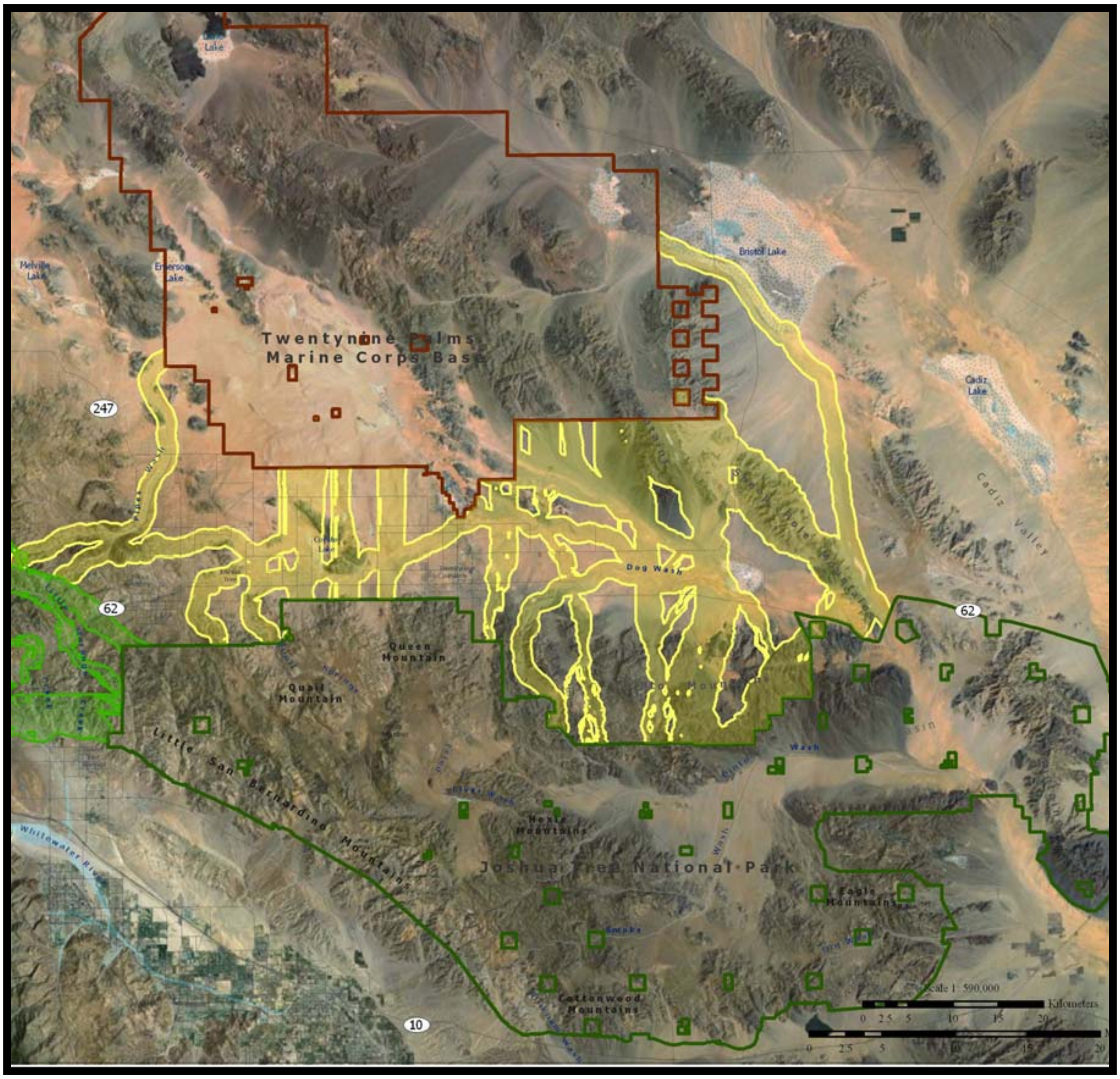
A Linkage Design for the Joshua Tree – Twentynine Palms Connection



December 2008

A Linkage Design for the Joshua Tree-Twentynine Palms Connection

SOUTH COAST WILDLANDS

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Introduction

Nature Needs Room to Roam

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

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

Patterns of Habitat Conversion

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

A Statewide Vision

In November 2000, a coalition of conservation and research organizations (California State Parks, California Wilderness Coalition, The Nature Conservancy, Zoological Society of San Diego's Center for Reproduction of Endangered Species, and U.S. Geological Survey) launched a statewide interagency workshop at the San Diego Zoo entitled "Missing Linkages: Restoring Connectivity to the California Landscape". The workshop brought together over 200 land managers and conservation ecologists representing federal, state, and local agencies, academic institutions, and non-governmental organizations to delineate habitat linkages critical for preserving the State's biodiversity. Of the 232 linkages identified at the workshop (Penrod et al. 2001), 46 are associated with the Desert Ecoregions (Figure 1). The Joshua Tree-Twentynine Palms Connection was identified as one of the 46 linkages that must be maintained.

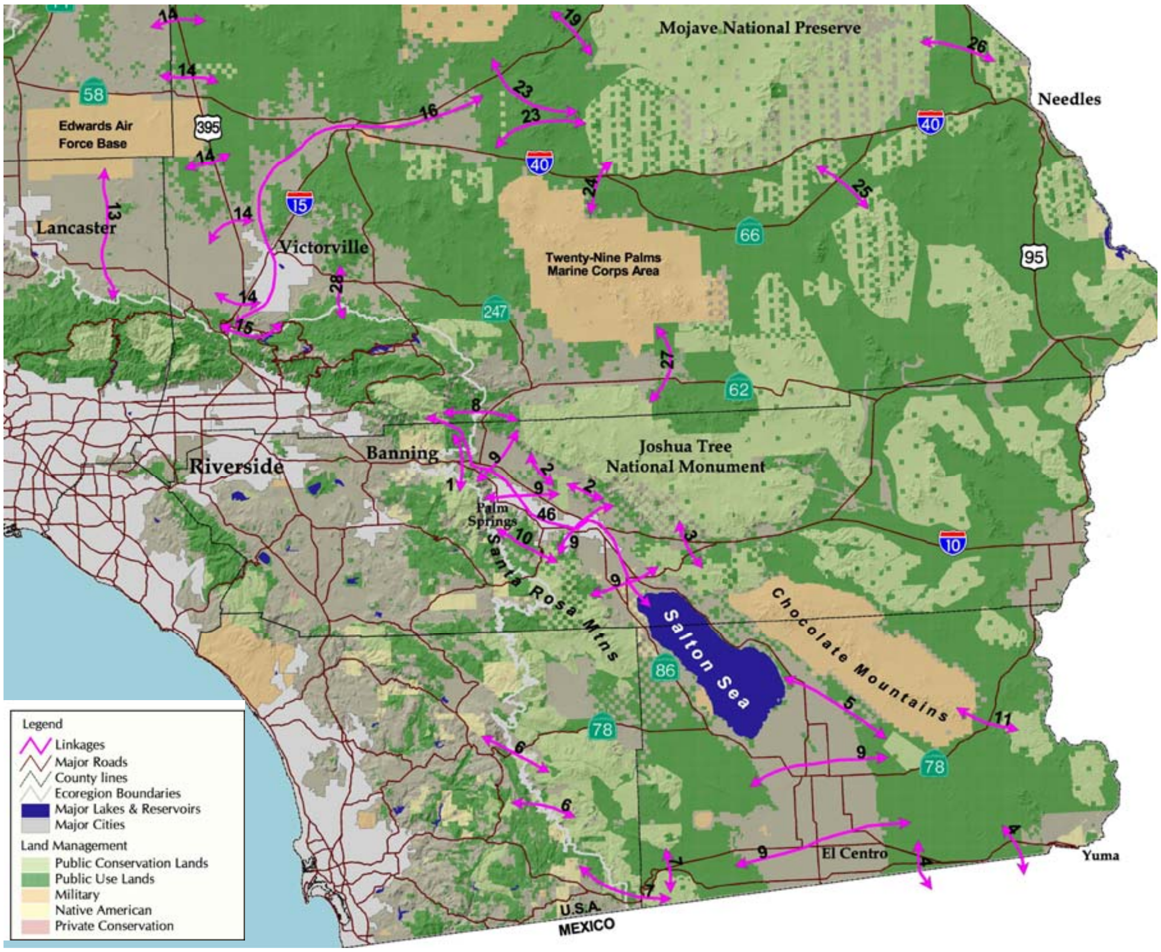
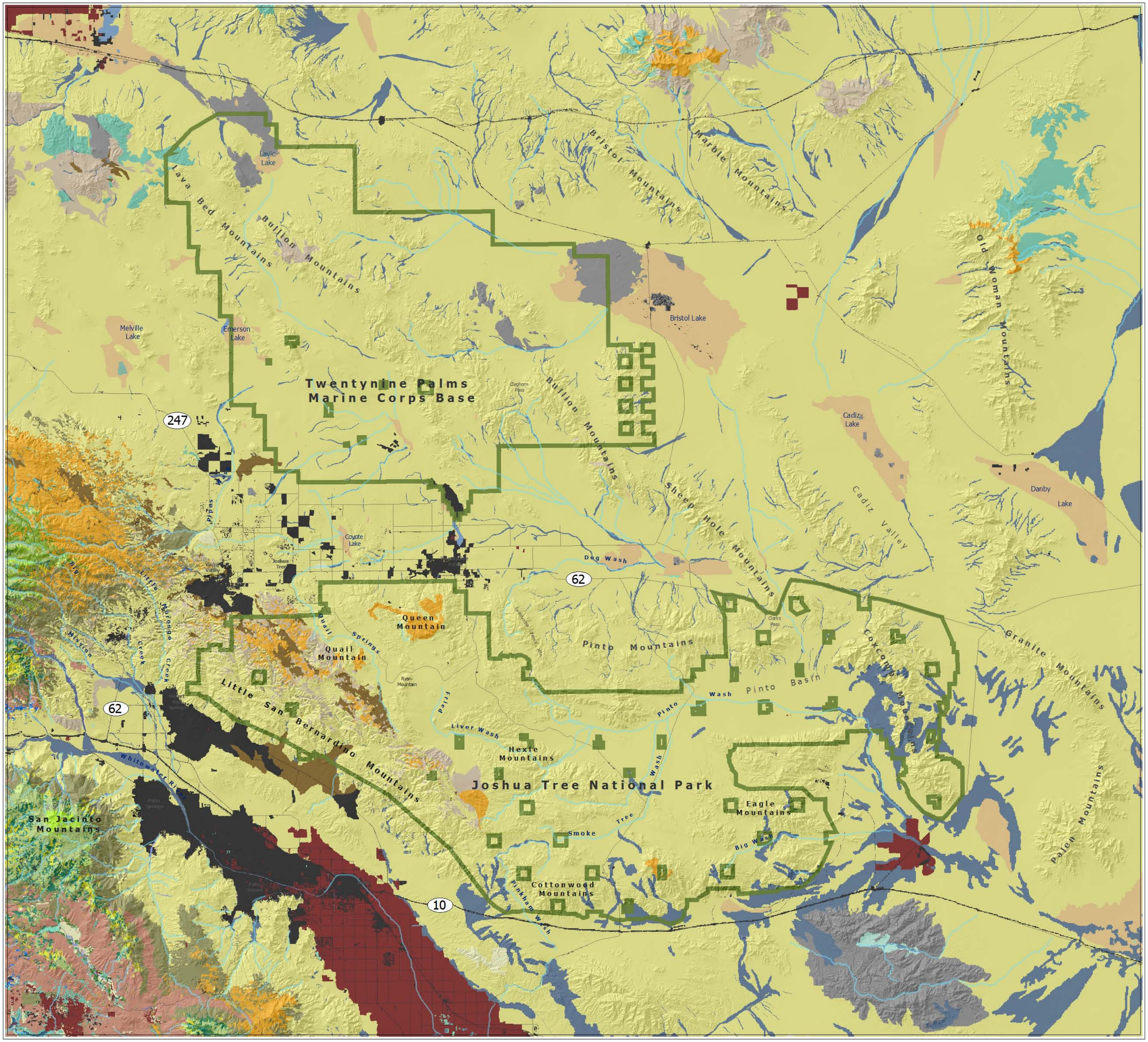


Figure 1. Habitat linkages identified in the Mojave and Sonoran (Colorado) deserts at the statewide Missing Linkages conference in November of 2000.

Ecological Significance of the Joshua Tree-Twentynine Palms Connection

The Joshua Tree-Twentynine Palms Connection occurs in an ecological transition zone between the Mojave and Sonoran (Colorado) desert ecoregions. The Little San Bernardino and Eagle Mountains, which are extensions of the Transverse Ranges, separate the Mojave from the Colorado Desert. The planning area depicted in Figure 2 encompasses a unique and diverse assemblage of plant communities. At higher elevations juniper and pinyon pine dominate, while at mid elevations evergreen trees such as the Joshua tree flourish, and creosote bush scrub, saltbush scrub, desert riparian, bajadas or desert washes, dry lakes, alluvial plains, valleys, and sand dunes are characteristic habitats at lower elevations (Figure 2). Blackbrush occurs between the arid scrub habitats at lower elevations and the pinyon dominated woodlands at

**Figure 2.
Vegetation Types
in the
Linkage Planning Area**



higher elevations (Bakker 1971). Creosote bush is what ties the Mojave and Colorado deserts together ecologically, giving the deserts a uniform appearance (Bakker 1971). In this land of predominantly dry vegetation, the desert riparian, washes, springs, and oases provide essential resources that attract a diversity of wildlife. Sensitive natural communities that occur in the planning area, include desert fan palm oasis woodland, Mojave riparian forest, and mesquite bosque (CDFG 2005). These include some of the most rare vegetation communities in the United States.

This variety of habitats support a diversity of organisms, including many species listed as endangered, threatened, or sensitive by government agencies (USFWS 1994, 1998, Hirsch et al. 2002, USDI BLM 2003, CDFG 2005a, 2005b). The desert riparian, wash, and oases provide breeding locations for many riparian birds and critical watering areas for bighorn sheep (*Ovis canadensis*). Several riparian songbirds, such as yellow-breasted chat (*Icteria virens*), yellow warbler (*Dendroica petechia*), and the endangered least Bell's vireo (*Vireo bellii pusillus*) have the potential to occur in riparian habitats in the linkage. Sensitive reptiles that prefer drier habitats and sparser vegetative cover, such as the threatened desert tortoise (*Gopherus agassizii*), rosy boa (*Lichanura trivirgata*), coast horned lizard (*Phrynosoma coronatum blainvillei*), desert horned lizard (*Phrynosoma platyrhinos*), and Mojave fringe-toed lizard (*Uma scoparia*) also have the potential to occur, as do a number of sensitive birds of prey, such as the long-eared owl (*Asio otus*) and burrowing owl (*Athene cunicularia*). The planning area also provides habitat for a number of imperiled plant species, including Robison's monardella (*Monardella robisonii*), triple-ribbed milk-vetch (*Astragalus tricarinatus*), Darwin's rock cress (*Arabis pulchra* var. *munciensis*), and Little San Bernardino Mountains linanthus (*Linanthus maculatus*).

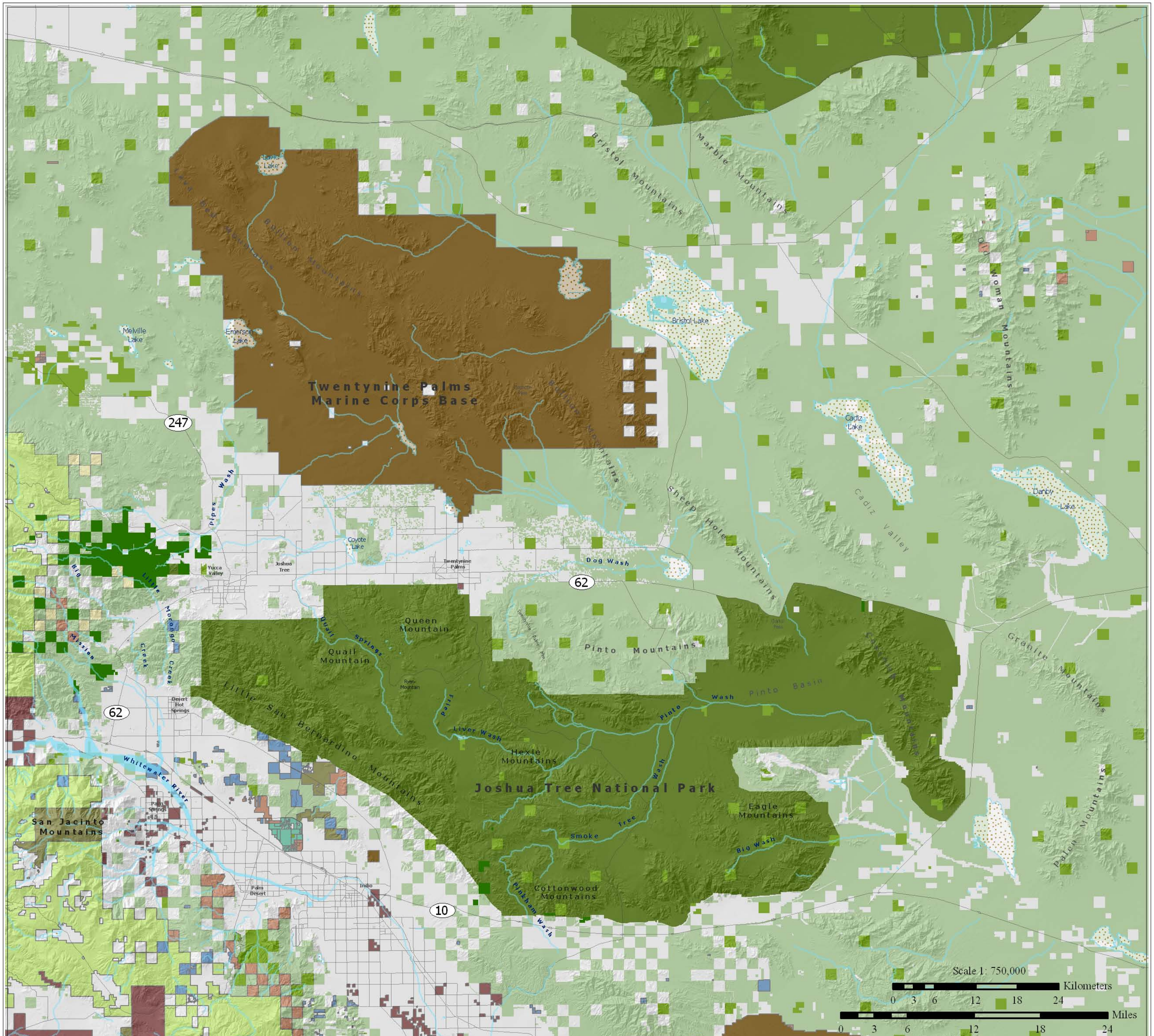
The two areas targeted to be served by the linkage, Joshua Tree National Park and the Marine Corps Air Ground Combat Center (MCAGCC) at Twentynine Palms, support a great diversity of species. Joshua Tree provides habitat for more than 250 resident and migratory birds, 52 mammals, 44 reptiles, 3 amphibians, and more than 700 vascular plant species (http://www.nps.gov/jotr), while MCAGCC supports nearly 400 plant species and more than 250 vertebrate wildlife species (MGAGCC 2002).

Existing Conservation Investments

Considerable conservation investments already exist in the region (Figure 3), but the resource values they support could be irreparably harmed by loss of connections between them. This linkage serves to connect two expansive natural areas. Joshua Tree National Park with an area of 3213 km^2 (1241 mi^2), the majority of which is designated as Wilderness (73% or 585,040 out of 794,000 acres), and MCAGCC at roughly 2422 km^2 (935 mi^2 or 596,480 ac), the world's largest US Marine Corps training site (MGAGCC 2002). While the MCAGCC's primary mission is to train marines, they also have a mission to preserve natural resources. The base takes a proactive role in the management of special status species and base lands support a diverse array of native plant and animal communities, including mesquite springs which many species depend upon for sustenance.

Much of the land in the planning area has already been protected though successful conservation planning efforts undertaken by the Bureau of Land Management (BLM), The Wildlands Conservancy (TWC), State Lands Commission, and California Department of Fish and Game, although gaps in critical pathways remain. The BLM

Figure 3.
Existing Land Ownership in the Linkage Planning Area



- National Park Service
- Dept. of Defense
- Bureau of Land Management
- Forest Service
- Fish and Wildlife Service
- Other Federal
- Dept. of Fish and Game
- Dept. of Parks and Recreation
- Other State
- Public/ Private Conservation
- Tribal Lands
- The Wildlands Conservancy

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Map Produced By:

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administers several hundred thousand acres of land in the planning area, including the 78,857 ha (194,861 ac) Sheephole Valley Wilderness Area, the Cleghorn Lakes Wilderness Area (13,310 ha or 32,891 ac), and the Cadiz Dunes Wilderness Area (7,814 ha or 19,308 ac). The West Mojave Plan reinforced the importance of maintaining open space linkages between mountain ranges to enhance dispersal opportunities for bighorn sheep (USDI BLM 2003). The planning area is also crucial for desert tortoise, with both the Pinto Mountains and Joshua Tree Desert Wildlife Management Areas in Joshua Tree National Park in the Western Mojave Recovery Unit, and the entire area between Joshua Tree and Twentynine Palms MCAGCC identified as tortoise survey areas (USDI BLM 2003). TWC has been a major partner in acquiring checkerboard sections of private land and transferring them to BLM. TWC has also been working to secure a connection just west of Yucca Valley that would include pinyon-juniper and Joshua tree woodland habitats between Joshua Tree National Park and TWC's Pioneertown Mountains Preserve. The majority of land in the planning area is also part of the California Desert Conservation Area. The value of already protected land in the region for biodiversity conservation, environmental education, outdoor recreation, and scenic beauty is immense.

Threats to natural habitats in the region have been recognized by federal and state agencies and non-governmental organizations that have launched a variety of successful conservation planning efforts. The Desert Managers Group is a highly collaborative interagency group that was formed in 1994 to address desert conservation; partners include the BLM, National Park Service, US Fish and Wildlife Service, US Geological Survey, US Forest Service, California Fish and Game, Parks and Recreation, Caltrans, and the Department of Defense. More recently, the Morongo Basin Open Space Group formed to address conservation initiatives in the Morongo Basin; partners include representatives from Joshua Tree National Park, Twentynine Palms MCAGCC, all of the desert communities in the basin (Morongo Valley, Yucca Valley, Joshua Tree, Twentynine Palms), the County of San Bernardino, the Bureau of Land Management, wildlife agencies, and non-governmental organizations. These conservation planning efforts recognize the importance of maintaining connectivity to sustain key biological and ecological processes across the landscape.

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 detrimental activities threaten to sever natural connections, forever altering the functional integrity of this remarkable natural system. The ecological, educational, recreational, and spiritual impacts of such a loss would be substantially felt by the humans, plants and animals who call these places home. Certainly, maintaining and restoring functional habitat connectivity to this regionally important landscape linkage is a wise investment that will serve to secure benefits for the future of these wildlands.

Conservation Planning Approach

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

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

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

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

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

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

Our approach is highly collaborative and interdisciplinary (Beier et al. 2005). We followed Baxter (2001) in recognizing that successful conservation planning is based on the participation of experts in biology, conservation design, and implementation in a reiterative process (Figure 4). To engage regional biologists and planners early in this process, we held a habitat connectivity workshop at the Joshua Tree Community Center on October 18, 2006. The workshop gathered indispensable information on conservation needs and opportunities in the linkage. The workshop engaged 34 participants representing over 26 different agencies, academic institutions, conservation organizations, and community groups (Appendix A).

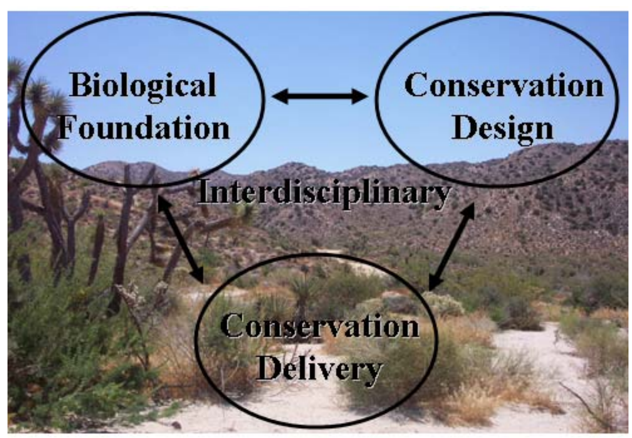


Figure 4. Successful conservation planning requires an interdisciplinary and iterative approach among biologists, planners and activists (Baxter 2001).

Focal Species Selection

Table 1. Regional ecologists selected 25 focal species for the Joshua Tree-Twentynine Palms Connection
Plants
Hesperocallis undulata (Desert lily)
Coleogyne ramosissima (Blackbrush)
Simmondsia chinensis (Jojoba)
Yucca schidigera (Mojave yucca)
Chilopsis linearis (Desert willow)
Invertebrates
Branchinecta mackini (Alkali fairy shrimp)
Lytta magister (Meloid beetle)
Dasymutilla coccinea (Velvet ant)
Papilio indra fordi (Ford's swallowtail)
Reptiles
Charina trivirgata (Rosy boa)
Sauromalus obesus obesus (Chuckwalla)
Uma scoparia (Mojave fringe-toed lizard)
Gopherus agassizii (Desert tortoise)
Birds
Polioptila melanura (Black-tailed gnatcatcher)
Toxostoma lecontei (LeConte's thrasher)
Amphispiza bilineata (Black-throated sparrow)
Lanius ludovicianus (Loggerhead shrike)
Athene cunicularia (Burrowing owl)
Mammals
Dipodomys deserti (Desert kangaroo rat)
Dipodomys merriami merriami (Merriam's kangaroo rat)
Spermophilus tereticaudus (Round-tailed ground squirrel)
Ovis canadensis (Bighorn sheep)
Taxidea taxus (American badger)
Lynx rufus (Bobcat)
Puma concolor (Mountain lion)

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

The 25 focal species identified at the workshop capture a diversity of movement needs and ecological requirements, from species that require large tracts of land (e.g., badger, bighorn sheep) to those with very limited spatial requirements (e.g., Mojave fringe-toed lizard). Species include habitat specialists (e.g., Chuckwalla who inhabit rocky outcrops) and those requiring a specific configuration of habitat types and elements (e.g., Ford’s swallowtail that require hilltopping habitat to search for mates). Dispersal distance capability of focal species ranges from 97 m to 274 km (318 ft to 170 mi); modes of dispersal include flying, swimming, climbing, walking, and slithering.

Landscape Permeability Analysis

Landscape permeability analysis is a Geographic Information Systems (GIS)-based technique that models the relative cost for a species to move between core areas. Cost is determined based on how each species is affected by habitat characteristics, such as slope, elevation, vegetation composition, and road density. Each analysis identifies a least cost corridor, which is 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 the land areas that will best accommodate all focal species living in or moving through the linkage. Species used in landscape permeability analysis must be carefully chosen, and were only included in this analysis if they met the following criteria:

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

Four species were found to meet these criteria. Permeability analyses were conducted for bobcat, badger, bighorn sheep, and desert tortoise to identify the least-cost corridor between Joshua Tree National Park and the MCAGCC. Ranks and weightings adopted for each species are shown in Table 2.

The relative cost of travel was assigned for each of these four focal species based upon its ease of movement through a suite of landscape characteristics (vegetation type, road density, and topographic features). The following spatial data layers were assembled in the GIS at 30-m resolution (cell size): vegetation, roads, elevation, and topographic features (Figure 5). We derived 4 topographic classes from elevation and slope models: canyon bottoms, ridgelines, flats, or slopes. Road density was calculated and stored in the database as kilometers of paved road per square kilometer.

Within each data layer, we ranked all categories between 1 (preferred) and 10 (avoided) based on focal species preferences as determined from available literature and expert opinion regarding how movement is facilitated or hindered by natural and urban landscape characteristics. Each input category was ranked and weighted, such that: (Land Cover * w%) + (Road Density * x%) + (Topography * y%) + (Elevation * z%) = Cost to Movement, where w + x + y + z = 100%.

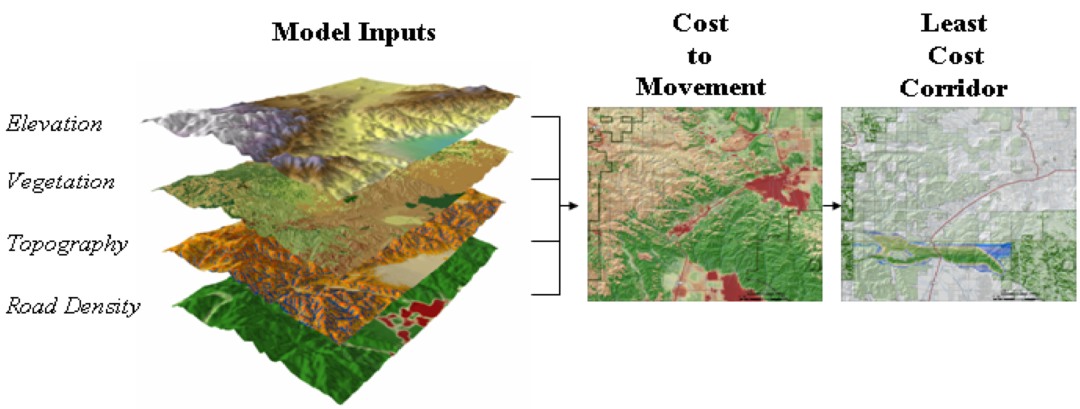


Figure 5. Permeability Model Inputs: elevation, vegetation, topography, and road density. Landscape permeability analysis models the relative cost for a species to move between core areas based on how each species is affected by various habitat characteristics.

Table 2. Model Parameters for Landscape Permeability Analyses	*Lynx rufus* (Bobcat)	*Ovis candadensis* (bighorn sheep)	*Taxidea taxus* (Badger)	*Gopherus agassizii* (Desert tortoise)
MODEL VARIABLES				
VEGETATION				
Alpine-Dwarf Shrub	4	2	4	10
Agriculture	10	9	7	10
Annual Grassland	6	5	1	10
Alkali Desert Scrub	5	1	2	2
Barren	10	2	9	10
Bitterbrush	2	3	3	7
Blue Oak-Foothill Pine	4	9	5	10
Blue Oak Woodland	4	9	5	10
Coastal Oak Woodland	4	9	5	10
Closed-Cone Pine-Cypress	5	9	6	10
Chamise-Redshank Chaparral	3	9	4	10
Coastal Scrub	3	9	4	10
Desert Riparian	3	1	3	7
Desert Scrub	5	1	2	1
Desert Succulent Shrub	5	1	2	2
Desert Wash	5	1	3	2
Eastside Pine	4	9	5	10
Estuarine	10	10	10	10
Freshwater Emergent Wetland	6	8	9	10
Jeffrey Pine	4	9	5	10
Joshua Tree	6	3	2	3
Juniper	4	3	3	9
Lacustrine	10	10	9	10
Lodgepole Pine	5	9	6	10
Mixed Chaparral	3	9	4	9
Montane Chaparral	3	1	4	10
Montane Hardwood-Conifer	4	2	6	10
Montane Hardwood	4	2	6	10
Montane Riparian	4	2	6	10
Perennial Grassland	6	5	1	10
Pinyon-Juniper	4	8	3	8
Palm Oasis	5	1	6	10
Ponderosa Pine	4	9	5	10
Riverine	10	10	9	10
Red Fir	5	9	6	10
Subalpine Conifer	5	2	6	10
Saline Emergent Wetland	6	10	10	10
Sagebrush	3	3	3	10
Sierran Mixed Conifer	4	9	6	10
Urban	10	8	10	10

Table 2. cont.	*Lynx rufus* (Bobcat)	*Ovis candadensis* (bighorn sheep)	*Taxidea taxus* (Badger)	*Gopherus agassizii* (Desert tortoise)
MODEL VARIABLES				
Valley Oak Woodland	4	9	4	10
Valley Foothill Riparian	4	9	4	10
Water	10	10	10	10
White Fir	4	9	6	10
Wet Meadow	6	8	4	10
Unknown Shrub Type	10	9	5	10
Unknown Conifer Type	10	9	5	10
Eucalyptus	7	9	6	10
ROAD DENSITY				
0-0.5 km/sq. km	1	1	1	1
0.5-1 km/sq. km	3	2	1	2
1-2 km/sq. km	4	4	2	5
2-4 km/sq. km	6	8	2	8
4-6 km/sq.km	9	10	4	10
6-8 km/sq. km	10	10	7	10
8-10 km/sq.km	10	10	10	10
10 or more km/sq. km	10	10	10	10
TOPOGRAPHY				
Canyon bottoms	1	1	2	1
Ridgetops	7	1	7	6
Flats	3	5	1	1
Slopes	5	1	9	4
ELEVATION (feet)				
-260-0	N/A	N/A	1	9
0-500			1	9
500-750			1	9
750-1000			1	9
1000-3000			2	1
3000-5000			3	1
5000-7000			3	8
7000-8000			5	10
8000-9000			5	10
9000-11500			5	10
>11500			8	10
WEIGHTS				
Land Cover	0.40	0.40	0.55	0.40
Road Density	0.30	0.20	0.15	0.20
Topography	0.30	0.40	0.20	0.25
Elevation	0.00	0.00	0.10	0.15

Weighting allowed the model to capture variation in the influence of each input (vegetation, road density, topography, elevation) on focal species movements. A unique cost surface was thus developed for each species. The analysis maps the relative degree of permeability based on the cumulative travel cost as determined by the cost raster and distance between targeted core areas. We then use a percentage of the output to delineate a least cost corridor that is biologically meaningful for the species.

Performing the permeability analysis required identifying the endpoints to be connected. Endpoints were selected as medium to highly suitable habitat for each focal species within the targeted natural areas. This suitability range gave the model broad latitude in interpreting functional corridors across the entire study area. For each focal species, the most permeable area was designated as the least-cost corridor.

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

Patch Size & Configuration Analyses

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

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

To identify areas of suitable habitat that were large enough to provide a significant resource for individuals in the linkage, we conducted a patch size analysis. The size of all suitable habitat patches in the planning area were identified and marked as potential core areas, patches, or less than a patch. *Potential core areas* were defined as the amount of contiguous suitable habitat necessary to sustain at least 50 individuals. A *patch* was defined as the area of contiguous suitable habitat needed to support at least one male and one female, but less than the potential core area. Potential cores are probably capable of supporting the species for several generations (although with erosion of genetic material if isolated). Patches can support at least one breeding pair (perhaps more if home ranges overlap greatly) and are probably useful to the species if the patch can be linked via dispersal to other patches and core areas (Figure 6).

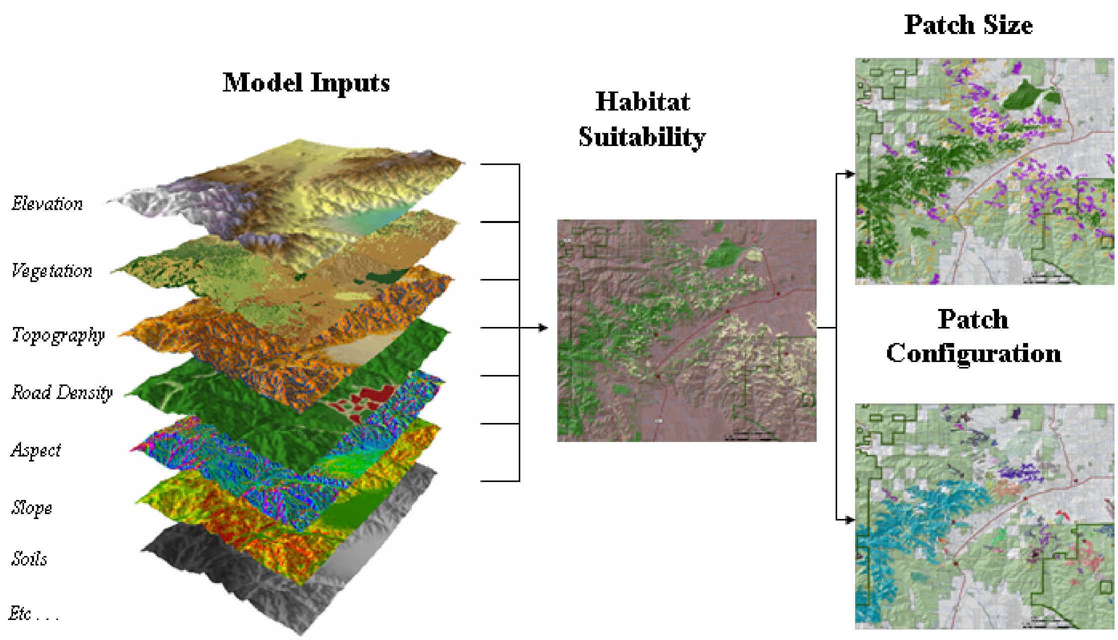


Figure 6. Model Inputs to Patch Size and Configuration Analyses vary by species. Patch size delineates cores, patches, and stepping-stones of potential habitat. Patch configuration evaluates whether suitable habitat patches and cores are within each species dispersal distance.

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

For each species we compared the configuration and extent of potential cores and patches, relative to the species dispersal ability, to evaluate whether the Least Cost Union was likely to serve the species. If necessary, we added additional habitat based on the results of the habitat suitability, patch size and patch configuration analyses to help ensure that the linkage provides sufficient live-in or “move-through” habitat for the species’ needs.

Minimum Linkage Width

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

For a variety of species, including those we did not formally model, a linkage at least 2 km wide helps ensure availability of appropriate habitat, host plants (e.g., for butterflies), pollinators, and areas with low predation risk. In addition, floods are part of the natural disturbance regime and a wide linkage allows for a semblance of these types of natural disturbances to operate with minimal constraints from adjacent urban areas. A wide linkage also enhances the ability of the biota to respond to climate change, and buffers against edge effects.

Field Investigations

We conducted field surveys to ground-truth existing habitat conditions, document existing barriers and potential passageways, and describe restoration opportunities. All location data were recorded using a mobile GIS/GPS with ESRI’s ArcPad. Because paved roads often present the most formidable potential barriers, biologists drove or walked each accessible section of road that transected the linkage. All types of potential crossing structures (e.g., bridge, culvert, pipe) were photo documented and measured. Data taken for each crossing included: shape; height, width, and length of the passageway; floor type (metal, dirt, concrete, natural); passageway construction (concrete, metal, other); visibility to other side; light level; fencing; and vegetative community within and/or adjacent to the passageway.

Existing highways are not considered permanent barriers to wildlife movement. In particular, crossing structures can be added or improved during projects to widen and realign highways. Therefore, we also identified areas where crossing structures could be improved or installed, and opportunities to restore vegetation to improve road crossings and minimize road kill.

Identify Conservation Opportunities

The Linkage Design serves as the target area for linkage conservation opportunities. We provide biological and land use summaries and identified implementation opportunities for agencies, organizations, and individuals interested in helping conserve the Joshua Tree-Twenytnine Palms Connection. Biological and land use summaries include descriptions and maps of land cover, roads, road crossings, and restoration opportunities. We also identified existing planning efforts addressing the conservation and use of natural resources in the planning area.

Landscape Permeability Analyses

We conducted landscape permeability analyses for 4 focal species (American badger, bobcat, bighorn sheep, and desert tortoise). The least cost corridors for these 4 species were quite distinct however; there was some overlap in the eastern part of the linkage (Figure 7). And, although these 4 focal species have diverse ecological and movement requirements (see following species accounts and Table 2) all branches of the Least Cost Union provide some suitable habitat for desert tortoise, badger and bobcat (See Figures 16 and 17 for bobcat, Figures 18 and 19 for badger, and Figures 38 and 39 for desert tortoise in the following section, Patch Size & Configuration Analyses).

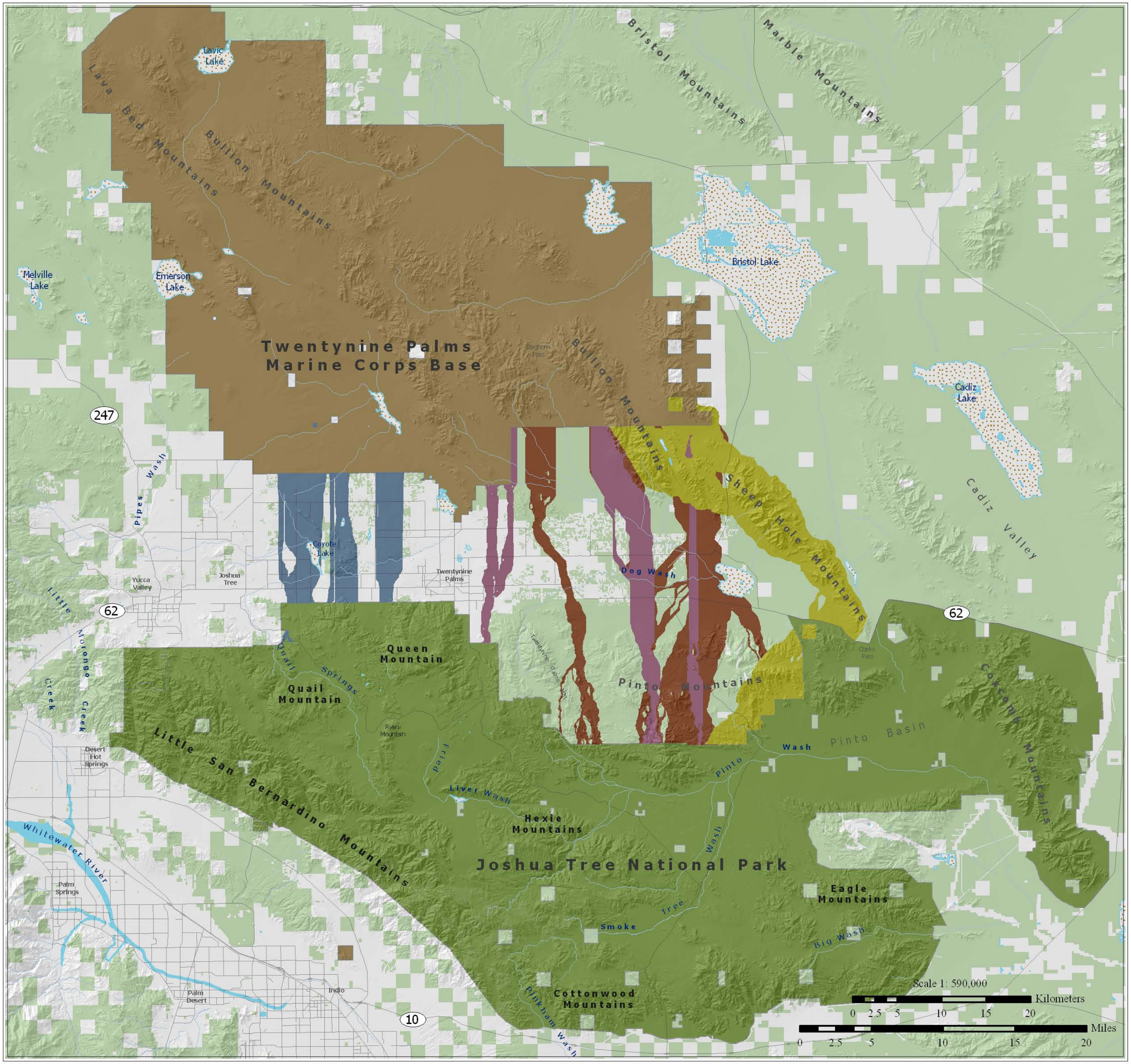
The Least Cost Union (i.e., the union of the least cost corridors for all 4 species) stretches between Twentynine Palms MCAGCC and Joshua Tree National Park and contains eight branches that vary in length from about 15 km (9.32 mi) on the western end of the Union to 35 km (21.75 mi) on the eastern end (Figure 8). The Union is characterized by gently sloping hills around Coyote Lake in the west, and the steep rugged topography of the Sheep Hole Mountains in the east, separated by broad alluvial plains and dry washes. The Union encompasses substantial land area administered by the Bureau of Land Management, particularly in the easternmost branches.

The numerous branches of the Union reflect the distribution of habitat for the various target species, and encompass a variety of vegetation communities and topographic features. Desert scrub, dominated by creosote bush, is by far the most widespread plant community, with saltbush scrub, desert wash and riparian habitats interspersed.

The next several pages summarize the permeability analyses for each of the 4 modeled species. For convenience, the narratives describe the most permeable paths from north to south, although our analyses gave equal weight to movements in both directions (i.e., north to south and south to north).

The following section (Patch Size and Configuration Analyses) describes how well the Least Cost Union would likely serve the needs of all focal species, including those for which we didn't conduct permeability analysis. The latter analyses expanded the Least Cost Union to provide critical live-in and/or move-through habitat for particular focal species.

Figure 7. Least Cost Union with Species Overlap



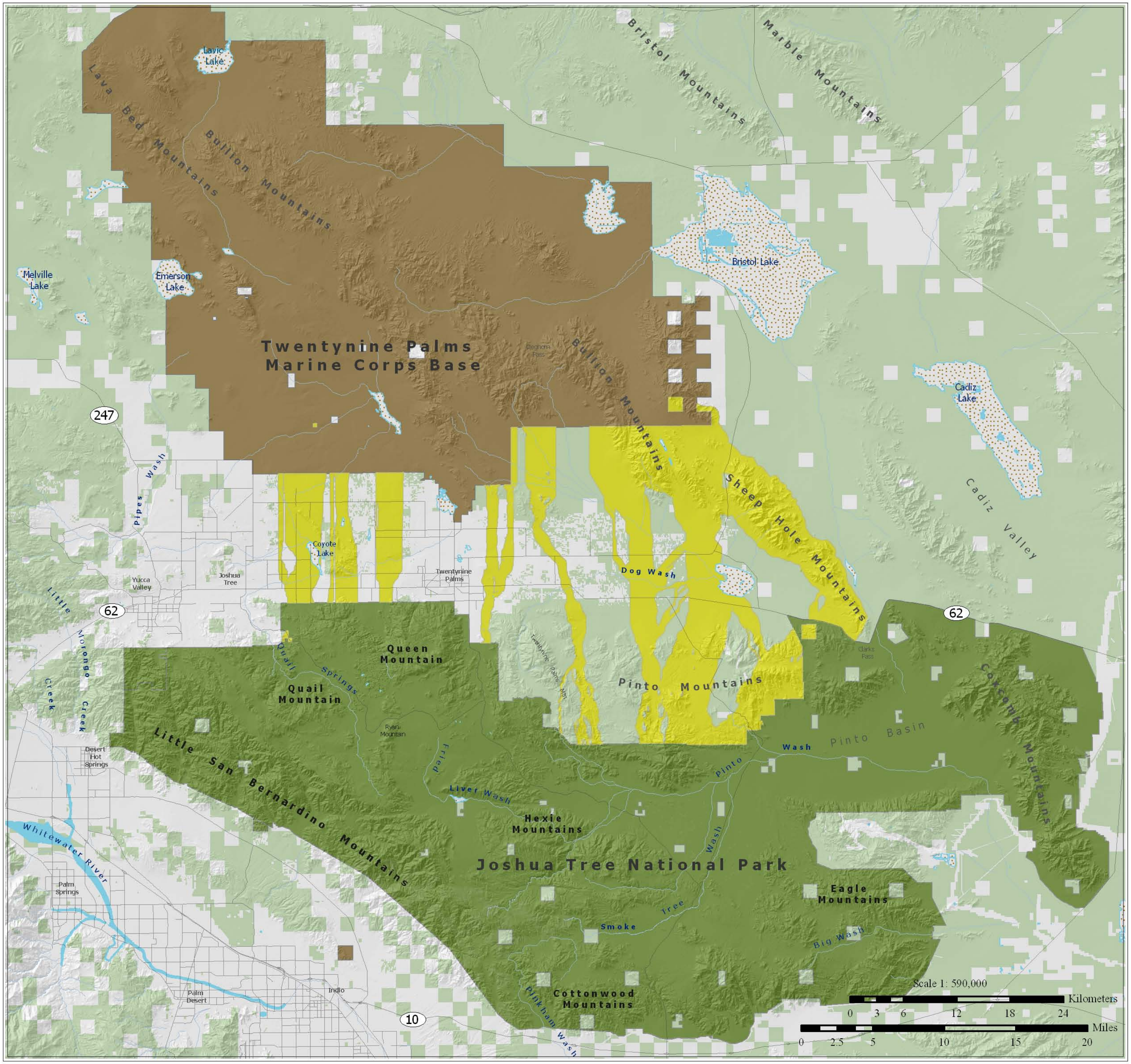
American badger
Bighorn sheep
Bobcat
Desert tortoise
Dept. of Defense
National Park Service
Public/Private Conservation
Roads
Streams
Dry Lakes
Waterbodies

N

Map Produced By:

SOUTH COAST WILDLANDS

Figure 8.
Least Cost Union



- Least Cost Union
- Dept. of Defense
- National Park Service
- Public/Private Conservation
- Roads
- Streams
- Dry Lakes
- Waterbodies

N

Map Produced By:

SOUTH COAST WILDLANDS

Bobcat (*Lynx rufus*)

Justification for Selection: Bobcats are excellent species to evaluate functional habitat connectivity at the landscape level because they are an area-dependent species that is sensitive to habitat fragmentation (Beier 1993, Noss et al. 1996, Soule and Terborgh 1999, Crooks 2002). Research has shown that there is a lower probability of finding bobcats in smaller and more isolated habitat patches (Crooks 2002). Roads are also a major source of bobcat mortality in southern California (Riley et al. 2003). Thus, in order for bobcat populations to persist, it is critical to maintain functional landscape connectivity, particularly in developing areas (Crooks 2002). Bobcats may utilize the remaining natural habitats on the developing valley floor of the linkage planning area, since bobcats are more sensitive to disturbance than coyotes and mesopredators (i.e., smaller carnivores like native raccoon and skunks and exotic species like opossum that prey on birds and other small vertebrates; Crooks and Soule 1999, Crooks 2002).

Conceptual Basis for Model Development: Bobcats may utilize a wide range of habitats, including coastal and desert scrub, chaparral, sagebrush, oak woodlands, and forests (Jameson and Peeters 1988). Within these habitats, they make use of cavities in rocky outcrops, logs, snags, and stumps, and dense brush for cover, and to site their dens. They show a marked preference for expansive natural areas with steep and rocky terrain (Zeiner et al. 1990).

Bobcats preferentially move through natural habitats with cover and avoid intensely developed areas. Please see Table 2 for model variable scorings for this species. Cost to movement for bobcat was defined by weighting these inputs as follows:

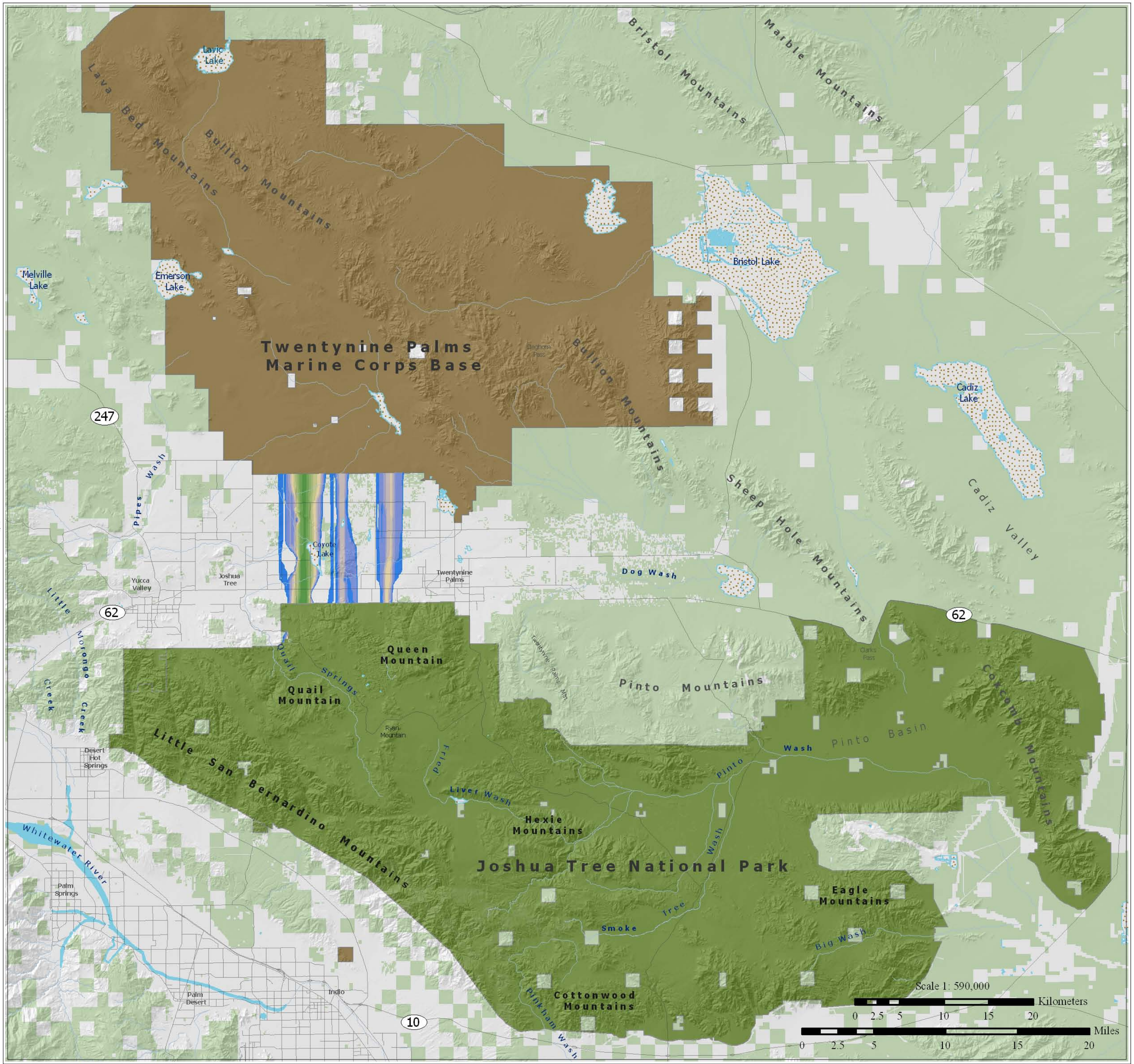
(Vegetation * 0.40) + (Topography * 0.30) + (Road Density *0.30)

Results & Discussion: The landscape permeability analysis for bobcat identified three potential movement corridors, all of which occur in the unincorporated area of Joshua Tree between the communities of Joshua Tree and Twentynine Palms (Figure 9). The western branch is the most permeable and widest route, ranging from 3 to 5 km (1.9-3.1 mi), and takes in habitat around and to the west of Coyote Lake. The central and eastern branches are both roughly 2 to 3.5 km (1.2-2.2 mi) wide and about 2 km apart. All three branches contain suitable habitat for bobcat traveling between targeted areas.

Figure 9. Least Cost Corridor for Bobcat

(Lynx rufus)

Least Cost Corridor
- Highly Permeable
- Less Permeable
- Dept. of Defense
- National Park Service
- Public/Private Conservation
- Roads
- Streams
- Dry Lakes
- Waterbodies



Map Produced By:

South Coast Wildlands

American badger (***Taxidea taxus***)

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

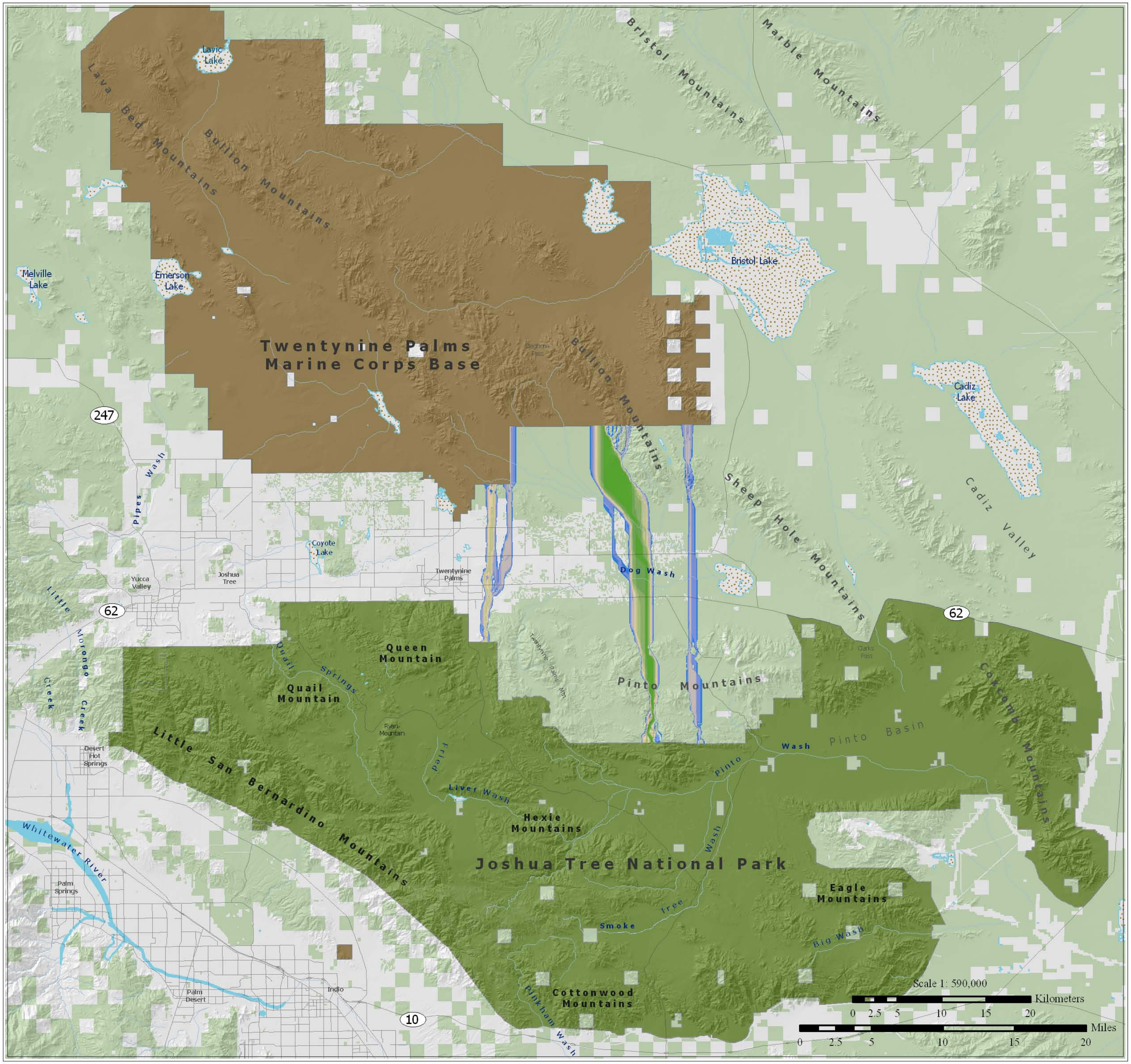
Conceptual Basis for Model Development: Badgers are associated with grasslands, prairies, and other open habitats that support abundant burrowing rodents (De Vos 1969, Banfield 1974, Sullivan 1996) but they may also be found in drier open stages of shrub and forest communities (Zeiner et al. 1990). They are known to inhabit forest and mountain meadows, marshes, riparian habitats, and desert communities including creosote bush, juniper, and sagebrush habitats (Long and Killingley 1983, Zeiner et al. 1990). The species is typically found at lower elevations (Zeiner et al. 1990) in flat, rolling or steep terrain but it has been recorded at elevations up to 3,600 m (12,000 ft) (Minta 1993).

Badgers can disperse up to 110 km (68 mi; Lindzey 1978), and preferentially move through open scrub habitats, fields, and pastures, and open upland and riparian woodland habitats. Denser scrub and woodland habitats and orchards are less preferred. They avoid urban and intense agricultural areas. Roads are difficult to navigate safely. Please see Table 2 for model variable scorings for this species. Cost to movement for badger was defined by weighting these inputs as follows:

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

Results & Discussion: The landscape permeability analysis for badger identified three potential movement routes between targeted areas that vary in width from approximately 1 to 3 km (0.6-1.9 mi; Figure 10). The most permeable and widest path is the central branch, which extends from the Bullion Mountains in Twentynine Palms MCAGCC to the Pinto Mountains in Joshua Tree National Park. The western branch was identified as the next most permeable; it lies to the east of the town of Twentynine Palms and extends from the central Bullion Mountains to the base of Twentynine Palms Mountain in Joshua Tree National Park. The eastern branch extends from the eastern fringe of the Bullion Mountains through Sheep Hole Pass to the Pinto Mountains in Joshua Tree National Park. All three movement routes contain highly suitable habitat for badger.

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



Map Produced By:
SOUTH COAST WILDLANDS

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

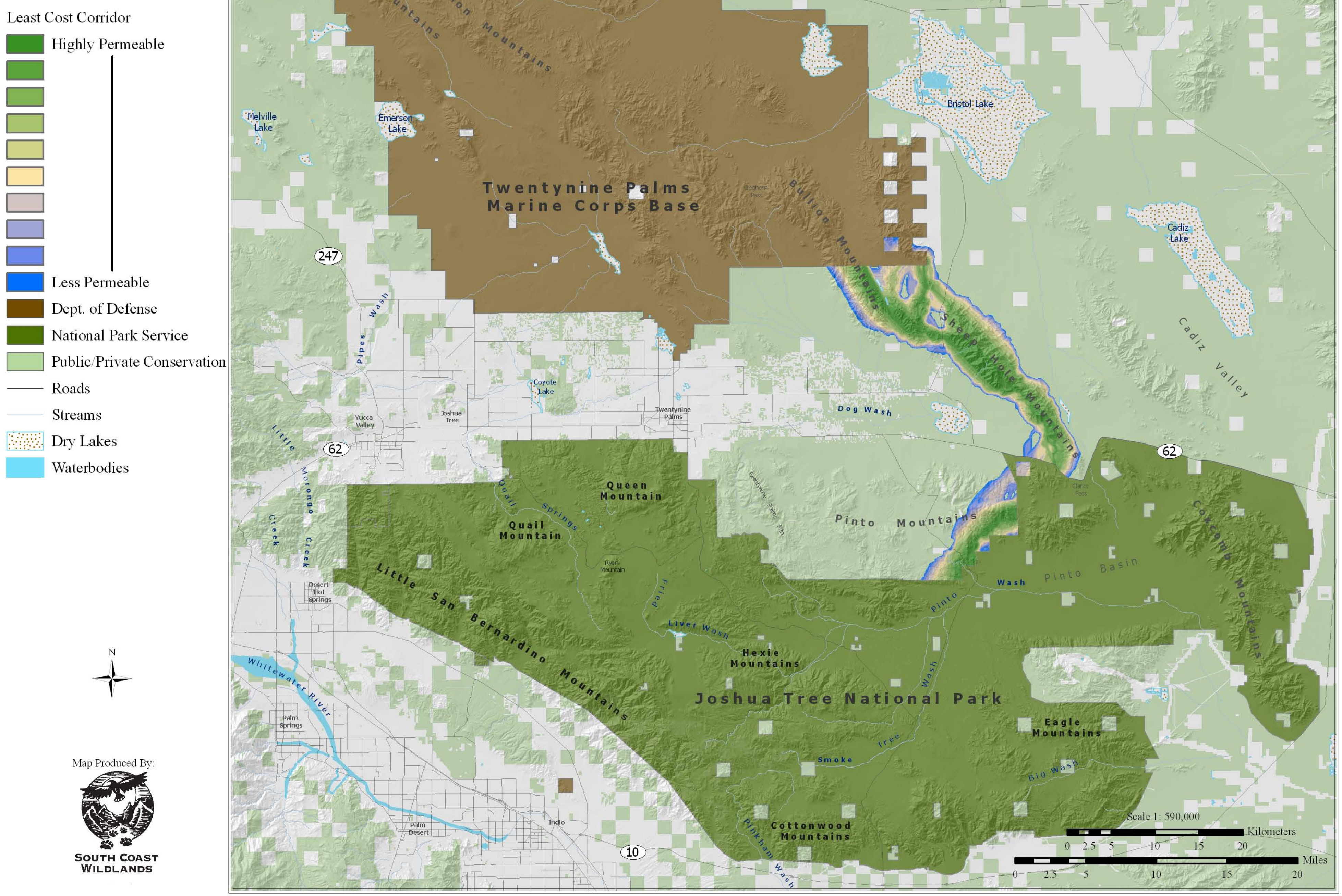
Conceptual Basis for Model Development: Bighorn sheep utilize alpine dwarf shrub, low sage, sagebrush, pinyon-juniper, palm oasis, desert riparian, desert scrubs, subalpine conifer, and perennial grassland (Zeiner et al. 1990, E. Rubin, pers. com.), as well as montane oak, conifer, riparian, and chaparral habitats (Holl and Bleich 1983). Adult rams exhibit the most movement (Weaver 1972, DeForge 1980, Holl and Bleich 1983, Holl et al. 2004); with movements up to 56 km (34.8 mi) observed (Witham and Smith 1979). The longest recorded movement in the San Gabriel Mountains was about 10 km (6.21 mi) (DeForge1980), although local movement data are sparse.

Bighorn sheep preferentially move through open habitats in close proximity to escape terrain, preferring ridgetops as travel routes. They avoid roads, impenetrable vegetation, urban land cover, and centers of human activity, even in suitable habitat. Please see Table 2 for model variable scorings for this species. Cost to movement for bighorn sheep was defined by weighting these inputs as follows:

(Vegetation * 0.40) + (Topography * 0.40) + (Road Density * 0.20)

Results & Discussion: The least cost corridor for bighorn sheep (Figure 11) varies in width from approximately 4-11 km (2.5-7 mi). As expected, the most permeable path closely follows the Sheep Hole Mountains, which provides the most contiguous suitable habitat for bighorn sheep traveling between targeted areas. The path extends from the Bullion and Sheep Hole mountains in Twentynine Palms MCAGCC to the eastern Pinto Mountains in Joshua Tree National Park, and crosses State Route 62 in the steepest terrain along this transportation route.

Figure 11.
Least Cost Corridor
for
Bighorn Sheep
(Ovis canadensis.)



Desert tortoise (*Gopherus agassizii*)

Justification for Selection: The desert tortoise is an umbrella species for rosy boa, coachwhip, glossy snake, desert horned lizard, western banded gecko, leaf-nosed snake, and burrowing owl such that maintaining functional core areas and linkages for the desert tortoise will effectively protect habitat for these species as well. Desert tortoise will move through many desert habitats but is fragmentation sensitive and inhibited by heavily traveled roads, and medium to high density housing (Boarman 2002, pers. comm.). They are also highly susceptible to road kill (Boarman and Sazaki 2006, USFWS 2008).

Conceptual Basis for Model Development: Desert tortoises are found on flats, valleys, alluvial fans, bajadas, rocky outcrops, mountainous slopes, and gently sloping hills in creosote bush scrub, saltbush scrub, blackbush scrub, cheesebush scrub, and scrub steppe communities (USFWS 1994).

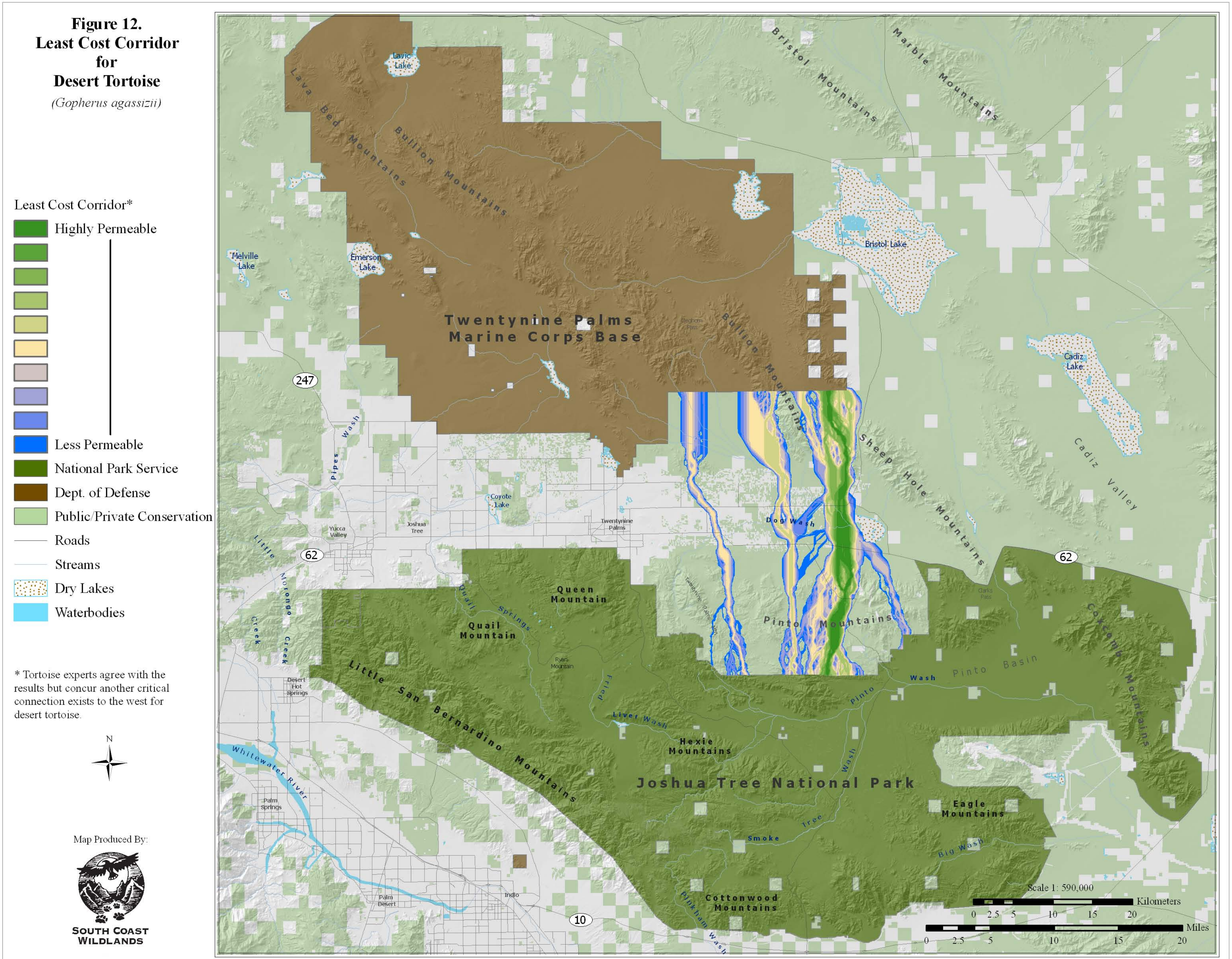
Desert tortoises preferentially move through desert scrub habitats with widely scattered shrubs. They have difficulty safely traversing heavily-traveled roads and avoid medium to high density developed areas. Please see Table 2 for model variable scorings for this species. Cost to movement for desert tortoise was defined by weighting these inputs as follows:

(Vegetation * 0.40) + (Elevation * 0.15) + (Topography * 0.25) + (Road Density *0.20)

Results & Discussion: The landscape permeability analysis identified three potential movement routes for desert tortoise traveling between Joshua Tree National Park and Twentynine Palms MCAGCC (Figure 12). All three branches occur to the east of the community of Twentynine Palms and vary in width, from 1 to 5 km (0.62-3.1 mi). The easternmost branch was identified as the most permeable and extends from the eastern Bullion Mountains, crossing Dog Wash to the Pinto Mountains near Pinto Wash in Joshua Tree National Park. All branches delineated by this analysis contain highly suitable habitat for desert tortoise, as do all other branches of the Least Cost Union. In fact, while experts on this species (William Boarman, Conservation Science Research & Consulting and Ed LaRue, Circle Mountain Biological Consultants) agree with the results of this analysis, they concur that another critical connection for desert tortoise lies to the west (see following section, Patch Size and Configuration Analyses, for more details). There is a semi-continuous swath of tortoises throughout the west Mojave that sweeps through Johnson Valley and into the southwest corner of MCAGCC (W. Boarman, pers. Comm.). Thus, maintaining connectivity in the area identified by the model and in between Joshua Tree and the Twentynine Palms could provide more connectedness between Joshua Tree National Park animals and the rest of the West Mojave population, providing useful stabilizing contact (W. Boarman, pers. Comm.).

Figure 12. Least Cost Corridor for Desert Tortoise

(Gopherus agassizii)



* Tortoise experts agree with the results but concur another critical connection exists to the west for desert tortoise.

Map Produced By:

SOUTH COAST WILDLANDS

The permeability models and Least Cost Union delineate swaths of habitat that based on model assumptions and available GIS data are best suited to facilitate species movement between targeted habitat areas. However, it does not address whether suitable habitat in the Union occurs in large enough patches to support viable populations or whether patches are close enough together to allow for inter-patch dispersal; and they are based on only 4 of the 25 focal species. We therefore perform habitat suitability; patch size and configuration analyses to evaluate the configuration and extent of potentially suitable habitat in the Least Cost Union for all 25 focal species. This helps determine whether there is sufficient habitat within the Union to support each species, and whether that habitat is distributed in a pattern that allows the species to move between patches.

Specifically, the patch size and configuration analyses for all 25 focal species addresses (1) whether the Least Cost Union provides sufficient live-in or move-through habitat to support individuals or populations of the species; (2) whether these habitat patches are within the species' dispersal distance; (3) whether any clearly unsuitable and non-restorable habitat (e.g., developed land) should be deleted from the Union; and (4) for any species not adequately served by the Least Cost Union, whether expanding the Union to incorporate more habitat would meet the species needs. The patch size and configuration analyses do not address existing barriers to movement (such as highways) or land use practices that may prevent species from moving through the linkage. These issues are addressed in the next section.

The Least Cost Union contains suitable habitat to support either inter- or intra-generational movements between the targeted core areas for several of the modeled focal species: mountain lion, bobcat, badger, bighorn sheep, round-tailed ground squirrel, Merriam's kangaroo rat, desert kangaroo rat, burrowing owl, loggerhead shrike, black-throated sparrow, LeConte's thrasher, desert tortoise, rosy boa, chuckwalla, Ford's swallowtail, velvet ant, meloid beetle, Mojave yucca, and jojoba. Model outputs suggest that the Union contains sufficient potential habitat to support populations of some species, or that patches are spaced close enough together to allow stepping-stone movement between core areas for others. Six focal species were determined to require habitat outside of the Least Cost Union, though there was significant overlap in the additional habitats required to meet their needs (Figure 13).

Species that require habitat outside of the Least Cost Union to protect the long-term viability of populations include black-tailed gnatcatcher, Mojave fringe-toed lizard, alkali fairy shrimp, desert willow, blackbrush, and desert lily. Habitat was added to the Union in eight general areas along washes, which are known movement corridors to ensure that the final Linkage Design accommodates all focal species (Figure 13):

Pipes Canyon Wash and Chaparrosa Wash: This habitat addition protects a key movement corridor and natural hydrological and fluvial processes, as well as preserving live-in habitat for several species. It also provides connectivity between the Joshua Tree-Twentynine Palms Connection and the San Bernardino-Little San Bernardino Connection. Riparian and upland habitats were added to the Union along Pipes Canyon Wash and Chaparrosa Wash to meet the habitat and movement requirements of the black-tailed gnatcatcher, desert willow, blackbrush, and desert lily, though several other focal species will also benefit from this addition, including the threatened desert tortoise. The minimum width of 2 km was imposed here to ensure that the functional processes of the linkage are protected.

Coyote Lake Wash: Habitat was added along a wash emanating from Coyote Lake (i.e., Coyote Lake Extension) using a minimum width of 2 km to accommodate the needs of two plant focal species, the desert lily and blackbrush. This habitat addition also provides an east-west movement corridor and habitat for a number of focal species, including the threatened desert tortoise, which has been recorded along the wash (Circle Mountain Biological Consultants).

Quail Springs Wash: The Least Cost Union was also modified to include habitat along Quail Springs Wash, which was particularly important for four focal species black-tailed gnatcatcher, desert willow, blackbrush and desert lily. This addition also provides an important east-west movement corridor that will serve most of the focal species. The minimum width of 2 km makes the linkage more robust to edge effects and provides adequate configuration of suitable habitat for these species.

Unnamed wash west of Quail Springs Wash: Habitat was added along this unnamed wash using a minimum width of 2 km to accommodate blackbrush and desert lily. Desert tortoise has also been recorded in this area (Circle Mountain Biological Consultants).

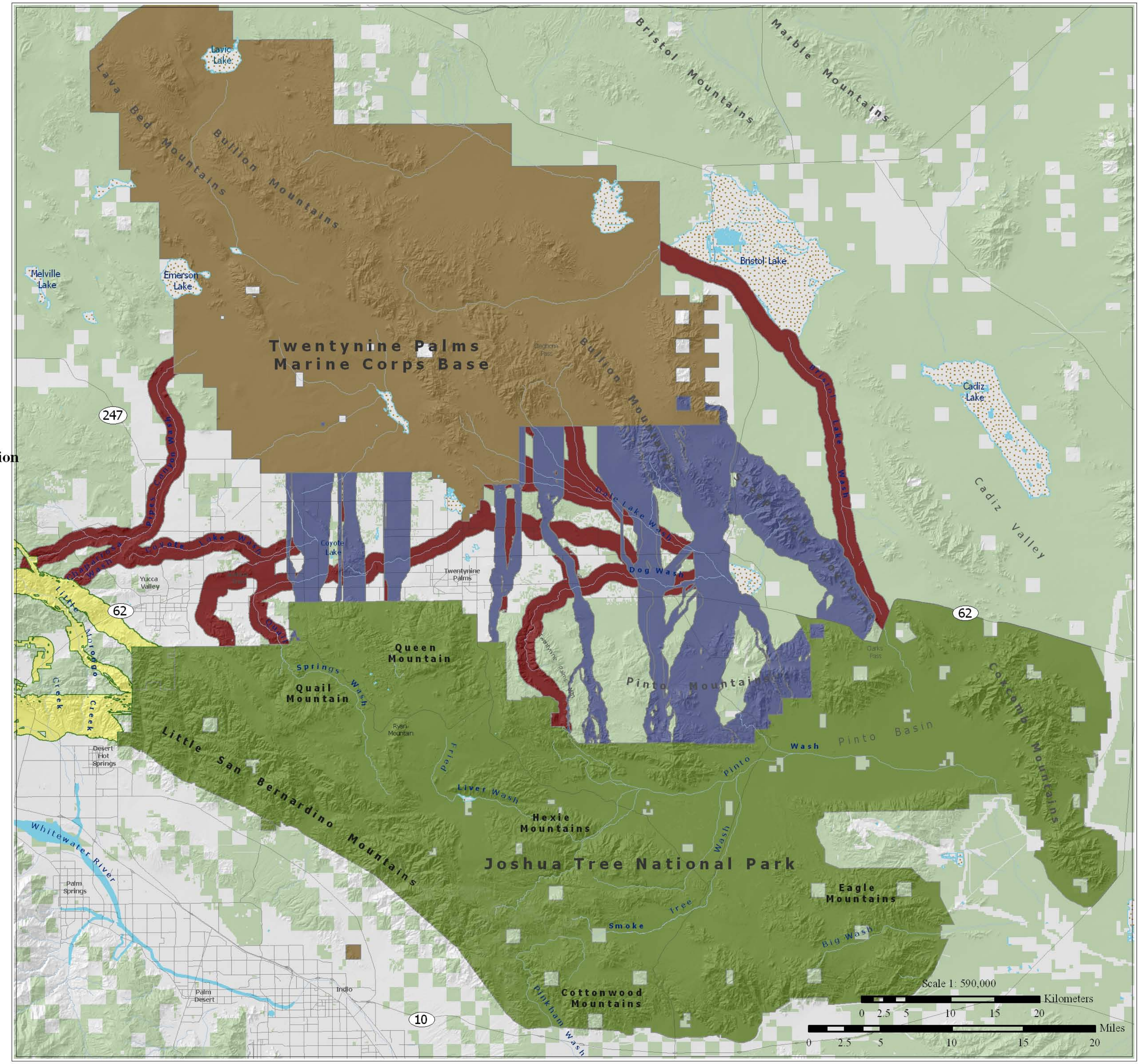
Dog Wash: We added habitat along Dog Wash for black-tailed gnatcatcher, Mojave fringe-toed lizard, alkali fairy shrimp, desert willow and desert lily, though this addition will benefit virtually all of the focal species. The minimum width of 2 km was also imposed here.

Unnamed wash in between Dog Wash and Dale Lake Wash: Habitat was added here using a minimum 2 km width to provide connectivity for black-tailed gnatcatcher, Mojave fringe-toed lizard, and desert willow.

Dale Lake Washes: We added habitat along several washes originating from Dale Lake (i.e., Dale Lake Extensions) for Mojave fringe-toed lizard (C. Barrows, pers. Comm.), and black-tailed gnatcatcher.

Bristol Lake Wash: We added habitat along a wash emanating from Bristol Lake (i.e., Bristol Lake Extension) for Mojave fringe-toed lizard (C. Barrows, pers. Comm.), and black-tailed gnatcatcher.

Figure 13.
Least Cost Union Additions

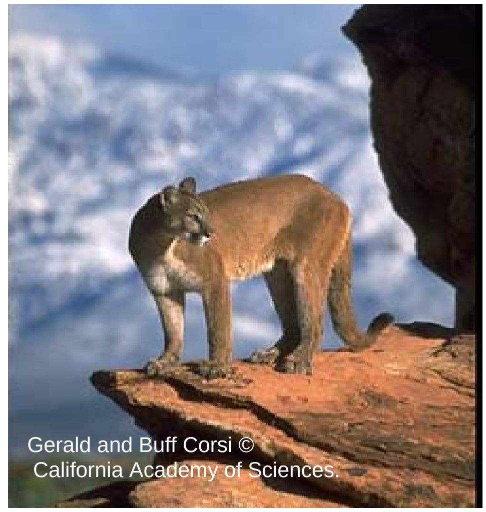


- Additions
- Least Cost Union
- SB-LSB Linkage Design*
- Dept. of Defense
- National Park Service
- Public/Private Conservation
- Roads
- Streams
- Dry Lakes
- Waterbodies

*South Coast Missing Linkages:
San Bernardino - Little San Bernardino Connection

Map Produced By:
SOUTH COAST WILDLANDS

Mountain lion (*Puma concolor*)



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

Distribution & Status: Mountain lions (also known as pumas or cougars) are widely distributed throughout the western hemisphere (Chapman and Feldhamer 1982, Currier 1983, Maehr 1992, Tesky 1995). The subspecies P*. c. californica* occurs in southern Oregon, California, and Nevada (Hall 1981), typically between 590-1780 m (1980 - 5940 ft) in elevation (Zeiner et al. 1990).

Proposition 117 was passed in 1990, which prohibited hunting and granted mountain lions the status of a California Specially Protected species, though depredation permits are still issued (Torres 2000).

Habitat Associations: Mountain lions are habitat generalists, utilizing many brushy or forested habitats if adequate cover is present (Spowart and Samson 1986, Zeiner et al. 1990). They use rocky cliffs, ledges, and vegetated ridgetops that provide cover when hunting prey, which most frequently consists of mule deer (*Odocoileus hemionus;* Chapman and Feldhamer 1982, Spowart and Samson 1986, Lindzey 1987). Den sites may be located on cliffs, rocky outcrops, caves, in dense thickets, or under fallen logs (Ingles 1965, Chapman and Feldhamer 1982). In southern California, most cubs are reared in thick brush (Beier et al. 1995). They prefer vegetated ridgetops and stream courses as travel corridors and hunting routes (Spowart and Samson 1986, Beier and Barrett 1993).

Spatial Patterns: Home range size varies by sex, age, and the distribution of prey. A recent study in the Sierra Nevada Mountains documented annual home range sizes between 250 and 817 km^2 (61,776-201,885 ac; Pierce et al. 1999). Home ranges in southern California averaged 93 km^2 (22,981 ac) for 12 adult females and 363 km^2 (89,699 ac) for 2 adult males (Dickson et al. 2004). Male home ranges appear to reflect the density and distribution of females (Maehr 1992). Males occupy distinct areas, while the home ranges of females may overlap completely (Zeiner et al. 1990, Beier and Barrett 1993). Regional population counts have not been conducted but in the Santa Ana Mountain Range, Beier (1993) estimated a density of 1.05-1.2 adults per 100 km^2 (24,711 ac).

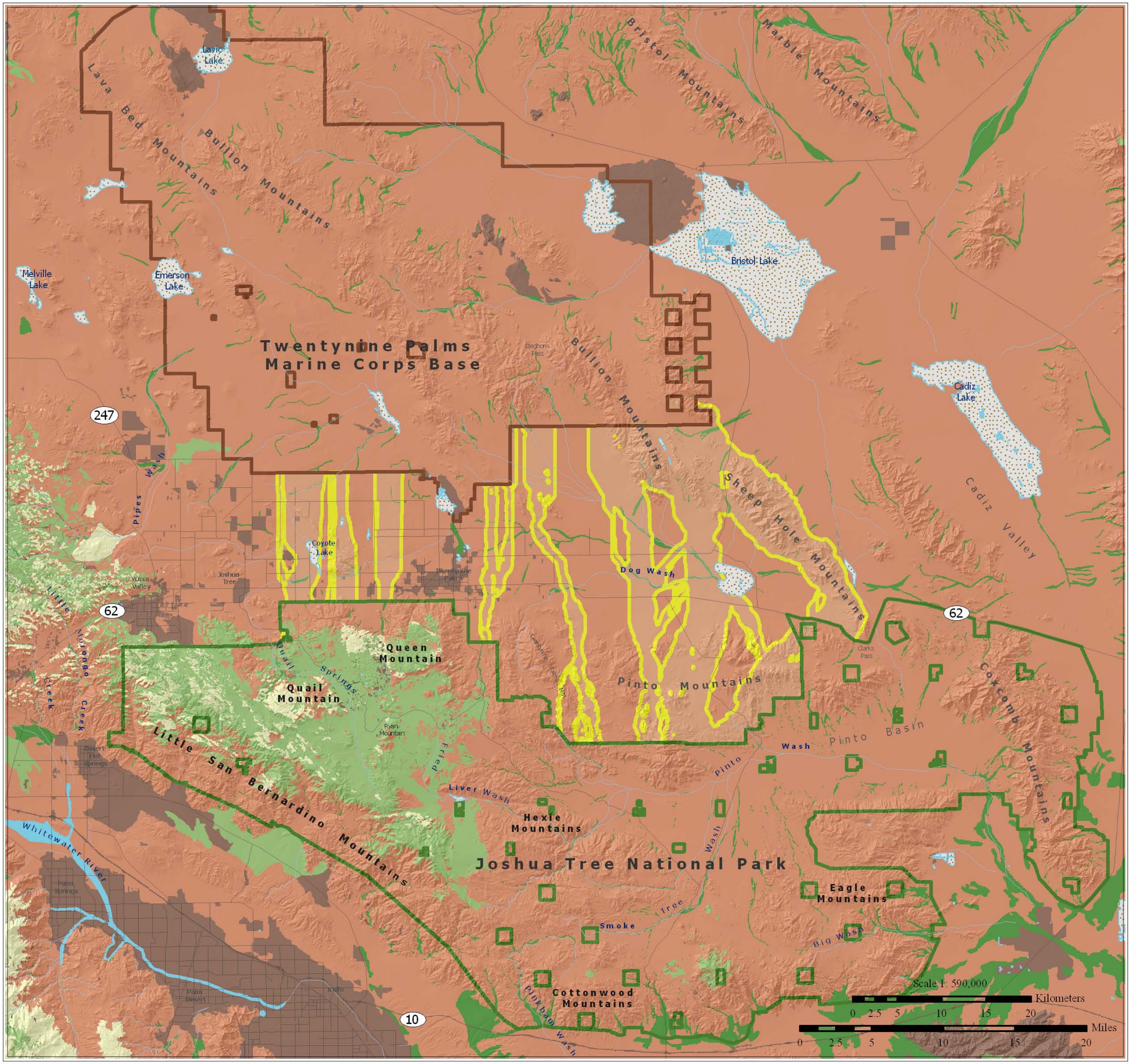
Mountain lions are capable of long-distance movements, and often move in response to changing prey densities (Pierce et al. 1999). Beier et al. (1995) reported mountain lions moving 6 km (3.7 mi) per night and dispersing up to 65 km (40 mi). Dispersal plays a crucial role in cougar population dynamics, because recruitment into a local population occurs mainly by immigration of juveniles from adjacent populations, while the population's own offspring emigrate to other areas (Beier 1995, Sweanor et al. 2000). Juvenile dispersal distances average 32 km (20 mi) for females and 85 km (53 mi) for males, with one male dispersing 274 km (170 mi; Anderson et al. 1992). Dispersing lions may cross large expanses of nonhabitat, although they prefer not to do so (Logan and Sweanor 2001). To allow for dispersal of juveniles and the immigration of transients, lion management should be on a regional basis (Sweanor et al. 2000).

Conceptual Basis for Model Development: Puma will use most habitats above 590 m (1,936 ft) elevation provided they have cover (Spowart and Samson 1986, Zeiner et al. 1990). Road density is also a significant factor in habitat suitability for mountain lions. Core areas potentially supporting 50 or more individuals were modeled as $\geq$ 10,000 km^2 (2,471,053 ac). Patch size was classified as $\geq$ 200 km^2 (49,421 ac) but < 10,000 km^2. Dispersal distance for puma was defined as 548 km (340 mi), or twice the maximum reported dispersal distance of 274 km (170 mi).

Results & Discussion: The most highly suitable habitat for mountain lion was identified along drainages, which are known hunting routes (Spowart and Samson 1986, Beier and Barrett 1993), and in the pinyon-juniper and Joshua tree woodlands in the western part of Joshua Tree National Park (Figure 14). Two significant prey species, bighorn sheep and mule deer, occur within the planning area, which likely attracts lions to the region (Chapman and Feldhamer 1982, Spowart and Samson 1986, Lindzey 1987, Hayes et al. 2000, Sweanor et al. 2003). Only a few very small patches of medium to high suitable habitat were identified in the Least Cost Union (Figure 15). The patch size analysis for mountain lion (Figure 15) identified two large habitat patches in the western part of the planning area that actually emphasize the importance of maintaining connectivity between Joshua Tree National Park and the San Bernardino National Forest to the west. Thus, mountain lion will also benefit from additions to the Union along Pipes Canyon Wash providing a secondary connection between Twentynine Palms MCAGCC and the San Bernardino-Little San Bernardino Connection (Penrod et al. 2005). All potential patches of suitable habitat are within the dispersal distance of this species (figure not shown). We conclude that the linkage will likely serve the movement needs of lions.

To maintain and protect habitat connections for mountain lions, we recommend that existing road density be maintained or reduced in the Linkage Design. Crossing structures should be provided under major roads, and speeds should be reduced where wildlife cross roads (Riley et al. 2003). Lighting should be directed away from the linkage and crossing structures, as species sensitive to human disturbance, like puma, avoid areas that are artificially lit (Beier 1995, Beier 2006). We suggest local residents be informed about the value of carnivores to the system, the use of predator safe enclosures for domestic livestock and pets, and the habits of being thoughtful and safe stewards of the land.

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



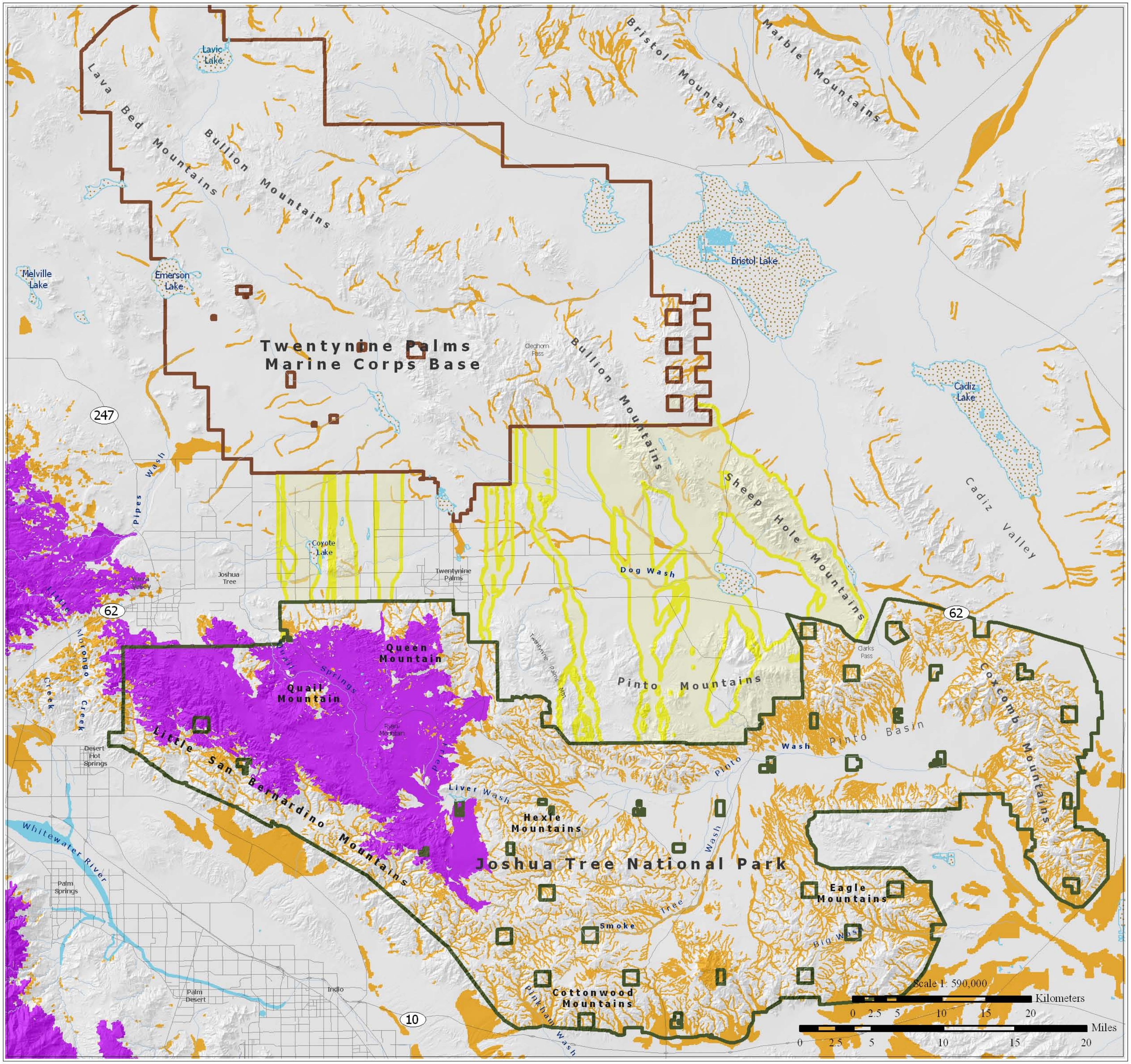
Degree of Suitability

- High
- Medium - High
- Medium
- Low - Medium
- Low
- Least Cost Union
- Dept. of Defense
- National Park Service
- Roads
- Streams
- Dry Lakes
- Waterbodies

Map Produced By:

SOUTH COAST WILDLANDS

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



Patch
< Patch
Least Cost Union
Dept. of Defense
National Park Service
Roads
Streams
Dry Lakes
Waterbodies

N

Map Produced By:

SOUTH COAST WILDLANDS

Bobcat (*Lynx rufus*)

Distribution & Status: Bobcats are distributed from southern Canada across most of the continental United States to central Mexico. They can be found throughout most of California, from the lowest elevations in Death Valley to the highest mountains in the state (Jameson and Peeters 1988).

Bobcat is classified as a game species by the Department of Fish and Game. Bobcats are fairly common in appropriate habitats, despite hunting, and the heavy trapping and predator control efforts of earlier times (Jameson and Peeters 1988). However, bobcats are an area-dependent species that can disappear from habitats that are isolated and fragmented by roads (Riley et al. 2006). Roads are also the major source of bobcat mortality (Riley et al. 2003).

Habitat Associations: Bobcats are considered habitat generalists, utilizing a variety of habitats including coastal and desert scrub, chaparral, sagebrush, woodlands and forests (Jameson and Peeters 1988). Within these natural communities, they may utilize cavities in rocky areas, logs, snags, and stumps, or dense brush for cover, and locating dens. They prefer expansive natural areas of broken, rough, and rocky terrain (Zeiner et al. 1990), and may actually favor unpaved roads for travel and hunting (e.g., Bradley and Fagre 1988, Riley et al. 2003).

Spatial Patterns: Bobcats are typically solitary and territorial, particularly between adult females (Bailey 1974, Zezulak 1998, Nielsen and Wiilf 2002, Anderson and Lovallo 2003, Riley et al. 2003). There is very little overlap in female home ranges, while those of males may overlap with other males or females (Bailey 1974, Lembeck 1978, Zezulak and Schwab 1980). Males maintain larger home ranges (Hall and Newsom 1976, Fuller et al. 1985, Rucker et al. 1989, Lovallo and Anderson 1996, Chamberlain et al. 2003). In Riverside Co., Zezulak and Schwab (1980) reported that home ranges varied from 4.7-53.6 km^2 (1.8-20.7 mi^2), with a mean of 26.3 km^2 (10.3 mi^2; N=7). In the Santa Monica Mountains in Los Angeles County, Riley et al. (2003) found home range size to average 6.82 km^2 (2.63 mi^2) for males and 3km^2 (1.16 mi^2) for females (Riley et al. 2003). Crooks (2002) found bobcats more likely to occur in habitat patches that are 10km^2 and greater.

There appears to be sex differences in the sensitivity of bobcats to urbanization (Tigas et al. 2002, Riley et al. 2003). Females maintain home ranges in high-quality habitats in the interior of natural areas, as they perceive urban areas as unsafe for raising young (Riley 1999, Riley et al. 2003). While males venture closer to the urban edge and may actually move through rural developments to reach other natural areas to increase their mating opportunities (Riley et al. 2003).

Movement patterns differ among genders, with males typically moving farther than females (Bailey 1974, Chamberlain et al. 2003). Zezulak and Schwab (1980) found distances traveled in a 24 hour period to range from 2.6 km (1.6 mi) for females and 4.8 km (3 mi) for adult males. Juveniles may disperse as much as 288 km (179 mi) over several months before finding a home range.

Conceptual Basis for Model Development: Bobcats utilize a variety of scrub, woodland, and forested habitats. Core areas were defined as greater than or equal to 657 km^2 (162348 ac). Patch size was defined as greater than or equal to 9 km^2 (2224 ac) but less than 657 km^2. Dispersal distance was defined as 576 km (358 mi).

Results & Discussion: The suitability model identified vast amounts of potential habitat for bobcat in the planning area, with all branches of the Least Cost Union providing contiguous habitat (Figure 16). The most highly suitable habitat for bobcat is in the western part of the planning area, around Quail Mountain, Queen Mountain, and the northern slopes of the Little San Bernardino Mountains in Joshua Tree National Park, and further west in Little Morongo Canyon in the foothills of the San Bernardino Mountains. The three westernmost branches of the Least Cost Union were delineated by the landscape permeability analysis for bobcat (Figure 9). The patch size analysis identified the majority of suitable habitat as potential core areas for bobcat (Figure 17). All potential cores and patches of suitable habitat are within the dispersal distance of this species (figure not shown). We conclude that the Least Cost Union will serve the movement needs of bobcat traveling between targeted areas.

To maintain and restore habitat connections for bobcats, we recommend crossing structures be provided under major roads, and speeds reduced where wildlife cross roads (Riley et al. 2003). Lighting should be minimized and directed away from the linkage and crossing structures for this nocturnally active species. We suggest local residents be informed about the value of carnivores to the system, the proper use of rodenticides to reduce the likelihood of ingestion of these lethal substances on small mammals that are prey species for bobcat, and the habits of being thoughtful and safe stewards of the land.

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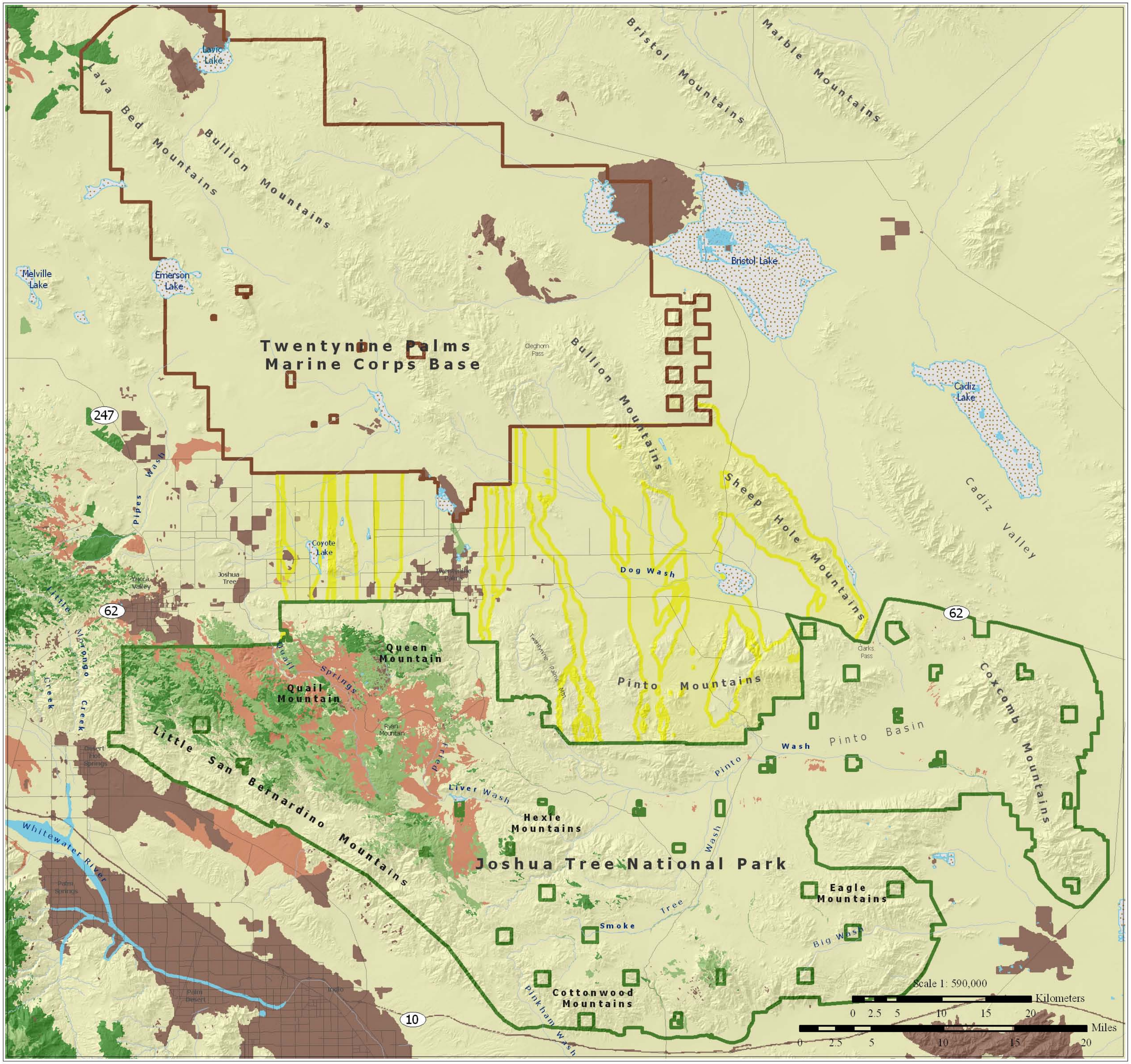
Figure 16.
Habitat Suitability
for
Bobcat
(Lynx rufus)



Degree of Suitability
- High
- Meidum - High
- Medium
- Low to Medium
- Low
- Least Cost Union
- Dept. of Defense
- National Park Service
- Roads
- Streams
- Dry Lakes
- Waterbodies

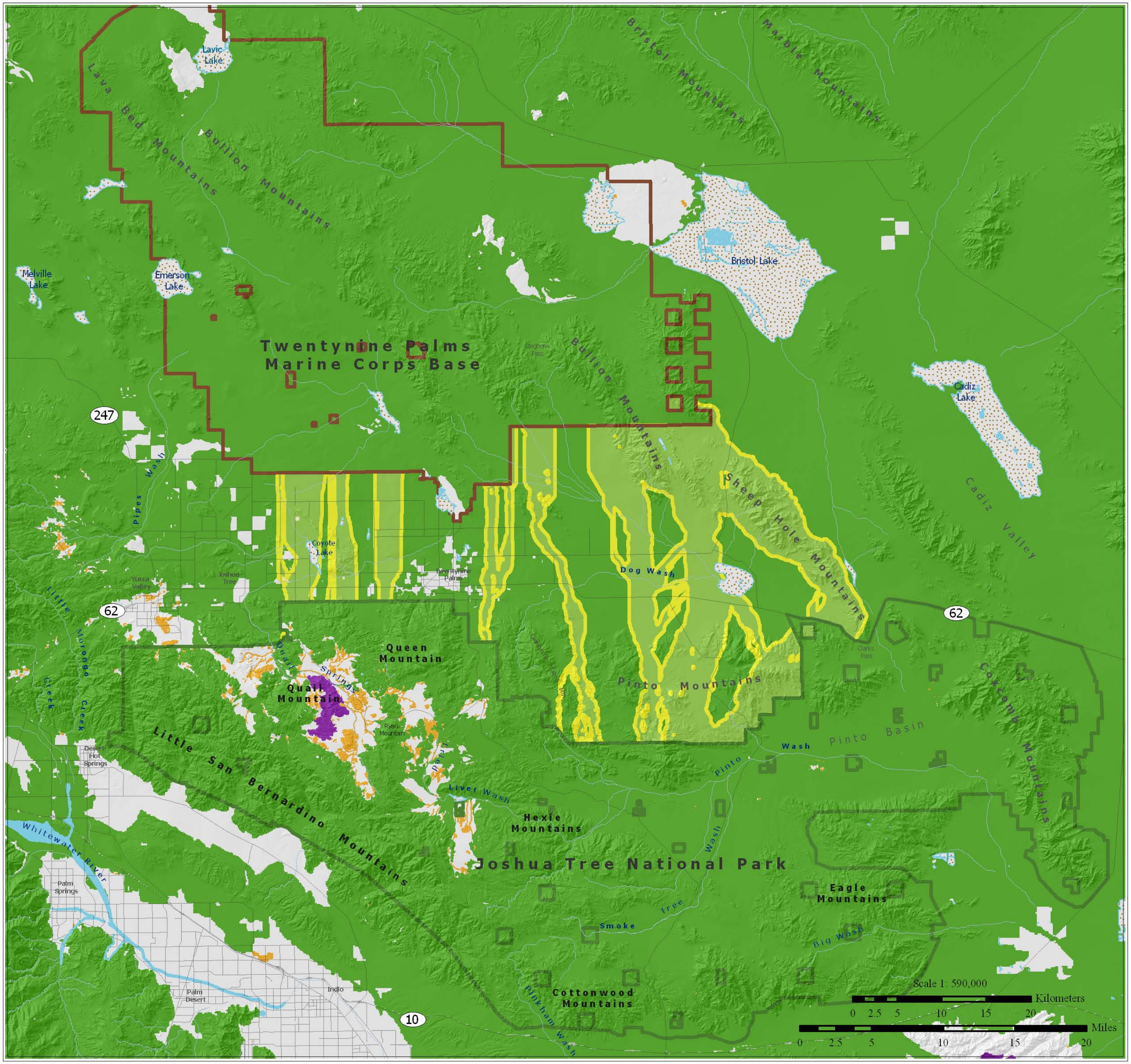
N

Map Produced By:

SOUTH COAST WILDLANDS

Figure 17.
Potential Cores & Patches
for
Bobcat
(Lynx rufus)

Core
Patch
< Patch
Least Cost Union
Dept. of Defense
National Park Service
Roads
Streams
Dry Lakes
Waterbodies



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Map Produced By:
SOUTH COAST WILDLANDS

American badger (*Taxidea taxus*)

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

Habitat Associations: Badgers are habitat specialists, associated with grasslands, prairies, and other open habitats (de Vos 1969, Banfield 1974, Sullivan 1996) but they may also be found in drier open stages of shrub and forest communities (Zeiner et al. 1990). They are known to inhabit forest and mountain meadows, marshes, riparian habitats, and desert communities including creosote bush, juniper, and sagebrush habitats (Long and Killingley 1983, Zeiner et al. 1990). They are occasionally found in open chaparral (< 50% cover) but have not been documented in mature stands of chaparral (Quinn 1990, Zeiner et al. 1990). Badgers prefer friable soils for excavating burrows and require abundant rodent populations (de Vos 1969, Banfield 1974, Sullivan 1996). They are typically found at lower elevations, in flat, rolling, or steep terrain, but have also been recorded at elevations up to 3,600 m (12,000 ft; Zeiner et al. 1990, Minta 1993).

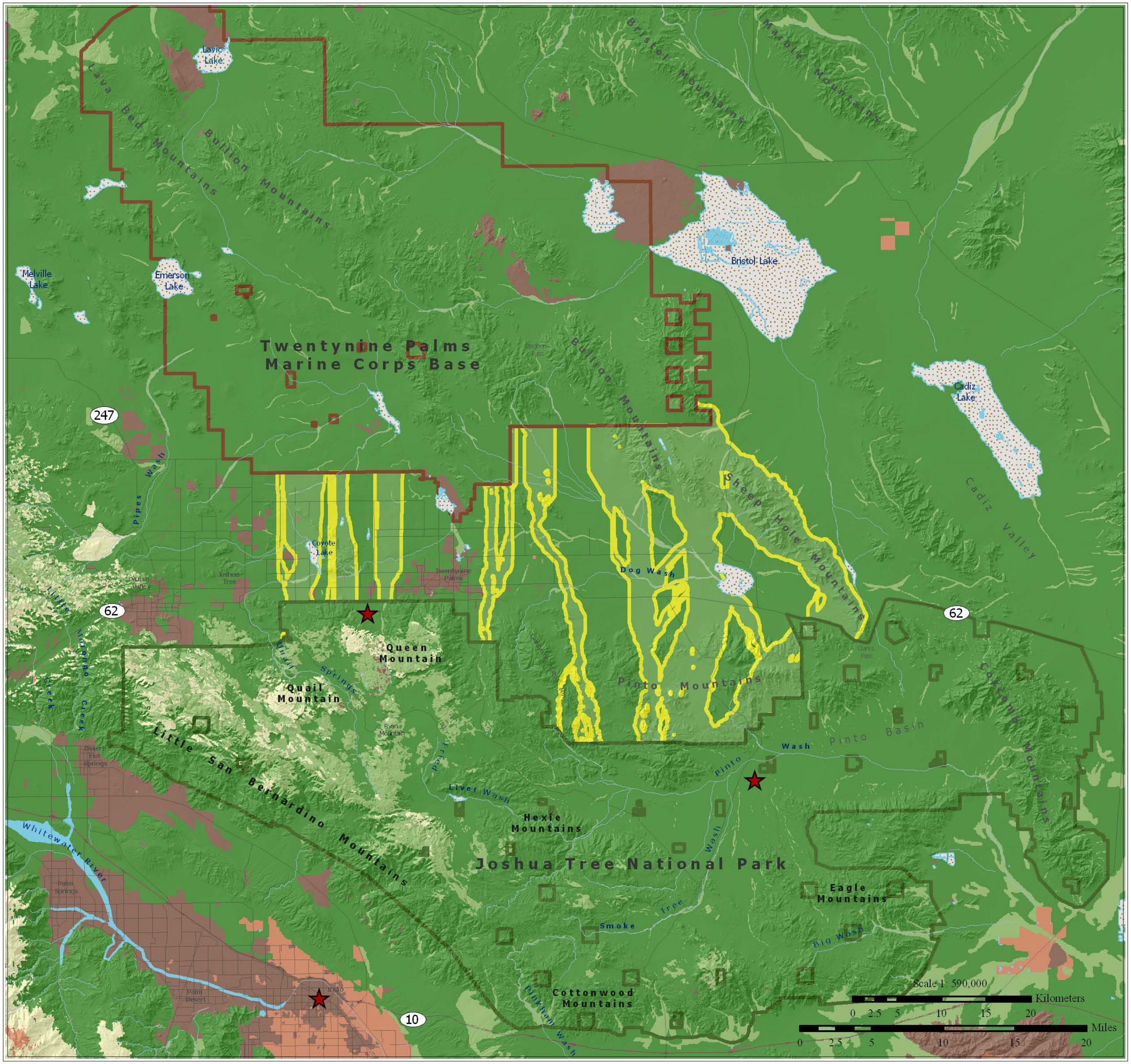
Spatial Patterns: Home range sizes for this species vary both geographically and seasonally. Male home ranges have been estimated to vary from 240 to 850 ha (593-2,100 ac) while reported female home ranges varied from from 137 to 725 ha (339-1,792 ac; Long 1973, Lindzey 1978, Messick and Hornocker 1981,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

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

Results & Discussion: The model identified abundant highly suitable habitat for badger in the planning area, with all branches of the Least Cost Union containing highly suitable and contiguous habitat (Figure 18). The central branch and two of the eastern branches of the Least Cost Union were delineated by the landscape permeability analysis for badger (Figure 10). Almost all of the suitable habitat in the planning area is contiguous, and thus was identified as core habitat for this species (Figure 19). All potential habitat is within badger's dispersal distance (figure not shown), although barriers to movement may exist between suitable habitat patches. We conclude that the linkage is likely to serve the movement needs of this wide-ranging species.

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

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



Degree of Suitability

- High
- Medium - High
- Medium
- Low - Medium
- Low
- Least Cost Union
- Dept. of Defense
- National Park Service
- Roads
- Streams
- Dry Lakes
- Waterbodies
- CNDDB Occurrence

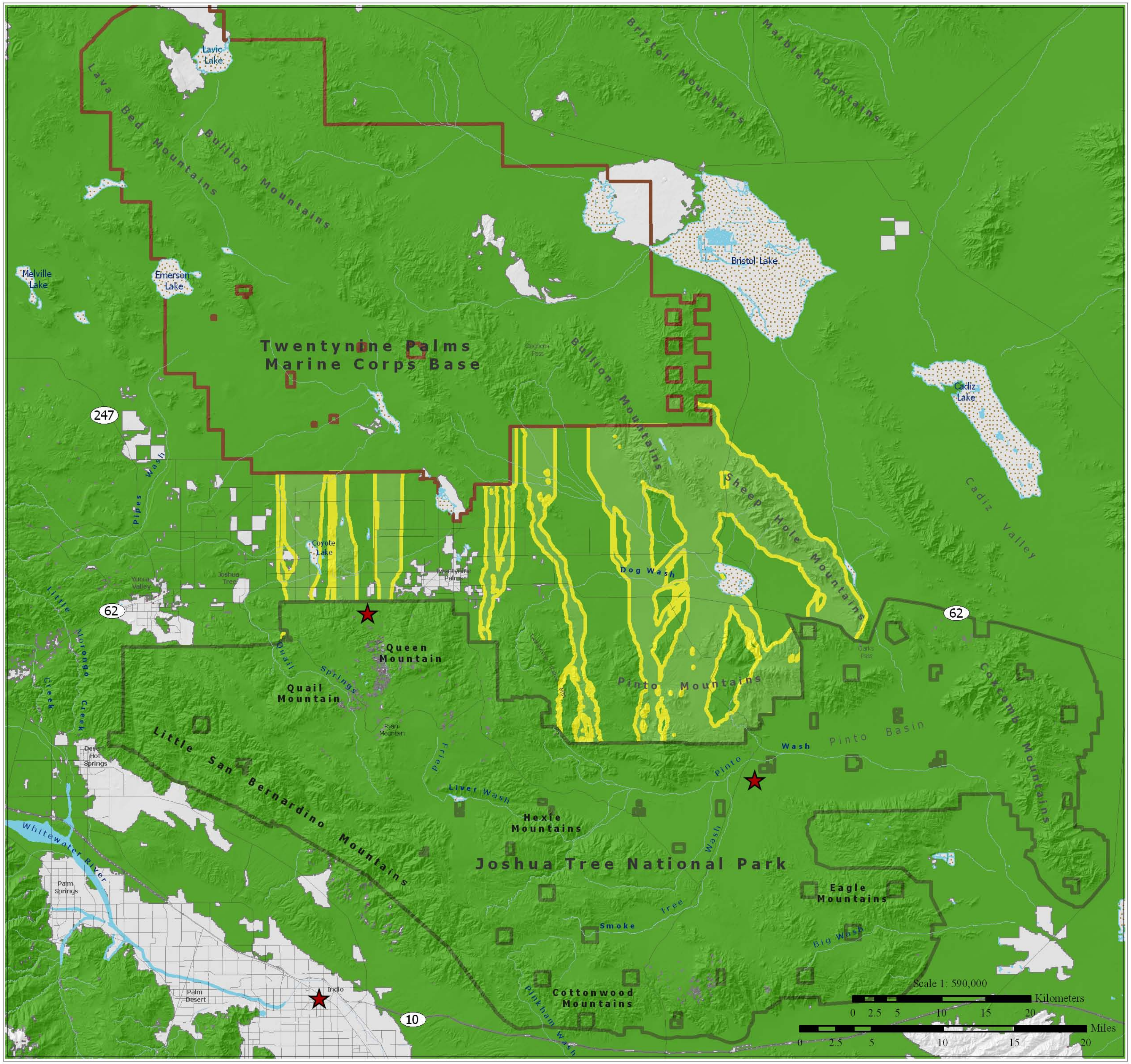
Species occurrence data from the California Natural Diversity Database

N

Map Produced By:

SOUTH COAST WILDLANDS

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



- Core
- Patch
- Least Cost Union
- Dept. of Defense
- National Park Service
- Roads
- Streams
- Dry Lakes
- Waterbodies
- ★ CNDDB Occurrence

Species occurrence data from the California Natural Diversity Database

N

Map Produced By:

SOUTH COAST WILDLANDS

Bighorn sheep (*Ovis canadensis*)

Distribution & Status: Bighorn sheep were previously divided into seven subspecies (Manville 1980). One subspecies has gone extinct while two others were combined (Manville 1980). In California, bighorn sheep inhabit mountain ranges from the White Mountains to the southern Sierra Madre Range, San Gabriel, San Bernardino Mountains, and Little San Bernardino Mountains, and south to the Mexican border (CDFG 1983, USFS 2002), typically between 914-3,068 m (3,000-10,064 ft) in elevation (Holl and Bleich 1983, USFS 2002).

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

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

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

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

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

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

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

Potential core areas were delineated as areas of suitable habitat greater than or equal to 300 km^2 (74,132 ac). Patches were defined $\geq$ 13 km^2 (3,212 ac) but less than 300 km^2. Dispersal distance for bighorn sheep was defined as 112 km (70 mi), twice the longest recorded distance for a male.

Results & Discussion: The output provided by the habitat suitability analysis corresponds with important habitat areas identified for this species (Stephenson and Calcarone 1999, USFS 2002, NPS 2003). The eastern branch of the Least Cost Union was delineated by the landscape permeability analysis for bighorn sheep and captured the most suitable contiguous habitat between targeted areas (Figure 20). The suitability model also captured habitat used by the 3 herds in Joshua Tree National Park, including the largest herd in the Eagle Mountains at the far eastern boundary of the park, the herd that ranges through the main part of the Little San Bernardino Mountains, and the smallest herd in the Wonderland of Rocks region (NPS 2003). The patch size analysis identified potential core areas and patches of suitable habitat in the planning area (Figure 21) that largely overlap with areas utilized by bighorn sheep. All potential habitat patches are within the species dispersal distance (figure not shown), though barriers to movement exist between areas of suitable habitat. Bighorn sheep will also benefit from additions to the Union along Pipes Canyon Wash, which provides a secondary connection between Twentynine Palms MCAGCC and the San Bernardino-Little San Bernardino Connection (Penrod et al. 2005). Maintaining connections for this species is particularly important because of its metapopulation structure. We believe that the linkage will serve the movement needs of bighorn sheep.

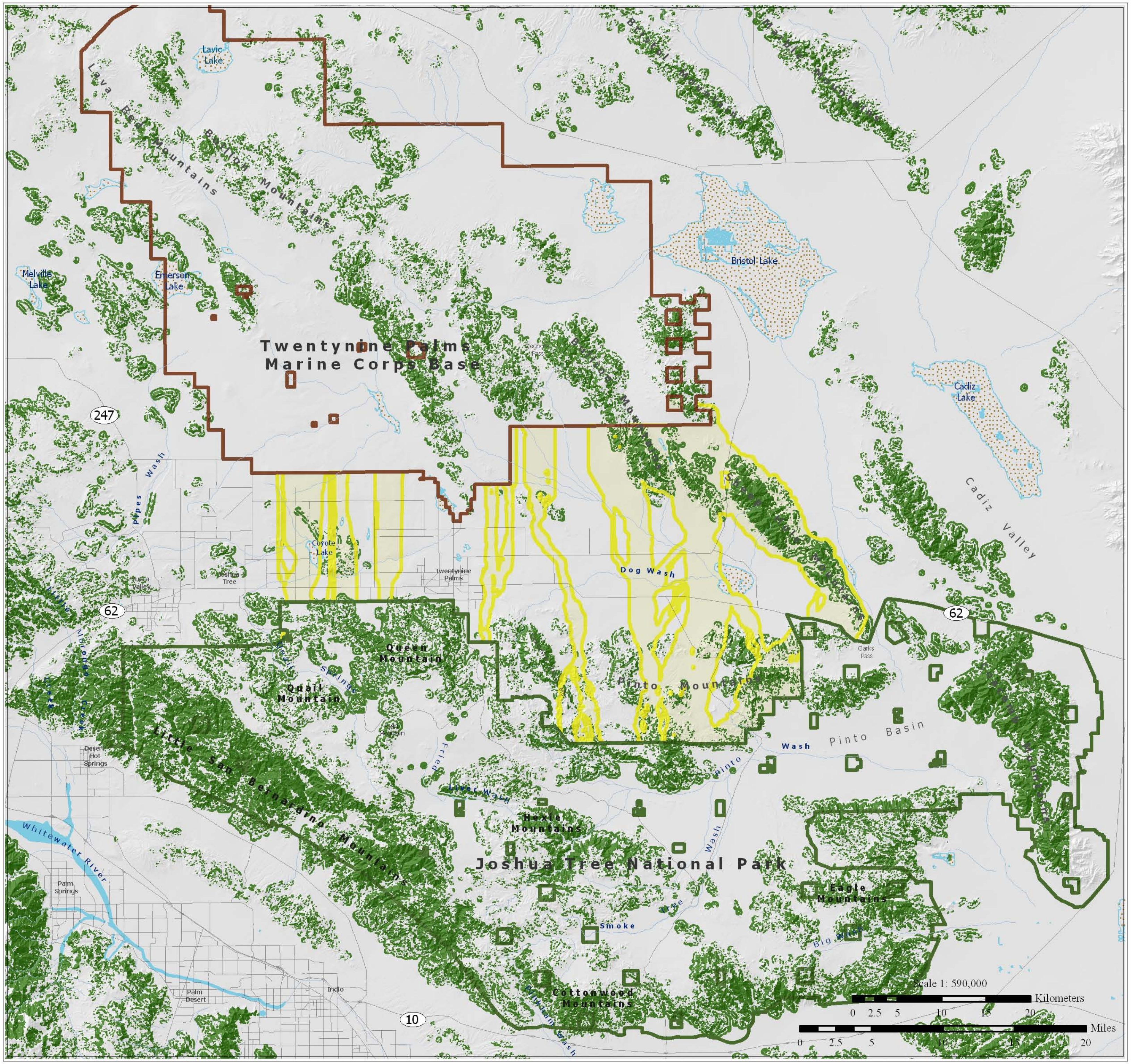
Bighorn sheep avoid heavily used roads (Jorgensen 1974, Wilson et al. 1980, Krausman et al. 1989, Ebert and Douglas 1993, Rubin et al. 1998, Papouchis et al. 2001), although females will cross busy roads on rare occasions and rams cross roads more frequently (Rubin et al. 1998). MacArthur et al. (1982)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

Other measures that should be taken to maintain this species include enforcing leash laws so that dogs are under restraint at all times (USFWS 2000, USFWS 2001, Holl et al. 2004); prohibiting domestic sheep and goats within 9 miles of bighorn sheep habitat to reduce the potential for disease transmission (USFWS 2000, USFWS 2001); and widely publicizing the CalTIP (Californians Turn in Poachers) program's toll free reporting number (800-952-5400) to inform citizens of the law against poaching bighorn sheep (Anonymous 1984).

Figure 20. Potential Habitat for Bighorn Sheep

(Ovis canadensis.)

- Potential Habitat
- Least Cost Union
- Dept. of Defense
- National Park Service
- Roads
- Streams
- Dry Lakes
- Waterbodies

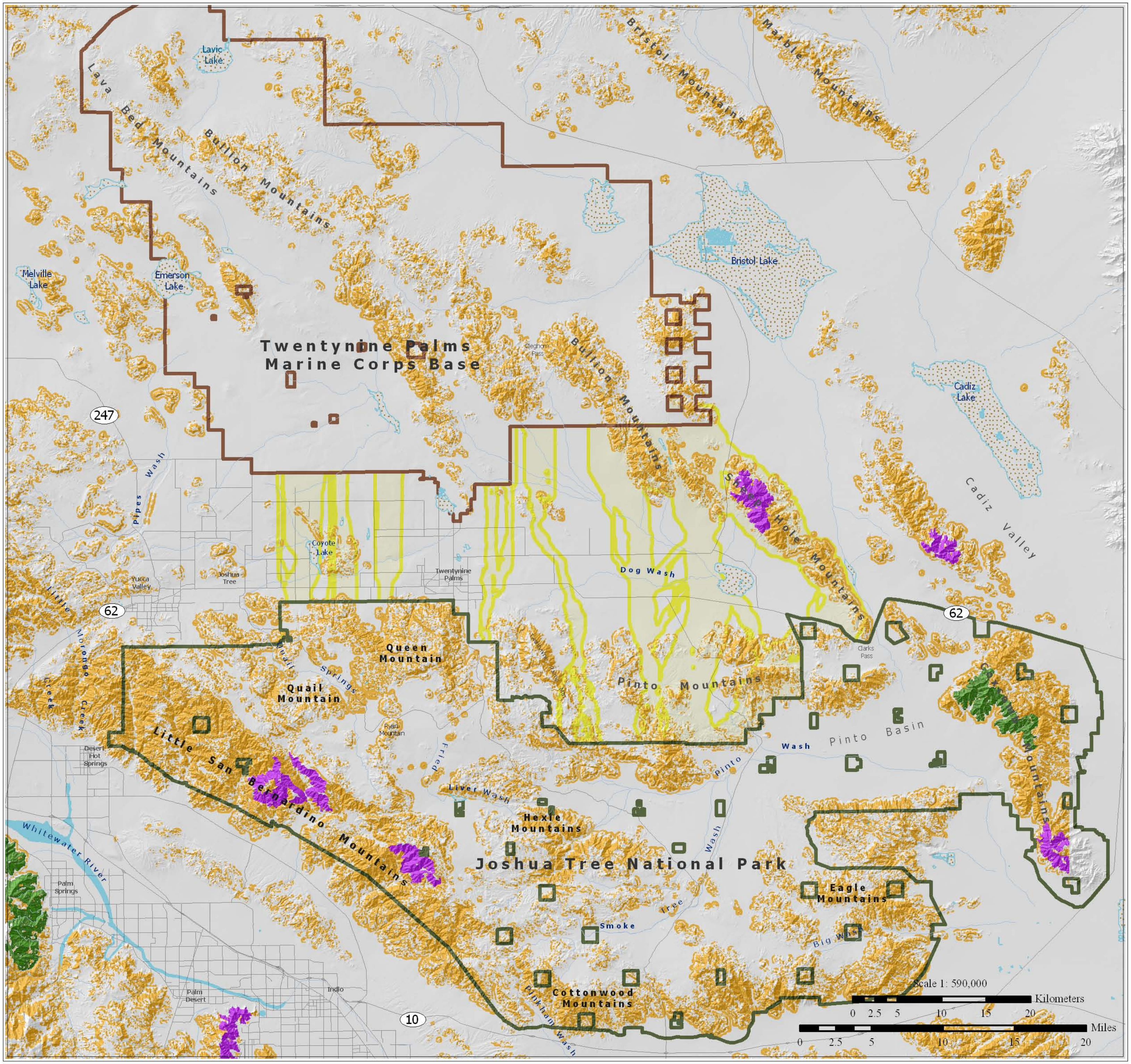


Map Produced By:

SOUTH COAST WILDLANDS

Figure 21.
PotentialCores & Patches
for
Bighorn sheep
(Ovis canadensis)

- Core
- Patch
- < Patch
- Least Cost Union
- Dept. of Defense
- National Park Service
- Roads
- Streams
- Dry Lakes
- Waterbodies



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Map Produced By:

SOUTH COAST WILDLANDS

Round-tailed ground squirrel (*Spermophilus tereticaudus*)

Justification for Selection: The round-tailed ground squirrel is a keystone species due to its extensive burrowing activity. Its burrows provide homes to several other creatures and the burrowing helps to loosen the soil and increase plant productivity. This species is also primarily associated with the lowlands between the targeted areas; an orthogonal species that if maintained can help protect the integrity of the linkage. This species readily crosses roads in high traffic areas but mortality is high.


Gerald and Buff Corsi © California Academy of Sciences

Distribution & Status: Round-tailed ground squirrels are restricted to portions of the Mojave, Yuma, and Colorado deserts in Arizona, California, and northern Mexico (Cockrum, 1982, Flink 2000), and are found from 60 to 900 m (180 to 2900 ft) in elevation (CDFG 2005). There are 4 subspecies, 2 of which occur in the southern California deserts (*S.t. tereticaudus* and *S.t. chlorus*). *S.t. tereticaudus* occurs in the study area, while *S.t. chlorus* (Palm Springs round-tailed ground squirrel) is restricted to the Coachella Valley (Hafner et al. 1998).

The primary threats to the round-tailed ground squirrels are habitat loss and fragmentation due to urban and agricultural development (CDFG 2005). House cats are also major predators at the urban-wildland interface (Dunford 1977).

Habitat Associations: Optimum habitats are desert succulent shrub, desert wash, desert scrub, and alkali desert scrub. Within these habitats, it occupies open, flat areas with finely textured sandy soil, but can also be found in the sand of dunes (Dunford 1977, Ernest and Mares 1987, Jameson and Peeters 1988, Flink 2000, CDFG 2005). It prefers a mixture of shrubs but habitats dominated by creosote bush had a lower density of squirrels (Dunford 1977).

Spatial Patterns: Round-tailed ground squirrels are semi-colonial but they keep and defend individual burrows (Dunford 1977, Flink 2000). Adult home ranges average 0.74 ha (1.85 ac), and may shift to encompass necessary resources (CDFG 2005). Densities are highest include preferred foods, but home ranges remain relatively stable for 2, or more, years. Densities varied from 25-225 per ha (10-100 per ac), and are highest when juveniles emerge (CDFG 2005).

Conceptual Basis for Model Development: Movement in the linkage is assumed to be multigenerational. Round-tailed ground squirrels prefer desert scrub, alkali desert scrub, desert succulent scrub, and desert wash habitats. Within these habitats, they occupy open and generally flat sandy terrain. Core areas were defined as $\geq$ 20 ha (50 ac). Patch size was defined as $\geq$ 0.81 ha (2 ac) and < 50 ha. Dispersal distance was not estimated as movement data are lacking for this species.

Results & Discussion: The model identified extensive potential habitat for the round-tailed ground squirrel in the planning area. All branches of the Least Cost Union contain highly suitable contiguous habitat, with the central and eastern branches providing the most direct connection between expansive areas of suitable habitat (Figure 22). The majority of suitable habitat was identified as potential core areas for this species (Figure 23). We conclude that the linkage will likely serve the live-in and move-through needs of round-tailed ground squirrels. To protect and restore habitat for round-tailed ground squirrel, we recommend that crossing structures for small mammals be added during the next transportation improvement project to facilitate movement across major roads, such as State Route 62.

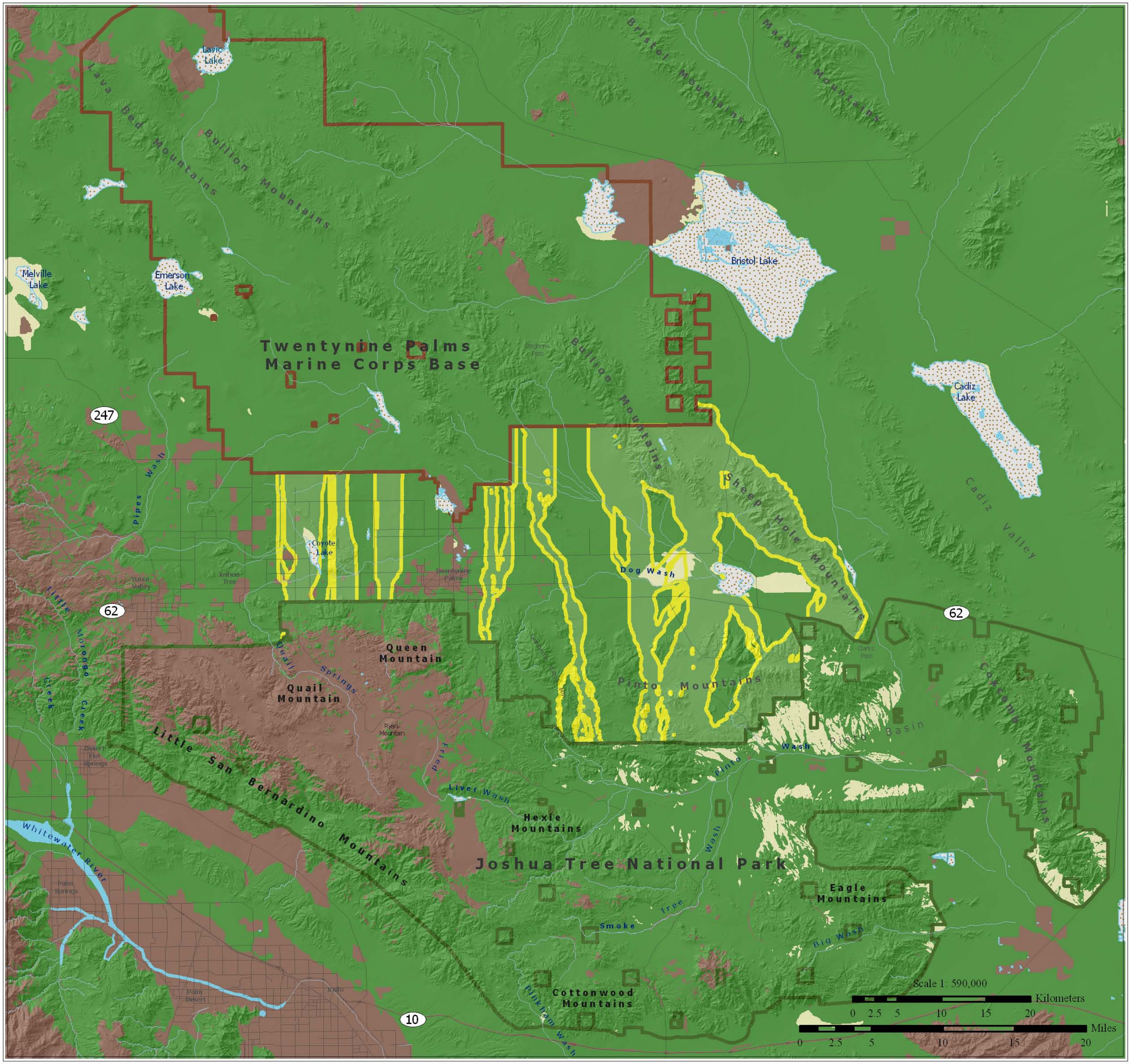


Figure 22.
Habitat Suitability
for
Round-tailed
ground squirrel
(Spermophilus tereticaudus)

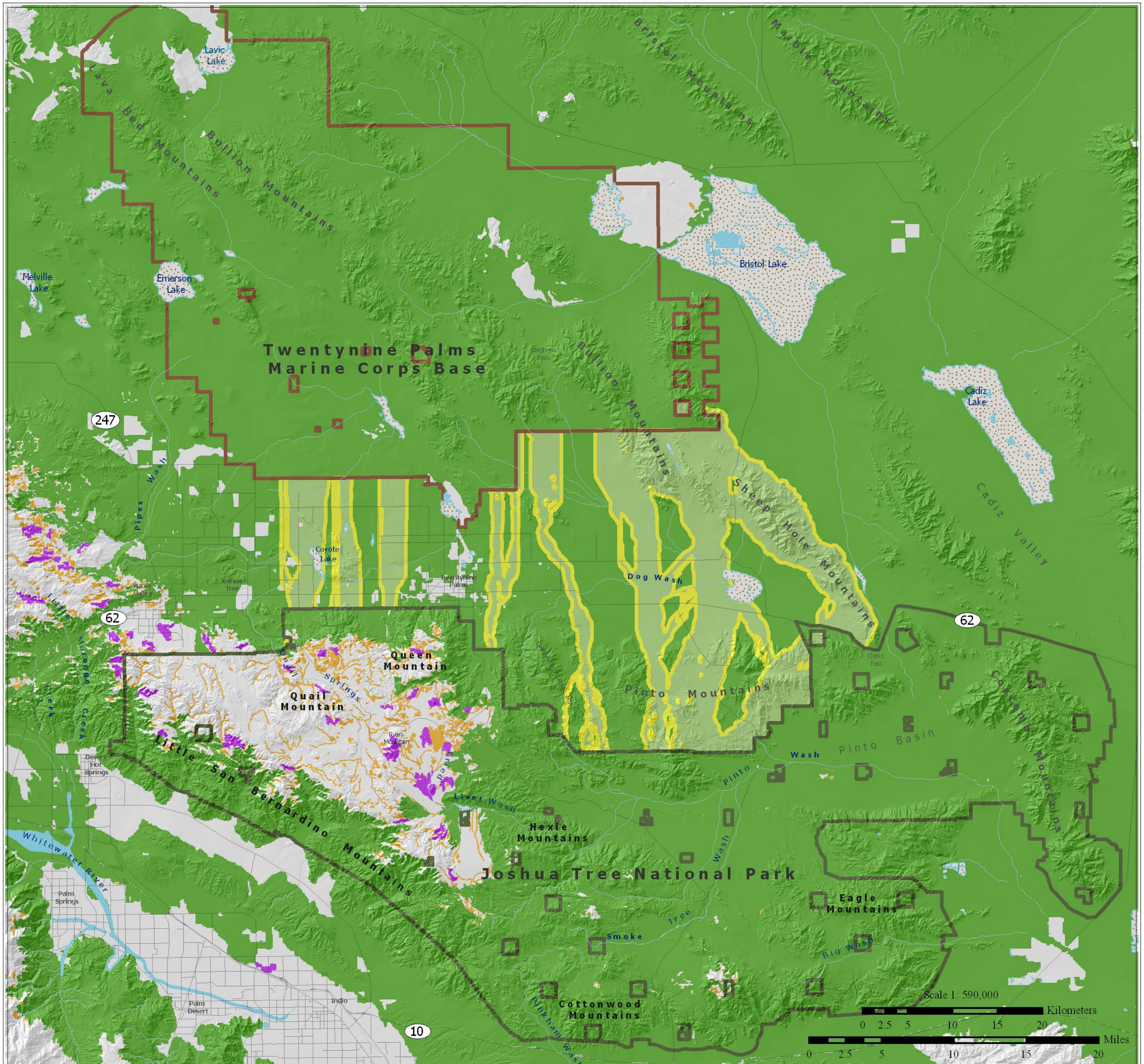
Degree of Suitability
- High
- Medium
- Low
- Least Cost Union
- Dept. of Defense
- National Park Service
- Roads
- Streams
- Dry Lakes
- Waterbodies

N

Map Produced By:
South Coast Wildlands

Figure 23.
Potential Cores & Patches
for
Round-tailed ground squirrel
(Spermophilus tereticaudus)

Core
Patch
< Patch
Least Cost Union
Dept. of Defense
National Park Service
Roads
Streams
Dry Lakes
Waterbodies



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Map Produced By:
SOUTH COAST WILDLANDS

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

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

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

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

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

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

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

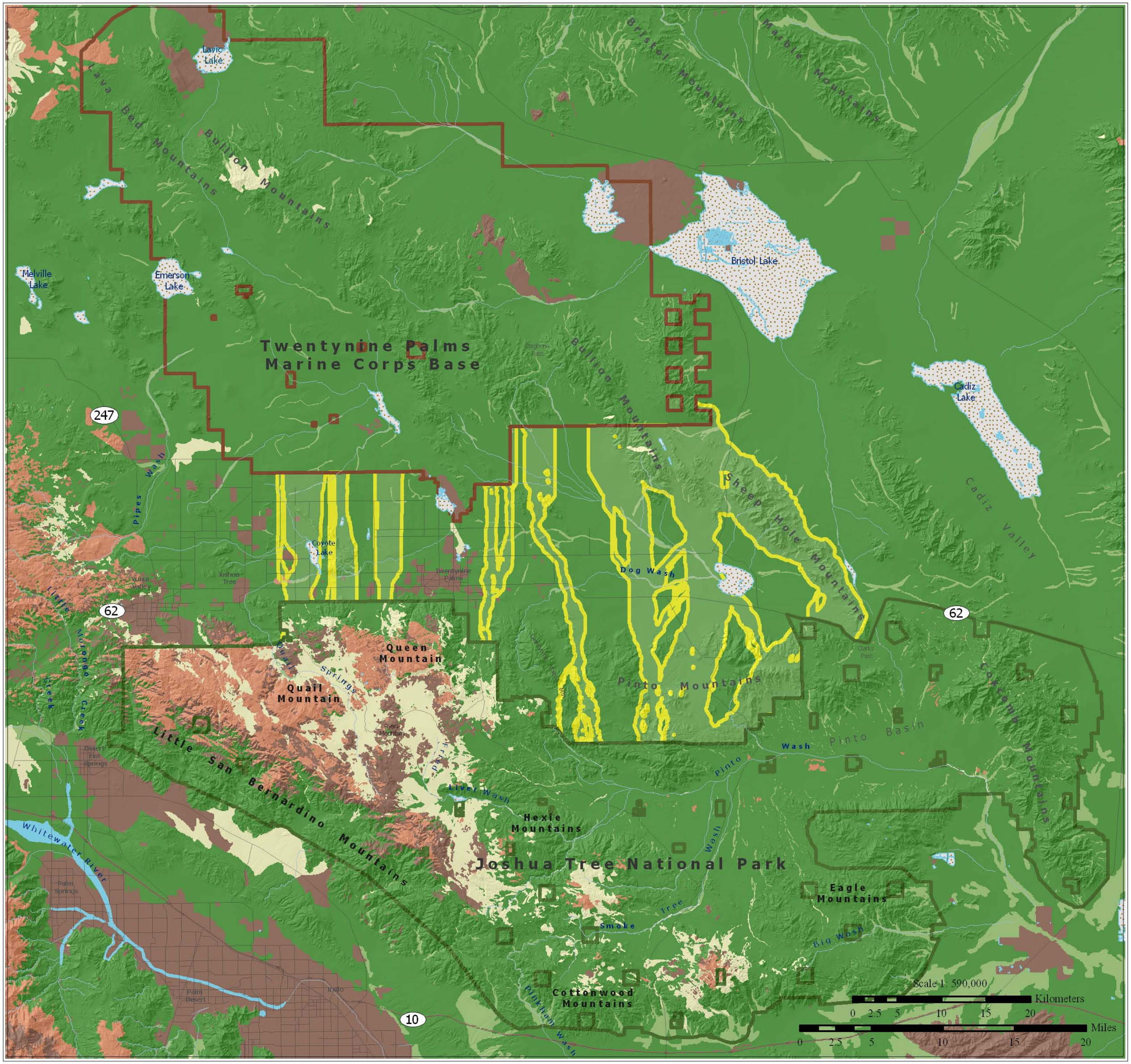
Conceptual Basis for Model Development: Movement in the linkage is assumed to be multigenerational. Merriam's kangaroo rat prefers desert scrub, alkali desert scrub, sagebrush, creosote scrub, Joshua tree, and pinyon-juniper habitats. Within these habitats, they occupy flat and gently sloping terrain.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

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

Results & Discussion: Highly suitable habitat for this species was identified in all branches of the Least Cost Union (Figure 24). The majority of suitable habitat was identified as potential core areas for this species (Figure 25). Distances among all core areas and patches are within the defined dispersal distance of this species (figure not shown), although barriers to movement may exist between suitable habitat patches. We conclude that the linkage is likely to serve the habitat and movement needs of Merriam's kangaroo rat.

Many small mammals are reluctant to cross roads or are highly susceptible to roadkill (Merriam et al. 1989, Diffendorfer et al. 1995, Brehme 2003). If transportation improvement projects are undertaken in the linkage, small crossing structures should be placed fairly frequently to facilitate movement and reduce travel distance for small mammals (Jackson and Griffin 2000, McDonald and St. Clair 2004). Merriam's kangaroo rat is a nocturnally active species, so lighting should be directed away from the linkage and crossing structures. Local residents should be informed about the proper use of rodenticides and pesticides to reduce the likelihood of ingestion of these lethal substances on small mammals indigenous to the area.

Figure 24.
Habitat Suitability
for
Merriam's kangaroo rat
(Dipodomys merriami)

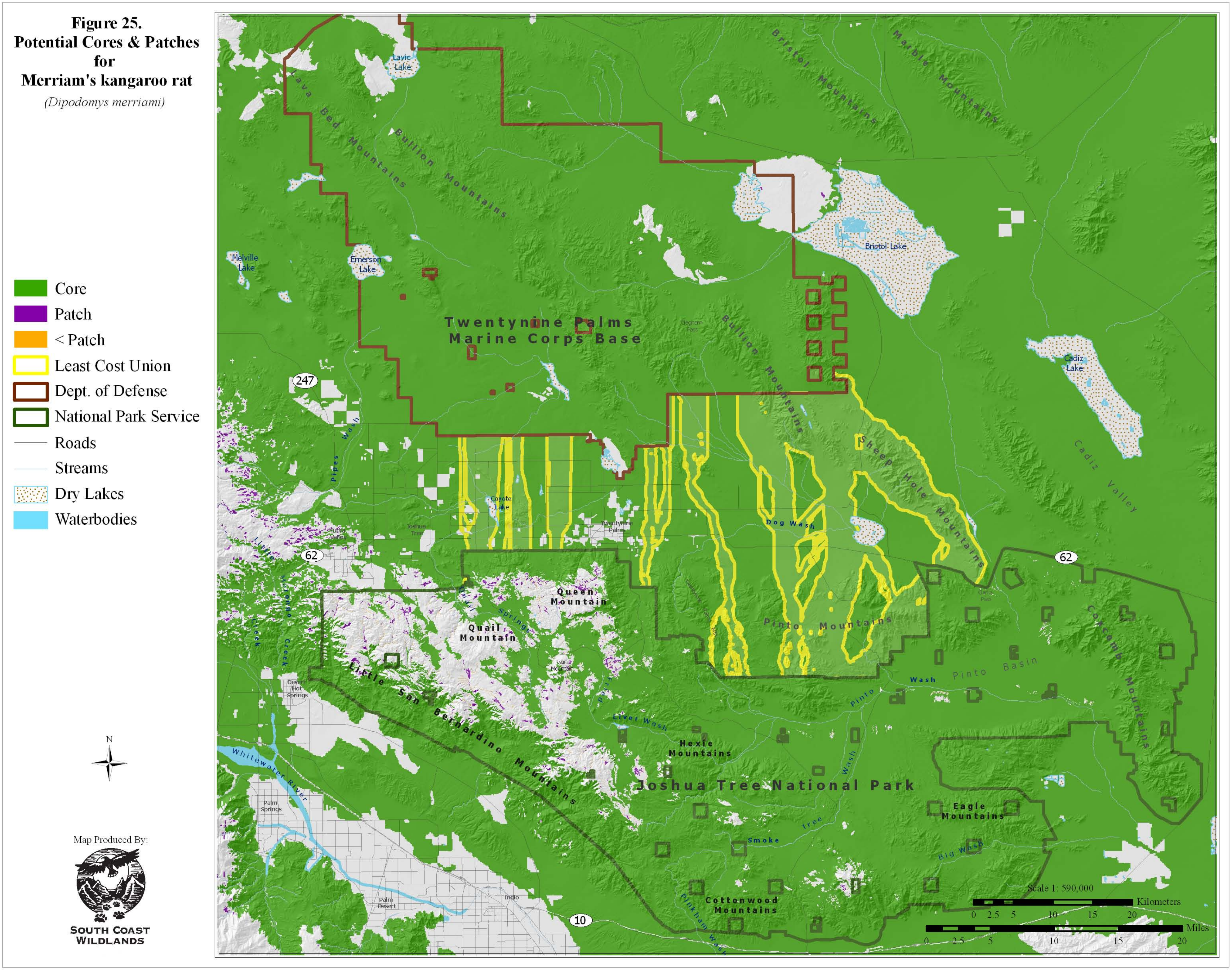


Degree of Suitability
- High
- Medium - High
- Medium
- Low - Medium
- Low
- Least Cost Union
- Dept. of Defense
- National Park Service
- Roads
- Streams
- Dry Lakes
- Waterbodies

N

Map Produced By:
SOUTH COAST WILDLANDS

Figure 25.
Potential Cores & Patches for Merriam's kangaroo rat
(Dipodomys merriami)



Desert kangaroo rat (Dipodomys deserti)

Justification for Selection: The desert kangaroo rat is a sand dune specialist; thus, its continued presence in the linkage can help ensure sand dune maintenance processes are maintained. This species is also an important component of the prey base. Finally, this species is sensitive to habitat fragmentation and roadkill, barriers include major roads, canals, dense vegetation, and brightly lit areas.

Distribution & Status: The desert kangaroo rat occurs in arid sandy desert regions of southeastern California, southern Arizona, and northern Mexico (Jameson and Peeters 1988). In California, it occurs in Olancha and Keeler in Inyo County, west to Palmdale in Los Angeles County, in Hesperia in San Bernardino County, and Borrego Springs in San Diego County (CDFG 2005).

The desert kangaroo rat is not a special status species. It is however, the largest of California's kangaroo rats (CDFG 2005).

Habitat Associations: The desert kangaroo rat is a sand dune specialist but can also be found in open sandy areas of a variety of desert scrub habitats including alkali sink, shadscale scrub, and creosote bush scrub. One of the most important habitat elements is a substrate of wind-drifted sand (Hall 1946), which they require to excavate their burrows (Hall 1946, Miller and Stebbins 1964, CDFG 2005). They often dig their burrows at the base of creosote bushes (Jameson and Peeters 1988).

Spatial Patterns: Information on home range size and dispersal distance is lacking for this species. In Death Valley, Grinnell (1937) reported a density of 3.2 individuals per 40 ha (100 ac; CDFG 2005).

Conceptual Basis for Model Development: This species prefers the open sandy habitats of desert scrub communities. Core areas were defined as $\geq$ 325 ha (803 ac). Patch size was defined as greater than or equal to 25 ha (62 ac) but less than 325 ha. We used the dispersal distance defined for Merriam's kangaroo rat (768 m or 2,520 ft), which is a similar sized species.

Results & Discussion: The habitat suitability model predicted extensive medium to high suitable habitat for desert kangaroo rat in the planning area, with all branches of the Least Cost Union containing contiguous habitat for this species (Figure 26). The patch size analysis identified the majority of suitable habitat as potential core areas for this species (Figure 27). Distances among all core areas and patches are within the defined dispersal distance of this species (figure not shown), although barriers to movement may exist between suitable habitat patches. We conclude that the linkage is likely to serve the habitat and movement needs of the desert kangaroo rat. To maintain and restore habitat connections for the desert kangaroo rat, we recommend the same guidance as for Merriam's kangaroo rat. In addition, we suggest protecting and restoring sand movement corridors and other processes that are critical to maintaining the dune ecosystems upon which this species depends.

Figure 26.
Habitat Suitability
for
Desert Kangaroo rat
(Dipodomys deserti)

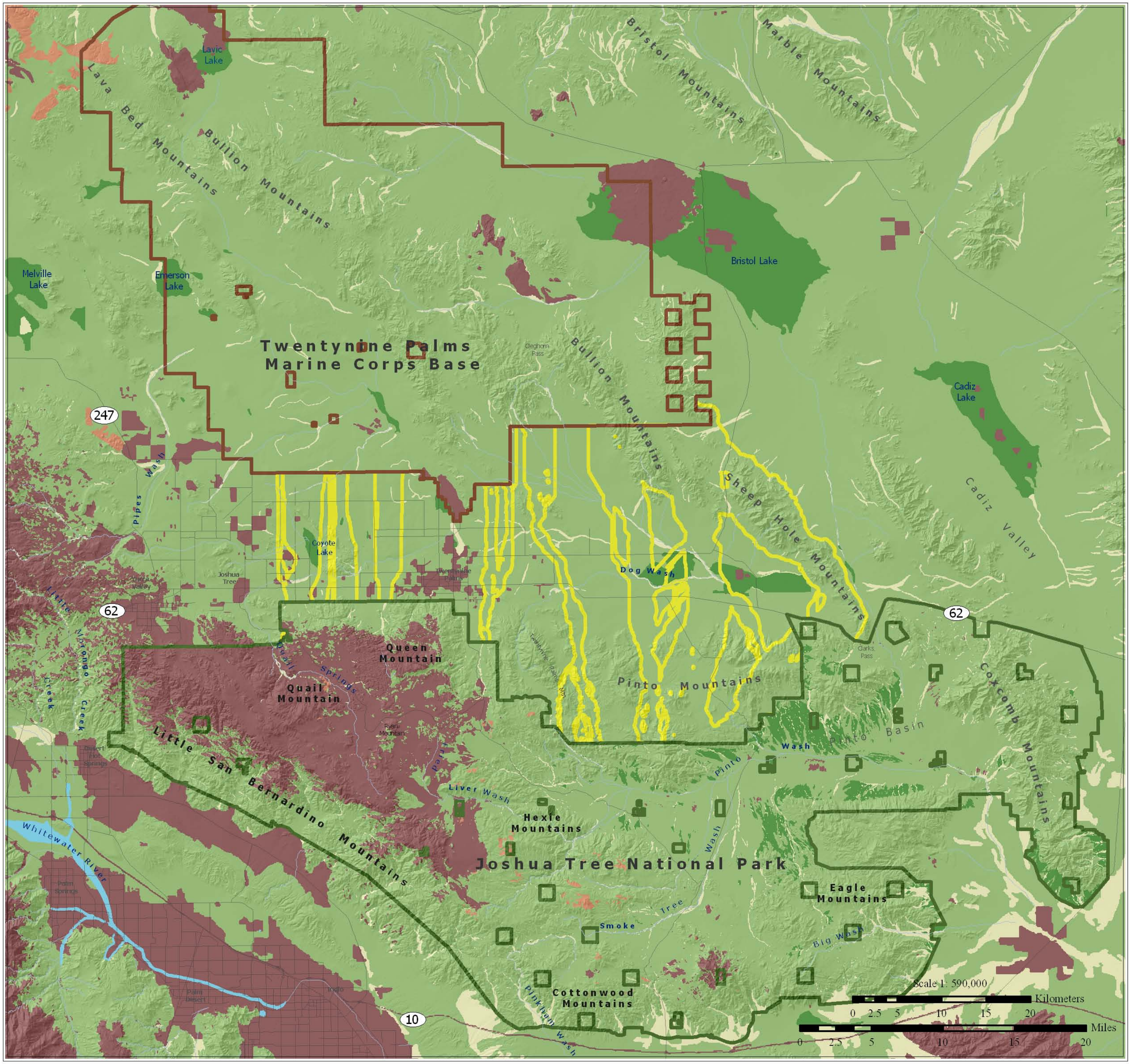
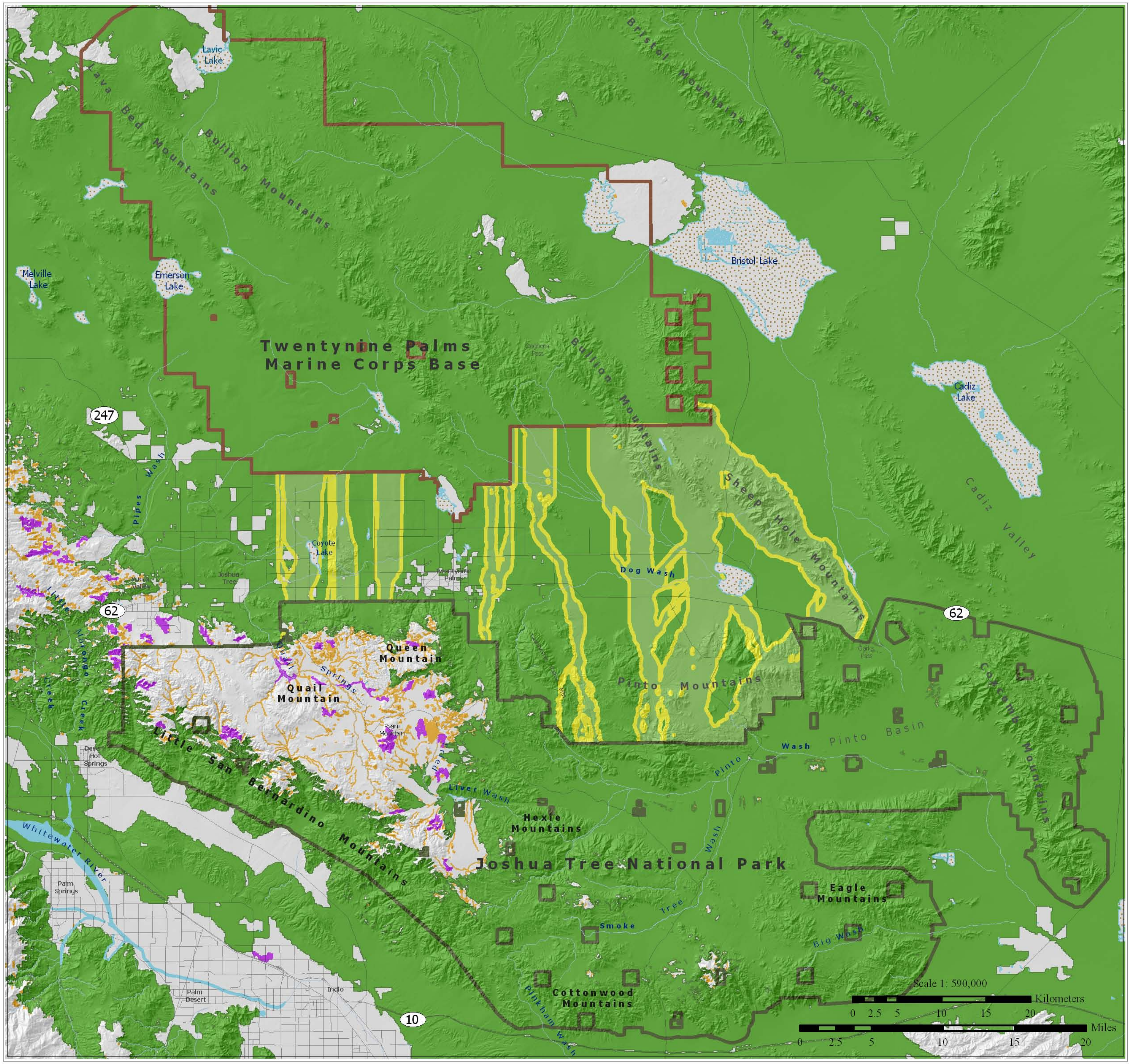


Figure 27.
Potential Cores & Patches
for
Desert kangaroo rat
(Dipodomys deserti)



- Core
- Patch
- < Patch
- Least Cost Union
- Dept. of Defense
- National Park Service
- Roads
- Streams
- Dry Lakes
- Waterbodies

N

Map Produced By:

SOUTH COAST WILDLANDS

Burrowing owl (*Athene cunicularia*)

Justification for Selection: Burrowing owls are sensitive to habitat loss and fragmentation from agricultural and urban land uses (Grinnell and Miller 1944, Zarn 1974, Remsen 1978, CDFG 1990). They are also 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 elevations of up to 1615 m (5300 ft), burrowing owls are primarily associated with low-elevation valleys (CDFG 1990, USFS 2002). The species is experiencing precipitous population declines throughout most of the western United States, and has disappeared from most of its historical range in California. Nearly 60% of California burrowing owl colonies that existed in the 1980s were gone by the early 1990s (DeSante and Ruhlen 1995, DeSante et al. 1997, USFS 2002). Once widespread, its distribution is now highly localized and fragmented. Burrowing owls are identified as both Federal and State Species of Special Concern (CDFG 2001).

Habitat Associations: Burrowing owls prefer 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 (Haug et al. 1993, Millsap and Bear 2000, USFS 2002), though they are relatively scarce in these environments. Key habitat characteristics include open, well-drained terrain; short, sparse vegetation; and underground burrows. They hunt in open habitats (Haug and Oliphant 1990). Throughout their range they depend on burrows excavated by fossorial mammals and reptiles for roosting and nesting (Karalus and Eckert 1987, USFS 2002). Though they've also been documented using pipes, culverts, or other tunnel like structures, and nest boxes where burrows are scarce (Robertson 1929, CDFG 1990, Haug et al. 1993).

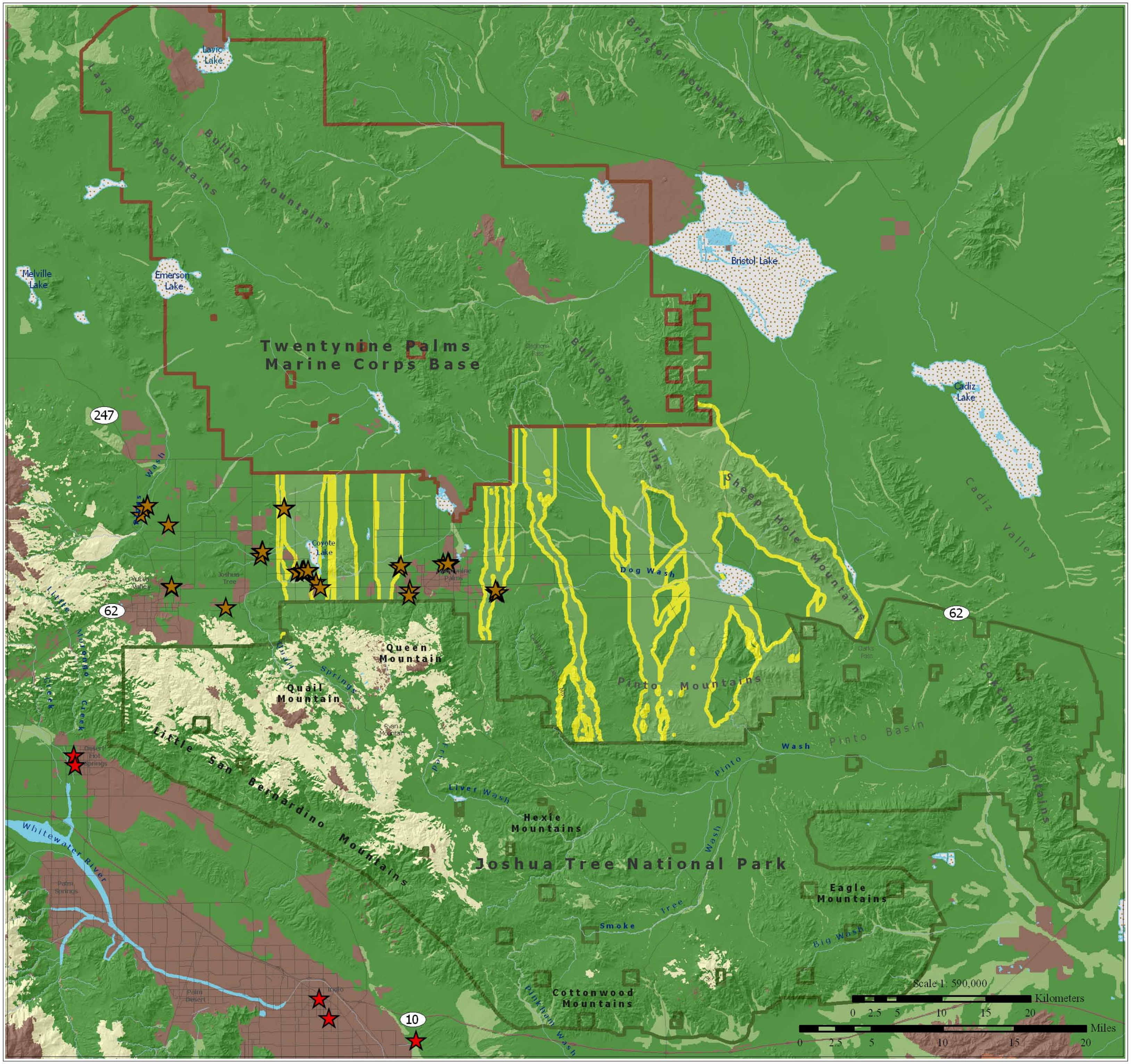
Spatial Patterns: Estimated home range sizes vary drastically, from 0.04 to 481 ha (0.99 to 1189 ac; Thomsen 1971, Haug and Oliphant 1990). Thomsen (1971) calculated home range sizes at Oakland Airport from 0.04 to 1.6 ha (0.99 to 3.95 ac). Grant (1965) reported home ranges sizes from 4.9 to 6.5 ha (12.11 to 16.06 ac), while Butts (1973) found home ranges up to 240 ha (593.7 ac). The largest home range recorded for this species is 481 ha (1189 ac) in Saskatchewan (Haug and Oliphant 1990). Breeding pairs in California are presumed to require a minimum of 2.6 ha (6.42 ac) of contiguous habitat (CDFG 1995, USFS 2002). Natal dispersal distances up to 30 km (18.64 mi) have been reported (Haug et al. 1993, USFS 2002).

Conceptual Basis for Model Development: This species prefers the open terrain of desert scrub communities below 1615 m (5300 ft) in elevation. Core areas were defined as $\geq$ 3000 ha (7413.16 ac). Patch size was defined as greater than or equal to 6 ha (14.83 ac) but less than 3000 ha. Dispersal distance was defined as 60 km (37.28 mi).

Results & Discussion: Extensive highly suitable habitat was identified for burrowing owl in the planning area, with all branches of the Least Cost Union containing highly suitable contiguous habitat (Figure 28). Burrowing owls have been recorded throughout the western and central branches of the Least Cost Union (Circle Mountain Biological Consultants, Inc. 2007). Almost all suitable habitats were delineated as potential core areas for burrowing owl (Figure 29). Distances among all core areas and patches are within the dispersal distance of this species (figure not shown), although barriers to movement may exist between suitable habitat patches. We believe that the Linkage Design will serve the needs of burrowing owl moving through or living in the linkage. The majority of habitats added to the Union will also benefit this species.

To restore and protect habitat for the burrowing owl, we recommend that lighting is directed away from the linkage to provide a dark zone for nocturnally active species. Species sensitive to human disturbance avoid areas that are artificially lit (Beier 1995, Longcore 2000). We also suggest local residents be informed about the proper use of rodenticides and pesticides to reduce the likelihood of ingestion of these lethal substances by the natural predators of rodent species.

Figure 28.
Habitat Suitability
for
Burrowing owl
(Athene cunicularia)



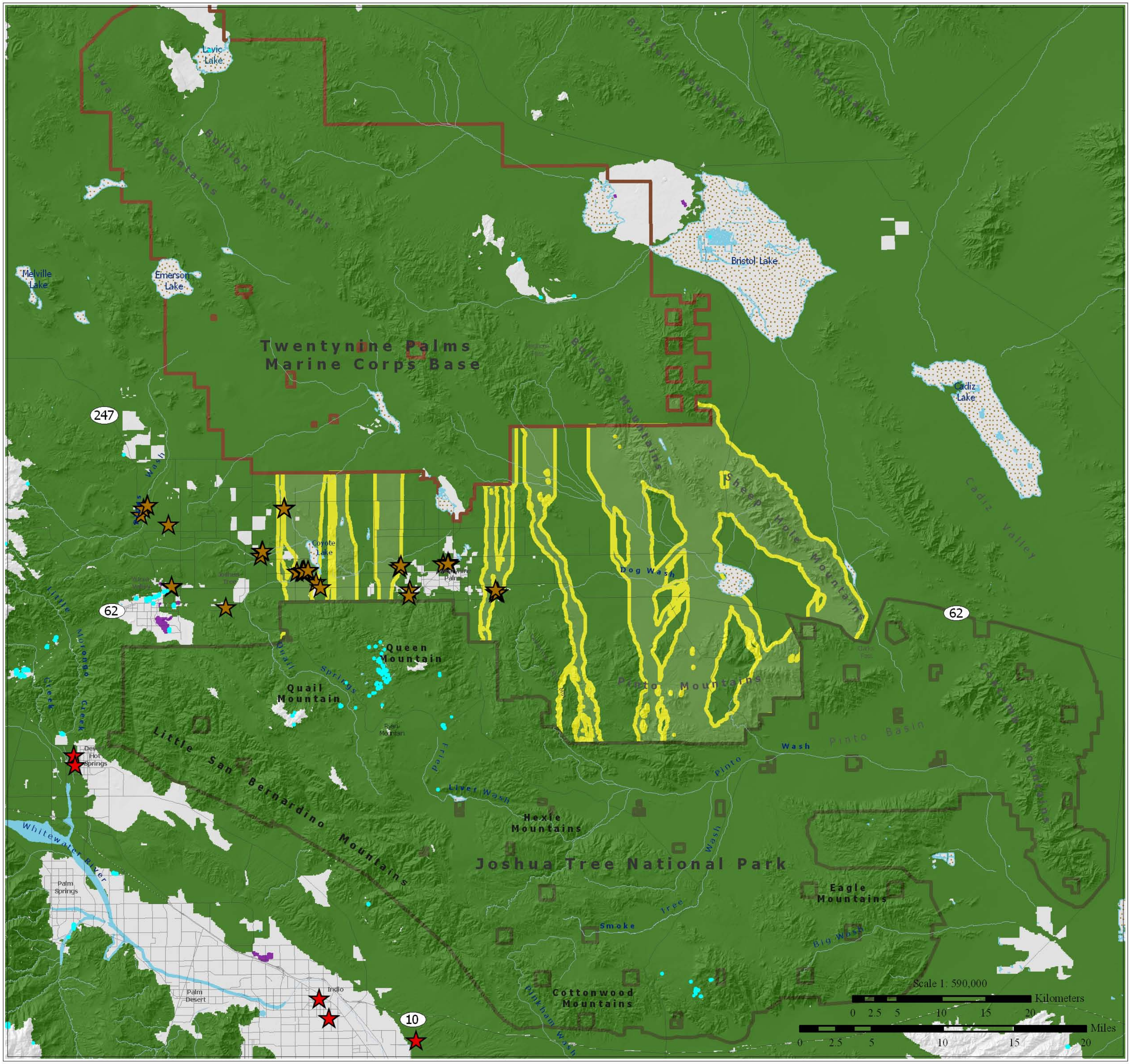
Degree of Suitability
- High
- Medium - High
- Medium
- Low - Medium
- Low
- Least Cost Union
- Dept. of Defense
- National Park Service
- Roads
- Streams
- Dry Lakes
- Waterbodies
- CNDDB Occurrence
- CMBC Occurrence

Species occurrence data from:
California Natural Diversity Database
Circle Mountain Biological Consultants, Inc.

N

Map Produced By:
SOUTH COAST WILDLANDS

Figure 29.
Potential Cores & Patches for Burrowing owl
(Athene cunicularia)



- Core
- Patch
- < Patch
- Least Cost Union
- Dept. of Defense
- National Park Service
- Roads
- Streams
- Dry Lakes
- Waterbodies
- CNDDB Occurrence
- CMBC Occurrence

Species occurrence data from:
California Natural Diversity Database
Circle Mountain Biological Consultants, Inc.

N

Map Produced By:
South Coast Wildlands

Loggerhead shrike (*Lanius ludovicianus*)

Justification for Selection: Loggerhead shrike is a resident species that requires a mosaic of open habitats with abundant prey to persist. They have been declining throughout North America since the 1960s (Robbins et al. 1986, Sauer et al. 2001). They are sensitive to habitat loss, fragmentation, and degradation (Fraser and Luukkonen 1986, Pruitt 2000).

Distribution & Status: Loggerhead shrike ranges throughout much of North America from southern Canada to northern Mexico. They are common residents and winter visitors in the lowlands and foothills of California (Faber et al. 1989, Zeiner et al. 1990). They are absent from heavily forested areas and higher elevations in the desert ranges, typically occurring below 1524 m (5000 ft) in elevation (Small 1994).

North American Breeding Bird Survey (BBS) data for the period 1966-2000 indicate a 71% population decline rangewide (-3.7% annually), with a decline of 75% in the western region (Sauer et al. 2001). Loggerhead shrike is designated as a federal and state Species of Special Concern (CDFG 2005).

Known or suspected threats to loggerhead shrike populations include habitat loss and degradation, fragmentation of suitable habitat, shooting, and pesticide and other toxic contamination (Fraser and Luukkonen 1986, Pruitt 2000). While there is evidence of some eggshell thinning in Illinois, there is no apparent eggshell thinning in California and Florida (Hands et al. 1989). Pesticides may pose a greater threat in reducing food availability (Yosef 1994, Yosef 1996). Threats to the grassland habitats preferred by loggerhead shrike include conversion to agriculture, overgrazing of livestock, spread of exotic species, urbanization and disrupted fire regimes (Knopf 1994, Knight et al. 1995, Saab et al. 1995, Vickery and Herkert 1999).

Habitat Associations: Loggerhead shrike prefers open country for hunting, with perches for scanning, and fairly dense shrubs and brush for nesting (Small 1994). They may utilize grasslands, pastures, savannah, pinyon-juniper woodlands, Joshua Tree woodlands, riparian woodlands, desert oases, desert scrub and washes, and to a lesser extent, agricultural fields and orchards (Small 1994). The highest density of shrike occurs in open-canopied valley foothill hardwood, valley foothill hardwood-conifer, valley foothill riparian, savannah, pinyon-juniper, juniper, desert riparian, and Joshua tree habitats (Zeiner et al. 1990, Small 1994). Shrikes are often found in open cropland, but only rarely occur in intensive agricultural areas where pesticides have limited their prey base (Zeiner et al. 1990). Loggerhead shrike isn't found on north slopes of mountain ranges, nor in pure chaparral (Small 1994), though they may use edges of denser habitats (Grinnell and Miller 1944, McCaskie et al. 1979, Garrett and Dunn 1981).

Spatial Patterns: Loggerhead shrikes are strongly territorial and aggressive during the breeding season. Shrikes maintain relatively large territories and all activities associated with reproduction (mating, foraging, brooding) occur within the territory (Yosef 1996). In mainland California, the average size of territories was 8.5 ha (21 ac), and ranged between 4.4 ha (10.9 ac) and 16 ha (39.5 ac; Yosef 1996). In Contra Costa and Kern counties, Miller (1931) found ten territories in open shrubland that averaged 7.6 ha (18.7 ac), and varied from 4.5 to 16 ha (11-40 ac). Typically, nesting territories are smaller in areas with a greater amount of good quality habitat (Kridelbaugh 1982).

Banding studies indicate that adult loggerhead shrikes exhibit some site fidelity and juveniles disperse widely (Yosef 1996). In Alberta, the average distance of juvenile dispersal was 6.7 km (4.2 mi) between years (Yosef 1996). Over a period of 3 years from the time of banding, loggerhead shrikes dispersed up to 70 km (43.5 mi) from their natal site (Yosef 1996). In Virginia, juveniles 10-13 weeks old moved an average of 5.5 km (3.42 mi) from their parents' territory to their fall territory (Blumton et al. 1989).

Conceptual Basis for Model Development: Loggerhead shrike prefers open habitat types, such as grassland and oak savanna but they may also be encountered in riparian, desert scrub and wash communities. Potential core areas were defined as greater than or equal to 213 ha (526 ac). Patch size was classified as ≥ 9 ha (22.2 ac) but less than 213 ha. Dispersal distance was defined as 13.4 km (8.3 mi).

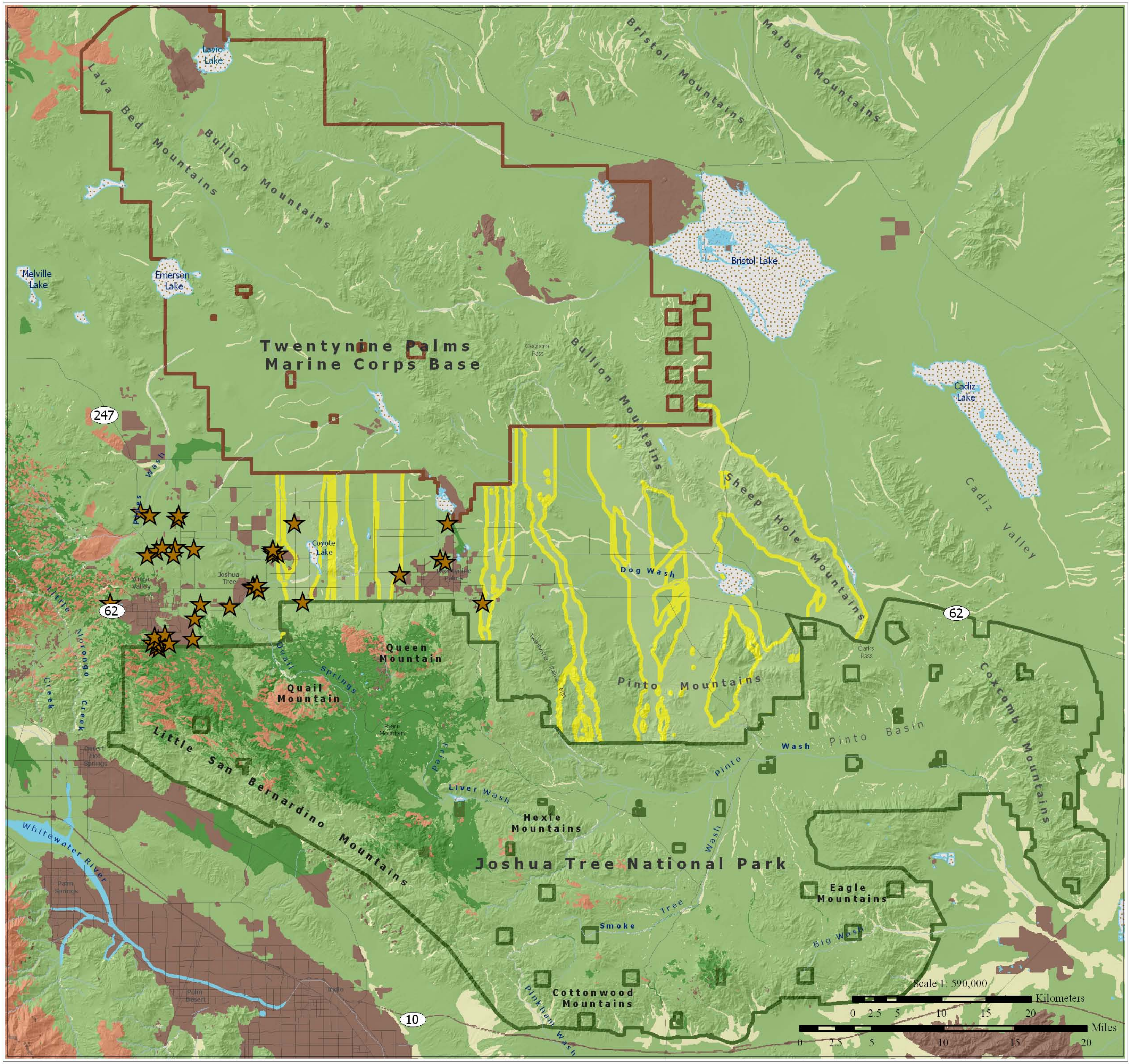
Results & Discussion: All branches of the Least Cost Union contain medium to high suitable habitat for loggerhead shrike (Figure 30). The most highly suitable habitat is concentrated in the western part of Joshua Tree National Park and westward up into the San Bernardino Mountains. The western and central branches of the Union contain recorded occurrences of this species, but the majority of sightings occur to the west of the Union between the communities of Yucca Valley and Joshua Tree, and up toward Pipes Canyon (Circle Mountain Biological Consultants, Inc. 2007). The majority of suitable habitat was identified as potential cores areas for this species (Figure 31). All potential core areas and patches of suitable habitat are within the defined dispersal distance of loggerhead shrike (figure not shown), though barriers to movement may exist between suitable habitat patches. We conclude that the linkage is likely to serve the needs of this species for movement among populations. However, loggerhead shrike would also benefit from all habitat additions to the Union.

To protect and restore habitat connectivity for loggerhead shrike, we recommend that pesticide use is restricted in shrike habitat to avoid depressing the abundance of potential prey items. Shrikes are subject to pesticide poisoning due to their position in the food chain (Hands et al. 1989).

Figure 30.
Habitat Suitability
for
Loggerhead shrike
(Lanius ludovicianus)

Degree of Suitability
- High
- Medium - High
- Medium
- Low - Medium
- Low
- Least Cost Union
- Dept. of Defense
- National Park Service
- Roads
- Streams
- Dry Lakes
- Waterbodies
- CMBC Occurrence

Species occurrence data from
Circle Mountain Biological Consultants, Inc.



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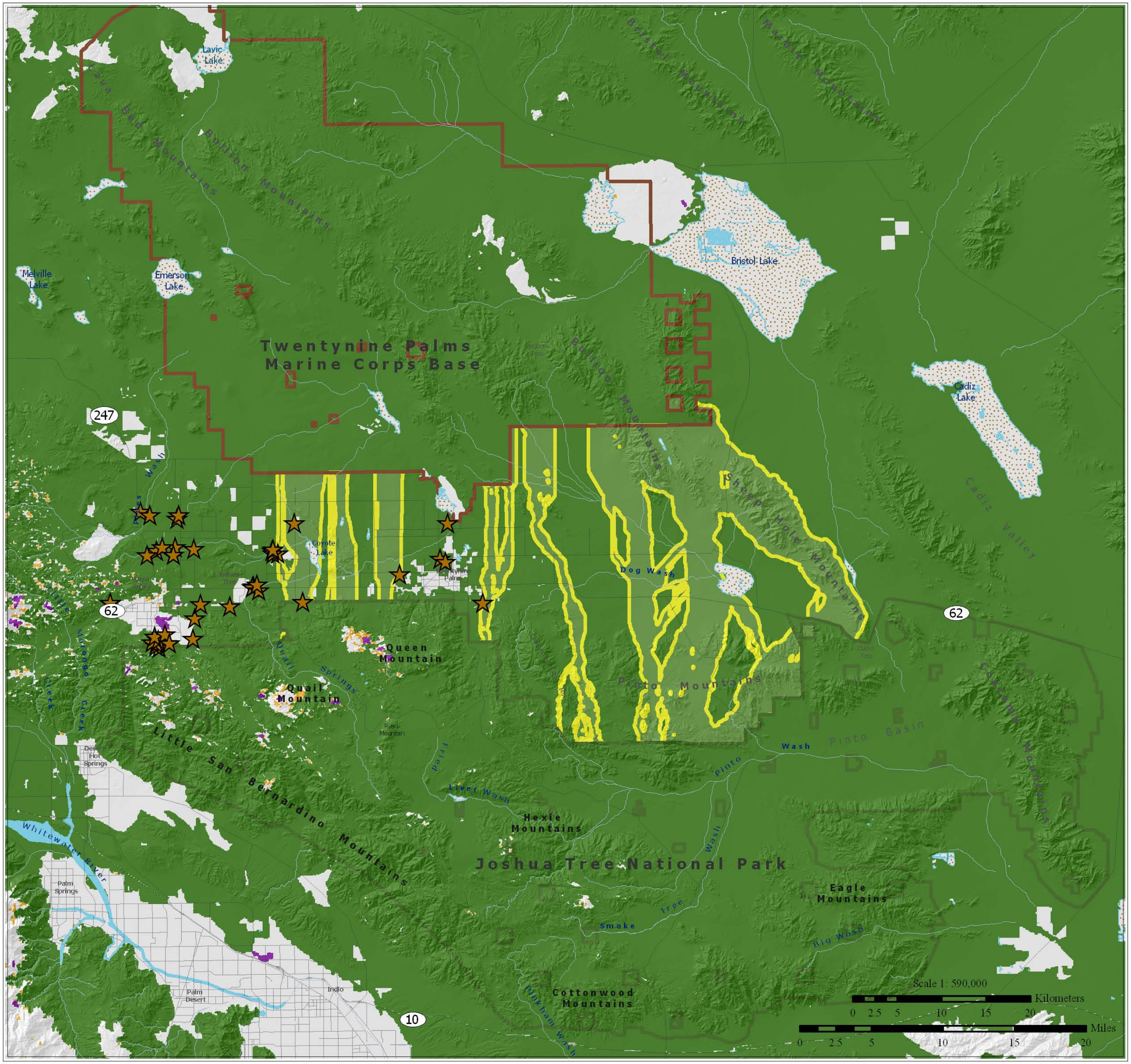
Map Produced By:
SOUTH COAST WILDLANDS

Figure 31.
Potential Cores & Patches for Loggerhead shrike
(Lanius ludovicianus)



Core
Patch
< Patch
Least Cost Union
Dept. of Defense
National Park Service
Roads
Streams
Dry Lakes
Waterbodies
CMBC Occurrence

Species occurrence data from
Circle Mountain Biological Consultants, Inc.

Map Produced By:
South Coast Wildlands

Black-throated sparrow (*Amphispiza bilineata*)

Justification for Selection: The black-throated sparrow population has declined by 63% over the last 40 years (Butcher and Niven 2007). This species has also declined in the linkage planning area where development is increasing.

Distribution & Status: The black-throated sparrow is a common summer resident east of the Cascades and the Sierra Nevada and in southern deserts; it is an uncommon, local winter resident of the Colorado and eastern Mojave deserts (CDFG 2005).

This species has no special status (CDFG 2007), despite the tremendous decline in the population (Butcher and Niven 2007). The primary reason cited for the decline is altered fire regimes, which reduces habitat quality due to invasion by nonnative plant species such as cheatgrass. Global warming is expected to make the southwestern United States even drier, resulting in even more frequent fires (Butcher and Niven 2007).

Habitat Associations: The black-throated sparrow inhabits a variety of chaparral and desert scrub habitats with sparse or open stands of shrubs, especially cholla (*Opuntia* spp.), ocotillo (*Fonquieria splendens*), creosotebush (*Larrea tridentate*), and saltbush (*Atriplex* spp.), or scattered Joshua trees (*Yucca brevifolia*; CDFG 2005). It also frequents rocky desert slopes and alluvial fans and can be found on both sloping and level terrain (Bent 1968, CDFG 2005).

Spatial Patterns: In California, Kubik and Remsen (1977) recorded black-throated sparrow densities in desert scrub dominated by creosote bush and burrobush to be 7 per 40 hectares (100 ac). In New Mexico, Raitt and Maze (1968) estimated 3.9 to 10.5 individuals per 40 ha (100 ac) in creosote dominated natural communities.

In New Mexico, territory size varied from 1.1 to 1.8 ha (2.7 to 4.4 ac) with an average of 1.5 ha (3.7 ac) in creosote bush scrub (Heckenlively 1967). In Texas, Dixon (1959) reported territory varied between 0.4 and 0.8 ha (1 and 2 ac) in desert scrub habitat.

Conceptual Basis for Model Development: Black-throated sparrow prefers sparsely vegetated areas in chaparral and desert scrub habitats. Potential core areas were defined as greater than or equal to 40.47 ha (100 ac). Patch size was classified as $\geq$ 2 ha (4.9 ac) but less than 40.47 ha. Dispersal distance was not estimated for this species.

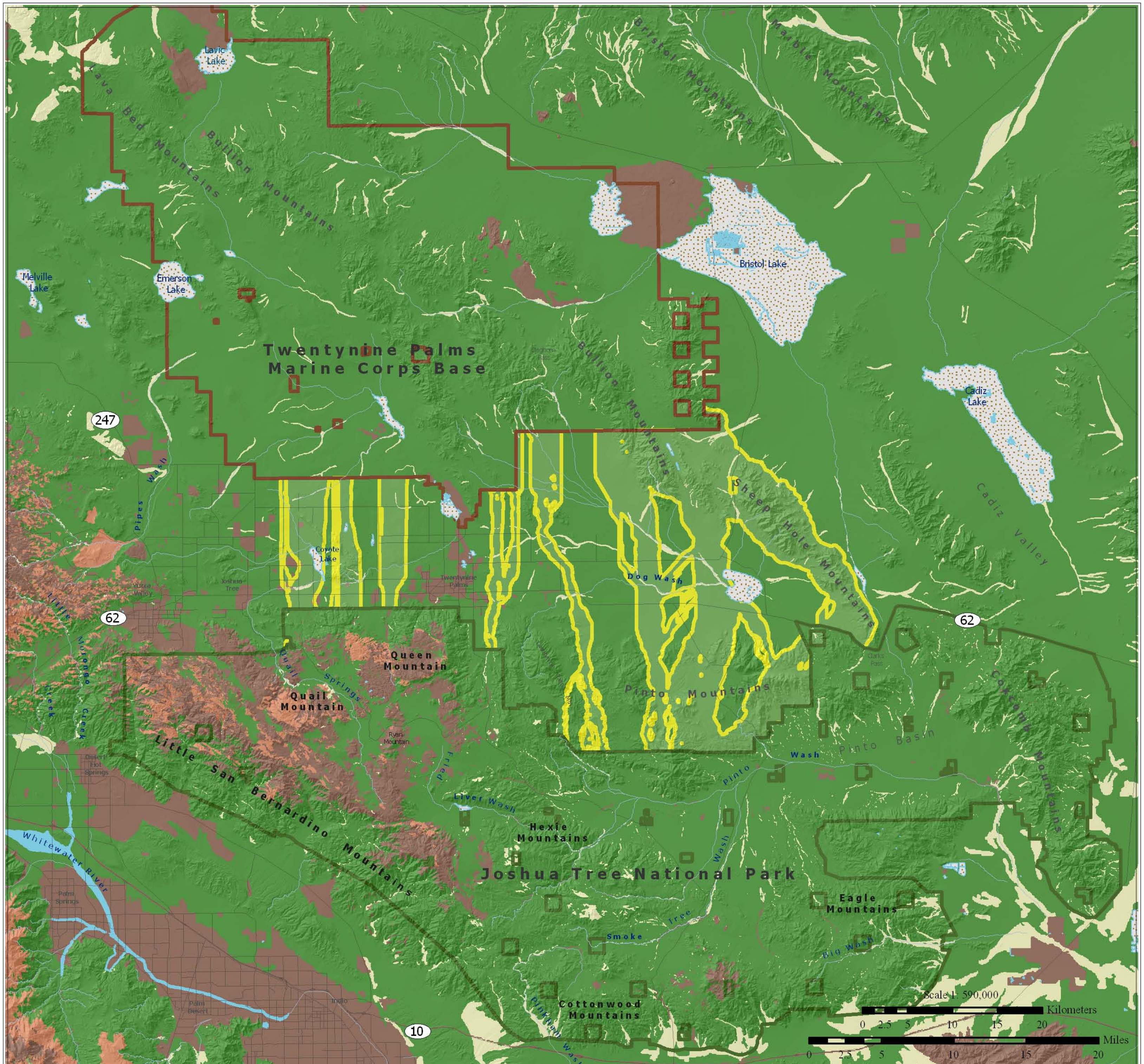
Results and Discussion: The majority of natural habitats in the planning area were identified as highly suitable for the black-throated sparrow, with all branches of the Least Cost Union containing highly suitable contiguous habitat for this species (Figure 32). Almost the entire planning area was identified as potential cores areas for this species, thus black-throated sparrow would also benefit from virtually all habitat additions to the Union (Figure 33). We conclude that the linkage is likely to serve the needs of this species for movement among populations.

To protect and restore habitat connectivity for black-throated sparrow, we recommend that fire frequency is controlled to prevent type conversion of sagebrush and desert scrub habitats to nonnative annual grassland, and that land in the linkage is managed for habitat values with strict regulations for grazing, mining, and energy development.

Figure 32.
Habitat Suitability
for
Black-throated sparrow
(Amphispiza bilineata)

Degree of Suitability

- High
- Medium - High
- Medium
- Low - Medium
- Low
- Least Cost Union
- Dept. of Defense
- National Park Service
- Roads
- Streams
- Dry Lakes
- Waterbodies



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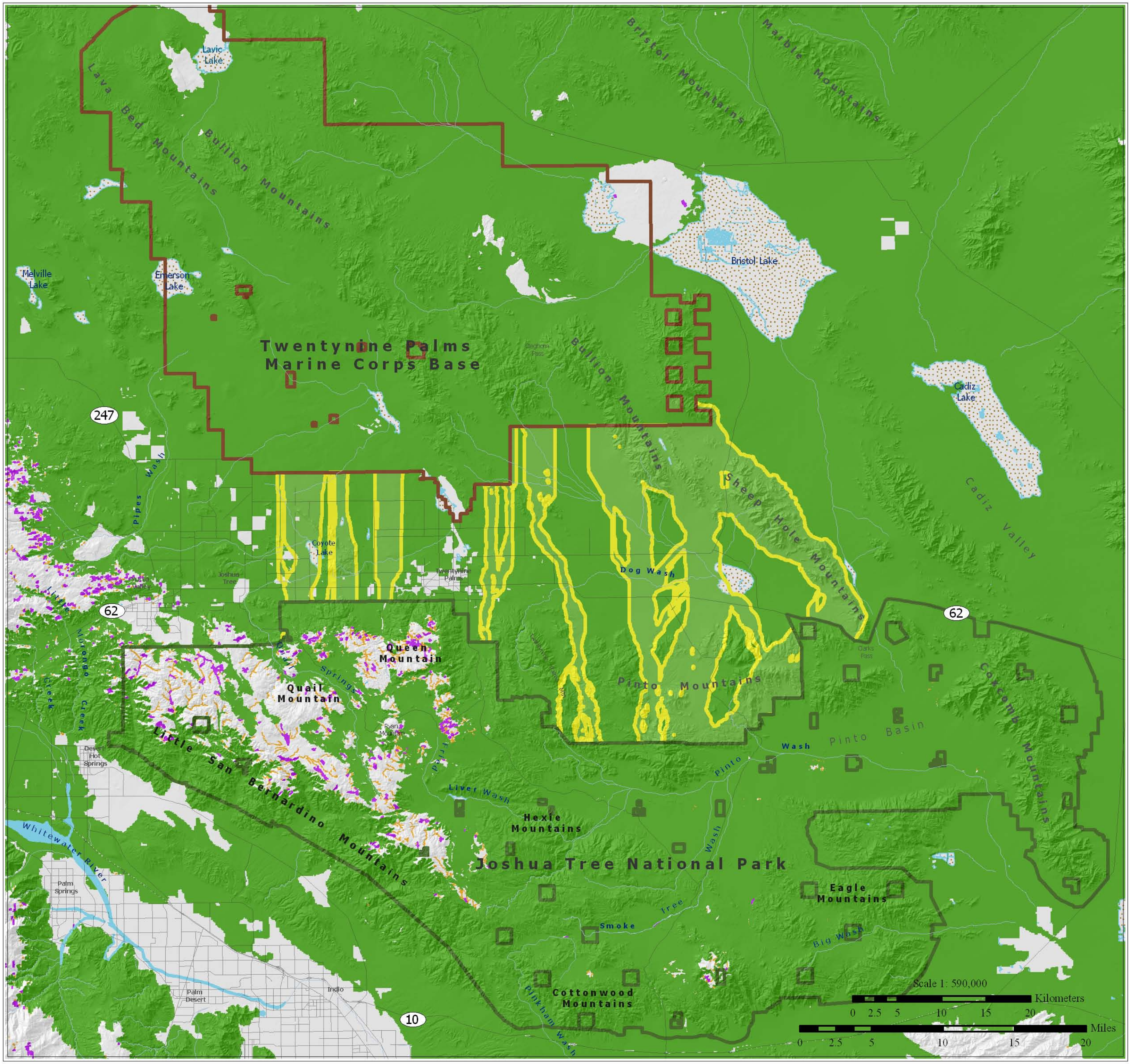
Map Produced By:

SOUTH COAST WILDLANDS

Figure 33.
Potential Cores & Patches for Black-throated sparrow
(Amphispiza bilineata)

- Core
- Patch
- < Patch
- Least Cost Union
- Dept. of Defense
- National Park Service
- Roads
- Streams
- Dry Lakes
- Waterbodies



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Map Produced By:
South Coast Wildlands

Le Conte's Thrasher (*Toxostoma lecontei*)

Justification for Selection: Populations of the Le Conte's thrasher are sensitive to habitat loss, fragmentation, and disturbance, due to urban and agricultural development, altered fire regimes, off-road vehicle use, livestock grazing, and oil drilling (Audubon 2002, CVMSHCP 2007).

Distribution & Status: The distribution of the Le Conte's thrasher includes the San Joaquin Valley, the Mojave and Colorado deserts of California and Nevada southward into Baja California, and the Sonoran Desert from southwestern Utah and western Arizona down into western Sonora, Mexico (CVMSHCP 2007). It is an uncommon, local resident in southern California deserts (CDFG 2005). Historically it occurred north to Fresno County, but it hasn't been recorded there since the 1950s (Grinnell and Miller 1944, McCaskie et al. 1979, 1988, Garrett and Dunn 1981). In the Mojave Desert, it can be found up to about 1,600 m (5,250 ft) in elevation (CVMSHCP 2007).

The Le Conte's thrasher is designated as a species of special concern by the California Department of Fish and Game, and a bird of conservation concern by the U.S. USFWS (CDFG 2007). The species is threatened by habitat loss due to conversion to urban, agricultural, and other uses. It is also impacted by habitat degradation from off-road vehicles, alteration of habitat from fire, pesticides near agricultural areas, predation of young by mesopredators such as house cats, and roadkill (CVMSHCP 2007).

Habitat Associations: The Le Conte's thrasher inhabits sparsely vegetated desert wash, desert scrub, alkali desert scrub, and desert succulent shrub habitats; they may also be found in open Joshua tree woodlands (Ziener, et al. 1990; Unitt 1984; Sheppard 1970, CDFG 2005). They frequent alluvial fans, washes, and gently sloping hills dominated by saltbush (*Atriplex* spp.) and cholla (*Opuntia* spp; CVMSHCP 2007).

Spatial Patterns: The Le Conte's thrasher has an average home range size of 40 ha (100 ac) in saltbush-cholla scrub. They are territorial, with average nesting territories of 6 ha (15 ac), which they actively defend (Sheppard 1970).

The average juvenile dispersal distance is 1200 m (3937 ft); the maximum recorded is 2500 m (8202 ft; Sheppard 1996).

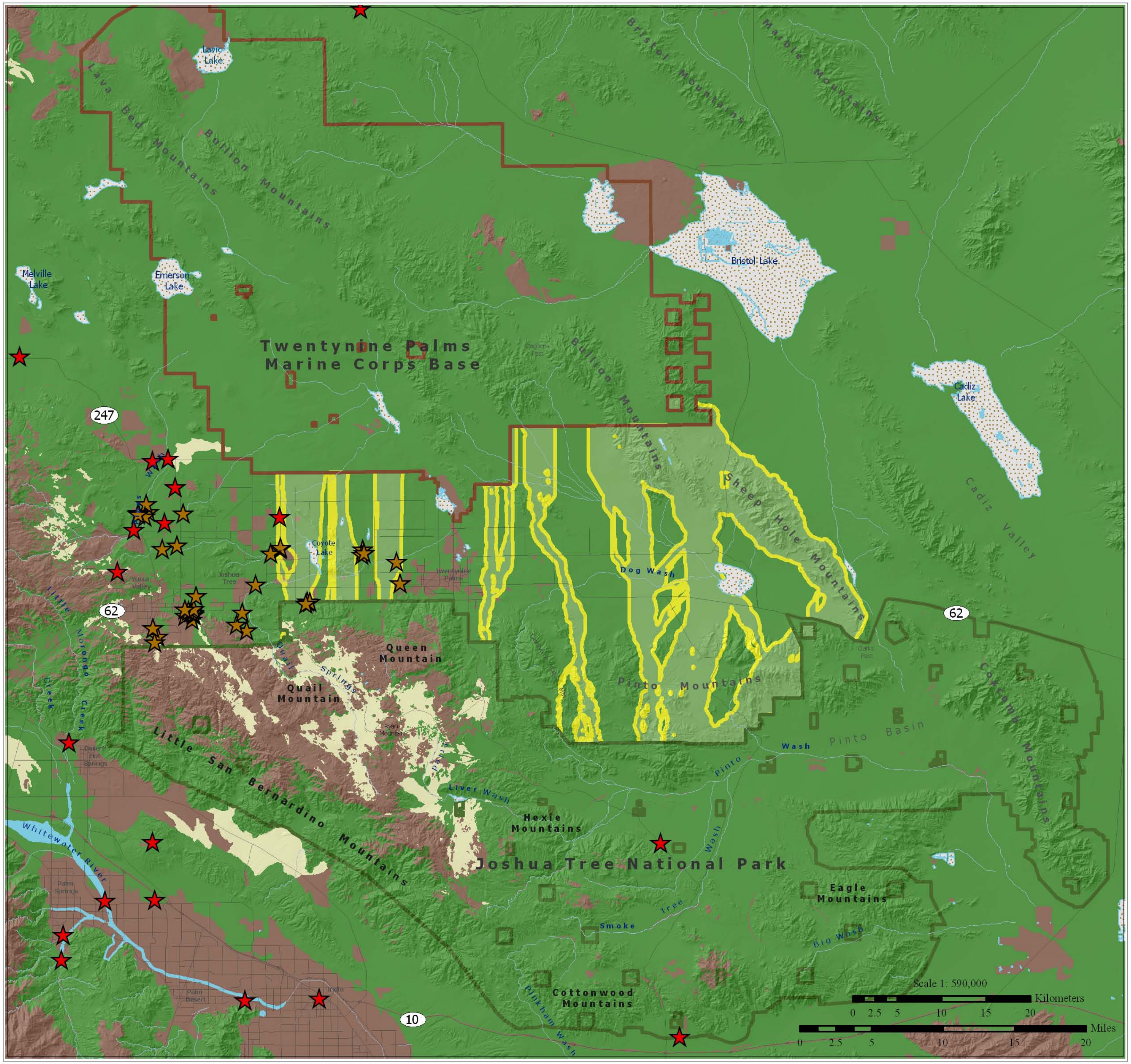
Conceptual Basis for Model Development: Le Conte's thrashers frequent desert scrub and wash habitats. Core areas were defined as greater than or equal to 1012 ha (2500 ac). Patch size is greater than or equal to 12 ha (30 ac) but less than 1012 ha. Dispersal distance was defined as 5000 m (16404 ft).

Results & Discussion: Nearly all of the natural habitats in the planning area were identified as highly suitable for the LeConte's thrasher, with all branches of the Least Cost Union containing highly suitable contiguous habitat (Figure 34). The LeConte's thrasher has been recorded throughout the three western branches of the Least Cost Union, with several other sightings to the west of the Union between the communities of Yucca Valley and Joshua Tree, and up toward Pipes Canyon (California Department of Fish and Game 2006, Circle Mountain Biological Consultants, Inc. 2007). Thus, several habitat additions to the Union will benefit this species. Almost all suitable habitats were delineated as potential core areas for LeConte's thrasher (Figure 35). Distances among all core areas and patches are within the dispersal distance of this species (figure not shown), although barriers to movement may exist between suitable habitat patches. We conclude that the Linkage Design will serve the needs of the LeConte's thrasher moving through or living in the linkage.

To protect and restore habitat connectivity for LeConte's thrasher, we recommend that fire frequency is controlled to prevent type conversion of desert scrub habitats to nonnative annual grassland. We also urge that land in the linkage be managed for habitat values with strict regulations for grazing, mining, and energy development.

Figure 34.
Habitat Suitability
for
LeConte's thrasher

(Toxostoma lecontei)



Degree of Suitability
- High
- Medium
- Low
- Least Cost Union
- Dept. of Defense
- National Park Service
- Roads
- Streams
- Dry Lakes
- Waterbodies
- CNDDB Occurrence
- CMBC Occurrence

Species occurrence data from:
California Natural Diversity Database
Circle Mountain Biological Consultants, Inc.

N

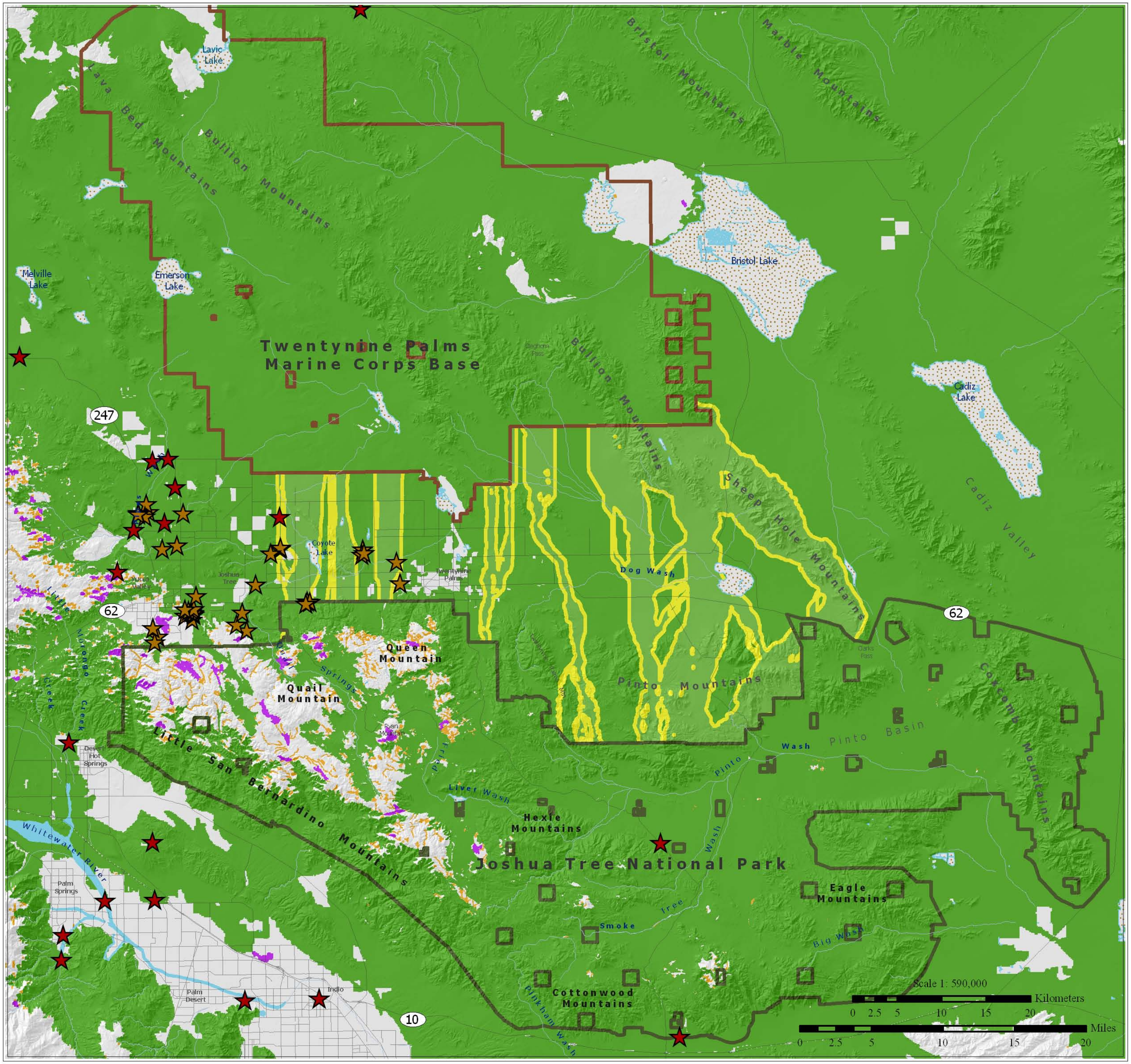
Map Produced By:
SOUTH COAST WILDLANDS

Figure 35.
Potential Cores & Patches for Leconte's thrasher
(Toxostoma lecontei)

- Core
- Patch
- < Patch
- Least Cost Union
- Dept. of Defense
- National Park Service
- Roads
- Streams
- Dry Lakes
- Waterbodies
- CNDDB Occurrence
- CMBC Occurrence

Species occurrence data from:
California Natural Diversity Database
Circle Mountain Biological Consultants, Inc.

Map Produced By:
SOUTH COAST WILDLANDS



Black-tailed Gnatcatcher (*Polioptila melanura*)

Justification for Selection: Black-tailed gnatcatchers are indicator species of high quality habitats (Farquhar 2002). They are highly sensitive to disturbance and quickly disappear from areas converted to urban and agricultural uses, or heavily degraded by intensive off-highway vehicle user (Tinant 2006).

Distribution & Status: Historically, the black-tailed gnatcatcher was considered to be conspecific with the California gnatcatcher (Atwood 1986). In 1989, the Ornithologists' Union (AOU) split *P. melunura* into two species: California gnatcatcher (*Polioptila californica*) and black-tailed gnatcatcher (*P. melanura*). There are three subspecies of the black-tailed gnatcatcher: *P.m. melanura*, *P.m. curtata*, and *P.m. lucida*; *P.m. lucida* is the subspecies that occurs in California (Tinant 2006).

In California, the species is distributed from southern Inyo County through eastern San Bernardino, Riverside, and Imperial counties to the Mexican border. It occurs in the Colorado and Mojave deserts as far west as Barstow and Morongo Valley in San Bernardino County, the San Gorgonio Pass in Riverside County, and Anza Borrego State Park in Imperial County (Small 1994). Black-tailed gnatcatchers are restricted to elevations ranging from 75 to 900 m (250 to 3000 ft), with breeding typically occurring below 300 m (1000 ft; Grinnell and Miller 1944, Atwood 1988, Small 1994).

The black-tailed gnatcatcher has no special status, while the California gnatcatcher is listed as threatened (CDFG 2007). Black-tailed gnatcatcher populations have declined in the last few decades due to habitat loss, fragmentation, and degradation (Remsen 1978, Farquhar 2002, Tinant 2006).

Habitat Associations: The black-tailed gnatcatcher prefers desert wash habitats dominated by mesquite (*Prosopis glandulosa*), palo verde (*Cercidium microphyllum*), ironwood (*Olneya tesota*), and acacia (*Acacia* spp.), but it may also be found in desert scrub habitats (Grinnell and Miller 1944, Garrett and Dunn 1981, CDFG 2005). The species is not present in areas where exotic vegetation, such as saltcedar (*Tamarix ramosissima*), dominates (Small 1994).

Spatial Patterns: Black-tailed gnatcatchers territory size during the breeding season ranges from 0.8 to 2.7 ha (2.0 to 6.7 ac; Laudenslayer 1981, Tinant 2006). They forage over a much larger area (4.8 ha [11.8 ac]) in winter (Smith 1967). Though resident throughout much of their range, they are known to wander outside the breeding season (Farquhar et al. 2002, Tinant 2006). Dispersal distances are unknown for the black-tailed gnatcatcher, but the maximum distance documented for the California gnatcatcher is 16 km (9.94 mi; Braden 1992, Mock 2004).

Conceptual Basis for Model Development: The black-tailed gnatcatcher inhabits desert wash and scrub habitats. Core areas were defined as greater than or equal to 125 ha (309 ac). Patch size was delineated as greater than or equal to 2 ha (5 ac) but less than 125 ha. Dispersal distance was defined as 32 km (19.88 mi); double the maximum recorded distance for the California gnatcatcher.

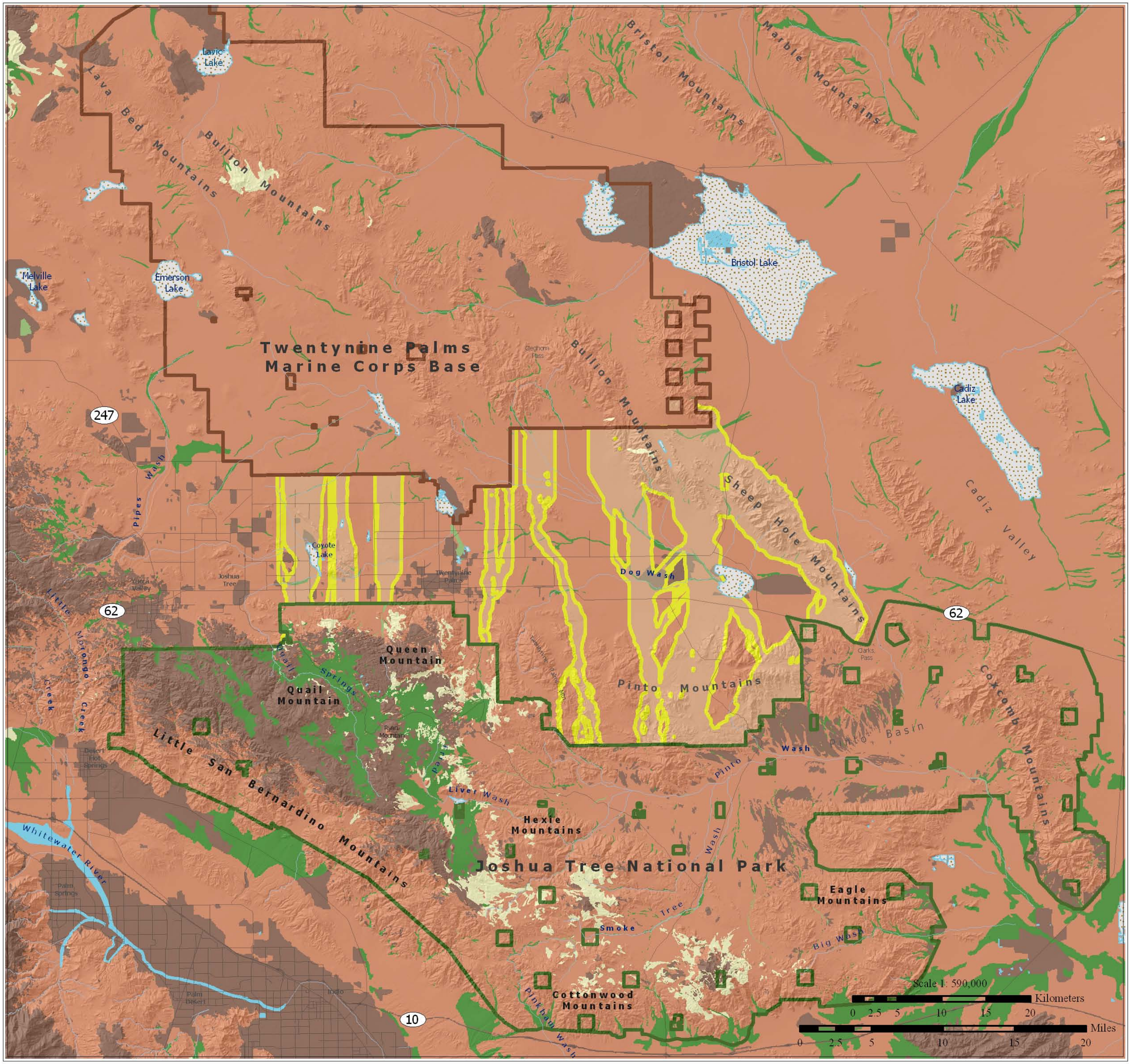
Results & Discussion: Potential habitat for the black-tailed gnatcatcher is largely restricted to desert riparian and wash habitats in the planning area, with very little potentially suitable habitat captured by the Least Cost Union (Figure 36). Though potential cores areas and patches of suitable habitat occur throughout the planning area for this species, the majority of larger core areas are within Joshua Tree National Park (Figure 37). Distances among all core areas and patches are within the dispersal distance of this species (figure not shown), although barriers to movement may exist between suitable habitat patches. The habitat additions along Pipes Canyon Wash, Quail Springs, Dog Wash, Dale Lake Wash and Bristol Lake Wash will provide habitat for this species, protect natural hydrological and fluvial processes, and protect key movement corridors. With these additions, we believe the linkage will accommodate the live-in and move-through needs of the black-tailed gnatcatcher.

To protect and restore habitat and connectivity for the black-tailed gnatcatcher, we recommend that riparian areas, washes and arroyos be protected and restored. These habitats should be left undisturbed by excluding intensive activities such as off-road vehicles, grazing, and mining.

Figure 36.
Habitat Suitability
for
Black-tailed gnatcatcher
(Polioptila melanura)

Degree of Suitability

- High
- Medium - High
- Medium
- Low - Medium
- Low
- Least Cost Union
- Dept. of Defense
- National Park Service
- Roads
- Streams
- Dry Lakes
- Waterbodies



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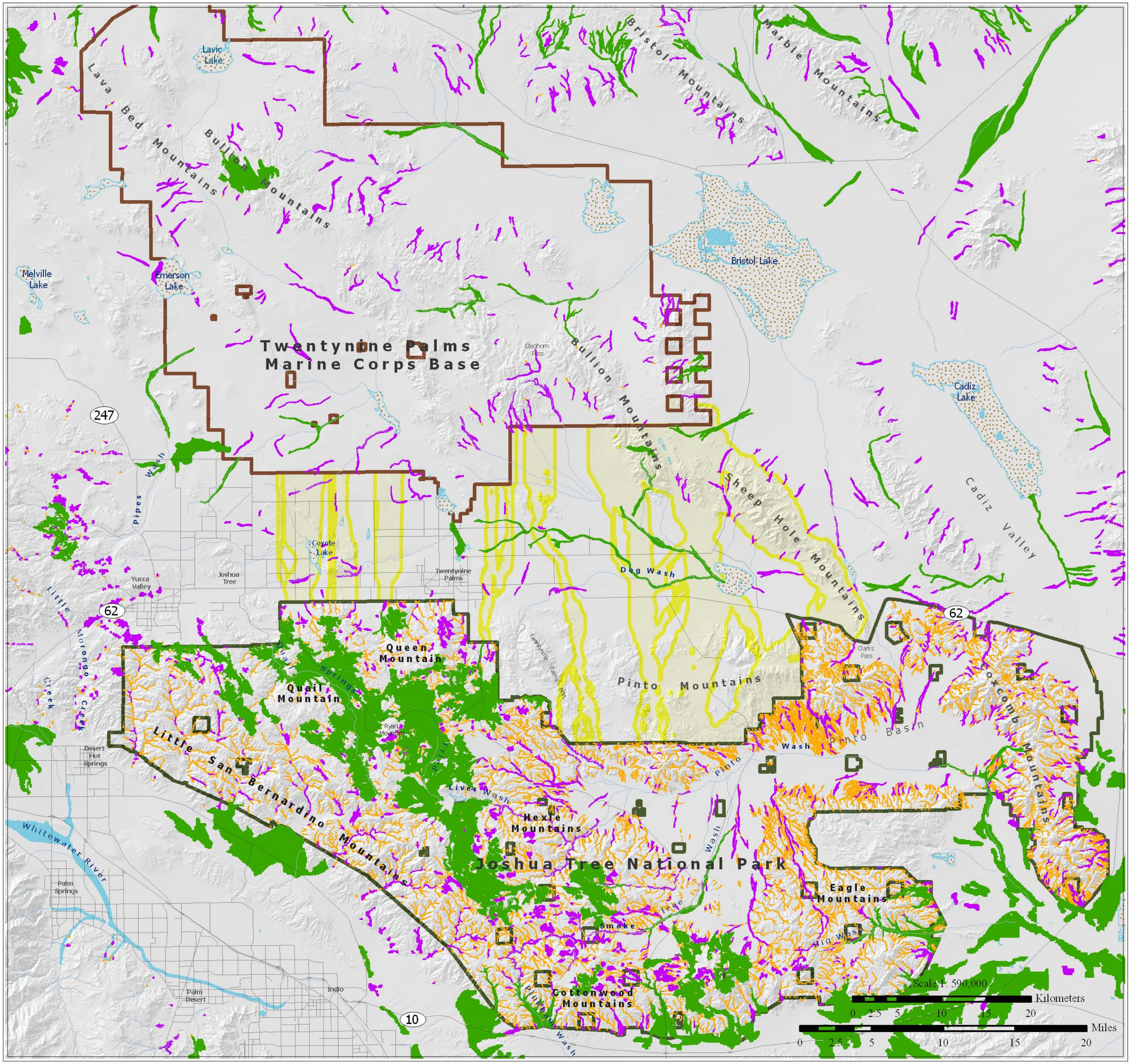
Map Produced By:

SOUTH COAST WILDLANDS

Figure 37.
Potential Cores & Patches
for
Black-tailed gnatcatcher
(Polioptila melanura)



Core
Patch
< Patch
Least Cost Union
National Park Service
Dept. of Defense
Roads
Streams
Dry Lakes
Waterbodies

N

Map Produced By:
SOUTH COAST WILDLANDS

Desert Tortoise (*Gopherus agassizii*)

Distribution & Status: The desert tortoise is distributed throughout the Mojave and Sonoran deserts of Nevada, Utah, Arizona, California, and Mexico from sea level to around 1220 m (4000 ft) in elevation (Stebbins 1985). There are two subspecies, the Sonoran population which is found south and east of the Colorado River, and the Mojave population found to the north and west of the river (Lamb et al. 1989, Boarman 2002a). The Mojave population typically occurs between 305 to 1524 m (1000-5000 ft) in elevation (W. Boarman, pers. comm.)

The Mojave population is federally and state listed as threatened. The precipitous decline in the Mojave population is attributed to the destruction, degradation, and fragmentation of desert tortoise habitat (USFWS 1994). Threats include urbanization, agricultural development, livestock grazing, energy and mineral development, collecting by humans, upper respiratory tract disease, drought, fire, garbage and litter, invasive plants, landfills, military operations, noise and vibration, off-road vehicle activities, predation, and roads, highways and railroads (USFWS 1994, Boarman 2002b). Roadkills are an important source of mortality and population decline (Berry and Nicholson 1978, Boarman and Sazaki 2006, USFWS 2008). For instance, Boarman and Sazaki (1996) reported finding 115 tortoise carcasses along 28.8 km of highway in the west Mojave. Roads fragment habitat by restricting movement between populations, increasing the rate of local extinctions, and the potential for inbreeding and inbreeding depression. These effects are exacerbated by increases in traffic volume, width of highways, and time (Nicholson 1978, Boarman et al. 1993, von Seckendorff Hoff and Marlow 2002).

Habitat Associations: The desert tortoise frequents desert oases, riverbanks, washes, and occasionally rocky slopes (Stebbins 1985). Vegetation communities utilized include creosote scrub, saltbush scrub, scrub steppe, and blackbush scrub (USFWS 2008). Within these communities, tortoises primarily occur on flats, valleys, alluvial fans, and bajadas, but they can also be found on rolling hills, rocky terrain and slopes in some areas (USFWS 2008). They require sandy to gravelly soils to dig their burrows (USFWS 2008). Creosote bush is often the dominant plant in its habitat (Stebbins 1985).

Spatial Patterns: Home range sizes range from 4 to 180 ha (10-450 ac), and vary depending on sex, age, season, and the availability of resources (USFWS 1994). In the western Mojave, home ranges as small as 2 ha (5 ac) have been recorded (USFWS 1994), with an average home range size of 50 ha (125 ac; Boarman 2002a).

Pre-breeding males have greater dispersal distances, which can be 10-15 km (6.21-9.32 mi) in some areas (Sazaki et al. 1995).

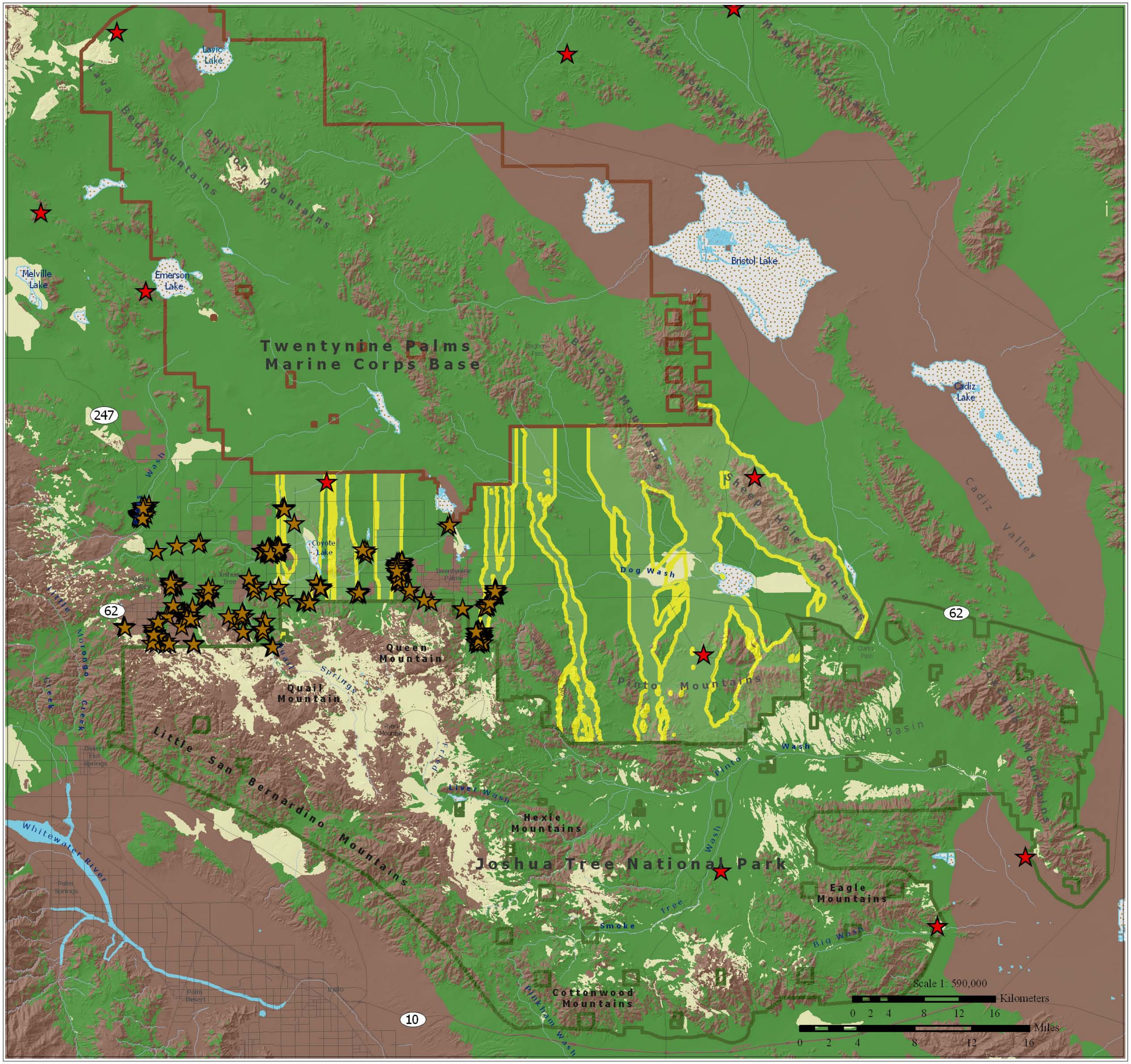
Conceptual Basis for Model Development: Desert tortoise inhabits creosote scrub, saltbush scrub, scrub steppe, and blackbush scrub habitats. They are typically associated with flats, valleys, bajadas, and rolling hills; they avoid plateaus, playas, steep slopes (>20%), and other significant barriers to movement (Weinstein 1989). Core areas were defined as greater than or equal to 1272 ha (3144 ac). Patch size was classified as greater than or equal to 4.05 ha (10 ac) but less than 1272 ha. Dispersal distance was defined as 32.19 km (20 mi).

Results & Discussion: The analysis identified highly suitable habitat for desert tortoise in all branches of the Least Cost Union (Figure 38). The western, central, and two easternmost branches of the Union all contain recorded occurrences of this species, with several additional sightings to the west of the Union along the boundary of the park, between the communities of Yucca Valley and Joshua Tree, and up toward Pipes Canyon (California Department of Fish and Game 2006, Circle Mountain Biological Consultants, Inc. 2007). As such, desert tortoise would certainly benefit from all habitat additions to the Union. We note that the numerous observations from Circle Mountain Biological Consultants, Inc. (2007) are limited to a certain geographic area where their surveys occurred and should not be taken to imply the species does not occur in high densities in other areas within the planning area. The majority of suitable habitat was identified as potential cores areas for this species (Figure 39). All potential core areas and patches of suitable habitat are within the defined dispersal distance of desert tortoise (figure not shown), though barriers to movement may exist between suitable habitat patches. We conclude that with the additions, the linkage is likely to serve the habitat and movement needs of the desert tortoise.

Road kills are an important cause of desert tortoise mortality and depletion of populations (Boarman and Sazaki 1996, 2006, USFWS 2008). To maintain and protect habitat and connectivity for desert tortoises, we recommend that existing road density be maintained or reduced in the Linkage Design. Crossing structures should be provided under freeways and major roads, and speeds should be reduced where tortoise cross roads. In 1990, the California Department of Transportation erected a tortoise-proof fence along State Highway 58 between Barstow and Kramer Junction and installed a series or tortoise crossings that have successfully reduced road kill along this stretch of highway (Boarman and Sazaki 1996). We urge similar tortoise crossing improvements along Highway 62 during the next transportation project along this route.

We recommend that inholdings that could fragment tortoise habitat be conserved through conservation easements, fee title agreements, acquisition, or other means to prevent conversion to urban or agricultural development. We also recommend that fire frequency be controlled to prevent type conversion of desert scrub habitats to nonnative annual grassland, and urge that land in the linkage be managed for habitat values with strict regulations for grazing, mining, off-road vehicle driving, and energy development.

Figure 38.
Habitat Suitability
for
Desert tortoise
(Gopherus agassizii)



Degree of Suitability
- High
- Medium
- Low
- Least Cost Union
- Dept. of Defense
- National Park Service
- Roads
- Streams
- Dry Lakes
- Waterbodies
- CNDDB Occurrence
- CMBC Occurrence

Species occurrence data from:
California Natural Diversity Database
Circle Mountain Biological Consultants, Inc.

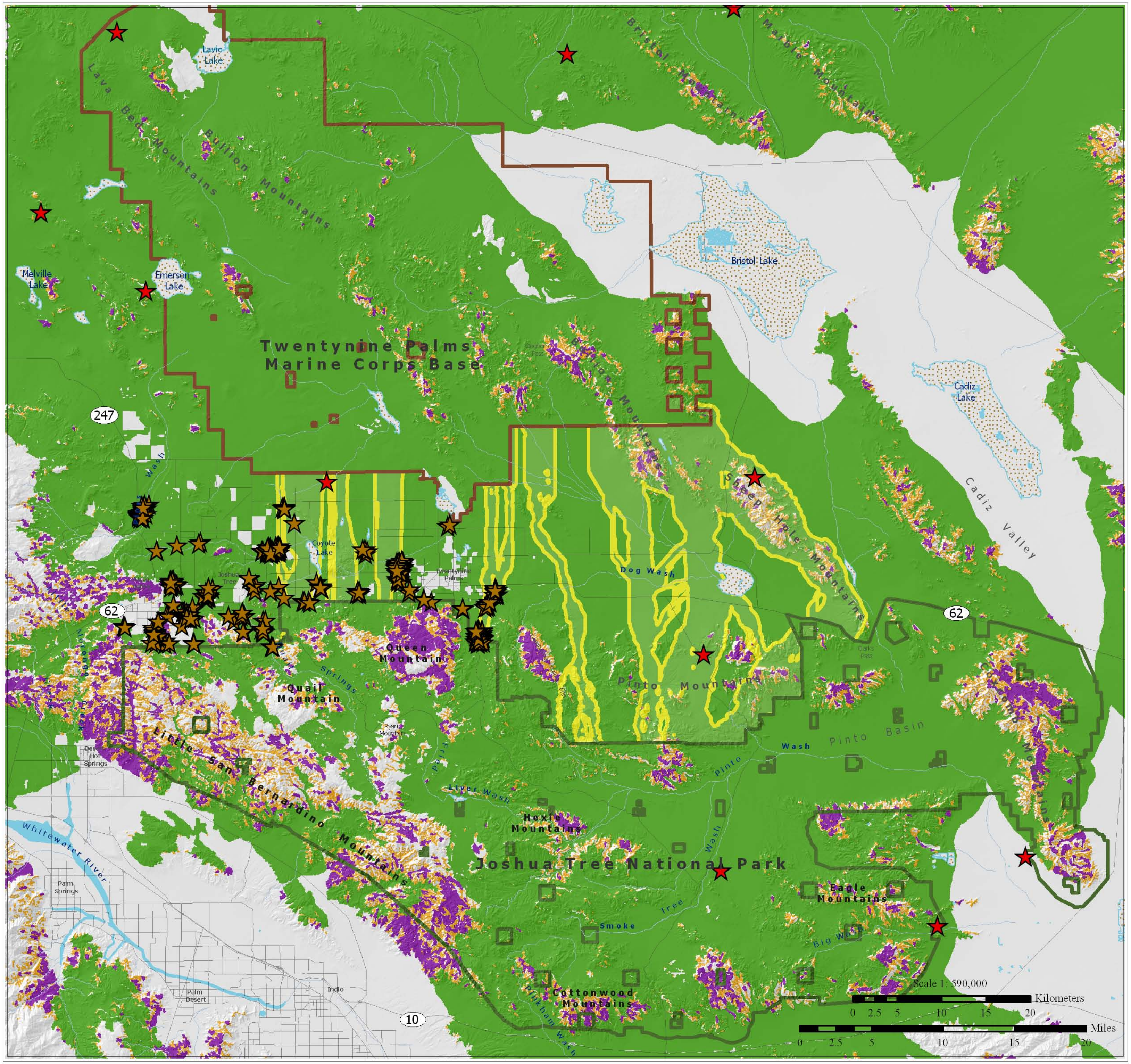
N

Map Produced By:
South Coast Wildlands

Figure 39.
Potential Cores & Patches for Desert tortoise
(Gopherus agassizii)

- Core
- Patch
- < Patch
- Least Cost Union
- National Park Service
- Dept. of Defense
- Roads
- Streams
- Dry Lakes
- Waterbodies
- CNDDB Occurrence
- CMBC Occurrence

Species occurrence data from:
California Natural Diversity Database
Circle Mountain Biological Consultants, Inc.



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Map Produced By:

SOUTH COAST WILDLANDS

Mojave fringe-toed lizard (*Uma scoparia*)

Justification for Selection: The Mojave fringe-toed lizard is a sand dune specialist that depends on the maintenance of dune ecosystem processes, such as sand transport and deposition (Hollingsworth and Beaman 2007), thus sand stabilization is a critical concern (C. Barrows, pers. comm.). This species is also considered an umbrella species for plants, arthropods, reptiles, and small mammals associated with these dune ecosystems. Dune systems are quite fragile to disturbances (Weaver 1981, Beatley 1994, Barrows 1996), which can include habitat loss from urban and agricultural development, or degradation from recreational overuse, such as off-road vehicles (Hollingsworth and Beaman 2007). Roads and rocky areas are considered barriers to movement (C. Barrows, pers. comm.).

Distribution & Status: The Mojave fringe-toed lizard is distributed from the Mojave Desert to the southern end of Death Valley in Inyo, San Bernardino, Los Angeles, and Riverside counties (CDFG 2005). It may be found from sea level up to 915 m (3,000 ft) in elevation (Stebbins 1985). Most of the areas where it occurs are associated with the drainages and sand dune complexes of the Mojave and Amargosa Rivers (Norris 1958).

This lizard is classified as a species of special concern by the California Department of Fish and Game, and a sensitive species by the Bureau of Land Management. It is highly sensitive to habitat loss, fragmentation, and degradation.

Habitat Associations: Habitat for the Mojave fringe-toed lizard includes sand dunes, sand sheets, and wind dominated transitional sand-vegetation areas in the Mojave Desert (Cablk and Heaton 2002). It is restricted to the fine, loose, wind-blown sand deposits that are found in dunes, dry lakebeds, riverbanks, desert washes, sparse alkali scrub and desert shrub habitats (Heifetz 1941, Stebbins 1944, 1972, 1985, Norris 1958, CDFG 2005). Key habitat features are intact processes for dune development, dry lakes, washes, and sand transport corridors (C. Barrows, pers. comm.).

Spatial Patterns: Males have larger home range sizes than females. Home range size varies between 0.3-0.7 ha (0.74-1.73 ac; C. Barrows, pers. comm.). Kaufmann (1982) found average home range size for males to be 0.10 ha (0.25 ac), while the average for females was 0.034 ha (0.08 ac). This species has limited dispersal abilities (C. Barrows, pers. comm.).

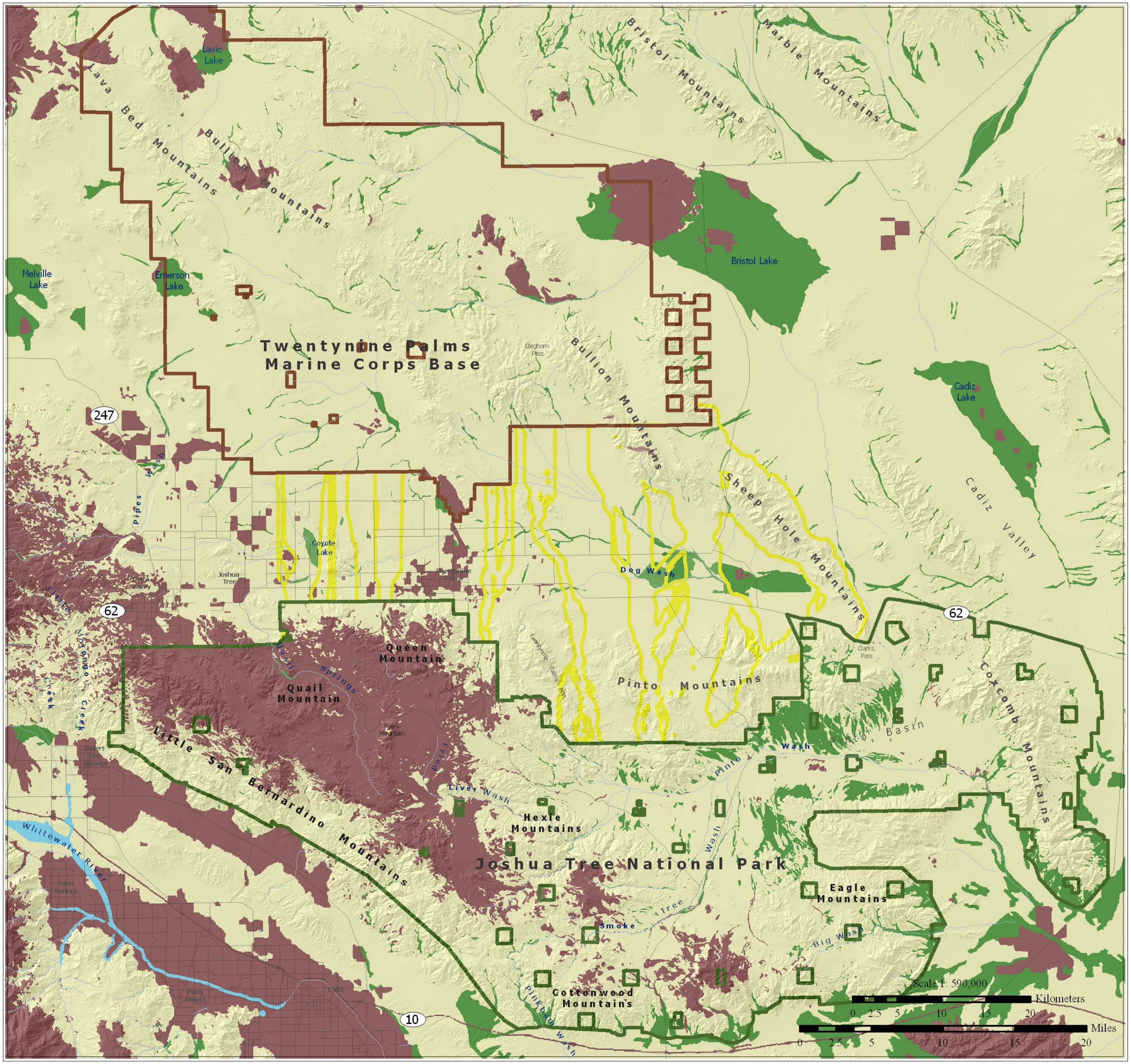
Conceptual Basis for Model Development: The Mojave fringe-toed lizard may be found in sand dunes, dry lakebeds, riverbanks, desert washes, and sparse desert scrub habitats. Core areas were defined as greater than or equal to 50 ha (124 ac). Patch size was defined as greater than or equal to 2 ha (4.94 ac) but less than 50 ha. Dispersal distance was not estimated for this species.

Results and Discussion: The most highly suitable habitat for Mojave fringe-toed lizard largely follows the desert riparian and wash habitats, which are also important sand transport corridors (Figure 40). All branches of the Least Cost Union contain fairly contiguous medium to high suitable habitats (Figure 40). The majority of suitable habitat was identified as potential core areas (Figure 41), with the central and eastern branches providing the most direct connection between large expanses of potentially suitable habitat. We conclude that the linkage is likely to serve the needs of this species if habitat is added to the Union along Dog Wash, Dale Lake Washes, the unnamed drainage in between Dale and Dog washes, and Bristol Lake Wash.

To protect and restore habitat connectivity for the Mojave fringe-toed lizard, we recommend that inholdings that could fragment habitat be conserved through conservation easements, fee title agreements, acquisition, or other means. We urge that land in the linkage be managed to maintain dune ecosystem processes, such as sand transport and deposition (Hollingsworth and Beaman 2007, C. Barrows, pers. comm.) for this sand dune specialist. We also suggest strict regulations for off-road vehicles, urban, agricultural, and energy development. When the next transportation improvement project occurs in this area, crossing structures should be placed fairly frequently to facilitate movement and reduce travel distance (Jackson and Griffin 2000, McDonald and St. Clair 2004). Short retaining walls should be installed in conjunction with structures to deter lizards from accessing roads (Jackson and Griffin 2000).

Figure 40.
Habitat Suitability
for
Mojave fringe-toed lizard
(Uma scoparia)

Degree of Suitability
- High
- Medium
- Low
- Least Cost Union
- Dept. of Defense
- National Park Service
- Roads
- Streams
- Waterbodies



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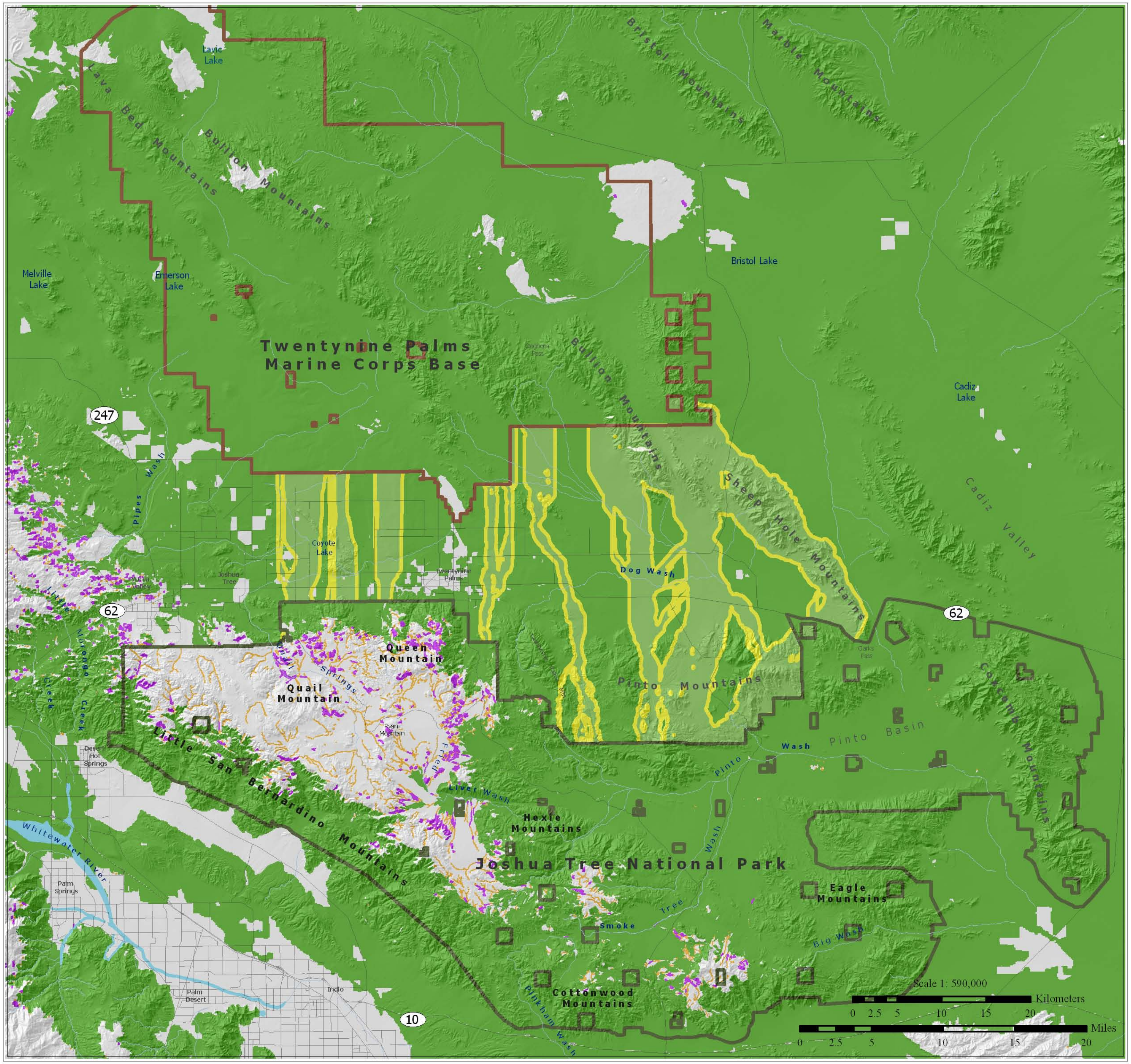
Map Produced By:

SOUTH COAST WILDLANDS

Figure 41.
Potential Cores & Patches for Mojave fringe-toed lizard
(Uma scoparia)



Map Produced By:

SOUTH COAST WILDLANDS

Justification for Selection: The chuckwalla is a habitat specialist that is restricted to rocky outcrops. It acts as an umbrella species for other reptiles such as the collared lizard, and speckled rattlesnake.

Distribution & Status: The chuckwalla is broadly distributed throughout the Mojave, Colorado, and Sonoran deserts from sea level to 1219 m (4000 ft; Stebbins 1985, Zeiner et al. 1988, Macey and Papenfuss 1991, Brodie et al. 2003).

The chuckwalla is considered a species of special concern. Its large body size, striking appearance, and tendency to perch out in the open make it particularly vulnerable to collecting (Fitch et al. 1982, Brodie et al. 2003).

Habitat Associations: The chuckwalla inhabits boulder piles, rock outcrops and crevices in a variety of desert woodland and scrub habitats but is most frequently associated with creosote communities. It is restricted to areas that provide rocky cover, usually on slopes and less frequently on flats (Shaw 1939, Stebbins 1954, Johnson 1965, Nagy 1971, Berry 1974, Zeiner et al. 1988). Chuckwalla abundance is greatest in mountainous terrain that contains both suitable basking sites and crevices for retreat (Brodie et al. 2003).

Spatial Patterns: Chuckwallas are territorial, though males are tolerant of females (Berry 1974, Zeiner et al. 1988). Berry (1974) found home range size to range from 1-3.3 ha (2.5-8.3 ac), and average 1.9 ha (4.8 ac; Zeiner et al. 1988). Other research found average home range size of 10 ha (24.71 ac; Johnson 1965, Berry 1974, Brodie et al. 2003). Kwiatkowski and Sullivan (2002*b*) found female home ranges to be related to the availability of food resources, while male home ranges were related to female distribution, population density, and geology (Brodie et al. 2003).

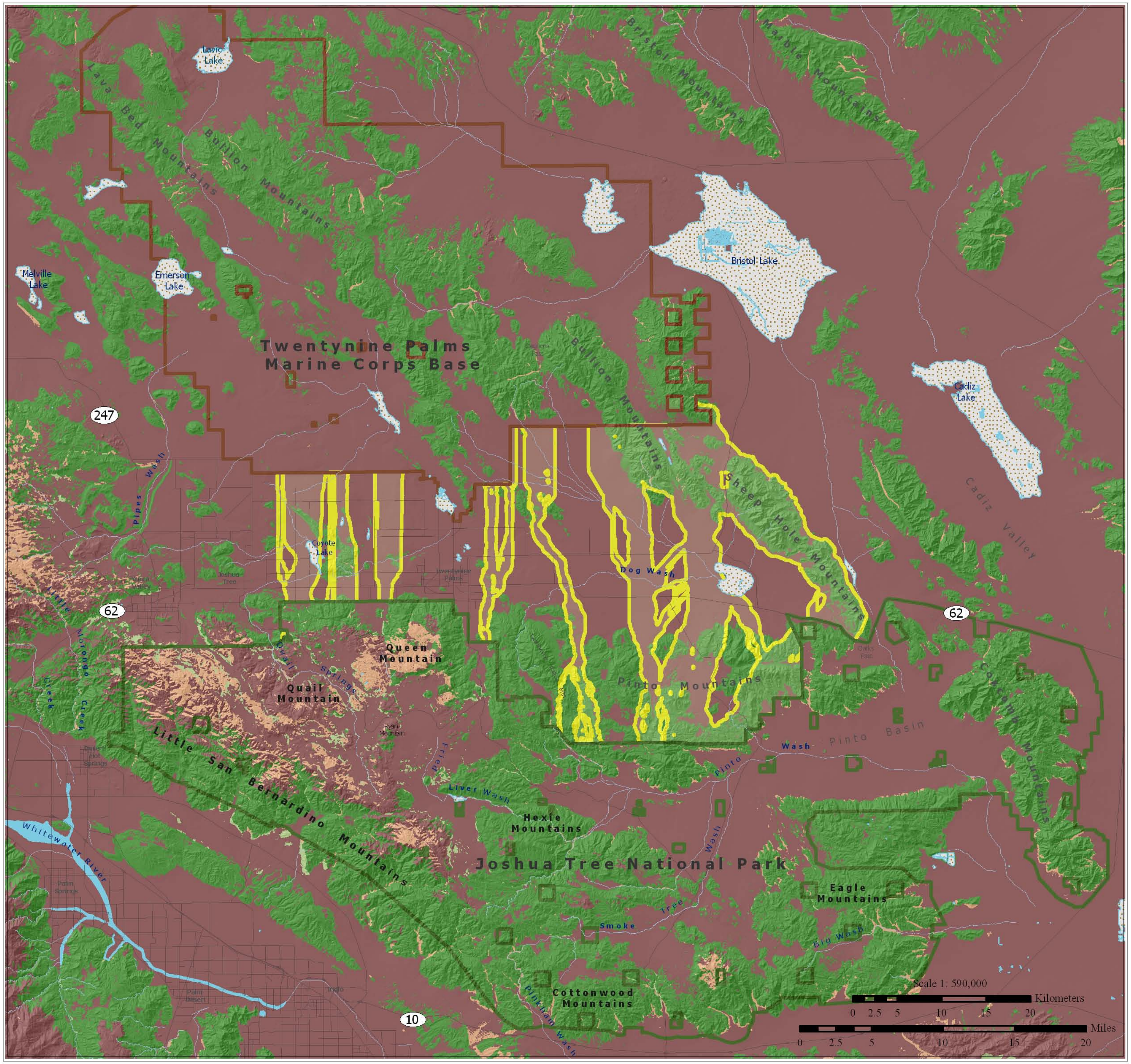
Chuckwallas evidently experience little or no detectable migration (Johnson 1965, Berry 1974, Abts 1987, Zeiner et al. 1988, Brodie et al. 2003).

Conceptual Basis for Model Development: Chuckwallas prefer rocky substrates in a variety of desert scrub and woodland communities. Core areas were defined as greater than or equal to 250 ha (618 ac). Patch size was delineated as greater than or equal to 2 ha (4.94 ac) but less than 250 ha. Dispersal distance was not estimated for this species.

Results & Discussion: Potential habitat for the chuckwalla is largely restricted to rocky terrain in the planning area, with the easternmost branch of the Least Cost Union providing the best connection between targeted areas for this species (Figure 42). Potential cores areas and patches of suitable habitat occur throughout the planning area for this species (Figure 43). We conclude that the easternmost branch of the linkage will likely serve the habitat and movement needs of the chuckwalla.

To protect and restore habitat and connectivity for the chuckwalla, we recommend that boulder piles and rocky outcrops in the linkage be managed for their habitat value. We strongly encourage the Bureau of Land Management, the Marine Corps Base, and the National Park Service to widely publicize the fact that collecting reptiles in the wild is illegal and punishable by fines and other means through regulatory agencies, such as the California Department of Fish and Game.

Figure 42.
Habitat Suitability for Chuckwalla
(Sauromalus obesus)



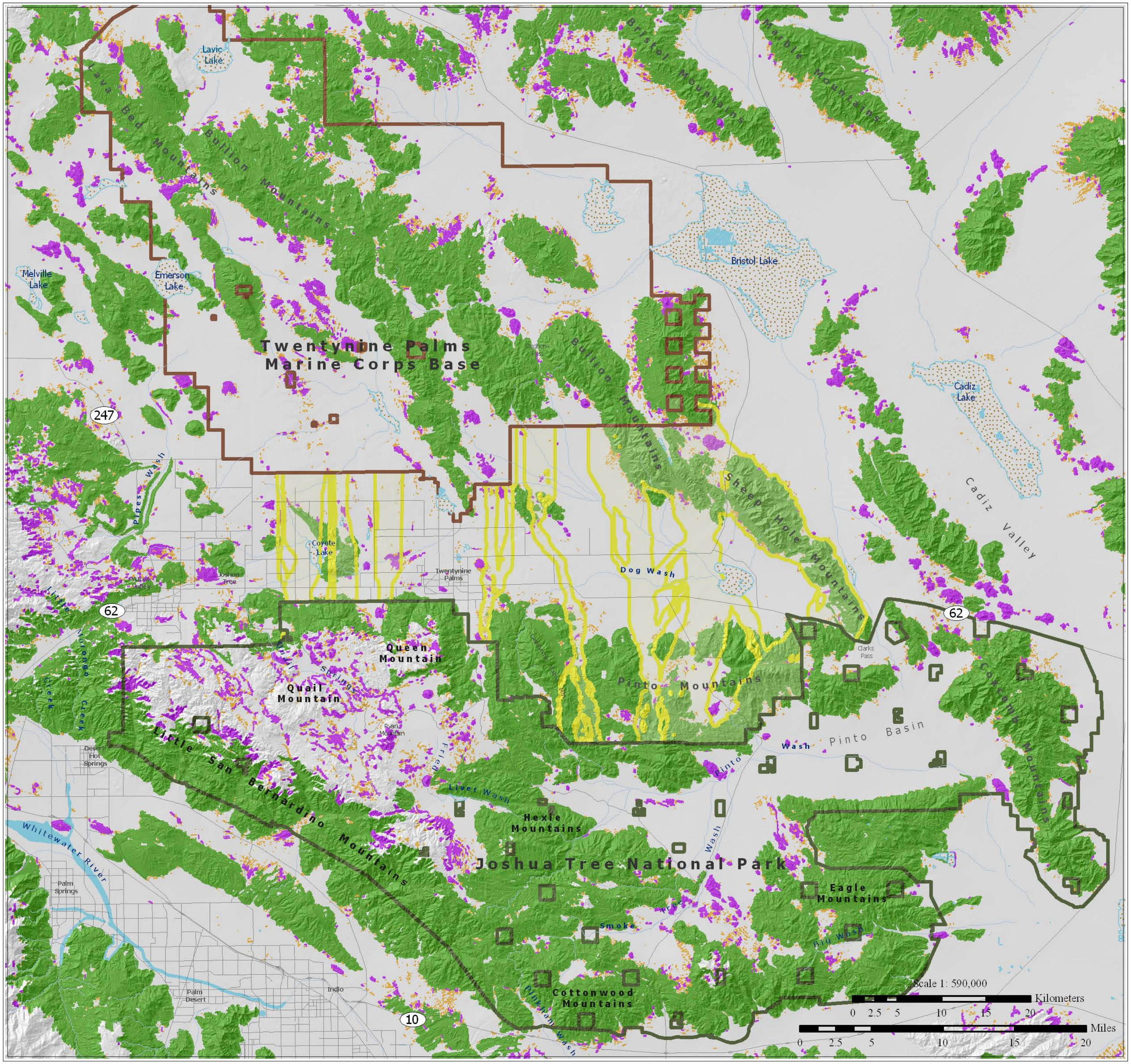
Degree of Suitability
- High
- Medium to High
- Low to Medium
- Low
- Least Cost Union
- Dept. of Defense
- National Park Service
- Roads
- Streams
- Dry Lakes
- Waterbodies

Map Produced By:

South Coast Wildlands

Figure 43.
PotentialCores & Patches
for
Chuckwalla
(Sauromalus obesus)

- Core
- Patch
- < Patch
- Least Cost Union
- Dept. of Defense
- National Park Service
- Roads
- Streams
- Dry Lakes
- Waterbodies



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Map Produced By:
SOUTH COAST WILDLANDS

Rosy boa (*Charina trivirgata*)

Justification for Selection: The rosy boa is a charismatic species associated with rocky alluvial fan habitats. This species is highly sought after by collectors, and there is concern regarding the sustainability of populations in the wild. There has been a dramatic increase in the variety of rosy boas now being bred in captivity, even though collecting this species in the wild is illegal (Fisher 2003). Furthermore, research indicates that populations of this species are heavily impacted by roads, habitat fragmentation, and urbanization (Fisher 2003).

Distribution and Status: The rosy boa inhabits the desert mountain ranges of western Arizona and southeastern California, from the Chocolate Mountains north to the Darwin Plateau and adjacent Panamint Mountains of Death Valley National Monument and from as far west as Lake Isabella in Kern County and Joshua Tree National Park east to the Weaver Mountains near Kingman, Arizona (Klauber 1931, Perrett 2002). In southern California, it is widely distributed in desert and chaparral habitats, from the coast to the desert. It is restricted to elevations from sea level to 1370 m (4500 ft; Stebbins 1985).

The rosy boa is a species of special concern, and is considered sensitive by the U.S. Forest Service (CDFG 2007). Threats include road kill, illegal collection for the pet trade, altered fire regimes, and conversion of habitat from urban and agricultural development (Rosen and Lowe 1994, Holland and Goodman 1998).

Habitat Associations: In the California deserts, the rosy boa is associated with moderate to dense vegetation in desert scrub, wash, and riparian habitats with rocky outcrops and boulder piles on flats, hillsides and in canyons, especially those with permanent or intermittent streams, springs or washes (Klauber 1931, Perrett 2002, CDFG 2005).

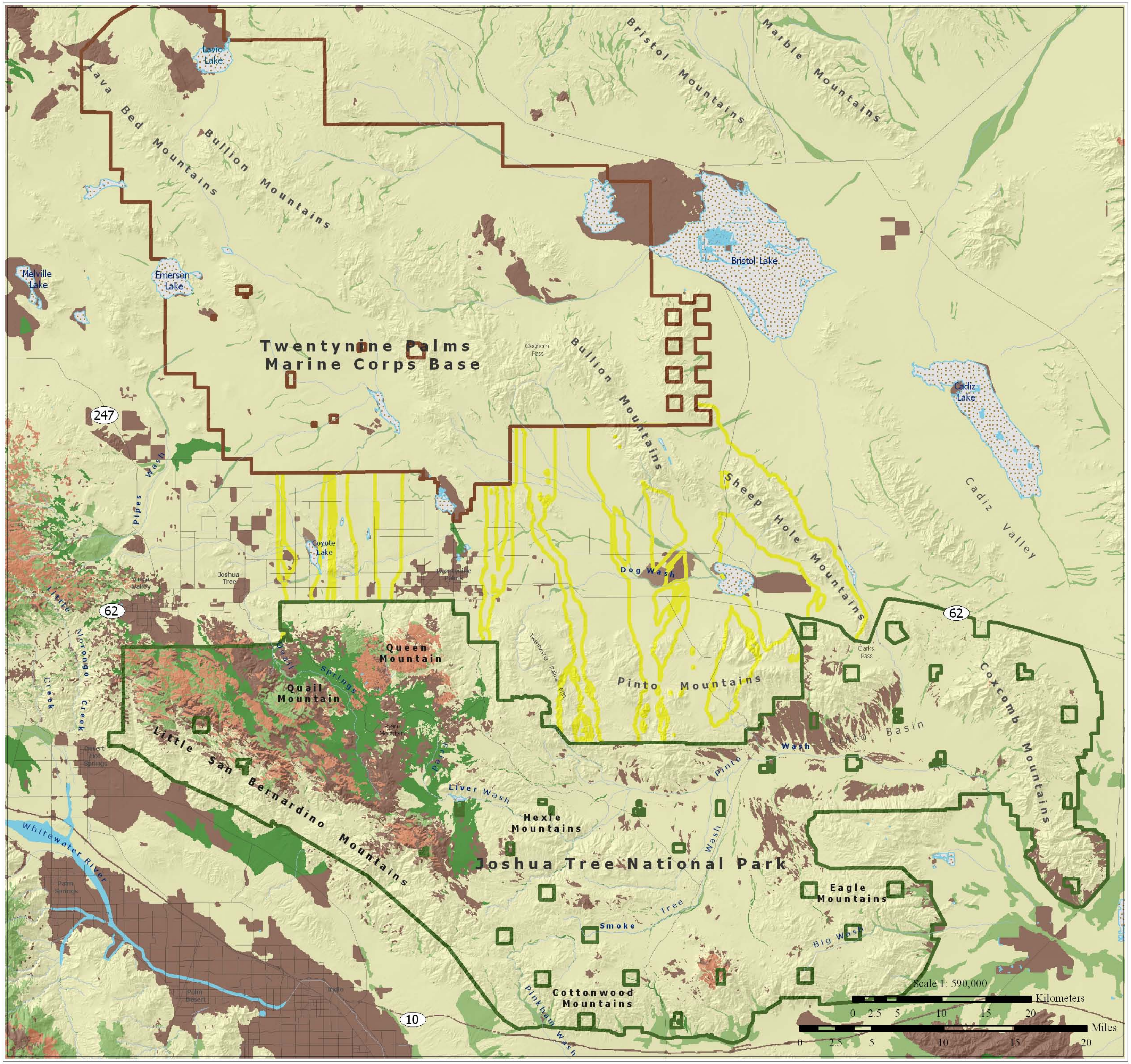
Spatial Patterns: Diffendorfer et al. (2005) found rosy boa home range sizes of about 1.5 ha (3.71 ac). Juvenile dispersal distances haven't been measured for this species but movements of 48.5 m (159 ft) have been recorded (Diffendorfer et al. 2005).

Conceptual Basis for Model Development: Rosy boas inhabit a variety of desert scrub communities. Core areas were defined as greater than or equal to 50 ha (124 ac). Patch size was delineated as greater than or equal to 3 ha (7 ac) but less than 50 ha. Dispersal distance was defined as 97 m (318 ft).

Results and Discussion: Extensive suitable habitat was identified for the rosy boa, with all branches of the Least Cost Union containing fairly contiguous suitable habitat (Figure 44). The most highly suitable habitats within the Union are the desert riparian and wash habitats. The majority of suitable habitat was identified as potential core areas (Figure 45). The patch configuration analysis suggests that the majority of cores and patches of suitable habitat are within the dispersal distance defined for this species (figure not shown), although numerous barriers to movement may exist between suitable habitat patches. We conclude that the linkage is likely to serve the needs of this species, though habitats added to the Union along Dog Wash, Quail Springs, Dale Lake Washes, and Pipes Canyon will also benefit rosy boa.

To protect and restore habitat connectivity for the rosy boa, we recommend that boulder piles and rocky outcrops in the linkage be managed for their habitat value. We also suggest that riparian areas, washes and arroyos be protected and restored. These habitats should be left undisturbed by excluding intensive activities such as off-road vehicles, grazing, and mining. When the next transportation improvement project occurs on Highway 62, crossing structures should be placed fairly frequently to facilitate movement and reduce travel distance (Jackson and Griffin 2000, McDonald and St. Clair 2004). Short retaining walls should be installed in conjunction with crossing structures to deter snakes from accessing roadways (Jackson and Griffin 2000). Finally, we strongly encourage the Bureau of Land Management, the Marine Corps Base, and the National Park Service to widely publicize the fact that collecting reptiles in the wild is illegal and punishable by fines and other means through regulatory agencies, such as the California Department of Fish and Game.

Figure 44.
Habitat Suitability for Rosy boa
(Lichanura trivirgata)



Degree of Suitability

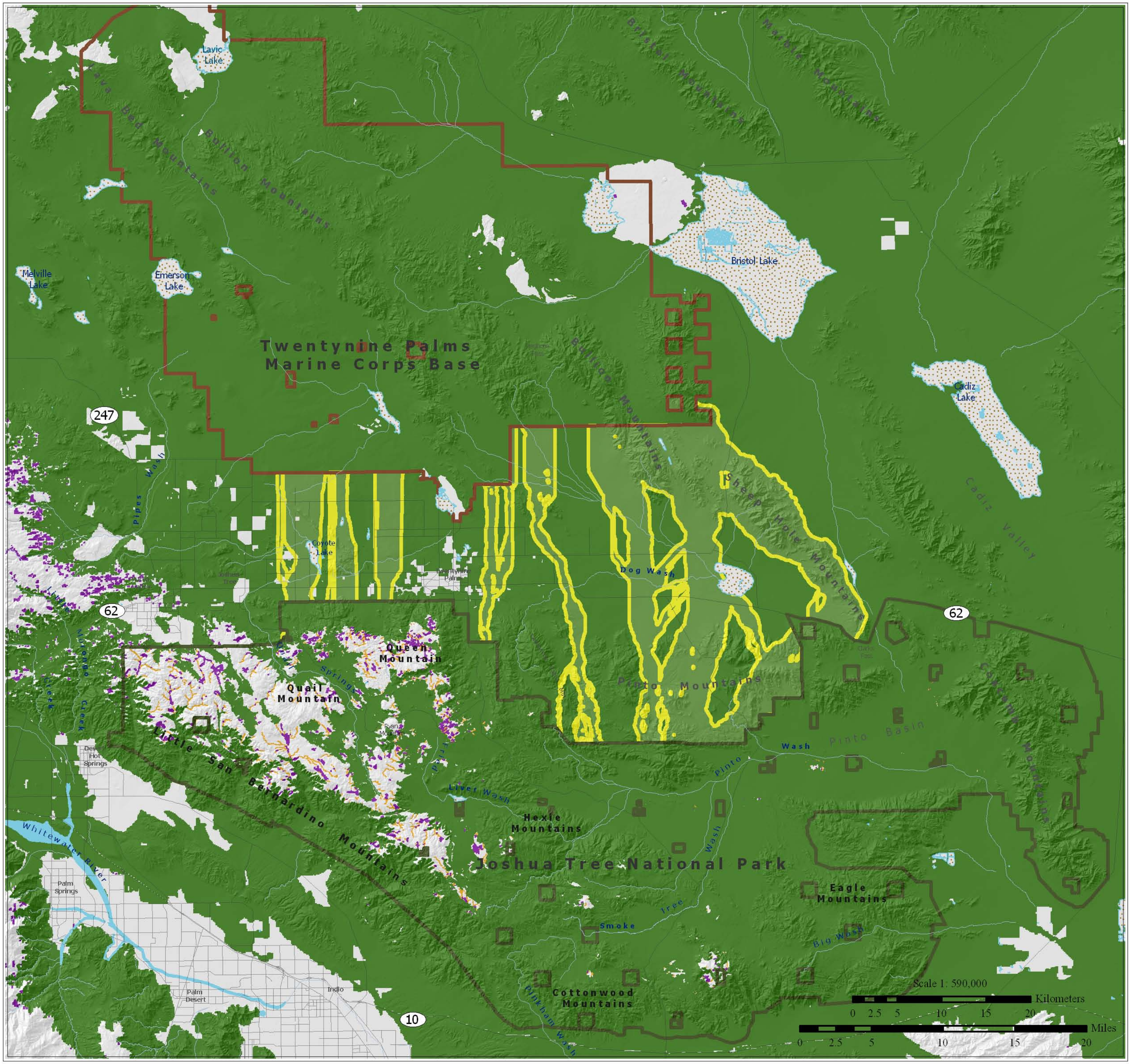
- High
- Medium - High
- Medium
- Low - Medium
- Low
- Least Cost Union
- Dept. of Defense
- National Park Service
- Roads
- Streams
- Dry Lakes
- Waterbodies

N

Map Produced By:
SOUTH COAST WILDLANDS

Figure 45.
Potential Cores & Patches
for
Rosy boa
(Lichanura trivirgata)

- Core
- Patch
- < Patch
- Least Cost Union
- Dept. of Defense
- National Park Service
- Roads
- Streams
- Dry Lakes
- Waterbodies



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Map Produced By:
SOUTH COAST WILDLANDS

Ford's swallowtail (*Papilio indra fordi*)

Justification for Selection: The Ford's swallowtail is specific to a particular host-plant which has a very restricted range in the Mojave Desert. Extensive urban and agricultural developments are causing local extinctions in swallowtail populations (Emmel and Emmel 1973).


www.worldinsect.com

Distribution & Status: Ford's swallowtail is one of five subspecies of the cliff swallowtail (*P. indra*), which is widely distributed in the west from California, Nevada, Arizona, and New Mexico north to South Dakota, and west to Washington. Ford's swallowtail (*P.i. fordi*) is restricted to the Mojave Desert (Scott 1986).

Ford's swallowtail has no special status. However, NatureServe (2007) ranks this species National Conservation Status as imperiled (N2) and vulnerable (N3) due to its restricted range and the limited number of populations.

Habitat Associations: Ford's swallowtail is associated with mountains and canyons in the Mojave Desert. Host-plants are aromatic herbs that grow in rocky habitats, and include species in the genus *Cymopterus* and *Lomatium* but larvae may also eat turpentine bush (*Thamnosma Montana*) when normal hosts are unavailable (Scott 1986). This species is specific to *C. panamintensis* var. *acutifolius* (G. Pratt, pers. comm.), which is restricted to dry rocky slopes and canyon walls between 700-1000 m (2296-3280 ft; Baldwin et al. 2002). Adults sip flower nectar and mud, and they can be found flying along undisturbed watercourses or in moist canyons (Scott 1986). Adults perch in rocky places just below the hilltop to attract females (Scott 1986).

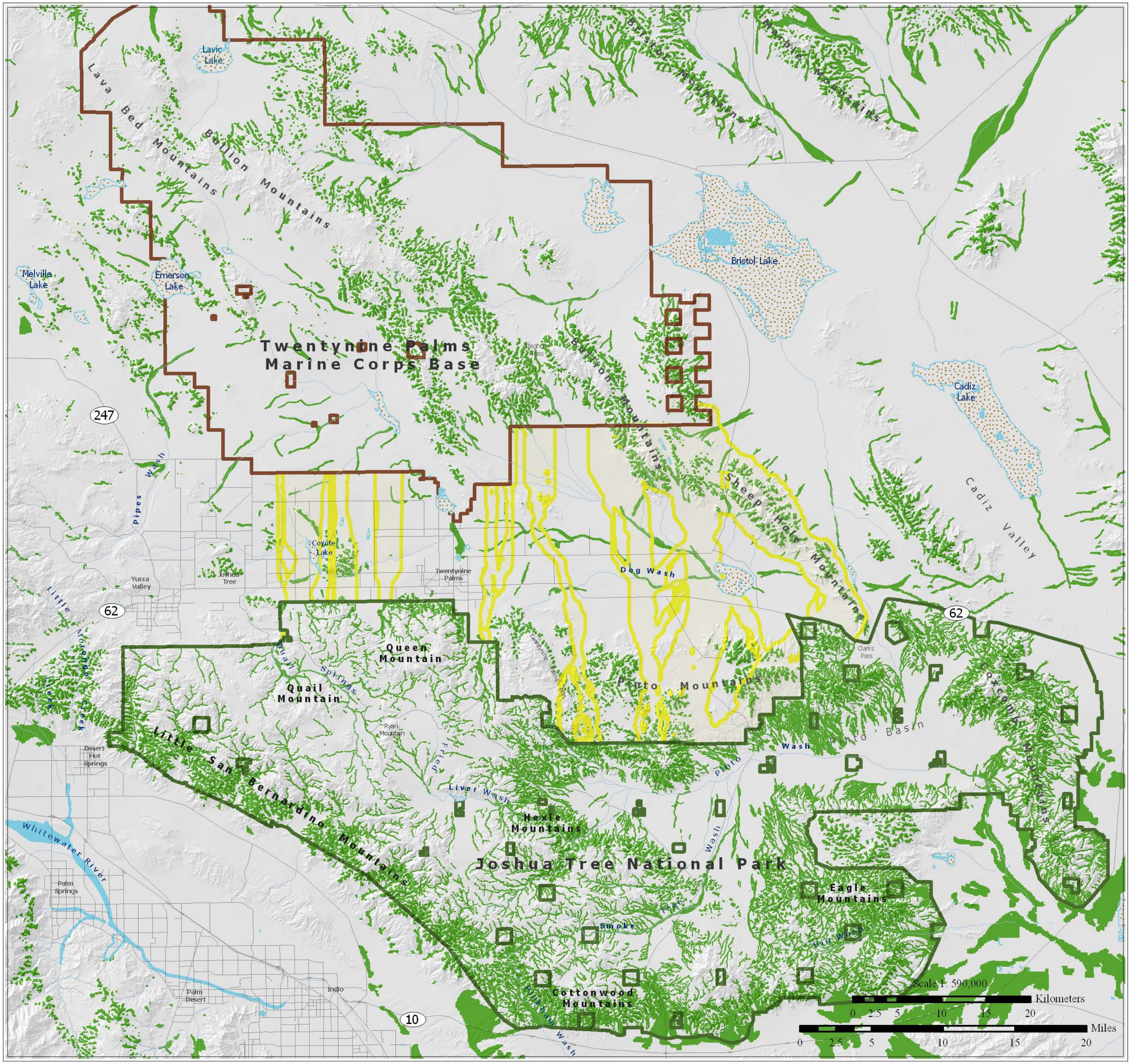
Spatial Patterns: No home range or density estimates exist for this species. Dispersal and movements have not been measured in this subspecies. However, its large body size suggests that it is capable of making long-distance flights. Adults in the Grand Canyon can move several kilometers from host-plants to mating places (Scott 1986). In addition, when western swallowtail (*P. zelicaon*) males, a congener of similar size, were displaced 5 km (3.11 mi) from hilltops, they returned to the site of capture (Scott 1986).

Conceptual Basis for Model Development: This swallowtail prefers rocky substrates in mountainous terrain and canyon walls between 700-1000 m (2297-3281 ft) where their host-plants grow. They can also be found flying along watercourses where they sip mud and in rocky areas near hilltops where they seek mating opportunities. Minimum patch and core area sizes are less than the 30-m minimum mapping unit used in this GIS analysis and therefore no habitat patches were excluded from the analysis. Dispersal distance used in the model is 10 km (6.22 mi; twice the reported return distance reported for a congener).

Results & Discussion*:* Potential habitat for the Ford's swallowtail is restricted to desert scrub habitats near and on ridge tops and along watercourses in the Least Cost Union (Figure 46). The easternmost branch provides extensive hilltopping habitat, which is the best connection between targeted areas for this swallowtail. Due to the wide dispersal capabilities for this species, no patch of potential habitat was deemed isolated (figure not shown). Based on this distribution, we conclude that the Least Cost Union provides adequate habitat connections for the swallowtail, though several of the habitat additions along washes provide further connectivity for this species.

Figure 46.
Habitat Suitability
for
Ford's swallowtail
(Papilio indra fordi)

Potential Habitat
Least Cost Union
Dept. of Defense
National Park Service
Roads
Streams
Dry Lakes
Waterbodies



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Map Produced By:

SOUTH COAST WILDLANDS

Velvet ant (*Dasymutilla coccinea*)

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

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

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

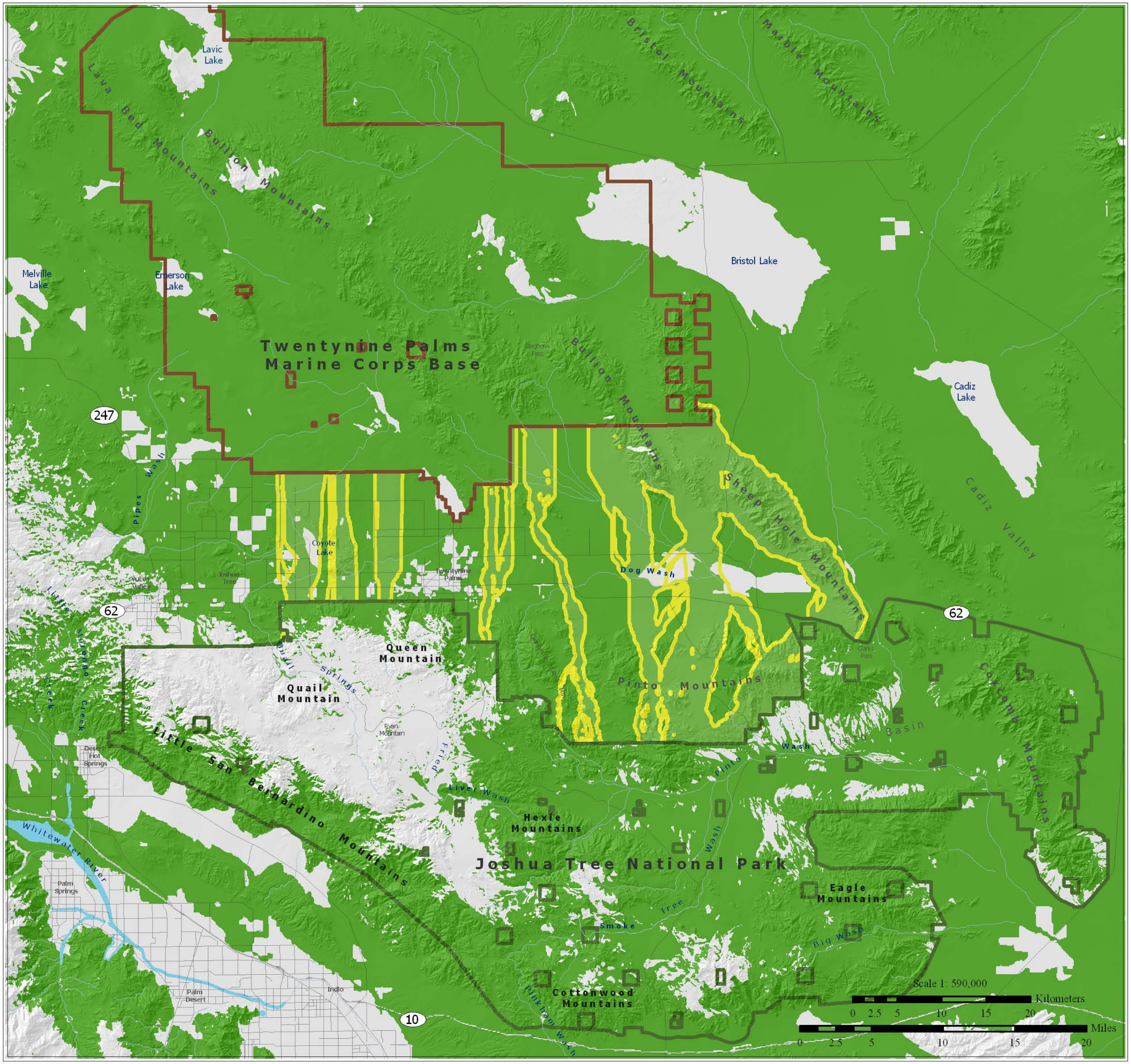
Spatial Patterns: Very little is known about these wasps. It has been suggested that they are parasitic on other ground-nesting wasps and bees, and that their patchy distribution is related to the distribution of ground-nesting bees (Hogue 1993). Males are winged while females are flightless.

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

Results & Discussion: Potential habitat for velvet ants is widespread in the planning area, with fairly contiguous suitable habitat identified in the Least Cost Union (Figure 47). We conclude that this species is served by the linkage, though most habitats added to the Union will also benefit the velvet ant.

Severing corridors can affect populations of ground nesting bees, the velvet ant’s host. Thus, linkages are needed to maintain subpopulation connectivity and gene flow between populations of velvet ants.

Figure 47.
Potential Habitat
for
Velvet ant
(Dasymutilla coccinea)



Potential Habitat
Least Cost Union
Dept. of Defense
National Park Service
Roads
Streams
Dry Lakes
Waterbodies

N

Map Produced By:
SOUTH COAST WILDLANDS

Meloid beetle (*Lytta magister*)

Justification for Selection: The meloid beetle is considered a boom and bust species that is dependent on rain levels (G. Pratt, pers. comm.). It feeds on grasshopper eggs.

Distribution & Status: The meloid beetle is distributed throughout the Mojave and Colorado deserts (Selander 1960). The family of the meloid beetle (Meloidae) consists of about 2500 species (Selander and Bouseman 1960, White 1983, Selander and Fasulo 2000, Arnett et al. 2002). The arid deserts of the southwest boast the greatest diversity of these beetles (White 1983, Arnett et al. 2002), which are quite colorful (White 1983).

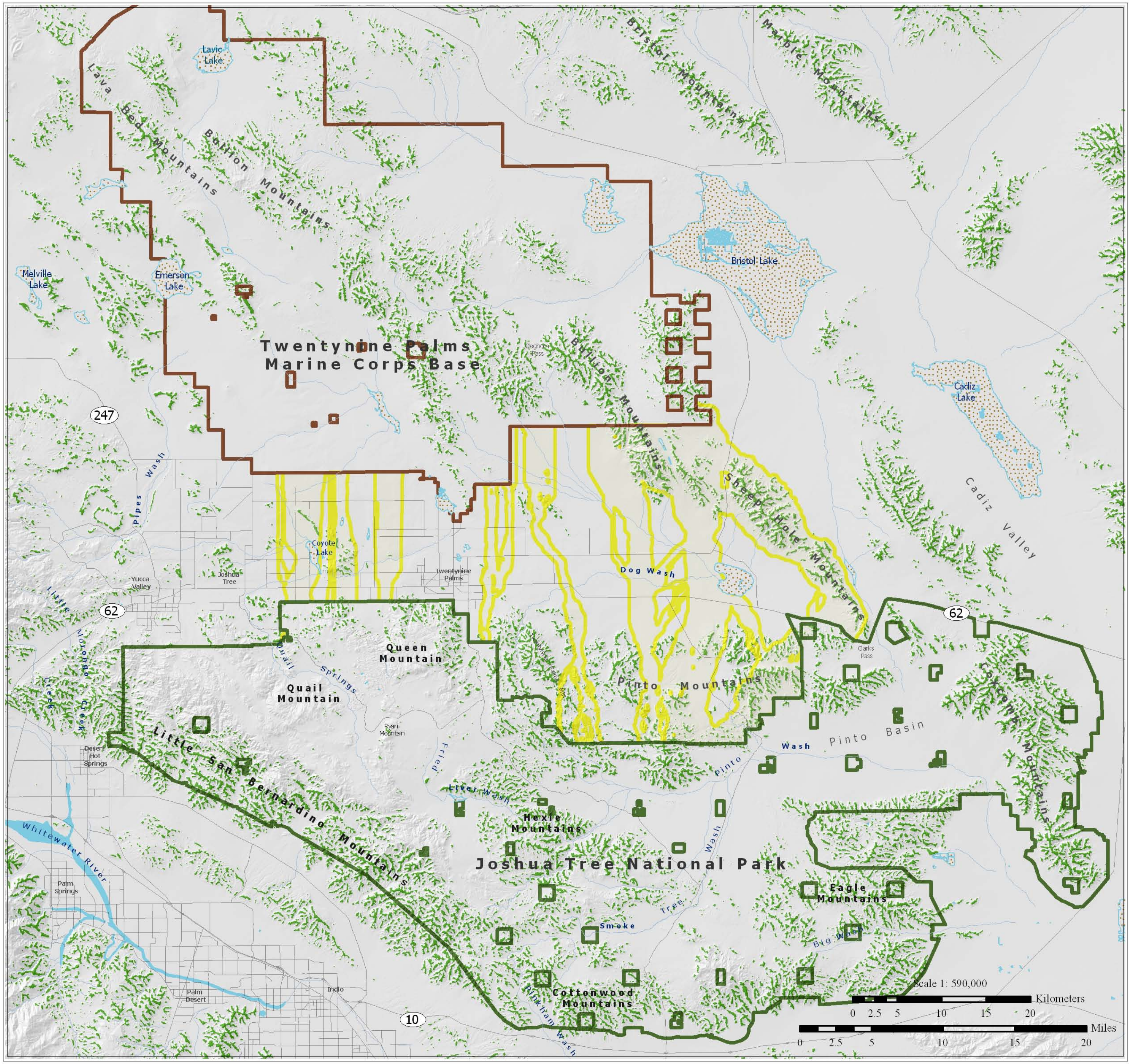
Habitat Associations: Adult beetles feed especially on plants in the families Asteraceae, Amaranthaceae, Fabaceae, and Solanaceae (Selander and Fasulo 2000, Arnett et al. 2002). Most adults eat only floral parts, but some eat leaves as well (Selander and Fasulo 2000). However, except for first instar larvae (triungulins) frequenting flowers or clinging to adult bees, larval beetles are seldom seen. So far as known, all larvae are specialized predators (Selander 1981, Selander and Fasulo 2000). Those of some Meloinae, including the meloid beetle, prey on the eggs of grasshoppers (G. Pratt, pers. comm.).

Spatial Patterns: Males and females congregate near ridge tops to feed and mate (Snead and Alcock 1985). The life cycle of the meloid beetle is hyper-metamorphic. Eggs are laid in soil near nests of grasshopper hosts, or on stems, foliage, or flowers. The first instar larvae (usually called *triungulins*) are active with well-developed legs to search for hosts. Later instars tend to be less active. The life cycle may be anywhere from 30 days to three years and usually corresponds with that of host (White 1983, Papp 1984, Arnett et al. 2002). Research is lacking on home range size and dispersal distance for this species.

Conceptual Basis for Model Development: Movement of this species in the linkage occurs over multiple generations. The meloid beetle is associated with ridge tops in desert scrub habitats.

Results & Discussion: Potential habitat for the meloid beetle is restricted to ridge tops within desert scrub habitats. The easternmost branch of the Least Cost Union provides a fairly contiguous habitat connection for this species along the ridges in the Pinto, Sheephole and Bullion mountains (Figure 48). We conclude that the linkage will likely facilitate movement of this species between targeted areas over multiple generations.

Figure 48.
Potential Habitat
for
Meloid beetle
(Lytta magister)



Potential Habitat
Least Cost Union
Dept. of Defense
National Park Service
Roads
Streams
Dry Lakes
Waterbodies

N

Map Produced By:
SOUTH COAST WILDLANDS

Alkali fairy shrimp (*Branchinecta mackini*)

Justification for Selection: The alkali fairy shrimp is the most common species of fairy shrimp in dry lakes and ephemeral pools in the linkage planning area. Any sort of hydrological discontinuity, including the presence of upland habitat, constitutes a separation barrier for this species (Cordeiro 2007).

Distribution & Status: The alkali fairy shrimp occurs in dry lakes and ephemeral pools in California, Idaho, New Mexico, Nevada, Utah, Oregon and Washington, and is also found in British Columbia (Cordeiro 2007).

The alkali fairy shrimp is not a special status species. Fairy shrimp populations are declining worldwide (Dimentman 1981, Herbst 1982, Brendonck 1989, Bratton and Fryer 1990, Löffler 1993, Mura 1993, Hödl 1994, Fugate 1996). However, habitat loss is cited as the major threat to fairy shrimp and other crusteceans (Fugate 1996). California's ephemeral waters are being lost at an alarming rate due to a variety of factors, including conversion to urban and agricultural development and intense recreation, such as off-road vehicles activities (Bauder 1986, Fugate 1996, Hathaway et al. 1996). Off-road vehicles degrade habitat by compacting soils and disrupting pool hydrology, and cause direct mortality by crushing cysts (Hathaway et al 1996). Habitat loss and degradation of pools can alter patterns of gene flow between pool complexes, resulting in increased isolation and therefore reduced recolonization following local extinctions of populations (Fugate 1996).

Habitat Associations: Vernal pools are temporary wetlands that form in depressions such as dry lakes. These depressions fill with rain and then begin to evaporate, lasting any where from a few weeks to a few months. Fairy shrimp have evolved to survive the ephemeral nature of their habitats and can complete their life cycle in a matter of weeks (Fugate 1996, RCIP 2000). Fairy shrimp have a two-stage life cycle with the majority of their life cycle spent in the egg, or cyst stage (Templeton and Levin 1979, Schaal and Leverich 1981, Herzig 1985, Hairston and De Stasio 1988, Venable 1989, Fugate 1996).

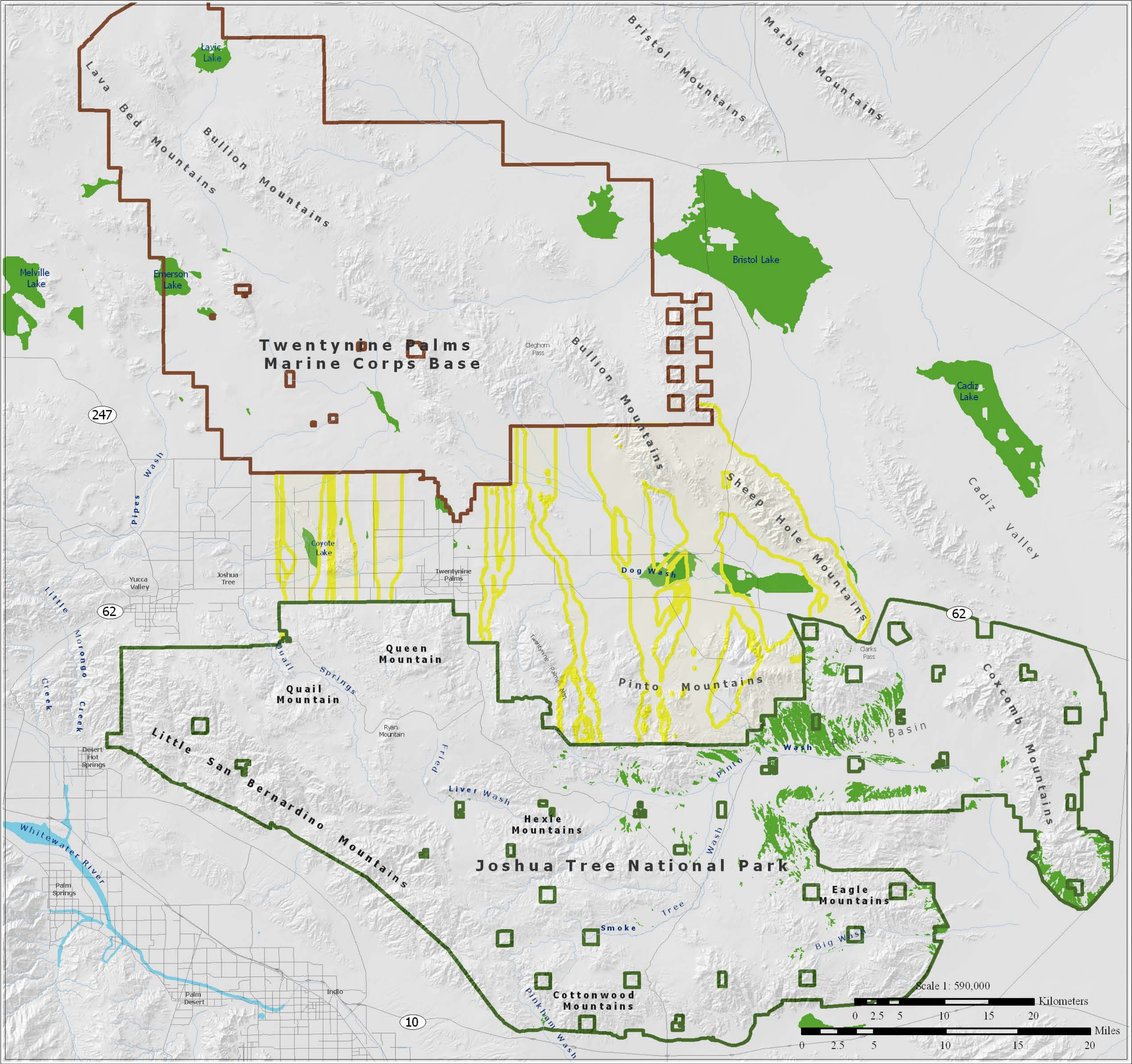
Spatial Patterns: Freshwater systems occur as small habitat patches surrounded by a matrix of uninhabitable terrain (Fugate 1996). Fairy shrimp eggs are passively dispersed between ephemeral pools by shore birds and other animals (Proctor 1964, Proctor et al. 1967, Moore and Faust 1972, Thiéry 1987, Fugate 1996). In California, pools are patchily distributed in complexes across the landscape (Simovich 1996).

Given the spatial pattern of pools and passive dispersal of cysts, the isolation-by-distance model (Slatkin 1993) suggests populations of species in the genus *Branchinecta* exchange between 3 to 100 migrants per generation (most species above 20) at 1 km (0.62 mi) separation and 0.1 - 0.2 per generation at 1000 - 2000 km (621-1243 mi; Wright 1943, Fugate unpubl. ms., in Fugate 1996, Cordeiro 2007).

Conceptual Basis for Model Development: The alkali fairy shrimp occurs in ephemeral pools and dry lakes. Minimum patch and core area sizes are less than the 30-m minimum mapping unit used in this GIS analysis and therefore no habitat patches were excluded from the analysis.

Results & Discussion: The alkali fairy shrimp is restricted to alkali desert scrub habitats in the dry lakes and ephemeral pools within the planning area (Figure 49). Very little habitat occurs in the Least Cost Union for this species, with the exception of some alkali desert scrub habitats in Coyote Lake and along Dog Wash. Habitat was added to the Union along Dog Wash to benefit the alkali fairy shrimp. However, given that fairy shrimp are passively dispersed between ephemeral pools by shore birds and other animals (Proctor 1964, Proctor et al. 1967, Moore and Faust 1972, Thiéry 1987, Fugate 1996), we believe that there is likely enough suitable habitat to accommodate the dispersers of fairy shrimp within the Least Cost Union.

Figure 49.
Potential Habitat
for
Alkali fairy shrimp
(Branchinecta mackini)



Map Produced By:

South Coast Wildlands

Desert willow (*Chilopsis linearis*)

Justification for Selection: The desert willow is a long-lived woody plant that provides nectar for numerous birds and insects, and is primarily pollinated by bees. This species also has a specific sphinx moth (*Manduca maculate*) associated with it.

Distribution & Status: The desert willow is distributed throughout the southwestern United States in Utah, Nevada, and southern California, and northern Mexico (Little 1976, Uchytil 1990). In California, it is found below 1524 m (5000 ft) in elevation (Munz 1974).

Desert willow is not a special status species. However, it provides important resources to numerous species. A number of desert songbirds nest in the desert willow, which also provides cover for other wildlife species (Lamb 1971, Uchytil 1990). The shape of the flower is particularly attractive to hummingbirds, which feed on the nectar (Gullion 1964, Brown et al. 1981, Uchytil 1990). The leaves and the fruit of the flower are also consumed by species such as mule deer (Short 1977, Uchytil 1990), and various birds eat the seeds (Vines 1960, Gullion 1964, Uchytil 1990).

Habitat Associations: The desert willow is restricted to areas where its long roots can reach the water table, such as dry washes, intermittent streams and other water courses in moist canyons (Kearney et al. 1960, Munz 1974, Johnson 1976, Burk 1977, Welsh et al.1987, Simpson 1988, Uchytil 1990).

Spatial Patterns: The desert willow flowers from May to September in southern California (Munz 1974). It is pollinated by numerous species of bees and hummingbirds (Brown et al. 1981, Uchytil 1990). Fruit set may be limited by inadequate movement of pollinators between trees (Petersen et al. 1982, Uchytil 1990). Desert willow produces abundant seed, which is wind dispersed and probably only viable until the spring following dispersal (Magill 1974, Pendleton et al. 1989, Uchytil 1990).

Conceptual Basis for model Development: Desert willow occupies desert riparian, desert wash, and palm oasis habitats in moist canyons in deserts and mountain foothills below 1524 m (5000 ft) in elevation.

Results & Discussion: Potential habitat for desert willow is restricted to hydrological systems in the planning area, with very little potentially suitable habitat captured by the Least Cost Union (Figure 50). The habitat additions along Dog Wash, Quail Springs, Dale Wash, and Pipes Canyon Wash will provide habitat for this species, protect natural hydrological and fluvial processes, and protect key movement corridors. With these additions, we believe the linkage will serve desert willow.

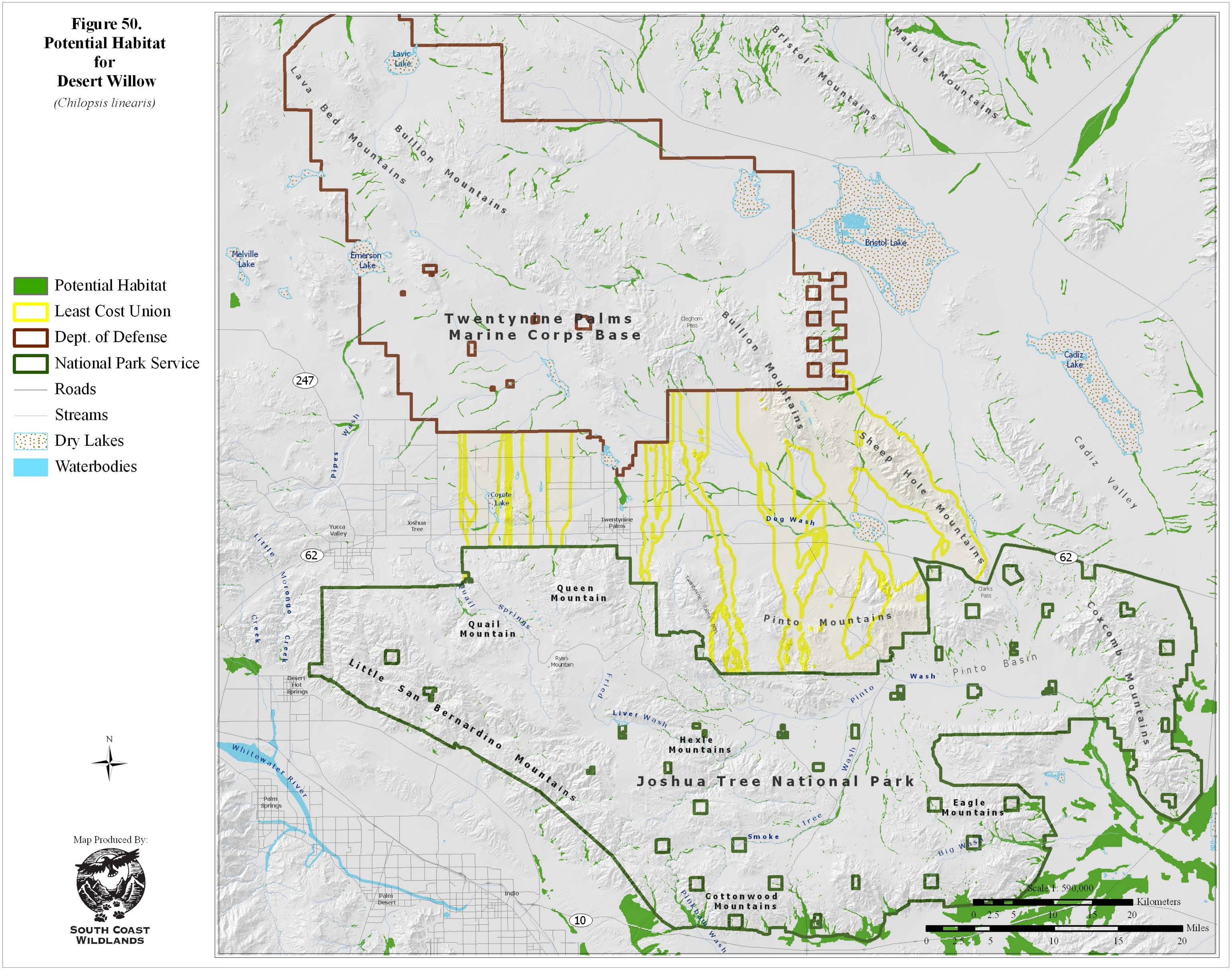


**Figure 50.
Potential Habitat
for
Desert Willow**
(Chilopsis linearis)

Mojave yucca (*Yucca schidigera*)

Justification for Selection: Mojave yucca is a long-lived slow-growing species (Wallace and Romney 1972). It provides important resources for a number of wildlife species. It is pollinated by a specific moth, and also has a specific giant skipper associated with it (G. Pratt, pers. comm.).

Distribution & Status: In California, Mojave yucca occurs from the Mojave Desert in southeastern California as far west as the Pacific Coast, reaching its northern limit in San Bernardino County and its southern limit in Baja Claifornia Norte (Webber 1953, Fried et al. 2004, Gucker 2006). Munz (1974) reports an upper elevation limit of 2377 m (7800 ft).

Mojave yucca is not a special status species. It provides food, nest materials, nesting sites and habitat for a variety of desert wildlife species, including small mammals, birds, and reptiles (England et al. 1984, Germano and Joyner 1988, Rundel and Gibson 1996, Gucker 2006). Bobcats use the Queen Valley area of Joshua Tree National Park extensively for hunting where Mojave yucca is the dominant plant species (Zezulak and Schwab 1981, Gucker 2006). Other research indicates that Mojave yucca is also an important water source (Cameron 1971, Cameron and Rainey 1972, Gucker 2006).

Habitat Associations: Mojave yucca can be found in desert scrub, desert washes, blackbrush scrub, Mojave yucca-buckhorn cholla, Mojave yucca-chamise, mixed steppe, and Joshua tree woodland habitats (Cardiff and LaPre 1980, Turner 1982, Fidelibus et al. 1996, Peinado et al. 1997, Gucker 2006). It is primarily associated with dry rocky slopes, flats, or washes (Cooper 1922, Wallace and Romney 1972, Munz 1973, Conrad 1987, Welsh et al. 1987, Kartesz 1988, MacKay 2003, Gucker 2006).

Spatial Patterns: Mojave yucca reproduces both sexually through seed production and asexually through sprouting and clonal growth (Webber 1953, Cardiff and LaPre 1980). Asexual is the principal type of reproduction. Research at the Deep Canyon Desert Research Center estimated the last successful seedling establishment occurred 40 or 50 years earlier, while the average age of monitored clone plants was 300 to 600 years old (LaPre 1979, Gucker 2006).

Mojave yucca blooms from April through May (Munz 1973). It has a mutualistic relationship with its pollinator, a yucca moth (*Tegeticula yuccasella*), which collects pollen from several flowers and transfers it to the stigma tube of other flowers for fertilization before laying its eggs in the ovary where the larvae feed on the developing seeds (Webber 1953, Gucker 2006).

Seed predation by small mammals is quite common (Arnott 1962, Force and Thompson 1984, Gucker 2006). The fruit and seeds are dispersed by mammals (Pendleton et al

1989), though seedlings are rarely observed in the field (Yeaton et al. 1985). Webber (1953) found only 6 seedlings in 4 years of field observations in southern California.

Conceptual Basis for Model Development: Mojave yucca occurs on dry rocky slopes, flats and washes in desert scrub, desert washes, blackbrush scrub, Mojave yucca-buckhorn cholla, Mojave yucca-chamise, mixed steppe, and Joshua tree woodland habitats below 2377 m (7800 ft) in elevation.

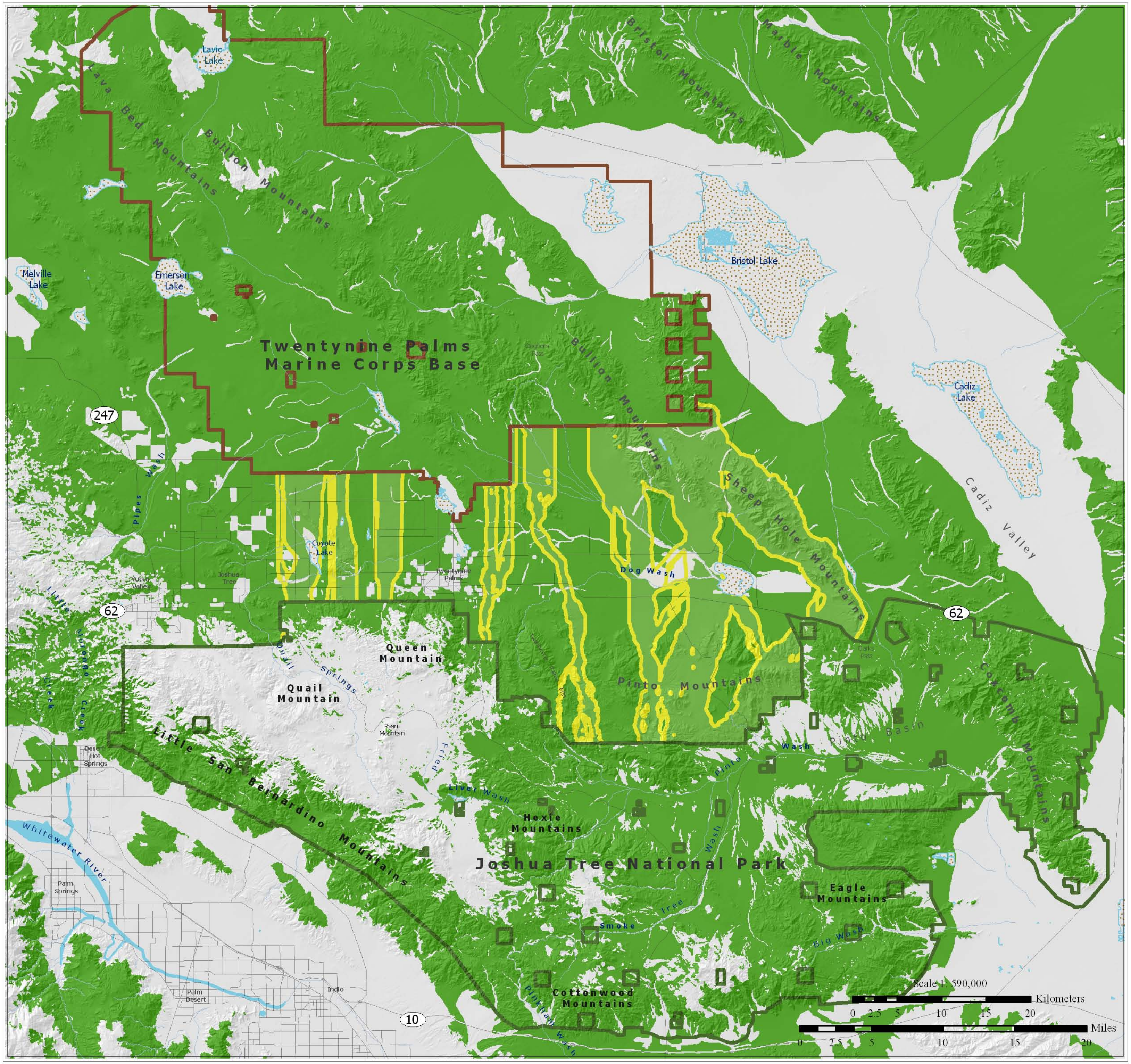
Results & Discussion: The suitability model identified extensive potential habitat for the Mojave yucca in the planning area with all branches of the Least Cost Union providing fairly contiguous potential habitat (Figure 51). We conclude that the linkage will provide for the needs of this plant species, though most of the habitat additions will also benefit this species.

The increase in nonnative annual grasses has increased fire frequency in the Mojave and Great Basin deserts (Esque and Schwalbe 2002, Brooks et al. 2004, Emming 2005). Although Mojave yucca sprouts following fire (Conrad 1987, Loik et al. 2000), the available literature does not address Mojave yucca recovery and survival following repeated fires at short intervals (Gucker 2006). To protect and restore habitat for the Mojave yucca, we recommend that fire frequency is controlled to prevent type conversion of desert habitats to nonnative annual grassland.

Figure 51. Potential Habitat for Mojave Yucca

(Yucca schidigera)

- Potential Habitat
- Least Cost Union
- Dept. of Defense
- National Park Service
- Roads
- Streams
- Dry Lakes
- Waterbodies



Map Produced By:

South Coast Wildlands

Jojoba (*Simmondsia chinensis*)

Justification for Selection: Jojoba is an important mid-elevation species that provides important cover and forage for many wildlife species in the planning area. Its insect fauna is well-documented.

Distribution & Status: Jojoba is distributed from western Riverside and San Diego counties through Imperial County in California, and in parts of Yavapai, Greenlee Cochise, Pima, and Yuma counties in Arizona (Kearney et al. 1960, Munz 1974, Hickman 1993, Matthews 1994). It also occurs throughout Baja California and Sonora, Mexico, and on islands in the Gulf of California (Kearney et al. 1960, Hastings et al. 1972, Munz 1974, Nord and Kadish 1974, Brooks 1978, Buchmann 1987, Matthews 1994). It is generally restricted to sites between 600-1200 m (2000-4000 ft) in elevation (Gentry 1958, Brooks 1978, Buchmann 1987, Matthews 1994).

Jojoba is not a special status species. It provides cover for many small mammals and birds (Goodwin and Hungerford 1977), and highly nutritious and important forage for wildlife (Gentry 1958, Swank 1958, Kearney et al. 1960, Nord and Kadish 1974, Brooks 1978, Medina and Betancourt 1987, Roundy et al. 1987, Conrad 1987, Hickman 1993, Matthews 1994). Jojoba foliage is consumed by mule deer (Swank 1958, Urness and McCulloch 1973, Brooks 1978, Krausman et al. 1990), bighorn sheep (Miller and Gaud 1989, Seegmiller et al. 1990), and jackrabbits (Hoagland 1992, Matthews 1994). Domestic livestock (sheep, goats, and cattle) also consume the foliage, and cattle may excessively browse preventing fruit development (Gentry 1958, Brooks 1978, Medina and Betancourt 1987, Matthews 1994). Jojoba nuts are eaten by several birds and mammals including ground squirrels, desert chipmunks, packrats, pocket gophers, mice, rabbits, and mule deer (Gentry 1958, Brooks 1978, Conrad 1987, Castellanos and Molina 1990, Matthews 1994).

Habitat Associations: Jojoba is primarily found in desert shrub habitats and lower elevations of chaparral communities (Nichol 1952, Swank 1958), on well-drained, coarse desert soils (Gentry 1958, Brooks 1978, Matthews 1994). In the desert, jojoba is typically associated with slopes over 3 percent and often over 30 percent (Brooks 1978).

Spatial Patterns: Jojoba is wind pollinated (Nord and Kadish 1974, Buchmann 1987, Castellanos and Molina 1990, Matthews 1994) and dispersed (Gentry 1958). Seed production is highly variable from year to year (Gentry 1958, Nord and Kadish 1974, Sherbrooke 1989, Castellanos and Molina 1990, Matthews 1994). Seeds are dispersed by animals and erosion (Sherbrooke 1989), and remain viable for long periods of time (Gentry 1958, Nord and Kadish 1974, Castellanos and Molina 1990, Matthews 1994). However, many seeds may be consumed by desert rodents, but some seedlings have been observed from abandoned burrows (Castellanos and Molina 1990). The seeds may wait many years before conditions are appropriate for germination (Sherbrooke 1989, Matthews 1994). Once established, this evergreen plant can persist for well over 100 years (Gentry 1958, Brooks 1978, Buchmann 1987, Matthews 1994).

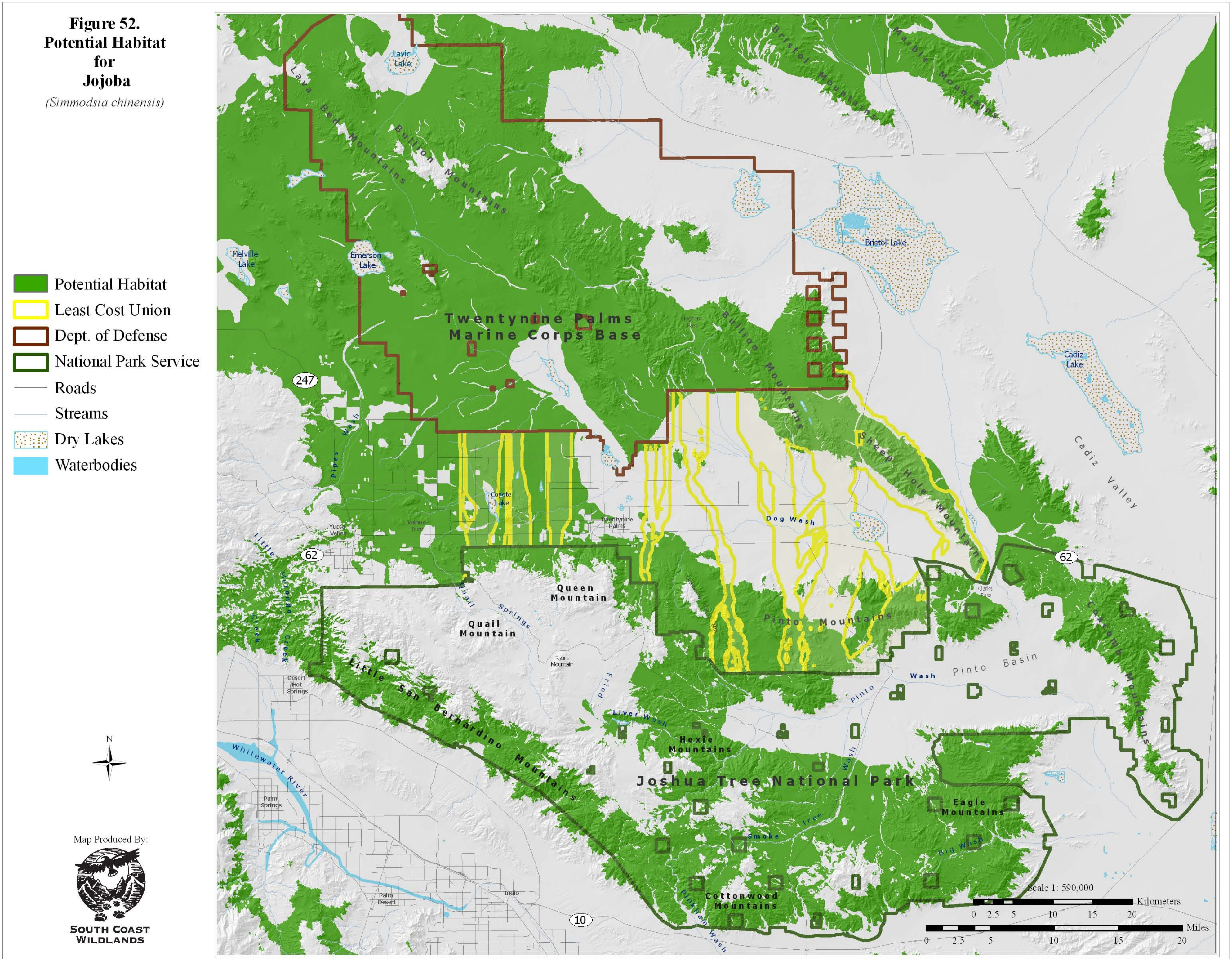
Conceptual Basis for Model Development: Jojoba may be found in chamise redshank chaparral, desert scrub, and sagebrush habitats between 600-1200 m (2000-4000 ft). It is primarily associated with slopes greater than 3 percent.

Results & Discussion: Potentially suitable habitat for jojoba was identified throughout the planning area at mid-elevations. The three western branches and the easternmost branch of the Least Cost Union provide the most contiguous potential habitat for this species (Figure 52). The Least Cost Union will likely accommodate this long-lived plant species, and jojoba will also benefit from additions to the Union along Pipes Canyon Wash, Quail Springs, Coyote Lake Wash, and Dog Wash.

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

Figure 52. Potential Habitat for Jojoba

(Simmodsia chinensis)



Blackbrush (*Coleogyne ramosissima*)

Justification for Selection: Blackbrush is a post pleistocene relict species that occurs on ancient granitic debris flows (Webb et al. 1987, Webb et al. 1988, Anderson 2001). It provides important cover and forage for mule deer and bighorn sheep, especially in winter (Bradley 1965, Stark 1966, Bowns and West 1976, Mozingo 1987, Urness and Austin 1989, Anderson 2001). In California, it comprises up to 25% of mule deer winter diet (Leach 1956). Blackbrush also provides cover and food for birds and small mammals (Brown and Smith 2000), who consume the seeds (Stark 1966, Mozingo 1987, Anderson 2001).

Distribution & Status: Blackbrush occurs in the transition between the Mojave and Great Basin deserts, from southeastern California, along the borders of Nevada, Utah, and Arizona to southwestern Colorado (Ackerman and Bamberg 1974, Bowns and West 1976, Banner 1992, Anderson 2001). It can occur from 760-2440 m (2500 and 8000 ft) in elevation (Bowns 1973, Banner 1992, Lei and Walker 1995, Lei and Walker 1997, Anderson 2001).

Blackbrush is not a special status species. In fact, it is often the dominant plant where it occurs (Bowns 1973, Bowns and West 1976, Bates 1983, Lei and Walker 1997, Anderson 2001). However, it is sensitive to disturbance and considered a declining plant community (I. Anderson, pers. comm.).

Habitat Associations: Blackbrush can occur in monotypic stands or as a component of other vegetation communities (Banner 1992, Anderson 2001). It occurs in virtually pure stands between the creosote scrub and Joshua tree communities at lower elevations of the Mojave and the sagebrush and juniper habitats at upper elevations in the Great Basin desert (Bradley 1965, Bowns 1973, Bowns and West 1976, Turner 1982, Bates 1983, Anderson 2001). Plants associated with blackbrush communities vary depending on the adjacent biome (Turner 1982). In the Mojave, subordinate shrubs may include Mojave yucca, creosote bush, and turpentine bush (Smith and Bradney 1990, Anderson 2001). Blackbrush stands occur on well-drained sites including alluvial fans, washes, valley bottoms, gentle slopes, and flatlands (Bowns 1973, Ackerman and Bamberg 1974, Ackerman et al. 1980, Bates 1983, Tueller et al. 1991, Banner 1992, Lei and Walker 1997, Anderson 2001).

Spatial Patterns: Fidelibus et al. (1996) found widely different densities of blackbrush in different plant communities. For example, in blackbrush scrub there was a density of 8,894 plants per ha, while in Joshua tree woodland there were 647 plants per ha.

Blackbrush is a long-lived species (Webb et al. 1987, Anderson 2001). It regenerates from wind-pollinated seed (McArthur 1989, Anderson 2001), though seed establishment is rare (Webb et al. 1987, Anderson 2001). Likely dispersers of the large, heavy fruits are rodents and erosion (Bowns 1973, Beatley 1974, Webb et al. 1987, McArthur 1989, Anderson 2001). Few seedlings survive due to rodents digging up the cache for remaining seeds, soil erosion, or limited moisture (Bowns 1973, Bowns and West 1976, Longland 1995, Anderson 2001). However, rodent caches may also produce clusters of seedlings (Bowns 1973, Beatley 1974, Bowns and West 1976, Webb et al. 1987, Lei 1997, Anderson 2001). Herbivore browsing may also contribute to irregular and inconsistent seed set and seedling establishment (Hughes and Weglinski 1991).

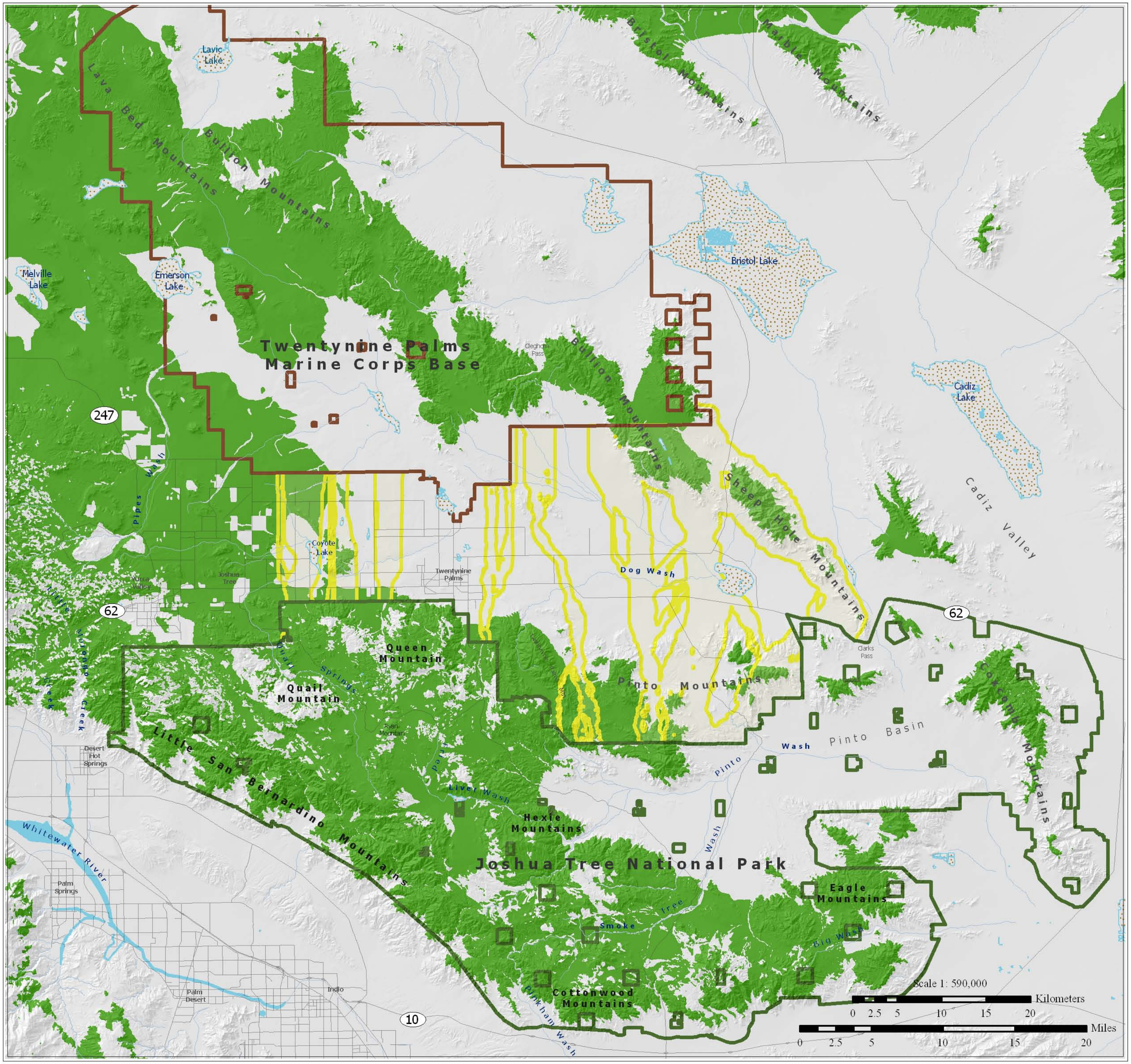
Blackbrush doesn't germinate easily (Beatley 1974, Webb et al. 1987, Anderson 2001). The seeds remain dormant until appropriate levels of soil moisture are met (Lei 1997). The seeds also require cold stratification without light for germination (Bowns 1973, Bowns and West 1976, Lei 1997, Anderson 2001). With heavy rains in early spring, blackbrush can germinate in large numbers, suggesting certain climatic conditions must be met to ensure establishment (Beatley 1974, Webb et al. 1987, Anderson 2001).

Conceptual Basis for Model Development: Blackbrush can be found in creosote bush scrub, desert scrub, sagebrush, Joshua tree woodland, juniper, and pinyon-juniper habitats between 760-2440 m (2500 and 8000 ft) in elevation.

Results & Discussion: Potential habitat for blackbrush is largely restricted to the western part of the planning area, with relatively little potential habitat captured by the Least Cost Union (Figure 53). Potentially suitable habitat does occur in both the westernmost and easternmost branches of the Union, which may facilitate movements of dispersers of blackbrush fruit and seeds. The habitat additions along Quail Springs, Coyote Lake Wash and Pipes Canyon Wash will also provide habitat for this species, and the Pipes Canyon addition ties in with the San Bernardino-Little San Bernardino Connection (Penrod et al. 2005). We conclude that the linkage will likely accommodate blackbrush if these additions are added to the Least Cost Union.

Figure 53. Potential Habitat for Blackbrush

(Coleogyne ramosissima)



- Potential Habitat
- Least Cost Union
- Dept. of Defense
- National Park Service
- Roads
- Streams
- Dry Lakes
- Waterbodies

N

Map Produced By:

SOUTH COAST WILDLANDS

Desert lily (*Hesperocallis undulata*)

Justification for Selection: The desert lily, or Ajo lily, is a perennial herb associated with sand dunes and sandy flats in desert scrub habitats.

Distribution & Status: The desert lily is widely distributed in California, Arizona and adjacent Mexico. In California, it is found in the southern and western Mojave Desert but it may also be present in the Sonoran Desert (Calflora 2004). It occurs primarily below 800 m (2625 ft) but can be found up to 1524 m (5000ft; Hickman 1993, Baldwin et al. 2002).

The desert lily is not considered a special status species. In some parts of its range it is protected by law (Bowers 1999).

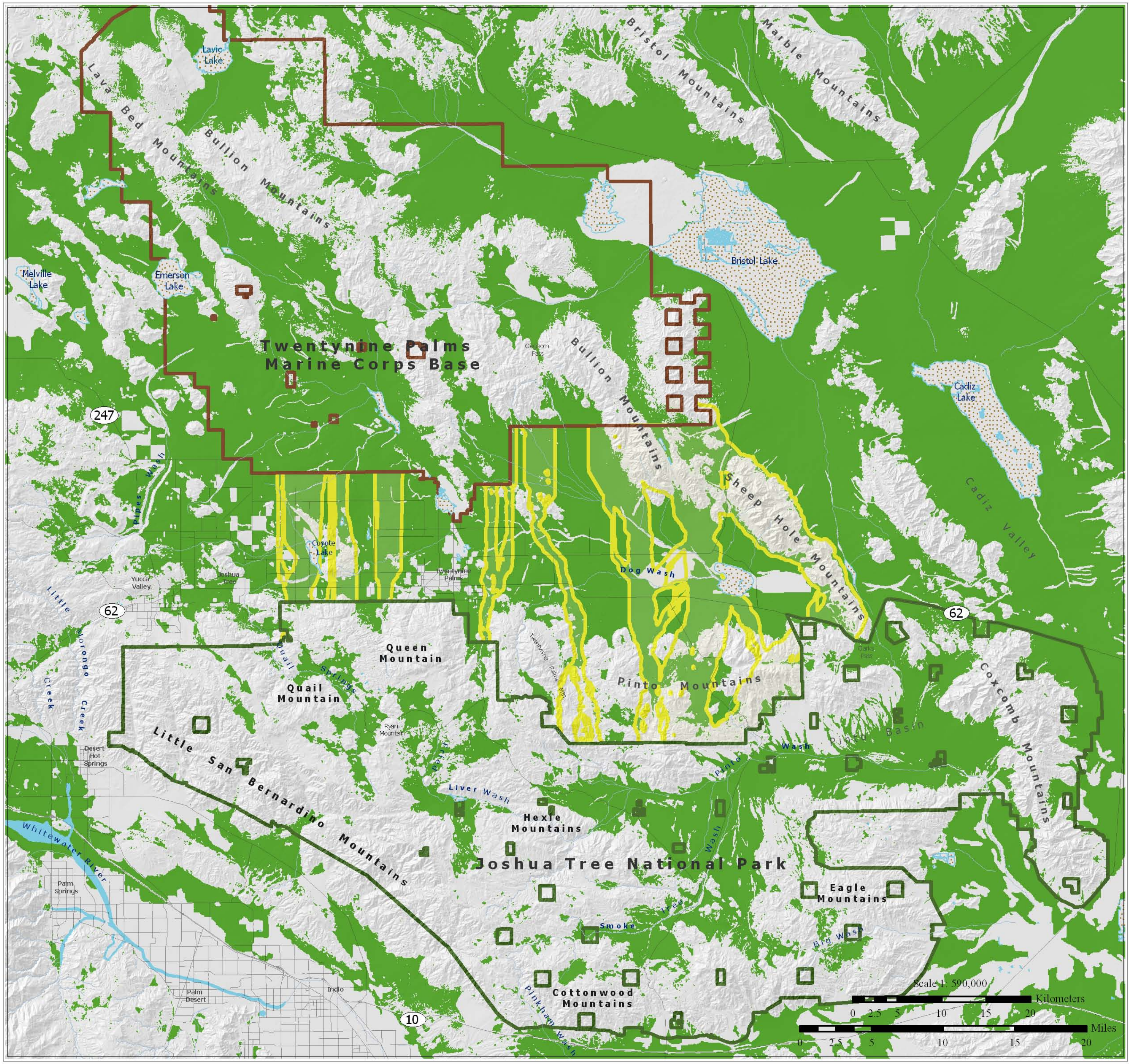
Habitat Associations: The desert lily is associated with dunes, sandy flats, and mesas in creosote bush scrub and Joshua tree woodland (Calflora 2004) (Hickman 1993, Epple and Epple 1995, Baldwin et al. 2002, Calflora 2004).

Spatial Patterns: This species blooms in April and May but may not show above ground growth every year (Calflora 2004). Hawkmoths are likely the most important pollinators (Epple and Epple 1995).

Conceptual Basis for Model Development: The desert lily is found on flats and mesas in desert scrub and Joshua tree woodland communities below 1524 m (5000 ft).

Results & Discussion: Potential habitat for the desert lily is widespread in the planning area but restricted to flat topography in desert scrub and Joshua tree woodlands. All of the branches of the Least Cost Union contain substantial potential habitat for desert lily, except the easternmost branch (Figure 54). Most of the habitat additions will provide additional habitat for this species. With these additions, we believe the linkage will likely accommodate the needs of the desert lily. Maintaining this plant species in the linkage will help to maintain the ecological integrity of the linkage over time.

Figure 54.
Potential Habitat
for
Desert Lily
(Hesperocallis undulata)



Potential Habitat
Least Cost Union
Dept. of Defense
National Park Service
Roads
Streams
Dry Lakes
Waterbodies

N

Map Produced By:
SOUTH COAST WILDLANDS

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

Goals of the Linkage Design

To accommodate the full range of target species and ecosystem functions, the Linkage Design (Figure 55) will optimally achieve the following goals: 1) provide live-in and move-through habitat for multiple species, 2) support metapopulations of smaller species, 3) ensure availability of key resources, 4) buffer against edge effects, 5) reduce contaminants in streams, 6) allow natural processes to operate, and 7) allow species and natural communities to respond to climatic changes. We elaborate on these goals below.

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

The Linkage Design must support metapopulations of less mobile species. Many small animals, such as Mojave fringe-toed lizard, rosy boa, kangaroo rats, and many invertebrates and plants, may require dozens of generations to move between targeted areas. These species need a linkage wide enough to support a constellation of populations, with movements among populations occurring over decades. We believe 2 km is adequate to accommodate most target species living as metapopulations within the linkage area.

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

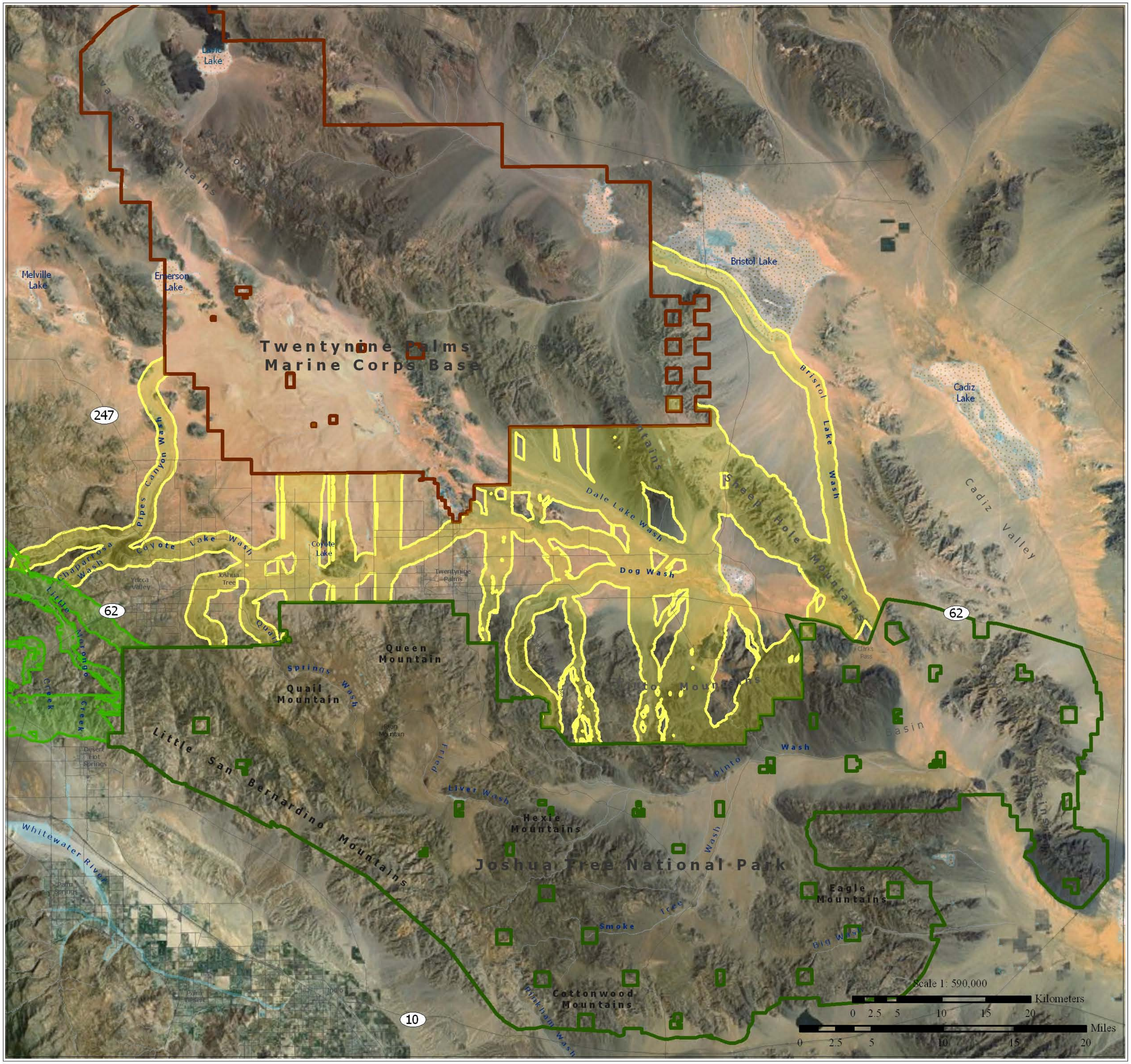
The Linkage was also designed to buffer against "edge effects", even if adjacent land becomes developed. Edge effects are adverse ecological changes that enter open space from nearby developed areas, such as weed invasion, artificial night lighting, predation by house pets, increases in opportunistic species like raccoons and ravens, elevated soil moisture from irrigation, pesticides and pollutants, noise, trampling, and domesticated animals that attract native predators. Edge effects have been best studied at the edge between forests and adjacent agricultural landscapes, where negative effects extend 300 m (980 ft) or more into the forest (Debinski and Holt 2000, Murcia 1995) depending on forest type, years since the edge was created, and other factors (Norton 2002). The best available data on edge effects for southern California habitats include reduction in leaf-litter and declines in populations of some species of birds and mammals up to 250 m (800 ft) in coastal scrub (Kristan et al. 2003), collapse of native plant and animals communities due to the invasion of argentine ants up to 200 m (650 ft) from irrigated areas (Suarez et al. 1998), and predation by house cats which reduce small vertebrate populations 100 m (300 ft) from the edge (K. Crooks, unpublished data). Domestic cats may affect wildlife up to 300 m (980 ft) from the edge based on home range sizes reported by Hall et al. (2000).

Upland buffers are needed adjacent to riparian vegetation and washes to prevent aquatic habitat degradation. Contaminants, sediments, and nutrients can reach streams from distances greater than 1 km (0.6 mi) (Maret and MacCoy 2002, Scott 2002, Naicker et al. 2001), and many species associated with aquatic environments are often more sensitive to land use at watershed scales than at the scale of narrow riparian buffers (Goforth 2000, Fitzpatrick et al. 2001, Stewart et al. 2001, Wang et al. 2001, Scott 2002, Willson and Dorcas 2003). For instance, some amphibians, such as the western toad, breed in riparian communities but use adjacent uplands to meet other life history requirements.

The Linkage Design must also allow natural processes of disturbance and recruitment to operate with minimal constraints from adjacent urban areas. The Linkage should be wide enough that temporary habitat impacts due to fires, floods, and other natural processes do not affect the entire linkage simultaneously. Wider linkages with broader natural communities may be more robust to changes in disturbance frequencies by human actions. Before human occupation, naturally occurring fires (due to lightning strikes) were rare in southern California (Radtke 1983). As human populations and disturbance by invasive species in the region has increased, fire frequency has also increased dramatically (Keeley and Fotheringham 2003). Native wildlife and vegetation in the Mojave and Sonoran deserts evolved largely in the absence of fire, and thus are not very resilient to frequent or intensive fires. Slow-growing Joshua trees are particularly susceptible. It takes decades to replace Joshua trees lost in fires (NPCA 2005). In 1999, Joshua Tree National Park suffered its largest fire on record, with 14,000 acres burned in the Juniper Fire (NPCA 2005), and the Paradise Fire burned over 3,000 acres in Morongo Valley in 2005. Although fire can reduce the occurrence of exotic species in native grasslands (Teresa and Pace 1998), it can have the opposite effect in some shrubland habitats (Giessow and Zedler 1996), encouraging the invasion of non-native plants, especially when fires are too frequent. While effects of altered fire regimes in this region are somewhat unpredictable, wider linkages with broader natural communities should be more robust to these disturbances than narrow linkages.

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

Figure 55.
Linkage Design



Linkage Design
SB-LSB Linkage
Dept. of Defense
National Park Service
Roads
Streams
Dry Lakes
Waterbodies

N

Map Produced By:
South Coast Wildlands

Description of the Linkage Design

The Linkage Design encompasses basin and range topography with an impressive array of geological formations and broad alluvial fans or bajadas. It includes several major swaths of habitat to accommodate diverse species and ecosystem functions (Figure 55). The distance between Joshua Tree National Park and Twentynine Palms MCAGCC varies in length from about 15 km (9.32 mi) on the western side of the Linkage Design to about 35 km (21.75 mi) on the eastern end.

The westernmost branch follows Pipes Canyon Wash and Chaperrosa Wash from TWC's Pioneertown Mountains Preserve and the San Bernardino-Little San Bernardino Connection (Penrod et al . 2006) to Twentynine Palms MCAGCC. Dominant habitats include pinyon-juniper and Joshua tree woodlands with mixed chaparral, desert scrub, and desert riparian and washes interspersed. This branch serves such species as mountain lion, bighorn sheep, rosy boa and blackbrush, as well as, sensitive and listed species such as burrowing owl, loggerhead shrike, LeConte's thrasher, and desert tortoise (Circle Mountain Biological Consultants, Inc. 2007). Much of this connection has already been conserved.

The next swath follows Coyote Lake Wash providing an east-west movement corridor between the Coyote Lake area and Pipes Canyon Wash. This branch serves virtually all of the focal species, but was particularly important for desert lily, blackbrush, and the threatened desert tortoise, which has been recorded along the wash (Circle Mountain Biological Consultants).

Quail Springs Wash flows off of Quail Mountain in Joshua Tree National Park toward Coyote Lake. This desert wash connection was particularly important for the black-tailed gnatcatcher and the desert lily. It also provides for east-west movement through the Linkage Design, which will serve most of the focal species, including the Mojave fringe-toed lizard, which relies on sand transport corridors. We imposed the minimum width of 2 km to ensure that the functional processes of the linkage are protected.

The other three roughly parallel branches that run north-south in the western portion of the Linkage Design range in width from 2 to 5 km (1.2-3.1 mi), and take in habitat around Coyote Lake and the Copper Mountains. These routes were delineated by the landscape permeability analysis for bobcat, but are also intended to serve species such as the round-tailed ground squirrel, desert kangaroo rat, black-throated sparrow, burrowing owl, LeConte's thrasher, desert tortoise, and velvet ant. Most of the land within these three connections is administered by BLM, with considerable public land north of Highway 62.

Another branch of the linkage extends from the Bullion Mountains near Cleghorn Pass on Twentynine Palms MCAGCC, through the alluvial filled valley to the foothills of Queen Mountain in Joshua Tree National Park. This branch was defined as the least cost corridor for badger, though it will also serve the habitat and movement needs of diverse species, including Merriam's kangaroo rat, rosy boa, and Mojave yucca.

Dog Wash and Dale Lake Wash provide live-in and move-through habitat for several species and maintain natural hydrological and fluvial processes that are important for sustaining habitat quality along the washes. These branches of the linkage are expected to serve the habitat and movement requirements of such species as black-tailed gnatcatcher, Mojave fringe-toed lizard, alkali fairy shrimp, desert willow and desert lily, but the majority of focal species will also benefit from maintaining connectivity here. Both of these branches contain substantial public ownership that protects natural habitats from development.

The three eastern roughly parallel branches of the Linkage Design were delineated by the landscape permeability analysis for desert tortoise, while the eastern two routes were also identified as the least cost corridor for badger. These connections also provide habitat and connectivity for most of the other focal species, and nearly all of the land is in public ownership administered by the BLM.

The next branch of the Linkage Design is the widest and largely follows the rocky terrain of the Sheephole Mountains. It extends from the Bullion Mountains, through the Sheephole Mountains to the Pinto Mountains. This swath of the linkage was delineated as the least cost corridor for bighorn sheep movement between targeted areas, but it is also an essential connection for other habitat specialists that depend on rocky terrain, such as the chuckwalla, Ford's swallowtail, meloid beetle, and jojoba. This branch of the linkage will also serve several other focal species as well, such as LeConte's thrasher, black-throated sparrow, and Merriam's kangaroo rat. The majority of this connection is administered by BLM, including the Sheephole Valley Wilderness Area. However, other uses may still threaten the integrity of the linkage and should be carefully managed on these lands. For example, use of off-road vehicles can impact habitat use patterns of several species. This branch of the linkage also supports habitat for several listed and sensitive species, including the desert tortoise (CDFG 2005).

The easternmost branch of the Linkage Design follows Bristol Lake Wash and was added specifically for the Mojave fringe-toed lizard and black-tailed gnatcatcher, though many other species will also benefit from maintaining habitat connectivity here.

The Linkage Design encompasses 12 different major vegetation types (Table 3). Desert scrub is by far the most common vegetation community covering 91% of the total Linkage Design. However, the desert scrub is quite diverse with elements from both the Mojave and Sonoran (Colorado) deserts. Roughly 72% of desert scrub habitat in the linkage is already in some sort of conservation status. A diversity of wetland habitats occur throughout the planning area, including riparian forests, woodlands, and scrubs, palm oases, alluvial fans, desert washes, dry lakes, springs, and seeps. However, only 2.05% of the total land area within the Linkage Design supports wetland habitats (desert riparian, desert wash, montane riparian, and water). Desert wash habitat is by far the most abundant of these four habitat types in the linkage, covering about 2442 ha (6034 ac), of which about 65% is in conservation lands. Conversely, desert riparian habitat only covers about 93 ha (229 ac) and less than 2/% is protected. In this xeric region, riparian and wash habitats support a disproportionately large number of species and are key movement areas for numerous focal species. While natural vegetation comprises most of the Linkage Design, residential and urban development covers roughly 0.7% of its area. These areas are considered stewardship zones, and should be targeted for outreach to maintain permeability through these areas.

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

Vegetation Type	Total Area Linkage Design		Total Protected Linkage Design		% Protected	% of Total Area
	Hectares	Acres	Hectares	Acres		
Alkali Scrub	3,736.39	9,232.78	2,858.82	7,064.27	76.51%	3.00%
Annual Grass	380.29	939.71	160.56	396.76	42.22%	0.31%
Barren	48.80	120.59	23.83	58.88	48.82%	0.04%
Desert Riparian	92.54	228.67	1.79	4.43	1.94%	0.07%
Desert Scrub	113,245.20	279,833.88	81,348.66	201,016.12	71.83%	90.91%
Desert Succulent Scrub	164.28	405.94	164.28	405.94	100.00%	0.13%
Desert Wash	2,441.81	6,033.83	1,584.19	3,914.59	64.88%	1.96%
Joshua Tree	596.19	1,473.20	214.39	529.76	35.96%	0.48%
Juniper	625.96	1,546.77	266.98	659.71	42.65%	0.50%
Mixed Chaparral	1,635.09	4,040.37	1,073.47	2,652.59	65.65%	1.31%
Montane Riparian	6.84	16.90	6.66	16.47	97.42%	0.01%
Pinyon-Juniper	753.91	1,862.94	618.66	1,528.73	82.06%	0.61%
Urban	827.68	2,045.23	19.85	49.05	2.40%	0.66%
Water	10.71	26.46	10.71	26.46	100.00%	0.01%
Total	**124,565.68**	**307,807.27**	**88,352.84**	**218,323.75**	**70.93%**	**100.00%**

All branches of the Linkage Design include substantial public ownerships that may help protect natural habitats from development. However, public lands are subject to multiple uses, some of which may not be compatible with maintaining linkage function (e.g., proposed energy developments). The final Linkage Design encompasses 124,566 ha (307,807 ac), of which approximately 71% (88,353 ha or 218,324 ac) currently receives some level of conservation protection, mostly in land administered by BLM and TWC.

Removing and Mitigating Barriers to Movement

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

This discussion focuses on structures to facilitate movement of terrestrial species across roads, and on structures to facilitate stream flow under roads. Although some documents refer to such structures as “corridors” or even “linkages,” we use these terms to describe the entire area required to link the landscape and facilitate movement between large targeted core areas. Crossing structures represent only small portions, or choke points, within an overall habitat linkage or movement corridor. Investing in specific crossing structures may be meaningless if other essential components of the linkage are left unprotected. Thus, it is essential to keep the larger landscape context in mind when discussing existing or proposed structures to cross movement barriers, such as State Route 62. This broader context also allows awareness of a wider variety of restoration options for maintaining functional linkages. Despite the necessary emphasis on crossing structures in this section, we urge the reader keep sight of the primary goal of conserving landscape linkages to promote movement between core areas over broad spatial and temporal scales.

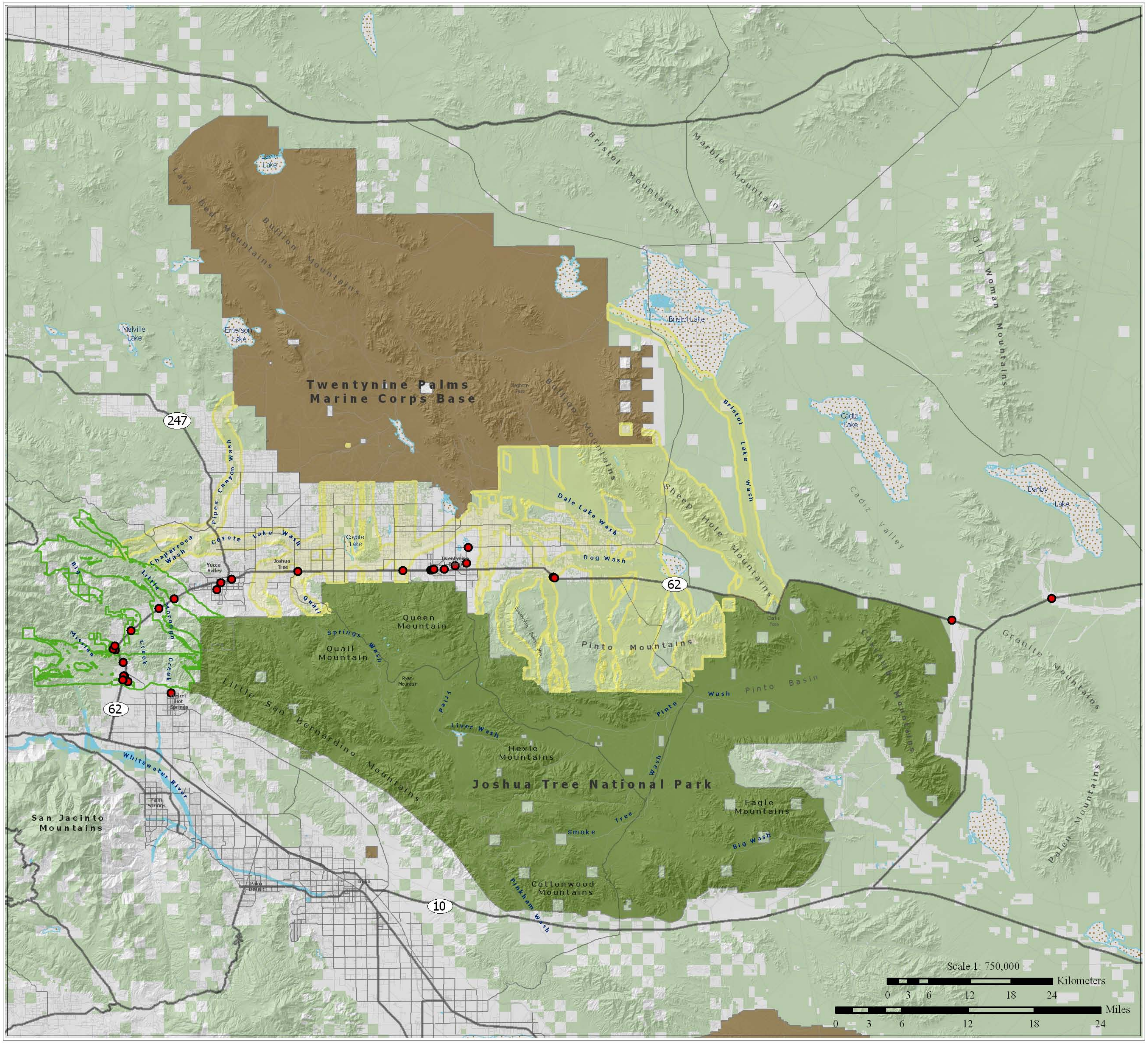
Roads as Barriers to Upland Movement: Wildland fragmentation by roads is increasingly recognized as one of the greatest threats to biodiversity (Noss 1983, Harris 1984, Wilcox and Murphy 1985, Wilcove et al. 1986, Noss 1987, Reijnen et al. 1997, Trombulak and Frissell 2000, Forman and Deblinger 2000, Jones et al. 2000, Forman et al. 2003). Roads kill animals in vehicle collisions, create discontinuities in natural vegetation (due to both the road itself and induced urbanization), alter animal behavior (due to noise, artificial light, human activity), promote invasion of exotic species, and pollute the environment (Lyon 1983, Noss and Cooperrider 1994, Forman and Alexander 1998). Roads also fragment populations by acting as semi-permeable to impermeable barriers for non-flying animals (e.g., insects, fish, amphibians, reptiles, and mammals) and even some flying species (e.g., butterflies and low-flying birds). Roads may even present barriers for large mammals such as bighorn sheep (Rubin et al. 1998). The resulting demographic and genetic isolation increases extinction risks for populations (Gilpin and Soulé 1986). For example, Ernest et al. (2003) have documented little flow of mountain lion genes between the Santa Ana and Palomar ranges (where I-15 is the most obvious barrier), and between the Sierra Madre and Sierra Nevada (where I-5 and urbanization along SR-58 are the most obvious barriers). Fragmentation also results in smaller populations, which are more susceptible to extinction due to demographic and environmental randomness.

The impact of a road on animal movement varies with species, context and setting (vegetation and topography near the road), and road type and level of traffic (Clevenger et al. 2001). For example, a road on a stream terrace can cause significant population declines in amphibians that move between uplands and breeding ponds (Stephenson and Calcarone 1999), but a similar road on a ridgeline may have negligible impact. Most documented impacts on animal movement concern paved roads. Dirt roads may actually facilitate movement of some species, such as mountain lions (Dickson et al. 2004), while adversely impacting other species, such as snakes that sun on them and may be crushed even by even infrequent traffic.

Roads in the Linkage Design: State Route 62 and 247 are the only major transportation routes in the planning area and pose the most substantial barriers to movement (Figure 56). State Route 62 bisects the linkage for a distance of roughly 39 km (25 mi), while the 247 crosses the Pipes Canyon branch of the linkage for about 5 ½ km (3.4 mi). A survey of State Route 62 found a variety of existing structures (i.e., bridges, pipes, and culverts) that might be useful for implementing road mitigation projects, though the majority of State Route 62 and all of 247 are at grade (Figure 56).

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

Figure 56.
Existing Infrastructure in the Linkage Planning Area



Potential Crossing Structures
Linkage Design
SB-LSB Linkage
Dept. of Defense
National Park Service
Public/Private Conservation
Roads
Streams
Dry Lakes
Waterbodies

Map Produced By:
SOUTH COAST WILDLANDS

There are approximately 50 vegetated wildlife overpasses (Figure 57) in Europe, Canada, and the U.S. (Evink 2002, Forman et al. 2003). They range from 50 m (164 ft) to more than 200 m (656 ft) in width (Forman et al. 2003). Soil depths on overpasses range from 0.5 to 2 m, allowing growth of herbaceous, shrub, and tree cover (Jackson and Griffin 2000). Overpasses can maintain ambient conditions of rainfall, temperature, light, vegetation, and cover, and are quieter than underpasses (Jackson and Griffin 2000). In Banff National Park, Canada, large mammals preferred overpasses to other crossing structures (Forman et al. 2003). Similarly, woodland birds used overpasses significantly more than they did open areas without an overpass. Other research indicates overpasses may encourage birds and butterflies to cross roads (Forman et al. 2003). Overpass value can be increased for small, ground-dwelling animals by supplementing vegetative cover with branches, logs, and other cover (Forman et al. 2003).

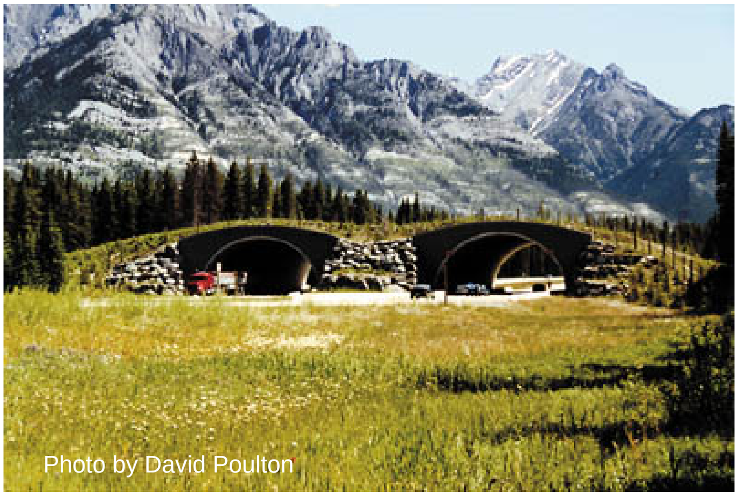


Figure 57. An example of a vegetated land bridge built to enhance movement of wildlife populations.

Bridges over waterways are also effective crossing structures, especially if wide enough to permit growth of both riparian and upland vegetation along both stream banks (Jackson and Griffin 2000, Evink 2002, Forman et al. 2003). Bridges with greater openness ratios (i.e., where the openness ratio = height x width/length) are generally more successful than low bridges and culverts (Veenbaas and Brandjes 1999, Jackson and Griffin 2000). The best bridges, termed *viaducts* (Figure 58), are elevated roadways that span entire wetlands, valleys, or gorges, but these are cost-effective only where topographic relief is sufficient to accommodate the structure (Evink 2002).

Figure 58. A viaduct in Slovenia built to accommodate wildlife, hydrology, and human connectivity.

Although inferior to bridges, culverts can be effective crossing structures for some species (Jackson and Griffin 2000). Only very large culverts are effective for carnivores and other large mammals (Figure 59). Gloyne and Clevenger (2001) suggest that underpasses for ungulates should be at least 4.27 m high and 8 m wide, with an openness ratio of 0.9 (where the openness ratio = height x width/length). Earthen flooring is preferable to concrete or metal (Evink 2002).

Figure 59. Arched culvert on German highway, with rail for amphibians and fence for larger animals.

For rodents, pipe culverts (Figure 60) about 1 ft in diameter without standing water are superior to large, hard-bottomed culverts, apparently because the overhead cover makes them feel secure against predators (Forman et al. 2003, Clevenger et al. 2001). In places where a bridged, vegetated undercrossing or overcrossing is not feasible, placing pipe culverts alongside box culverts can help serve movement needs of both small and large animals. Special crossing structures that allow light and water to enter have been designed to accommodate amphibians (Figure 61). Retaining walls should be installed, where necessary, along paved roads to deter small mammals, amphibians, and reptiles from accessing roadways (Jackson and Griffin 2000). Concrete retaining walls are relatively maintenance free, and better than wire mesh, which must be buried and regularly maintained.

Figure 60. Pipe culvert designed to accommodate small mammals.

Figure 61. Amphibian tunnels allow light and moisture into the structure.

Noise, artificial night lighting, and other human activity can deter animal use of a crossing structure (Yanes et al. 1995, Pfister et al. 1997, Clevenger and Waltho 1999, Forman et al. 2003). Noise can also deter animal passage (Forman et al. 2003). Shrub or tree cover should occur near the entrance to the structure (Evink 2002). However, the behaviors of individual focal species should carefully be considered. For example, structures designed primarily for bighorn sheep use should be sparsely vegetated as bighorn sheep avoid dense vegetation (USFWS 2000). Existing structures can be substantially improved with little investment by installing wildlife fencing, earthen berms, and vegetation to direct animals to passageways (Forman et al. 2003). Regardless of crossing type, wildlife fencing is necessary to funnel animals towards road crossing structures and keep them off the road surface (Falk et al. 1978, Ludwig and Bremicker 1983, Feldhammer et al. 1986, Forman et al. 2003). Earthen one-way ramps can allow animals that wander into the right of way to escape over the fence (Bekker et al. 1995, Rosell Papes and Velasco Rivas 1999, Forman et al. 2003).

Recommended Crossing Structures on State Route 62: For most species, State Route 62 is the most obvious barrier between Joshua Tree National Park and Twentynine Palms MCAGCC. BLM land abuts both sides of the highway for much of its length to the east of the community of Twentynine Palms, especially to the south of the highway. Some crossing structures adequate to accommodate wildlife movement currently exist, while others need to be improved or built.

The precise timing and location for constructing new or improved crossing structures may not be critical, and will be determined by cost, feasibility, and other factors. Opportunities for using natural topographic features to enhance connectivity in the linkage are limited. The speed limit ranges from 55 to 65 mph but many vehicles far exceed these limits. Although flat desert highways seem to be destined for high speeds, we suggest reducing the speed limit to 45 mph through each branch of the linkage. This is the simplest and most cost effective way to reduce wildlife/vehicle collisions (Bertwistle 1999). We also recommend installing wildlife crossing signs to alert drivers they are entering a wildlife movement corridor. Laser and infrared activated warning signs with flashing lights have been used to alert drivers to slow down for wildlife (Reed 1981, Messmer et al. 2000, Gordon 2001, Robinson et al. 2002, Huijser and McGowen 2003). The systems flashing lights are activated when wildlife step over the sensing device on the approach to the monitored roadway (Gordon 2001). These two actions alone could significantly reduce wildlife mortality in the linkage area but other measures can be taken to improve wildlife movement when the next highway improvement projects are undertaken.

Currently, there are only a few structures along State Route 62 that accommodate animal movement. We recommend maintaining these structures, protecting adjacent land from development, and ensuring that future road projects do not degrade these crossing structures. These existing structures should be supplemented with major bridges or overpasses at appropriate locations when transportation projects are undertaken in the Linkage Design.

Figure 62. Looking south towards Joshua Tree National Park at the structure for Quail Wash on Highway 62.

Quail Wash currently passes under Highway 62 via a series of concrete box culverts (Figure 62), each measuring approximately 4.6 m (15 ft) wide, 2.3 m (7.5 ft) high, and 28.4 m (93 ft) long. Suitable habitat occurs in the vicinity of the structure for a number of focal species including badger, round-tailed ground squirrel, burrowing owl, LeConte's thrasher, desert tortoise, and blackbrush. Animals that follow washes could take Quail Wash to Coyote Lake and the Copper Mountains about midway through the linkage, and then pickup several unnamed drainages that lead toward Twentynine Palms MCB. We observed an abundance of animal tracks throughout this area, including under the State Route 62 bridges. There were also signs of heavy off-road vehicle use, trash, and graffiti in the vicinity of the structure. Efforts should be made to discourage these activities, which impact soils and vegetation and likely inhibit species from using this structure. We advise purchase or conservation easements of any large parcels in this branch of the linkage and urge conservation agreements to preclude any further development of parcels that straddle the highway near the culvert to enhance the integrity of the linkage.

The next branch of the linkage to the east of the Quail Wash crossing was delineated by the landscape permeability analysis for bobcat. However, several other focal species will also benefit from maintaining connectivity here, including the desert tortoise which has been recorded in this vicinity (Circle Mountain Biological Consultants, Inc. 2007). Currently, there are only a few pipe culverts in this branch of the linkage, which are located between Sunfair Road and Cascade Road. Each pipe measures roughly 0.61 m (2 ft) in diameter. The pipe culverts shown in Figure 63 occur about 325 m (1066 ft) to the west of Cascade Road. These structures may facilitate movement of small mammals and reptiles across Highway 62, but larger mammals such as the bobcat must currently cross the highway at grade. We recommend installing at least one large box culvert (at least 3 m [6.56 ft] high and wide) in this stretch of highway during the next transportation improvement project to accommodate larger mammals such as bobcat and badger. We also suggest additional pipe culverts be installed to reduce travel distance for less mobile species, such as kangaroo rats and terrestrial invertebrates like the velvet ant. Fencing should be installed in conjunction with the culverts to guides animals to the structures. The land in this branch of the linkage should be targeted for conservation easement, purchase, or other action to maintain its wild character.

Figure 63. Pipe culverts on Highway 62 roughly 325 m west of Cascade Road.

No existing structures occur in the next branch, essentially between Kerr Avenue and Mantonya Road, largely because the highway is at grade through much of this area (Figure 64). This swath of the linkage was also delineated by the permeability analysis for bobcat but several other focal species will benefit from maintaining connectivity here, including badger, round-tailed ground squirrel, and desert kangaroo rat. The LeConte's thrasher and desert tortoise have also both been recorded in this area (Circle Mountain Biological Consultants, Inc. 2007). Since the topography is not well-suited to accommodate large undercrossings beneath the road, we suggest small culverts be built to accommodate tortoise and other smaller species during the next transportation improvement project. For larger mammals, birds, and other species, we suggest speeds be reduced and several wildlife corridor signs be installed to alert drivers to be attentive to wildlife movement in the area.

Figure 64. View of the habitat along Highway 62 between Kerr Ave and Mantonya Rd.

Figure 65. Bridge for Savahia Peak Wash on Highway 62 (left), and pipe culverts under Highway 62 near Shoshone Valley Road (right).

The next branch of the linkage encompasses habitats between Shoshone Valley Road and Sherman Road. There are two structures in this area (Figure 65) -- a series of 3 box culverts for Savahia Peak Wash that each measure roughly 3 m (10 ft) wide and 4 m (13 ft) high, and a double pipe culvert that is about 0.6 m (2 ft) in diameter. Off-road vehicle use in the wash likely deters animal movement, though bobcat and other small mammal tracks were noted during field surveys. The pipe culverts are in need of replacement; they were observed to be completely blocked at the northern entrance, and a 1/3 of the southern entrance was submerged. There were plenty of small mammal tracks in the vicinity. Although this portion of State Route 62 is not currently an impermeable barrier, especially at night, permeability for most species is likely to be lost if further development occurs here. We recommend maintaining the rural character of the landscape with appropriate measures to confine light and noise pollution to existing home sites. We advise purchase or conservation easements of any large parcels in the broad bajada of

Savahia Peak Wash and urge conservation agreements to preclude development of parcels that straddle the highway near the culvert to enhance the integrity of the linkage.

The next major swath of the linkage crosses Highway 62 between Wilshire Avenue and Charlotte Road. No crossing structures exist along this stretch of the highway, which is also at grade for most of its length. The least cost corridor for badger crossed the highway here, and other focal species that use desert scrub would also benefit from maintaining connectivity here. We suggest reducing the speed limit and installing signs along this stretch to minimize road kills. When the next transportation project occurs in this section of the road, we suggest incorporating a series of pipe culverts, and where topography permits, larger box culverts.

The next three braided swaths of the linkage were delineated by the landscape permeability analysis for desert tortoise, with the two eastern branches also defined as the least cost corridor for badger (Figure 66). Potential crossing structures in these four branches are limited to two bridges in the westernmost branch. The majority of this vast area is already in public ownership and managed by the BLM. And, since this area is to the east of the city of Twentynine Palms, traffic is much reduced. Since this area is in such close proximity to the Pinto Mountains Desert Wildlife Management Area, and potential desert tortoise habitat occurs throughout this stretch, we suggest tortoise surveys to determine if road kill is an issue here. If results indicate that significant road kill is occurring, we suggest installing culverts and fencing that can accommodate the tortoise and other species of interest, such as the badger.

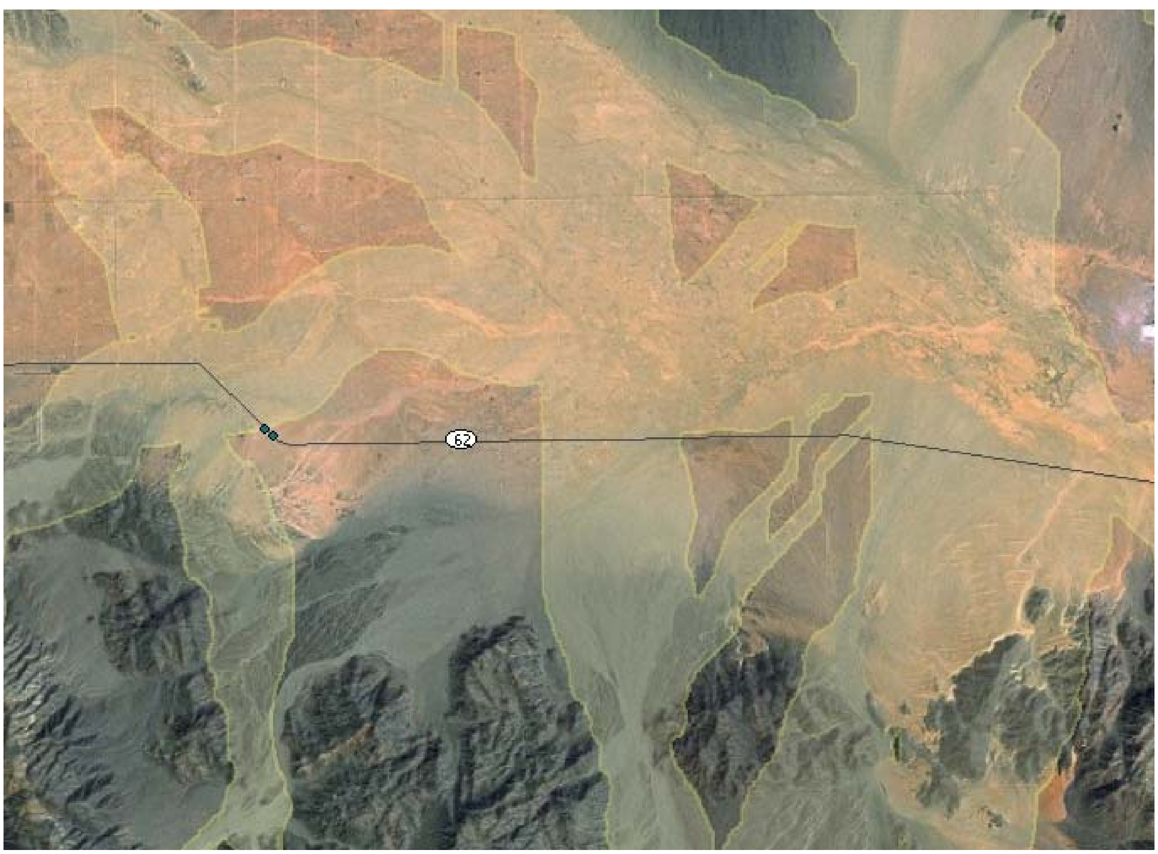


Figure 66. The above branches of the linkage were delineated by the landscape permeability analysis for desert tortoise and badger.

The least cost corridor for bighorn sheep crossed Highway 62 in the most rugged topography along the highway (Figure 67). This branch is administered by BLM, with land to the north of the highway in the Sheephole Valley Wilderness Area, and the land to the south of the highway in the Pinto Mountains where several designated off-road vehicle routes occur. This branch provides secure opportunities for bighorn movement between the two mountain ranges, facilitating seasonal moves, long-term gene flow, and dispersal opportunities for bighorn sheep. Although the topography in this area is well-suited to accommodate a ridge-to-ridge vegetated overpass, traffic is much reduced this far east of the community of Twentynine Palms, and bighorn sheep are known to move through valleys to get between mountain ranges. Thus, we suggest speed reductions in this stretch of the highway to reduce the potential for road kill (Bertwistle 1999). We also recommend that laser and infrared activated bighorn sheep crossing signs be installed (Reed 1981, Messmer et al. 2000, Gordon 2001, Robinson et al. 2002, Huijser and McGowen 2003), to alert drivers to the possible danger of wildlife-vehicle collisions, as well as of the potential to glimpse this spectacular creature in the wild.

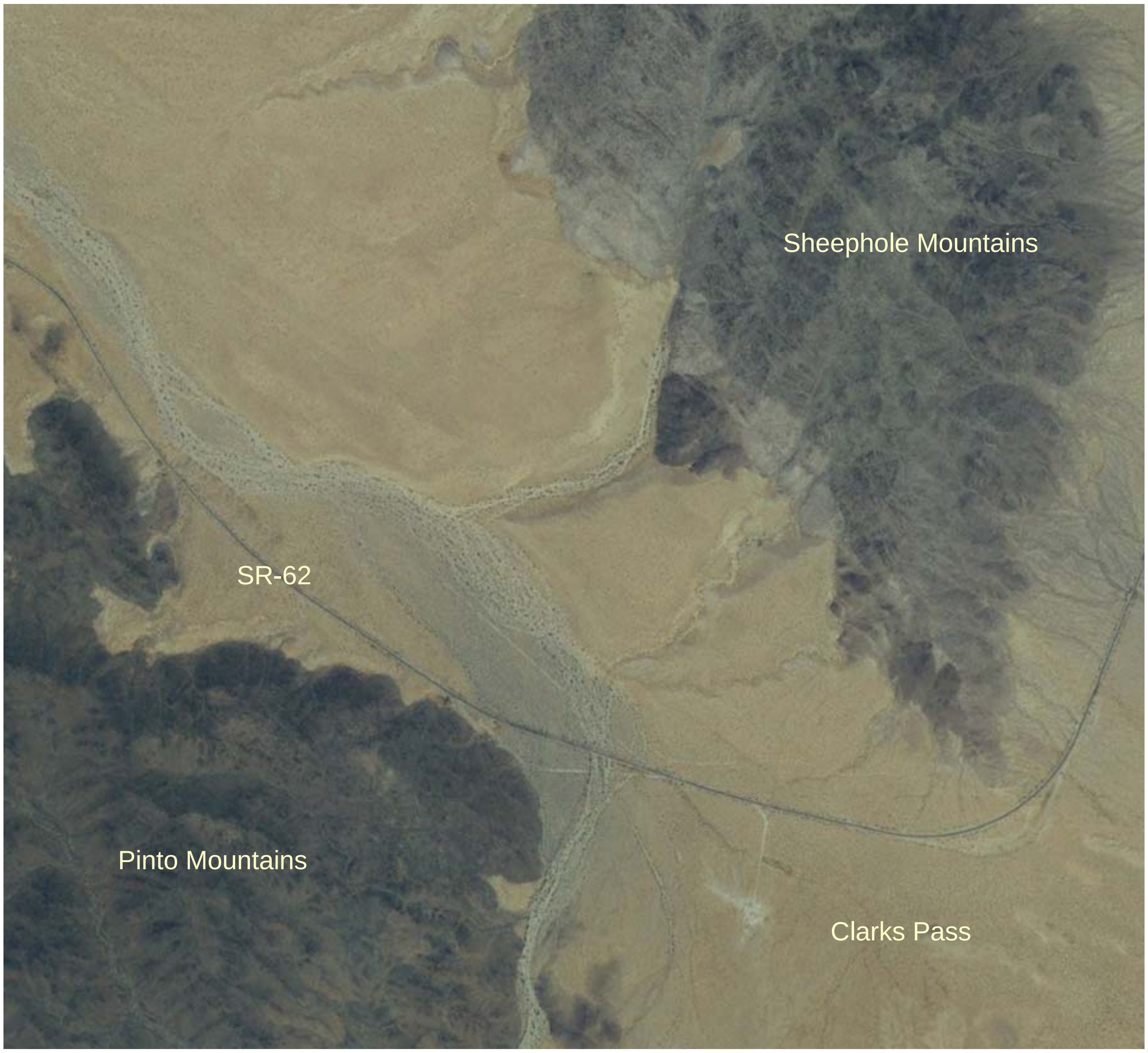


Figure 67. This branch was delineated by the permeability analysis for bighorn sheep, which was largely expected given this is a known movement corridor for this species.

Other Recommendations Regarding Paved Roads within the Linkage Design:

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

- Land managers, planners, and transportation agencies should coordinate with researchers doing radio telemetry studies in the area to identify additional locations where crossing structures should be installed.

- We suggest a road kill study as part of any future transportation improvement projects, with design of crossing structures guided by the results.

- Encourage woody vegetation leading up to both sides of crossing structures to provide cover for wildlife and to direct their movement toward the structure. Work with the NPS, California Native Plant Society, local Resource Conservation District, or other non-profit organizations to restore riparian communities and vegetative cover at passageways. However, crossing structures designed primarily for bighorn sheep should not be heavily vegetated, but should mimic vegetation composition and structure of nearby bighorn sheep habitat.

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

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

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

Finally, reducing traffic speeds and installing signage to alert drivers to watch for wildlife can be very cost effective ways of reducing wildlife vehicle collisions. Motorists are more likely to respond to posted wildlife crossing signs and other traffic control measures if they are educated about wildlife movement in a particular area and local agency efforts to reduce property loss and injury through the use of traffic calming measures. The communities of Morongo Valley, Yucca Valley, Joshua Tree, and Twentynine Palms should pursue available federal, state, and non-profit grant funding to develop and implement public education campaigns that help to reduce the negative impacts of development and transportation infrastructure.

Roads as Ephemeral Barriers: Structures designed for wildlife movement are increasingly common. In southern California, 26 wildlife crossing structures were installed along 22 miles of State Route 58 in the Mojave Desert specifically for desert tortoise movement (Boarman et al. 1993, Boarman et al. 1997, Evink 2002). In the South Coast Ecoregion of southern California, the Coal Canyon Interchange on State

Route 91 is now being converted, through a partnership with CalTrans, California State Parks, and Hills for Everyone, from a vehicle interchange into a wildlife underpass to facilitate movement between the Chino Hills and the Santa Ana Mountains. About 8 wildlife underpass bridges and viaducts were installed along State Route 241 in Orange County, although urbanization near this toll road has compromised their utility (Evink 2002). Elsewhere, several crossing structures, including 3 vegetated overpasses, have been built to accommodate movement across the Trans-Canada Highway in Banff National Park (Clevenger et al. 2001). In south Florida, 24 underpasses specifically designed for wildlife were constructed along 64 km (38 mi) of Interstate 75 in south Florida. The structures are readily used by endangered Florida panthers and bears, and have reduced panther and bear road kill to zero on that route (Land et al. 2001). Almost all of these structures were retrofitted to existing highways rather than part of the original road design. This demonstrates that barrier or filter effects of existing roads are at least partially reversible with well-designed improvements.

CalTrans has been fully engaged in the South Coast Missing Linkages effort, and the agency is incorporating wildlife crossing improvements into its projects with a focus in important linkage areas. For example, CalTrans recently proposed building a wildlife overpass over SR-118, and in February 2003 CalTrans started removing pavement from the Coal Canyon interchange in Orange County and transferred the property to California State Parks expressly to allow wildlife movement between Cleveland National Forest and Chino Hills State Park.

Implementing these recommendations will take cooperation among land managers, planners, land conservancies and other non-profits and transportation agencies. We urge all parties to work together to develop a long-term coordinated plan to ensure that wildlife-crossing structures are aligned in a way that maximizes their utility to animals. We recognize that it is unrealistic to expect all of the crossing structures to be built at the same time. However, an overall plan will ensure that, for instance, a planned crossing structure on State Route 62 adjoins protected lands or land targeted for conservation.

Impediments to Streams

Organisms moving through rugged landscapes often use streams and washes as travel routes. For example, many butterflies and frogs preferentially move along stream corridors (Orsack 1977, Kay 1989, USGS 2002). Although southwestern pond turtles are capable of overland movements of up to 0.5 km (0.3 mi) (Holland 1994), they preferentially move along stream courses (Bury 1972). Even large, mobile vertebrates such as mountain lions have shown preferences for moving along riparian corridors (Beier 1995, Dickson et al. 2004).

For plants and animals associated with streams or washes, impediments are presented by water diversions and extractions, road crossings, exotic species, water recharge basins, farming in streambeds, gravel mining, and concrete structures that stabilize stream banks and streambeds. Increased runoff can also create permanent streams in areas that were formerly ephemeral; permanent waters can support aggressive invasive species, such as bullfrogs and exotic fish that prey on native aquatic species, and giant reed that supplants native plant communities (Fisher and Crooks 2001).

Impediments to Streams in the Linkage Design: The Linkage Design encompasses several connections for species associated with streams and washes. Broad alluvial fans or bajadas are typical landscape features in the basin and range topography of the region. However, no single tributary provides a direct riparian connection between the two targeted areas. Pipes Canyon Wash flows out of the San Bernardino Mountains towards Twentynine Palms MCB; Quail Springs emanates from Quail Mountain in Joshua Tree National Park; Dog Wash flows out of the Pinto Mountains towards Dale Lake; and several unnamed drainages flow out of the Bullion and Sheephole mountains towards Dale Lake. These streams and washes are key movement areas for most riparian and terrestrial organisms, and may provide avenues along which species journey between Joshua Tree National Park and Twentynine Palms MCB.

With an average annual rainfall of just 4 to 6 inches (DWR 1975) and increased demand in the Morongo Basin for limited groundwater supplies (NPCA 2005), water extraction is a concern for the long-term viability of riparian and aquatic habitats in the Linkage Design. Recent water monitoring studies at Joshua Tree National Park indicate that discharge at some springs may be declining and, while researchers aren't certain of the cause, it's likely due to extraction (http://www.nps.gov/jotr/manage/bcmp/affected.html). Other studies indicate groundwater levels have been reduced by an average of one foot per year for the last 30 years, withdrawing water that is vital to sustaining the springs and water sources that so many species in the desert depend upon (NPCA 2005). Groundwater extraction may have caused the decline in surface water that in turn contributed to the recent loss of 4 out of 7 populations of the California treefrog from Joshua Tree National Park (NPS 2003, NPCA 2005). The oases in Joshua Tree National Park symbolize the value of water in shaping this striking landscape and sustaining life in this arid environment.

In addition to loss of surface and groundwater, water quality is also a concern. Much of the area has been developed with septic tanks and leachfield systems and, although groundwater supplies in the planning area appear to be adequate, water quality is poor (County of San Bernardino 2005). Algae blooms, which are indicative of excessive nutrient levels and lower dissolved oxygen, have been reported in Joshua Tree National Park. The Park Service Water Resources Division stated that 68% of the dissolved oxygen measurements for 17 spring stations in Joshua Tree National Park from 1985 to 1997 failed to meet the EPA criteria for the protection of freshwater aquatic life (NPCA 2005). However, thus far no drainages in the Linkage Design have been listed as impaired under Section 303(d) of the Clean Water Act (USEPA 2003, http://www.ice.ucdavis.edu/wqsid/wblist.asp?region_pkey=7).

The planning area is located within the Colorado River Water Basin regulated by the Colorado River Regional Water Quality Control Board. If any drainage were listed as impaired in the future, these riparian stretches would be eligible for the development of intensive management plans called Total Maximum Daily Load (TMDL) plans. TMDL plans are enacted by the Regional Water Quality Control Board to determine the cause of water quality deterioration and then an implementation plan is developed to return water quality to targeted values.

Invasive species also need to be addressed in the Linkage Design as part of stream impediment issues. For example, Twentynine Palms MCB eradicated 30,000 tamarisk or saltcedar (*Tamarix* ramosissima) over a 3 year period (R.M. Evans, MCAGCC, pers. comm.). This introduced species has escaped cultivation and invaded stream courses in the arid southwest, out-competing native plant species and forming monocultures that provide reduced habitat value to wildlife. Tamarisk can transpire at least 200 gallons of water per plant each day and will often dry up ponds and streams (Whitson et al. 2000, Baldwin et al. 2002) to the detriment of native flora and fauna.

Examples of Mitigation for Stream Barriers: Continuity between upland and riparian vegetation is important to maintaining healthy riparian communities. Many species commonly found in riparian areas depend on upland habitats during some portion of their lifecycle. Examples include butterflies that use larval host plants in upland habitat and drink water as adults and toads that summer in upland burrows. While the width of upland habitats needed beyond the stream's edge is unknown for many species, information on the western pond turtle suggests that a 1-km (0.6-mi) upland buffer (i.e., 0.5 km to either side of the stream; Holland 1994) is needed to sustain populations of this species. Buffers must contain enough upland habitat to maintain water-quality and habitat characteristics essential to the survival of many aquatic and semi aquatic organisms (Brosofske et al.1997, Wilson and Dorcas 2003).

Recommendations to Mitigate the Effects of Streams Barriers: To enhance species use of streams and washes and restore riparian connections through the Linkage Design area, we recommend:

- Wherever possible restore the natural historic flow regime or create a regime that provides maximum benefit for native biodiversity. Work with the NPS, MCAGCC, BLM, CDFG, USGS, Water Districts, watershed groups, and others to investigate the historic flow regimes and develop a surface and groundwater management program to restore properly functioning wetland and riparian conditions.

- Minimize the effects of road crossings in riparian zones. Coordinate with the California Department of Transportation, NPS, MCAGCC, BLM, USGS, and CDFG, to further evaluate existing stream and wash crossings and upgrade culverts, Arizona crossings (in stream crossings), bridges, and roads that impede wildlife movement. Use several strategies, including information on preferred crossings, designing new culverts, retrofitting or replacing culverts, post construction evaluation, maintenance, and monitoring (Carey and Wagner 1996, NMFS 2000, Evink 2002).

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

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

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

- Prevent off-road vehicles from driving in riparian areas and washes and enforce closures. Review existing regulations relative to linkage goals and develop additional restrictions (installation/maintenance of barriers for off-road vehicles) or recommend closures in sensitive areas.

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

- Increase and maintain high water quality standards. Work with the Resource Conservation District to help establish use of Best Management Practices for rural communities in the Linkage Design and surrounding communities.

- Support efficient water use and education programs that promote water conservation (County of San Bernardino 2005).

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

- Educate and encourage local jurisdictions to prohibit mass grading as part of local development practices, and opt for spot grading or other techniques with less potential to cause local flooding and impacts.

Other Land Uses that Impede Utility of the Linkage

Land management policies in the protected areas and the linkage can have substantial impact on habitat and movements of species through the Linkage Design area. It is essential that major land-management and planning entities (e.g., BLM, NPS, MCAGCC, TWC, and San Bernardino County) integrate the linkage plan into their policies and regulations.

Urban Barriers to Movement

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

Urban Barriers in the Linkage Design Area: Rural residential developments comprise just 0.7% of the Linkage Design area. The communities of Yucca Valley and Joshua

Tree are near the western part of the linkage, while Twentynine Palms is in the central part of the linkage. Small portions of these communities are in the Linkage Design, and some residential areas on the outskirts of these towns are becoming impermeable to wildlife movement due to the density of development, rural housing development patterns, traffic volume, large numbers of pets, and light and noise pollution. These areas should be considered stewardship zones and targeted for outreach to maintain linkage function. The long term sustainability of the region's ecosystems and their inter-connectivity will depend largely upon the land use changes that will occur in the next decade. Existing and future land use policy and practice will dictate how the demand for urban and rural land use expansion will alter the region's landscape. Voluntary cooperation is essential to the functionality of the linkage, to limit impacts of lighting, roads, domestic livestock, pets, and traffic on wildlife movement in the Linkage Design area. Of course, any large-scale development either within or near the perimeter of the Linkage Design is incompatible with maintaining habitat values and the functionality of the linkage due to edge effects that can penetrate beyond the development footprint.

Examples of Mitigation for Urban Barriers: Urban developments, unlike roads, create movement barriers that cannot be readily removed, restored, or mitigated. Preventing urban developments in key areas through acquisition or conservation easements is therefore the strongest option. Mitigation for existing urban developments focuses on managing stewardship zones to reduce penetration of undesirable effects into natural areas (Marzluff and Ewing 2001). Management in stewardship zones can include fencing in pets, reducing human traffic in sensitive areas or constriction points, limiting noise and lighting, reducing traffic speeds, minimizing use of irrigation, encouraging the planting of locally native vegetation, minimizing the use of pesticides, poisons and other harmful chemicals, and increasing enforcement of existing regulations.

Recommendations to Mitigate the Effects of Urban Barriers: We recommend the following mitigation actions for urban, suburban, and rural developments in the Linkage Design area:

- Encourage land acquisition and conservation easements with willing private land owners in the Linkage Design.
- Encourage homes abutting the linkage area to have minimal outdoor lighting, 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. Fencing that is impermeable to wildlife should be restricted to within 100 feet of structures. All other fencing outside of the 100-foot zone for each structure should be permeable to wildlife. Residents should be encouraged to keep cats indoors at all times.
- Enforce the Night Sky and Hillside Preservation Ordinances (County of San Bernardino 2005).
- Work with the communities of Yucca Valley, Joshua Tree, and Twentynine Palms, and the County of San Bernardino to discourage new residential or urban developments in the Linkage Design.

- If development proposals are approved in the vicinity of the Linkage Design, we recommend land management and regulatory agencies work with the project proponent to conserve linkage function (e.g., land set asides, restrictive covenants, no paved roads).

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

- Other forms of public education and outreach may include, but are certainly not limited to, an adopt-a-corridor program, public education seminars, information brochures, flyers, and posters, direct mail campaigns, public service announcements, local cable access commercials, wildlife corridor signs, and informational websites.

Recreation

Recreational use is not inherently incompatible with wildlife movement, although intense recreational activities have been shown to cause significant impacts to wildlife and plants (Knight and Cole 1995). Areas with high levels of off-road vehicle use are more readily invaded by invasive plant species (Davidson and Fox 1974), accelerate erosion and reduce soil infiltration (Iverson 1980), and alter habitat use by vertebrates (Brattstrom and Bondello 1983, Nicolai and Lovich 2000). Even such relatively low-impact activities as wildlife viewing, hiking, and horse back riding have been shown to displace wildlife from nutritionally important feeding areas and prime nesting sites (Anderson 1995, Knight and Cole 1995). The increased time and energy spent avoiding humans can decrease reproductive success and make species more susceptible to disease (Knight and Cole 1995). In addition, humans, horses, and pets can carry seeds of invasive species into natural areas (Benninger 1989, Benninger-Traux et al. 1992).

Recreation in the Linkage Design Area: Areas currently available for recreation in the Linkage Design area include Joshua Tree National Park, TWC's Pioneertown Mountains Preserve, existing and proposed county park lands, and lands administered by the BLM, including the Sheephole Valley Wilderness Area, the Cleghorn Lakes Wilderness Area, and the Cadiz Dunes Wilderness Area. BLM and NPS lands provide a wide range of recreational opportunities, from nature-based dispersed recreational activities (e.g., hiking, bird watching) to high-density recreation in developed sites. The majority of recreational use is concentrated in developed facilities with road access. Recreational activities in the vicinity of the linkage include birding, hiking, rock climbing, horseback riding, and off-road vehicle use. Unauthorized off-road vehicle use also occurs in the linkage. Designated off-road vehicle areas occur on BLM land in the Copper Mountains around Coyote Lake, on lands abutting the base to the east of Mesquite Lake, and in the Pinto Mountains adjacent to Joshua Tree National Park (BLM 2003). Poachers are also a serious concern, with collection for the illegal reptile trade threatening snakes, tortoise, and lizard populations (Associated Press 2005).

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

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

- Work with regional monitoring programs, such as the NPS Mojave Network Vital Signs Inventorying and Monitoring Plan and the State's Resource Assessment Program, to collect information on special status species, species movements, and vegetation disturbance in areas of high recreational activity.

- Monitor trail development and recreational uses (e.g., hiking, horseback riding) to provide a baseline for decisions regarding levels, types, and timing of recreational use.

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

- Prohibit new off-road vehicle routes within the Linkage Design. Close, obliterate, and restore to natural habitat any unauthorized off-road vehicle routes and enforce closures.

- Widely publicize the fact that collecting reptiles in the wild is illegal

- Enforce existing regulations on recreation, such as leash laws that require dogs to be under restraint at all times.

- Work with the land management agencies and non-governmental organizations to develop and conduct on-the-ground, multi-lingual outreach programs to recreational users on how to lessen impacts in the Linkage Design.

Land Protection & Stewardship Opportunities

A variety of conservation planning efforts are currently underway in the Linkage Design area. This section provides information on planning efforts, agencies, and organizations that may represent opportunities for conserving the Joshua Tree-Twentynine Palms Connection. This list is not exhaustive, but provides a starting point for persons interested in becoming involved in preserving and restoring linkage function.

Basin Wide Foundation: The Basin Wide Foundation works to improve quality of life in the Morongo Basin by bringing together community leaders, non-profits and philanthropic individuals to address community concerns in the economic, health, cultural and environmental realms. Visit http://www.basinwidefoundation.com for more information.

Bighorn-Desert View Water Agency: The BDVWA serves the communities of Flamingo Heights, Johnson Valley and Landers in the northwest Morongo Basin. Their mission is high quality water and reliable service at reasonable rates to the clients in their service area. For more information visit their website at http://www.bdvwa.org.

Building Industry Association: Several chapters in Southern California represent the Building Industry Association, a statewide trade association representing more than 5,000 companies including homebuilders, trade contractors, architects, engineers, designers, suppliers and other industry professionals. In San Bernardino County the BIA has been involved in the "Green County San Bernardino" program (see http://www.greencountysb.com for information on the Green County program). The BIA of Southern California has a website at http://www.biasc.org.

Bureau of Land Management: BLM sustains the health, diversity and productivity of the public lands for the use and enjoyment of present and future generations. For more information on lands administered by the BLM, visit http://www.ca.blm.gov.

California Department of Fish and Game: CDFG manages California's diverse fish, wildlife, and plant resources, and the habitats upon which they depend, for their ecological values and for their use and enjoyment by the public. Acquisition dollars for CDFG projects are authorized through the Wildlife Conservation Board as part of their Concept Area Protection Plan (CAPP) process. For more information on the Department, visit their website at http://www.dfg.ca.gov.

California Department of Transportation: CalTrans strives to achieve the best safety record in the nation, reduce traveler delays due to roadwork and incidents, deliver record levels of transportation system improvements, make transit a more practical travel option, and improve the efficiency of the transportation system. CalTrans representatives have attended each of the South Coast Missing Linkages workshops and have shown leadership and a willingness to improve linkage function in the most important linkage areas. CalTrans recently proposed building a wildlife overpass over SR-118. In February 2003, CalTrans started removing pavement from the Coal Canyon interchange on SR 91 in Orange County and transferred the property to California State Parks expressly to allow wildlife movement between the Santa Ana Mountains of the Cleveland National Forest and Chino Hills State Park. To find out more about the innovative plans being developed by Caltrans, visit their website at http://www.dot.ca.gov.

California State Parks: California State Parks provides for the health, inspiration and education of the people of California by helping to preserve the state's extraordinary biological diversity, protecting its most valued natural and cultural resources, and creating opportunities for high-quality outdoor recreation. The Department is actively engaged in the preservation of the State's rich biological diversity through their acquisition and restoration programs. Ensuring connections between State Park System wildlands and other protected areas is one of their highest priorities. CSP is involved in the Coal Canyon habitat connection restoration project to preserve mountain lion movement under SR 91 at the north end of the Santa Ana Mountains. CSP co-sponsored the statewide Missing Linkages conference and is a key partner in the South Coast Missing Linkages effort. For more information, visit their website at http://www.parks.ca.gov.

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

California Wilderness Coalition: The California Wilderness Coalition builds support for threatened wild places on a statewide level by coordinating efforts with community leaders, businesspeople, decision-makers, local organizations, policy-makers, and activists. CWC was also a co-sponsor of the statewide Missing Linkages effort. For more information, visit them at http://www.calwild.org.

California Wild Heritage Campaign: The mission of the California Wild Heritage Campaign is to ensure the permanent protection of California's remaining wild public lands and rivers. Congresswoman Hilda Solis has introduced the Southern California Wild Heritage Act. The bill would significantly expand the National Wild and Scenic Rivers System and the National Wilderness Preservation System on federally managed public lands in Southern and Central California. A total of 13 new Wild and Scenic Rivers are included in the bill, totaling more than 312 miles, and 47 new Wilderness Areas and Wilderness Additions totaling 1,686,393 acres. The Campaign builds support for Wilderness and Wild and Scenic River protection by compiling a detailed citizen's inventory of California's remaining wild places; organizing local communities in support of those places; building a diverse, broad-based coalition; and educating the general public, government officials and the media about the importance of protecting California's wild heritage. For more information on the status of the Act, visit http://www.californiawild.org.

City of Twentynine Palms: The City was incorporated in 1987 and encompasses an area of approximately 54 square miles in the Morongo Basin, home of Joshua Tree National Park and "proud host of the Marine Corps Air Ground Combat Center." The city's mission is to provide an open and effective City government that protects the health, safety and welfare of its citizens, maintains a strong sense of community, nurtures prosperity, and creates the highest quality of life with the resources available. Information is available on their website at http://www.ci.twentynine-palms.ca.us.

Copper Mountain College: Copper Mountain College initially began offering classes in the Morongo basin as part of the Desert Community College District in 1967. In 1982 the college and the community came together to build a permanent campus in Joshua Tree. In 1999 Copper Mountain Community College District was approved by the community and in 2001 became an independent accredited college. CMC has created a variety of unique programs and services designed to provide specialized support to the growth and stability of the local region. As part of campus expansion, CMC has been involved in desert tortoise mitigation projects in the Morongo Basin. For more information please visit the college website at http://www.cmccd.edu/.

County of San Bernardino: San Bernardino County recently completed the process of a 2025 General Plan Update that consisted of two phases, the first of which was completed in 2002. During Phase I, a strategic analysis of the 1989 General Plan and Environmental Impact Report (EIR) was conducted. Phase II was a three-year process which began in mid-2003. The General Plan text was adopted by the Board of Supervisors on March 13, 2007. It became effective on April 12, 2007. The Joshua Tree community plan was adopted on March 13, 2007. The County also recently (2005) completed a Morongo Valley Community Plan. To find out more about the General Plan Update, go to: www.sbcountygeneralplan.net, or visit the county's website at http://www.co.san-bernardino.ca.us/.

Desert Managers Group: Desert Managers Group is a highly collaborative interagency group that was formed in 1994 to address and discuss issues of common concern. Through cooperative management each agency achieves greater operation efficiency, enhances resource protection, and the public is better served. Partners include the BLM, National Park Service, US Fish and Wildlife Service, US Geological Survey, US Forest Service, California Fish and Game, Parks and Recreation, Caltrans, and the Department of Defense. For more information, visit http://www.dmg.gov.

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

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

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

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

Friends of Big Morongo Canyon Preserve: Friends was organized solely for the advancement of programs at Big Morongo Canyon Preserve. The primary purpose of Friends is to enhance the wildlife viewing, protection, and educational programs, and recreation opportunities provided by the Bureau of Land Management within the Preserve. Friends provide ongoing support to the Bureau in their conservation, education, and recreation programs within Big Morongo Canyon Preserve. Friends achieve these goals by raising funds, accepting donations, recruiting volunteers, and assisting BLM in the planning, creation, and maintenance of programs and facilities at the Preserve. For more information, visit http://www.bigmorongo.org

Hi-Desert Water District: This water district serves the Town of Yucca Valley and a portion of the unincorporated area of the County of San Bernardino. Their mission is to provide a dependable water supply & wastewater treatment for their 10,000 service customers in a safe, efficient, and financially responsible manner. For more information, visit their website at http://www.hdwd.com/.

Joshua Basin Water District: The Joshua Basin Water District was formed in 1963 and serves an area of 96 square miles in southwestern San Bernardino County, including the community of Joshua Tree. The mission of JBWD is to provide a high standard of water quality and customer services at responsible cost, protect the water resources of the District, and promote cooperation and respect with customers, employees, neighboring communities and public and private agencies. Their website can be viewed at http://www.jbwd.com/.

Joshua Tree Municipal Advisory Council: The Joshua Tree MAC is an appointed board of five community members who work with County elected officials to represent the community to the Supervisor on local community issues, providing an opportunity for citizen involvement in reviewing community needs. The JTMAC holds monthly meetings at the Joshua Tree Community Center. Contact the Supervisor's Field Representative at 760-228-5400 for more information on the JTMAC.

Joshua Tree Turtle and Tortoise Rescue: This non-profit organization is permitted by the State of California Department of Fish and Game to rescue and rehabilitate the threatened California Desert Tortoise. Their mission is dedicated to the survival of the desert tortoise through education and adoption programs. For more information visit http://www.desertgold.com/tort/tort.html.

Mojave Desert Land Trust: The Mojave Desert Land Trust protects the Mojave Desert ecosystem and its scenic and cultural resource values. For more information on their programs, please visit their website at http://www.mojavedesertlandtrust.org.

Morongo Basin Conservation Association: The Morongo Basin Conservation Association was formed in 1969 and works to protect the environmental and economic welfare of the Morongo Basin. Their vision for the Basin is a healthy environment, rural character, prosperous communities and cultural wealth. Their website is at www.mbconservation.org.

Morongo Basin Open Space Group: The Open Space Group was created by local agencies and organizations as a forum to collaboratively protect our unique natural landscapes and open spaces through regional conservation and land use planning in the Morongo Basin of California. Partners include representatives from Joshua Tree National Park, Twentynine Palms MCAGCC, all of the desert communities in the basin (Morongo Valley, Yucca Valley, Joshua Tree, Twentynine Palms), County of San

Bernardino, Bureau of Land Management, wildlife agencies, and non-governmental organizations. Their website is at http://www.mbopenspacegroup.org.

Morongo Valley Community Services District: The Community Services District meets monthly to address local issues, including parks and the provision of fire service and the citizen's patrol. Morongo Valley is an unincorporated community in the western end of the Morongo Basin in San Bernardino County. To contact the CSD, call 760-363-6454 or send an email to mvcsd@roadrunner.com.

National Parks Conservation Association: Their mission is to protect and enhance America's National Park System for present and future generations. NPCA plays a crucial role in ensuring that these special places are protected in perpetuity by advocating for the national parks and the National Park Service, educating decision-makers and the public about the importance of preserving the parks, helping to convince members of Congress to uphold the laws that protect the parks, supporting new legislation that addresses threats to the parks, fighting attempts to weaken these laws in the courts, and assessing the health of the parks and park management to better inform advocacy work. For more information, visit their website at http://www.npca.org.

National Park Service: The purpose of the National Park Service is "...to promote and regulate the use of the...national parks...which purpose is to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." NPS manages Joshua Tree National Park and is a vital partner in the South Coast Missing Linkages project and this planning effort. For more on the National Park Service, see http://www.nps.gov.

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

Resource Conservation Districts (RCD): This non-profit agency supports conservation of natural ecosystems through programs that reduce the effects of on-going land-use practices on the environment. A major portion of their effort is to advise residents on the management of soil, water, soil amendments and other resources used for agriculture and home gardening. RCDs are supported by state and local grants. They provide leadership in partnership efforts to help people conserve, maintain, and improve our natural resources and environment. Programs include Emergency Watershed Protection, Environmental Quality Incentives, Resource Conservation and Development, Soil Survey Programs, Soil and Water Conservation Assistance, Watershed Protection, River Basin, and Flood Operations, Wetlands Reserve and Wildlife Habitat Incentives. They do not enforce regulations but instead serve the interests of local residents and businesses. To find out more about their programs, go to http://www.carcd.org.

San Bernardino Valley Audubon: Audubon members are dedicated to protecting birds, wildlife, and our shared environment. They work with policymakers in

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

Sonoran Institute: The Sonoran Institute promotes community decisions that respect the land and people of the West. Collaborating with communities and partners in the U.S. and Mexico, the Sonoran Desert Program works to conserve and restore unique natural and cultural assets of the region. Sonoran Institute is involved with the work of the Morongo Basin Open Space Group. For more information on their programs, go to www.sonoran.org

South Coast Wildlands: South Coast Wildlands is a non-profit group established to create a protected network of wildlands throughout the South Coast Ecoregion and is the key administrator and coordinator of the South Coast Missing Linkages Project. For all priority linkages, South Coast Wildlands supports and enhances existing efforts by providing information on regional linkages critical to achieving the conservation goals of each planning effort. For more information on SCW, visit their website at http://www.scwildlands.org.

South Coast Missing Linkages Project: SCML is a coalition of agencies, organizations and universities committed to conserving 15 priority landscape linkages in the South Coast Ecoregion. The project is administered and coordinated by South Coast Wildlands. Partners in the South Coast Missing Linkages Project include but are not limited to The Wildlands Conservancy, The Resources Agency California Legacy Project, California State Parks, California State Parks Foundation, United States Forest Service, National Park Service, Santa Monica Mountains Conservancy, Conservation Biology Institute, San Diego State University Field Station Programs, The Nature Conservancy, Environment Now, and the Zoological Society of San Diego's Conservation and Research for Endangered Species. For more information on this ambitious regional effort, go to http://www.scwildlands.org.

The Nature Conservancy: TNC preserves the plants, animals and natural communities that represent the diversity of life on Earth by protecting the lands and waters they need to survive. For more information on their activities, go to http://www.tnc.org.

The Summertree Institute: Plants of the arid southwest survive conditions that commonly defeat other life forms. In order to help the rapidly developing communities of the southwest recognize and retain their long-lived native plants, The SummerTree Institute has launched SAVING THE ANCIENTS campaign. This community awareness program is currently focused on the native plants of the Mojave and Colorado Deserts, and is designed to encourage protection and planting of long-lived southwest native plants, while improving the environment for people and wildlife. For more information on the Institute, go to http://www.summertree.org.

The Wildlands Conservancy: The Wildlands Conservancy is a non-profit, member-supported organization dedicated to land and river preservation, trail development and environmental stewardship through education. Their Save the Saints Program brings together multiple land trusts and conservancies to identify key lands for acquisition within

National Forest boundaries and lands contiguous with the Forests in the Santa Ana, San Gabriel, San Jacinto, and San Bernardino Mountains. TWC has acquired thousands of acres in the Linkage Design and owns and manages Pipes Canyon Preserve. TWC is a vital partner in the South Coast Missing Linkages project and this planning effort. For more information, please visit their website at http://www.wildlandsconservancy.org.

Town of Yucca Valley: Yucca Valley was incorporated in 1991 and chose to be called a town to reflect the rural atmosphere. Yucca Valley's website notes that the town has "maintained its small town atmosphere while experiencing recent residential and commercial growth." For more information, visit their website at http://www.yucca-valley.org.

Twentynine Palms Marine Corps Air Ground Combat Center: MCAGCC is the largest Marine Base in the country, and has established facilities at their desert base to allow Marines to "train as they fight". While the MCAGCC's primary mission is to train marines, they also have a mission to preserve natural resources. The base takes a proactive role in the management of special status species and base lands support a diverse array of native plant and animal communities. A portion of the MCAGCC is designated as a Tortoise Research and Captive Rearing Site, designed to nurture young tortoises until their shells are strong enough to withstand predator attacks. For more information, visit their website at http://www.29palms.usmc.mil/.

Twentynine Palms Water District: The TPWD serves residents of Twentynine Palms and areas of unincorporated San Bernardino County. The District is dedicated to providing a safe and adequate supply of water at the lowest feasible cost to the people of the District and to preserve and protect the water resources within its established boundaries. Their website at http://29palmswater.org offers information on incorporating native plants into landscapes and other water conservation measures.

US Fish and Wildlife Service: The U.S. Fish and Wildlife Service works to conserve, protect and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people. The agency can provide support for prosecuting violations to the Endangered Species Act, law enforcement, permits, and funding for research on threatened and endangered species. The federal Endangered Species Act as amended (16 U.S.C. 1534) authorizes USFWS to acquire lands and waters for the conservation of fish, wildlife, or plants with the Land and Water Fund Act appropriations. The added protection provided by the Endangered Species Act may also be helpful for protecting habitat in the linkage from federal projects. For more information, visit their website at http://www.fws.gov.

US Fish and Wildlife Service Partners for Fish and Wildlife Program This program supplies funds and technical assistance to landowners who want to restore and enhance wetlands, native grasslands, and other declining habitats, to benefit threatened and endangered species, migratory birds, and other wildlife. This program may be helpful in restoring habitat on private lands in the Linkage Design. For more information on this program, please go to http://partners.fws.gov.

US Forest Service: The mission of the USDA Forest Service is to sustain the health, diversity, and productivity of the Nation's forests and grasslands to meet the needs of present and future generations. The four southern California Forests (Los Padres, Angeles, San Bernardino, and Cleveland) have recently finalized their Resource

Management Plans. The Final Environmental Impact Statement and Forest Plans have identified connecting the four forests to the existing network of protected lands in the region as one of the key conservation strategies for protecting biodiversity on the forests. For more information, go to http://www.fs.fed.us/r5/scfpr.

US Geological Survey, Biological Resources Division: The Biological Resource Division (BRD) works with others to provide the scientific understanding and technologies needed to support the sound management and conservation of our Nation's biological resources. BRD develops scientific and statistically reliable methods and protocols to assess the status and trends of the Nation's biological resources. BRD utilizes tools from the biological, physical, and social sciences to understand the causes of biological and ecological trends and to predict the ecological consequences of management practices. BRD enters into partnerships with scientific collaborators to produce high-quality scientific information and partnerships with the users of scientific information to ensure this information's relevance and application to real problems. For more information, go to http://www.biology.usgs.gov.

Wildlife Conservation Board: The Wildlife Conservation Board administers capital outlay for wildlife conservation and related public recreation for the State of California. The Wildlife Conservation Board, while a part of the California Department of Fish and Game, is a separate and independent Board with authority and funding to carry out an acquisition and development program for wildlife conservation. For more information on WCB, go to http://www.dfg.ca.gov/wcb.

A Scientifically Sound Plan for Conservation Action

Humans are significant agents of biogeographic change in southern California by converting native habitats to urban and agricultural uses and altering the movements of organisms, nutrients, and water through the ecosystem. The resulting fragmentation of natural landscapes threatens to impede the natural processes that support one of the world's greatest warehouses of species diversity.

This interaction between human development and biodiversity is one of the great and potentially tragic experiments of our time. It creates a unique challenge for land managers and conservation planning efforts – to mitigate massive changes to once intact ecosystems. The conservation plan for the Joshua Tree-Twentynine Palms Connection addresses these challenges by seeking to influence regional patterns of development in a manner that best preserves natural landscape-level processes.

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

Next Steps

The Joshua Tree-Twentynine Palms Connection is a scientifically sound starting point for conservation implementation and evaluation. This plan can be used as a resource by regional land managers to assist them in their critical role in sustaining biodiversity and ecosystem processes. Existing conservation investments in the region are already extensive, including lands managed by the US Forest Service, National Park Service, Bureau of Land Management, The Wildlands Conservancy, California Department of Fish and Game, and the State Lands Commission. Incorporating relevant aspects of this plan into ongoing regional planning efforts as well as local land management plans provides an opportunity to collaboratively implement a regional conservation strategy.

Additional conservation action will also be needed. Recommended tools include working with residents in stewardship zones to maintain permeability and linkage integrity, road renovation and construction of wildlife crossings, watershed planning, habitat restoration, conservation easements, zoning, acquisition, and others. These recommendations are not exhaustive, but are meant to serve as a starting point for agencies, organizations, and individuals interested in preserving and restoring linkage function. We urge the reader to keep sight of the primary goal of conserving landscape linkages -- to promote movement between targeted core areas over broad spatial and temporal scales -- and to work within this framework to develop a wide variety of restoration options for maintaining and improving linkage function. To this end, we provided a list of organizations, agencies, and regional projects that provide opportunities for collaborative implementation.

Public education and outreach is vital to the success of this effort – both to change land-use activities that threaten species existence and movement in the linkage and to generate support for the conservation effort. Public education can encourage recreational users and residents at the urban-wildland interface to become active stewards of the land and to generate a sense of place and ownership for local habitats and processes. Such voluntary cooperation is essential to preserving linkage function. The biological information, figures, and tables in this plan are ready materials for interpretive programs.

Successful conservation efforts are iterative, incorporating and encouraging the collection of new biological information that can increase understanding of linkage function. We strongly support the development of a monitoring and research program to address the habitat needs of species in the Linkage Design area and their movements (of individuals and genes). The suite of predictions generated by the GIS analyses conducted in this planning effort represent hypotheses to be tested and refined by long-term monitoring programs.

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

Abts, M. L. 1987. Environment and variation in life history traits of the chuckwalla, *Sauromalus obesus*. Ecological Monographs 57:215.232.

Ackerman, T. L., E.M. Romney, A. Wallace, and J.E. Kinnear. 1980. Phenology of desert shrubs in southern Nye County, Nevada. In: The Great Basin Naturalist Memoirs No. 4. Nevada desert ecology. Provo, UT: Brigham Young University: 4-23.

Ackerman, T.L. and S.A. Bamberg. 1974. Phenological studies in the Mojave Desert at Rock Valley (Nevada Test Site). In: Lieth, Helmut, ed. Phenology and seasonality modeling. New York: Springer-Verlag: 215-226. (Ecological studies; Analysis and synthesis, volume 8).

Ahlborn, G. 1988-1990. Mountain lion, *Felis concolor*. In: D.C. Zeiner, W.F. Laudenslayer Jr., K.E. Mayer, and M. White (eds.). California wildlife habitat relationships system. Volume III: Mammals. Sacramento: California Department of Fish and Game, California Interagency Wildlife Task Group.

Anderson, M.D. 2001. Coleogyne ramosissima. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2007, October 17].

Anderson, E. M., and M. J. Lovallo. 2003. Bobcat and lynx. Pages 758–786 in G. A. Feldhammer, B. C. Thompson, and J. A. Chapman, editors. Wild mammals of North America: biology, management, and conservation. John Hopkins University, Baltimore, Maryland, USA.

Anderson, S.H. 1995. Recreational disturbance of wildlife populations. In: Wildlife and recreationists, coexistence through management and research, edited by R.L. Knight and K.J. Gutzwiller. Island Press, Washington D.C.

Andrew, N.G., V.C. Bleich, and P.V. August. 1999. Habitat selection in mountain sheep in the Sonoran desert: Implications for conservation in the United States and Mexico. California Wildlife Conservation Bulletin 12. California Department of Fish and Game, Sacramento.

Anonymous. 1984. A management plan for bighorn sheep in California. Supported by Federal Aid in Wildlife Restoration Projects W-51-R, “Big Game Investigations” and W-26-D, “Wildlife Habitat Development.”

Armentrout, D.J., and W.R. Brigham. 1988. Habitat suitability rating system for desert bighorn sheep in the Basin and Range Province. USDI Bureau of Land Management Technical Report Note 384. USDI Bureau of Land Management, Denver, Colorado.

Arnett, R.H., Jr., M. C. Thomas, P. E. Skelley and J. H. Frank. (eds.). 2002. American Beetles, Volume II: Polyphaga: Scarabaeoidea through Curculionoidea. CRC Press LLC, Boca Raton, FL.

Arno, S.F.; and R.P Hammerly. 1977. Northwest trees. Seattle, WA: The Mountaineers. 222pp.

Arnott, H.J. 1962. The seed, germination, and seedling of Yucca. In: Silva, P. C.; Baker, H. G.; Foster, A. S., eds. University of California Publications in Botany. Berkeley, CA: University of California Press. 35(1): 1-96.

Associated Press. 2005. Rangers are stepping up their hunt for reptile and plant poachers in Joshua Tree National Park. July 18, 2005. http://www.sacbee.com/state_wire/story/13254731p-14097282c.html

Atwood, J. L. 1988. Speciation and geographic variation in the Black-tailed Gnatcatchers. Ornithol. Monogr. No. 42. 74pp.

Audubon 2002. Audubon Birds and Science, The 2002 Audubon WatchList, Le Conte's Thrasher. http://www.audubon2.org/watchlist/viewSpecies.jsp?id=121> Accessed October 4, 2007

Bailey, T. N. 1974. Social organization in a bobcat population. J. Wildl. Manage. 38:435-446.

Bailey, J.A. 1984. Bighorn zoogeography: response to McCutchen, Hansen and Wehausen. Wildlife Society Bulletin 12:86-89.

Bailey, J.A. 1980. Desert Bighorn, forage competition, and zoogeography. Wildlife Society Bulletin 8:208-216.

Bakker, E. 1971. An Island Called California. University of California Press, Berkeley. 484pp.

Baldwin B.G., S. Boyd, B.J. Ertter, R.W. Patterson, T.J. Rosatti, and D.H. Wilken, editors. M. Wetherway, Managing Editor. 2002. The Jepson Desert Manual Vascular Plants of Southeastern California. University of California Press, Berkeley, Los Angeles, London. 624pp.

Banfield, A.W.F. 1974. The mammals of Canada. University of Toronto Press, Toronto.

Banner, R.E. 1992. Vegetation types of Utah. Journal of Range Management. 14(2): 109-114.

Barrows, C. 1996. An ecological model for the protection of a dune ecosystem. Conserv. Biol. 10(3):888-891.

Bates, P.A. 1983. Prescribed burning blackbrush for deer habitat improvement. Cal-Neva Wildlife Transactions. [Volume unknown]: 174-182.

Bauder, E.T. 1986. San Diego vernal pools. Report to California Fish and Game Endangered Plant Project. U.S. Fish and Wildlife Service Contract EP85II-1.

Baxter, C. 2001. An integrated approach to bird conservation in the Mississippi Alluvial Valley. Keynote Address. Riparian Habitat and Floodplains Conference March 12-14, 2001, Sacramento, California.

Beatley, T. 1994. Habitat conservation planning: endangered species and urban growth. Univ. Texas Press, Austin, Texas.

Beatley, J.C. 1974. Effects of rainfall and temperature on the distribution and behavior of Larrea tridentata (creosote-bush) in the Mojave Desert of Nevada. Ecology. 55: 245-261.

Behrends, P., M. Daly, and M.I. Wilson. 1986. Above-ground activity of Merriam's kangaroo rat (*Dipodomys merriami*) in relation to sex and reproduction. Behavior 96:210-226.

Beier, P. 2006. Impact of artificial night lighting on terrestrial mammals. In T. Longcore and C. Rich, editors, Environmental consequences of artificial night lighting. Island Press.

Beier, P., K. L. Penrod, C. Luke, W. D. Spencer, and C. Cabañero. 2005. South Coast Missing Linkages: Restoring connectivity to wildlands in the largest metropolitan area in the United States. Invited Chapter In K R. Crooks and MA Sanjayan, editors, Connectivity conservation: maintaining connections for nature. Oxford University Press.

Beier, P. and R.F. Noss. 1998. Do habitat corridors provide connectivity? Conservation Biology 12:1241-1252.

Beier, P. 1996. Metapopulation models, tenacious tracking, and cougar conservation. Pages 293-322 in D. R. McCullough, editor. Metapopulations and wildlife conservation. Island Press, Covelo, California.

Beier, P. 1995. Dispersal of juvenile cougars in fragmented habitats. Journal of Wildlife Management 5:228-237.

Beier, P., D. Choate, and R.H. Barrett. 1995. Movement patterns of mountain lions during different behaviors. Journal of Mammalogy 76:1056-1070.

Beier, P. and R. Barrett. 1993. The cougar in the Santa Ana Mountain Range, California. Final Report for Orange County Cooperative Mountain Lion Study.

Beier, P. 1993. Determining minimum habitat areas and habitat corridors for cougars. Conservation Biology 7:94-108.

Beier, P., and S. Loe. 1992. A checklist for evaluating impacts to wildlife movement corridors. Wildlife Society Bulletin 20:434-440.

Bekker, H., B. van den Hengel, H. van Bohmen, and H. van der Sluijs. 1995. Natuur over wegen (Nature across motorways). Ministry of Transport, Public Works and Water Management, Delft, Netherlands.

Bell, G P. 1997. Ecology and management of *Arundo donax*, and approaches to riparian habitat restoration in southern California. In J.H. Brock, M. Wade, P. Pysek, and D. Green: (eds.) Plant invasions: studies from North America and Europe. Backhuys Publications, Leiden, The Netherlands.

Benninger, M. C. 1989. Trail as conduits of movement for plant species in coniferous forests of Rocky Mountain National Park, Colorado. M.S. Thesis, Miami University.

Benninger-Truax, M.C., J.L. Vankat, and R.L. Schaefer. 1992. Trail corridors as habitat and conduits for movement of plant species in Rocky Mountain National Park, Colorado, USA. Landscape Ecology 6:269–278.

Bent, A. C. (O. L. Austin, Jr., ed.). 1968. Life histories of North American cardinals, grosbeaks, buntings, towhees, finches, sparrows, and allies. 3 Parts. U.S. Natl. Mus. Bull. 237. 1889 pp.

Bentz, J.A., and D.M. Woodard. 1988. Vegetation characteristics and bighorn sheep use on burned and unburned areas in Alberta. Wildlife Society Bulletin 16:86-193.

Berry, K.H. and L.L. Nicholson. 1984. A summary of human activities and their impacts on desert tortoise populations and habitat in California. In Berry, K.H., ed. The status of the desert tortoise (*Gopherus agassizii*) in the United States. U.S. Department of the Interior, Bureau of Land Management. Riverside, California.

Berry, K. H. 1974. The ecology and social behavior of the chuckwalla, *Sauromalus obesus obesus* Baird. University of California Publications in Zoology 101:1.60.

Bertwistle, J. 1999. The effects of reduced speed zones on reducing bighorn and elk collisions with vehicles on the Yellowhead Highway in Jasper National Park. In: Proceedings of the Third International Conference on Wildlife Ecology and Transportation. Eds: Evink G.L., P. Garrett and D. Zeigler. FL-ER-73-99. Missoula, Montana. pp. 89-97

Beuchner, H.K. 1960. The bighorn sheep in the United States, its past, present and future. Wildlife Monographs 4.

Blair, W.F. 1943. Populations of the deer mouse and associated small mammals in the mesquite association of southern New Mexico. Contrib. Lab. Vertebrate Biology University Michigan, Vol. 21, pp. 1-40.

Bleich, V.C., J.D. Wehausen, R.R. Ramey II, and J.L. Rechel. 1996. Metapopulation theory and mountain sheep: implications for conservation. Pages 353-373 in D.R. McCullough, editor. Metapopulations and wildlife conservation. Island Press, Washington, D.C.

Blood, D.A. 1963. Some aspects of behavior of a bighorn herd. Canadian Field Naturalist 77:79-94.

Blumton, A. K., J. D. Fraser, and K. Terwilliger. 1989. Loggerhead shrike survey and census. Pages 116-118 in Virginia nongame and endangered wildlife investigative annual report, July 1, 1988 through June 30, 1989. Virginia Department of Game and Inland Fisheries, Richmond, Virginia.

Boarman, W.I. 2003. Managing a Subsidized Predator Population: reducing common raven predation on desert tortoises. Environmental Management Vol. 32, No. 2, pp. 205-217.

Boarman, W.I. 2002a. Desert Tortoise (*Gopherus agassizii*). *In*: Boarman, W.I. and K. Beaman, editors. The sensitive plant and animal species of the Western Mojave Desert. U. S. Geological Survey, Western Ecological Research Center, Sacramento, CA.

Boarman, W.I. 2002b. Threats to Desert Tortoise Populations: A Critical Review of the Literature. Prepared for West Mojave Planning Team Bureau of Land Management. Prepared by USGS Western Ecological Research Center. Pp. 91.

Boarman, W.I. and S.J. Coe. 2002. An evaluation of the distribution and abundance of Common Ravens at Joshua Tree National Park. *Bull. Southern California Acad. Sci.*101(2), 2002, pp. 86–102 Southern California Academy of Sciences, 2002

Boarman, W.I., M. Sazaki, and W.B. Jennings. 1997. The Effect of Roads, Barrier Fences, and Culverts on Desert Tortoise Populations in California, USA. *Proceedings: Conservation, Restoration, and Management of Tortoises and Turtles—An International Conference,* pp. 54–58 © 1997 by the New York Turtle and Tortoise Society

Boarman, W. I. and M. Sazaki. 1996. Highway mortality in desert tortoises and small vertebrates: success of barrier fences and culverts. Pages 169 - 173 in Transportation and wildlife: reducing wildlife mortality and improving wildlife passageways across transportation corridors. G. Evink, D. Zeigler, P. Garrett, and J. Berry, editors. U.S. Department of Transportation, Federal Highway Administration, Washington, DC.

Boarman, W.I., M. Sazaki, K.H. Berry, G.0. Goodlett, W. B. Jennings, and A.P. Woodman. 1993. Measuring the Effectiveness of a Tortoise-Proof Fence and Culverts : Status Report from First Field Season

Bolger, D.T., A.V. Suarez, K.R. Crooks, S.A. Morrison, and T.J. Case. 2000. Arthropods in urban habitat fragments in the Southern California: area, age, and edge effects. Ecological Applications 10:1230-1248.

Bowers, J.E. 1999. Flowers and Shrubs of the Mojave Desert. Southwest Parks and Monuments Association, Tucson, AZ. Pp. 142.

Bowns, J.E. 1973. An autecological study of blackbrush (Coleogyne ramosissima Torr.) in southeastern Utah. Logan, UT: Utah State University. 115 p. Dissertation.

Bowns, J.E. and N.E. West. 1976. Blackbrush (Coleogyne ramosissima Torr.) on southwestern Utah rangelands. Research Report 27. Logan, UT: Utah State University, Utah Agricultural Experiment Station. 27 p.

Braden, G.T. 1992. California Gnatcatchers (Polioptila californica) at three sites in western Riverside County. Prepared for Metropolitan Water District. November.

Bradley, L. C., and D. B. Fagre. 1988. Coyote and bobcat responses to integrated ranch management practices in south Texas. Journal of Range Management 41:322–327.

Bradley, W. G. 1965. A study of the blackbrush plant community of the Desert Game Range. Transactions, Desert Bighorn Council. 11: 56-61.

Bratton, J.H., and G. Fryer. 1990. The distribution and ecology of *Chirocephalus diaphanus* Prévost (Branchiopoda: Anostraca) in Britain. Journal of Natural History 24:955-964.

Brattstrom, B.H., and M.C. Bondello. 1983. Effects of off-road vehicles noise on desert vertebrates. Pages 167-204 in R.H. Webb and H.G. Wilshire, editors. Environmental effects of off-road vehicles: impacts and management in arid regions. Springer-Verlag, New York.

Braun, W.R.H. and Espericueta, B.M. 1979. Biomesa y produccion ecologica de jojoba (*Simmondsia chinensis* Link) en el deserto costero de Sonora. Deserta 5(1978):57–72.

Brehme, C.S. 2003. Responses of small terrestrial vertebrates to roads in a coastal sage scrub ecosystem. Master's Thesis, San Diego State University.

Brendonck, L. 1989. A review of the phyllopods (Crustacea: Anostraca, Notostraca, Conchostraca) of the Belgian fauna. Verhandelingen van het Symposium “Invertebres van Belgie”. pp.129-135.

Brodie Jr., E.D., T.C. Edwards Jr., and P.C. Ustach. 2003. Status of Distribution, Populations, and Habitat Relationships of the Common Chuckwalla, *Sauromalus obesus*, in Nevada.

Submitted to: Division of Wildlife, Department of Conservation and Natural Resources, State of Nevada

Brooks, W.H. 1978. Jojoba--a North American desert shrub; its ecology, possible commercialization, & potential as an introd. Into other arid regions. Journal of Arid Environments. 1: 227-236.

Brooks, M.L., C.M. D'Antonio, D.M. Richardson, J.B. Grace, J.E. Keeley, J.M. DiTomaso, R.J. Hobbs, M. Pellant, and D. Pyke. 2004. Effects of invasive alien plants on fire regimes. Bioscience. 54(7): 677-688.

Brosofske, K.D., J. Chen, R.J. Naiman, and J.R. Franklin. 1997. Harvesting effects on microclimatic gradients from small streams to uplands in western Washington. Ecological Applications 7:1188-1200.

Brown, J.H., A. Kodric-Brown, T.G. Whitham, and H.W. Bond. 1981. Competition between hummingbirds and insects for the nectar of two species of shrubs. The Southwestern Naturalist. 26(2): 133-145.

Brown, J.K. and J.K. Smith, eds. 2000. Wildland fire in ecosystems: Effects of fire on flora. Gen. Tech Rep. RMRS-GRT-42-vol. 2. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 257 p.

Buchmann, S.L. 1987. Floral biology of jojoba (Simmondsia chinensis), an anemophilous plant. Desert Plants. 8(3): 111-124.

Burk, J.H. 1977. Sonoran Desert. In: Barbour, M. G.; Major, J., eds. Terrestrial vegetation of California. New York: John Wiley and Sons: 869-899.

Bury, R.B. 1988. Habitat relationships and ecological importance of amphibians and reptiles. Pages 61-76 in K. J. Raedeke, editor. Streamside management: riparian wildlife and forestry interactions. Contribution 59 of the Institute of Forest Resources, University of Washington, Seattle, Washington, USA.

Butcher, G.S., and D.K. Niven. 2007. Combining Data from the Christmas Bird Count and the Breeding Bird Survey to Determine the Continental Status and Trends of North America Birds. National Audubon Society, Ivyland, PA. 34 pp. + appendices.

Butts, K. O. 1973. Life history and habitat requirements of Burrowing Owls in western Oklahoma. M.S. thesis. Oklahoma State University, Stillwater, Oklahoma. 188pp.

Calflora: Information on California plants for education, research and conservation. Desert Lily. [web application]. 2004. Berkeley, California: The Calflora Database [a non-profit organization]. Available: http://www.calflora.org/. (Accessed: Jul 07, 2008)

California Department of Fish and Game. 2007. Biogeographic Data Branch. California Natural Diversity Database. Special Animals (848 taxa). Available <http://www.dfg.ca.gov/biogeodata/cnddb/pdfs/SPAnimals.pdf>

California Department of Fish and Game. 2005a. Rare Find California Natural Diversity Database.

California Department of Fish and Game, Natural Diversity Database. 2005b. Special Vascular Plants, Bryophytes, and Lichens List. Quarterly publication, Mimeo. April 2005. 88 pp.

California Department of Fish and Game. California Interagency Wildlife Task Group. 2005. California Wildlife Habitat Relationships version 8.1 personal computer program. Sacramento, California.

California Department of Fish and Game. 2001. Special Animals. State of California, The Resources Agency, Department of Fish and Game Wildlife Habitat Data Analysis Branch, California Natural Diversity Database, January 2001.

California Department of Fish and Game. 1995. Wildlife Gallery Mammal Index: American Badger. http://www.delta.dfg.ca.gov/gallery/badger.html.

California Department of Fish and Game. 1983. California's Wildlife, Mammals, Nelson's bighorn sheep. California Wildlife Habitat Relationships System, http://www.dfg.ca.gov/whdab/
California Department of Public Works (DPW). 1954. Ground Water Occurrence and Quality, Colorado River Basin Region. Water Quality Investigations Report No. 4. 59pp.
California Department of Water Resources (DWR). 2003. California's Groundwater Bulletin 118. Hydrologic Region Colorado River California's Groundwater Morongo Valley Groundwater Basin Bulletin 118. Last update 10/1/03
California Department of Water Resources (DWR). 1975. California's Ground Water. Bulletin 118.
Cameron, G.N. 1971. Niche overlap and competition in woodrats. Journal of Mammalogy. 52(2): 288-296.
Cameron, G.N.; Rainey, Dennis G. 1972. Habitat utilization by Neotoma lepida in the Mohave Desert. Journal of Mammalogy. 53(2): 251-266.
Cardiff, S.W and L.F. LaPre. 1980. The effects of commercial harvesting of Mojave yucca (Yucca schidigera) on desert bird populations. Contract CA-060-CT8-000077. [Riverside, CA]: [U.S. Department of the Interior, Bureau of Land Management, Desert Plan Staff]. 28 p. Unpublished paper on file with: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory, Missoula, MT.
Carey, M. and P. Wagner. 1996. Salmon passages and other wildlife activities in Washington State. Trends in addressing transportation related wildlife mortality. Proceedings of the transportation related wildlife mortality seminar FL-ER-58-96. Florida Department of Transportation, Tallahassee, Florida.
Castellanos, A. E. and F.E. Molina. 1990. Differential survivorship and establishment in Simmondsia chinensis (jojoba). Journal of Arid Environments. 19: 65-76.
Chapman, J.A., and G.A. Feldhamer (eds.). 1982. Wild mammals of North America. The John Hopkins University Press. Baltimore, Maryland.
Chamberlain, M.J., Leopold, B.D., and L.M. Conner. 2003. Space Use, Movements, and Habitat Selection of Adult Bobcats (Lynx rufus) in Central Mississipi. American Midland Naturalist 149:395-405.
D. agilis. Journal of Mammalogy 54:317-326.
Churcher, J.B. and J.H. Lawton. 1987. Predation by domestic cats in an English village. Journal of Zoology 212:439-456.
Circle Mountain Biological Consultants, Inc. 2007. Unpublished reports prepared by Ed LaRue or Sharon Dougherty for multiple clients between 1989 and 2007. Wrightwood, California."
Clevenger, A.P., and J. Wierzchowski. 2005. Maintaining and restoring connectivity in landscapes fragmented by roads. Chapter in K. R. Crooks and M. A. Sanjayan, editors. Connectivity conservation: maintaining connections for nature. Oxford University Press.
Clevenger, A.P., and N. Waltho. 1999. Dray drainage culvert use and design considerations for small-and medium-sized mammal movement across a major transportation corridor. Pp. 263-277 in G.L. Evink, P. Garrett, and D. Zeigler (eds.) Proceedings of the Third International Conference on Wildlife Ecology and Transportation. FL-ER-73-99. Florida Department of Transportation, Tallahassee, Florida.
Clevenger, A.P., B. Chruszez, and K. Gunson. 2001. Highway mitigation fencing reduces wildlife vehicle collisions. Wildlife Society Bulletin 29:646-653.
Coachella Valley Multiple Species Habitat Conservation Plan (CVMSHCP) 2007. Final Recirculated Coachella Valley Multiple Species Habitat Conservation Plan and Natural Community Conservation Plan September 2007.
Cockrum, E. 1982. *Mammals of the Southwest*. Tuscon: University of Arizona Press.

Conrad, C.E. 1987. Common shrubs of chaparral and associated ecosystems of southern California. Gen. Tech. Rep. PSW-99. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest, and Range Experiment Station. 86pp.

Cooper, W.S. 1922. The broad-sclerophyll vegetation of California: an ecological study of the chaparral and its related communities. Publ. No. 319. Washington, DC: The Carnegie Institution of Washington. 145 p.

Cordeiro, J. 2007. NatureServe Comprehensive Report Species Branchinecta mackini. NatureServe Explorer. An Online Encyclopedia of Life (Web Application). Version 6.2 NatureServe, Arlington, Virginia. http://natureserve.org/explorer (Accessed January 2, 2008).

County of San Bernardino. 2005. Morongo Valley Community Plan, General Plan County of San Bernardino. Draft Community Plan March 2005 – Version 3.

Cowan, I. McT. 1940. Distribution and variation in the native sheep of North America. American Midland Naturalist 24:505-580.

Craighead, A. C., E. Roberts, F. L. Craighead. 2001. Bozeman Pass Wildlife Linkage and Highway Safety Study. Prepared for American Wildlands, http://www.wildlands.org/research.html.

Crooks, K.R. 2002. Relative Sensitivities of Mammalian Carnivores to Habitat Fragmentation. Conservation Biology, Vol. 16, No. 2, pp. 488-502.

Crooks, K.R., A.V. Suarez, D.T. Bolger, and M.E. Soulé. 2001. Extinction and colonization of birds on habitat islands. Conservation Biology 15:pp. 159-172.

Crooks, K. 1999. Mammalian carnivores, mesopredator release, and avifaunal extinctions in a fragmented system. Ph.D. Dissertation. University of California Santa Cruz.

Crooks, K. and M. Soulé. 1999. Mesopredator release and avifaunal extinctions in a fragmented system. Nature 400:563-566.

Cunningham, S.C. 1989. Evaluation of desert bighorn sheep habitat. Pages 135-160 in R.M. Lee, editor. The desert bighorn sheep in Arizona. Arizona Game and Fish Department, Phoenix, Arizona.

Currier, M.J.P. 1983. *Felis concolor*. Mammalian Species No. 200, pp. 1-7.

Daly, M., L.F. Jacobs, M.I. Wilson, and P.R. Behrends. 1992. Scatter-hoarding by kangaroo rats (*Dipodomys merriami*) and pilferage from their caches. Behavioral Ecology 3:102-111.

Davidson, E., and M. Fox. 1974. Effects of off-road motorcycle activity on Mojave Desert vegetation and soil. Madroño 22:381-412.

Debinski, D.M., and R.D. Holt. 2000. A survey and overview of habitat fragmentation experiments. Conservation Biology 2:342-355.

DeForge, J.R., S.D. Ostermann, C.W. Willmott, K.B. Brennan, and S.G. Torres. 1997. The ecology of Peninsular bighorn sheep in the San Jacinto Mountains, California. Desert Bighorn Council Transactions, Vol. 41, pp. 8-25.

DeForge, J.R. 1980. Population biology of desert bighorn sheep in the San Gabriel Mountains of California. Transactions of the Desert Bighorn Council, Vol. 24, pp. 29-32.

Demaynadier, P.G., and M.L. Hunter, Jr. 1998. Effects of silvicultural edges on the distribution and abundance of amphibians in Maine. Conservation Biology 12:340-352.

DeSante, D. R., E. D. Ruhlen, S. L. Adamany, K. M. Burton, and S. Amin. 1997. A census of burrowing owls in central California 1991. Journal of Raptor Research, Vol. 9, pp. 38–48.

DeSante, D.F., and E. Ruhlen. 1995. A census of burrowing owls in California, 1991-1993. Point Reyes Station, CA: Institute for Bird Populations.

DeSante, D.F., and D.G. Ainley. 1980. The avifauna of the South Farallon Islands, California. Studies in Avian Biol. No. 4. Cooper Ornithol. Soc., Lawrence, KA. 104pp.

De Vos, A. 1969. Ecological conditions affecting the production of wild herbivorous mammals on grasslands. In: Advances in ecological research. (Publisher unknown, place of publication unknown). On file at: U.S.D.A. Forest Service, Fire Sciences Laboratory, Intermountain Research Station, Missoula, Montana.

Dickson, BG, JS Jenness, and P. Beier. 2004. Influence of vegetation, roads, and topography on cougar movement in southern California. Journal of Wildlife Management 69(1):264-276.

Diffendorfer, J.E., C. Rochester, R.N. Fisher, and T.K. Brown. 2005. Movement and Space Use by Coastal Rosy Boas (Lichanura trivirgata roseofusca) in Coastal Southern California. Journal of Herpetology, Vol. 39, No. 1, pp. 24–36.

Diffendorfer, J.E., M.S. Gaines, and R.D. Holt. 1995. The effects of habitat fragmentation on movements of three small mammal species. Ecology 76:827-839.

Dimentman, C. 1981. The rainpool ecosystem of Israel: geographical distribution of freshwater Anostraca (Crustacea). Israel Journal of Zoology 30(1-2):1-15.

Dixon, K. L. 1959. Ecological and distributional relations of desert scrub birds of western Texas. Condor 61:397-409.

Dunford, C. 1977. Kin selection for ground squirrel alarm calls. *American Naturalist*, 58: 782-785.

Ebert, D.W., and C.L. Douglas. 1993. Desert bighorn sheep movement and habitat use in relation to the proposed Black Canyon Bridge Project, Nevada. Final Report, U.S. Bureau of Reclamation, Boulder City, Nevada, USA.

Emmel, T.C., and J.F. Emmel. 1973. The butterflies of southern California. Natural History Museum of Los Angeles County. Science Series 26:87, 135, 137.

Emming, J. 2005. Special conservation report: Nevadagascar? The threat that invasive weeds and wildfires pose to our North American desert biomes. Part 1: The Mojave Desert and Joshua tree woodlands. Cactus and Succulent Journal. 77(6): 302-312.

England, A. S., L.D. Foreman and W.F. Laudenslayer Jr. 1984. Composition and abundance of bird populations in riparian systems of the California deserts. In: Warner, Richard E.; Hendrix, Kathleen M., eds. California riparian systems: Ecology, conservation, and productive management. Berkeley, CA: University of California Press: 694-705.

Epple. A.O. and L.E. Epple. 1995. A Field Guide to the Plants of Arizona. Falcon Publishing Inc., Helena, MT. Pp. 347.

Ernest, H.B., W.M. Boyce, V.C. Bleich, B. May, S.J. Stiver, and S.G. Torres. 2003. Genetic structure of mountain lion (*Puma concolor*) populations in California. Conservation Genetics 4:353-366.

Ernest, K.A., and M.A. Mares. 1987. Mammalian Species: Spermophilus tereticaudus. Published 27 February 1987 by the American Society of Mammalogists, No. 274, pp. 1-9, 3 figs.

Esque, T.C and C.R. Schwalbe. 2002. Alien annual grasses and their relationships to fire and biotic change in Sonoran desertscrub. In: Tellman, Barbara, ed. Invasive exotic species in the Sonoran region. Arizona-Sonora Desert Museum Studies in Natural History. Tucson, AZ: The University of Arizona Press; The Arizona-Sonora Desert Museum: 165-194.

Evink, Gary L. 2002. Interaction between roadways and wildlife ecology. National Academy Press, Washington, D.C.

Faber, P.A., E. Keller, A. Sands, and B.M. Massey. 1989. The ecology of riparian habitats of the southern California coastal region: a community profile. Biological Report 85. U.S. Fish and Wildlife Service. Washington D.C.

Falk, N.W., H.B. Graves, and E.D. Bellis. 1978. Highway right-of-way fences as deer deterrents. Journal of Wildlife Management 42:646-650.

Farquhar, C. Craig and Karen L. Ritchie. 2002. Black-tailed Gnatcatcher (Polioptila melanura). In The Birds of North America, No. 690 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Feldhammer, G.A., J.E. Gates, D.M. Harmon, A.J. Loranger, and K.R. Dixon. 1986. Effects of interstate highway fencing on white-tailed deer activity. Journal of Wildlife Management 50:497-503.

Fidelibus, M., R. Franson, and D. Bainbridge. 1996. Spacing patterns in Mojave Desert trees and shrubs. In: Barrow, J.R.; E. D. McArthur, R.E. Sosebee, and R.J. Tausch, compilers. Proceedings: shrubland ecosystem dynamics in a changing environment; 1995 May 23-25; Las Cruces, NM. Gen. Tech. Rep. INT-GTR-338. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station: 182-186.

Field, C.B., G.C. Daily, S. Gaines, P.A. Matson, J. Melack, and N.L. Miller. 1999. Confronting climate change in California: ecological impacts on the Golden State. Union of Concerned Scientists and Ecological Society of America, Washington D.C.

Fisher, R. N. 2003. Population Status and Conservation of the Rosy Boa (*Lichanura trivirgata*). United States Geologic Survey, Western Ecological Research Center. Available < http://www.werc.usgs.gov/sandiego/boas.html> Accessed October 5, 2007.

Fisher, R., and K. Crooks. 2001. Baseline biodiversity survey for the Tenaja Corridor and southern Santa Ana Mountains. U.S. Geological Survey Biological Resources Division and Department of Biology, San Diego State University, San Diego, California.

Fitch, H. S., R. W. Henderson and D. M. Hillis. 1982. Exploitation of Iguanas in Central America, p. 397-417, *In* G. M. Burghardt and A. S. Rand (Eds.), Iguanas of the world: behavior, ecology, and conservation. Noyes Publishers, New Jersey.

Fitzpatrick, F.A., B.C. Scudder, B.N. Lenz, and D.J. Sullivan. 2001. Effects of multi-scale environmental characteristics on agricultural stream biota in eastern Wisconsin. Journal of the American Water Resources Association, Vol. 37, pp.1489-1508.

Flink, C. 2000. "Spermophilus tereticaudus" (On-line), Animal Diversity Web. Accessed October 25, 2007 at http://animaldiversity.ummz.umich.edu/site/accounts/information/Spermophilus_tereticaudus.html.

Force, D.C. and M.L. Thompson. 1984. Parasitoids of the immature stages of several southwestern yucca moths. The Southwestern Naturalist. 29(1): 45-56.

Forman, R.T.T., D. Sperling, J.A. Bissonette, A.P. Clevenger, C.D. Cutshall, V.H. Dale, L. Fahrig, R. France, C.R. Goldman, K. Heanue, J.A. Jones, F.J. Swanson, T. Turrentine, and T.C. Winter. 2003. Road Ecology: Science and Solutions. Island Press, Washington, D.C.

Forman, R.T.T., and R.D. Deblinger. 2000. The ecological road-effect zone of a Massachusetts (U.S.A) suburban highway. Conservation Biology 14:36-46.

Forman, R.T.T., and L.E. Alexander. 1998. Roads and their major ecological effects. Annual Review of Ecology and Systematics 29:207-231.

Forman, R.T.T. 1995. Land Mosaics: The Ecology of Landscapes and Regions. Cambridge University Press, Cambridge, England.

Fraser, J. D., and D. R. Luukkonen. 1986. The loggerhead shrike. Pages 933-941 in R. L. DiSilvestro, editor. Audubon Wildlife Report 1986. Academic Press, New York.

Freeman, D. 1999. Programmatic Biological Assessment Peninsular Bighorn Sheep. San Jacinto Ranger District, San Bernardino National Forest. 70 pp. + Appendices.

Fried, J.S., C.L. Bolsinger and D. Beardsley. 2004. Chaparral in southern and central coastal California in the mid-1990s: area, ownership, condition, and change. Resource Bulletin

PNW-RB-240. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 86 p.

Fugate, M. 1996. *Branchinecta* of North America: Population Structure and Its Implications for Conservation Practice. Pages 140-146 *in:* C.W. Witham, E. Bauder, D. Belk, W. Ferren, and R. Ornduff (Editors). Ecology, Conservation, and Management of Vernal Pool Ecosystems – Proceedings from a 1996 Conference. California Native Plant Society, Sacramento, CA. 1998.

Fuller, T. K., W. E. Berg and D. W. Kuehn. 1985. Bobcat home range size and daytime cover type use in northcentral Minnesota. J. Mammal., 66:568–571.

Garrett, K., and J. Dunn. 1981. Birds of southern California: status and distribution. Los Angeles Audubon Society. 408pp.

Geist, V. 1985. On Pleistocene bighorn sheep: some problems of adaptation, and relevance to today's American megafauna. Wildlife Society Bulletin 13:351-359.

Geist, V. 1971. Mountain sheep-a study in behavior and evolution. Chicago, IL: University of Chicago Press.

Gelbard, J. L., and J. Belnap. 2003. Roads as conduits for exotic plant invasions in a semiarid landscape. Conservation Biology 17:420-432

Gentry, H.S. 1958. The natural history of jojoba (Simmondsia chinensis) and its cultural aspects. Economic Botany. 12(3): 261-295.

Germano, D.J. and M.A. Joyner. 1988. Changes in a desert tortoise (Gopherus agassizii) population after a period of high mortality. In: Szaro, R.C., K.E. Severson, and D.R. Patton, technical coordinators. Management of amphibians, reptiles, and small mammals in North America: Proceedings of the symposium; 1988 July 19-21; Flagstaff, AZ. Gen. Tech. Rep. RM-166. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 190-204.

Giessow, J., and P. Zedler. 1996. The effects of fire frequency and firebreaks on the abundance and species richness of exotic plant species in coastal sage scrub. California Exotic Pest Plant Council. 1996 Symposium Proceedings. Berkeley, California.

Gilpin M. E. and M. E. Soulé 1986. Minimum viable populations: processes of species extinction. Pages 19-34 in Conservation biology: the science of scarcity and diversity. M.E. Soule (ed), Sinauer Associates, Inc. Sunderland, Mass

Gloyne, C.C., and A.P. Clevenger. 2001. Cougar (*Puma concolor*) use of wildlife crossing structures on the Trans Canada highway in Banff National Park, Alberta. Wildlife Biology 7:117-124.

Goforth, R.R. 2000. Local and landscape-scale relations between stream communities, stream habitat and terrestrial land cover properties. Dissertation Abstracts International Part B: Science and Engineering 8:3682.

Goodwin, J.G., Jr. and C.R. Hungerford. 1977. Habitat use by native Gambel's and scaled quail and released masked bobwhite quail in southern Arizona. Res. Pap. RM-197. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 8 p.

Graham, H. 1980. The impact of modern man. Pages 288-309 *in* G. Monson and L. Sumner, editors. The desert bighorn – its life history, ecology, and management. University of Arizona Press, Tucson, Arizona.

Graham, H. 1971. Environmental analysis procedures for bighorn in the San Gabriel Mountains. Desert Bighorn Council Transactions, Vol. 15, pp. 38-45.

Grant, R.A. 1965. The Burrowing Owl in Minnesota. Loon 37:2-17.

Grinnell, J., and A.H. Miller. 1944. The distribution of the birds of California. Pacific Coast Avifauna No. 27, 608pp.

Grinnell, J. 1937. Mammals of Death Valley. Proc. Calif. Acad. Sci. 23:115-169.

Gucker, C.L. 2006. Yucca schidigera. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2007, December 30].

Gullion, G.W. 1964. Contributions toward a flora of Nevada. No. 49: Wildlife uses of Nevada plants. CR-24-64. Beltsville, MD: U.S. Department of Agriculture, Agricultural Research Service, National Arboretum Crops Research Division. 170 p.

Hafner, D.J., E. Yensen, and G.L. Kirkland. 1998. North American Rodents: Status Survey and Conservation Action Plan.

Hairston, N.G., Jr., and B.T. De Stasio. 1988. Rate of evolution slowed by a dormant propagule pool. Nature 336:239-242.

Hall, H. T. and J. D. Newsom. 1976. Summer home ranges and movement of bobcats in bottomland hardwoods of southern Louisiana. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies, 30:422–436.

Hall, L.S., M.A. Kasparian, D. Van Vuren, and D.A. Kelt. 2000. Spatial organization and habitat use of feral cats (*Felis catus* L.) in Mediterranean California. Mammalia, Vol. 64, pp 19-28.

Hall, E. R. 1981. The mammals of North America. 2nd ed. Vol. 2. John Wiley and Sons. New York.

Hall, E. R., and K. R. Kelson. 1959. The mammals of North America. 2 Vols. The Ronald Press, New York. 1162pp.

Hall, E.R. 1946. Mammals of Nevada. University California Press, Berkeley. 710pp.

Hands, H. M., R. D. Drobney, and M. R. Ryan. 1989. Status of the loggerhead shrike in the northcentral United States. Missouri Coop. Fish Wildl. Res. Unit Rep. 15 pp.

Hansen, C.G. 1980. Habitat evaluation. Pages 320-335 in G. Monson and L. Sumner, editors. The desert bighorn – its life history, ecology, and management. University of Arizona Press, Tucson, Arizona.

Hanski, I., and M. Gilpin. 1991. Metapopulation Dynamics. Academic Press, London.

Harris, L.D., and P.B. Gallagher. 1989. New initiatives for wildlife conservation: the need for movement corridors. Pages 11-34 in G. Mackintosh, editor. Preserving communities and corridors. Defenders of Wildlife, Washington, D. C.

Harris, L.D. 1984. The fragmented forest: island biogeography theory and the preservation of biotic diversity. University of Chicago Press, Chicago, Illinois.

Harrison, R.L. 1992. Toward a theory of inter-refuge corridor design. Conservation Biology 6:293-295.

Hastings, J.R., R.M. Turner, and D.K. Warren. 1972. An atlas of some plant distributions in the Sonoran Desert. Technical Reports on the Meteorology and Climatology of Arid Regions No. 21. Tuscon, AZ: University of Arizona, Institute of Atmospheric Physics. 255 p.

Hathaway, S.A., D.P. Sheehan, and M.A. Simovich. 1996. Vulnerability of Branchiopod Cysts to Crushing. Journal of Crustacean Biology, Vol. 16, No. 3 (Aug., 1996), pp. 448-452.

Haug, E.A., B.A. Millsap, and M.S. Martell. 1993. Burrowing Owl (*Speotyto cunicularia*). *In* A. Poole and F. Gill [EDS.], The birds of North America, No. 61. The Academy of Natural Sciences, Philadelphia and The American Ornithologists' Union, Washington, DC.

Haug, E.A., and L.W. Oliphant. 1990. Movements, activity patterns, and habitat use of Burrowing Owls in Saskatchewan. J. Wildl. Manage. 54:27–35.

Hayes, C., E.S. Rubin, M.C. Jorgensen, R.A. Botta, and W.M. Boyce. 2000. Mountain lion predation on bighorn sheep in the Peninsular Ranges, California. Journal of Wildlife Management 64:954–959.

Heckenlively, D. B. 1967. Role of song in territoriality of black-throated sparrows. Condor 69:429-430.

Heifetz, W. (1941). A review of the lizards of the genus Uma. Copeia 1941: 99–111.
Herbst, H-V. 1982. Deutsche existenzbedrohte Branchiopoda und Copepoda (Crustacea). Archiv für Hydrobiologie 95(1/4):107-114.
Herzig, A. 1985. Resting eggs-a significant stage in the life cycle of crustaceans *Leptodora kindti* and *Bythotrephes longimanus*. Verhandlungen der Internationalen Vereinigung für theoretische und angewandte Limnologie 22:3088-3098.
Hickman, J.C. 1993. The Jepson Manual Higher Plans of California, University of California Press, Berkeley, Los Angeles, and London.
Hirsch, R., S. Hathaway, and R. Fisher. 2002. Herpetofauna and Small Mammal Surveys on the Marine Corps Air Ground Combat Center, Twentynine Palms, CA March 1999-October 2001. US Geological Survey Western Ecological Research Center. Prepared for Marine Corps Air Ground Combat Center Twentynine Palms, CA.
Hoagland, D.B. 1992. Feeding ecology of an insular population of the black-tailed jackrabbit (Lepus californicus) in the Gulf of California. Southwestern Naturalist. 37(3): 280-286.
Hödl, W. 1994. A short review of the Anostraca, Notostraca, and Conchostraca of Austria. Anostracan News 2:2-3.
Hogue, C.L. 1993. Insects of the Los Angeles Basin. Natural History Museum of Los Angeles County, Los Angeles, CA. 446pp.
Holl, S., J. Davis, C. Davis, R. Barboza, L. Konde, B. Brown, A. Stamps, K. Meyer, and S. Loe. 2004. Draft: Implementation strategy to restore the San Gabriel Mountains bighorn sheep population. California Department of Fish and Game, Los Angeles County Fish and Game Commission, and U.S.D.A. Forest Service.
Holl, S.A. and V.C. Bleich. 1983. San Gabriel mountain sheep: biological and management considerations. Unpublished report on file at the San Bernardino National Forest, San Bernardino, CA. 136pp.
Holl, S.A. 1982. Evaluation of bighorn sheep habitat. Desert Bighorn Sheep Council Transactions, Vol. 26, pp. 47-49.
Holland, D.C., R.H. Goodman. 1998. A guide to the amphibians and reptiles of MCB Camp Pendleton, San Diego County, California. Prepared for AC/S Environmental Security Resource Management Division MCB Camp Pendleton, CA. Contract M00681-94-C-0039.
Holland, D.C. 1994. The western pond turtle: habitat and history. U.S. Department of Energy, Bonneville Power Administration, Portland, Oregon.
Hollingsworth, B. D. and K. R. Beaman. Date Unknown. Mojave fringe-toed lizard (*Uma scoparia*) natural history species account. http://www.blm.gov/ca/pdfs/cdd_pdfs/fringe1.pdf> Accessed October 5, 2007.
Hudson, R.J., D.M. Hebert, and V.C. Brink. 1976. Occupational patterns of wildlife on a major East Kootenay winter-spring range. Journal of Range Management 29:38-43.
Hughes, H. and E. Weglinski. 1991. Blackbrush, Coleogyne ramosissima propagation and revegetation of disturbed sites. In: Plumb, Glenn E., ed. University of Wyoming: National Park Service Research Center: 15th annual report 1991. Laramie, WY: University of Wyoming: 67-74.
Huijser, M. P. and P. T. McGowen. 2003. Overview of animal detection and animal warning systems in North America and Europe. Pp. 368-382, in: The International Conference on Ecology and Transportation (ICOET); August 24-29, 2003; Lake Placid, NY.
Hunter, R. 1999. South Coast Regional Report: California Wildlands Project Vision for Wild California. California Wilderness Coalition, Davis, California.
Hurley, K., and L.L. Irwin. 1986. Prescribed burning vs. mitigation for bighorn sheep ranges. Biennial Symposium of the Northern Wild Sheep and Goat Council, Vol. 4, pp. 298-312.
Ingles, L.G. 1965. Mammals of the Pacific states. Stanford University Press, Stanford, CA.

506pp.
Iverson, R.M. 1980. Processes of accelerated pluvial erosion on desert hillslopes modified by vehicular traffic. Earth Surface Processes 5:369-388.
Jackson, S.D. and C.R. Griffin. 2000. A Strategy for Mitigating Highway Impacts on Wildlife. Pp. 143-159 In Messmer, T.A., and B. West (eds.). Wildlife and Highways: Seeking Solutions to an Ecological and Socio-economic Dilemma. The Wildlife Society.
Jameson, Jr., E.W., and H.J. Peeters. 1988. California Mammals. University of California Press, Berkeley, Los Angeles, London. 403pp.
Johnson, S. R. 1965. An ecological study of the chuckwalla, *Sauromalus obesus* Baird, in the western Mojave Desert. American Midland Naturalist 73:1.29.
Johnson, H.B. 1976. Vegetation and plant communities of southern California deserts--a functional view. In: Latting, June, ed. Symposium proceedings: plant communities of southern California; 1974 May 4; Fullerton, CA. Special Publication No. 2. Berkeley, CA: California Native Plant Society: 125-164.
Jones, J.A., F.J. Swanson, B.C. Wemple, and K.U. Snyder. 2000. Effects of roads on hydrology, geomorphology, and disturbance patches in stream networks. Conservation Biology 14:76-85.
Jones W.T. 1993. The social systems of heteromyid rodents. Pages 575-595 In: Genoways HH and JH Brown (eds.) Biology of the Heteromyidae. The American Society of Mammalogists, Special Publication No. 10.
Jones, W.T. 1989. Dispersal distance and the range of nightly movements in Merriam's kangaroo rats. Journal of Mammalogy 70:27-34.
Jorgensen, P. 1974. Vehicle use at a desert bighorn watering area. Transaction of the Desert Bighorn Council, Vol. 18, pp 18-24.
Karalus, K.E., and A.E. Eckert. 1987. The owls of North America. Weavervane Books, New York, New York, USA.
Kartesz, J.T. 1988. A flora of Nevada. Reno, NV: University of Nevada. 1729 p. [In 2 volumes]. Dissertation.
Kauffman, J.S. 1982. Patterns of habitat resource utilization in a population of *Uma scoparia*, the Mojave fringe-toed lizard. M.S. Thesis, Univ. of Illinois, Chicago, Illinois.
Kay, D.W. 1989. Movements and homing in the canyon tree frog (Hyla cadaverina). The Southwestern Naturalist, Vol. 34, pp. 293-294.
Kearney, T.H., R.H. Peebles, J.T. Howell, and E. McClintock. 1960. Arizona flora. 2d ed. Berkeley, CA: University of California Press. 1085 p.

Keeley, J.E., and C.J. Fotheringham. 2003. Impact of past, present, and future fire regimes on North American Mediterranean shrublands. In: Fire and Climatic Change in Temperate Ecosystems of the Western Americas, edited by T.T. Veblen, W.L. Baker, G. Montenegro, and T.W. Swetnam. Springer-Verlag, New York.
Klauber, L.M. 1931. A new subspecies of the California boa, with notes on the genus Lichanura. Transactions of the San Diego Society of Natural History 6 (20): 305-318.
Knight, R.L. and D.N. Cole. 1995. Wildlife responses to recreationists. In: R.L. Knight and K.J. Gutzwiller, eds. Wildlife and recreationists, coexistence through management and research. Island Press, Washington D.C.
Knight, R.L., G.N. Wallace, and W.E. Riebsame. 1995. Ranching the view: subdivisions versus agriculture. Conservation Biology 9:459-461.
Knopf, F.L. 1994. Avian assemblages in altered grasslands. Studies in Avian Biology 15: 247-257.

Kristan, W.B. III, A.J. Lynam, M.V. Price, and J.T. Rotenberry. 2003. Alternative causes of edge-abundance relationships in birds and small mammals of California coastal sage scrub. Ecography 26:29-44.
Krausman, P.R., L.L. Ordway, F.M. Whiting, and W.H. Brown. 1990. Nutritional compostition of desert mule deer forage in the Picacho Mountains, Arizona. Desert Plants. 10(1): 32-34.
Krausman, P.R., W. Dunn, L.K. Harris, W.W. Shaw, and W.B. Boyce. 2000. Can mountain sheep and humans coexist? International Wildlife Management Congress: (in press).
Krausman, P.R. 2000. An Introduction to restoration of bighorn sheep. Restoration Ecology, 8:3-5.
Krausman, P. R, A. V. Sandoval, and R. C. Etchberger. 1999. Natural history of desert bighorn sheep. Pages 139-191 in Mountain Sheep of North America, R. Valdez and P. R. Krausman (eds.). The University of Arizona Press, Tucson. 353pp.
Krausman, P.R., G. Long, R.F. Seegmiller, and S.G. Torres. 1989. Relationships between desert bighorn sheep and habitat in western Arizona. Wildlife Monographs 102.
Kridelbaugh, A.L. 1982. An ecological study of loggerhead shrikes in Central Missouri. University of Missouri.
Kubik, M. R., Jr., and J. V. Remsen, Jr. 1977. Creosote-burrobush desert scrub. Pages 76-77 in W. T. Van Velzen, ed. Fortieth breeding bird census. Am. Birds 31:24-93.
Kwiatkowski, M. A., and B. K. Sullivan. 2002. Mating system structure and population density in a polygynous lizard, *Sauromalus obesus* (=*ater*). Evolution 56:2039. 2051.
LaHaye, W.S., R.J. Gutierrez, and J.R. Dunk. 2001. Natal dispersal of the spotted owl in southern California: dispersal profile of an insular population. Condor 103:691-700.
Lamb, T., J. C. Avise, and J. W. Gibbons. 1989. Phylogeographic patterns in mitochondrial DNA of the desert tortoise (*Xerobates agassizii*) and evolutionary relationships among North American gopher tortoises. Evolution 43: 76-87.
Land, D., D. Shindle, and M. Lotz. 2001. A summary of Florida panther mortality caused by vehicular collisions. Florida Fish and Wildlife Commission and Bureau of Wildlife Diversity Conservation. 7pp.
LaPre, L.F. 1979. Physiological ecology of Yucca schidigera. Riverside, CA: University of California. 117 p. Dissertation.
Laudenslayer, W. F., Jr. 1981. Habitat utilization by birds of three desert riparian communities. Ph.D. thesis, Arizona State Univ., Tempe. 148pp.
Leach, H.R. 1956. Food habits of the Great Basin deer herds of California. California Fish and Game. 38: 243-308.
Lei, S.A. 1997. Variation in germination response to temperature and water availability in blackbrush (Coleogne ramosissima) and its ecological significance. The Great Basin Naturalist. 57(2): 1720177.
Lei, S.A. and L.R. Walker. 1995. Composition and distribution of blackbrush (Coleogyne ramosissima) communities in southern Nevada. In: Roundy, B.A.; McArthur, E.D, Haley, J.S.; Mann, D.K, compilers. Proceedings: wildland shrub and arid land restoration symposium; 1993 October 19-21; Las Vegas, NV. Gen. Tech. Rep. INT-GTR-315. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station: 192-195.
Lei, S.A. and L.R. Walker. 1997. Classification and ordination of Coleogyne communities in southern Nevada. The Great Basin Naturalist. 57(2): 155-162.
Lembeck, M. 1978. Bobcat study, San Diego County, California. Calif. Dep. Fish and Game, Sacramento. Project E-W-2, Study IV, Job 1.7. 22pp.
Leslie, D.M., Jr., and C.L. Douglas. 1979. Desert bighorn sheep of the River Mountains, Nevada. Wildlife Monographs No. 66. 56pp.

Levins, R. 1970. Extinction. Pages 77-107 in M. Gerstenhaber, ed. Some Mathematical Questions in Biology. Lectures on Mathematics in the Life Sciences, Vol. 2. American Mathematical Society, Providence, RI.

Light, J.T., F.A. Winter, and H. Graham. 1967. San Gabriel bighorn habitat management plan. USDA San Bernardino National Forest, San Bernardino, CA 32 pp + Appendices.

Light, J.T. and R. Weaver. 1973. Report on bighorn sheep habitat study in the area for which an application was made to expand the Mt. Baldy winter sports facility. USDA, San Bernardino National Forest, San Bernardino, CA 39pp.

Lindzey, F. 1987. Mountain lion. Pp. 656-668 In: M. Novak, J. Baker, M.E. Obbard, and B. Mllock, eds. Wild furbearer management and conservation in North America. Ontario Trappers Association. North Bay, Ontario.

Lindzey, F.G. 1978. Movement patterns of badgers in northwestern Utah. Journal of Wildlife Management 42:418-422.

Little, E.L., Jr. 1976. Atlas of United States trees. Volume 3. Minor western hardwoods. Misc. Publ. 1314. Washington, DC: U.S. Department of Agriculture, Forest Service. 13 p. 290 maps.

Löffler, H. 1993. Anostraca, Notostraca, Laevicaudata and Spinicaudata of the Pannonian Region and its Austrian area. Hydrobiologia 264:169-174.

Logan, K.A., and L.L. Sweanor. 2001. Desert Puma: evolutionary ecology and conservation of an enduring carnivore. Island Press, Washington, D.C.

Loik, M.E.; C.D. St. Onge, and J. Rogers. 2000. Post-fire recruitment of Yucca brevifolia and Yucca schidigera in Joshua Tree National Park, California. In: Keeley, J.E.; M. Baer-Keeley, and C.J. Fotheringham, eds. 2nd interface between ecology and land development in California. U.S. Geological Survey: Open-File Report 00-62. Sacramento, CA: U.S. Department of the Interior, Geological Survey, Western Ecological Research Center: 79-85.

Long, C.A. and C.A. Killingley. 1983. The badgers of the world. Charles C. Thomas Publishing, Springfield, Illinois.

Long, C.A. 1973. *Taxidea taxus*. Mammalian Species, Vol. 26, pp. 1-4.

Longcore, T. 2000. Ecological effects of fuel modification on arthropods and other wildlife in an urbanizing wildland. In: L.A. Brennan et al., eds. National Congress on Fire Ecology, Prevention and Management Proceedings, No. 1. Tall Timbers Research Station, Tallahassee, Florida.

Longland, W.S. 1995. Desert rodents in disturbed shrub communities and their effects on plant recruitment. In: Roundy, B.A.; McArthur, E.D, Haley, J.S.; Mann, D.K, compilers. Proceedings: wildland shrub and arid land restoration symposium; 1993 October 19-21; Las Vegas, NV. Gen. Tech. Rep. INT-GTR-315. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station: 209-215.

Lotz, M.A., E.D. Land, and K.G. Johnson. 1996. Evaluation of state road 29 wildlife crossings. Final report, study no. 7583. Florida Game and Freshwater Fish Commission. Tallahassee, Florida. 15pp.

Lovallo, M. J. and E.M. Anderson. 1996. Bobcat (Lynx rufus) home range size and habitat use in northwest Wisconsin. Am. Midl. Nat., 135:241–252

Ludwig, J., and T. Bremicker. 1983. Evaluation of 2.4-m fences and one-way gates for reducing deer-vehicle collisions in Minnesota. Transportation Research Record, Vol. 913, pp 19-22.

Lyon, L.J. 1983. Road density models describing habitat effectiveness for elk. Journal of Forestry 81:592-5.

MGAGCC. 2002. Integrated Natural Resource Management Plan and Environmental Assessment Fiscal Years 2002-2006. Marine Air Ground Task Force Training Command Twentyine Palms, California. Pp. 174 + Appendices.

MacArthur, R.A., V. Geist, and R.H. Johnson. 1982. Cardiac and behavioral responses of mountain sheep to human disturbance. Journal of Wildlife Management 46:351-358.

MacArthur, R.H., and E.O. Wilson. 1967. The Theory of Island Biogeography. Princeton University Press, Princeton, NJ.

Macey, J. R. and T. J. Papenfuss. 1991. Reptiles. Pages 291-360 in C.A. Hall, Jr., editor. Natural History of the White-Inyo Range eastern California. Univ. Calif. Press, Berkeley, California. 536 pp.

MacKay, P. 2003. Mojave Desert wildflowers: a field guide to wildflowers, trees, and shrubs of the Mojave Desert, including the Mojave National Preserve, Death Valley National Park, and Joshua Tree National Park. A Falcon Guide. Guilford, CT: Falcon. 338 p.

Maehr, D.S. 1992. Florida panther: *Felis concolor* coryi. Pages 176-189 In: S.R. Humphrey, (ed.). Rare and endangered biota of Florida. Mammals: Volume 1. Florida Game and Fresh Water Fish Commission. Naples, Florida.

Magill, A.W. 1974. Chilopsis linearis (Cav.) Sweet desertwillow. In: Schopmeyer, C. S., technical coordinator. Seeds of woody plants in the United States. Agric. Handb. 450. Washington, DC: U.S. Department of Agriculture, Forest Service: 321-322.

Manville, R. H. 1980. The origin and relationships of American wild sheep. Pages 1-6 *in* The Desert Bighorn: Its Life History, Ecology, and Management. G. Monson and L. Sumner (eds). The University of Arizona Press, Tucson. 370pp.

Maret, T. and D. MacCoy. 2002. Fish assemblages and environmental variables associated with hard-rock mining in the Coeur d'Alene River Basin, Idaho. Trans. American Fisheries Society, Vol. 131, pp. 865-884. Bethesda, Maryland.

Marzluff, J.M., and K. Ewing. 2001. Restoration of fragmented landscapes for the conservation of birds: a general framework and specific recommendations for urbanizing landscapes. Restoration Ecology. 9:280-292.

Matthews, R.F. 1994. Simmondsia chinensis. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2007, October 17].

McArthur, E.D. 1989. Breeding systems in shrubs. In: McKell, Cyrus M., ed. The biology and utilization of shrubs. San Diego, CA: Academic Press, Inc.: 341-361.

McCaskie, G., P. De Benedictis, R. Erickson, and J. Morlan. 1979. Birds of northern California, an annotated field list. 2nd ed. Golden Gate Audubon Soc., Berkeley. 84pp.

McCaskie, G., P. De Benedictis, R. Erickson, and J. Morlan. 1988. Birds of northern California, an annotated field list. 2nd ed. Golden Gate Audubon Soc., Berkeley. Reprinted with suppl. 108pp.

McCullough, Y.B. 1980. Niche separation of seven North American ungulates on the National Bison Range, Montana. PhD Dissertation, University of Michigan, Ann Arbor. 226pp.

McCutcheon, H.E. 1981. Desert bighorn zoogeography and adaptation in relation to historic land use. Wildlife Society Bulletin. 9:171-179.

McDonald, W. and C.C. St Clair. 2004. Elements that promote highway crossing structure use by small mammals in Banff National Park. Journal of Applied Ecology 41:82-93.

McQuivey, R.P. 1978. The desert bighorn sheep of Nevada. Nevada Department of Fish and Game, Biological Bulletin No. 6, Reno, Nevada.

Medina, A.L. and J.S. Betancourt. 1987. Strategies for enhanced production of beef and jojoba on northern Baja California rangelands. In: Aldon, E.F., C.E. Gonzales Vicente, and W.H.

Moir technical coordinators. Strategies for classification and management of native vegetation for food production in arid zones: Proceedings; 1987 October 12-16; Tucson, AZ. Gen. Tech. Rep. RM-150. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 190-195.

Merriam, G., M. Kozakiewicz, E. Tsuchiya, and K. Hawley. 1989. Barriers as boundaries for metapopulations and demes of *Peromyscus leucopus* in farm landscapes. Landscape Ecology 2:227-236.

Messick, J.P., and M.G. Hornocker. 1981. Ecology of the badger in southwestern Idaho. Wildlife Monographs 76:1-53.

Messmer, T.A., C.W. Hedricks, and P.W. Klimack. 2000. Modifying human behavior to reduce wildlife-vehicle collisions using temporary signing. In: Wildlife and highways: seeking solutions to an ecological and socio-economic dilemma. September 12-16: Nashville, TN.

Miller, A.H., and R.C. Stebbins. 1964. The lives of desert animals in Joshua Tree National Monument. University California Press, Berkeley. 452pp.

Miller, G.D. and W.S. Gaud. 1989. Composition and variability of desert bighorn sheep diets. Journal of Wildlife Management. 53(3): 597-606.

Miller, A. H. 1931. Systematic revision and natural history of the American shrikes (Lanius). Univ. Calif. Publ. Zool. 38:11-242.

Mills, L.S., and P.E. Smouse. 1994. Demographic consequences of inbreeding in remnant populations. American Naturalist 144:412-431.

Millsap, B.A. and C. Bear. 1988. Cape Coral burrowing owl population monitoring. Florida Game and Fresh Water Fish Commission (Nongame Wildlife Section), Tallahassee, Florida.

Minta, S.C. 1993. Sexual differences in spatio-temporal interaction among badgers. Oecologia 96:402-409.

richest and most endangered terrestrial ecosystems. CEMAX, Mexico City.

Mock, P. 2004. California Gnatcatcher (*Polioptila californica*). *In* The Coastal Scrub and Chaparral Bird Conservation Plan: a strategy for protecting and managing coastal scrub and chaparral habitats and associated birds in California. California Partners in Flight. http://www.prbo.org/calpif/htmldocs/scrub.html

Monson, G. 1980. Distribution and abundance. Pages 40-51 in G. Monson and L. Sumner, editors. The desert bighorn sheep, its life history, ecology, and management. University of Arizona Press, Tucson, Arizona.

Moore, W.G., and B.F. Faust. 1972. Crayfish as possible agents of dissemination of fairy shrimp into temporary ponds. Ecology 53:314-316.

Mozingo, H.N. 1987. Shrubs of the Great Basin: A natural history. Reno, NV: University of Nevada Press. 342 p.

Munz, P.A. 1974. A flora of southern California. University of California Press, Berkeley and Los Angeles, California.

Mura, G. 1993. Italian Anostraca: distribution and status. Anostracan News 1:3.

Murcia, C. 1995. Edge effects in fragmented forests: implications for conservation. Trends in Ecology and Evolution 10:58-62.

Nagy, K. A. 1971. Seasonal metabolism of water, energy and electroytes in a field population of desert lizards, Saurmalus obesus. Ph.D. Thesis, Univ. California, Riverside.

Naicker, K., E. Cukrowska, and T.S. McCarthy. 2001. Acid mine drainage arising from gold mining activity in Johannesburg, South Africa and environs. Environmental Pollution, Vol.122, No.1.

National Park Service. 2003. http://www.nps.gov/jotr/nature/animals.html.

National Parks Conservation Association. 2005. State of the Parks; The California Desert Parks: Joshua Tree National Park, Death Valley National Park, Mojave National Preserve; A Resource Assessment. June 2005.
NatureServe. 2007. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.0. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: October 15, 2007).
Nichol, A. A. [revisions by Phillips, W. S.]. 1952. The natural vegetation of Arizona. Tech. Bull. 68 [revision]. Tucson, AZ: University of Arizona, Agricultural Experiment Station: 189-230.
Nicholson, L. 1978. The effects of roads on desert tortoise populations . Proceedings of the Desert Tortoise Council Symposium 1978 :127-129 .
Nicolai, N.C. and J.E. Lovich. 2000. Preliminary observations of the behavior of male, flat-tailed horned lizards before and after an off-highway vehicle race in California. California Fish and Game 86:208-212.
Nielsen, C. K., and A. Woolf. 2002. Social organization of bobcats in Southern Illinois. American Midland Naturalist 146:43–52.
Nord, E.C. and A. Kadish. 1974. Simmondsia chinensis (Link) C. K. Schneid. jojoba. In: Schopmeyer, C. S., ed. Seeds of woody plants in the United States. Agriculture Handbook No. 450. Washington, DC: U.S. Department of Agriculture, Forest Service: 774-776.
Norris, K.S. 1958. The evolution and systematics of the iguanid genus *Uma* and its relation to the evolution of other North American desert reptiles. Bull. Amer. Mus. Nat. Hist. 114(3):251-317.
Norton, D.A. 2002. Edge effects in a lowland temperate New Zealand rainforest. DOC Science Internal Series 27. Department of Conservation, Wellington.
Noss, R.F., H.B. Quigley, M.G. Hornocker, T. Merrill, and P. Paquet. 1996. Conservation biology and carnivore conservation. Conservation Biology 10:949-963.
Noss, R.F., and A.Y. Cooperrider. 1994. Saving nature's legacy: protecting and restoring biodiversity. Island Press, Washington, D.C.
Noss, R. F. 1992. The Wildlands Project: Land conservation strategy. Wild Earth (Special Issue), Vol. 1, pp. 10-25.
Noss, R. F. 1991. Landscape linkages and biodiversity. Pages 27-39 In: W. E. Hudson, ed. Washington, D.C.
Noss, R. F. 1987. Protecting natural areas in fragmented landscapes. Natural Areas Journal 7:2-13.
Noss, R. F. 1983. A regional landscape approach to maintain diversity. Bioscience 33:700-706.
Orsack, L.J. 1977. The Butterflies of Orange County, California. Center for Pathobiology Miscellaneous Publication No. 3. University of California Press, New York. 349pp.
Papouchis, C.M., F.J. Singer, and W.B. Sloan. 2001. Responses of Desert Bighorn sheep to increased human recreation. Journal of Wildlife Management 65:573-582.
Papp, C.S. 1984. Introduction to North American Beetles. Entomography Pubns, 1984
Peinado, M., J.L. Aguirre, and J. Delgadillo. 1997. Phytosociological, bioclimatic and biogeographical classification of woody climax communities of western North America. Journal of Vegetation Science. 8: 505-528.
Pendleton, R.L., B.K. Pendleton, and K.T. Harper. 1989. Breeding systems of woody plant species in Utah. In: Wallace, A., E.D. McArthur, and M.R. Haferkamp, compilers. Proceedings--symposium on shrub ecophysiology and biotechnology; 1987 June 30 - July 2; Logan, UT. Gen. Tech. Rep. INT-256. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station: 5-22.

Penrod, K., C. Cabañero, P. Beier, C. Luke, W. Spencer, and E. Rubin. 2005. South Coast Missing Linkages Project: A Linkage Design for the San Bernardino-Little San Bernardino Connection. South Coast Wildlands, Idyllwild, CA. www.scwildlands.org.

Penrod, K., R. Hunter, and M. Merrifield. 2001. Missing Linkages: Restoring connectivity to the California landscape. California Wilderness Coalition, The Nature Conservancy, US Geological Survey, Center for Reproduction of Endangered Species, and California State Parks.

Perrett, J.A. 2002. Rosy Boa Taxonomy. www.rosyboas.com.

Petersen, C.B., J.H. Brown, and A. Kodric-Brown. 1982. An experimental study of floral display and fruit set in Chilopsis linearis (Bignoniaceae). Oecologia. 55(1): 7-11.

Pierce, B.M., V.C. Bleich, J.D. Wehausen, and R.T Bowyer. 1999. Migratory patterns of mountain lions: implication for social regulation and conservation. Journal of Mammalogy 80:986-992.

Pfister, H., V. Keller, H. Reck and B. Georgii. 1997. Bio-ökologische Wirksamkeit von Grünbrücken über Verkehrswege. Forschung, Strassenbau und Strassenverkehrstechnik 756. Bundesministerium für Verkehr, Bonn.

Proctor, V.W. 1964. Viability of crustacean eggs recovered from ducks. Ecology 45(3):656-658.

Proctor, V.W., C.R. Malone, and V.L. DeVlaming. 1967. Dispersal of aquatic organisms: Viability of disseminules recovered from the intestinal tract of captive Kildeer. Ecology 48(4):672-676.

Pruitt, L. 2000. Loggerhead Shrike Status Assessment, USFWS report, USFWS. Bloomington, IN.

Quinn, R.D. 1990. Habitat preferences and distribution of mammals in California chaparral. Research Paper PWS-202. Pacific Southwest Research Station, Department of Agriculture, Forest Service, Berkeley, California.

Radtke, K.W.H. 1983. Living more safely in the chaparral-urban interface. USDA Forest Service, Pacific Southwest Forest and Range Experimental Station. General Technical Report PSW-67.

Raitt, E. J., and R. L. Maze. 1968. Densities and species composition of breeding birds of creosote bush community in southern New Mexico. Condor 70:193-205.

Reed, D.F. 1981. Effectiveness of highway lighting in reducing deer-vehicle accidents. Journal of Wildlife Management. 45:1981.

Reijnen, R., R. Foppen, and G. Veenbaas. 1997. Disturbance by traffic of breeding birds: Evaluation of the effect and considerations in planning and managing road corridors. Biodiversity and Conservation 6:567-581.

Remsen, J. V., Jr. 1978. Bird species of special concern in California. Calif. Dept. Fish and Game, Sacramento. Wildl. Manage. Admin. Rep. No. 78-1. 54pp.

Riley, S.P.D., R.M. Sauvajot, T.K. Fuller, E.C. York, D.A. Kamradt, C. Bromley, and R.K. Wayne. 2003. Effects of urbanization and habitat fragmentation on Bobcats and coyotes in southern California. Conservation Biology 17:566-576.

Riley, S.P.D., J.P. Pollinger, R.M. Sauvajot, E.C. York, C. Bromley, T.K. Fuller, and R.K. Wayne. 2006. A Southern California Freeway is a Physical and Social Barrier to Gene Flow in Carnivores. Molecular Ecology Vol. 15, pp. 1733-1741.

Riley, S.P.D. Spatial Ecology of Bobcats and Gray Foxes in Urban and Rural Zones of a National Park. The Journal of Wildlife Management 70(5) 1425-1435.

Risenhoover, K.L. and J.A. Bailey. 1985. Visibility: an important factor for an indigenous, low-elevation bighorn herd in Colorado. Biennial Symposium of the Northern Wild Sheep and Goat Council, Vol. 2, pp. 18-28.

Risenhoover, K.L., J.A. Bailey, and L.A. Wakelyn. 1988. Assessing the Rocky Mountain bighorn sheep problem. Wildlife Society Bulletin 16:345-352.

Riverside County Integrated Project (RCIP). 2003. County of Riverside. Riverside County Integrated Project General Plan, October, 2003.

Robbins, C. S., D. Bystrack, and P. H. Geissler. 1986. The breeding bird survey: its first fifteen years, 1965-1979. U.S. Fish and Wildlife Service Resource Publ. 157. Washington, D.C.

Robertson, J. M. 1929. Some observations on the feeding habits of the burrowing owl. Condor, Vol. 31, pp. 38-39.

Robinson, M., P. McGowen, A. Habets, and C. Strong. 2002. Safety Applications of ITS in Rural Areas. Section 7.1.1. Science Applications International Corporation, McLean, VA, USA.

Rosell Papes, C. and J.M. Velasco Rivas. 1999. Manual de prevencio I correccio dels impactes de les infrastructures viaries sobre la fauna. Departament de Medi Ambient, Numero 4. Generalitat de Catalunya. Barcelona, Spain.

Rosen, P.C., and C.H. Lowe. 1994. Highway mortality of snakes in the sonoran desert of southern Arizona. Biological Conservation. 68:143-148.

Roundy, B.A., G.B. Ruyle, and A.K. Dobrenz. 1987. Growth, nutrient, and water status of jojoba (Simmonsia chinensis) in relation to livestock grazing. In: Provenza, F.D., J.T. Flinders, and E.D. Durant, compilers. Proceedings--symposium on plant-herbivore interactions; 1985 August 7-9; Snowbird, UT. Gen. Tech. Rep. INT-222. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station: 146-153.

Rubin, E.S., W.M. Boyce, C.J. Stermer, and S.G. Torres. 2002. Bighorn sheep habitat use and selection near an urban environment. Biological Conservation 104:251-263.

Rubin, E.S., W.M. Boyce, M.C. Jorgensen, S.G. Torres, C.L. Hayes, C.S. O'Brien, and D.A. Jessup. 1998. Distribution and abundance of bighorn sheep in the Peninsular Ranges, California. Wildlife Society Bulletin 26:539-551.

Rucker, R. A., M. L. Kennedy, G. A. Heidt and M. J. Harvey. 1989. Population density, movements, and habitat use of bobcats in Arkansas. Southwest. Nat., 34:101–108.

Rundel, P.W. and A.C. Gibson. 1996. Ecological communities and processes in a Mojave Desert ecosystem: Rock Valley, Nevada. Cambridge; New York: Cambridge University Press. 369 p.

Saab, V.A., C.E. Bock, T.D. Rich, and D.S. Dobkin. 1995. Livestock grazing effects in western North America, p. 311-353. *In* T.E. Martin and D.M. Finch (eds.), Ecology and management of Neotropical migratory birds. Oxford University Press, New York. Sakai, H.F. and B.R. Noon. 1993. Dusky-footed woodrat abundance in different aged forests in northwestern California. Journal of Wildlife Management 57:373-382.

Sandoval, A.V. 1979. Preferred habitat of desert bighorn sheep in the San Andres Mountains, New Mexico. M.S. Thesis, Colorado St. University, Ft. Collins. 314pp.

Sargeant, A.B., and D.W. Warner. 1972. Movement and denning habitats of badger. Journal of Mammalogy 53:207-210.

Sauer, J. R., J. E. Hines, and J. Fallon. 2001. *The North American Breeding Bird Survey, Results and Analysis 1966 - 2000. Version 2001.2.* USGS Patuxent Wildlife Research Center, Laurel, MD. Available at: http://www.mbr.nbs.gov/bbs/bbs.html.

Sazaki, M., W.I. Boarman, G. Goodlett, and T. Okamoto. 1995. Risk associated with long distance movements by desert tortoises. Proceedings of the 1994 Desert Tortoise Council Symposium 1995:33-48.

Schaal, B.A., and W.J. Leverich. 1981. The demographic consequences of two-stage life cycles: survivorship and the time of reproduction. American Naturalist 118:135-138.

Schonewald-Cox, C.M. 1983. Conclusions. Guidelines to management: A beginning attempt. Pages 141-145 in C.M. Schonewald-Cox, S.M. Chambers, B. MacBryde, and W.L. Thomas,

eds. Genetics and Conservation: A Reference for Managing Wild Animal and Plant Populations. Benjamin/Cummings, Menlo Park, CA.
Scott, J.A. 1986. The butterflies of North America: a natural history and field guide. Stanford University Press, Stanford, California. 583pp.
Scott, M. C. 2002. Integrating the stream and its valley: Land use change, aquatic habitat, and fish assemblages (North Carolina). Dissertation Abstracts International Part B: Science and Engineering, Vol. 63:51.
Seegmiller, R.F., P.R. Krausman, W.H. Brown, and F.M. Whiting. 1990. Nutritional composition of desert bighorn sheep forage in the Harquahala Mountains, Arizona. Desert Plants. 10(2): 87-90.
Selander RB. 1981. Evidence for a third type of larval prey in blister beetles (Coleoptera: Meloidae). Journal of the Kansas Entomological Society 54: 757-783.
Selander RB, Bouseman JK. 1960. Meloid beetles (Coleoptera) of the West Indies. Proceedings of the U.S. National Musuem 111: 197-226.
Selander, R.B. and T.R. Fasulo. 2000. Images, & Information For Insects, Spiders & Their Kin For the United States & Canada. http://bugguide.net.
Seton, E.T. 1929. The bighorn. Pages 519-573 in E.T. Seton, ed. Lives of the game animals. Volume 3, Part 2. Doubleday, Garden City, New York.
Shannon, N.H., R.J. Hudson, V.C. Brink, and W.D. Kitts. 1975. Determinants of spatial distribution of Rocky Mountain bighorn sheep. Journal of Wildlife Management 39:387-401.
Shaffer, M.L. 1981. Minimum population sizes for species conservation. BioScience 31:131-134.
Shaw, C. E. 1939. Food habits of the chuckwalla, Sauromalus obesus. Herpetologica 1:153.
Sheppard, J. M. 1970. A study of the Le Conte's thrasher. California Birds 1:85-94.
Sheppard, J. M. 1996. Le Conte's Thrasher (Toxostoma lecontei). In The Birds of North America, No. 230 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, and The American Ornithologists' Union, Washington, D.C.
Sherbrooke, W.C. 1989. Seedling survival and growth of a Sonoran Desert shrub, jojoba (Simmondsia chinensis), during the first 10 years. Southwestern Naturalist. 34(3): 421-424.
Short, H.L. 1977. Food habits of mule deer in a semi-desert grass-shrub habitat. Journal of Range Management. 30: 206-209.
Simovich, M.A. 1996. Crustacean Biodiversity and Endemism in California's Ephemeral Wetlands. Pages 107-118 *in:* C.W. Witham, E.T. Bauder, D. Belk, W.R. Ferren Jr., and R. Ornduff (Editors). Ecology, Conservation, and Management of Vernal Pool Ecosystems – Proceedings from a 1996 Conference. California Native Plant Society, Sacramento, CA. 1998.
Simpson, B.J. 1988. A field guide to Texas trees. Austin, TX: Texas Monthly Press. 372 p.
Singer, F.J., L.C. Zeigenfuss, and L. Spicer. 2001. Role of patch size, disease, and movement in rapid extinction of bighorn sheep. Conservation Biology 15:1347-1354.
Singer, F.J., V.C. Bleich, and M.A. Gudorf. 2000. Restoration of bighorn sheep metapopulations in and near western National Parks. Restoration Ecology 8:14-24.
Singer, F.J., M.E. Moses, S. Bellew, and W. Sloan. 2000. Correlates to colonizations of new patches by translocated populations of bighorn sheep. Restoration Ecology. 8:66-74.
Singleton, P.H., W.L. Gaines, and J.F. Lehmkuhl. 2002. Landscape Permeability for Large Carnivores in Washington: A Geographic Information System weighted-distance and least-cost corridor assessment. USDA Forest Service, Pacific Northwest Research Station, Research Paper PNW-RP-549.
Slatkin, M. 1993. Isolation by distance in equilibrium and nonequilibrium populations. Evolution 47(1):264-279.

Small, A. 1994. California Birds: Their status and distribution. Ibis Publishing Company. Vista, California. 342pp.

Smith, E.L. 1967. Behavioral adaptations related to water retention in the black- tailed gnatcatcher (Polioptila melanura). Unpublished Thesis (M.S.)--University of Arizona. 43 pp.

Smith, S.D. and D.J.M. Bradney. 1990. Mojave Desert field trip. In: McArthur, E. Durant; Romney, Evan M.; Smith, Stanley D.; Tueller, Paul T., compilers. Proceedings--symposium on cheatgrass invasion, shrub die-off, and other aspects of shrub biology and management; 1989 April 5-7; Las Vegas, NV. Gen. Tech. Rep. INT-276. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station: 350-351.

Smith, T.S. and J.T. Flinders. 1991. The bighorn sheep of Bear Mountain: ecological investigations and management recommendations. Utah Division of Wildlife Resources, Salt Lake City, Utah.

Smith, T.S., J.T. Flinder, and D.S. Winn. 1991. A habitat evaluation procedure for Rocky Mountain bighorn sheep in the intermountain west. Great Basin Naturalist 51:205-225.

Snead, J.S. and J. Alcock. 1985. Aggregation formation and Assortative Mating in two meloid beetles. Evolution 39(5) pp. 1123-1131.

Soulé, M.E., and J. Terborgh, editors. 1999. Continental conservation: scientific foundations of regional reserve networks. Island Press.

Soulé, M.E., ed. 1987. Viable Populations for Conservation. Cambridge University Press, Cambridge, UK.

Spowart, R.A. and F.B. Samson. 1986. Carnivores. Pages 475-496 In: A.Y. Cooperrider, R.J. Boyd, and H.R. Stuart (eds.). Inventory and monitoring of wildlife habitat. U.S. Department of the Interior, Bureau of Land Management, Service Center. Denver, Colorado

Stark, N. 1966. Review of highway planting information appropriate to Nevada. Bull. No. B-7. Reno, NV: University of Nevada, College of Agriculture, Desert Research Institute. 209 p. In cooperation with Nevada State Highway Department.

Stebbins, R.C. 1985. A field guide to western reptiles and amphibians. 2nd Ed., revised. Houghton Mifflin, Boston.

Stebbins, R. C. 1972. California amphibians and reptiles. Univ. California Press, Berkeley. 152pp.

Stebbins, R.C. 1954. Amphibians and Reptiles of Western North America. McGraw-Hill Book Company, Inc. New York. 536pp.

Stebbins, R. C. 1944. Field notes on a lizard, the mountain swift, with special reference to territorial behavior. Ecology 25:233-245.

Stephenson, J.R. and G.M. Calcarone. 1999. Southern California mountains and foothills assessment: habitat and species conservation issues. General Technical Report GTR-PSW-172. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture.

Stewart, J.S., L. Wang, J. Lyons, J.A. Horwatich, and R. Bannerman. 2001. Influences of watershed, riparian-corridor, and reach-scale characteristics on aquatic biota in agricultural watersheds. Journal of the American Water Resources Association 37:1475-1488.

Suarez, A.V., D.T. Bolger, and T.J. Case. 1998. Effects of fragmentation and invasion on native ant communities in coastal southern California. Ecology 79:2041-2056.

Sullivan, J. 1996. *Taxidea taxus*. In: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (2002, April). Fire Effects Information System, [Online]. Available: http://www.fs.fed.us/database/feis/.

Swank, W.G. 1958. The mule deer in Arizona chaparral. Wildlife Bulletin No. 3. Phoenix, AZ: State of Arizona, Game and Fish Department. 109 p.

Sweanor, L.L., K.A. Logan, and M.G. Hornocker. 2000. Cougar dispersal patterns, metapopulation dynamics, and conservation. Conservation Biology 14:798-808.
Taylor, A.D. 1990. Metapopulation structure in predator-prey systems: an overview. Ecology 71:429-433.
Templeton, A.R., and D.A. Levin. 1979. Evolutionary consequences of seed pools. American Naturalist 114(2);232-249.
Teresa, S. and B.C. Pace. 1998. Planning Sustainable Conservation Projects: Large and Small-Scale Vernal Pool Preserves Pages 255-262 *in:* C.W. Witham, E.T. Bauder, D. Belk, W.R. Ferren Jr., and R. Ornduff (Editors). Ecology, Conservation, and Management of Vernal Pool Ecosystems – Proceedings from a 1996 Conference. California Native Plant Society, Sacramento, CA.
Tesky, J.L. 1995. *Felis concolor*. In: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (2002, April). Fire Effects Information System, [Online]. Available: http://www.fs.fed.us/database/feis/.
Tewksbury, J.L., D.J. Levey, N.M. Haddad, S. Sargent, J.L. Orrock, A. Weldon, B.J. Danielson, J. Brinkerhoff, E.L. Damschen, and P. Townsend. 2002. Corridors affect plants, animals, and their interactions in fragmented landscapes. PNAS, Vol. 99, No. 20, pp. 12923-12926.
Thiéry, A. 1987. Les Crustacés Branchiopodes Anostraca Notostraca et Conchostraca des Milieux Limniques Temporaires (Dayas) au Maroc. Taxonomie, Biogéographie, Écologie. Thèse D. Sc. Marseille.
Thomsen, L. 1971. Behavior and ecology of burrowing owls on the Oakland Municipal Airport. The Condor, Vol. 73, pp. 177-192.
Thorne, E.T., W.O. Hickey, and S.T. Stewart. 1985. Status of California and Rocky Mountain bighorn sheep in the United States. Pages 56-81 in M. Hoefs, editor. Wild sheep: distribution and management. Special report of the Northern Wild Sheep and Goat Council. Whitehorse, Yukon, Canada.
Tigas, L. A., D. H. Van Vuren, and Sauvajot. 2002. Behavioral responses of bobcats and coyotes to habitat fragmentation and corridors in an urban environment. Biological Conservation 108:299– 306.
Tilton, M.E., and E.E. Willard. 1982. Winter habitat selection by mountain sheep. Journal of Wildlife Management 46:359-366.
Tinant, J. 2006. Black-tailed Gnatcatcher (*Polioptila melanura*). In The Draft Desert Bird Conservation Plan: a strategy for reversing the decline of desert-associated birds in California. California Partners in Flight. http://www.prbo.org/calpif/htmldocs/desert.html
Torres, S. 2000. Counting Cougars in California. Outdoor California, May-June.
Trombulak, S.C., and C.A. Frissell. 2000. Review of ecological effects of roads on terrestrial and aquatic communities. Conservation Biology 14:18-30.
Tueller, P. T., R.J. Tausch, and V. Bostick. 1991. Species and plant community distribution in a Mojave-Great Basin desert transition. Vegetatio. 92(2): 133-150.
Turner, R.M. 1982. Great Basin desertscrub. In: Brown, David E., ed. Biotic communities of the American Southwest--United States and Mexico. Desert Plants. 4(1-4): 145-155.
Turner, R.M. 1982. Mohave desert scrub. In: Brown, David E., ed. Biotic communities of the American Southwest--United States and Mexico. Desert Plants. 4(1-4): 157-168.
Uchytil, R.J. 1990. Chilopsis linearis. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2007, October 19].
Unitt, P. 1984. The birds of San Diego County. San Diego Society of Natural History, San Diego.

Urness, P. J. and C.Y. McCulloch. 1973. Part III: Nutritional value of seasonal deer diets. In: Special Report 3. Deer nutrition in Arizona chaparral and desert habitats. Phoenix, AZ: Arizona Game and Fish Department: 53-68.

Urness, P. J. and D.D. Austin. 1989. The effects of grazing and browsing animals on wildlife habitats. Utah Science. 50(2): 104-107.

USDA Forest Service. 2002. Southern California Forest Plan Revision Process, Species Reports for Scientific Review.

U.S. Department of the Interior, Bureau of Land Management. 2003. Draft Environmental Impact Report and Statement for the West Mojave Plan A Habitat Conservation Plan and California Desert Conservation Area Plan Amendment Vol. 1. May 2003.

U.S. Department of the Interior, Bureau of Land Management. 2003. Western Mojave Desert Off Road Vehicle Designation Project Environmental Assessment and Draft CDCA Plan Amendment.

U.S. Environmental Protection Agency (USEPA). 2003. Watershed Assessment Tracking, and Environmental Results (WATER) Database: United States Geological Survey (USGS). 1998a. 1995 National Water-Use Data Files for California Watersheds. http://ca.water.usgs.gov/archive/waterdata/

U.S. Geological Survey. 2002. Butterflies of North America, Butterflies of California. Northern Prairie Wildlife Research Center http://www.npwrc.usgs.gov.

U.S. Fish and Wildlife Service. 2008. Draft revised recovery plan for the Mojave population of the desert tortoise (*Gopherus agassizii*). U.S. Fish and Wildlife Service, California and Nevada Region, Sacramento, California. 209 pp.

U.S. Fish and Wildlife Service. 2001. Biological and Conference Opinions on the Continued Implementation of Land and Resource Management Plans for the Four Southern California National Forests, as Modified by New Interim Management Direction and Conservation Measures (1-6-00-F-773.2)

U.S. Fish and Wildlife Service. 2000. Recovery plan for bighorn sheep in the Peninsular Ranges, California. Portland, OR: USDI Fish and Wildlife Service.

U.S. Fish and Wildlife Service. 1998. Endangered and threatened wildlife and plants; final rule to list the San Bernardino kangaroo rat as endangered. Federal Register 63(185):51005-51017.

U.S. Fish and Wildlife Service. 1998. Draft Recovery Plan for the least Bell's Vireo. U.S. Fish and Wildlife Service, Portland, Oregon. 139pp.

U.S. Fish and Wildlife Service. 1994. Desert tortoise (Mojave population) Recovery Plan. U.S. USFWS, Portland, Oregon. 73 pages plus appendices.

Valdez, R. and P.R. Krausman. 1999. Description, distribution, and abundance of mountain sheep in North America. Pages 3-22 in R. Valdez and P.R. Krausman, editors. Mountain Sheep of North America. The University of Arizona Press, Tucson, Arizona.

Van Dyke, W.A., A. Sands, J. Yoakum, A. Polentz, and J. Blaisdell. 1983. Wildlife habitat in management rangelands – bighorn sheep. U.S. Forest Service General Technical Report, PNW-159. Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.

Veenbaas, G. and J. Brandjes. 1999. Use of fauna passages along waterways under highways. In: Proceedings of the third international conference on wildlife ecology and transportation, edited by G.L. Evink, P. Garrett, and D. Zeigler. FL-ER-73-99. Florida Department of Transportation, Tallahassee, Florida.

Venable, D.L. 1989. Modeling the evolutionary ecology of seed banks. Pages 67-87 *in*: M.A. Leck, V.T. Parker and R.L. Simpson (Editors). Ecology of Soil Seed Banks. Academic Press, San Diego, CA.

Vickery, P.D. and J.R. Herkert (eds). 1999. Ecology and conservation of grassland birds of the western hemisphere. Studies in Avian Biology 19.

Vines, R.A. 1960. Trees, shrubs, and woody vines of the Southwest. Austin, TX: University of Texas Press. 1104 p.

Von Seckendorff Hoff, K., and R. W. Marlow. 2002. Impacts of vehicle road traffic on desert tortoise populations with consideration of conservation of tortoise habitat in southern Nevada. Chelonian Conservation and Biology. 4:449-456. .

Walker, R. and L. Craighead. 1997. Analyzing Wildlife Movement Corridors in Montana Using GIS. ESRI User Conference Proceedings.

Wallace, A. and E.M. Romney. 1972. Radioecology and ecophysiology of desert plants at the Nevada Test Site. Rep. TID-25954. [Washington, DC]: U.S. Atomic Energy Commission, Office of Information Services. 439 p.

Wang, L., J. Lyons, P. Kanehl, and R. Bannerman. 2001. Impacts of urbanization on stream habitat and fish across multiple spatial scales. Environmental Management 28:255-266.

Weaver, D.C. 1981. Aeolian sand transport and deposit characteristics at ten sites in Coachella Valley, California. Part II. In: The effect of blowsand reduction on the abundance of the fringe-toed lizard (*Uma inornata*) in the Coachella Valley, California. A report submitted to U.S. Army Corps of Engineers, Los Angeles District.

Weaver, R.A. 1972. Desert bighorn sheep in Death Valley National Monument and adjacent areas. Wildlife Management and Administrative Report 72-74. California Department of Fish and Game, Sacramento.

Webb, R.H., J.W. Steiger, and E.B. Newman. 1988. The response of vegetation to disturbance in Death Valley National Monument, California. U.S. Geological Survey Bulletin 1793. Washington, DC: U.S. Department of the Interior, U.S. Geological Survey. 69 p.

Webb, R.H., J.W. Steiger, and R.M. Turner. 1987. Dynamics of Mojave Desert shrub assemblages in the Panamint Mountains, California. Ecology. 68(3): 478-490; 1987.

Webber, J.M. 1953. Yuccas of the Southwest. Agriculture Monograph No. 17. Washington, DC: U.S. Department of Agriculture, Forest Service. 97pp.

Wehausen, J.D. 1980. Sierra Nevada bighorn sheep: history and population ecology. Ph.D. Dissertation. Univ. Michigan, Ann Arbor. 240pp.

Wehausen, J.D. 1983. White Mountain bighorn sheep: an analysis of current knowledge and management alternatives. USDA, For. Serv., Inyo Nat. For. Bishop, CA. Adm. Rep., Contract No. 53-9JC9-0-32. 93pp.

Welch, R.D. 1969. Behavioral patterns of desert bighorn sheep in southcentral New Mexico. Desert Bighorn Council 13:114-129.

Welsh, S.L., N.D. Atwood, S. Goodrich, and L.C. Higgins, eds. 1987. A Utah flora. The Great Basin Naturalist Memoir No. 9. Provo, UT: Brigham Young University. 894 p.

White, R.E. 1983 Peterson Field Guides: Beetles. Houghton Mifflin Company.

Whitson, T.D., L.C. Burrill, S.A. Dewey, D.W. Cudney, B.E. Nelson, R.D. Lee, and R. Parker. 2000. Weeds of the West. Published in cooperation with the Western Society of Weed Science, the Western United States Land Grant Universities Cooperative Extension Services and the University of Wyoming. Jackson, WY 628pp.

Wilcove, D.S., C.H. McLellan, and A.P. Dobson. 1986. Habitat fragmentation in the temperate zone. Pages 879-887 In: M.E. Soulé, ed. Conservation Biology. Sinauer Associates, Sunderland, Massachusetts, USA.

Wilcox, B.A., and D.D. Murphy. 1985. Conservation Strategy: the effects of fragmentation on extinction. American Naturalist 125:879-887.

Williams, D.F., H.H. Genoways, and J.K. Braun. 1993. Taxonomy. In: Biology of the Heteromyidae (ed. Genoways and Brown), pp. 38-196. Special Publication No. 10,

American Society of Mammalogists.
Wilson, J.D. and M.E. Dorcas. 2003. Effects of habitat disturbance on stream salamanders: Implications for buffer zones and watershed management. Conservation Biology 17: 763-771.
Wilson, L.O., J. Blaisdell, G. Welsh, R. Weaver, R. Brigham, W. Kelly, J. Yoakum, M. Hinks, J. Turner, and J. DeForge. 1980. Desert bighorn habitat requirements and management recommendations. Desert Bighorn Council Transactions, Vol. 24, pp. 1-7.
Wishart, W. 1978. Bighorn sheep. Pages 161-171 in J.L. Schmidt and D.L. Gilbert, editors. Big game of North America. Stackpole Books, Harrisburg, Pennsylvania.
Witham, J.H. and E.L. Smith. 1979. Desert bighorn movement in a southwestern Arizona mountain complex. Transactions Desert Bighorn Council, Vol. 23, pp. 20-24.
Wright, S. 1943. Isolation by distance. Genetics 28:114-138.
Yanes, M., J.M. Velasco, and F. Suarez. 1995. Permeability of roads and railways to vertebrates: the importance of culverts. Biological Conservation 71:217-222.
Yeaton, R. I., R.W. Yeaton, J.P. Waggoner III, and J.E. Horenstein. 1985. The ecology of yucca (Agavaceae) over an environmental gradient in the Mohave Desert: distribution and interspecific interactions. Journal of Arid Environments. 8: 33-44.
Yosef, R. 1994. Evaluation of the global decline in the true shrikes (family Laniidae). Auk 111:228-233.
Yosef, R. 1996. Loggerhead Shrike (*Lanius ludovicianus*). In A. Poole and F. Gill (eds.), The birds of North America, No. 231. Philadelphia, PA: the Academy of Natural Sciences and Washington, DC: the American Ornithologists' Union.
Zarn, M. 1974b. Burrowing Owl (Speotyto cunicularia hvpugaea) Habitat Management Series for Unique or Endangered Species. U. S. Dept. Int.
Zeigenfuss, L.C., F.J. Singer, and M.A. Gudorf. 2000. Test of a modified habitat suitability model for bighorn sheep. Restoration Ecology 8:38-46.
Zeiner, D.C., W.F. Laudenslayer, and K.E. Mayer (eds.). 1988. California's wildlife. Volume I: Amphibians and reptiles. California Statewide Wildlife Habitat Relationships System. Sacramento, CA: California Department of Fish and Game.
Zeiner, D.C., W.F. Laudenslayer, and K.E. Mayer (eds.). 1990. California's wildlife. Volume 3: Mammals. California Statewide Wildlife Habitat Relationships System. Sacramento, CA: California Department of Fish and Game.
Zeiner, D.C., W. Laudenslayer, Jr., K. Mayer, and M. White, eds. 1990. California's wildlife. Vol. 2: Birds. California Department of Fish and Game, Sacramento, 732pp.
Zeng, Z., and J.H. Brown. 1987. Population ecology of a desert rodent: Dipodomys merriami in the Chihuahuan Desert. Ecology 68:1328-1340.
Zezulak, D.S. and R.G. Schwab. 1981. A comparison of density, home range and habitat utilization of bobcat populations at Lava Beds and Joshua Tree National Monuments, California. In: Blum, L. G.; Escherich, P. C., eds. Bobcat research conference: Proceedings; 1979 October 16-18; Front Royal, VA. NWF Science and Technical Series No. 6. Washington, DC: National Wildlife Federation: 74-79.
Zezulak, D. S. 1998. Spatial, temporal, and population characteristics of two bobcat, Lynx rufus, populations in California. Dissertation, University of California Davis, USA.
Zezulak, D. S. 1981. Northeastern California bobcat study. Calif. Dep. Fish and Game, Sacramento. Fed. Aid Wildl. Rest. Proj. W-54-R-12, Job IV-3. 19pp.
Zezulak, D. S., and R. G. Schwab. 1980. Bobcat biology in a Mojave Desert community. Calif. Dep. Fish and Game, Sacramento. Fed. Aid Wildl. Rest. Proj. W-54-R-12, Job IV-4. 25pp.. 1976. California mountain lion study. Calif. Dep. Fish and Game, Sacramento. 40pp.

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Appendix B
Habitat Connectivity Workshop

Selecting Small Mammals for Linkage Planning
Wayne Spencer, Conservation Biology Institute

Summary: Because most large reserve areas in southern California comprise mountain ranges, whereas development pressures are focused in the intervening lowlands, most major landscape linkages of conservation concern here connect across valleys between the mountain ranges. For good reasons, linkage planning in these situations tends to focus on large, wide-ranging mammals, like mountain lions and bighorn sheep, that are associated with the mountainous reserve areas but that need to move between them at least occasionally. However, smaller mammals living in core reserves, or within the lower lands between them, also need to be considered, because they 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 linkage function. 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; (5) consider the limited dispersal tendencies of most small mammals between suitable habitat patches; and (6) consider that structures like roads and canals may present movement barriers for some small mammals. 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. We will discuss a variety of small mammal species that may benefit linkage planning in the Joshua Tree to Twentynine Palms linkage area.

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 serves as a scientific advisor or leads science-advisory processes for a variety of large-scale conservation planning efforts in California, mostly under California's Natural Communities Conservation Planning (NCCP) Act.

Road Ecology and Desert Tortoises

William I. Boarman, Conservation Science Research & Consulting

Summary: Roads are a pervasive landscape feature throughout the Mojave Desert. Their impacts on desert tortoise (*Gopherus agassizii*) populations are manifold and may extend well away from the road edge. The most immediate impact to tortoises is through mortality from collisions with vehicles. By one very conservative estimate, an average of 1 tortoise died annually along every 3.3 km of one highway in the western Mojave Desert. The components of the population most vulnerable to road mortality are probably adults and subadult males. Roads also cause the spread of exotic weeds, facilitate increases in local raven populations, and may introduce toxicants to the environment. Roads also aid intrusions into tortoise habitat by many human activities, some of which may be hazardous to tortoises. A zone of reduced tortoise density occurs within at least 400 m of highway edges and may extend much farther. The exact cause of this depression zone is unknown, but is likely to be the cumulative effects of the many detrimental aspects of roads. Barrier fences reduce mortality along roads, but increase population fragmentation. Passageways can help mitigate the fragmenting effects of roads and fences.

Biography: Dr. William I. Boarman is a freelance Conservation Scientist and Wildlife Biologist. He is the proprietor of Conservation Science Research & Consulting, a company that provides research and technical support for government agencies, conservation organizations, and industry. As a Research Wildlife Biologist for the U.S. Geological Survey for fifteen years, Dr. Boarman studied common raven ecology, desert tortoise conservation, and dynamics of the Salton Sea ecosystem. One important focus of his research has been impacts of roads on tortoise populations, and the effectiveness of barrier fences and culverts at recovering tortoise populations. The association between raven ecology and anthropogenic resources to develop means to reduce raven predation on juvenile tortoises is the aim of his work with ravens. He is continuing these studies now as an independent scientist. Dr. Boarman is currently writing the California State Burrowing Owl Conservation Strategy for California Department of Fish and Game. He is an adjunct professor of Biology at San Diego State University, Research Associate of University of California, Riverside, and Scientist Emeritus of the USGS. He received his Ph.D. in ecology from Rutgers University. He has published over papers 25 papers in peer-reviewed scientific journals.

An Examination of the Reptiles of the Joshua Tree and Twentynine Palms Region and Issues of Concern for Connectivity.

Chris Brown, USGS Western Ecological Research Center

Summary: The diversity of habitats in the Joshua Tree and Twentynine Palms region, from high elevation woodlands and chaparral to low elevation desert flats, presents difficulties for building linkages for species that may have limited distributions within the planning area, such as ground dwelling reptiles. Within this region, the USGS Western Ecological Research Center has conducted focused surveys to assess habitat utilization by reptiles and impacts of fragmentation. These survey efforts produced over 3,000 observations, combined with historic records to total 36 reptile species. Several species were observed throughout the various habitat types of the region while others show clear habitat affinities. Furthermore, some species have shown declines in locations with increased human activity. This study can help answer questions as to which species of

reptile have specific needs, which are habitat specialists and which may be impacted more heavily by human activities

Biography: Chris Brown is a biologist for the US Geological Survey, Western Ecological Research Center (WERC). Since 1995, he has been studying the herpetofauna of southern California to support research needs of WERC and its partners, including California State Parks, National Park Service, Department of Defense and US Forest Service. He has also been working with the USGS Amphibian Research and Monitoring Initiative to support analysis of amphibian trends at a National level.

Little Blue Butterflies and their problems crossing roads
Gordon Pratt, University of California at Riverside

Summary: Insects are an important group of organisms to provide corridors for connecting different regions in California. This importance is not only due to their sheer species numbers, but their importance in performing environmental jobs such as pollination, recycling of nutrients, and as a source of food for many other organisms. Butterflies are good representatives of insects since they perform most of these jobs as well as being well understood geographically, biologically, and taxonomically. Small blue butterflies are chosen to exemplify the problems of butterflies crossing roads because of their small size, often restricted ranges, and many species and subspecies in California. The vernal blue of the northwest corner of the San Bernardino Mountians is chosen to further exemplify the problems crossing roads since this species has a very restricted range and a well defined habitat. Despite the species restricted range, the vernal blue has the highest genetic diversity of all blues studied to this point, showing the importance of movement between populations for this species.

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 research scientist at the University of California at Riverside working on endangered butterflies and the diversity of insects in various desert areas. He has taught and co-taught a course on the ecology of butterflies of southern California through extension at UCR and the Desert Institute at Joshua Tree National Park. Pratt has authored and coauthored 40 papers on insects, most of which are on different aspects of butterfly evolution and biology.

Linkages from a Plant Perspective
Ileene Anderson, Center for Biological Diversity

Summary: The workshop’s geographic area is rich in diversity of plant species / associations due to the convergence of the Colorado and Mojave deserts and the Transverse ranges. 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. The ecotonal nature of the area is another important component to consider when

appraising linkages. Focus on indispensable mutualisms, dispersal mechanisms, great regional diversity of species, and rare plant issues should help to frame the vegetation theme, and provide context for the afternoon breakout sessions. Some considerations involved in assessing viable habitat corridors regarding plants are that abiotic and biotic pollen and propagule dispersal needs for plants are essential functions that linkages provide. Pollination of flowering plants in fragmented landscapes is significantly increased by corridors, and highly correlated to the size and number of those corridors (Townsend and Levey 2002). Different dispersal strategies are used by different plant species, and all must be considered when linkages are identified. Dispersal opportunity is a factor in determining species richness in successional stands of vegetation (Matlack 1994). Linkages must provide opportunities for plant movement across the landscape over the long-term. On the geologic timescale, plants move in elevation and latitude to exploit changes in climatic conditions –historically from glacial / interglacial periods, but contemporarily from human-caused changes (global warming). Rare plants are often associated with unique substrates. Linkages promote an increased chance of persistence in rare plants that utilize these naturally occurring fragmented habitats through propagule dispersal (Kirchner et al. 2002).

Biography: Ileene Anderson works as an ecologist for the non-profit Center for Biological Diversity. 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.

Inventory and Monitoring Program at Joshua Tree National Park
Paul DePrey, Joshua Tree National Park

Summary: As part of the National Park Service's effort to "improve park management through greater reliance on scientific knowledge," a primary role of the Inventory and Monitoring Program is to collect, organize, and make available natural resource data and to contribute to the Service's institutional knowledge by facilitating the transformation of data into information through analysis, synthesis, and modeling.
The five goals of the Inventory & Monitoring Program are to:

1. Inventory the natural resources and park ecosystems under National Park Service stewardship to determine their nature and status.
2. Monitor park ecosystems to better understand their dynamic nature and condition and to provide reference points for comparisons with other, altered environments.
3. Establish natural resource inventory and monitoring as a standard practice throughout the National Park system that transcends traditional program, activity, and funding boundaries.
4. Integrate natural resource inventory and monitoring information into National Park Service planning, management, and decision making.
5. Share National Park Service accomplishments and information with other natural resource organizations and form partnerships for attaining common goals and objectives.

Biography: Paul DePrey is the Chief of Resources at Joshua Tree National Park. Prior to coming to Joshua Tree, he was the Chief of Resources at Whiskeytown National

Recreation Area, which is at the juncture of the Klamath Mountain range and the northern edge of the Sacramento Valley.

Considerations for Connectivity and Overview of Working Group Session
Kristeen Penrod, South Coast Wildlands

Summary: This presentation provides an overview of the afternoon working group session to help workshop participants understand the purpose of the focal species groups, identification of critical biological issues regarding connectivity, and qualities of species that may be particularly vulnerable to loss of connectivity.

Biography: Kristeen Penrod is the founder and Executive Director of South Coast Wildlands, an organization dedicated to ensuring habitat connectivity across the South Coast Ecoregion of southern California. She graduated from UCLA in 1999, and soon thereafter got her start in linkage conservation planning by coordinating the statewide Missing Linkages Workshop and authoring the conference proceedings. She is the project director for the South Coast Missing Linkages Project; a highly collaborative effort focused on several major landscape-level connections in southern California. South Coast Wildlands serves as overall project coordinator for over a dozen partners, which entails planning and hosting regional workshops, developing systematic and scientifically valid methods, performing consistent GIS analyses across the priority linkages, compiling and distributing the linkage-design reports, and helping to raise public awareness about connectivity needs.