Conceptual Basis for Model Development: Vegetative communities in which the species is likely to occur (i.e., chaparral, mixed oak woodlands and coniferous forests) were queried in a GIS to evaluate general distribution and potential suitable habitat.

Results: This species also appears to be addressed by the Least Cost Union (Figure 60). It is primarily distributed in Beartrap and Tejon canyons in the middle and eastern prongs of the Linkage Design. California buckeye will also benefit from chaparral habitat added to the Least Cost Union.

Figure 60.
Potential Habitat for California buckeye
(Aesculus californica)



Legend

- Least Cost Union
- Paved Roads
- Ownership Boundaries
- County Lines
- Blue oak-Foothill pine
- Blue oak woodland
- Mixed chaparral

N

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Jeffrey Pine (*Pinus jeffreyi)*

Justification for Selection: Jeffrey pine is an important tree for providing wildlife cover and food resources (Evans 1988 *in* Habeck 1992).

Distribution & Status: Jeffrey pine is distributed from the Klamath Mountains into southwestern Oregon, across the Sierra Nevada into western Nevada, and south to the Transverse and Peninsular Ranges and into northern Baja California (Haller 1962, Jenkinson 1990 *in* Habeck 1992). Jeffrey pine is the dominant tree at the higher levels of the yellow pine forest, especially along ridgetops and other exposed places in the Greenhorn Range and on Breckenridge Mountain, occurring mostly over 6,000 feet elevation. It basically replaces the ponderosa pine at all altitudes on the Kern Plateau, in the Piute and Tehachapi Mountains, and in the Mt. Pinos region. Important to the Jeffrey pines distribution is even more its high tolerance of cold and than its great drought resistance (Twisselman 1967). An isolated colony of trees of all ages can be found at the western end of the Tehachapi Mountains east of Keene. It also occurs on the steep north slopes at the head of desert-facing Pine Tree Canyon (Twisselman 1967).

Habitat Associations: Jeffrey pine occupies many sites from the edges of moist high montane meadows to arid slopes bordering deserts. It generally occurs on the drier or higher elevations. It forms pure stands along the eastern slope of the Sierra Nevada. It grows in mixed stands with ponderosa pine, incense cedar, white fir, and juniper (Habeck 1992). Jeffrey pine overlaps extensively with ponderosa pine and sugar pine on the western slopes of the Sierra Nevada, California.

Spatial Patterns: Factors relating to poor seed dispersal seem to be the major limiting factor in the natural succession of Jeffrey pine (Heath 1967 *in* Habeck 1992). Heavy winds may disperse seeds up to 2,460 feet (750 m) from a tree height of 164 feet (50 m). Wildlife also aid in seed dispersal. Vander Wall (1992) found dissemination patterns of Jeffrey pine linked extensively to animal hoarding of seeds in shallow surface caches (*in* Habeck 1992). Small mammals such as the western gray squirrel harvest and store the seeds (Fowells and Stark 1965, Jenkinson 1990, Krugman and Jenkinson 1974, Temple 1988 *in* Habeck 1992).

Conceptual Basis for Model Development: Vegetative communities in which the species is likely to occur (i.e., montane hardwood and coniferous forests, Jeffrey, Eastside, and Ponderosa pine) were queried in a GIS to evaluate general distribution and potential suitable habitat.

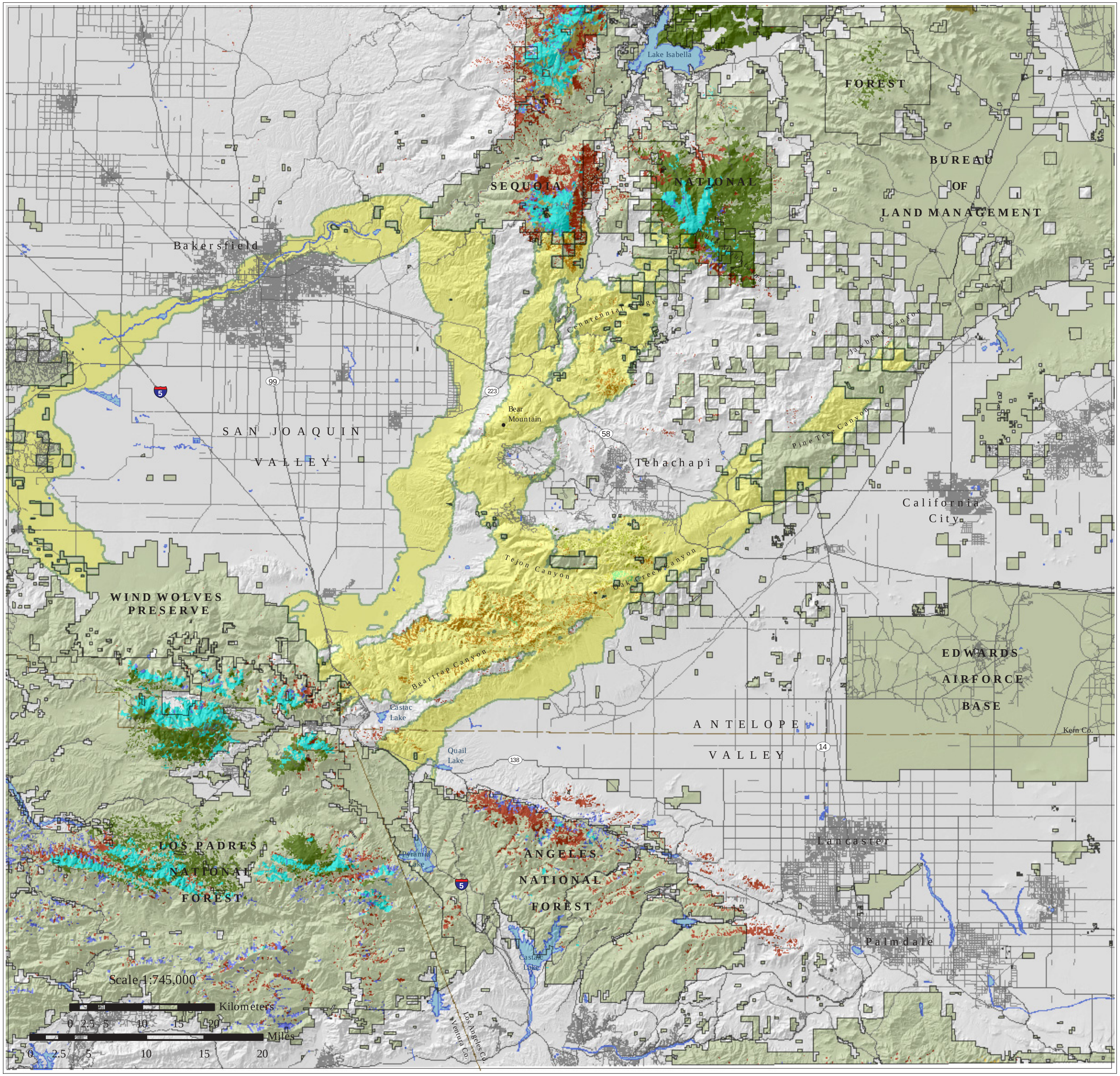
Results: Jeffrey pine is occurs throughout the central portion of the Tehachapi Mountains, with a distribution resembling that of the 2 oak species, with larger populations in the Sierra Madre and Sierra Nevada cores areas (Figure 61). The species appears to be accommodated by the Least Cost Union.

Figure 61.
Potential Habitat for Jeffrey pine
(Pinus jeffreyi)

Legend

- Least Cost Union
- Eastside pine
- Jeffrey pine
- Montane hardwood-conifer
- Montane hardwood
- Ponderosa pine
- Sierran mixed conifer
- Paved Roads
- Ownership Boundaries
- County Lines

N



SOUTH COAST WILDLANDS PROJECT

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August 2003

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Singleleaf Pinyon Pine (*Pinus monophylla*)

Justification for Selection: Provides important food resources for various wildlife species.

Distribution & Status: Pinyon-juniper woodlands cover more than 55.6 million acres in the western United States. It is the predominant tree species in the isolated mountain ranges of the Great Basin, ranging from southern Idaho, western Utah and northwestern Arizona, through most of Nevada (it's Nevada's state tree) and eastern and central California to northern Baja California (Zouhar 2001). The common singleleaf pinyon often forms distinct woodlands and can be found on the desert slopes of the mountains west to the Piute Mountains and the east slope of the Greenhorn Range southwest to the east end of Cuyama Valley. It also occurs on ridgetops along the mountains bordering the desert in the Jawbone Canyon. Singleleaf pinyon can also be found growing in conjunction with digger pine on the east slope of the Piute Mountains, the southern Kern Plateau and at the head of Tejon Canyon (Twisselman, 1967). Pinyon/juniper woodland is found up to 2800 m in elevation (Hickman 1993 *in* Zouhar 2001).

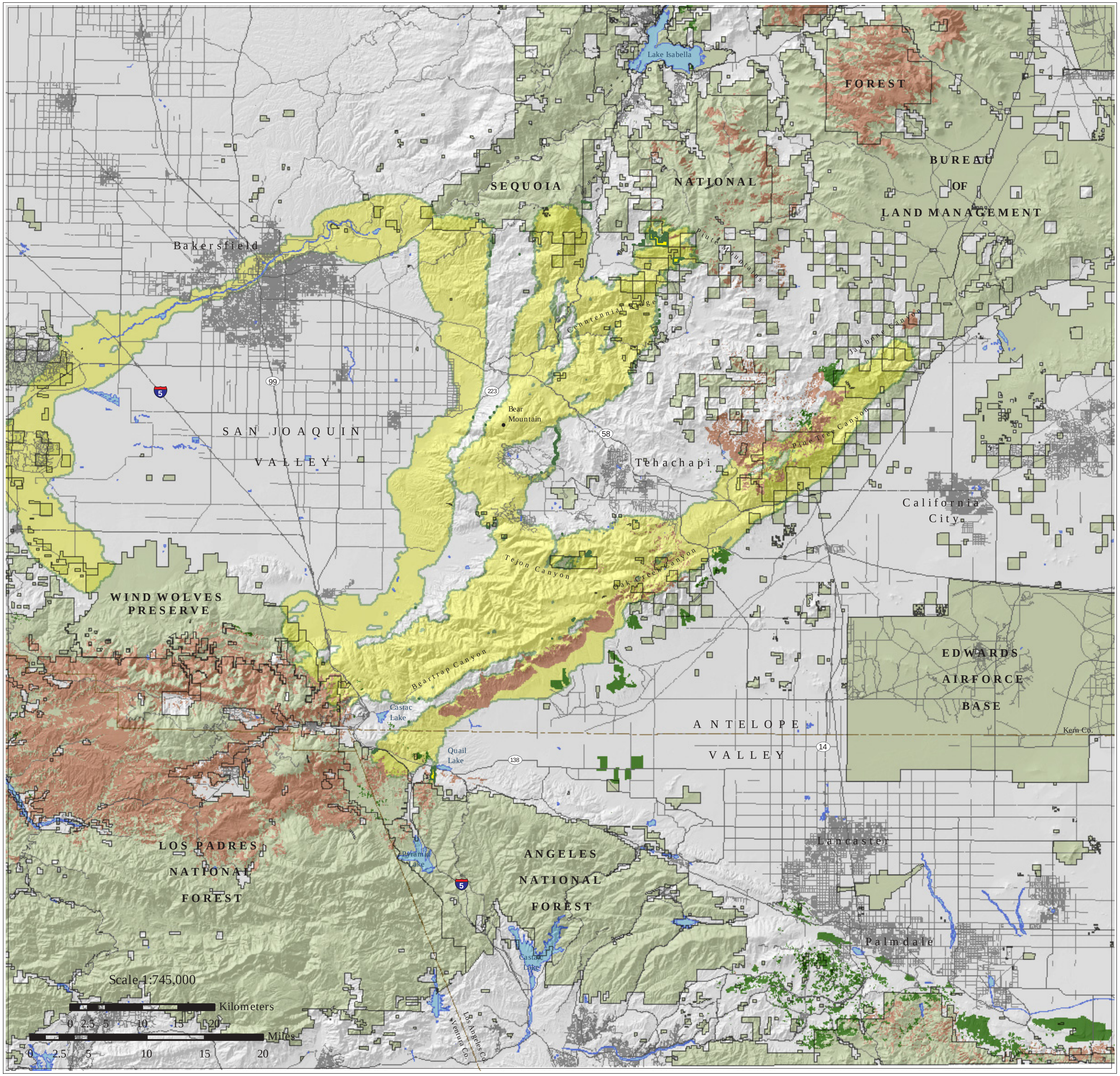
Habitat Associations: Pinyons (*Cembroides*) typically grow in association with juniper (*Juniperus* spp.), with juniper dominating the lower elevations of their range and pinyons the upper. On the eastern slopes of the Sierra Nevada singleleaf pinyon is found with western juniper, Jeffrey pine, ponderosa pine, big sagebrush, curlleaf mountain-mahogany, and rabbitbrush scrub (Zouhar 2001). They may also be found in associations with bigcone Douglas-fir at upper elevations in southern California (Zouhar 2001). In southern California, singleleaf pinyon is a common component of the desert montane landscape on arid slopes and is most commonly found with California juniper (Zouhar 2001).

Spatial Patterns: Home range can be feet to miles. The dispersal distance is very small and it has to rely on mammals and birds. Wind is needed for pollination. (I. Anderson pers. comm.).

Conceptual Basis for Model Development: Vegetative communities in which the species is likely to occur (i.e., desert scrub and woodlands) were queried in a GIS to evaluate general distribution and potential suitable habitat.

Results: This species appears to be well represented in the Least Cost Union (Figure 62). It has the potential to occur along the southeastern slopes of the Tehachapi Mountains and in the Pine Tree, Oak Creek, and Jawbone canyon areas within the Least Cost Union. Larger populations occur in the two core areas.

Figure 62.
Potential Habitat for Single-leaf pinyon pine
(Pinus monophylla)



Legend

- Least Cost Union
- Juniper
- Pinyon - juniper
- Paved Roads
- Ownership Boundaries
- County Lines

N

SOUTH COAST WILDLANDS PROJECT

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Bakersfield cactus (*Opuntia basilaris* var. *treleasei*)

Justification for Selection: Bakersfield cactus is threatened by the conversion and degradation of its habitat due to urbanization, agriculture, oil field development, overgrazing, off-road vehicles, sand mining, competition from non-native grasslands, and anything that blocks streams (USFWS 1998, CDFG 2000, E. Cypher pers. comm.).

Distribution & Status: This endemic species is now restricted to the mesas east of Bakersfield to Comanche Point in Kern County, though it once formed extensive colonies from the Kern River to Caliente Wash (Twisselman 1967, CDFG 1995, CDFG 2000). The first specimen was recorded at "Caliente, in the Tehachapi Mountains" (Coulter 1896 *in* USFWS 1998). By 1987 it was limited to 4 general locales, Granite Station, Comanche Point, Caliente, and Oildale (CDFG 1995 *in* USFWS 1998). In 1989, the species was recorded as extant at the following locations: Caliente Creek, Comanche Point, Cottonwood Creek, Fairfax Rod-Highway 78 Highway 184, Kern Bluffs-Hart Park, Fuller Acres, Granite Station, mouth of Kern Canyon, Oildale, Poso Creek, Sand Ridge, and Wheeler Ridge in the Plieto Hills (CDFG 1995, Moe 1989 *in* USFWS 1998). When last inventoried, fewer than 20,000 clumps remained, only 4 areas (Comanche Point, Kern Bluff, Wheeler Ridge and Sand Ridge) with 1,000 clumps or more: (CDFG 1995, Moe 1989, R. van de Hoek pers. Comm. *in* USFWS 1998). The species is federally and state listed as endangered.

Habitat Association: Bakersfield cactus prefers sandy or gravelly substrates in chenopod scrub, valley and foothill grasslands, and cismontane woodlands, between 120-550 m in elevation (CDFG 2000, CNPS 2001). They may also occur in is the sandy soils of washes and ridges or streams, where they are often associated with *Lepidospartum squamatum* (E. Cypher pers. comm.). The highest elevation record was at Caliente (550 m), while the lowest was documented at Fuller Acres (121 m) (CDFG 1995 *in* USFWS 1998). However, historical records indicate that this species was most commonly found between 140 to 260 m (USFWS 1998).

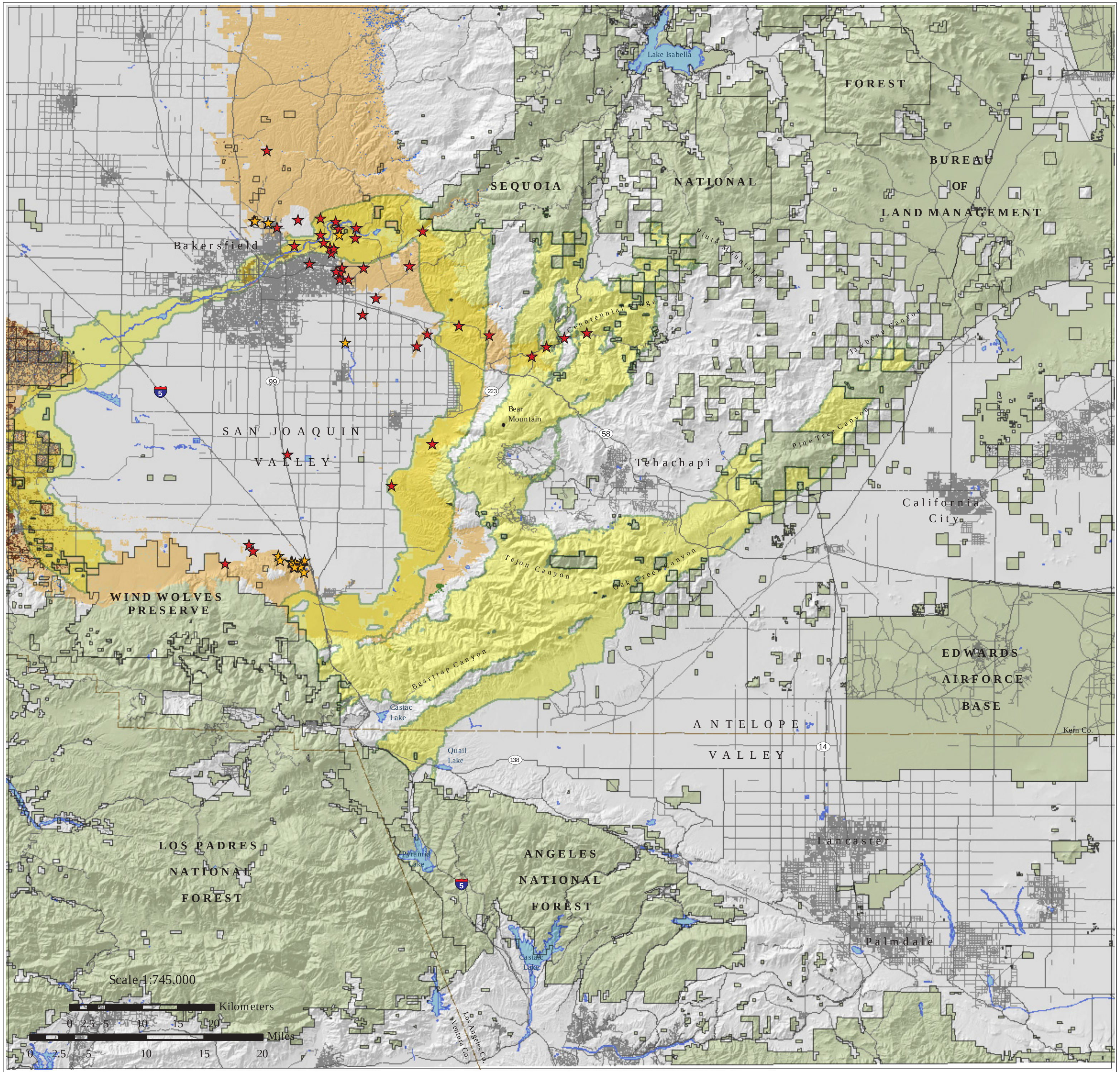
Spatial Patterns: Cactus populations are typically recorded by the number of clumps rather than by individuals. Clumps of Bakersfield cactus are known to grow up to 35 cm (14 in) high and 10 m (33 feet) across (R. van de Hoek pers. comm. *in* USFWS 1998). In 1967, Twisselman estimated the colony at Caliente Wash and Sand Ridge to be approximately 4 miles long and up to a ½ mile across.

No studies have been conducted on the reproductive biology of this species, but other Opuntia species require cross-pollination for seed set and many are pollinated by bees (Benson 1982, Spears 1987, Osborn et al. 1988 *in* USFWS 1998). A potential pollinator of Bakersfield cactus is the native solitary bee *Diadasia australis* ssp. *californica*, which specializes in collecting pollen from Opuntia species (Thorp in litt. 1998 *in* USFWS 1998). Animals may occasionally aid in seed dispersal (E. Cypher pers. comm.). The flowing water of streams and rivers may also provide dispersal opportunities for this species whose pads may detach, flow down stream and vegetatively reproduce (E. Cypher pers. comm.).

Conceptual Basis for Model Development: Bakersfield cactus is associated with the grasslands that rim the valley, but it also occurs into the foothills and mountains in grassland, chenopod scrub, and cismontane woodlands. They may also occupy habitat along washes, rivers, or streams. The elevational range for this species is 120-550 m.

Results & Discussion: The habitat suitability output corresponds nicely to the recorded occurrences for this species (Figure 63). The majority of potentially suitable habitat included in the Least Cost Union is comprised of annual grassland, though patches of alkali desert scrub, blue oak-foothill pine, blue oak woodland, perennial grassland, and valley oak woodland may also provide appropriate habitat within the elevational range of the species. A large portion of the habitat identified for this species that occurs between protected lands in the planning area was captured in the Least Cost Union, including the grassland habitat that rims the valley floor from Wind Wolves Preserve to the southwestern boundary of Sequoia National Forest. This area was also identified as a linkage zone for this species in the recovery plan (Recovery Task 5.3.8) for upland species of the San Joaquin Valley (USFWS 1998). Other areas captured in the Least Cost Union include the grassland and alkali scrub communities between Wind Wolves and Elk Hills and habitat along the upper Kern River near Bakersfield. Other potentially key areas not incorporated into the Least Cost Union include habitat on Wheeler Ridge, in Tejon Canyon, south of the Kern River just east of Bakersfield, and in the Sierra foothills to the north. This species may also benefit from habitat added to the Least Cost Union.

F i g u r e 63.
Potential Habitat for Bakersfield cactus
(Opuntia basilaris* var. *treleasei)



L e g e n d

- Least Cost Union
- Annual grassland
- Alkali desert scrub
- Blue oak-foothill pine
- Blue oak woodland
- Perennial grassland
- Valley oak woodland
- SERP Occurences*
- CNDDB observation
- Paved Roads
- Ownership Boundaries
- County Lines

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

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Tejon poppy (*Eschscholzia lemmonii* ssp. *kernensis*)

Justification for Selection: This species was selected as an indicator for the valley floor grassland community. It is sensitive to habitat loss and fragmentation from urban and agricultural developments. Non-native plants also inhibit seed germination (E. Cypher pers. comm.).

Distribution & Status: Tejon poppy is an endemic restricted to Kern County. The species was first described from a specimen collected from the "Tejon Hills, 2 miles northwest of Tejon Ranch headquarters, Kern County" (Munz 1958 *in* USFWS 1998). The species has been recorded from 6 areas in the grassland habitats that surround the southern tip of the San Joaquin Valley. Twisselman recorded this species in the Tejon Hills between Chanac and Tejon Canyons (1967). The recovery plan (USFWS 1998) described recorded occurrences on Dry Bog Knoll in Adobe Canyon, on the mesas east of Bakersfield, at Comanche Point (Twisselmann 1967), in the Elk and Pleito Hills (CDFG 1995), and near Maricopa (CNPS 2001). The only known extant population is at Elk Hills; all other populations are on private land and have not been surveyed in over 3 decades (USFWS 1998).

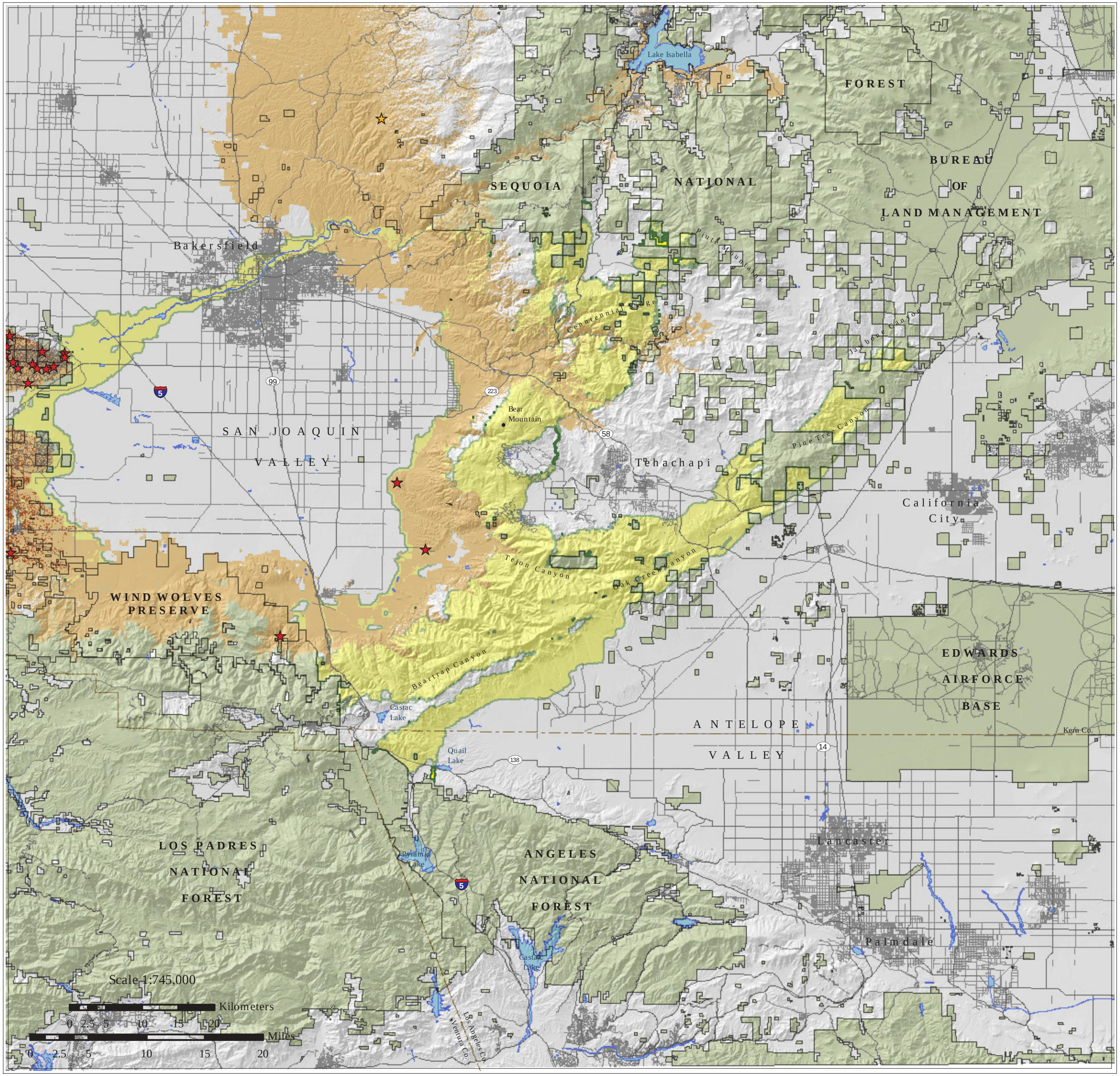
Habitat Associations: It prefers clay soils in open grasslands between 250-600 m in elevation (Twisselmann 1967, CDFG 1995). At Comanche Point, the species was found in association with Kern brodiaea, sunset lupine, and Comanche point layia (Twisselman 1969 *in* USFWS 1998).

Spatial Patterns: This species is associated with grassland habitat on the slopes above the valley floor (E. Cypher pers. comm.) and may be quite conspicuous in years with abundant rainfall (Twisselman 1967). Wind and possibly rodents may assist in seed dispersal (E. Cypher pers. comm.).

Conceptual Basis for Model Development: This species may be associated with open grassland or alkali scrub communities between 250-600 m in elevation. Vegetative communities in which the species is likely to occur were queried in a GIS to evaluate general distribution and potential suitable habitat.

Results & Discussion: The habitat suitability output also corresponds nicely to the recorded occurrences for this species (Figure 64). A large portion of the habitat identified for this species was captured in the Least Cost Union, including the grassland habitats along the arc of the valley floor. Other potentially key areas not captured in the Least Cost Union include habitats on Wheeler Ridge, in Tejon Canyon, south of the Kern River just east of Bakersfield, and in the Sierra foothills to the north. This species may also benefit from the additional habitat included in the Linkage Design.

Figure 64.
Potential Habitat for
Tejon poppy
(Eschscholzia lemmonii kernensis)



Legend

- Least Cost Union
- Annual grassland
- Alkali desert scrub
- SERP Occurences*
- CNDDB Observations
- Paved Roads
- Ownership Boundaries
- County Lines

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

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Appendix E: Literature Cited

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