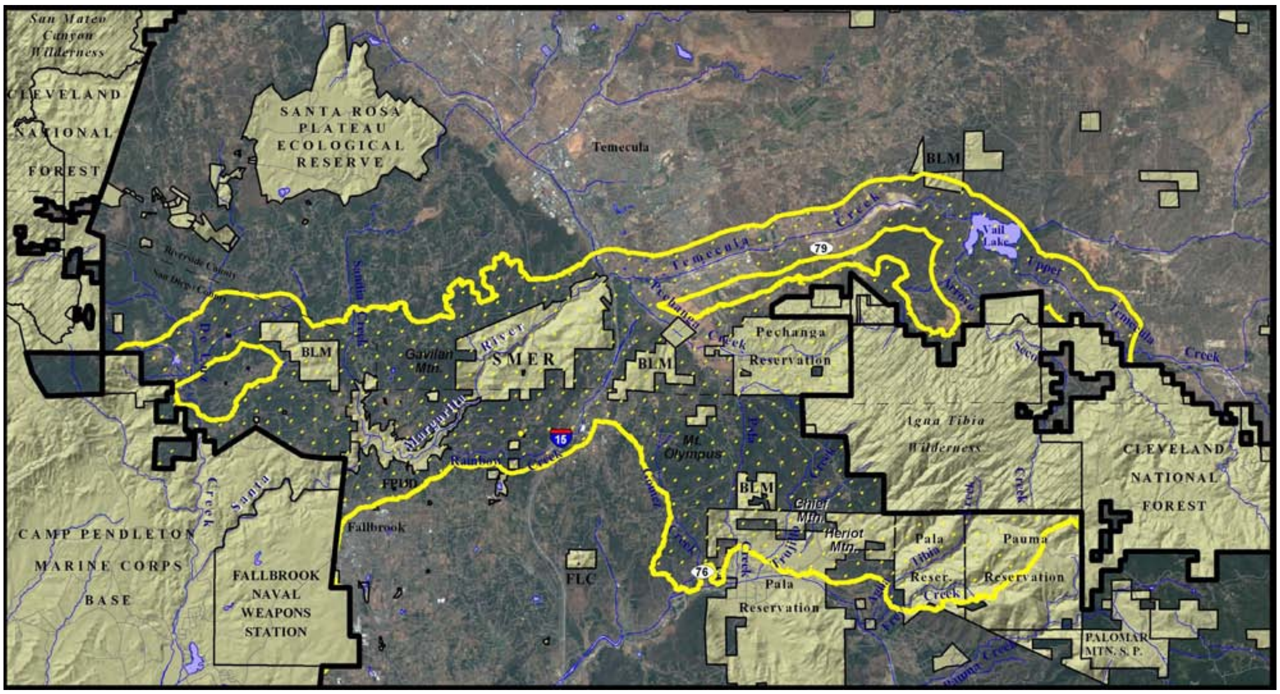
A Linkage Design for the Santa Ana - Palomar Mountains Connection

Prepared in collaboration with the South Coast Missing Linkages Project



San Diego State University Field Station Programs
and
South Coast Wildlands

Dr. Claudia Luke
Kristeen Penrod
Clint R. Cabañero
Dr. Paul Beier
Dr. Wayne Spencer
Sedra Shapiro

May 2004

A Linkage Design for the Santa Ana – Palomar Mountains Connection

Prepared in collaboration with the South Coast Missing Linkages Project

Prepared By:

Dr. Claudia Luke, SDSU Field Station Programs
Kristeen Penrod, South Coast Wildlands
Clint R. Cabañero, South Coast Wildlands
Dr. Paul Beier, Northern Arizona University
Dr. Wayne Spencer, Conservation Biology Institute
Sedra Shapiro, SDSU Field Station Programs

Primary Contact: San Diego State University Field Station Programs

SDSU Field Station Programs
5500 Campanile Drive
San Diego, California 92182-4614
www.fs.sdsu.edu

South Coast Wildlands
P.O. Box 1102
Idyllwild, CA 92549-1102
www.scwildlands.org

May 2004

Preferred Citation:
Luke, C., K. Penrod, C.R. Cabañero, P. Beier, W. Spencer, and S. Shapiro. 2004. A linkage design for the Santa Ana – Palomar Mountains connection. Unpublished report. San Diego State University Field Station Programs, San Diego, California, www.fs.sdsu.edu and South Coast Wildlands, P.O. Box 1102, Idyllwild, California 92549-1102, www.scwildands.org.

This planning effort was made possible with financial support from: San Diego State University Field Station Programs, The Nature Conservancy, The Wildlands Conservancy, The Resources Agency, The Nature Conservancy, U.S. Forest Service, and California State Parks Foundation.

This project was conducted in collaboration with:

What is the Santa Ana – Palomar Mountains Linkage?

The Santa Ana – Palomar Mountains Linkage encompasses the only remaining natural habitats connecting the Santa Ana Mountains and adjacent coastal lowlands to a large inland chain of protected mountain ranges. The majority of land in this linkage is privately owned and at risk of being developed for agriculture and housing. Large-scale ecosystem processes are expected to be substantially altered in the range, and other areas of the South Coast Ecoregion, should the linkage be severed.

What is the regional significance of the linkage?

The Santa Ana – Palomar Mountains Linkage is one of only two remaining natural areas in southern coastal California that provides connections between protected coastal and inland habitats. It is listed by the South Coast Missing Linkages Project as one of 15 priority linkages needed to establish an ecologically viable network of wildlands in the South Coast Ecoregion. Maintaining the linkage provides important long-term insurance for ecosystem viability by allowing species freedom to move under changing and unpredictable environmental conditions.

Who is developing a conservation plan for the linkage?

Conservation planning is a collaborative endeavor lead by San Diego State University Field Station Programs and the South Coast Wildlands. The effort was undertaken as a conservation planning initiative by the Field Station Programs. The methods and approach were jointly developed with the South Coast Wildlands in support of the South Coast Missing Linkages Project. Additional funding and support were provided by The Nature Conservancy, US Geological Survey, and over 100 participants from 40 universities, agencies, and organizations.

About San Diego State University Field Station Programs

SDSU Field Station Programs develops projects and initiatives that integrate research with regional management challenges. The Field Station Programs is the project lead for the Santa Ana – Palomar Mountains Linkage planning effort. The Santa Margarita Ecological Reserve, one of four SDSU Field Stations, protects key lands in the Santa Ana – Palomar Mountains linkage and provides lands and facilities for the purposes of research and education on natural ecosystems (www.fs.sdsu.edu).

About South Coast Wildlands

The South Coast Wildlands is a non-profit group established to create a protected network of wildlands throughout the South Coast Ecoregion. SCWP works collaboratively with local conservation efforts, develops plans for priority linkages without local efforts, and coordinates the South Coast Missing Linkages Project (www.scwildlands.org).

About South Coast Missing Linkages Project

The South Coast Missing Linkages Project is a coalition of agencies, universities and organizations dedicated to quickly securing a network of wildlands that conserves ecosystem processes in the South Coast Ecoregion. Partners in the coalition 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, The Wildlands Project, California Wilderness Coalition, and the Zoological Society of San Diego Center for Reproduction of Endangered Species.

(this page intentionally left blank)

Table of Contents

Appendices

List of Tables

List of Tables in Appendices

List of Figures

List of Figures in Appendices

Acknowledgements

Workshop Speakers: We thank the invited speakers who provided valuable information that served as a basis for workshop activities at habitat connectivity planning workshops: Pat Atchison (TAIC), Paul Beier (Northern Arizona University and the South Coast Wildlands [SCWP])), Robert Fisher (U.S. Geological Survey [USGS]), Scott Fleury (TAIC), Paul Gonzales (CalTrans District 8), Julie Hussman (The Nature Conservancy [TNC]), Jerry Jolliffe (Riverside County Transportation and Land Management Agency), Ross Kiester, Claudia Luke (San Diego State University Field Station Programs [SDSU FSP]), Tom Oberbauer (San Diego Co, Department of Planning), Gordon Pratt (University of California Riverside [UCR]), Gary Pryor (San Diego County 2020 Planning), Tom Scott (UCR), and Sedra Shapiro (SDSU FSP). And to John Gomez (Pechanga Cultural Committee) who was unable to attend due to travel conditions after 9/11/01.

Taxonomic Working-Group Participants: We thank the following individuals for their participation in planning workshop working groups: Alison Anderson (US Fish and Wildlife Service [USFWS]), Andrea Atkinson (US Geological Survey [USGS]), Greg Ballmer (UCR), Rolf Baumberg (University of Zurich), Peter Beck (USFWS), Deborah Bieber (MCB Camp Pendleton), David Bittner (Wildlife Research Institute [WRI]), Leigh Bittner (WRI), Margaret Bornyasz (UCR), Barbara Carlson (UC Natural Reserve System), Larry Carlson (MCB Camp Pendleton), Caroline Crowley (SDSU), Jesse D'Ella (USFWS), Jay Diffendorfer (SDSU), Jenny Duggan (SDSU), Corey Ferguson (USFWS), Robert Fisher (USGS), Pat Flanagan (San Diego Natural History Museum), Chris Haas (USFS), Maeve Hanley (San Diego County), Joseph Jackson (Fallbrook Public Utility District), Ross Kiester (US Forest Service [USFS]), Dawn Lawson (US Navy), John Lovio (Southwest Division of Navy Natural Resources), Cynthia Mallette (Mission Resource Conservation District), Robin Maloney-Rames (California Department of Fish and Game [CDFG]), Will Miller (USFWS), Thomas Oberbauer (San Diego County), Brock Ortega (Dudek and Associates), Mark Pavelka (USFWS), Jamie Phillips (Fallbrook Land Conservancy [FLC]), Gordon Pratt (UCR), Kris Preston (UCR), Zack Principe (The Nature Conservancy [TNC]), Scott Quinnell (California Department of Transportation), Karin (Pandora) Rose, Lynn Sadler (Mountain Lion Foundation), Sedra Shapiro (SDSU FSP), Tom Scott (UCR), Trish Smith (TNC), Jerre Stallcup (Conservation Biology Institute [CBI]), Camm Swift (Los Angeles County Natural History Museum), Eileen Takata (SCWP), Mary Thomas (USFS), Karen Tucker (Fallbrook Land Conservancy [FLC]), Wallace Tucker (FLC), Greta Turschak (USGS), Manna Warburton (USGS), Ken Weaver (San Diego County Bird Atlas), Jeff Wells (USFS), Mike White (CBI), Maria Wiehe (SDSU FSP), Kathy Williams (SDSU), Clark Winchell (USFWS), Kirstin Winters (USFS), and Jim Zimmer (SDSU).

Technical Assistance: We also thank Jeff Iles from the SDSU FSP for GIS support and Andrea Warniment and Elizabeth Chattin for their assistance with field surveys.

Reviewers and/or Contributing Authors: We especially thank the following individuals who have provided significant input in development on this planning effort, reviewed drafts of this manuscript, or both: Kathy Daly (Wildlands Project), Robert Fisher (USGS), Rob Lovich (USGS), Scott Morrison (TNC), Esther Rubin (Zoological Society of San Diego), Ray Sauvajot (National Park Service), Cam Swift (LA County Natural History Museum), Mike White (CBI), Jerre Ann Stallcup (CBI), and Manna Warburton (USGS).

SDSU Field Stations Steering Committee: We thank the SDSU FSP strategic planning steering committee for their work in developing the conservation research program vision and goals that identified this priority project: Mike Allen (UCR Center for Conservation Biology), Laura Benedict (The Nature Conservancy), Cynthia Carson (Strategic Planning Consultant), Patrick Caughey (Wimmer, Yamada, and Caughey), Jay Diffendorfer (SDSU), Robert Fisher (USGS) Janet Franklin (SDSU), Theodore Griswold (Corey, Hargreaves, and Savitch), Michael Hagar (San Diego Natural History Museum), Kim Hill (SDSU), Don Hunsacker (Environmental Trust), Timothy Hushen (SDSU), Al Johnson (SDSU), Bill Leahy (TNC), Walt Oechel (SDSU), Tod Reeder (SDSU), Sally Rousch (SDSU), Gerald Scheid (RECON), Sedra Shapiro (SDSU), Mike Simpson (SDSU), James Sulentich (TNC), Susan Weber (SDSU), and Richard Wright (SDSU).

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

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

(this page intentionally left blank)

Executive Summary

Nature Needs Room to Move: Habitat loss and fragmentation are the leading threats to biodiversity, both globally and in Southern California. Efforts to combat these threats must focus on conserving well-connected networks of large wildland areas where natural ecological and evolutionary processes can continue to operate over large spatial and temporal scales. These processes include top-down regulation by large predators, and natural patterns of gene flow, pollination, dispersal, energy flow, nutrient cycling, inter-specific competition, and mutualism. Landscape connections that link large blocks of protected habitat can provide resiliency to ecosystems responding to natural and anthropogenic environmental perturbations, such as fire, flood, climate change, and invasions by alien species.

The tension between habitat fragmentation and conservation is particularly acute in southern California, one of 25 global hotspots of biological diversity and one of the nation's largest and fastest urbanizing areas. Yet despite a half-century of rapid habitat conversion, southern California retains some large and valuable wildlands, and opportunities remain to conserve and restore a functional wildland network.

The Santa Ana – Palomar Mountains Linkage: The Santa Ana – Palomar Mountains Linkage is critical for sustaining a regional network of interconnected wildlands in the South Coast Ecoregion. The area contains the last remaining natural habitats that connect the Santa Ana Mountains and the coastal lowland areas of Camp Pendleton to an inland chain of largely-protected mountain ranges (Palomar, San Diego, San Jacinto, and San Bernardino mountains). Rugged foothills, plateaus and drainages in the linkage support a diversity of habitats including grasslands, coastal scrub, chaparral, and oak and riparian woodlands. The Santa Margarita River, which winds through the linkage, is the longest intact riparian corridor in southern California.

Conservation Planning for the Linkage: Scientists and conservationists have long recognized the ecological value of natural lands in Santa Ana – Palomar Mountains region. Drawing on decades of research and localized planning efforts, SDSU Field Station Programs and South Coast Wildlands targeted the area for further planning to address on-going habitat loss that threatened existing conservation investments and ecosystems processes. This planning effort for the Santa Ana – Palomar Linkage was instigated by the Field Station Programs as part of a conservation planning initiative. The methods and analysis for identifying key lands necessary to preserve the connection were jointly developed with South Coast Wildlands in support of the South Coast Missing Linkages Project, a coalition of agencies, universities, and organizations dedicated to securing a network of wildlands in the South Coast Ecoregion. In a prioritization analysis designed to assess the biological importance and vulnerability of habitat linkages in the South Coast Ecoregion, the South Coast Missing Linkages Project identified the Santa Ana – Palomar Connection, as one of 15 linkages of crucial biological value that is likely to be compromised by development projects unless immediate conservation action occurs. This conservation plan for the Santa Ana –

Palomar Mountains Linkage provides valuable support for local conservation efforts (e.g., Natural Community Conservation Planning) by identifying landscape level connections and ecoregional processes necessary to sustain the local biodiversity within smaller planning areas.

Methods: Conservation planning for the linkage was based on the needs of 20 focal species identified as indicators of linkage function by biological experts at regional workshops. Species included 3 plants, 4 insects, 2 amphibians, 2 fish, 2 reptiles, 4 birds and 3 mammals. This diverse taxonomic group was chosen so that linkage planning could capture the broadest possible array of movement needs for all species in the planning area. These species preferred a variety of habitat types, represented many dispersal modes and abilities, and varied in their susceptibility to human barriers. They were specifically chosen based upon their sensitivity to habitat fragmentation or loss in the linkage area rather than their current status of endangerment.

Focal species were subjected to geographic information system (GIS) modeling analyses to identify the best remaining habitats in the linkage area that support movement needs between the Santa Ana and Palomar Mountains:

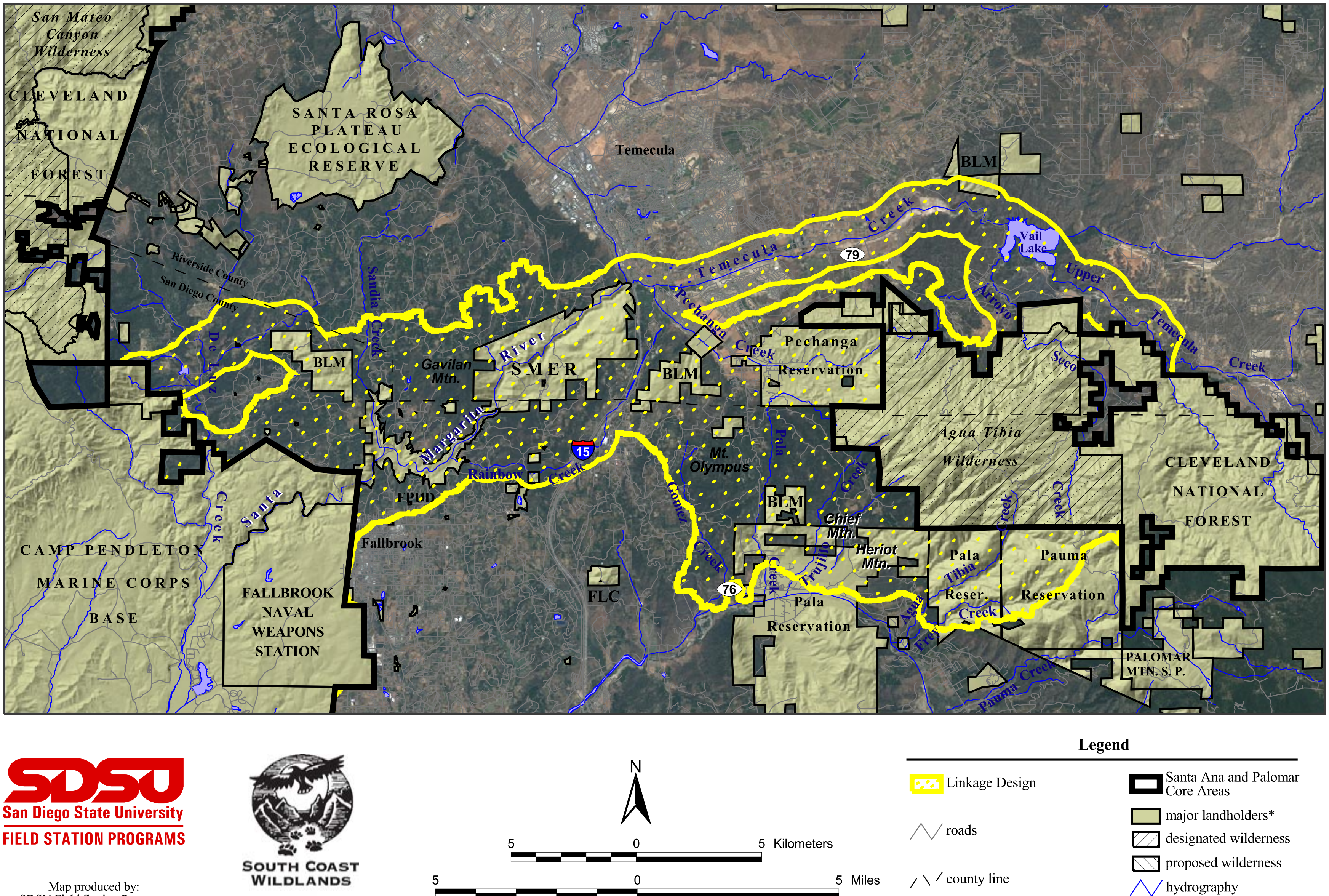
- Permeability analysis was used to model the relative cost of travel (based on species responses to vegetation, road density, elevation, and slope) for selected focal species to move between protected Core Areas. Combining output results for the 8 focal species modeled identified an area with the lowest cost of travel (Least-Cost Union) for these species in the linkage planning area.

- Patch size and configuration analysis further evaluated whether distribution and size of suitable habitat in the Least-Cost Union would allow focal species to successfully travel, either inter- or intra-generationally, between the Santa Ana and Palomar Mountains. These analyses were conducted for all 20 focal species. In areas where the Least Cost Union was inadequate to meet species needs, the boundaries were modified.

The Final Linkage Design: The final Linkage Design (Figure ES-1) is a band of habitat roughly 7 km (4 mi) wide and 25 km (16 mi) long that extends from the CNF Trabuco Ranger District, Camp Pendleton MCB, and the Fallbrook Naval Weapons Station to the western and northern boundaries of the CNF Palomar Ranger District. The Linkage Design encompasses riparian (Santa Margarita River – Temecula Creek-Vail Lake-Arroyo Seco/Temecula Creeks) and upland habitat components (Santa Margarita Mountains-Gavilan Mountain-Mt. Olympus) to meet the movement needs of all focal species.

Key Recommendations: Based on field surveys conducted in the Linkage Design area, we provide the following recommendations to preserve plant and animal movement between the Palomar and Santa Ana Core Areas through the Linkage. We encourage the reader to use these recommendations as a starting point for linkage conservation. Many of these conservation actions will require additional planning and modification as new information on biology and regional planning becomes available.

Figure ES-1. Linkage Design for the Santa Ana - Palomar Connection.
This zone encompasses the best areas for movement and reproduction of a diverse assemblage of species between the Santa Ana and Palomar Core Areas with minimal constraints from adjacent urban and agricultural areas. BLM = Bureau of Land Management, FLC = Fallbrook Land Conservancy, FPUD = Fallbrook Public Utility District, SMER = Santa Margarita Ecological Reserve.



SDSU San Diego State University FIELD STATION PROGRAMS

SOUTH COAST WILDLANDS

Map produced by:
SDSU Field Station Programs
March 10, 2004
http://fs.sdsu.edu

SDSU San Diego State University FIELD STATIONS

SOUTH COAST WILDLANDS

- Habitat Protection – The major causes of habitat loss and fragmentation in the Linkage Design area are agriculture (predominantly avocado orchards) and home construction. We recommend using a variety of tools to reduce habitat conversion and degradation:

    - Conservation Action - work with willing land owners to acquire property or establish conservation easements,
    - Regulatory Action - encourage zoning to larger lot sizes (e.g., 40-80 acres), discourage major new residential, urban or agricultural developments,
    - Education - develop education programs that allow residents to understand the effects of their activities on species and ecosystem processes in the linkage and encourage them to become active stewards of the land,
    - Land Management – incorporate linkage conservation as a priority in existing land management agency documents, support exotic species control programs, develop community fire preparedness plans that do not compromise linkage function, help local farmers to adopt best management practices (BMPs) that reduce the negative effects of agriculture, and develop implementation plans to return water quality to targeted values.

- Habitat Overpass - Interstate-15 is the most substantial impediment to plant and animal movement in the Linkage Design area. Due to the significance of I-15 as a barrier and the inadequacy of existing infrastructure to accommodate wildlife movement, installation of a habitat overpass (just north of the Border Patrol checkpoint) is a top priority for restoring linkage function. The effectiveness of habitat overpasses to enhance movement of wildlife has been documented both in the United States and other countries.

- Habitat Restoration - Restoration of both upland and riparian habitat is needed in some areas of the linkage to meet the needs of focal species. Restoration in upland habitat requires restoring segments of orchards back to native habitat in areas where agricultural development has created severe constrictions to wildlife movement. In riparian habitats, the most notable challenge is establishing a natural vegetation connection along Temecula Creek. We recommend re-establishing hydrological regimes sufficient to support riparian vegetation, determining the feasibility of fish passages, vegetated causeways or dam removal, modifying road crossings, restoring natural vegetation within 0.5 km (0.3 mi) of streams and rivers to reduce erosion that compromises water quality, discouraging construction of concrete-banked streams and other channelization projects, removing exotic aquatic plants and animals, enforcing existing regulations protecting streams and stream vegetation, and pursuing cooperative programs with landowners to improve conditions in riparian corridors on private lands.

- Roadkill Reduction – All paved roads, especially those with high levels of traffic, can reduce or prevent animal movement through the Linkage Design area. To reduce wildlife mortality, we recommend: using road improvement projects as an opportunity to install crossing structures more amenable to wildlife movement (e.g., bridges or box culverts in place of culverts and drain pipes). Use of these and existing structures can be enhanced with fencing to direct wildlife to crossing structures, and by restoring vegetation adjacent to both sides of crossing structures. We also support minimizing artificial night lighting, discouraging the construction of additional roads, and evaluating the feasibility of reduced speed limits, limiting traffic, road closures and restoration.

A Valuable Conservation Investment: The ecological, educational, recreational, and economic values of protected wildlands in the South Coast Ecoregion are immense. The Linkage Design for the Santa Ana – Palomar Mountains Linkage represents an opportunity to protect a truly functional landscape-level connection. The cost of implementing this vision will be substantial—but this cost is small compared with the benefits to existing conservation investments and long-term viability of ecosystem processes. If implemented, this plan would not only conserve valuable habitats and ecological processes between the Santa Ana and Palomar Mountains, but would conserve large-scale ecosystem processes essential to the continued integrity of existing conservation investments throughout the South Coast Ecoregion.

(this page intentionally left blank)

Nature Needs Room to Move

Movement is essential to survival, whether it is 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 the 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. At various spatial and temporal scales, movements themselves become significant agents of ecosystem function, affecting community dynamics and the cycling of energy, nutrients and water.

In environments fragmented by human development, movement patterns and the ecosystem processes they provide are disrupted. Without the ability to move among and within natural habitats, species become more susceptible to environmental disturbances (e.g., fire, flood), disease, inbreeding and other stochastic processes (Soulé and Terborgh 1999). Isolated populations marooned on islands of fragmented habitat show elevated rates of extinction as they succumb to environmental and genetic perturbations (MacArthur and Wilson 1967, Levins 1970, Shaffer 1981, Schonewald-Cox et al. 1983, Soulé 1987, Taylor 1990, Hanski and Gilpin 1991, Mills and Smouse 1994). Maintaining connections that allow individuals to move among habitats is an important tool for sustaining biodiversity and ecosystem function (Noss 1987, Harris and Gallagher 1989, Noss 1991, Beier and Loe 1992, Noss 1992, Beier 1993, Forman 1995, Beier and Noss 1998, Crooks and Soulé 1999, Soulé and Terborgh 1999, Penrod et al. 2001, Crooks et al. 2001, Tewksbury et al. 2002, Forman et al. 2003).

Guiding Patterns of Development in Southern California

Southern California's wildlands are one of the world's greatest biological warehouses of species diversity. The South Coast Ecoregion (Figure 1) is part of the California Floristic Province, one of 25 global hotspots of biodiversity, and the only one in North America (Mittermeier et al. 1998, Mittermeier et al. 1999). As a consequence of rapid habitat conversion to urban and agricultural uses, southern California has also become a hotspot for species at risk of extinction (Wilcove et al. 1998). In an analysis that identified "irreplaceable" places for preventing species extinctions (Stein et al. 2000), Southern California stood out as one of the six most important areas in the United States (along with Hawaii, the San Francisco Bay Area, Southern Appalachians, Death Valley, and the Florida Panhandle).

An expanding network of roads, agriculture, cities, and towns is further fragmenting wildlands that historically functioned as a single ecological system. Should these severances be allowed to occur, the ecological, educational, recreational, and economic loss would be substantial. A modest investment now in planning and conservation, that guides patterns of development away from critical habitat connections, can support the integrity of South Coast ecosystems, and the quality of life they bestow. Achieving this vision requires identifying, protecting, and restoring functional habitat connections that allow essential ecological processes to continue operating across the landscape as they have for millennia.

The Santa Ana – Palomar Mountains Linkage: Last Chance for a Coastal Range

The Santa Ana – Palomar Mountains Linkage is a landscape-level linkage needed to sustain a network of interconnected wildlands in the South Coast Ecoregion. The linkage joins the Santa Ana Mountains and its coastal lowlands to the Palomar Mountains and inland ranges of San Diego County. The Santa Ana Mountains are a low coastal range spanning parts of San Diego, Orange and Riverside counties. From 1,500-m (5,000-ft) peaks topped with coniferous pine forests, the western slopes of the range descend through chaparral, coastal scrub, and grasslands to 27-km (17-mi) of coastal habitats, the largest contiguous block of coastal habitat in the Ecoregion and the only remaining native coastline in San Diego County. The sole remaining natural habitat connections for this significant expanse of habitat is the Santa Ana – Palomar Mountains Linkage, natural habitats stretching to the southeast through the foothills of the Santa Ana Mountains to the Palomar Mountains. Recent studies have shown that should this linkage be severed, mountain lions will likely become extinct in the Santa Ana Range (Beier 1993).

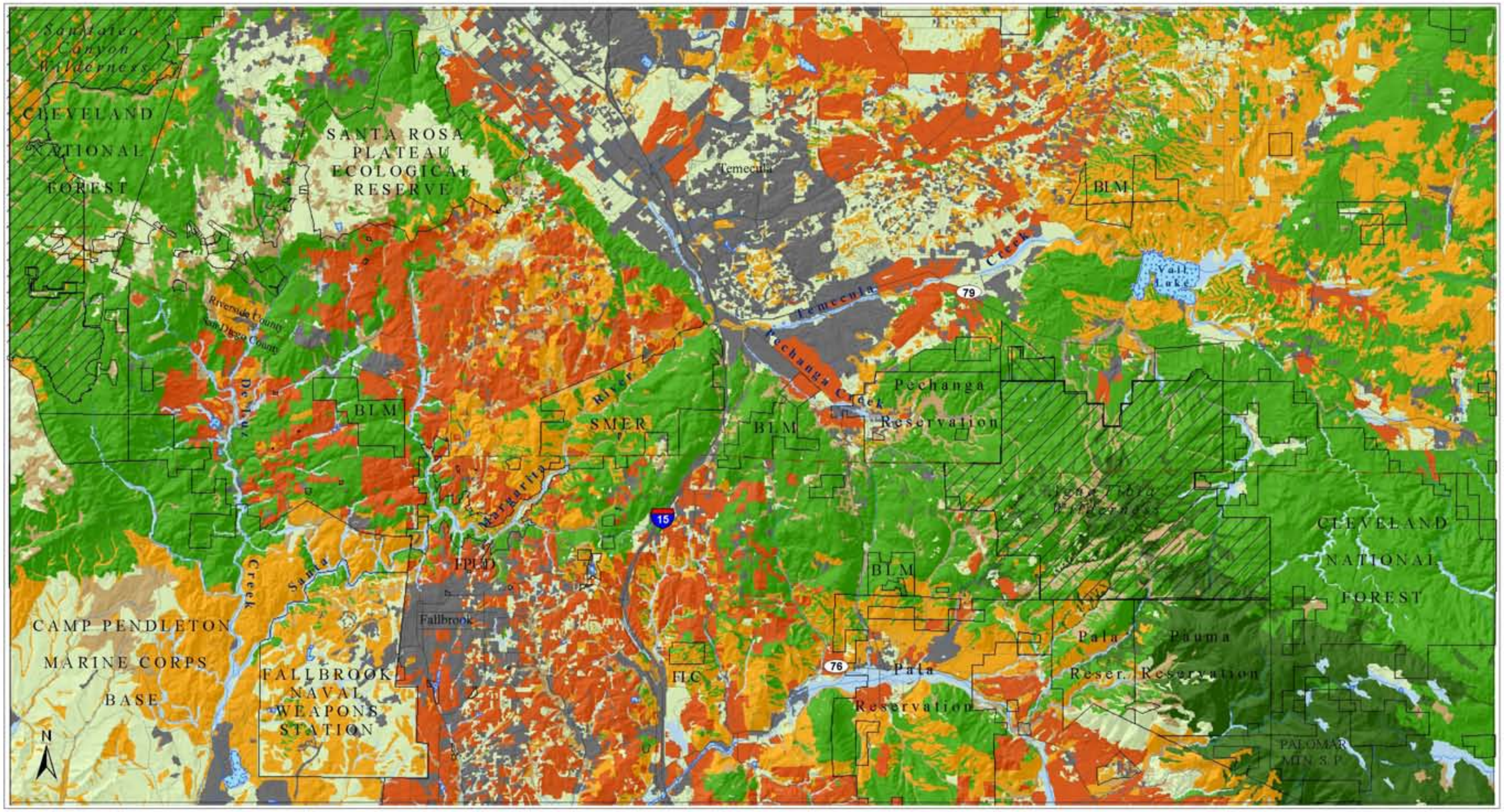
Figure 1. South Coast Ecoregion encompasses roughly 8% of California and extends 300 km (190 mi) into Baja California.

The linkage is characterized by rugged foothills, plateaus and drainages that support a diversity of habitats including vernal pools, grasslands, coastal scrub, chaparral, and oak and riparian woodlands (Figure 2). The Santa Margarita River, is a dominant feature of the linkage, draining 1900 km^2 (750 mi^2) of the Santa Ana, Palomar and San Jacinto mountains and cutting transversely through the linkage area to a large estuary at the coast. The 48-km (30-mi) riparian community along the main stem of the river is the longest intact riparian corridor in southern California.

Numerous imperiled plant and animal species occur in the linkage area (Appendix A). Twelve vegetation types are listed as sensitive by the State. Iron rich gabbro soils in the linkage support a variety of rare plants, including one

Figure 2. Aggregated vegetation types in the planning area

BLM = Bureau of Land Management, FLC = Fallbrook Land Conservancy, FPUD = Fallbrook Public Utility District, SMER = Santa Margarita Ecological Reserve



SOUTH COAST WILDLANDS

Map Produced By:
South Coast Wildlands
May 2004
www.scwildlands.org

San Diego State University
FIELD STATIONS

Scale 1:230,000

0 1 2 4 6 8 Kilometers

0 1 2 4 6 8 Miles

Legend

- Confierous Forest
- Chaparral
- Woodland
- Scrub
- Riparian
- Urban/Developed
- Herbaceous
- Agriculture
- Roads
- County Boundary
- Major Landholders*
- Designated Wilderness
- Proposed Wilderness
- Hydrography
- Lakes & Reservoirs

*Land management varies by ownership.

species (Rainbow manzanita, *Arctostaphylos rainbowensis*) that occurs nowhere else in the world. Twenty-one species are listed as threatened or endangered by federal or state agencies, including Parish's meadowfoam (*Limnanthes gracilis* ssp. *parishii),* vernal pool fairy shrimp (*Brachynecta lynchi*), southwestern willow flycatcher (*Empidonax traillii extimus*), and Stephens' kangaroo rat (*Dipodomys stephensi*). Roughly 1/3 of the linkage area is designated as critical habitat for five threatened or endangered species: Riverside fairy shrimp (*Streptocephalus woottoni*), Quino checkerspot butterfly (*Euphydreas editha quino*), arroyo toad (*Bufo microscaphus*), California gnatcatcher (*Polioptila californica californica*), and least Bell's vireo (*Vireo belli pusillus*). In addition, recent studies show that the linkage supports territories for 4 of the remaining 10 nesting golden eagles in the region (D. Bittner pers. comm.).

Existing Conservation Investments in the Linkage

Conservation investments already exist (Figure 3) that could be irreparably harmed by the loss of habitat connections between the Santa Ana and Palomar Mountains. The majority of protected areas in the ranges are managed under federal jurisdiction. To the west of the linkage, the Cleveland National Forest's Trabuco Ranger District (160,498 acres [64,951 ha]) protects most of the Santa Ana Range and includes the San Mateo Canyon Wilderness (40,494 ac [16,388 ha], USFS 1986). Adjacent coastal zones lie within Camp Pendleton Marine Corps Base (130,965 ac [542653 ha]). While Camp Pendleton's primary mission is to train marines, the base takes a proactive role in the management of special status species, and base lands support an array of native plant and animal communities. To the east of the linkage, 135,050 ac (53,885 ha) of the Palomar Mountain range lies within the Palomar Ranger District of the Cleveland National Forest and Palomar Mountains State Park. The Agua Tibia Wilderness (15,904 ac [6,436 ha]) lies on the northwest boundary of the District and additional Wilderness Areas are proposed (Figure 3, http://www.californiawild.org).

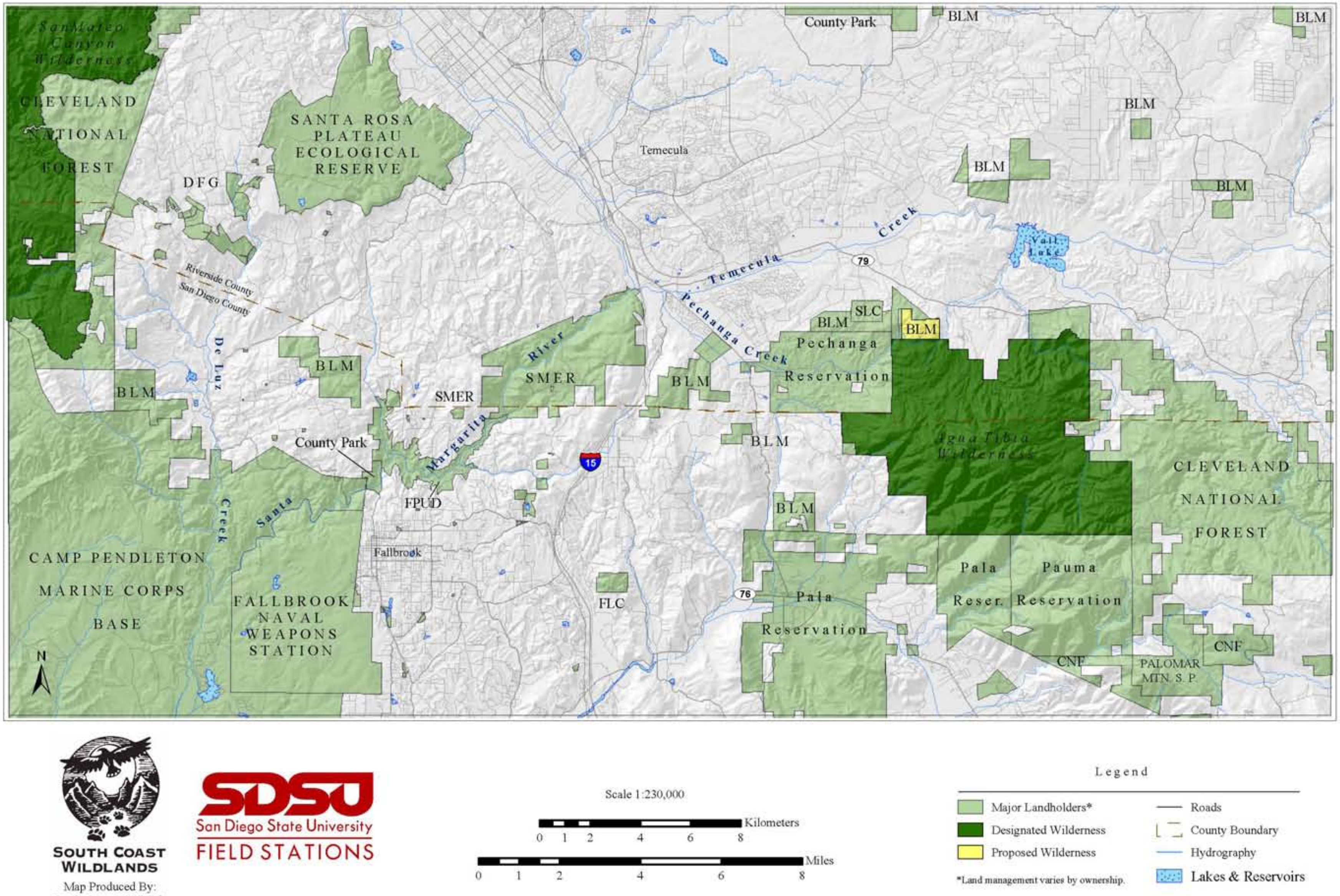
Significant conservation efforts have been undertaken to link smaller, more vulnerable natural areas to the Santa Ana Mountains. However, protected lands in the range are not large enough to sustain ecosystem processes without connections in turn to other large blocks of protected habitat. Should such connections be severed, mountain lions are predicted to go extinct in the Santa Ana Mountains (Beier 1993). The Santa Ana–Palomar Mountains Linkage is the only remaining habitat connection that could prevent this loss. On-going conservation efforts that rely on the integrity of this linkage include:

- San Diego and Riverside County Natural Community Conservation Planning efforts delineate corridors that link smaller blocks of habitat to the Santa Ana Range.
- The Coal Canyon Corridor project, lead by CalTrans, California State Parks, and Hills for Everyone, is converting an underpass on Highway 91 into a wildlife crossing for mountain lions to move from the Santa Ana Range to the Chino Hills.
- The Tenaja Corridor project, lead by The Nature Conservancy and California Department of Fish and Game, conserves a key habitat connection for mountain lions and other species to move from the Santa Ana Mountains to the Santa Rosa Plateau Ecological Reserve.

By addressing ecosystem viability at larger spatial scales, this plan can support, inform, and identify common issues of concern among more localized conservation efforts.

Figure 3. Existing conservation investments and major landholders in the planning area

BLM = Bureau of Land Management, CNF = Cleveland National Forest, DFG = Department of Fish & Game, FLC = Fallbrook Land Conservancy, FPUD = Fallbrook Public Utility District, SLC = State Lands Commision, SMER = Santa Margarita Ecological Reserve



SOUTH COAST WILDLANDS
Map Produced By:
South Coast Wildlands
May 2004
www.scwildlands.org

SDSU
San Diego State University
FIELD STATIONS

Threats to natural habitats in the linkage have been recognized by federal and state agencies and non-governmental organizations that have launched a variety of successful conservation planning efforts. As a result, roughly 35% of the linkage is already afforded some form of protection from habitat conversion by the Bureau of Land Management, State Lands Commission, California Department of Fish and Game, County Parks and Recreation, The Nature Conservancy, and San Diego State University (SDSU) Field Station Programs. These properties represent a substantial conservation investment. Securing a habitat linkage between the Santa Ana and Palomar Mountains would not only benefit the larger ranges, it would also help sustain key ecological processes on these lands, and support a history of investment made by these organizations.

A State, Regional, and Local Conservation Priority

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

Following the statewide Missing Linkages conference, South Coast Wildlands, a non-profit organization established to pursue habitat connectivity planning in the South Coast Ecoregion, brought together regional ecologists to conduct a formal evaluation of these 69 linkages. The evaluation was designed to assess the biological importance and vulnerability of each linkage (Noss et al. 2002). This process identified 15 linkages (Penrod, unpublished) of crucial biological value that are likely to be irretrievably compromised by development projects over the next decade unless immediate conservation action occurs (Figure 4). The

South Coast Missing Linkages Project's 15 Linkage Priorities:

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

Figure 4. The South Coast Missing Linkages Project addresses habitat fragmentation at a landscape scale, and the needs of a variety of species. The Santa Ana – Palomar Mountains Linkage is one of 15 landscape linkages identified as irreplaceable and imminently threatened.

Santa Ana – Palomar Mountains Linkage was one of the 15 linkages whose protection is crucial to maintaining ecological and evolutionary processes among large blocks of protected habitat within the South Coast Ecoregion as well as adjoining ecoregions. Identification of these 15 priority linkages launched the South Coast Missing Linkages Project.

The South Coast Missing Linkages Project is a coalition of agencies, universities, and organizations dedicated to securing a network of wildlands that conserves ecosystem processes in the South Coast Ecoregion. South Coast Wildlands coordinates this ambitious regional effort. 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, SDSU Field Station Programs, The Nature Conservancy, Environment Now, The Wildlands Project, California Wilderness Coalition, and the Zoological Society of San Diego Center for Reproduction of Endangered Species.

Local conservation efforts in the Santa Ana – Palomar Mountains linkage were already underway prior to the initiation of the South Coast Missing Linkages Project. SDSU Field Station Programs, alarmed at the rapid rate of habitat conversion surrounding its 4,500-acre Santa Margarita Ecological Reserve, brought together organizations and agencies with a history of conservation planning and acquisition in the linkage area. Together, The Nature Conservancy, US Geological Survey, South Coast Wildlands, and the SDSU Field Station Programs sponsored workshops to collect key biological information and galvanize support for this significant habitat connection. With the formation of the South Coast Missing Linkage Project, planning in the linkage garnered interest from regional partners. South Coast Wildlands became a co-manager of the planning effort, bringing additional regional resources, and working collaboratively with the SDSU Field Station Programs to assemble a team of scientists (the South Coast Missing Linkages Methods Development Working Group) that could develop rigorous and consistent methods for linkage conservation design throughout the Ecoregion. The Santa Ana – Palomar Mountains linkage became a demonstration site for other priority linkages in the South Coast Missing Linkages Project.

South Coast Missing Linkages
Methods Development Working Group

Dr. Paul Beier	Northern Arizona State University
Clint Cabanero	South Coast Wildlands
Dr. Claudia Luke	SDSU Field Station Programs
Kristeen Penrod	South Coast Wildlands
Dr. Esther Rubin	Center for Reproduction on Endangered Species, Zoological Society of San Diego
Dr. Wayne Spencer	Conservation Biology Institute

Conservation Planning Team for Santa Ana – Palomar Mountains Linkage

The goal of this planning effort is to protect and restore a functional habitat connection between the Santa Ana Mountains (and adjacent coastal areas) and the Palomar Mountains. The lead partners on this effort are:

- SDSU Field Station Programs. Field Station Programs (FSP) is project lead and primary contact on the planning effort. FSP develops programs that generate synergy between research, education, and land management, and provides lands and facilities that support the study of natural ecosystems. In the linkage, FSP works collaboratively to develop methods and analyses, incorporates input from regional specialists and researchers, and is key contact for plan implementation.

- South Coast Wildlands. SCW is a non-profit group established to create a protected network of wildlands throughout the South Coast Ecoregion. For all 15 priority linkages in the Ecoregion, South Coast Wildlands works with its partners to develop common linkage design protocols and GIS analyses, hosts workshops, supports plan preparation and implementation, and raises public awareness of habitat connectivity needs throughout the ecoregion.

Conservation Planning Approach

The goal of linkage conservation planning is to identify lands needed to preserve functional connections between protected core habitat areas. For this plan, we sought to prescribe an area that would provide the greatest flexibility for an ecosystem in motion, one capable of responding to unpredictable fluctuations in climate and rebounding from random events, such as wildfire and flood. In this analysis, large blocks of protected habitat are referred to as the Santa Ana and Palomar Core Areas. The Santa Ana Core Area contains the mountainous Trabuco Ranger District of the Cleveland National Forest and the adjacent lowland coastal areas of the Camp Pendleton Marine Corps Base and the Fallbrook Naval Weapons Station. The Palomar Core Area encompasses the largest blocks of the Palomar Ranger District in the Cleveland National Forest and contiguous parcels of Bureau of Land Management, State Lands Commission and other Conservancy Lands (Figure 3). Lands in between these Core Areas are the linkage planning area.

To determine lands best suited to preserve linkage function in the planning area, we conducted a series of spatial analyses designed to evaluate the movement needs of selected focal species. Our approach can be generally summarized as follows:

1) Focal Species Selection: Select focal species from diverse taxonomic groups that represent a variety of movement needs and ecosystem functions.
2) Landscape Permeability Analysis: Identify the area that allows focal species to move most easily between the Core Areas
3) Patch Size and Configuration Analysis: Assess the ability of the resulting area to sustain populations of focal species and modify if needed.
4) Linkage Design: Conduct field surveys in the resulting Linkage Design area to identify barriers and other conservation management needs.

Our approach has been highly collaborative and interdisciplinary. We followed Baxter (2001) in recognizing that successful conservation planning is based on the participation of experts in biology, conservation design, and conservation implementation in a reiterative process (Figure 5). To engage regional biologists and planners early in the linkage design process, we held two habitat connectivity workshops in March and September of 2001. The workshop engaged 100 participants representing over 40 agencies, academic institutions, land managers and planners, conservation organizations, and community groups (Appendix A).

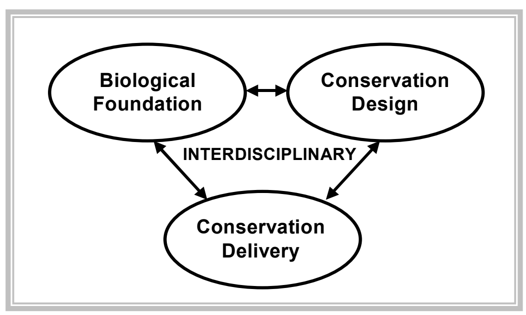


Figure 5. Successful conservation planning requires an interdisciplinary and reiterative approach among biologists, planners and activists (Baxter 2001).

Focal Species Selection

Focal species choice (Beier and Loe 1992) must be specifically tailored to the project goals. For this project, we sought to delineate a viable connection that would serve all species in the ecosystem and be resilient to unpredictable fluctuations and catastrophic events. To this end, we identified a suite of species that were sensitive to habitat fragmentation and loss and represented a wide diversity of movement needs. Focal species were chosen by working groups of professional biologists with expertise in the region. Working groups identified 3-6 focal species within their taxonomic area of expertise that were sensitive to habitat fragmentation and summarized information on species occurrence, movement, and habitat preferences. (For more information about the workshops see Appendices A and B.)

The 21 focal species identified at the workshop included 4 plants, 4 insects, 2 fish, 2 amphibians, 2 reptiles, 4 birds and 3 mammals (Table 1). These species preferred a variety of habitat types, elements, configurations, and sizes; represented many dispersal modes and abilities; and varied in their susceptibility to human barriers. Because they were chosen to represent the needs of as many species as possible in the ecosystem, they are not necessarily species with threatened or endangered status. Instead, the needs of these species represent those of special status species (Appendix A) as well as other key processes needed for the ecosystem to function.

The expert opinions of the workshop participants and subsequent review of the literature indicated a number of potential movement routes for the 21 focal species in the linkage planning area (Figure 6). Building on these results, we undertook a suite of quantitative Geographic Information System (GIS) analyses to prioritize these lands for conservation action.

Table 1. Focal species selected by taxonomic working groups at the March 2001 workshop.

Plants
Rainbow manzanita (*Arctostaphylos rainbowensis*)
Yucca whipplei (*Hesperoyucca whipplei*)
Engelmann oak (*Quercus engelmannii)*
*Cuyamaca meadowfoam (*Limnanthes gracilis* var *parishii*)
Invertebrates
Timema walkingstick (*Timema podura*)
California sister (*California Sister (Adelpha bredowii)*
Comstock's Fritillary (*Speyeria callippe comstocki*)
Pale Swallowtail (*Papilio eurymedon*)
Fish
Arroyo Chub (*Gila orcutti*)
Southern Steelhead Trout (*Oncorhynchus mykiss irideus*)
Amphibians and Reptiles
Western Toad (*Bufo boreas*)
California Treefrog (*Hyla cadaverina*)
Western Pond Turtle (*Clemmys marmorata*)
Red Diamond Rattlesnake (*Crotalus ruber*)
Birds
Oak Titmouse (*Baeolophus inornatus*)
California Quail (*Callipepla californica*)
Golden Eagle (*Aquila chrysaetos*)
Yellow warbler (*Dendroica petechia*)
Mammals
American Badger (*Taxidea taxus*)
Dusky-footed Woodrat (*Neotoma fuscipes*)
Mountain Lion (*Felis concolor*)

* This species was not modeled

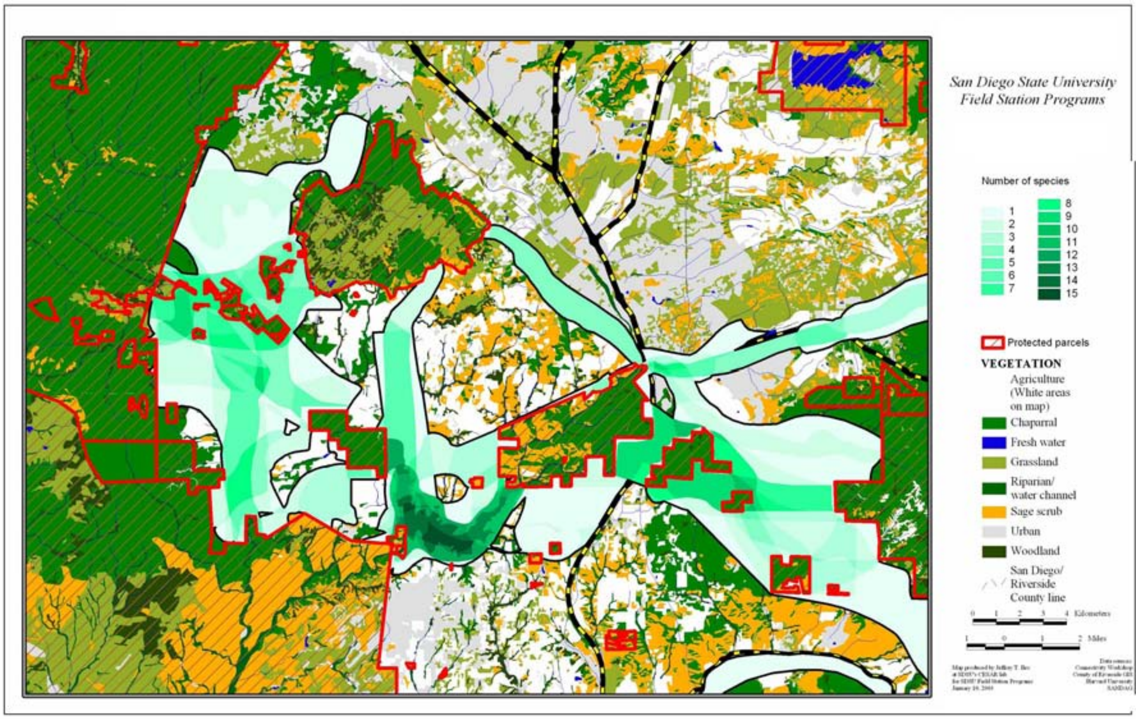


Figure 6. Potential linkages in the planning area for 21 focal species based on input from workshop participants and literature searches. Additional analyses were needed to prioritize conservation action.

Landscape Permeability Analysis

Landscape permeability analysis is a geographic information system (GIS) technique that models the relative cost for a species to move between Core Areas. The analysis identifies the shortest and most easily traversable zone (Walker and Craighead 1997, Craighead et al. 2001, Singleton et al. 2002). Combined outputs of permeability analyses for a suite a focal species can be used to identify the most important areas needed to sustain a diversity of movement needs.

Permeability analysis was used to model ease of movement for a focal species only if:

- Information available on species natural history was adequate to reasonably estimate the cost of travel relative to available data layers
- Data layers available for the analysis reflected the species ability to move.
- The species historically or currently occurred in both Core Areas
- The species potentially required linkage features for movement between Core Areas either intra- or inter-generationally
- The time required for gene flow between populations in the Core Areas was less than the time over which substantial changes in vegetation distribution were expected (i.e., 100-200 yrs (e.g., Field et al. 1999)).

Eight species met these criteria and were used in permeability analyses: mountain lion, badger, dusky-footed woodrat, oak titmouse, California quail, red diamond rattlesnake, western pond turtle, and western toad.

To conduct the permeability analysis, we used the following spatial data layers at 30-m resolution: vegetation, road density, slope, and elevation (Figure 7). For the vegetation layer, USFS CalVeg and SANDAG veg95 from Riverside and San Diego counties were merged. Updates were made to this layer using 1-m aerial imagery (2001) to reflect current conditions in urban/developed and agricultural land uses. For the road density layer, US Bureau of the Census TIGER/Line 2000 data for Riverside, San Diego, and Orange County were merged. Updates were made on this layer as well using 1-m aerial imagery (2001) to differentiate between paved and unpaved roads as well as add roads that were missing in the original database. Road density was prepared as length of miles per square mile. For the elevation layer, a mosaic of USGS 7.5 minute digital elevation models was prepared. The slope layer was derived from the digital elevation model.

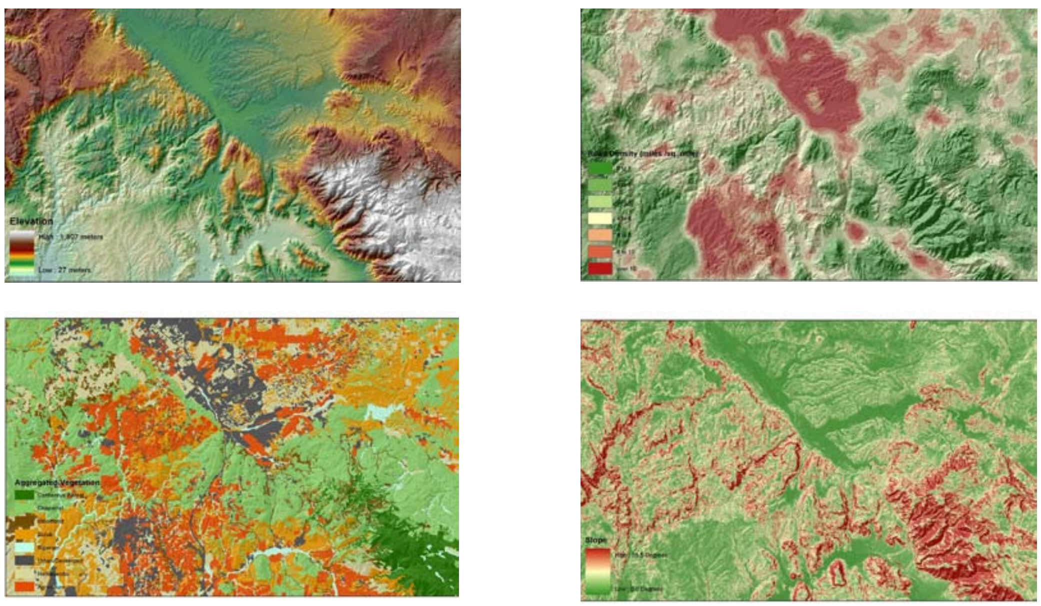


Figure 7. Permeability model inputs left to right and top to bottom are elevation, road density, slope, and vegetation.

Values were assigned to each of the categories in the spatial data layers to represent the predicted relative cost of travel for each of the 8 focal species. Assignments were made for focal species between 1 (preferred) and 10 (avoided) based on available literature and expert opinion (Table 2). The category rankings for the four spatial data layers were then weighted and combined using the following equation to create a unique cost surface for each species:

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

Table 2. Relative weights for 4 factors (first 4 lines) and movement costs for each species used in Landscape Permeability analyses. The weights and costs were determined by expert opinion and literature review. Costs varied from 1 (most likely to move through) to 10 (least likely to move through).

	Western Toad	Western Pond Turtle	Red Diamond Rattlesnake	Oak Titmouse	California Quail	American Badger	Dusky-footed Woodrat	Mountain Lion
Weightings for Cost Surface								
Vegetation	0.5	0.5	0.4	0.5	0.5	0.5	0.6	0.5
Road density	0.5	0.4	0.4	0.5	0.5	0.5	0.4	0.5
Slope		0.1						
Elevation			0.2					
Vegetation								
Alluvial Fan Scrub	3	3	5	6	1	1	4	1
Bigcone Spruce -Canyon Oak Forest	3	5	5	1	3	4	1	1
Black Oak Forest	3	5	5	1	3	4	1	1
Black Oak Woodland	3	5	5	1	3	4	1	1
Canyon Live Oak Forest	3	5	5	1	3	4	1	1
Ceanothus crassifolius Chaparral	3	3	1	6	1	4	1	2
Chamise Chaparral	3	3	1	6	1	4	1	4
Chaparral	3	3	1	6	1	4	1	3
Cismontane Woodland	3	5	5	1	3	1	1	1
Coast Live Oak Forest	3	5	5	1	3	4	1	1
Coast Live Oak Woodland	3	3	5	1	3	4	1	1
Coast Range, Klamath, and Peninsular Coniferous Forest	3	5	5	1	3	4	1	2
Coastal and Valley Freshwater Marsh	1	1	5	6	5	4	6	3
Coastal Sage-Chaparral Scrub	3	3	1	6	1	1	1	1
Coulter Pine Forest	3	5	5	1	3	4	1	2
Dense Coast Live Oak Woodland	3	5	1	1	3	4	1	1
Dense Engelmann Oak Woodland	3	5	1	1	3	4	1	1
Diegan Coastal Sage Scrub	3	3	5	6	1	1	4	1
Disturbed Habitat	8	5	10	10	6	1	6	7
Dry Montane Meadow	3	5	5	6	5	1	6	2
Emergent Wetland	1	1	5	6	5	4	6	4
Eucalyptus Woodland	8	5	10	10	6	4	6	2
Extensive Agriculture	10	10	10	10	10	10	10	9
Field/Pasture	3	5	10	10	2	1	6	5
Flat-topped Buckwheat	3	5	5	5	3	4	1	1
Foothill/Mountain Perennial	3	5	5	6	5	1	6	2
Freshwater	1	1	1	1	5	4	10	8
General Agriculture	10	10	10	10	10	10	10	8
Granitic Northern Mixed Chaparral	3	5	1	6	1	4	1	4
Granitic Southern Mixed Chaparral	3	5	1	6	1	4	1	3
Intensive Agriculture	10	10	10	10	10	10	10	9
Jeffrey Pine Forest	3	5	5	1	3	4	1	2

Table 2 (cont.) Relative weights for 4 factors and movement costs for each species used in Landscape Permeability analyses.

	Western Toad	Western Pond Turtle	Red Diamond Rattlesnake	Oak Titmouse	California Quail	American Badger	Dusky-footed Woodrat	Mountain Lion
Vegetation (cont.)								
Mafic Northern Mixed Chaparral	3	3	1	6	1	4	1	4
Mafic Southern Mixed Chaparral	3	3	1	6	1	4	1	3
Meadow and Seep	1	2	5	6	5	1	6	1
Mixed Evergreen Forest	3	5	5	1	3	4	1	2
Montane Chaparral	3	3	1	6	1	4	1	3
Montane Manzanita Chaparral	3	3	1	6	1	4	1	3
Montane Meadow	3	3	5	6	5	1	6	2
Montane Scrub Oak Chaparral	3	5	1	5	1	4	1	3
Mule Fat Scrub	1	1	1	6	1	4	4	1
Non-Native Grassland	3	3	5	6	5	1	6	4
Non-Vegetated Channel, Floodway, Lakeshore Fringe	1	1	5	6	5	1	10	6
Northern Mixed Chaparral	3	3	1	6	1	4	1	4
Oak Woodland	3	3	1	1	3	4	1	1
Open Coast Live Oak Woodland	3	3	5	1	3	1	1	1
Open Engelmann Oak Woodland	3	3	5	1	3	1	1	1
Orchards and Vineyards	3	5	5	10	5	4	6	7
Peninsular Pinyon Woodland	3	5	5	1	3	4	1	1
Red Shank Chaparral	3	5	1	6	1	4	1	3
Riparian Forests	1	1	1	1	3	4	1	1
Riversidian Sage Scrub	3	3	5	6	1	1	4	1
Row Crops	10	10	10	10	10	10	10	9
Sagebrush Scrub	3	3	5	6	1	4	1	2
Scrub Oak Chaparral	3	5	1	5	1	4	1	3
Sierran Mixed Coniferous Forst	3	5	5	1	3	4	1	2
Southern Arroyo Willow Riparian Forest	1	1	1	1	3	4	1	1
Southern Coast Live Oak Riparian Forest	1	1	1	1	3	4	1	1
Southern Cottonwood-willow Riparian Forest	1	1	1	1	3	4	1	1
Southern Mixed Chaparral	3	3	1	6	1	4	1	3
Southern Riparian Forest	1	1	1	1	1	4	1	1
Southern Riparian Scrub	1	1	1	6	1	4	1	1
Southern Sycamore-alder Riparian Woodland	1	1	1	1	3	4	1	1
Southern Willow Scrub	1	1	1	1	1	4	1	1
Undifferentiated Open Woodland	3	5	5	1	3	4	1	1
Urban/Developed	10	10	10	10	10	10	10	10
Valley and Foothill Grassland	3	3	5	6	5	1	6	3
Valley Needlegrass Grassland	3	3	5	6	5	1	6	3
Wet Montane Meadow	3	3	5	6	5	1	6	2
White Alder Riparian Forest	1	1	1	1	3	4	1	1

Table 2 (cont.) Relative weights for 4 factors and movement costs for each species used in Landscape Permeability analyses.

	Western Toad	Western Pond Turtle	Red Diamond Rattlesnake	Oak Titmouse	California Quail	American Badger	Dusky-footed Woodrat	Mountain Lion
Road Density								
0 to 1 mile per square mile	1	1	1	1	1	1	1	0
1 to 2 miles per square mile	6	3	3	1	2	1	1	0
2 to 4 miles per square mile	8	10	5	4	2	4	5	1
4 to 6 miles per square mile	10	10	8	6	8	8	8	5
6 to 8 miles per square mile	10	10	10	8	10	8	8	8
8 to 10 miles per square mile	10	10	10	10	10	10	10	10
over 10 miles per square mile	10	10	10	10	10	10	10	10
Slope								
0-5 degrees		1						
5-13 degrees		1						
13-20 degrees		1						
20-29 degrees		1						
29-56 degrees		5						
Elevation								
89-933 feet			1					
933-1708 feet			1					
1708 - 2712 feet			10					
2712-4058 feet			10					
4058-5928 feet			10					

Weighting allowed the model to reflect variation in the influence of each input (e.g., vegetation, road density, topography, elevation) on focal species movements. The ArcGIS Spatial Analyst corridor function generated a data layer showing the relative degree of permeability between two Core Areas. The top 10% (i.e., most permeable zone) was designated as the least-cost corridor for that species. Least-cost corridor outputs for all species were then combined to generate a Least-Cost Union. The biological significance of this Union can best be described as the zone in which the 8 focal species would encounter the least energy expenditure (i.e., the optimal combination of short travel route and the most favorable habitat) as they move between protected Core Areas.

Patch Size & Configuration Analysis

Although the Least-Cost Union identifies the best zone available for focal species movement based on the data layers used in the analyses, it does not address whether suitable habitat in the Least-Cost Union occurs in large enough patches to support viable populations or whether dispersal distances would allow individuals to move among habitat patches. To address this need, we conducted patch size and configuration analyses for all 20 focal species (identified in Table 1) and adjusted the boundaries of the Least-Cost Union where necessary to enhance the likelihood of movement among areas of suitable habitat. 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 some species, gene flow is dependent on the existence of these meta-populations as individuals move sequentially among suitable habitat patches in the linkage. These processes must be accommodated by the linkage if it is to functionally support ecological and evolutionary processes.

A habitat suitability model formed the basis for patch size and configuration analyses. Data layers used to model potentially suitable habitat varied by focal species and included vegetation, elevation, topographic features, slope, aspect and hydrology. These data sources were the same as those used for the permeability analysis, except aspect was derived from the US Geological Survey digital elevation model using the aspect function in ArcGIS Spatial Analyst, and hydrography was from US Bureau of the Census (TIGER/Line 2000) and was updated using 1-m natural color and infra-red aerial imagery and 10-m DEMS. Both were 30-m resolution.

In most cases, vegetation served as the primary basis for delineating potentially suitable habitat. Vegetation types that occurred in the planning area were assigned relative values for their ability to support populations. These values were defined by experts or taken from the California Department of Fish and Game's Wildlife Habitat Relationships database. Assigned values were then divided into 5 classes using natural breaks: low, low to medium, medium, medium to high, or high. Potentially suitable vegetation types (Tables 3 and 4) were identified as those that scored medium, medium to high, or high. Where information was available on species preferences for other environmental characteristics that could be defined by spatial datasets, we further modified the habitat suitability model. For example, hilltops and ridgelines with natural vegetation types were added for butterflies that use these areas to find mates. Details of models used for each species are included in Tables 3 and 4.

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 identified and marked as:

- Core areas - Core areas were defined as the amount of contiguous potential suitable habitat necessary to sustain at least 50 individuals or, when data were available, as the minimum area in which the species is documented to persist (for values used see Tables 3 and 4). These cores were meant to represent sites where a population may serve as a source population for individuals that disperse into and occupy smaller areas of suitable habitat. (Here core area (lower case) is defined as a suitable habitat patch that potentially supports large populations of the species, while Core Area (both capitalized) refers to the large protected blocks of habitat in the Santa Ana and Palomar Mountains).
- Patches - Patches were defined as the amount of contiguous suitable habitat needed to support at least one male and one female, but less than the potential

Table 3. Focal species habitat suitability values. Values in this table were used as input for Patch Size and Configuration analyses in the planning area. An "x" in the vegetation/land use row (30-m resolution SANDAG Veg29) indicates that the class is considered suitable habitat. For southern steelhead trout, golden eagle, American badger and mountain lion, see Table 4.

Variable	Rainbow Manzanita	Our Lord's Candle	Engelmann Oak	Timema Walkingstick	Comstock's Fritillary	California Sister	Pale Swallowtail	Arroyo Chub	Southern Steelhead Trout	Western Toad	Calif Treefrog	Western Pond Turtle	Red Diamond Rattlesnake	Oak Titmouse	California Quail	Yellow Warbler	Dusky-footed Woodrat
Patch and Core Sizes																	
Minimum Patch Size (sq km)	----	----	----	----	----	----	----	----	---	----	----	----	0.10	0.008	0.069	0.004	0.23
Minimum Core Area (sq km)	1	0.01	0.11	----	----	----	----	----	----	----	----	----	2.50	15.8	1	4	5.8
Dispersal Distance																	
Maximum Dispersal Distance (km)	2	0.102	0.40	0.05	96	160	10	----	----	10	1	5	0.14	1.2	3.2	1.0	4.4
Vegetation Mapped as Suitable Habitat																	
Alluvial Fan Scrub		x			x					x		x	x		x		x
Bigcone Spruce (Bigcone Douglas Fir) - Canyon Oak										x				x	x	x	x
Black Oak Forest (oak in midst of coniferous)										x				x	x	x	x
Black Oak Woodland (Cuyamaca and Mesa Grande)										x				x	x	x	x
Canyon Live Oak Forest			x		x	x	x			x				x	x	x	x
Ceanothus crassifolius Chaparral	x			x	x		x			x		x	x	x	x		x
Chamise Chaparral	x			x	x		x						x		x		x
Chaparral	x			x	x		x			x		x	x	x	x		x
Cismontane Woodland					x		x			x		x		x	x	x	x
Coast Live Oak Forest			x		x	x	x			x		x		x	x	x	x
Coast Live Oak Woodland			x		x	x	x			x		x		x	x	x	x
Coast Range, Klamath, and Peninsular Coniferous Forest					x					x		x		x	x	x	x
Coastal and Valley Freshwater Marsh										x		x					
Coastal Sage-Chaparral Scrub	x	x			x		x			x		x	x		x		x
Coulter Pine Forest										x				x	x	x	x
Dense Coast Live Oak Woodland			x			x	x			x		x		x	x	x	
Dense Engelmann Oak Woodland			x			x	x			x		x		x	x	x	
Diegan Coastal Sage Scrub		x			x					x		x	x		x		x
Disturbed Habitat										x		x			x		
Dry Montane Meadow					x												

Table 3 (cont.). Focal species habitat suitability values. Values in this table were used as input for Patch Size and Configuration analyses in the planning area.

Variable	Rainbow Manzanita	Our Lord's Candle	Engelmann Oak	Timema Walkingstick	Comstock's Fritillary	California Sister	Pale Swallowtail	Arroyo Chub	Southern Steelhead Trout	Western Toad	Calif Treefrog	Western Pond Turtle	Red Diamond Rattlesnake	Oak Titmouse	California Quail	Yellow Warbler	Dusky-footed Woodrat
Vegetation Mapped as Suitable Habitat (cont.)																	
Emergent Wetland					x					x		x					
Eucalyptus Woodland										x							
Extensive Agriculture - Field/Pasture, Row Crops																	
Field/Pasture										x		x			x		
Flat-topped Buckwheat					x					x		x	x		x		x
Foothill/Mountain Perennial					x					x		x		x	x	x	x
Freshwater										x		x					
Granitic Northern Mixed Chaparral	x			x	x		x			x		x	x	x	x		x
Intensive Agriculture - Dairies, Nurseries, Chicken Farms																	
Jeffrey Pine Forest																	
Lower Montane Coniferous Forest										x				x	x	x	x
Mafic Northern Mixed Chaparral	x			x	x		x			x		x	x	x	x		x
Mafic Southern Mixed Chaparral	x			x	x		x			x		x	x	x	x		x
Meadow and Seep					x					x		x			x		
Mixed Evergreen Forest (Palomar Mountain)										x				x	x	x	x
Montane Chaparral	x			x	x		x					x			x	x	x
Montane Manzanita Chaparral	x			x	x		x					x			x	x	x
Montane Meadow					x												
Montane Scrub Oak Chaparral	x			x	x		x					x			x	x	x
Mule Fat Scrub					x					x	x	x		x	x	x	x
Non-Native Grassland					x					x		x			x		
Non-Vegetated Channel, Floodway, Lakeshore Fringe										x	x	x					
Northern Mixed Chaparral	x			x	x		x			x		x	x	x	x		x
Oak Woodland			x		x	x	x			x		x		x	x	x	x
Open Coast Live Oak Woodland			x		x	x	x			x		x		x	x	x	x
Open Engelmann Oak Woodland			x		x	x	x			x		x		x	x	x	x
Orchards and Vineyards																	
Peninsular Pinyon Woodland																	

Table 3 (cont.). Focal species habitat suitability values. Values in this table were used as input for Patch Size and Configuration analyses in the planning area.

Variable	Rainbow Manzanita	Our Lord's Candle	Engelmann Oak	Timema Walkingstick	Comstock's Fritillary	California Sister	Pale Swallowtail	Arroyo Chub	Southern Steelhead Trout	Western Toad	Calif Treefrog	Western Pond Turtle	Red Diamond Rattlesnake	Oak Titmouse	California Quail	Yellow Warbler	Dusky-footed Woodrat
Vegetation Mapped as Suitable Habitat (cont.)																	
Red Shank Chaparral	x			x	x		x						x		x		x
Riparian Forests					x		x			x	x	x		x	x	x	x
Riversidian Sage Scrub		x			x					x		x	x		x		x
Row Crops																	
Sagebrush Scrub		x			x					x		x			x		
Scrub Oak Chaparral	x			x	x		x			x		x	x	x	x		x
Sierran Mixed Coniferous Forst					x					x					x	x	x
Southern Arroyo Willow Riparian Forest					x		x			x	x	x		x	x	x	x
Southern Coast Live Oak Riparian Forest			x		x	x	x			x	x	x		x	x	x	x
Southern Cottonwood-willow Riparian Forest					x		x			x	x	x		x	x	x	x
Southern Riparian Scrub					x					x	x	x		x	x	x	x
Southern Sycamore-Alder Riparian Woodland					x		x			x	x	x		x	x	x	x
Southern Willow Scrub					x		x			x	x	x		x	x	x	x
Undifferentiated Open Woodland					x		x			x		x		x	x	x	x
Urban/Developed																	
Valley and Foothill Grassland					x					x		x			x		
Valley Needlegrass Grassland					x					x		x			x		
Wet Montane Meadow					x												
White Alder Riparian Forest										x	x	x		x	x	x	x
Additional Habitat Suitability Notes																	
Footnotes:					1	2	2	3	3	4		5					

1 Comstock's Fritillary: The vegetation types listed above were mapped as suitable habitat only if they occurred on canyons and slopes. Ridgetops with native vegetation were added as suitable habitat.

2 California sister and pale swallowtail: Canyons with perennial water and ridgelines were added to the vegetation communities as suitable habitat if they had natural vegetation.

3 Arroyo chub and southern steelhead trout: The minimum requirement for suitable breeding habitat is perennial surface streams. Perennial surface streams are mapped as areas with water observed during summer field surveys (Warburton pers. comm.). Because surveys were not conducted throughout the entire planning area, we included areas with vegetation types that typically occur where surface water is present (i.e., cottonwood-willow riparian forest, southern sycamore alder riparian woodland, and white alder riparian forest).

4 Western toad: Vegetation types were mapped as suitable only if they occurred within 1 km of drainages and ponds.

5 Western pond turtle: Vegetation types were mapped as suitable habitat only if they occurred within 0.5 km of perennial streams and ponds.

Table 4. Focal species habitat suitability values for species with core area sizes greater than the size of the planning area. An "x" in the vegetation/land use row (100-m resolution FRAP data) indicates that the class is considered suitable habitat.

Variable	Golden Eagle	American Badger	Mountain Lion
Patch and Core Sizes			
Minimum Patch Size (sq km)	93	4.8	93
Minimum Core Area (sq km)	2325	120	2325
Dispersal Distance			
Maximum Dispersal Distance (km)	120	220	130
Vegetation Mapped as Suitable Habitat			
Alkalia Desert Scrub		x	
Annual Grassland	x	x	
Barren	x		
Chamise-Redshank Chaparral	x	x	x
Closed-Cone Pine-Cypress			x
Coastal Oak Woodland	x	x	x
Coastal Scrub	x	x	x
Desert Riparian	x	x	x
Desert Scrub		x	
Desert Succulent Scrub		x	
Desert Wash		x	x
Eucalyptus	x		x
Freshwater Emergent Wetland			x
Jeffrey Pine	x	x	x
Joshua Tree		x	x
Juniper	x	x	x
Lodgepole Pine	x		x
Mixed Chaparral	x	x	x
Montaine Hardwood	x		x
Montane Chaparral	x	x	x
Montane Hardwood-Conifer	x		x
Montane Riparian	x		x
Palm Oasis			x
Perennial Grassland		x	x
Pinyon-Juniper	x	x	x
Ponderosa Pine	x	x	x
Sagebrush		x	
Saline Emergent Wetland			x
Sierran Mixed Conifer	x		x
Subalpine Conifer			x
Valley Foothill Riparian	x	x	x
Wet Meadow		x	x
White Fir	x		x

core area (for values used see Table 3 and 4). Patches are probably useful to the species if the patch can be linked via dispersal to other patches and core areas.

- Other – Other suitable habitat were areas too small to support one male and one female of the species. While these lands may be used by individuals moving through the area, they are not large enough to sustain reproduction.

In cases where more than 50 individuals can exist within a single 30-m pixel or no information was available regarding the habitat size needed to support focal species, suitable habitat was mapped without distinction regarding patch size.

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 (for values used, see Table 3). Areas of suitable habitat smaller than the minimum patch size were not used in this analysis. Groupings of core areas and patches that were equal to or greater than the adopted dispersal distance from other suitable habitat were identified using a unique color.

For the majority of focal species, patch size and configuration analyses were run within the planning area. For species with a core area size larger than the planning area (i.e., southern steelhead trout, mountain lion, badger, and golden eagle), the analysis was run using 100-m resolution Fire and Resource Assessment Program (FRAP) vegetation data (CALVEG) from the California Department of Forestry and Fire Protection. For golden eagle, American badger and mountain lion, the analyses were run for an area extending on the coast from Los Angeles to Oceanside and then eastward to the San Diego County boundary line (longitude: 118 30 00 to 116 00 00 and latitude 34 00 00 to 33 00 00). Model inputs were based on Wildlife Habitat Relationship (WHR) vegetation (Table 4). Results of the analyses were then cropped to the planning area. For all focal species, we used the output of patch size and configuration analyses to compare the distribution and extent of potential cores and patches relative to the Least-Cost Union. The Least-Cost Union boundaries were modified to include additional suitable habitat if these areas provided sufficient live-in and/or "move-through" habitat for each species to move between the Core Areas.

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 areas of the Least-Cost Union. This width was adopted based upon a review of Least-Cost Union goals. These goals are:

- To provide move-through habitat for a diversity of species – both through the linkage and among populations in the linkage. The Least-Cost Union must support species capable of making long-distance movements through the linkage area as well as those with dispersal distance too short to make the journey in one lifetime. Many small animals, such as rodents and lizards, require dozens of generations to move between Core Areas. These species need a linkage wide enough to support a constellation of metapopulations, with appropriate habitat between these subpopulations to allow for multi-generational movement over decades. Although there are no estimates of widths needed to support metapopulations of any species, 2 km is probably adequate for most species, although it may be narrow for species with little suitable habitat in the linkage.

- To provide live-in habitat that supports species with dispersal distances too short to traverse the linkage in one lifetime. 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 8 km^2 (3 mi^2). All focal species have home ranges less than this size except mountain lion. Fortunately, because they can move long distances in a single night, mountain lions and other species with large habitat requirements do not need live-in habitat and should be able to move through the Least-Cost Union into larger protected areas.

- To provide appropriate configuration of key resources and habitats within live-in habitat. The Least-Cost Union is expected to ensure the availability of key resources for all species of native plants and animals, including host plants (e.g., for butterflies), pollinators, predator-free areas, or other elements. For example, many species commonly found in riparian areas depend on upland habitats during some portion of their cycle. These species include butterflies that use larval host plants in upland areas and drink from water sources as adult, western pond turtles that live most of their lives in water but lay their eggs in sandy upland habitats, and western toads that spend the summer in upland burrows but return to the water to breed. In addition, most fish feed on the aquatic larvae of insects, many of which depend on terrestrial habitats as adults. Although the width of upland habitats needed beyond the streams edge has rarely been estimated for these species, information on the western pond turtle suggests that a 1-km (0.6-mi) upland buffer (i.e., 0.5 km to either side of the stream) (Holland 1991) is needed to sustain populations.

- To buffer against edge effects from neighboring urban and agricultural areas. The Least-Cost Union must be of sufficient width to buffer against edge effects even after adjacent land is converted to urban and agricultural uses. Human activities in neighboring areas can have undesirable effects on protected areas. These "edge effects" include artificial night lighting, predation by species supported by human activities (e.g., pets, released pets, and native predators such as raccoons that reach high density due to availability of garbage), elevated soil moisture and stream flow from irrigation, pesticides & pollutants, noise, hobby animals that increase risk of interactions with native predators, and removal of natural vegetation. Edge effects (Murcia 1995) have been best-studied at the edge between forests and adjacent agricultural landscapes (Debinski and Holt 2000). The best available data on edge effects for southern California habitats include: reduction in leaf-litter and population declines in birds and mammals up to 250 m (800 ft) (Kristan et al. 2003), collapse of native ant population due the invasion of argentine ants up to 200 m (650 ft) from irrigated areas (Suarez et al. 1998), and predation by pet cats which decimate small vertebrate populations (Churcher and Lawton 1987, Hall et al. 2000) up to 100 m (300 ft) (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). In addition, homeowners with homes at their property boundary may clear vegetation up to 61 m (200 ft) into protected areas to reduce fire risk and meet insurance requirements at the wildland-urban interface (Longcore 2000).

- To protect aquatic habitat quality. Upland habitat protection is needed to prevent the degradation of aquatic habitat quality. 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. 2003), and fish, amphibians, and aquatic invertebrates often are more sensitive to land use at watershed scales than at the scale of narrow riparian buffers (Goforth 2000, Fitzpatrick et al. 2001, Stewart et al. 2001, Wang et al. 2001, Scott 2002, Willson and Dorcas 2003).

- To allow natural disturbance and recruitment processes to operate with minimal constraints from adjacent urban areas. Least-Cost Union width should be sufficient such that the temporary devastation caused by fires, floods and other natural processes does not affect all habitats in the linkage simultaneously. Fire as a natural process is especially challenging to sustain in a relatively small linkage area. Large fires, such as those occurring under Santa Ana wind conditions, easily burn large areas. Before human occupation, naturally occurring fires (due to lightning strikes) were relatively rare in the coastal ranges of southern California (Radtke 1983). As populations in the region soared, fire frequency has also increased dramatically (Keeley and Fotheringham 2000). Homeowners at the wildland-urban interface, alarmed by the devastation of these wildland fires are further promoting the use of prescribed burns to reduce fuels in surrounding natural areas. Although fire has been shown to reduce the occurrence of exotic species in native grasslands (Teresa and Pace 1996), it has the opposite effect in shrublands (Giessow and Zedler 1996), encouraging the invasion of non-native plants. While the pattern of disturbance caused by this altered fire regime is unpredictable, wider linkages with broader natural communities may be more robust to these disturbances.

- To allow species and natural communities to respond to climate changes. The Least-Cost Union must also allow species to respond to climate change. Over the past century, the earth's warming rate has increased four-fold, and predictions for changes in California's weather include warmer winters with increases in flooding and fire (Field et al. 1999). Plant and animal distributions are predicted to change with the climate, expanding and contracting and rising and falling in elevation (Field et al. 1999). The Least-Cost Union width must be broad enough to allow for these wholesale movements in natural communities, and should encompass a diversity of microhabitats (e.g., slopes, aspects, elevations, and soil types) that allow species to colonize new areas.

In areas where the Least-Cost Union was less than 2 km in width, we first added available natural habitats to either side of the Least-Cost Union. If no natural habitats were available, agricultural lands were added since these areas could potentially be restored. Urban developments were added only if no other lands were available and were identified as possible target areas for education and best management practices.

Field Investigations

The modified Least-Cost Union was identified as the final Linkage Design. Within this area, we conducted field surveys to ground-truth existing habitat conditions, document existing barriers and potential passageways, and describe restoration opportunities in the Linkage Design area. A spatial database of all location data was created using a mobile GIS/GPS.

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

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

Identifying Conservation Opportunities

The Linkage Design serves as the target area for linkage conservation opportunities. We provided biological and land use summaries, and implementation opportunities for agencies, organizations, and individuals interested in participating in conservation activities in the Santa Ana – Palomar Connection. Biological and land use summaries include descriptions and maps of vegetation, and focuses on existing and potential barriers in the Linkage Design area: roads, stream barriers, urban development, agriculture and recreation. We also identified existing planning efforts addressing the conservation and use of natural resources in the planning area. Finally, we developed a flyover animation using aerial imagery, satellite imagery, and digital elevations models, which provides a visualization of the linkage from a landscape perspective (Appendix D) for use in conservation implementation activities.

Focal Species

Twenty focal species were chosen to assist in the design of a habitat connection that supports viable ecosystem processes between the Santa Ana and Palomar Mountains. Note that focal species choice in this plan was not limited to special status species. A successful linkage design protects processes that not only support species currently in decline but also insure against future listings.

The primary criterion used by biologists in the 5 taxonomic working groups for focal species choice was sensitivity to habitat fragmentation between the Core Areas. Biological characteristics identified as making species particularly sensitive to habitat fragmentation varied among working groups depending upon the natural history characteristics of species in that group. Common reasons given for species choice included the need to represent a variety of dispersal modes and abilities, value as an indicator of the quality, quantity and configuration of habitats, and susceptibility to human barriers. Although status was not used as a choice criterion, 10 of the 20 focal species have some level of protected status by state, federal, or non-governmental organizations. Detailed justifications for selection for each focal species are provided in species accounts in the Landscape Permeability Analysis and Patch Size and Configuration Analyses sections and in Appendix C. Here we review briefly results from each of the 5 taxonomic working groups.

Plants: Englemann Oak, Our Lord's Candle, and Rainbow Manzanita

Seed and pollen movement are necessary for long-term viability of plant populations, allowing habitat colonization and genetic exchange among populations. Plant focal species were chosen to represent the need for movement among populations in the Santa Ana and Palomar Core Areas (Englemann oak, our lord's candle) and among sites and individuals in the linkage planning area (Rainbow manzanita). Plant movement needs represented by focal species include: gravity/wind seed dispersal (our lord's candle), animal-assisted seed dispersal (Englemann oak and Rainbow manzanita), wind-dispersed pollen (Engelmann oak), animal-dispersed pollen (our lord's candle, Rainbow manzanita), short (our lord's candle, Engelmann oak) or moderate dispersal capabilities (Rainbow manzanita) and moderate (Rainbow manzanita) or long multi-generational linkage crossing (Englemann oak, our lord's candle). Habitat connections for the plant focal species are needed among oak and riparian woodlands, chaparral and coastal scrub.

Invertebrates: Timema Walkingstick, California Sister, Comstock's Fritillary, Pale Swallowtail

Insect focal species were chosen primarily for their value as indicators of habitat quality, although one (Timema walkingstick) was highlighted as an indicator of habitat continuity through the linkage. The 3 butterflies required the juxtaposition of key habitats elements for successful reproduction in the linkage (e.g., hilltops, drainages, specific host plants). Focal species dispersed as low (Comstock's fritillary) or high flyers (California sister and pale swallowtail) and walkers (Timema walkingstick). Dispersal distances varied from a few meters (Timema walkingstick) to many times the linkage length (butterflies) and required one (butterflies) or many generations (Timema walkingstick) for travel through the linkage. One species required near-continuous habitat for successful dispersal (Timema walkingstick).

Fish, Amphibians and Reptiles: Arroyo Chub, Southern Steelhead Trout, Western Toad, California Treefrog, Western Pond Turtle, Red Diamond Rattlesnake

Fish, amphibians and reptile species choice was based upon the need to sustain connections among populations in the Santa Ana and Palomar Core Areas or between feeding and breeding habitat (steelhead trout, presently extirpated from the linkage). Dispersal distances varied from a hundred meters (red diamond rattlesnake) to greater than the linkage length (western toad). Connections needed to support these species included aquatic habitat between the ocean and inland areas (steelhead trout), and riparian, aquatic and chaparral (red diamond rattlesnake) connections between the Core Areas. All but red diamond rattlesnake were additionally highlighted as indicators of aquatic habitat quality. To sustain focal species that require multiple generations to move through the linkage, the configuration of aquatic and upland habitats (western pond turtle, western toad) and water quality and flow (steelhead, arroyo chub, California treefrog, western pond turtle) and other barriers must be addressed.

Birds: oak titmouse, California quail, golden eagle, yellow warbler

Bird focal species choice was based on the need to sustain connections for species sensitive to terrestrial human barriers (California quail) or those preferring travel through natural habitats (oak titmouse). To sustain a full complement of bird species in the linkage, the need for large blocks of contiguous upland habitat (golden eagle) and the quality and amounts of riparian vegetation (yellow warbler) must be addressed.

Mammals: American badger, dusky-footed woodrat, mountain lion

Mammal focal species were chosen based on the need to sustain connections between source and sink populations in the Santa Ana and Palomar Core Areas (mountain lion) and maintain connections among viable populations in the Core Areas (American badger, dusky-footed woodrat). Focal species were capable of using a variety of habitats and dispersal abilities were either very long (mountain lion, badger) or very short (woodrat). Small mammal species that cannot disperse through the linkage in a single generation were generally represented by woodrats, which have low dispersal abilities, small home ranges, and require a wide variety of habitats.

Landscape permeability modeling was the first step in a two-step GIS analysis to identify a linkage design that provides a viable landscape connection. Landscape permeability model outputs, called least-cost corridors, identify the most permeable areas (best 10%) between protected lands in the Santa Ana and Palomar Mountains. Highly permeable areas are sites where focal species travel the shortest distance, encounter the fewest obstacles or hazards, and have the greatest chance of finding food and shelter between Core Areas.

In this section, we present background information and results of the permeability analyses for 8 focal species (mountain lion, American badger, dusky-footed woodrat, oak titmouse, California quail, western pond turtle, red diamond rattlesnake, and western toad). Of the 20 focal species chosen, these 8 species met our criteria for appropriate applications to the model (see Approach section) and had been studied sufficiently to yield data needed for model inputs. The permeability model outputs from these analyses were combined to create the Least-Cost Union, an area containing the best movement habitat in the linkage for all 8 species (Figure 8). The Least-Cost Union serves as the basis for further GIS linkage-design analyses in the next section.

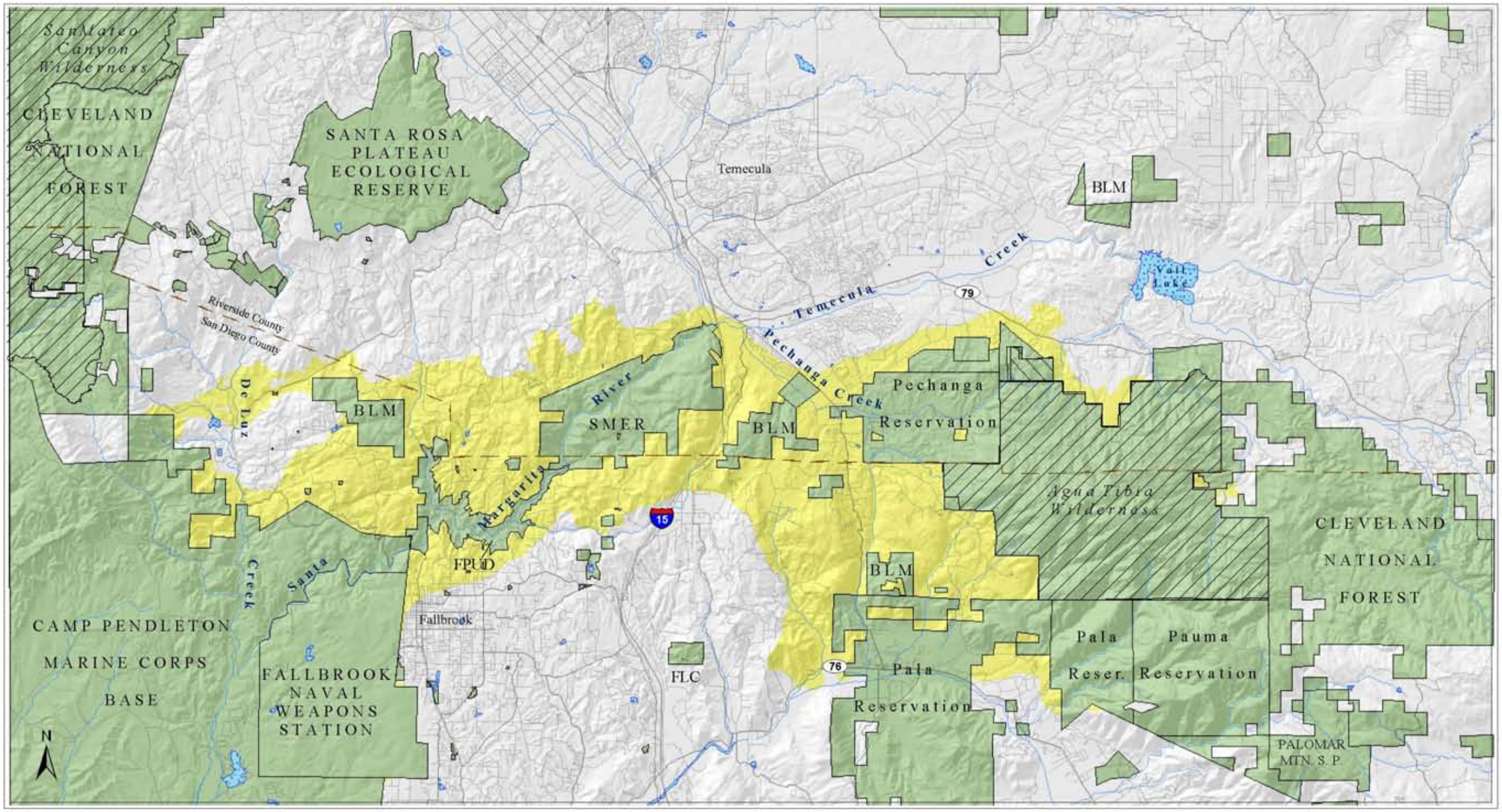
Permeability Model Results for Focal Species

Despite diverse ecological and movement requirements (see following species accounts and Table 2), least-cost corridors for the 8 focal species are remarkably similar (Figures 9-16). Only the mountain lion model diverged from other species outputs in the western portion of the linkage: despite the occurrence of agriculture and homes in the area, the model predicted a narrow band of permeable habitat (0.06 to 0.21 km (0.03 to 0.13 mi) in width lying along the upper De Luz and lower Camps Creek drainages (Figure 9). With such low variability in the outputs, we forgo a separate discussion for each species and instead describe the common pattern observed in all outputs and contrast the minor differences observed.

In general, least-cost corridors for all 8 species extend from the CNF Trabuco Ranger District, Camp Pendleton Marine Corps Base, and the Fallbrook Naval Weapons Station, across I-15 adjacent to the Santa Margarita Ecological Reserve, and through Bureau of Land Management parcels to the western and northern boundaries of the Palomar Ranger District of the Cleveland National Forest (Figures 9-16). Least-cost corridors were generally narrowest (3 to 8 km [2 to 5 mi]) on the western side of the linkage where urban and agricultural developments in the De Luz area are most abundant, and are widest at the eastern side of the linkage (8 to 13 km [5 to 8 mi]) where habitat conversion is the least prevalent (Figures 9-16). Western pond turtle, a species that prefers to travel through riparian habitats along the midline of the linkage, showed the narrowest least-cost corridor (3 km [2 mi] at the western end and 8 km [5 mi] on eastern end) (Figure 10). As a habitat generalist, mountain lions had the widest least-cost corridor (5.6 km [3.5 mi] at the western end and 13 km [8 mi] on the eastern end).

Figure 8. Least-Cost Union

BLM = Bureau of Land Management, FLC = Fallbrook Land Conservancy, FPUD = Fallbrook Public Utility District, SMER = Santa Margarita Ecological Reserve



SOUTH COAST WILDLANDS

Map Produced By:
South Coast Wildlands
May 2004
www.scwildlands.org

San Diego State University
FIELD STATIONS

Scale 1:230,000

0 1 2 4 6 8 Kilometers

0 1 2 4 6 8 Miles

Legend

Least Cost Union
Roads
County Boundary
Major Landholders*
Designated Wilderness
Proposed Wilderness
Hydrography
Lakes & Reservoirs

*Land management varies by ownership.

The Least-Cost Union, a union of the least-cost corridor outputs of all 8 species, identifies 398 km^2 (98,298 ac) of the best movement habitat through the linkage (Figure 8) and encompasses both upland and riparian habitat connections. Riparian habitat runs along the Santa Margarita River, crosses under Interstate I-15 and continues up Pechanga Creek, an ephemeral drainage dominated by riparian oak woodland. The upland habitat extends eastward from the CNF Trabuco Ranger District, Camp Pendleton MCB, and the Fallbrook Naval Weapons Station through the ridgelines and canyons of the DeLuz and Sandia Creek drainages and over Gavilan Mountain into the Santa Margarita Ecological Reserve. At I-15, it continues eastward across Bureau of Land Management lands and the Pechanga and Pala Indian Reservations to Mount Olympus and the Agua Tibia Wilderness of the CNF Palomar Ranger District.

Discussion of Model Results

The similarity of the 8 focal species outputs is due in large part to existing constraints on movement posed by development and agriculture in the northern (Santa Rosa Community Service District and City of Temecula) and southern (communities of Fallbrook and Rainbow) portions of the planning area. Because the cost of travel is lower through natural habitats than in areas with roads, agriculture and urban development, all of the least-cost corridors take advantage of the only remaining contiguous natural habitats between the ranges.

These analyses reveal the already constricted nature of the linkage and the urgent need to protect this vital landscape linkage by guiding development away from natural habitats in this area. In the remaining pages of this section, we present permeability model inputs and results for each of the 8 focal species modeled.

Landscape Permeability Analysis: Mountain Lion (*Felis concolor*)

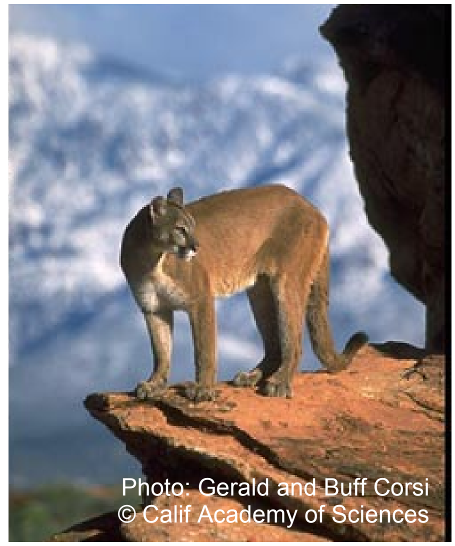


Photo: Gerald and Buff Corsi
© Calif Academy of Sciences

Justification for Selection: Habitat fragmentation at a landscape scale is best analyzed relative to the needs of large mammalian carnivores (Noss 1991, Soule and Terborgh 1999), such as mountain lions, which occur at low densities and require large tracts of land for persistence (Beier 1996). Mountain lions in southern California have already lost a number of dispersal corridors between mountain ranges. Loss of the dispersal corridor between the Santa Ana and Palomar Mountains is predicted to lead to local extinctions of mountain lions in the Santa Ana Mountains (Beier 1993). Major highways are barriers to movement. Mountain lions are listed as protected by the State of California.

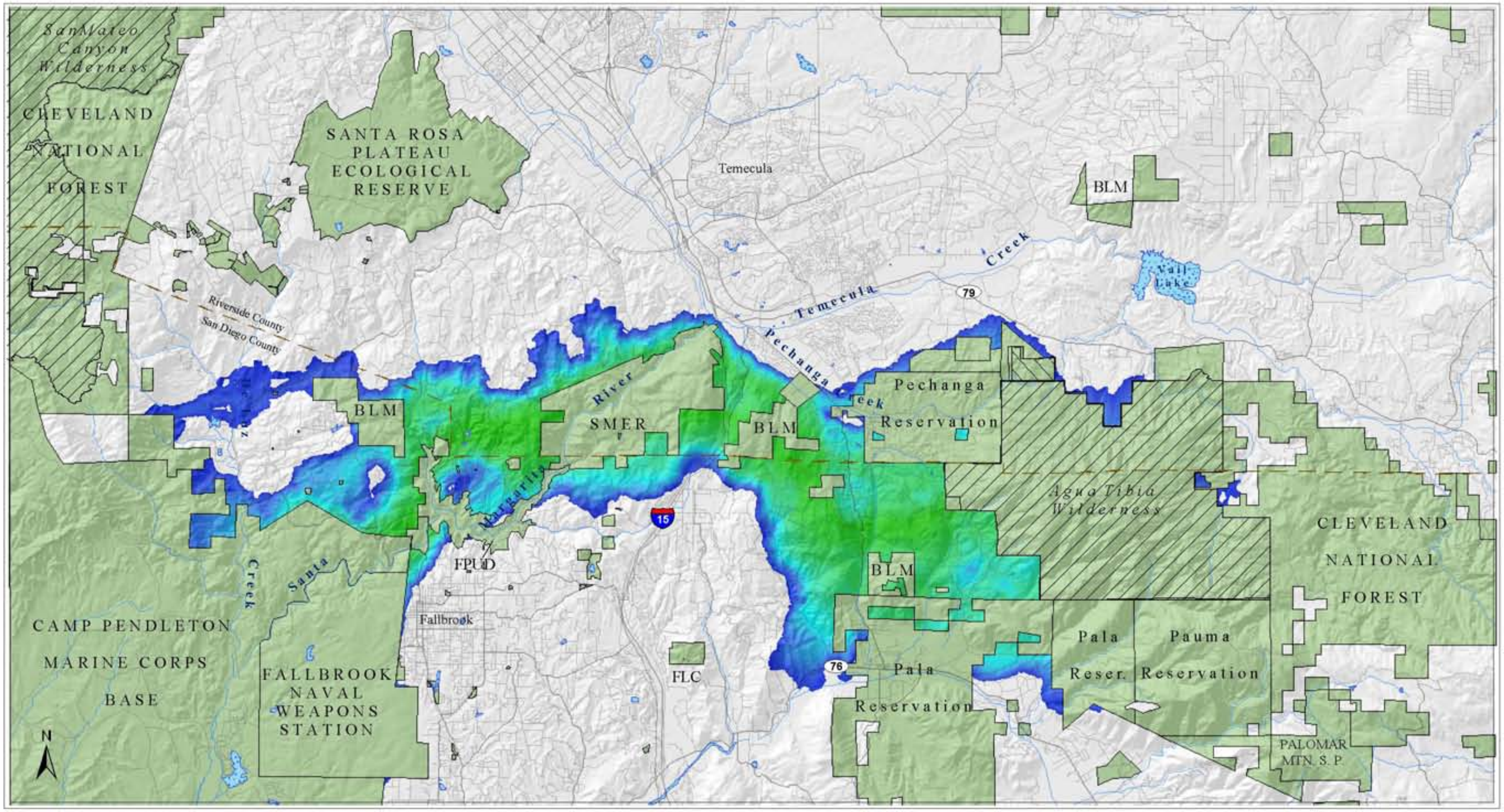
Distribution: Mountain lions are widely distributed throughout the western hemisphere (Currier 1983, Maehr 1992, Tesky 1995). Historically, they ranged from northern British Columbia to southern Chile and Argentina and from the west to east coast of North American continent (Currier 1983). The subspecies *F. c. californica* occurs in southern Oregon, California, and Nevada (Hall 1981) and occurs between 590 and 1,780 m (1,980 and 5,940 ft)(Ahlborn 1988). Approximately 20 mountain lions sustain territories in the Santa Ana Mountains (Beier and Barrett 1993).

Habitat Association: Mountain lions are habitat generalists. In California, they occur primarily in brushy stages of woodland and scrub habitats (Ahlborn 1988). In the Santa Ana Mountains, they commonly occur in oak woodlands, chaparral and other habitats with good cover (Dickson and Beier 2002). Within these habitats, mountain lions prefer vegetation or topography that provide cover when hunting prey (Dickson and Beier 2002) which is primarily mule deer, *Odocoileus hemionus* (Lindzey 1987, Beier and Barrett 1993). Vegetated stream courses and areas of relatively gentle topography are used as travel corridors and hunting routes. Mountain lions avoid urban developments, disturbed habitats, and areas with a high density of paved roads, and traveling individuals tend to minimize crossing paved roads (Diskson et al. 2004).

Conceptual Basis for Model Development: Travel habitat is characterized by all habitats with good cover (forests, woodlands and chaparral). Grasslands, agricultural and urban areas are avoided. Mountain lions avoid roads and areas with human activity. Mountain lions occur at all elevations throughout the linkage planning area. See Table 2 for rankings used in this analysis. Spatial data layers were weighted as follows: (Vegetation x 40%) + (Road Density x 30%) + (Topography x 30%) = cost surface. For a discussion of model outputs, see first 3 pages of this section.

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

BLM = Bureau of Land Management, FLC = Fallbrook Land Conservancy, FPUD = Fallbrook Public Utility District, SMER = Santa Margarita Ecological Reserve



Legend

Least Cost Corridor
Less Permeable
Highly Permeable
Roads
County Boundary
Major Landholders*
Designated Wilderness
Proposed Wilderness
Hydrography
Lakes & Reservoirs

*Land management varies by ownership.

Scale 1:230,000

0 1 2 4 6 8 Kilometers

0 1 2 4 6 8 Miles

SOUTH COAST WILDLANDS

Map Produced By:
South Coast Wildlands
May 2004
www.scwildlands.org

SDSU San Diego State University FIELD STATIONS

Landscape Permeability Analysis: Badger (*Taxidea taxus*)

Justification for Selection: Badgers are area-dependent grassland specialists that are sensitive to habitat fragmentation and loss. Movement needs represented by badger that guided linkage design include: movement through a wide variety of natural habitats, very long dispersal distances, large home range size, terrestrial locomotion, and sensitivity to road barriers. The primary mortality factors for this species are collisions with vehicles and predator control activities (Long 1973, CDFG 1999). Badgers are listed as a Species of Special Concern by the State of California.

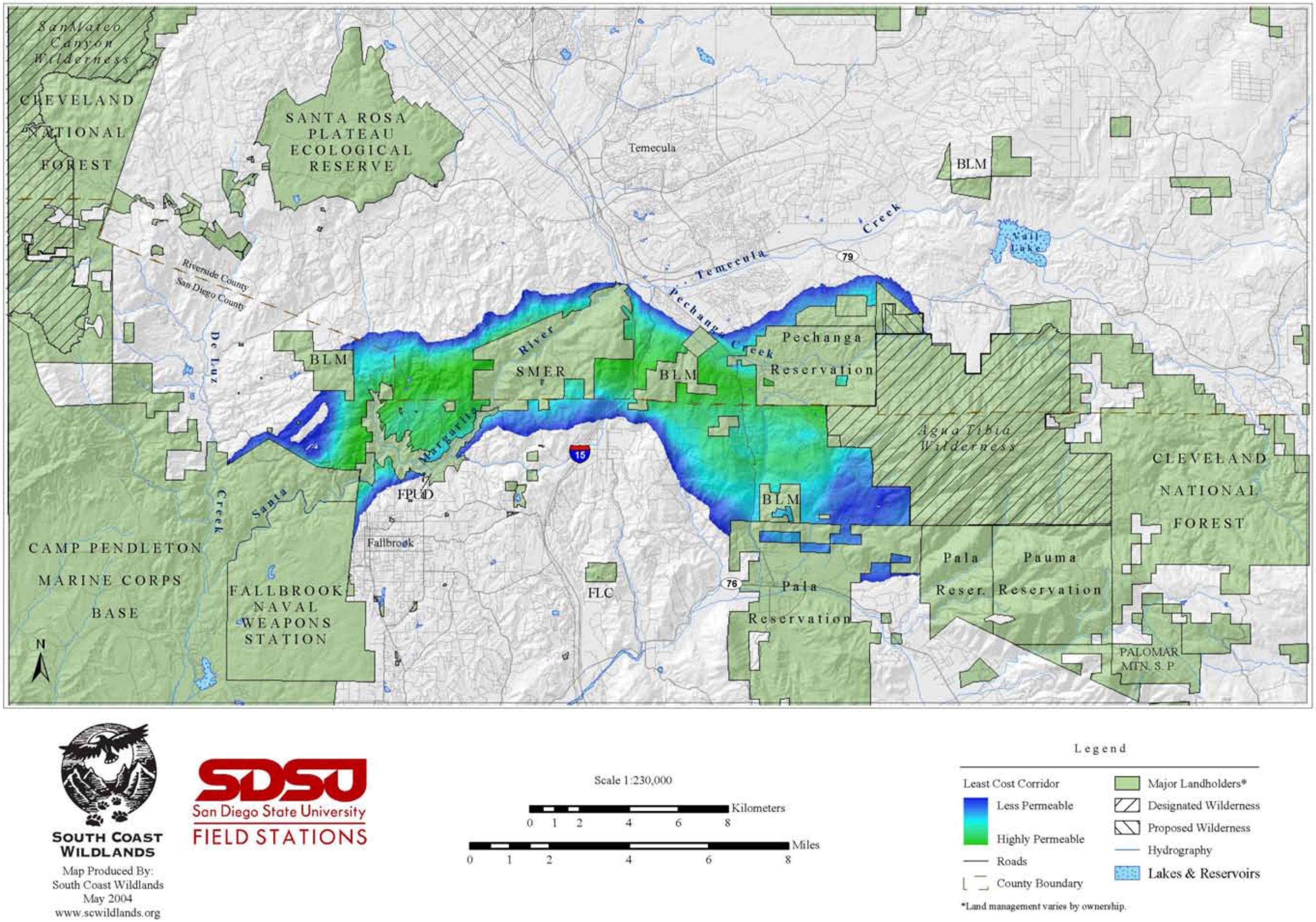
Distribution: Badgers occur throughout North America from central Alberta south to central Mexico and from the Pacific coast to the Great Lake States (Long and Killingley 1983). Although usually found at lower elevations (Long and Killingley 1983), they may occur at elevations up to 12,000 feet (3,600 m) but are usually found at lower elevations (Long and Killingley 1983). Badgers have been recently observed at the Santa Rosa Plateau (C. Bell, pers. comm.) and are occasionally observed on Marine Corps Base Camp Pendleton, but they are becoming increasingly rare in the Santa Ana Mountains region, probably due to habitat fragmentation (P. Bloom and W. Spencer, personal communications).

Habitat Association: Badgers are most common in grasslands, prairies, farms and other treeless areas with friable soil and abundant rodent prey, including grassy rights-of-way along roads (de Vos 1969, Banfield 1974, Ver Steeg and Warner 1995, Sullivan 1996, Apps et al. 2002). They are also found in forest and mountain meadows, marshes, brushy habitats, and deserts. In California, badgers are occasionally found in open chaparral (< 50% cover), woodlands, and riparian zones, but do not usually occur in mature chaparral (Vaughan 1954, Quinn 1990, Stephenson and Calcarone 1999).

Conceptual Basis for Model Development: Badgers commonly disperse through open scrub habitats, fields, and pastures, and open upland and riparian woodland habitats. Denser scrub, woodland habitats, and orchards are less preferred. They avoid urban and intense agricultural areas. Roads are difficult to navigate safely. See Table 2 for rankings used in this analysis. Spatial data layers were weighted as follows: (Vegetation x 50%) + (Road Density x 50%) = cost surface. For a discussion of model outputs, see first 3 pages of this section.

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

BLM = Bureau of Land Management, FLC = Fallbrook Land Conservancy, FPUD = Fallbrook Public Utility District, SMER = Santa Margarita Ecological Reserve



Landscape Permeability Analysis: Dusky-footed Woodrat (*Neotoma fuscipes intermedia*)


Photo: www.or.blm.gov

Justification for Selection: Dusky-footed woodrat was chosen as a surrogate for many small mammals. Movement needs represented by woodrats that guided linkage design include: movement through a wide variety of natural habitats, short dispersal distances, small home range sizes, and sensitivity to road barriers. *N. f. intermedia* is listed as Federal candidate and State Species of Special Concern.

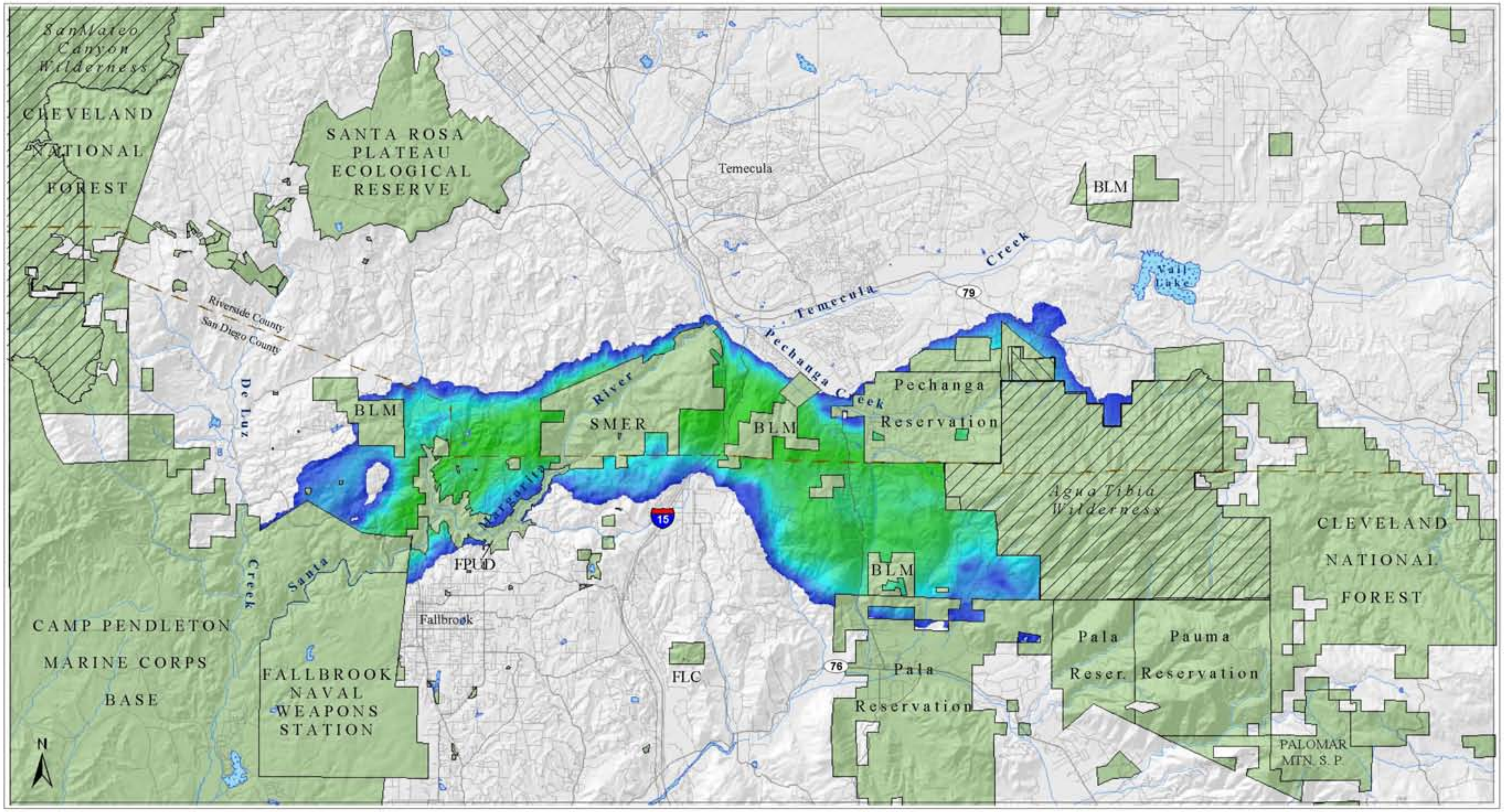
Distribution: Dusky-footed woodrats range from the Columbia River in Washington southward through California west of the Sierra Nevada to northwestern Baja California (Miller and Stebbins 1964). Woodrats are common and often abundant in both Core Areas and in the linkage. Woodrats mostly occur below 2150 m (7000 ft) (Brylski 1988).

Habitat Association: Dusky-footed woodrats occur in woodland, chaparral, and forest habitats with a moderate canopy and a moderate to dense understory (Brylski 1988). They build stick houses at the base of trees, in dense bushes or in rocky outcrops. They feed mainly on oak leaves and acorns (Atsatt and Ingram 1983), but also eat a wide variety of berries, mast crops, and vegetation (Cahalane 1961, Lindsdale and Tevis 1971). They are generally absent from cultivated land and open grasslands (Brylski 1988), but can tolerate rural low-density residential housing.

Conceptual Basis for Model Development: Woodrats prefer to move through forested habitats and chaparral communities. Coastal sage and more open habitats are less preferred due to lack of cover. Grassland is avoided. Woodrats avoid agricultural and urban areas but may venture into orchards. Woodrats are excellent climbers and can easily move on steep slopes. See Table 2 for rankings used in this analysis. Spatial data layers were weighted as follows: (Vegetation x 60%) + (Road Density x 40%) = cost surface. For a discussion of model outputs, see first 3 pages of this section.

Figure 11. Least-Cost Corridor for dusky-footed woodrat *(Neotoma fuscipes)*

BLM = Bureau of Land Management, FLC = Fallbrook Land Conservancy, FPUD = Fallbrook Public Utility District, SMER = Santa Margarita Ecological Reserve



South Coast Wildlands
Map Produced By:
South Coast Wildlands
May 2004
www.scwildlands.org

SDSU
San Diego State University
FIELD STATIONS

Scale 1:230,000

Kilometers: 0 1 2 4 6 8

Miles: 0 1 2 4 6 8

Legend

Least Cost Corridor
- Less Permeable
- Highly Permeable
- Roads
- County Boundary
- Major Landholders*
- Designated Wilderness
- Proposed Wilderness
- Hydrography
- Lakes & Reservoirs

*Land management varies by ownership.

Landscape Permeability Analysis: California Quail (*Callipepla californica*)

Justification for Selection: California quail is a resident species that is sensitive to habitat fragmentation (Crooks and Soule 1999). Movement needs represented by quail that guide linkage design include: movement through a wide variety of natural habitats, short dispersal distances, weak flight or terrestrial locomotion, and sensitivity to road barriers. To support a multi-generational crossing of the linkage, linkage design must maintain diverse blocks of natural habitat of sufficient size to support quail coveys and address mortality due to roadkill and hunting.

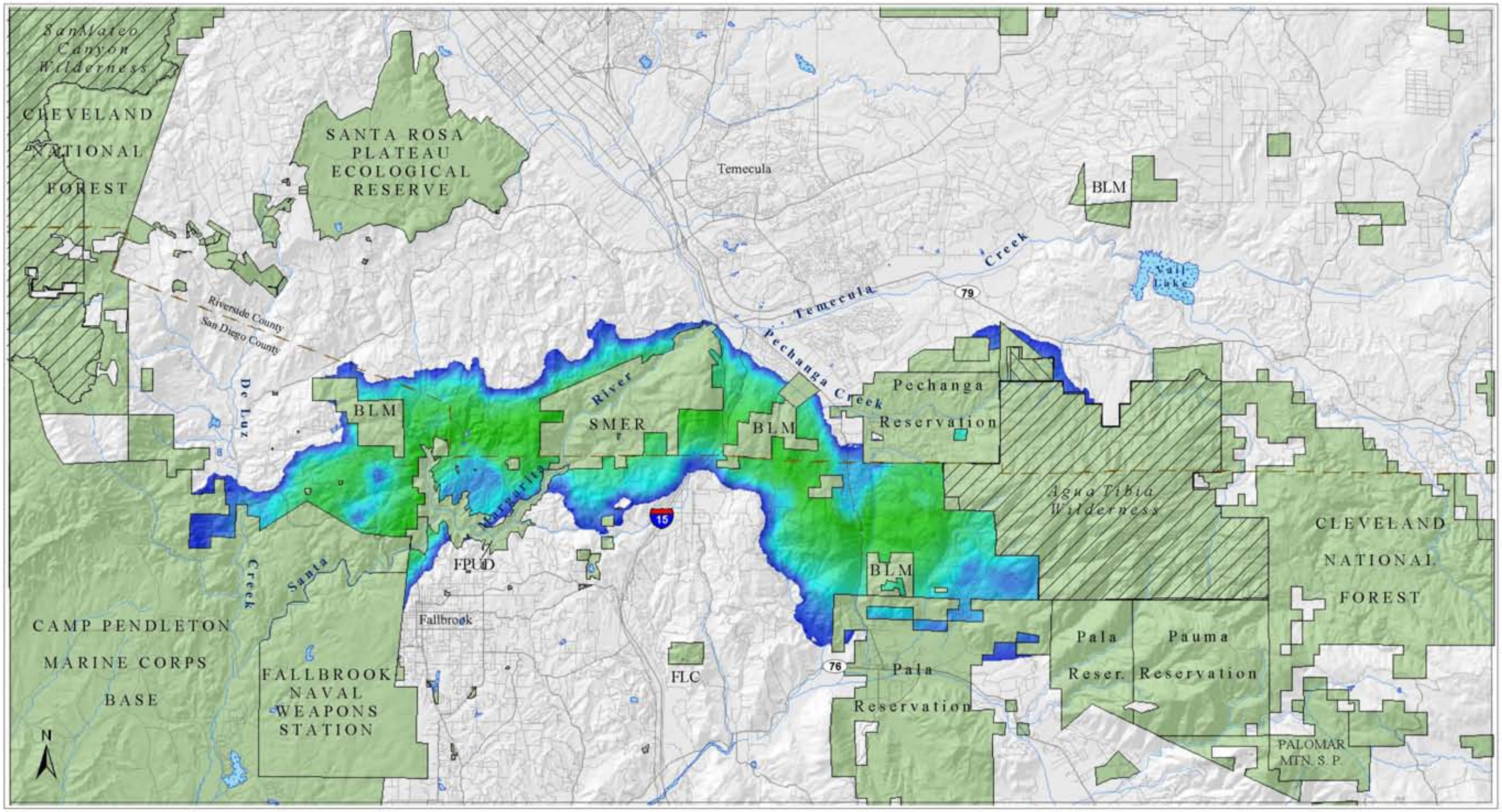
Distribution: California quail range from southern British Columbia south to the Baja California peninsula and eastward into Idaho, Nevada and Utah (Peterson 1990). They are common in the linkage planning area (C. Luke personal observation).

Habitat Association: California quail require a mosaic of habitat types with low, brushy vegetation, grass/forb openings, taller shrubs and trees, and surface water (Ahlborn 1999). They occur in scrub and brush habitats (e.g., coastal sage, chaparral) and open conifer and open woodlands (e.g., oak), near the margins of grasslands and croplands (Leopold 1977). California quail have been observed roosting on the edges of orchards (C. Luke personal observation).

Conceptual Basis for Model Development: Quail prefer to travel through brushy habitats that provide good cover, especially near areas with water. They travel less preferentially through open habitats (e.g., grasslands). They can move through low-density rural housing areas, open fields, and orchards. They avoid intensive agriculture and urban areas. See Table 2 for rankings used in this analysis. Spatial data layers were weighted as follows: (Vegetation x 50%) + (Road Density x 50%) = cost surface. For a discussion of model outputs, see first 3 pages of this section.

Figure 12. Least-Cost Corridor for California quail *(Callipepla californica)*

BLM = Bureau of Land Management, FLC = Fallbrook Land Conservancy, FPUD = Fallbrook Public Utility District, SMER = Santa Margarita Ecological Reserve



South Coast Wildlands

Map Produced By:
South Coast Wildlands
May 2004
www.scwildlands.org

SDSU San Diego State University FIELD STATIONS

Scale 1:230,000

0 1 2 4 6 8 Kilometers

0 1 2 4 6 8 Miles

Legend

Least Cost Corridor
- Less Permeable
- Highly Permeable
- Roads
- County Boundary
- Major Landholders*
- Designated Wilderness
- Proposed Wilderness
- Hydrography
- Lakes & Reservoirs

*Land management varies by ownership.

Justification for Selection: Oak titmice are local residents. Movement needs represented by titmice that guide linkage design include: movement preferences through natural habitats and moderate dispersal distances. To support a multi-generational crossing of the linkage, linkage design must maintain blocks of oak and riparian woodland habitat of sufficient size to support populations of titmice.

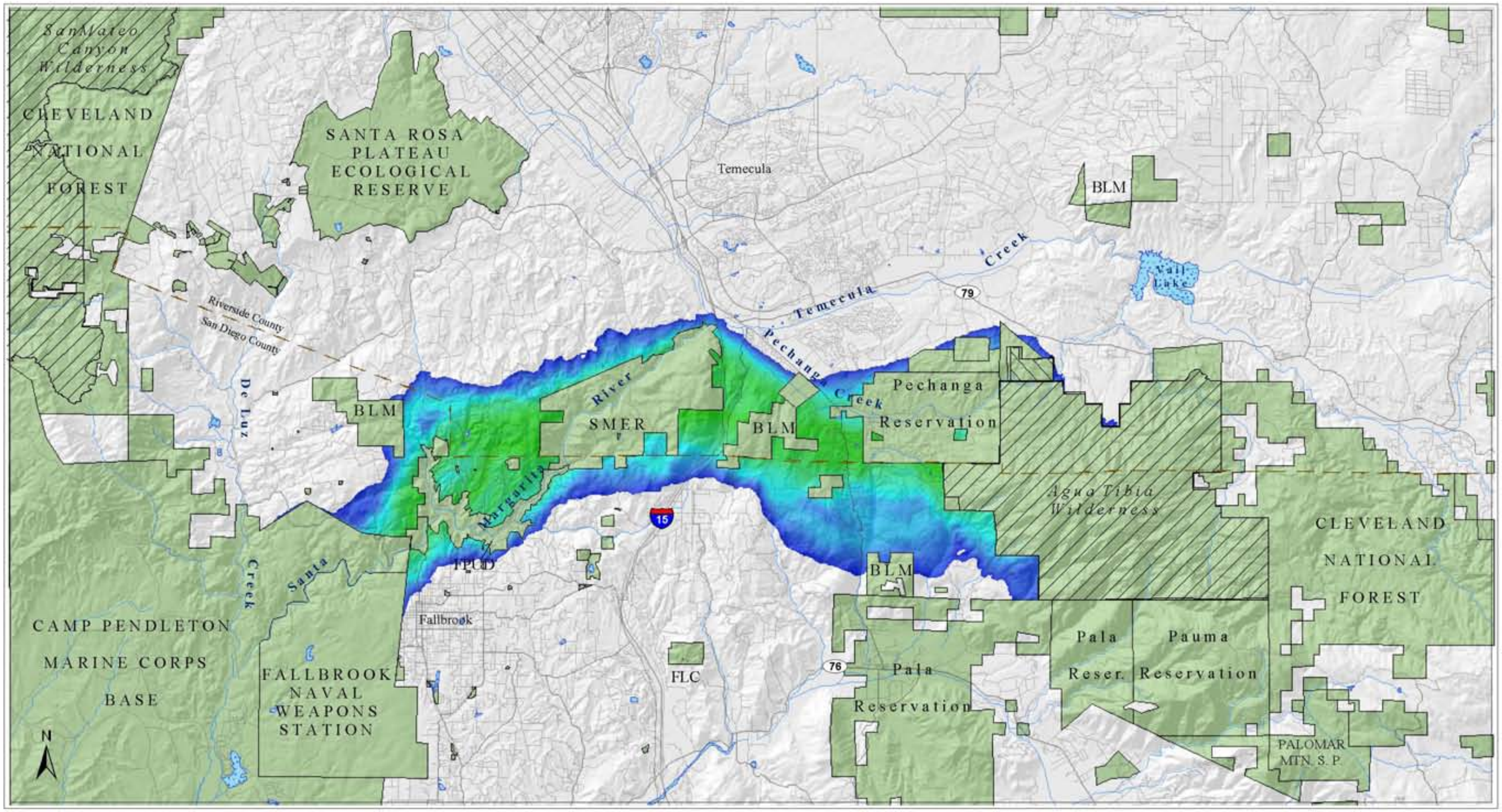
Distribution: The oak titmouse ranges from Humboldt County south along the Sierra Nevada and Coast Ranges to northern Baja California (Peterson 1990) and seldom ranges above 1100 m (3500 ft)(Bent 1946).

Habitat Associations: Oak titmice are a common, year-round resident in a variety of habitats but prefer open woodlands with oak and pine/oak (Kucera 1999). They occur in montane hardwood-conifer, montane hardwood, oak woodlands, and montane and valley foothill riparian habitats in cismontane California (Kucera 1999). They sometimes forage and breed in riparian habitats and can occur in rural residential areas (Kucera 1999).

Conceptual Basis for Model Development: Titmice prefer to move through oak woodlands and riparian forests and woodlands. They less preferentially move through other native habitats, and avoid urban and agricultural areas, including orchards. They are able to avoid mortality along roads because they generally fly in the canopy. See Table 2 for rankings used in this analysis. Spatial data layers were weighted as follows: (Vegetation x 50%) + (Road Density x 50%) = cost surface. For a discussion of model outputs, see first 3 pages of this section.

Figure 13. Least-Cost Corridor for oak titmouse *(Baeolophus inornatus)*

BLM = Bureau of Land Management, FLC = Fallbrook Land Conservancy, FPUD = Fallbrook Public Utility District, SMER = Santa Margarita Ecological Reserve



Scale 1:230,000

0 1 2 4 6 8 Kilometers

0 1 2 4 6 8 Miles

Legend

Least Cost Corridor
- Less Permeable
- Highly Permeable
- Roads
- County Boundary
- Major Landholders*
- Designated Wilderness
- Proposed Wilderness
- Hydrography
- Lakes & Reservoirs

*Land management varies by ownership.

SOUTH COAST WILDLANDS

Map Produced By:
South Coast Wildlands
May 2004
www.scwildlands.org

SDSU San Diego State University FIELD STATIONS

Landscape Permeability Analysis: Red Diamond Rattlesnake (*Crotalus ruber*)

Justification for Selection: This reptile is endemic to southern California. Movement needs represented by red diamond rattlesnakes for developing the linkage design include: movement through chaparral and other brushy habitats, slow-moving terrestrial locomotion, and very short dispersal distances. To support a multi-generational crossing of the linkage, linkage design must maintain continuity among chaparral habitats, and address species that are preferentially killed by humans or while crossing roads. Red diamond rattlesnakes are listed as Federal Candidates and State Species of Special Concern.

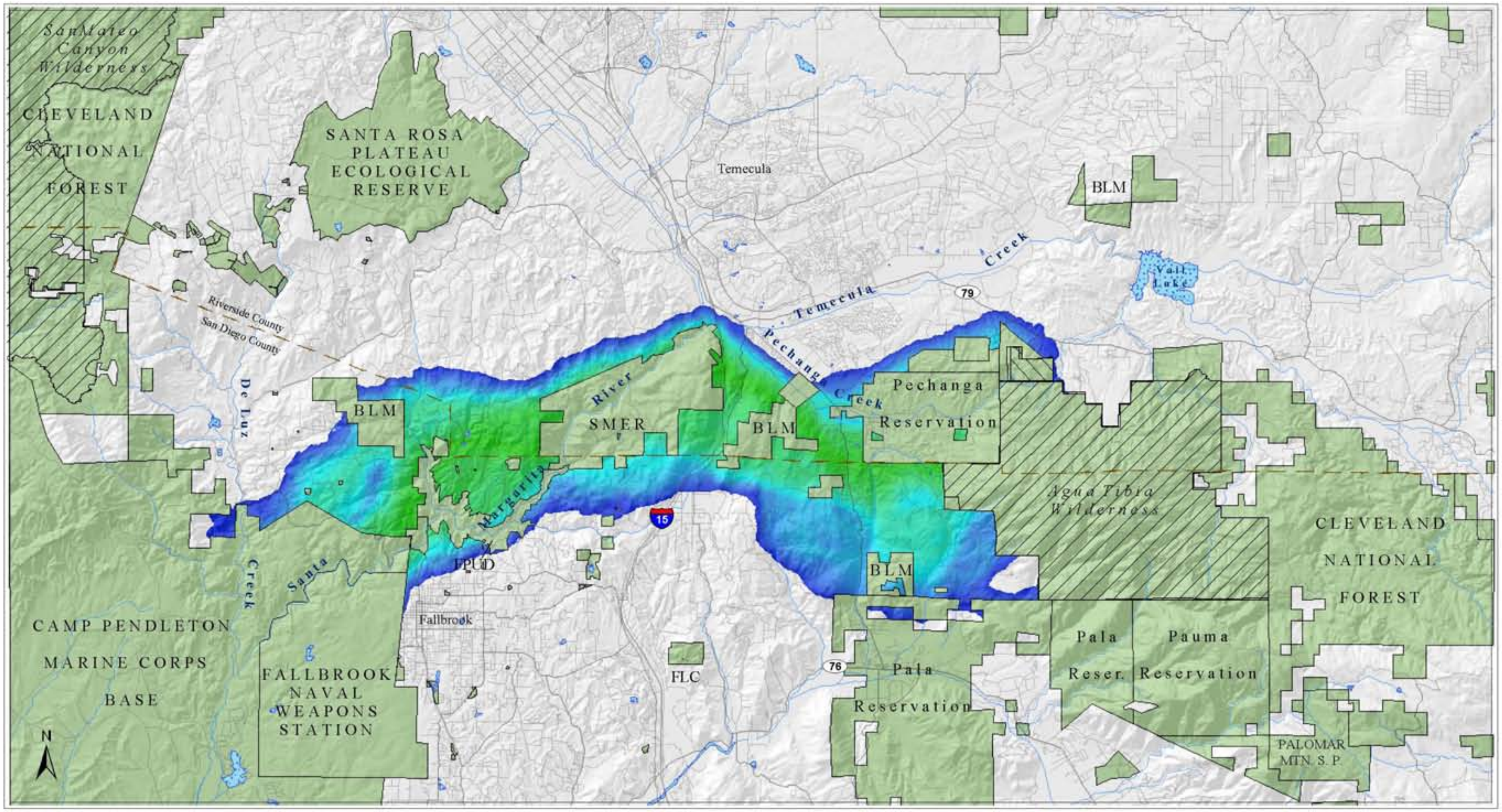
Distribution: Red diamond rattlesnakes range from southern San Bernardino County south along both desert and coastal sides of the Peninsular Ranges to coastal San Diego County (Peugegnat 1951, Stebbins 1985, Marlow 1988). They range from sea level to 1,520 m (0 to 5,000 ft) but are more commonly encountered below 1,200 m (4,000 ft)(Klauber 1972). They occur within the project area and are commonly encountered in the Santa Margarita Ecological Reserve (C. Luke, personal observation). They were recently recorded in the western portion of the linkage area as well (Fisher and Crooks 2001).

Habitat Association: Red diamond rattlesnakes prefer sage scrub and chaparral habitats with heavy brush and large boulder and rock outcroppings (Klauber 1972) and avoid open areas (Tracey 2000). They are most abundant in areas with rock cover and vegetation height between 0.5 and 1.5 m (2 and 5 ft)(Tracey 2000). Woodrat middens are favorite microhabitats as are crevices or rocks (Tracey 2000). Rattlesnakes are good climbers and swimmers (Klauber 1972). They are often killed by humans when encountered, and are also killed while crossing roads.

Conceptual Basis for Model Development: Red diamond rattlesnakes prefer to move through habitats that provide good cover including chaparral, dense upland and riparian woodlands. Less preferred are open habitats such as coastal sage, grassland, or orchards. Rattlesnakes avoid open agricultural fields and urban developments. Roads are difficult to cross. They avoid areas above 1500 m. See Table 2 for rankings used in this analysis. Spatial data layers were weighted as follows: (Vegetation x 40%) + (Road Density x 40%) + (Elevation x 20%) = cost surface. For a discussion of model outputs, see first 3 pages of this section.

Figure 14. Least-Cost Corridor for red diamond rattlesnake *(Crotalus ruber)*

BLM = Bureau of Land Management, FLC = Fallbrook Land Conservancy, FPUD = Fallbrook Public Utility District, SMER = Santa Margarita Ecological Reserve



SOUTH COAST WILDLANDS

Map Produced By:
South Coast Wildlands
May 2004
www.scwildlands.org

SDSU
San Diego State University
FIELD STATIONS

Scale 1:230,000

0 1 2 4 6 8 Kilometers

0 1 2 4 6 8 Miles

Legend

Least Cost Corridor
Less Permeable
Highly Permeable
Roads
County Boundary
Major Landholders*
Designated Wilderness
Proposed Wilderness
Hydrography
Lakes & Reservoirs

*Land management varies by ownership.

Landscape Permeability Analysis: Western Pond Turtle (*Clemmys marmorata*)

Justification for Selection: This species has experienced widespread declines throughout California. Movement needs represented by western pond turtles that guide linkage design include movement through a variety of upland and riparian habitats, slow-moving terrestrial locomotion, moderate dispersal distances, and road barriers. To support a multi-generational crossing of the linkage, linkage design must maintain continuity among upland and aquatic habitats, maintain water quality, and address species that are poached by humans or frequently killed while crossing roads (Holland 1991). Western pond turtles are listed as Federal candidates, State Species of Special Concern, State protected and US Forest Service sensitive species.

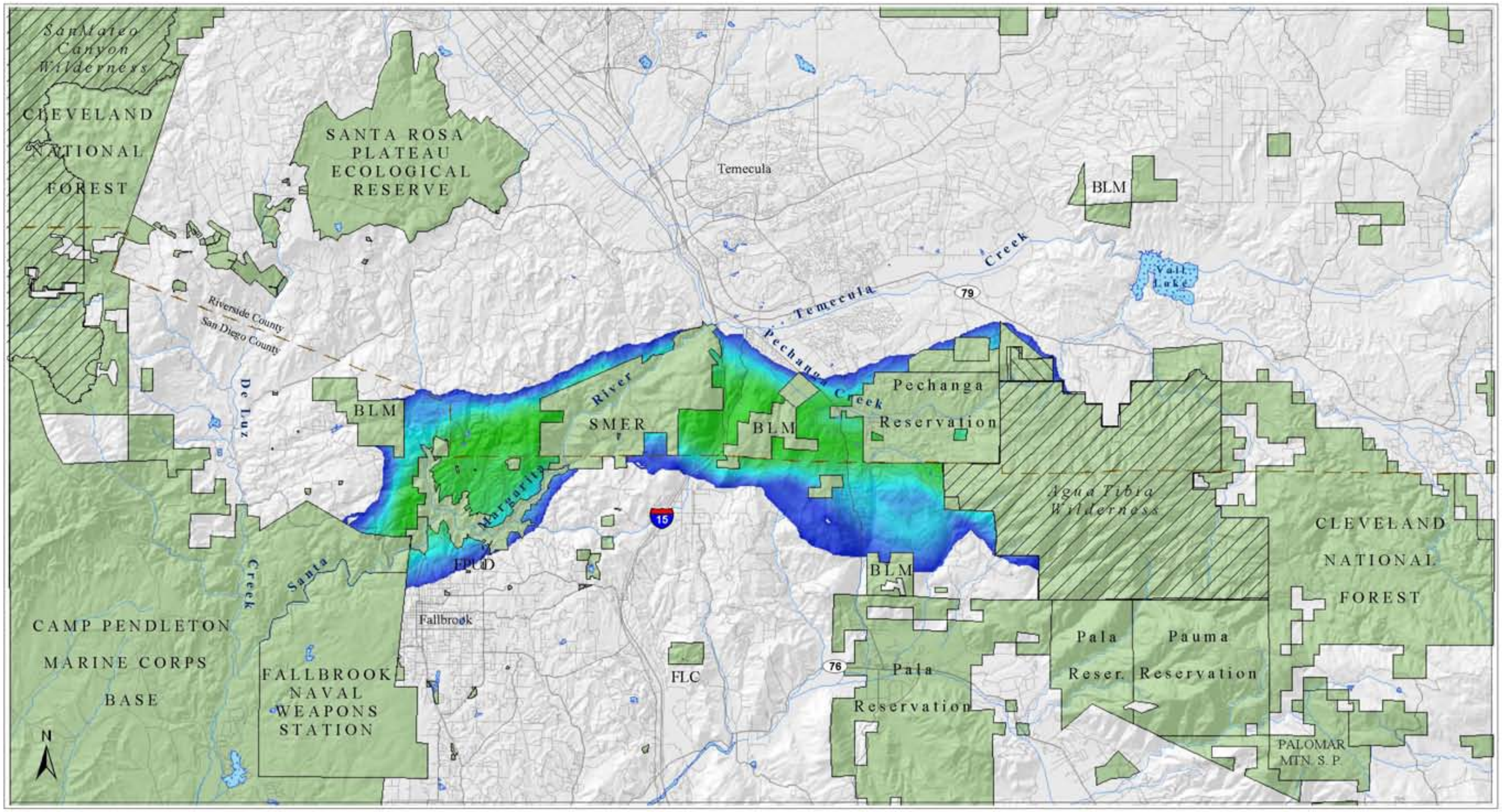
Distribution: Western pond turtles range from Washington State, south along the Pacific slopes and interior valley of California into northern Baja California (Stebbins 1985). The species generally occurs below 1800 m (6000 ft) elevation in suitable aquatic habitat throughout California (Morey 1988c). In 1987, surveys revealed large populations of pond turtles in beaver ponds on the Santa Margarita River at the I-15 crossing and near Fallbrook, and moderately sized populations were located in San Mateo Creek and the Santa Rosa Plateau (Brattstrom and Messer unpubl.). Turtles also fell into pitfall traps during surveys conducted between 1996 and 2000 in the Tenaja corridor (west of the Santa Rosa Plateau Ecological Reserve) and in the Santa Margarita Ecological Reserve (Fisher and Crooks 2001).

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

Conceptual Basis for Model Development: Turtles move most easily along watercourses and in riparian vegetation. Movements are common through a variety of natural upland habitats but may be more difficult in habitats with dense cover that prevent basking in the sun. Turtles avoid urban and intensive agricultural areas. They climb well and avoid only the steepest slopes. Roads are very difficult for turtles to successfully cross. See Table 2 for rankings used in this analysis. Spatial data layers were weighted as follows: (Vegetation x 50%) + (Road Density x 40%) + (Slope x 10%)= cost surface. For a discussion of model outputs, see beginning of this section.

Figure 15. Least-Cost Corridor for western pond turtle *(Clemmys marmorata)*

BLM = Bureau of Land Management, FLC = Fallbrook Land Conservancy, FPUD = Fallbrook Public Utility District, SMER = Santa Margarita Ecological Reserve



SOUTH COAST WILDLANDS
Map Produced By:
South Coast Wildlands
May 2004
www.scwildlands.org

SDSU San Diego State University FIELD STATIONS

Scale 1:230,000

0 1 2 4 6 8 Kilometers

0 1 2 4 6 8 Miles

Legend

Least Cost Corridor
Less Permeable
Highly Permeable
Roads
County Boundary

Major Landholders*
Designated Wilderness
Proposed Wilderness
Hydrography
Lakes & Reservoirs

*Land management varies by ownership.

SDSU San Diego State University FIELD STATIONS

SOUTH COAST WILDLANDS

Justification for Selection: Movement needs represented by western toads for developing the linkage design include: movement through a variety of upland habitats, slow-moving terrestrial locomotion and moderate dispersal distances. To support a multi-generational crossing of the linkage, linkage design must maintain continuity between high-quality slow-moving aquatic and upland habitats. The species is one of the most commonly killed species on roads in the linkage area (Fisher and Crooks 2001).


Photo: Chris Brown

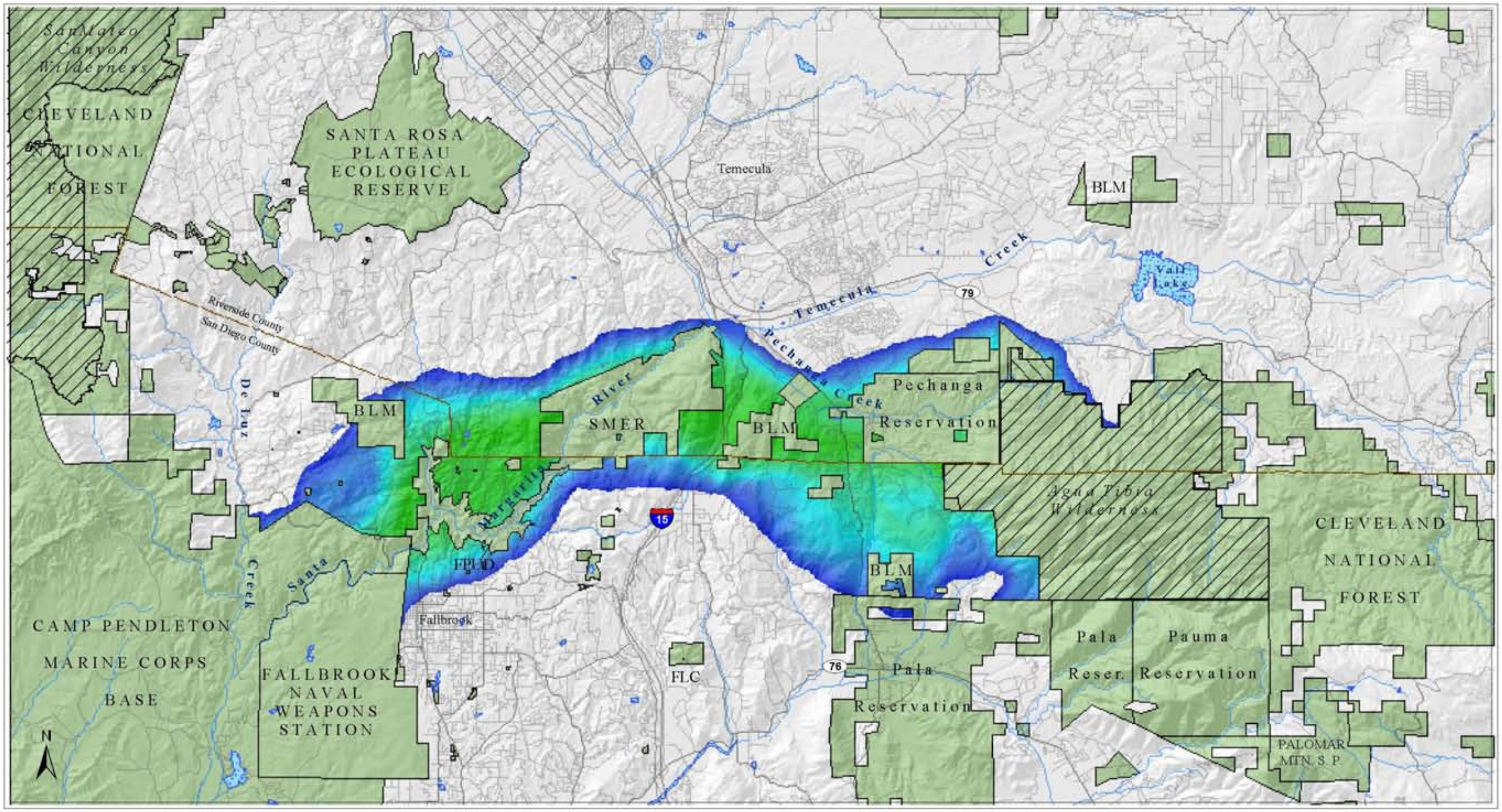
Distribution: The western toad ranges from western British Columbia and southern Alaska south through Washington, Oregon, and Idaho to northern Baja California, and east to Montana, western and central Wyoming, Nevada, high elevation areas in Utah, and western Colorado (Stebbins 1985). In the linkage planning area, relatively high densities of toads occur on MCB Camp Pendleton, the Santa Rosa Plateau Ecological Preserve, Tenaja Corridor, and along the Santa Margarita River (Fisher and Crooks 2001).

Habitat Associations: In California, western toads occur up to 10,000 ft elevation in most habitats except deserts (Morey 1988a, Sullivan 1994). They require open water for breeding, using lakes, ponds, vernal pools, roadside ditches, irrigation canals, permanent and intermittent streams, and rivers (Morey 1988b). Eggs are laid in water 6 to 12 inches (15 to 30 cm) deep (Stebbins 1954, Olson 1992).

Conceptual Basis for Model Development: Western toads can easily move through all kinds of upland habitats in the linkage but prefer to travel through moist habitats when available. They avoid agricultural areas and urban developments but they may travel through orchards for short distances to reach higher quality habitats. Roads are difficult to safely traverse for slow-moving toads, even at low road density. See Table 2 for rankings used in this analysis. Spatial data layers were weighted as follows: (Vegetation x 50%) + (Road Density x 50%) = cost surface. For a discussion of model outputs, see first 3 pages of this section.

Figure 16. Least-Cost Corridor for western toad *(Bufo boreas)*

BLM = Bureau of Land Management, FLC = Fallbrook Land Conservancy, FPUD = Fallbrook Public Utility District, SMER = Santa Margarita Ecological Reserve



SOUTH COAST WILDLANDS

Map Produced By:
South Coast Wildlands
May 2004
www.scwildlands.org

SDSU San Diego State University FIELD STATIONS

Scale 1:230,000

0 1 2 4 6 8 Kilometers

0 1 2 4 6 8 Miles

Legend

Least Cost Corridor
- Less Permeable
- Highly Permeable
- Roads
- County Boundary
- Major Landholders*
- Designated Wilderness
- Proposed Wilderness
- Hydrography
- Lakes & Reservoirs

*Land management varies by ownership.

SDSU San Diego State University FIELD STATIONS

SOUTH COAST WILDLANDS

(this page intentionally left blank)

Patch Size & Configuration Analyses

Patch size and configuration analyses are the second step in a two-step GIS analysis to identify a linkage design that provides a viable landscape connection between the Santa Ana and Palomar Mountains. During the first step (permeability analysis) we identified the best movement habitat available for focal species, a zone identified as the Least-Cost Union. Patch size and configuration analyses were next used to determine whether this movement zone contained sufficient suitable habitat to allow focal species to survive and move between the Santa Ana and Palomar Core Areas. In this section, we present the results of the patch size and configuration analyses for all 20 focal species and, where necessary, prescribe modifications to the Least-Cost Union boundary that are needed to sustain them (Figure 17). The Least-Cost Union with the modifications added from the patch size and configuration analyses constitute the final Linkage Design for the Santa Ana – Palomar Mountains Linkage.

Focal Species Model Outputs

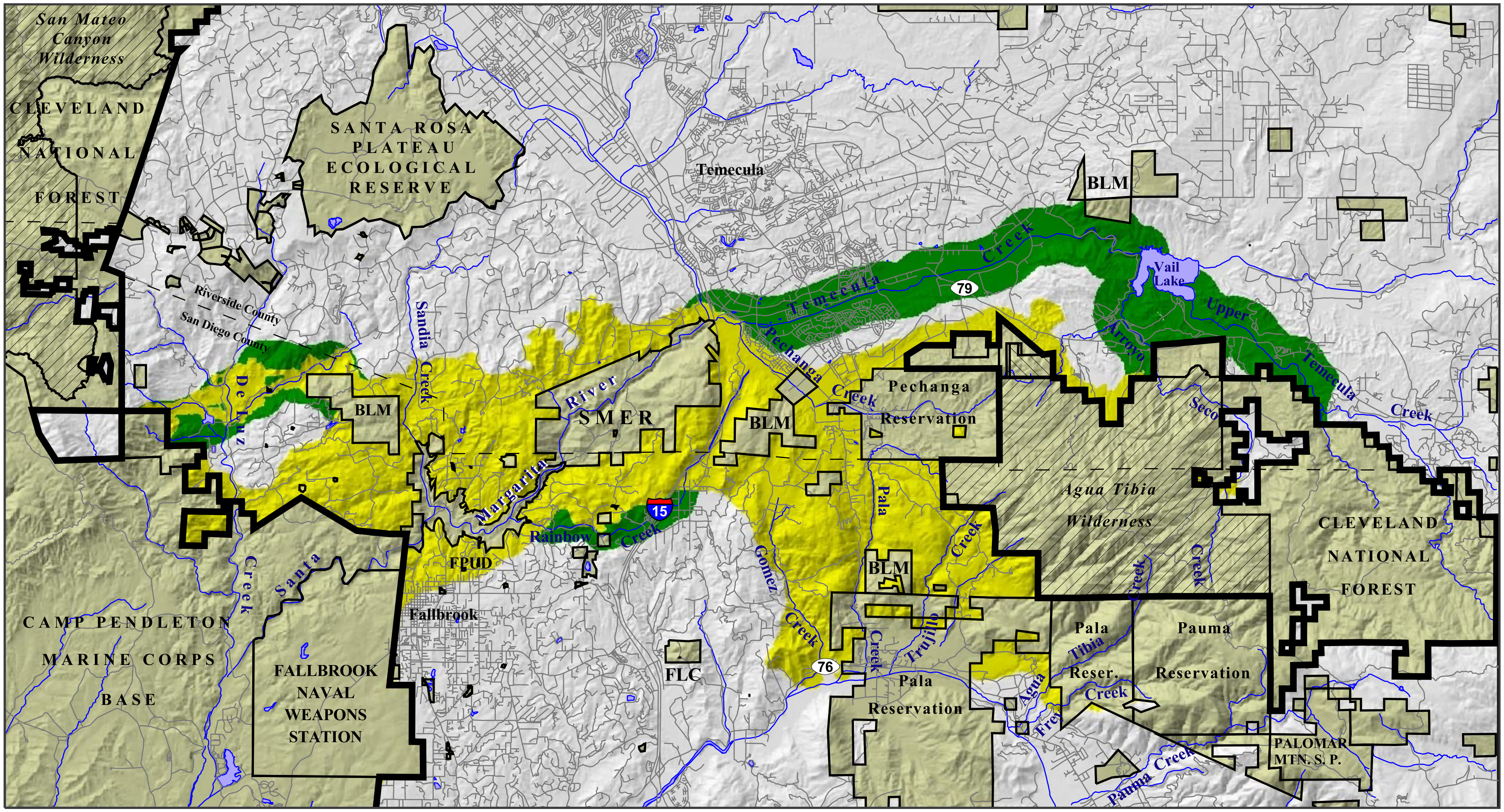
The Least-Cost Union contains potentially suitable habitat that may support viable populations and movements, either inter- or intra-generationally, between the Santa Ana and Palomar Mountain Core Areas for 16 of the 20 focal species: mountain lion, American badger, dusky-footed woodrat, golden eagle, yellow warbler, oak titmouse, California quail, red diamond rattlesnake, western toad, Comstock's fritillary, pale swallowtail, California sister, Timema walkingstick, Engelmann oak, our Lord's candle, and Rainbow manzanita. For these species, model outputs indicated that areas with potential suitable habitat in the Least-Cost Union were large enough to support viable populations and close enough together to allow individuals to eventually move from between Core Areas. Appendix C contains the results and interpretation of analyses for these species.

Four species required habitat additions to ensure adequate core area size and movement routes: western pond turtle, California treefrog, arroyo chub, and southern steelhead trout (Figures 18-23). Steelhead trout has been extirpated from the Santa Margarita River and reintroductions have been recommended for the recovery this threatened species. The analysis addresses potential connectivity issues for this species, should it be reintroduced.

For all species, patch size and configuration analyses assumed that areas mapped with suitable habitat are capable of supporting focal species, and additions to the Least-Cost Union were assigned on this premise. Detailed field surveys are highly recommended to assess habitat quality and confirm the presence of these species. For all species, it was recognized that model outputs did not address existing barriers or land use practices that may prevent species from moving through the linkage. These potential barriers are addressed in the Linkage Design section.

Figure 17. Additions to the Least-Cost Union.

BLM = Bureau of Land Management, FLC = Fallbrook Land Conservancy, FPUD = Fallbrook Public Utility District, SMER = Santa Margarita Ecological Reserve.



Map produced by:
SDSU Field Station Programs
March 11, 2004
http://fs.sdsu.edu

SDSU San Diego State University FIELD STATION PROGRAMS

SOUTH COAST WILDLANDS

N

5 0 5 Kilometers

5 0 5 Miles

Legend

- Least-Cost Union
- Additions to Least-Cost Union
- roads
- county line
- Santa Ana and Palomar Core Areas
- major landholders*
- designated wilderness
- proposed wilderness
- hydrography
- lakes & reservoirs

*land management varies by ownership.

Modifications to the Least-Cost Union

As a result of the patch size, configuration, and minimum width analyses, we added 56.3 km^2 (13,936 ac) of habitat in three areas of the Least-Cost Union (Figure 17), increasing the Least-Cost Union acreage by 12%:

- Temecula/Arroyo Seco Creek - The 50.2-km^2 (12,413-ac) Temecula Creek/Arroyo Seco Creek addition in the eastern section of the Least-Cost Union is expected to preserve core habitat and connectivity for aquatic and semi-aquatic species (represented by arroyo chub, southern steelhead trout, California treefrog, and western pond turtle). The area includes one of only 6 places in the watershed where arroyo chubs are known to occur and provides the only riparian connection between perennial water sources in the Santa Ana and Palomar Core Areas. The Temecula/Arroyo Seco Creek addition also provides suitable live-in and/or move-through habitat for 12 other focal species with a variety of habitat needs: mountain lion, American badger, dusky-footed woodrat, yellow warbler, golden eagle, California quail, oak titmouse, western toad, California sister, pale swallowtail, Comstock's fritillary, and Engelmann oak.

  The habitat in this addition extends from the Santa Margarita River along Temecula Creek through Vail Dam to the Temecula and Arroyo Seco creek drainages in the Palomar Mountains (Figure 17). The connection includes a 2-km (1.2-mi) buffer (1 km to either side of the creeks) to support meet minimum Least-Cost Union width guidelines that insure the appropriate configuration of habitat to sustain intergenerational movements, resist edge effects, and allowing for natural disturbance processes. This addition encompasses the majority of urban development in the Linkage Design. In these urban areas, the riparian corridor and hydrological regime have been substantially altered and a restoration effort is needed. While we do not recommend restoration of urban areas, we do suggest that best management practices in this area, coupled with restoration in undeveloped areas could be used to support a viable movement corridor.

- Rainbow Creek – The 5.2-km^2 (1,294-ac) Rainbow Creek addition in the central section of the Least-Cost Union preserves core habitat for arroyo chub and possibly spawning habitat for southern steelhead trout (should they be reintroduced to the watershed). The additional habitat includes a 2-km (1.2-mi) buffer (1.0 km of upland habitat to either side of the creek) to preserve water quality. This addition also benefits the other 19 focal species by increasing available suitable habitat, providing a secondary riparian movement corridor in the central portion of the linkage, or preserving water quality. The additional riparian habitat runs along the southern bank of Rainbow Creek eastward to Interstate 15 (Figure 17).

- De Luz – The 0.9-km^2 (229-ac) De Luz addition in the western section of the Least-Cost Union increases the minimum width of the Least-Cost Union to 2 km (Figure 17). The majority of the Least-Cost Union varied in width from 3 to 12 km (2 to 8 mi). The narrowest region was near De Luz, an area in the western portion of the Least-Cost Union, where the connection is split into a northern and southern route.

The northern arm varied in width from 0.05 to 0.21 km (0.03 to 0.13 mi). The De Luz addition in the eastern section of the Least-Cost Union widened the Least-Cost Union to a minimum width of 2 km (3.2 mi), making it more robust to edge effects, providing adequate configuration of habitat, and allowing for natural disturbance processes. The additional habitat extends through predominantly chaparral and riparian habitats from Camp Pendleton Marine Corps Base to the BLM Parcel, which spans the De Luz and Sandia creek drainages. The addition provides live-in and/or move-through habitat for 12 focal species (mountain lion, American badger, dusky-footed woodrat, golden eagle, California quail, red diamond rattlesnake, western toad, pale swallowtail, Comstock's fritillary, Timema walkingstick, and Rainbow manzanita) and potentially preserves water quality by protecting upland habitats for 4 of the focal species (western pond turtle, California treefrog, arroyo chub, and southern steelhead trout).

Linkage Design

The Least-Cost Union plus additions resulting from the patch and configuration analyses (Figure 17) is defined as the final Linkage Design for the Santa Ana – Palomar Mountains Linkage. This area provides for reproduction and movement of a diverse assemblage of focal species chosen to represent a variety of natural ecosystem processes. We caution that the Linkage Design is a minimum estimate of lands needed to preserve this landscape linkage. Simplifying assumptions of the GIS analyses used to create the linkage generally cause the models to overestimate species occurrence and mobility and underestimate the amount of habitat needed to sustain species needs. For this reason, we not only encourage conservation of lands within the Linkage Design boundaries, but also support other efforts in the planning area that serve to make the connection wider, more robust, or otherwise enhance planning goals.

In the remaining pages of this section, we present patch size and configuration model inputs and results for each of the four focal species for which habitat additions were required to ensure adequate core area size and movement routes: western pond turtle, California treefrog, arroyo chub, and southern steelhead trout.

Patch Size and Configuration Analysis:
Western Pond Turtle (*Clemmys marmorata*)


Photo: Chris Brown

Justification for Selection: This species has experienced widespread declines throughout California. Movement needs represented by western pond turtles that guide linkage design include movement through a variety of upland and riparian habitats, slow-moving terrestrial locomotion, moderate dispersal distances, and road barriers. To support a multi-generational crossing of the linkage, linkage design must maintain continuity among upland and aquatic habitats, maintain water quality, and address species that are poached by humans or frequently killed while crossing roads (Holland 1991). Western pond turtles are listed as Federal candidates, State Species of Special Concern, State protected and US Forest Service sensitive species.

Distribution: Western pond turtles range from Washington State, south along the Pacific slopes and interior valley of California into northern Baja California (Stebbins 1985). The species generally occurs below 1830 m (6000 ft) elevation in suitable aquatic habitat throughout California (Morey 1988c). In 1987, surveys revealed large populations of pond turtles in beaver ponds on the Santa Margarita River at the I-15 crossing and near Fallbrook, and moderately sized populations were located in San Mateo Creek and the Santa Rosa Plateau (Brattstrom and Messer unpubl.). Turtles also fell into pitfall traps during surveys conducted between 1996 and 2000 in the Tenaja corridor (west of the Santa Rosa Plateau Ecological Reserve) and in the Santa Margarita Ecological Reserve (Fisher and Crooks 2001).

Habitat Associations: Pond turtles typically occur in permanent ponds, lakes, streams, irrigation ditches or permanent pools along intermittent streams (Morey 1988c). They tend to favor habitats with abundant basking sites such as partially submerged logs, rocks, mats of floating vegetation, or open mud banks (Bury 1972, Morey 1988c), but can also occur where basking sites are scarce (Holland 1985). Pond turtles tend to aggregate in large, deep pools along streams, especially those with cover (boulder piles) or underwater escape sites (undercut banks, and tangles of roots) (Bury 1972). Access to sandy banks is needed for nesting (Storer 1930, Rathburn et al. 1993). Turtle abundance has been positively correlated with number of basking sites (logs, boulders), and pond size and depth (Bury 1972). Due to nesting and overwintering movement requirements, upland habitat corridor width of 0.5 km (0.3 mi) to either side of the watercourse may be needed to support pond turtle populations (Rathburn et al. 1993).

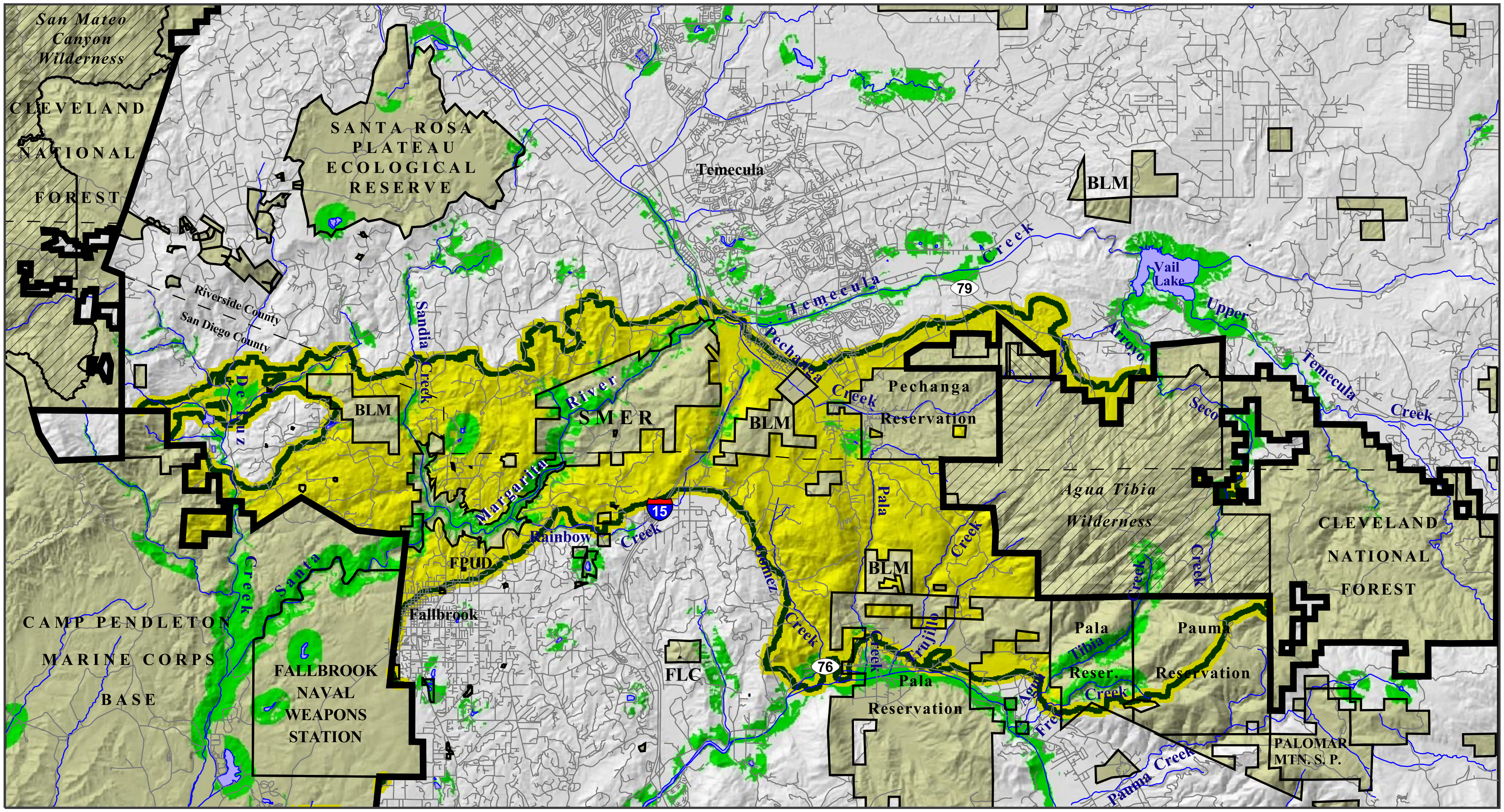
Home Range and Core Area Sizes: Turtles are non-territorial but exhibit aggressive behaviors (Bury and Wolfheim 1973). In northern California, pond turtles have relatively small home ranges in aquatic habitats (Bury 1972, 1979). Male home ranges average 1 ha (range: 0.2 - 2.4 ha) of water surface and they move an average of 367 m (1204 ft) along watercourses among years. Females average 0.3 ha (range: 0 - 0.7 ha) with movements up and down stream of 149 m. Most females nest within 50 m (160 ft) of water (Rathburn et al. 1992, Reese and Welsh 1997), but can make long overland treks up to 0.4 km 0.2 (mi) and 90 m (290 ft) in elevation rise to deposit their eggs at suitable nesting sites in sandy banks or open, grassy fields (Storer 1930, Rathburn et al. 1992, Lovich and Meyer 2002). In southern California, 2 of 4 radio-tracked female pond turtles traveled about 1 and 2 km (0.6 and 1.2 mi) upstream between 19 May and 9 August (Rathburn et al. 1992). A nesting female moved 14 to 59 m (46 to 194 ft) roughly perpendicular from the water's edge when excavating nests. Turtles may move out of the flood plain during winter months to escape flooding (Rathburn, Holland 1994, Reese and Welsh 1997) and have been found buried in duff and leaf litter under willow/blackberry thicket or buckwheat (Holland 1991).

Dispersal: Males tend to move greater average and total distances than females or juveniles and can move over 1.5 km (0.9 mi) along watercourses (Bury 1972). Both males and females can move overland 0.5 km (0.3 mi) from nearest watercourse (Holland 1991), and a small proportion of the population even makes long distance movements among drainages: of 1200 individuals marked between 1981 and 1991 in central coast of California, less than 10 recaptures were outside of the original drainage (Holland 1991). The maximum linear distance between capture and recapture was 2.5 km (1.6 mi). One marked turtle moved 1.5 km (0.9 mi) in 2 weeks (Bury 1972) and a radio-tagged male pond turtle in northern California traveled 700 m (2300 ft) in 4 days (Bury 1972).

Conceptual Basis for Model Development: The best suitable habitat for pond turtles in the planning area are forests, woodland, coastal scrub and grassland habitats within 0.5 km of perennial streams, ponds and lakes. Perennial water sources without adjacent native vegetation were not considered suitable. Minimum patch size for 2 pond turtles is less than the 30-m minimum mapping unit. Because habitat quantity is a poor predictor of population density in pond turtles, we did not designate a minimum core area size, but included all suitable habitat as potential core habitat. Dispersal distance is 5 km (twice the maximum reported dispersal distance).

Results and Discussion: Pond turtle habitat occurs in both Santa Ana and Palomar Core Areas: along the Santa Margarita River and De Luz Creek on Camp Pendleton MCB and the Fallbrook Naval Weapons Station and along upper Temecula and Arroyo Seco creeks in the Palomar Ranger District of the Cleveland National Forest (Figure 18). Habitat also occurs through drainages in the Least-Cost Union along the Santa Margarita River, De Luz, Sandia, and Pechanga creeks. With a dispersal distance of 5 km (3 mi), pond turtles theoretically could move among almost all habitat patches in the planning area, although populations on Las Pulgas Canyon Creek in the southwestern planning area, Wilson Creek in northeastern planning area, and French Creek in the southeastern planning area may be isolated from other populations in the planning area (Figure 19).

Figure 18. Potential suitable habitat for western pond turtle *(Clemmys marmorata).*
Potential suitable habitat includes upland areas within 0.5 km of perennial streams and ponds. See text for assumptions regarding model inputs. BLM = Bureau of Land Management, FLC = Fallbrook Land Conservancy, FPUD = Fallbrook Public Utility District, SMER = Santa Margarita Ecological Reserve.



N

5 0 5 Kilometers

5 0 5 Miles

Legend

- Least-Cost Union
- suitable habitat
- paved roads
- county line
- Santa Ana and Palomar Core Areas
- major landholders*
- designated wilderness
- proposed wilderness
- hydrography
- lakes & reservoirs

*land management varies by ownership.

SDSU San Diego State University FIELD STATION PROGRAMS

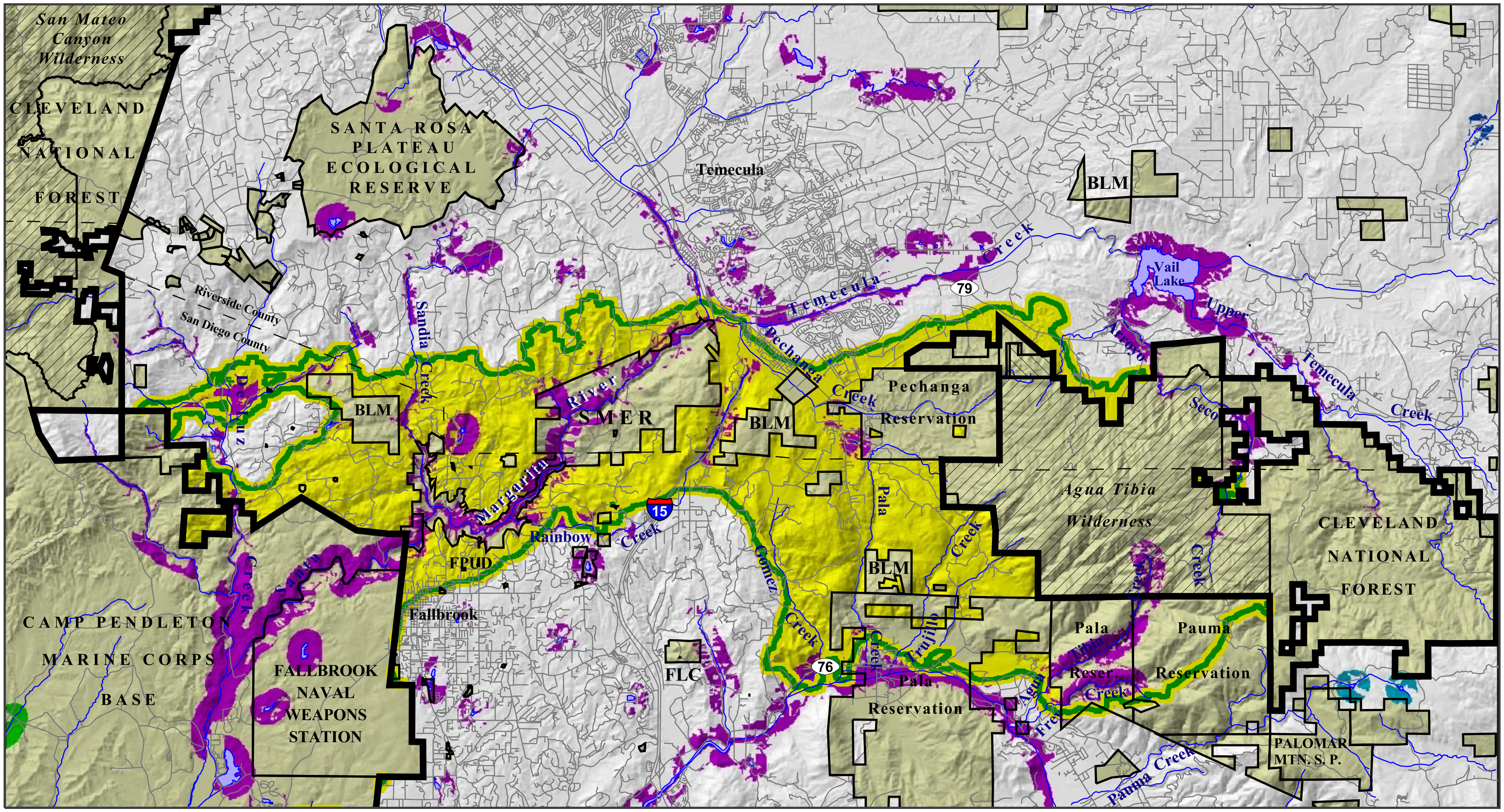
SOUTH COAST WILDLANDS

Map produced by:
SDSU Field Station Programs
March 11, 2004
http://fs.sdsu.edu

SDSU San Diego State University FIELD STATIONS

SOUTH COAST WILDLANDS

Figure 19. Distances among cores and patches of suitable habitat for western pond turtle *(Clemmys marmorata)*. Suitable habitat polygons that are farther apart than the species' dispersal distance (5 km) are shown in different colors. See text for assumptions regarding model inputs. BLM = Bureau of Land Management, FLC = Fallbrook Land Conservancy, FPUD = Fallbrook Public Utility District, SMER = Santa Margarita Ecological Reserve.



N

5 0 5 Kilometers

5 0 5 Miles

Legend

- Least-Cost Union
- Various Colors: Each color represents suitable habitat polygons within the species' dispersal distance.
- Paved Roads
- County Line
- Santa Ana and Palomar Core Areas
- major landholders*
- designated wilderness
- proposed wilderness
- hydrography
- lakes & reservoirs

*Land management varies by ownership.

SDSU San Diego State University FIELD STATION PROGRAMS

SOUTH COAST WILDLANDS

Map produced by:
SDSU Field Station Programs
March 15, 2004
http://fs.sdsu.edu

SDSU San Diego State University FIELD STATIONS

SOUTH COAST WILDLANDS

The movements predicted by the model along Temecula Creek are not currently likely. Surface water along lower Temecula Creek is too shallow to support turtle populations and the area downstream of Vail Lake is devoid of vegetation for almost 5 km (3 mi). For these reasons, populations in the Palomar Mountains are likely isolated from those on the main stem of the Santa Margarita River and De Luz Creek.

To restore and protect habitat connections for pond turtles between the Santa Ana and Palomar Mountain Core Areas, we recommend that:

- additional core areas of suitable habitat along Arroyo Seco and upper Temecula Creek be added to the Least-Cost Union (see Figure 17),
- perennial reaches of the Temecula and Arroyo Seco creeks be surveyed to determine if potential suitable habitat is of high quality and/or occupied by turtles,
- a riparian connection, with a 2-km (1.2-mi) upland buffer (see discussion at beginning of this section regarding edge effects), between Santa Margarita River and upper Temecula Creek be added to the Least-Cost Union (Figure 17),
- riparian and upland habitats needed for breeding and movement in the Temecula Creek and Arroyo Seco additions be restored,
- Vail Dam be modified, if necessary, to allow turtles to move around the dam,
- road barriers be modified to allow turtles to move along riparian corridors throughout the Core Areas and Least-Cost Union,
- invasive species that destroy pond turtle habitat (e.g., giant reed), prey on hatchlings (e.g., bullfrogs), and compete with turtles or carry diseases (e.g., introduced turtles) be eradicated,
- water quality compromised by agricultural and urban runoff be restored, and
- anti-poaching laws be enforced and poaching be included as part of educational outreach programs.

The Rainbow Creek and De Luz additions to the Least-Cost Union that were recommended to support other focal species would also benefit western pond turtles. The Rainbow Creek addition would provide additional aquatic and upland habitats and the De Luz Chaparral addition would protect water quality by preserving upland habitats.

Patch Size and Configuration Analysis:
California Treefrog (*Hyla cadaverina*)


Photo: Chris Brown

Justification for Selection: California treefrog movement needs include movement restricted to streamside habitats, slow-moving terrestrial locomotion, short dispersal distances and road barriers. To support a multi-generational crossing of the linkage, linkage design must maintain continuity among moist riparian habitats, maintain water quality, and address mortality due to roadkill.

Distribution: California treefrogs are patchily distributed from central San Luis Obispo County south to the Mexican border (Morey 1988b) and can occur at elevations up to 1690 m (5500 ft)(Stebbins 1985). In the planning area, they have been recently documented in DeLuz and Sandia creeks and in the main stem of the Santa Margarita River (Fisher and Crooks 2001).

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

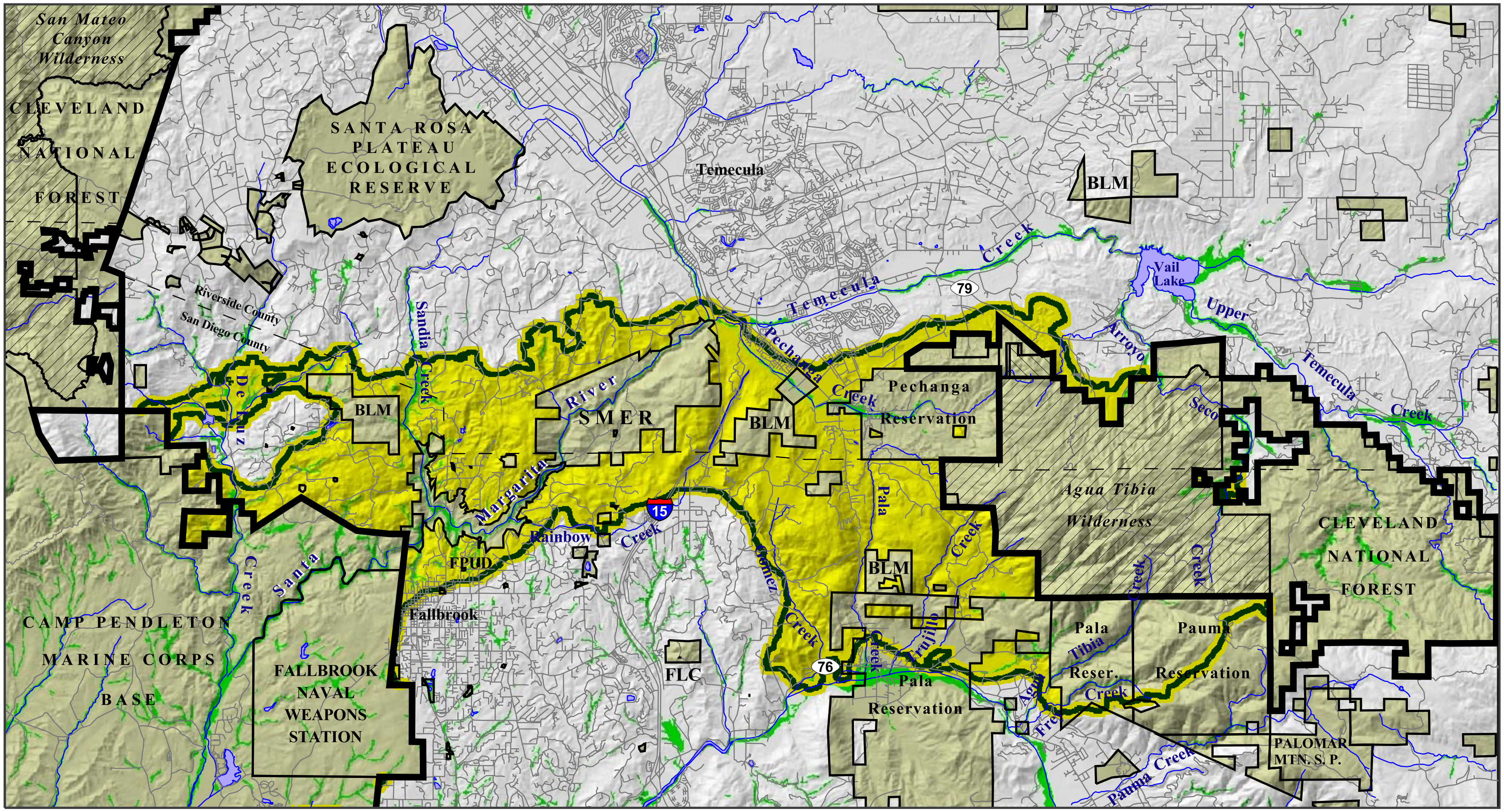
Home Range and Core Area Sizes: Frogs in the Los Angeles County living along an ephemeral stream made daily movements up to 200 m, although 83% of all movements measured were less than 25 m (82 ft) (Kay 1989). Home ranges of individuals overlap.

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

Conceptual Basis for Model Development: Suitable habitat was defined as riparian obligate vegetation types (i.e., riparian forests, woodlands, and scrubs). Because habitat quantity is a poor predictor of population density in treefrogs, we did not designate a minimum patch size, and included all suitable habitat as potential core habitat. Dispersal distance is 1 km (twice the maximum reported long-distance movement).

Results and Discussion: Treefrog habitat occurs in both Santa Ana and Palomar Mountain Core Areas: on the Santa Margarita River and De Luz Creek on Camp

Figure 20. Potential suitable habitat for California treefrog *(Hyla cadaverina).*
Suitable habitat includes obligate riparian vegetation communities. See text for assumptions regarding model inputs. BLM = Bureau of Land Management, FLC = Fallbrook Land Conservancy, FPUD = Fallbrook Public Utility District, SMER = Santa Margarita Ecological Reserve.



Legend

- Least-Cost Union
- suitable habitat
- paved roads
- county line
- Santa Ana and Palomar Core Areas
- major landholders*
- designated wilderness
- proposed wilderness
- hydrography
- lakes & reservoirs

*land management varies by ownership.

N

5 0 5 Kilometers

5 0 5 Miles

Map produced by:
SDSU Field Station Programs
March 15, 2004
http://fs.sdsu.edu

SDSU San Diego State University FIELD STATION PROGRAMS

SOUTH COAST WILDLANDS

Pendleton Marine Corps Base and the Fallbrook Naval Weapons Station and on upper Temecula and Arroyo Seco creeks in the Palomar Ranger District of the Cleveland National Forest. Habitat also occurs through drainages in the Least-Cost Union along Santa Margarita, De Luz, Sandia, Rainbow, and Pechanga creeks (Figure 20).
Core areas of potential suitable habitat in the Santa Ana and Palomar Mountains are separated by distances greater than the dispersal distance for this species (Figure 21). While individuals may be relatively mobile among areas with suitable habitat in the Santa Ana Mountains and the Least-Cost Union, distances among suitable habitat are too great to allow movements between Temecula Creek and the main stem of the river, two reaches along Wilson Creek, two reaches along upper Temecula Creek, and two reaches along Arroyo Seco Creek. Isolation of between upper Temecula and the Santa Margarita River and between two reaches on upper Temecula Creek are likely caused by habitat conversion. Habitat in these areas have been reduced by agricultural and urban developments.

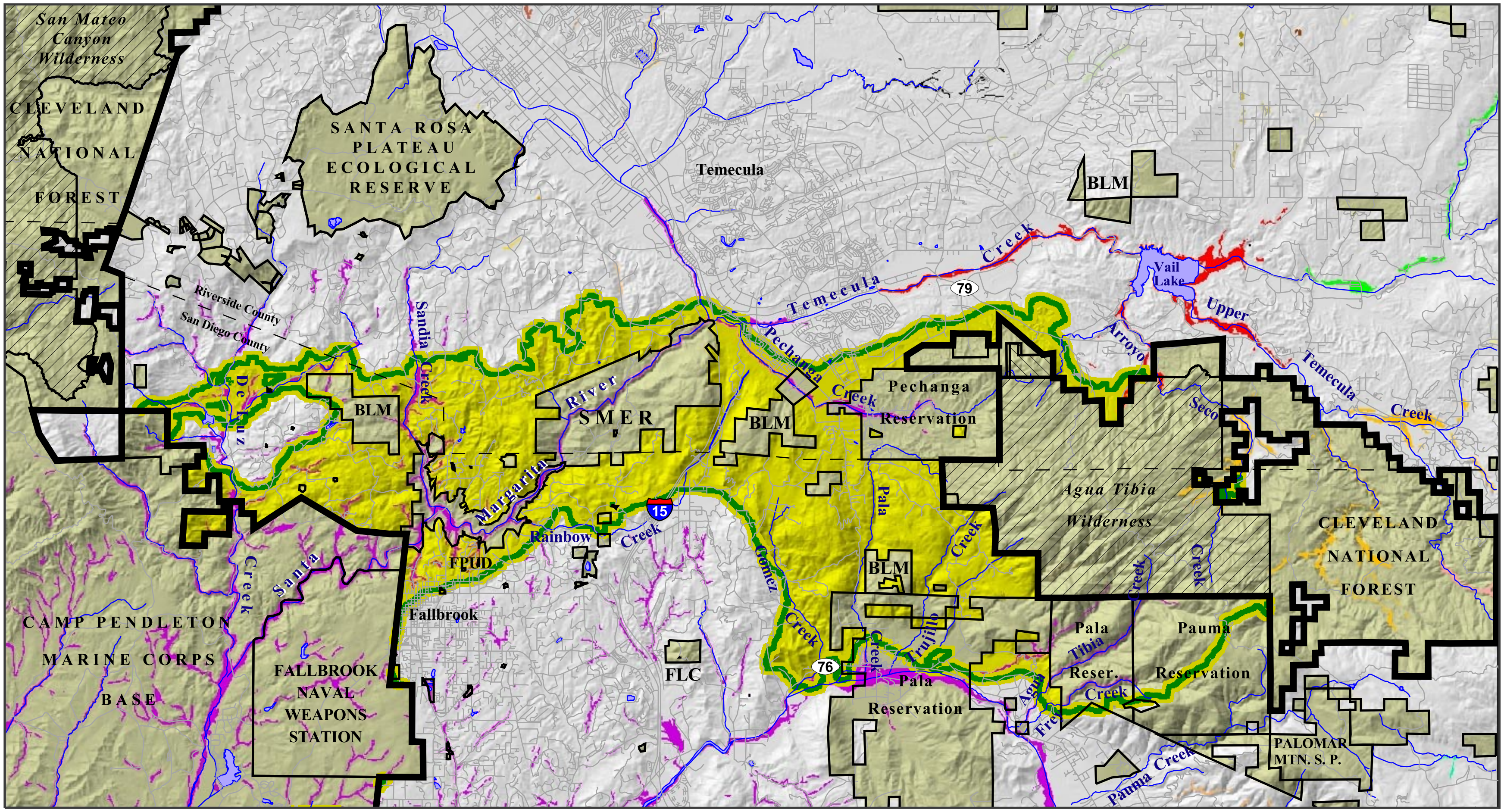
Connections between populations in the Santa Ana Mountains and higher areas of the Palomar Mountains are possible if habitat were to be restored along Temecula Creek and Vail Lake so that a contiguous habitat connection was available to populations in upper Temecula and Arroyo Seco creeks.

To restore and protect habitat connections for treefrogs between the Santa Ana and Palomar Mountain Core Areas, we recommend that:

- additional core areas of suitable habitat along Arroyo Seco and upper Temecula Creek be added to the Least-Cost Union (see Figure 17),
- perennial reaches of the Temecula and Arroyo Seco creeks be surveyed to determine if potential suitable habitat is of high quality and/or occupied by treefrogs,
- a riparian connection, with a 2-mi (3.2-km) upland buffer (see discussion at beginning of this section regarding edge effects), between Santa Margarita River and upper Temecula Creek be added to the Least-Cost Union (see Figure 17),
- riparian habitats needed for breeding and movement in the Temecula Creek and Arroyo Seco additions (above) be restored,
- Vail Dam be modified if necessary to allow amphibians to move around the dam,
- invasive species be eradicated that destroy treefrog habitat (e.g., giant reed) and prey on tadpoles (e.g., bullfrogs and fish),
- road barriers be modified, where necessary, to allow amphibians to move along water corridors, and
- water quality that is compromised by agricultural and urban runoff be restored.

The Rainbow Creek and De Luz habitat additions to the Least-Cost Union that are recommended to support other focal species would also benefit California treefrogs. The Rainbow Creek addition would provide additional aquatic and upland habitat for the frog and the De Luz addition would protect water quality by preserving upland habitat.

Figure 21. Distances among potential suitable habitat polygons for California tree frog *(Hyla cadaverina).*
Suitable habitat polygons that are farther apart than the species' dispersal distance (1 km) are shown in different colors. See text for assumptions regarding model inputs. BLM = Bureau of Land Management, FLC = Fallbrook Land Conservancy, FPUD = Fallbrook Public Utility District, SMER = Santa Margarita Ecological Reserve.



N

5 0 5 Kilometers

5 0 5 Miles

Legend

- Least-Cost Union
- Various Colors: Each color represents suitable habitat polygons within the species' dispersal distance.
- Paved Roads
- County Line
- Santa Ana and Palomar Core Areas
- major landholders*
- designated wilderness
- proposed wilderness
- hydrography
- lakes & reservoirs

*Land management varies by ownership.

SDSU San Diego State University
FIELD STATION PROGRAMS

SOUTH COAST WILDLANDS

Map produced by:
SDSU Field Station Programs
March 15, 2004
http://fs.sdsu.edu

Patch Size and Configuration Analysis:
Arroyo Chub (*Gila orcutti*)

Justification for Selection: Arroyo chub is the only native fish remaining in the watershed and populations occur in both Core Areas. Movement needs represented by arroyo chubs that guide linkage design include movement restricted to aquatic habitats, moderate dispersal distances, and sensitivity to aquatic barriers such as dams. To support this species and others like it, linkage design must minimize stream channel alteration and maintain water quality and natural hydrological regimes.

Distribution: Arroyo chub is native to the Los Angeles, San Gabriel, Santa Ana, San Luis Rey, and Santa Margarita River drainages (Wells and Diana 1975, Page and Burr 1991). It has also been introduced into other river drainages in southern California (Miller 1968, Moyle 1976, Page and Burr 1991). Arroyo chub occurs in 6 locations in the watershed: main stem of the Santa Margarita River, and De Luz, lower Sandia, Rainbow, Murrieta (near the confluence), Cole, and Temecula (upstream of Vail Lake) creeks (Swift et al. 1993, Fisher and Swift 1998, Swift et al. 2000).

Habitat Associations: Arroyo chubs prefer low-gradient, warm fluctuating streams with native emergent vegetation and slow-moving backwater areas with sandy substrates (Moyle 1976, 2000). Stream depth where this species occurs is typically greater that 40 cm (Moyle 1976).

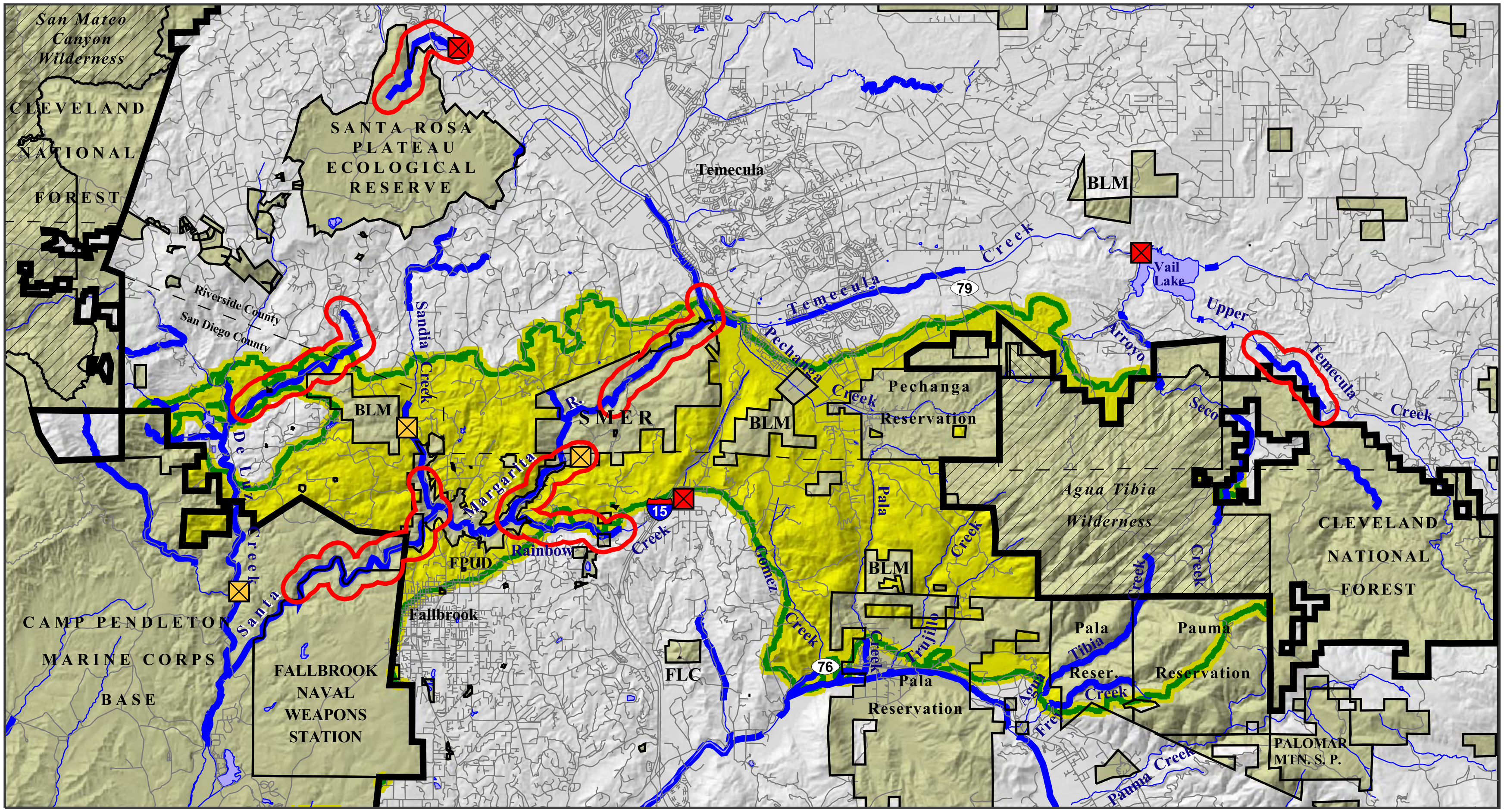
Home Range and Core Area Sizes: No home range or density estimates exist for this species.

Dispersal: Dispersal is facilitated during flooding events (Moyle 1976). The distribution of arroyo chubs on the mainstem of the Santa Margarita River increased after scouring floods (Fisher and Swift 1998, Swift et al. 2000, Warburton et al. 2001). In the Santa Ana River, larvae tend to invade standing backwaters or disperse downstream (Swift 2001). Distances traveled during these events are unknown.

Conceptual Basis for Model Development: Suitable habitat was modeled as areas with perennial surface streams. No other appropriate GIS data were available to model suitable habitat. Current locations of arroyo chub populations were mapped on top of the perennial surface streams.

Results and Discussion: Arroyo chubs are known to occur in the Santa Ana and Palomar Mountain Core Areas: in the Santa Margarita River on Camp Pendleton Marine Corps Base and the Fallbrook Naval Weapons Station and in upper Temecula

Figure 22. Potential suitable habitat for arroyo chub *(Gila orcutti)*.
Suitable habitat is shown as stream reaches that are likely to support perennial surface water. Polygons identify areas where arroyo chubs are known to occur. Barrier locations are provided by Warburton (pers. comm.) See text for assumptions regarding model inputs. BLM = Bureau of Land Management, FLC = Fallbrook Land Conservancy, FPUD = Fallbrook Public Utility District, SMER = Santa Margarita Ecological Reserve.



San Diego State University
FIELD STATION PROGRAMS

Map produced by:
SDSU Field Station Programs
March 16, 2004
http://fs.sdsu.edu

SOUTH COAST WILDLANDS

N

5 0 5 Kilometers

5 0 5 Miles

Legend

- Least-Cost Union
- suitable habitat
- known arroyo chub locations
- aquatic barriers (artificial)
- aquatic barriers (natural)
- paved roads
- county line
- Santa Ana and Palomar Core Areas
- major landholders*
- designated wilderness
- proposed wilderness
- hydrography
- lakes & reservoirs

*land management varies by ownership.

SDSU San Diego State University FIELD STATIONS

SOUTH COAST WILDLANDS

Creek at the boundary of the Palomar Ranger District in the Cleveland National Forest (Figure 22). The Least-Cost Union includes known locations on De Luz and Rainbow Creeks and on the upper Santa Margarita River. Three of the 6 areas where arroyo chub are known to occur are isolated by artificial or natural barriers: a natural water fall on De Luz Creek (populations upstream are likely introduced), a housing development on Cole Creek (the northernmost population in the planning area), and a dam on Vail Lake (Fisher and Crooks 1998).

To restore and protect habitat connections for arroyo chubs between the Santa Ana and Palomar Mountain Core Areas, we recommend that:

- additional core areas of suitable habitat along Rainbow and upper Temecula creeks where arroyo chubs are known to occur be added to the Least-Cost Union (see Figure 17),
- a riparian connection between Santa Margarita River and upper Temecula Creek be added to the Least-Cost Union (see Figure 17),
- riparian buffers extending at least 1.0 km (0.6 mi) into upland habitat on either side of aquatic habitat additions be protected. Contaminants, sediments, and nutrients can reach streams from even longer distances (Maret and MacCoy 2002, Scott 2002, Naicker et al. 2003), and fish, amphibians, and aquatic invertebrates often are more sensitive to land use at watershed scales than at the scale of narrow riparian buffers (Goforth 2000, Fitzpatrick et al. 2001, Stewart et al. 2001, Wang et al. 2001, Scott 2002, Willson and Dorcas 2003).
- hydrological regimes, water quality, and riparian vegetation be maintained or restored in and among core areas of suitable habitat (most notably along lower Temecula Creek between the Santa Margarita River and Vail Lake),
- artificial aquatic barriers (e.g., Vail Dam, the Hwy 79 crossing of Temecula Creek upstream of Vail Lake, and the gauging station at confluence of Temecula and Murrieta creeks (Fisher and Crooks 1998) be modified to allow for chub movement, and
- exotic species be eradicated that degrade or eliminate arroyo chub habitat (e.g., giant reed and tamarisk) or prey on arroyo chub (e.g., exotic fish such as largemouth bass, redeye bass, lack bullheads, green sunfish and mosquitofish).

The De Luz habitat addition to the Least-Cost Union that was recommended for other focal species would also benefit arroyo chub. The addition would provide increased protection for water quality for the population in this area.

Patch Size and Configuration Analysis: Southern Steelhead Trout (*Oncorhynchus mykiss irideus*)

Photo:

Justification for Selection: This species has been extirpated from the Santa Margarita watershed. Southern steelhead are habitat quality indicators that depend on all reaches of riparian systems, from ocean to headwaters, for spawning and rearing. Impassible aquatic barriers are the primary reason for population declines (Titus et al. 1994), and road crossings are the primary barriers in the Santa Margarita River main stem (Finney and Edmondson, no date). To reintroduce this species and others like it, linkage design must minimize stream channel alteration, restore breeding habitat, and maintain water quality and natural hydrological regimes.

Distribution: Southern steelhead trout once spawned in most of the major coastal streams in southern California and northern Baja California (Swift et al. 1993, Moyle et al. 1995). They have been extirpated from the Santa Margarita River, San Luis Rey River and 9 other southern California drainages (Higgins 1991, Moyle et al. 1995, Moyle 2002). Documentation of steelhead populations in the Santa Margarita River occurred for the first time during the 1940s when their numbers were already low. The cause of extirpation from the Santa Margarita watershed was most likely an extended dry cycle from the mid 1940s to late 1970s coupled with urban and agricultural growth in the watershed (Lang et al. 1998). This combination was sufficient to prevent surface flows from reaching the ocean during the winter for extended periods in the mid 1950s. Landlocked fish were likely extirpated due to fishing, disease and the introduction of exotic fish. Hatchery trout were planted in De Luz Creek in 1941-42 and in the main stem of the river in 1960s, 1970s and 1980s. Southern steelhead trout were recently rediscovered in 1999 in San Mateo Creek in the Santa Ana Core Area (CDFG 2000). Although documentation of the historic distribution of this species in difficult, they were known from Fern Canyon, a tributary to De Luz creek (C. Swift pers. comm.).

Habitat Associations: Adults spawn upstream soon after winter and spring flows reach the ocean. Adults spawn in perennial reaches of the river or its drainages and the juveniles emigrate to the sea the following winter (Land et al. 1998). Southern steelhead trout can be land-locked for several years as adults (Finney and Edmondson, no date) and require cold, clear, flowing water (California Trout 1996) and a sand or cobble substrate for successful spawning (Fisher and Swift 1998, Moyle 2002, Finney and Edmondson, no date). Riparian woodlands and thickets of herbaceous understory provide shading and maintain cool water temperature. To find these habitats, fish migrate great distances up into well-oxygenated cool waters of headwater tributaries (Moyle et al. 1995, 2002, Finney and Edmondson, no date). Dams and diversions restrict steelhead to lower elevation streams where summer water temperatures are too high for rearing young (Finney and Edmondson, no date). Roads and other ground disturbing activities increase siltation.

Home Range and Core Area Sizes: The size of spawning habitat needed to sustain breeding is unknown.

Dispersal: Juvenile fish spend 1-3 years in coastal streams before migrating to the estuary to adjust to saltwater. From the estuary, they move into the open ocean (Finney and Edmondson, no date). After 1 to 3 years in the ocean, adults return to their natal streams in December through April, navigating seasonally dry rivers during winter rainstorms (Finney and Edmondson, no date).

Conceptual Basis for Model Development: Suitable habitat was modeled as areas with perennial surface streams (see Table 3 for values used). No information is available on the historic location of breeding habitat in the watershed.

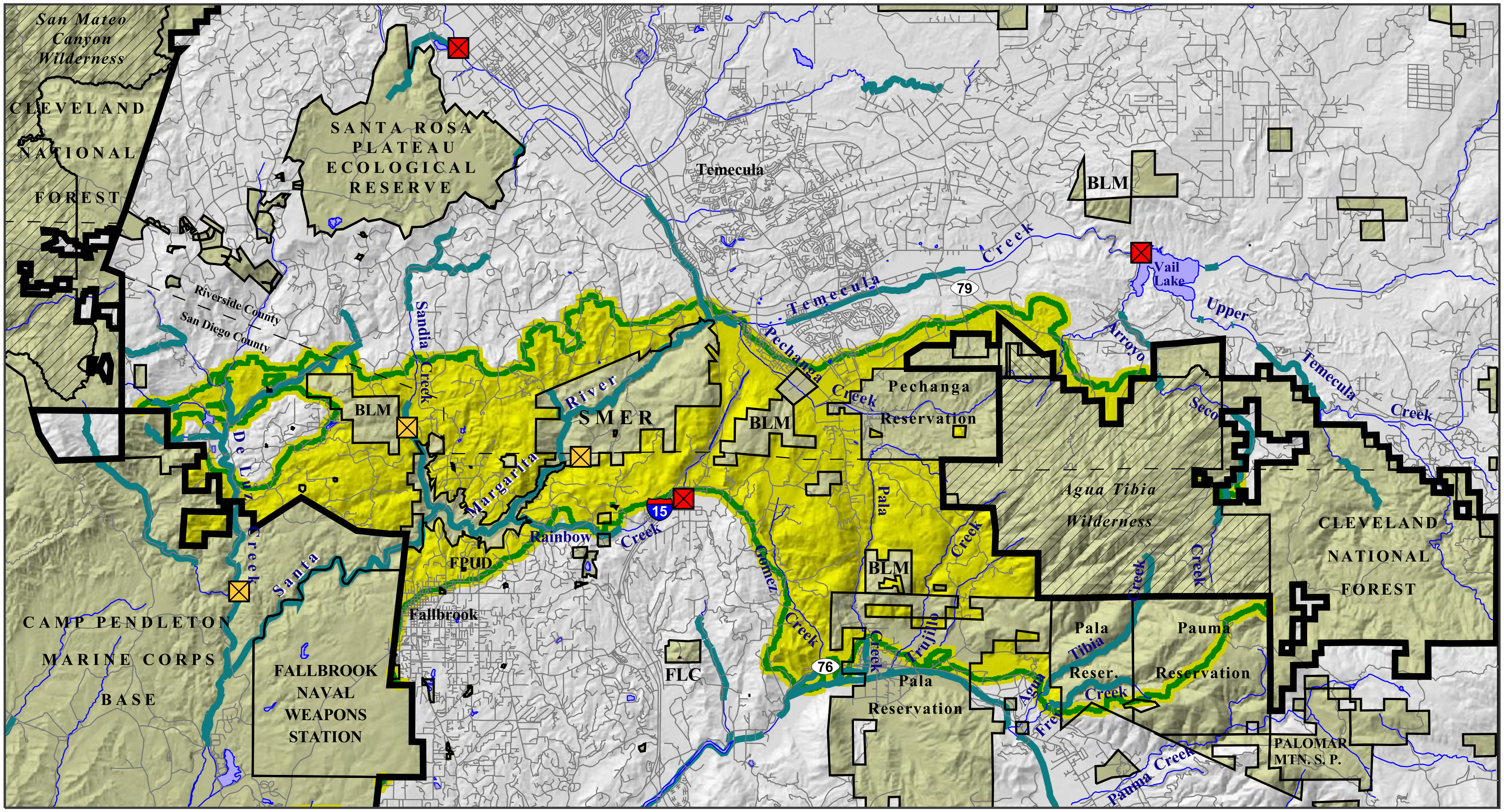
Results and Discussion: Historically, southern steelhead trout occurred within the Santa Ana and Palomar Core Areas in the San Mateo Creek, Santa Margarita River and San Luis Rey drainages. This species is capable of making long-distance inland movements. Whether fish ventured far enough inland to spawn in the drainages of the Palomar Mountains is unknown. Reestablishing steelhead movement through the Least-Cost Union between the Core Areas will require that suitable spawning and rearing habitat be restored so that the species may be encouraged to return to the Santa Margarita Watershed. Surveys will be necessary to establish whether spawning habitat may exist in perennial waters this far inland.

Surveys for existing potentially suitable spawning habitat have been conducted on Camp Pendleton Marine Corps Base (Lang et al. 1998). The most appropriate habitat was found on Roblar Creek (Figure 23), although a natural waterfall occurring 1.4 km (0.9 mi) upstream of the confluence of Roblar and DeLuz creeks would prevent fish movement into the upper reaches of the creek (Lang et al. 1998). A stretch of habitat 2-4 km below De Luz Road bridge could also provide spawning habitat if finer silt were to be flushed from the gravel substrate during high flow years (C. Swift pers. comm.). Spawning habitat surveys have not been conducted further upriver, but habitat may exist in the Santa Margarita River in Temecula Gorge. Rising bedrock in this area pushes water to the surface and the narrow canyon ensures strong scouring flows that remove silt from gravel substrates during winter storms. Additional surveys are needed in the perennial reaches of Temecula, Long and Arroyo Seco creeks above Vail Lake to determine if spawning habitat is or was historically present.

To restore and protect habitat connections for southern steelhead trout, we recommend that:

- perennial reaches of the Santa Margarita River and Rainbow, Temecula, Long and Arroyo Seco creeks be surveyed to determine if potential spawning habitat exists or can be restored in these areas,
- additional spawning habitat identified during field surveys be added to Least-Cost Union (possible areas include Rainbow and upper Temecula creeks) (see Figure 17),

Figure 23. Potential suitable habitat for southern steelhead trout *(Oncorhynchus mykiss irideus)*.
Suitable habitat is shown as streams reaches that are likely to support perennial surface water. Steelhead trout have been extirpated from the Santa Margarita and San Luis Rey watersheds. See text for assumptions regarding model inputs. BLM = Bureau of Land Management, FLC = Fallbrook Land Conservancy, FPUD = Fallbrook Public Utility District, SMER = Santa Margarita Ecological Reserve.



Legend

- Least-Cost Union
- suitable habitat
- aquatic barriers (artificial)
- aquatic barriers (natural)
- paved roads
- county line
- Santa Ana and Palomar Core Areas
- major landholders*
- designated wilderness
- proposed wilderness
- hydrography
- lakes & reservoirs

*land management varies by ownership.

N

5 0 5 Kilometers

5 0 5 Miles

SDSU San Diego State University FIELD STATION PROGRAMS

SOUTH COAST WILDLANDS

Map produced by:
SDSU Field Station Programs
March 16, 2004
http://fs.sdsu.edu

SDSU San Diego State University FIELD STATIONS

SOUTH COAST WILDLANDS

- if potential spawning habitat exists above Vail Dam, a riparian connection between Santa Margarita River and upper Temecula Creek be added to the Least-Cost Union and include a 2-mi upland buffer (see Figure 17).
- hydrological regimes be restored to maintain high quality habitat in spawning areas and provide surface water for movement during winter and spring,
- riparian vegetation be maintained or restored in areas with suitable spawning habitat, upstream of Vail Lake, and the gauging station at the confluence of Temecula and Murrieta creeks (Fisher and Crooks 1998)) be modified to allow for steelhead movement,
- exotic species be eradicated that degrade steelhead habitat (e.g., giant reed and tamarisk) or prey on young fish (e.g., exotic fish such as largemouth bass, redeye bass, lack bullheads, green sunfish and mosquitofish), and
- water quality that is compromised by agricultural and urban runoff be restored.

The De Luz habitat addition to the Least-Cost Union that was recommended for other focal species would also benefit southern steelhead trout by providing increased water quality protection in the watershed.

The final Linkage Design is a band of habitat roughly 7 km (4 mi) wide and 25 km (16 mi) long that spans the San Diego/Riverside county boundary near the communities of De Luz, Fallbrook, Rainbow, and Temecula (Figure 24). The area within the Linkage Design boundaries is designed to provide habitat for reproduction and movement of a diverse assemblage of species and allow natural processes to operate with minimal constraints from adjacent urban areas. In this section, we provide a detailed description of the Linkage Design, its land cover and use patterns, and prescriptions for mitigating a variety of movement barriers within its boundaries.

Description of the Linkage Design Area

The Linkage Design extends from the Santa Ana Core Area (Cleveland National Forest Trabuco Ranger District, Camp Pendleton MCB, and the Fallbrook Naval Weapons Station) to the western and northern boundaries of the Palomar Core Area (Cleveland National Forest Palomar Ranger District). The linkage boundaries encompass movement connections for species whose movements may be restricted to either riparian or upland habitats.

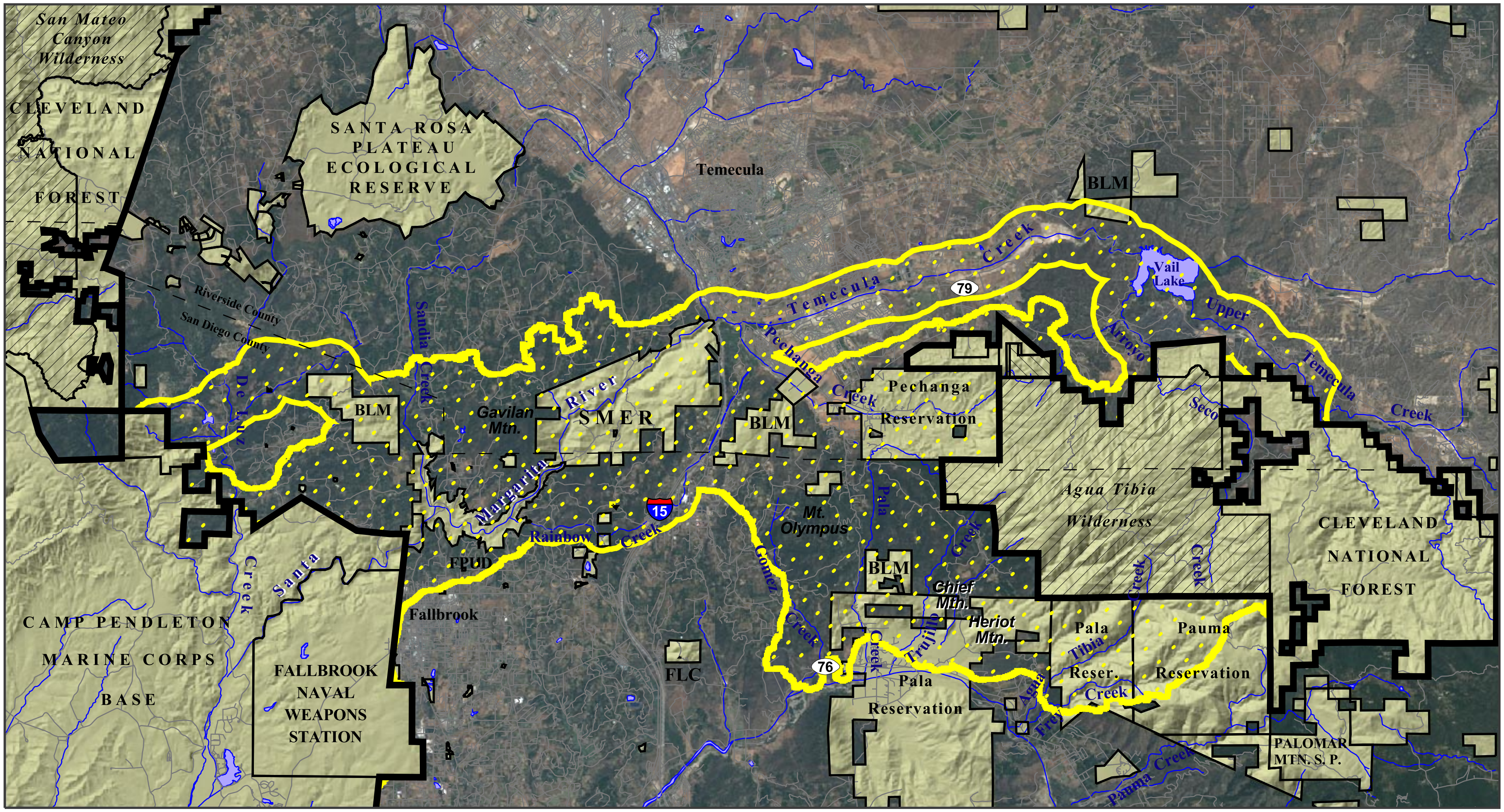
Riparian specialists move back and forth along the Santa Margarita River through Temecula Gorge to the confluence of Temecula and Murrieta creeks. From there they pass under I-15 up the broad sandy river bed of Temecula Creek in Pauba Valley into a narrow canyon in the foothills of the Palomar Mountains. The upper reaches of the canyon are damned to create Vail Lake. Passing across Vail Lake, riparian habitats fork to follow the Arroyo Seco and Temecula creek drainages to the boundary of the Palomar Ranger District of the Cleveland National Forest. For aquatic and semi-aquatic species (e.g., western pond turtle, California treefrog, arroyo chub), the Temecula Creek connection is the only area of the Linkage Design that provides for movement between populations in the Core Areas. While the connection was

LINKAGE DESIGN GOALS

- To provide move-through habitat for a diversity of species – both through the linkage and among populations in the linkage
- To provide live-in habitat that supports species with dispersal distances too short to traverse the linkage in one lifetime.
- To provide appropriate configuration of key resources and habitats within live-in habitat
- To protect aquatic and upland habitat quality (e.g., buffering against edge effects)
- To allow natural disturbance and recruitment processes to operate with minimal constraints
- To allow species and natural communities to respond to climate changes

For a more detailed description of these goals, see Approach Section.

Figure 24. Linkage Design for the Santa Ana - Palomar Connection.
This zone encompasses the best areas for movement and reproduction of a diverse assemblage of species between the Santa Ana and Palomar Core Areas with minimal constraints from adjacent urban and agricultural areas. BLM = Bureau of Land Management, FLC = Fallbrook Land Conservancy, FPUD = Fallbrook Public Utility District, SMER = Santa Margarita Ecological Reserve.



SDSU San Diego State University FIELD STATION PROGRAMS

SOUTH COAST WILDLANDS

Map produced by:
SDSU Field Station Programs
March 10, 2004
http://fs.sdsu.edu

N

5 0 5 Kilometers

5 0 5 Miles

Legend

- Linkage Design
- roads
- county line
- Santa Ana and Palomar Core Areas
- major landholders*
- designated wilderness
- proposed wilderness
- hydrography
- lakes & reservoirs

*land management varies by ownership.

historically viable, today it will require significant restoration efforts to preserve linkage function: in Pauba Valley, vegetation and surface water are currently absent due to agricultural and urban developments, and the dam at Vail Lake may pose a significant barrier for some species. Other drainages in the Linkage Design (i.e., De Luz, Sandia, Rainbow, and Pechanga creeks in the Santa Margarita Watershed and Gomez, Pala, Trujillo, Agua Tibia, Frey and Pauma creeks in the San Luis Rey watershed), also provide important habitat for upland, aquatic and semi-aquatic species, but aquatic habitats in these drainages stop short of providing a continuous connection between protected Core Areas.

Upland specialists can move back and forth in habitats extending from the eastern edge of the Santa Margarita Mountains in Santa Ana Core Area. The connection rises and falls through De Luz and Sandia canyons and over Gavilan Mountain into the granitic ridgelines of the Santa Ana foothills at I-15. This area of the linkage encompasses upland habitats south of the Santa Margarita River and Rainbow Creek and includes Red Mountain. From I-15, upland habitats continue eastward through Rainbow Valley (north of the Monserate Mountains) across the Gomez, Pala, and Trujillo drainages to the Agua Tibia Wilderness of the Cleveland National Forest Palomar Ranger District. The connection includes Mount Olympus, and Tourmaline Queen, Chief, and Heriot mountains. This upland component of the Linkage Design area provides significant habitat for all terrestrial and semi-aquatic focal species. The crossing at I-15 has been previously identified as a key habitat connection ("Pechanga Corridor") for mountain lion (Beier and Barrett 1993). Most of the upland connection is intact although natural habitats are perforated or highly constricted in several places by agricultural and urban developments in the De Luz area, and I-15 is a significant barrier for most species.

Land Cover, Use and Ownership

Approximately 1/3 of the Linkage Design area is protected under ownership and management policies that do not allow conversion to urban or agricultural use. These lands owners are Bureau of Land Management (BLM), California Department of Fish and Game (CDFG), County of San Diego, State Lands Commission, San Diego State University (SDSU), and The Nature Conservancy (TNC) (Figure 24). CDFG, TNC and some BLM lands are administered by SDSU's Field Station Programs as part of the Santa Margarita Ecological Reserve. Other major landholders include the Fallbrook Public Utility District (along the Santa Margarita River) and the Pechanga, Pala, and Pauma Reservations (in the foothills of the Palomar Mountains in the eastern portion of the Linkage Design).

The Linkage Design area encompasses 33 natural vegetation communities (Table 5), 11 of which are considered sensitive by the State of California (CDFG 2002). These vegetation communities cover the majority of the Linkage Design area (about 89%); urban developments and agriculture cover the remaining 11% of the land. Habitats within the linkage are similar to those found in the two Core Areas, with chaparral, coastal scrub, and woodland communities dominating. Chaparral is by far the most common vegetation community, occurring on north-facing slopes and throughout

Table 5. Vegetation communities in the Linkage Design. Asterisks (**) indicate communities designated as sensitive by the State of California.

Vegetation Community	Hectares	Acres
CHAPARRAL COMMUNITIES (40%)		
Southern Mixed Chaparral	14,821	36,625
Ceanothus crassifolius Chaparral	1,336	3,301
Chaparral	946	2,337
Northern Mixed Chaparral	842	2,081
Red Shank Chaparral	301	744
Chamise Chaparral	249	616
SCRUB COMMUNITIES (22%)		
Diegan Coastal Sage Scrub	7,733	19,109
Coastal Sage-Chaparral Scrub	1,746	4,317
Riversidian Sage Scrub**	383	947
Alluvial Fan Scrub**	119	295
WOODLAND AND FOREST COMMUNITIES (12%)		
Coast Live Oak Woodland	2,611	6,453
Black Oak Forest	1,268	3,134
Engelmann Oak Woodland**	685	1,691
Jeffrey Pine Forest	412	1,017
Bigcone Spruce (Bigcone Douglas Fir) - Canyon Oak	303	749
Mixed Evergreen Forest (Palomar Mountain)	168	415
Oak Woodland	70	173
HERBACEOUS COMMUNITIES (7%)		
Non-Native Grassland	2,823	6,976
Valley Needlegrass Grassland**	438	1,081
Valley and Foothill Grassland**	104	256
Montane Meadow	4	9
RIPARIAN COMMUNITIES (4%)		
Southern Sycamore-Alder Riparian Woodland**	440	1,088
Southern Coast Live Oak Riparian Forest**	409	1,010
Southern Cottonwood-Willow Riparian Forest**	393	971
Southern Willow Scrub	300	741
Southern Riparian Scrub	143	354
Mule Fat Scrub	140	346
Freshwater	63	157
Southern Arroyo Willow Riparian Forest	45	112
Coastal and Valley Freshwater Marsh**	24	58
Southern Riparian Forest	10	25
White Alder Riparian Forest**	9	22
Meadow and Seep	2	5
OTHER LAND COVER (15%)		
Agriculture: Orchards and Vineyards	3,051	7,540
Agriculture: Other	914	2,259
Urban/Developed	2,628	6,495
Non-Vegetated Channel, Floodway, Lakeshore Fringe	190	469
Eucalyptus Woodland	16	39
Disturbed Habitat	7	17

higher elevation areas of the linkage. Coastal scrub is the second most common, dominating south-facing slopes and lower coastal areas of Camp Pendleton Marine Corps Base. Coast live oak and Engelmann oak woodlands are spotty throughout the linkage, occurring along ephemeral drainages or as small groves in higher elevation areas.

Despite the relatively low amount of acreage encompassed by riparian communities (about 4.5%), these habitats support a disproportionately large number of species and are key movement areas for most aquatic and terrestrial organisms. Southern Sycamore-Alder Riparian Forest, a sensitive plant community, is the most common riparian community and occurs primarily in areas with surface water. Historical aerial photographs provide evidence that well-developed stands of riparian scrub and woodland provided avenues for riparian and aquatic species to move between the Santa Ana and Palomar Ranges (see Figure 36 in Stream Barriers Section). Today, riparian forests are significantly reduced and in some places absent along Temecula Creek.

The pine associations found at higher elevations in the Core Areas are rare in the linkage, occurring only on the eastern edge near the Agua Tibia wilderness. However, affinities between high-elevation plant assemblages (e.g. canyon live oak, and knob-cone pine) in the Santa Ana Mountains and northern inland ranges suggest that under moister climatic conditions, the linkage may have allowed dispersal of plant species from inland ranges into the Santa Ana Mountains.

Removing and Mitigating Barriers to Movement

Five common features impede species movements through the Linkage Design area to varying degrees:

- roads,
- dams and other impediments to stream flow,
- urban development,
- agriculture, and
- recreation.

Although these comprise only a small portion of the Linkage Design area, their adverse effects on species habitat and movements are disproportionately large. In this section, we provide suggestions for improving linkage function. For each barrier type, we present background information available on effects and mitigation approaches, describe how barriers are distributed in the Linkage Design area, and provide recommendations for ameliorating, preventing, or removing barrier effects.

We encourage the reader to use these recommendations as a starting point for linkage conservation. Many of the conservation actions will require additional planning and modification as new information on biology and regional planning becomes available. 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, and to work within this framework to develop a wide variety of restoration options for maintaining linkage function.

Road Barriers

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, Forman and Deblinger 2000, Jones et al. 2000, Trombulak and Frissell 2000). Roads fragment plant and animal populations by killing animals in vehicle collisions, creating discontinuities in natural vegetation (the road itself and induced urbanization), altering animal behavior (noise, artificial light, human activity), promoting invasion of exotic species, and degrading the chemical environment (Lyon 1983, Noss and Cooperrider 1994). The genetic isolation of populations caused by roads is an increasing cause of concern. For example, Ernest et al. (2003) documented little flow of mountain lion genes between the Santa Ana and Palomar ranges (where I-15 is the most obvious barrier), and between the Sierra Madre and Sierra Nevada (where I-5, and urbanization along SR-58, are the most obvious barriers). Population fragmentation increases the risk of inbreeding and genetic drift, disrupts meta-population processes, and potentially contributes to extinctions of local populations.

The low permeability across existing roads should not be accepted as irreversible. Although crossing structure improvements may require many years to plan and construct, genomic and metapopulation processes are expected to recover quickly once connectivity is restored. For this reason, a lack of permeability should not be used as an excuse to develop lands adjacent to roads on the grounds that the road is a permanent and absolute barrier. (In contrast to roads, urban and suburban developments make particularly inappropriate landscapes for most plant and animal movements and create a more significant and permanent obstacle to landscape connectivity than the road itself.)

Restoring connectivity across roads has already begun in the United States and other countries. California, Florida, New Jersey, and Hawaii have all undertaken projects to mitigate the effects of road barriers (see review below). The potential for similar successes in the South Coast Ecoregion is high. Representatives from CalTrans have attended each of the four workshops of the South Coast Missing Linkages effort, and the agency is eager to spend its mitigation dollars in the most important linkage areas. For example, CalTrans recently proposed building a wildlife overpass over SR-118, and in February 2003 CalTrans started removing pavement from the Coal Canyon interchange in Orange County and transferred the property to California State Parks expressly to allow wildlife movement between Cleveland National Forest and Chino Hills State Park. These activities are indicators of the potential for successful collaborations to restore landscape connectivity.

***Examples of Mitigation for Roads in Upland Habitats*:** Wildlife crossing structures that have been used to enhance movements across roads both in the United States and in other countries include vegetated overpasses, bridges, underpasses and culverts. (Although some documents refer to such structures as “corridors” or even "linkages," we restrict the use of these terms to their original meaning which refers to the collection of habitats that link two larger protected core areas.) Most structures (Figures 25 and 26) were originally built to provide adequate drainage under roads, but research has confirmed the value of these structures in facilitating wildlife movements. The main types of structures, from most to least effective, are vegetated land-bridges, bridges, and culverts.

Figure 25. Examples of existing potential crossing structures (from left to right): viaduct, bridge, cement box culvert, and drainage pipe (in a fill slope).

Some structures can be built to allow species to move safely over roads. There are about 50 vegetated land bridges, or wildlife overpasses (Figure 26), in Europe, Canada, Florida, Hawaii, New Jersey, and Utah (Evink 2002, Forman et al. 2003) ranging in width from 50 m (164 ft) to 200 m (656 ft) (Forman et al. 2003). Soils on the bridges support growth of herbaceous, shrub and tree cover and range in depth from 0.5 to 2 m (Jackson and Griffin 2000). The overpasses maintain ambient conditions of rainfall, temperature, light, vegetation, and cover, and are quieter than underpasses (Jackson and Griffin 2000). In Banff, large mammals preferred overpasses to other crossing structures (Clevenger et al. 2001, Forman et al. 2003). Similarly, birds associated with woodland habitats preferentially used overpasses to cross roads. Other research indicates overpasses may encourage birds and butterflies to cross roads (Forman et al. 2003).

Structures can also be constructed to allow species to move *under* roads. Of these, bridges that allow cars to drive over the habitat are the most successful and cost-effective means of providing connectivity (Evink 2002). Tall bridges are generally more

Figure 26. Examples of vegetated land bridges built to enhance movement of wildlife populations. Photos by Scott Jackson (left) and David Poulton (right).

successful than low bridges and culverts (Veenbaas and Brandjes 1999, Jackson and Griffin 2000). The best bridges, sometimes termed viaducts (Figure 25), are elevated roadways that span entire wetlands, valleys, or gorges (Jackson and Griffin 2000). Viaducts permit growth of both riparian and upland vegetation along both stream banks (Veenbaas and Brandjes 1999, Jackson and Griffin 2000, Evink 2002, Forman et al. 2003,) and are cost-effective where topographic relief is sufficient to accommodate the structure (Evink 2002).

Although inferior in performance to bridges, culverts can be effective for many species depending on the materials and dimensions of the structure (Jackson and Griffin 2000). For carnivores and other large mammals, large box culverts with natural earthen substrate flooring are most effective (Evink 2002). For rodents, pipe culverts 0.3 m (1 ft) in diameter without standing water are superior to large, hard-bottomed culverts, apparently because the overhead cover makes them feel secure from predators (Clevenger et al. 2001, Forman et al. 2003). In places where a bridge or vegetated overpass is not feasible, placing pipe culverts alongside box culverts can help serve movement needs of both small and large animals.

The performance of wildlife crossing structures can be substantially improved by installing wildlife fencing, earthen berms, and vegetation with little additional investment (Falk et al. 1978, Ludwig and Bremicker 1983, Feldhammer et al. 1986, Forman et al. 2003). Fences direct animals to passageways and away from roads (Forman et al. 2003). Escape routes or devices, such as spaced earthen ramps on the inside of a fence, should also be installed to allow animals that wander into a fenced road section to pass over fences (Bekker et al. 1995, Rosell Papes and Velasco Rivas 1999, Forman et al. 2003). Shrubs and trees can be planted near the crossing structure entrance (Evink 2002) to reduce the effects of noise, artificial night lighting, and other human activities that deter animal use of passageways (Yanes et al. 1995, Pfister et al. 1997, Clevenger and Waltho 2000, Forman et al. 2003). Bobcat use of culverts increases dramatically as woody cover near the structure increases, and structures with less than 50% woody cover within 100 m (320 ft) received little or no bobcat traffic; in seasonally flooded areas, bobcats strongly prefer culverts with a catwalk to provide a dry floor (Cain 1999). Contiguous vegetation throughout the crossing also enhances movement, particularly for small ground-dwelling animals. Branches, logs, and other cover can be placed along overpasses and under bridges (Forman et al. 2003).

Wildlife crossing structures are gaining popularity in the United States. In California, these structures allow the federally threatened desert tortoise to move across a 35-km (22-mi) section of SR 58 in the Mohave Desert (Evink 2002). The Coal Canyon interchange on SR 91 is being converted, through a partnership with CalTrans, California State Parks, and Hills for Everyone, from a vehicle interchange into a wildlife underpass that facilitates movement between the Chino Hills and the Santa Ana Mountains. In Orange County, bridges and viaducts were specifically installed during the construction of SR 241 to facilitate wildlife movement, although urbanization near this toll road has compromised their utility (Evink 2002). In south Florida, underpasses constructed for wildlife on 64 km (40 mi) of Interstate 75 are used by federally endangered Florida panthers and bears, and have reduced panther and bear roadkill to zero on that route. Smaller wildlife crossings on SR 29 in south Florida have proved nearly as effective (Lotz et al. 1996). All of these structures were constructed for wildlife movement or were part of existing structures that were modified.

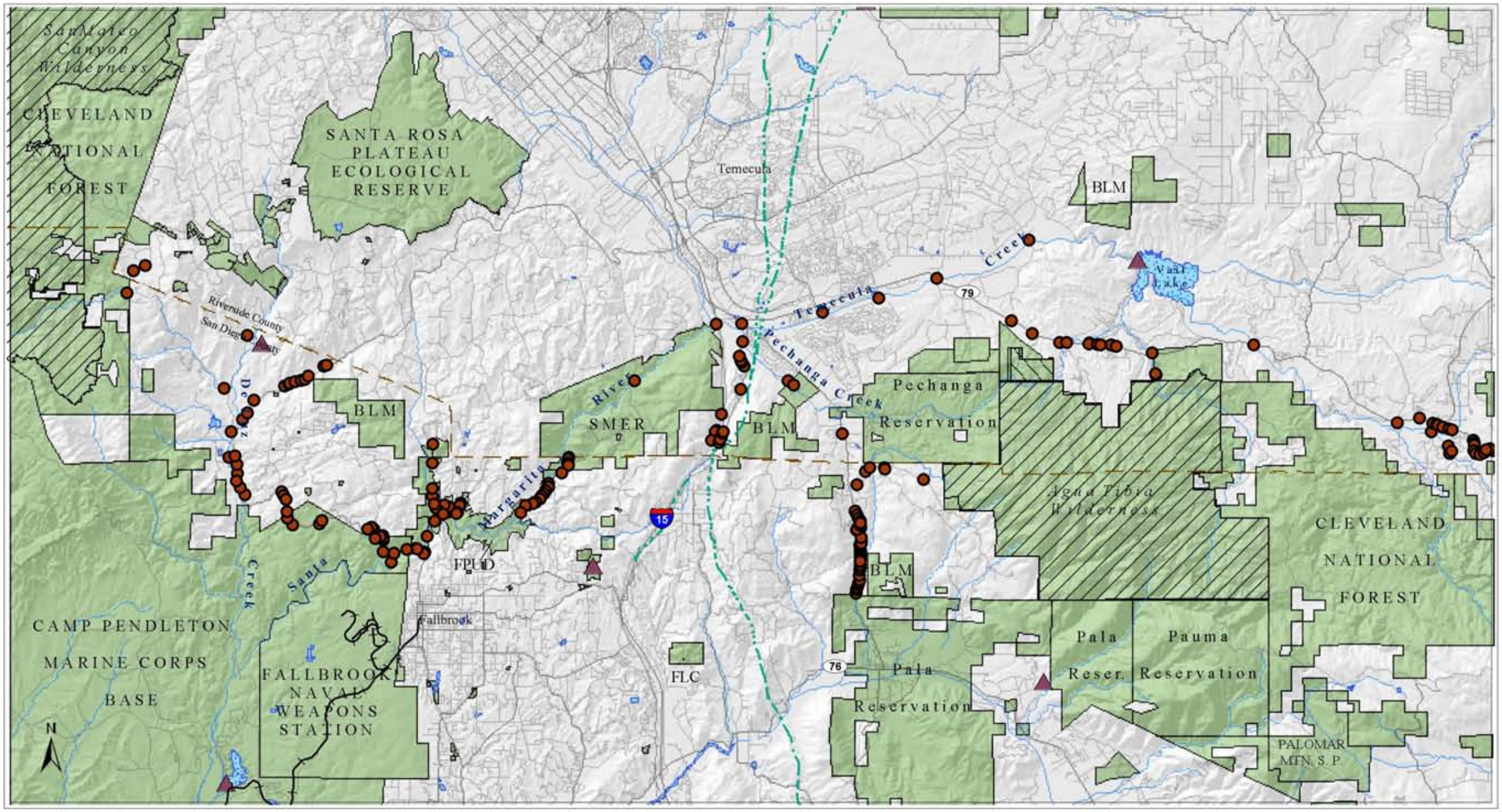
***Roads in the Linkage Design Area*:** At the time of this report, there are 1,022 km (635 mi) of paved roads in the Linkage Design area. Thirteen of these roads are major transportation routes and pose the largest impacts since they run roughly north-south through the linkage (Table 6). These include one interstate highway and 3 state or county highways. By far, the largest of these impediments is Interstate 15 which bisects the linkage for a distance of 10 km (6 mi). We conducted detailed surveys of many of these roads to document existing structures (Figure 27, Table 7) that could be

Table 6. Major transportation routes in areas of the Linkage Design. Roads separated by slashes form a common transportation route.

Road Type	Name	km	mi
Eastern Linkage			
State Highway	State Highway 79	22	14
Neighborhood Road	Rancho Heights Road/Magee Rd	13	8
Neighborhood Road	Anza Rd	11	7
Central Linkage			
Interstate Highway	I-15 (Temecula Valley Freeway, Avocado Hwy)	10	6
State Highway/Neighborhood Rd	Old Highway 395/Frontage Rd/Rainbow Cyn Rd	10	6
Neighborhood Road	Rainbow Valley Blvd	3	2
Neighborhood Road	Rainbow Glen Rd	3	2
Neighborhood Road	Willow Glen Rd	2	1
Western Linkage			
Neighborhood Road	Sandia Creek Dr	8	5
Neighborhood Road	De Luz Rd	19	12
Neighborhood Road	De Luz Murrieta Rd	5	3
Neighborhood Road	Harris Trail/De Luz Heights Rd	6	4
Neighborhood Road	Supale Ranch Rd	2	1
TOTAL		**114**	**71**

Figure 27. Existing infrastructure in the Linkage Design area

BLM = Bureau of Land Management, FLC = Fallbrook Land Conservancy, FPUD = Fallbrook Public Utility District, SMER = Santa Margarita Ecological Reserve



SOUTH COAST WILDLANDS
Map Produced By:
South Coast Wildlands
May 2004
www.scwildlands.org

SDSU San Diego State University FIELD STATIONS

modified to enhance species movements through the area. We found a variety of bridges, culverts and drainage pipes that were installed to move water under existing roads. These structures could be modified to enhance movements. (An extensive database of the roads surveyed, crossing structures and their conditions is available). Here we provide more detailed descriptions of each of these roads.

Table 7. Summary of existing road infrastructure found during field surveys that could be used to support movement in the Linkage Design. See text for detailed descriptions and recommendations for each road.

Road Surveyed	Bridges (No.)	Drainage Pipes No. (diam. in m)	Other Structures	Opportunities for Increasing Wildlife Movement
Interstate 15	2	2 (1.5), 1 (0.6)	none identified	Install upland habitat overpass. Riparian habitat restoration needed east of I-15 for both bridges. Replace drainage pipes with underpasses.
St Rt 79	4	0	none identified	Use fencing to direct animal movements under bridges.
Old Hwy 395	1	0	none identified	Riparian habitat restoration needed to the east of I-15.
County Hwy 16 - Pala Temecula Road	1	30 (< 0.6), 3 (1)	none identified	Larger structures in good condition. Remove debris on smaller pipes and focus animal movements with fencing.
Sandia Creek	1	7 (< 0.6), 3 (1-2 m)	none identified	Larger pipes OK. Remove debris and repair smaller pipes. Replace the pipes on Sandia Creek with a culvert or bridge to allow for movement.
De Luz	2	24 (< 0.8 m), 3 (1-2 m)	3 fords	Remove debris and repair smaller pipes and focus animal movements with fencing.
De Luz Murrieta	0	6	3 culverts	Replace 3 insufficient culverts on De Luz Creek. Remove debris and repair smaller pipes and focus animal movements with fencing.

Interstate 15 Description: Interstate 15 bisects the linkage at its midpoint (Figures 27 and 28) and, despite the occurrence of two large bridges and 3 drainage pipes, lacks adequate crossing structures to accommodate species moving through upland and aquatic habitats.

The Temecula Creek Bridge spans Temecula Creek just east of the point where it joins Murietta Creek to form the Santa Margarita River (Figure 29). Although the structure of the bridge would permit use by both upland and riparian focal species, the adjacent

Red Hawk Golf Course and commercial and residential developments in the growing city of Temecula may hinder movements by some species to and from the bridge on the bridge's eastern side. Riparian habitats further upstream fail to connect to other natural habitats in the Palomar Mountains and are currently a dead-end for species moving eastward along Temecula Creek.

Figure 28. Looking west across Interstate 15, toward the Santa Ana Mountains from Sage Scrub Ridge in the Palomar Mountains.

The Rainbow Creek bridge (Figure 29) is bounded to the west by a rural residential area and to the east by a highly urbanized and agricultural area. Riparian habitat stretches along Rainbow Creek under the bridge but then passes abruptly into agriculture and nurseries. Bobcat, striped skunk, dusky-footed woodrat, and a number of coyote were killed on Interstate 15 in the vicinity of this structure (Fisher and Crooks 2001). Although species acclimated to the urban fringe may find and attempt to use this structure, the level of human activity on the east side of the freeway probably precludes successful passage for fragmentation sensitive species.

The other existing drainage pipes along I-15 in the Linkage Design area are inadequate for the majority of focal species. Two of the 3 corrugated metal pipes are 1.5 m (4.9 ft) in diameter and the remaining is 0.6 m (1.9 ft) in diameter. All are roughly 90 m (144 ft) in length. Curvature in the pipes prevents visibility from one side to the

Figure 29. Interstate 15 bridges. Two extended bridges crossing Temecula Creek (left, photo: © Andrew Harvey, Visual Journeys.net) and Rainbow Creek (right) in the Linkage Design area.

other. Drainage pipes 1.5 m (4.9 ft) in diameter and over 50 m (164 ft) long have been used by amphibians and reptiles (Forman et al. 2003), but the lack of visibility through the I-15 pipes may deter even this usage. There is probably little, if any, passage by small mammals, which prefer shorter culverts (Yanes et al. 1995, Rosell Papes and Velasco Rivas 1999, Forman et al. 2003).

Interstate 15 Recommendations

- Due to the significance of I-15 as a barrier and the compromised function of the Temecula and Rainbow Creek bridges, a top priority for restoring linkage function is to install a habitat overpass just north of the Border Patrol checkpoint (Figure 30). On the western side of I-15, most of the lands are protected by the Santa Margarita Ecological Reserve. To the east of I-15, a band of relatively undisturbed habitat winds eastward towards the Palomar Ranger District of the Cleveland National Forest. Between October 1990 and December 1992, 3 mountain lions were killed, but a young mountain lion successfully crossed the highway at this location (Beier and Barrett 1993). Based on population models, Beier and Barrett (1993) concluded that this connection must be secured for immigration of cougars from the Palomar Range to prevent the extinction of the population in the Santa Ana Mountains. We support the recommendations of Barrett and Beier (1993) that a habitat overpass be built at this site (Figure 30) and wildlife fencing be installed to funnel animals towards the structure.

- To make the Temecula Bridge a functional passageway, we recommend restoring a vegetated riparian corridor from the Temecula Creek crossing to natural habitats in the Palomar Mountains and restoring a chaparral connection near the bridge on the east side of I-15. Viability of the bridge for species moving through upland habitats can be achieved by restoring a broad band of chaparral habitat that extends from the Temecula Creek bridge to the habitats on the ridgeline above the golf course, and removing existing golf course fences and any other barriers. (We address the riparian restoration needs in the section on stream barriers).

Figure 30. Potential site for vegetated land bridge on Interstate 15; near call box 15-16.

- To make the Rainbow Creek Bridge a functional passageway, we recommend restoring riparian habitat on the east side of I-15 through the town of Rainbow.

- To improve the functionality of existing drainage pipes, we recommend replacing the pipes with concrete underpasses that are large enough to provide visibility to the other side. Underpasses should have earthen flooring, and appropriate fencing and cover should be used to guide animals to underpasses and facilitate the movement of smaller species.

***Other Paved Roads Descriptions*:** Other paved roads in the Linkage Design area are two lanes wide (including State Route 79, Old Highway 395 and the Pala Temecula Road). If traffic is not too heavy, some larger mammals, birds and insects are often able to successfully cross roads of this type, but small mammal and reptile mortalities are fairly high (Fisher and Crooks 2001). Fisher and Crooks (2001) showed that roads in the linkage area vary substantially in their danger to wildlife depending upon level of use. Here we highlight some of the needs for movement across four of the high-use roads in the Linkage Design area: State Route 79, Pala Temecula, Sandia Creek, De Luz, and De Luz Murrietta roads. We summarize specific recommendations at the end of this section.

Figure 31. Arroyo Seco Bridge on Highway 79; the Cleveland National Forest boundary is directly east of this point. Bridge design allows for wildlife passage.

State Route 79 Description: State Highway 79 is a 2-lane, high-speed road with heavy traffic that crosses key riparian drainages in the eastern portion of the Linkage Design area. The highway runs east from I-15, paralleling Temecula Creek in the City of Temecula where it is bordered by dense urban and agricultural development. Near Anza Road, it crosses Temecula Creek and turns southward out of the Linkage Design area and then reenters to cross Arroyo Seco (Figure 31) and Temecula creek drainages above Vail Lake near the Cleveland National Forest Palomar Ranger District. These bridges vary in height from 2 to 10 m (7 to 33 ft) and in depth from 8 to 10 m. All four bridge locations have well-developed riparian and/or upland vegetation and a clear view from one side to the other. Few modifications are needed to these bridges; appropriate fencing should be used to enhance utility of these bridges.

Old Highway 395 is a 2-lane road that runs along the eastern side of Interstate 15 for roughly 5 km (3 mi) and then sequentially joins Frontage Road and Rainbow Canyon Road to cross the Linkage Design area. Immediately after Rainbow Creek flows under the Interstate (Figure 29, it passes under a bridge (20m wide X 3m high X 22m in length) on Old Highway 395 (Figure 32). The remaining upland habitat in the vicinity of the structure is comprised of chaparral and coastal sage scrub. Coast live oak riparian forest and periodic Sycamores line the creek immediately east of the structure before flowing into the agricultural and developed areas in the community of Rainbow. While the structure is adequate for most species, habitats to the east of I-15 have been replaced by nurseries and other urban developments. For this connection to be functional, habitat will need to be restored through the community of Rainbow.

Figure 32. Rainbow Creek Bridge at Old Highway 395. Bridge design allows for wildlife passage.

County Highway 16 - Pala Temecula Road runs from SR 79 near Pala Road to State Highway 76. There is rural residential and agricultural development along the northern section of the road, but extensive habitat exists on either side for most of its length. Chaparral blankets much of the hillsides and coast live oak woodlands dominate Pala Creek and other drainages. Due to the rugged terrain, numerous drainage pipes were installed on the southern portion of the road, creating the highest density of crossing structures in the Linkage Design area. Thirty-three corrugated metal pipes (30 of which were less than 0.6 m (2.0 ft) diameter, 3 pipes 1 m (3 ft) diameter) are spaced roughly 75 m (250 ft) apart along the southern section of the road. While the majority of the larger structures (1 m (3 ft) in diameter) were in good condition with vegetative cover at the approaches, the smaller structures were generally in need of maintenance or replacement, because they were either clogged with sediment, leaves, or trash, or crushed. Some provided visibility to the other side, but light levels were low inside the pipes. Some amphibians, reptiles, or small mammals may currently use a few of these smaller drainage pipes, but circular metal pipes with non-natural flooring aren't ideal crossing structures, and there is presently no fencing to guide animals to these potential passageways. One bridge (2.4 m (7.9 ft) wide, 1.5 m (4.9 ft) high, and 11 m (36 ft) long) crosses over an unnamed tributary of Pala Creek dominated by coast live oak riparian forest near Encinos Road.

Sandia Creek Road runs north-south through the western portion of the Linkage Design area (Figure 27), cutting across the main stem of the Santa Margarita River and following Sandia Creek for most of its distance. Sycamores and alders with an understory of mulefat and willow line both sides of the road. Upland habitats are predominantly chaparral, although coastal sage scrub occurs on gentle slopes to the east, and oak woodlands line the canyons. Some rural residential and agricultural development also occurs along this road.

Crossing structures on Sandia Creek Road include the bridge at the Santa Margarita River and 10 drainage pipes. The bridge is adequate for allowing movements for most upland and aquatic species. The drainage pipes vary in size from less than 0.6 m (2.0 ft) in diameter (7 pipes; 4 of these provide no visibility to the other side), to 1 - 2 m (3 – 6 ft) in diameter (3 pipes). Most of the larger pipes have vegetative cover at the approaches and may currently function for smaller species in addition to some mid-sized mammals. One structure is a combination of 3 corrugated metal pipes that cross the creek (similar to that shown in Figure 33 crossing De Luz Creek). Some of the smaller pipes may currently serve some reptiles or small mammals (Hunt et al. 1987, Rodriguez et al. 1996, Rosell et al. 1997, Clevenger and Waltho 1999, Forman et al. 2003), but most of the structures are sub-optimal. A few of the smaller drainage pipes are in need of maintenance or replacement. Many are more than half filled with sediment and debris, a few had steep drop offs with severe erosion, and one was crushed on one side.

De Luz Murrieta Road is a 2-lane road that runs north through the western portion of the Linkage Design area crossing De Luz Creek and running along its northeastern tributary (Figure 27). This section of road is notable for the poor quality of the existing 3 culverts and 6 pipes (e.g., Figure 33), which are not sufficient to provide for the movement of smaller vertebrates.

De Luz Road runs east-west through the Linkage Design area (Figure 27). Some of the habitat in the upper portion of De Luz Road has been converted to agricultural uses, and rural residential dwellings occur sporadically along the length of the road, but the majority of habitat on either side of the road consists of native vegetation. Amphibians, reptiles and small mammals were found commonly as roadkill along De Luz Road (Fisher and Crooks 2001), with western

Figure 33. Insufficient crossing structure on De Luz Murrieta Rd; 3 such riparian crossings exist on this road.

toad comprising 1/3 of the carcasses found. Other roadkill recorded included gopher snake, coachwhip, California ground squirrel, brush rabbit, and one of our focal species, the dusky-footed woodrat.

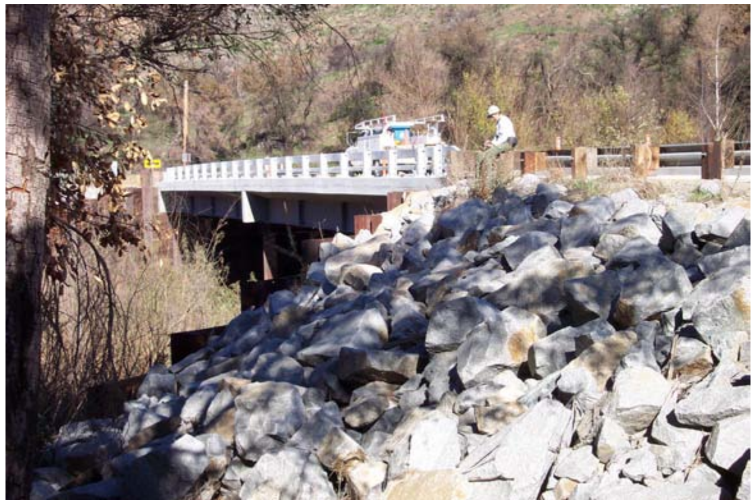


Figure 34. Santa Margarita River crossing under De Luz Road. Bridge design is adequate to accommodate wildlife movement.

The two bridges where De Luz Road crosses an intermittent stream and the main stem of the Santa Margarita River (Figure 34) have lush riparian vegetation with intermittent or perennial water sources, and likely meet the movement needs of most focal species. A total of 27 drainage pipes occur along De Luz Road, 24 less than 0.80 m (2.6 ft) diameter, and 3 between 1-2 m (3 – 6 ft) wide. For the majority of the pipe entryways, there was no vegetative cover but good habitat in the surrounding areas; a number were causing severe erosion problems; and a few had steep drop offs. Most of the smaller structures are in need of maintenance or replacement. Three fords (Arizona crossings) occur on or near De Luz Road. Two of these in-stream crossings intersect De Luz Creek on De Luz Road and Roblar Truck Trail. The third intersects Cottonwood Creek just before its confluence with De Luz Creek on De Luz Truck Trail. Habitat in the crossing is comprised of southern coast live oak riparian forest, southern willow scrub, or southern cottonwood willow riparian forest.

Other Paved Road Recommendations: We provide the following initial recommendations to mitigate the effects of paved roads on species movement in the Linkage Design area. Although these recommendations focus on changes to existing infrastructure, in some cases, additional structures may best serve the species' needs. Information on road mortality (e.g., Fisher and Crooks 2001) and other biological studies should be used to place crossings in the most suitable locations (e.g., between aquatic and upland habitat for semi-aquatic species).

- Encourage transportation agencies and community service districts to use road improvement projects as an opportunity to replace inadequate road-crossing structures. In larger drainages, drainage pipes should be replaced with bridges (large enough to allow vegetation to grow) or box culverts (large enough to allow a clear view to the other side). In critical locations where a bridge is not feasible, 2 parallel culverts should be considered: a pipe and a box culvert that encourage passage for species of a variety of sizes. In smaller drainages, determine if it's feasible to replace some existing metal pipes with concrete box culverts at least 1.5 m (5 ft) wide, with as much height as possible to address movement needs of larger mammals. Work with CalTrans or County Departments of Public Works to remove the concrete trash guards on existing drainage pipes (Figure 35). Where flowing water is regularly present, structures should be large enough to support both stream flow and dry natural substrate. This can also be achieved by adding additional culverts in a location that will usually remain dry, or adding an elevated catwalk within the structure (Cain 1999).

- For road crossings intended to accommodate aquatic species, coordinate with the California Department of Transportation, National Marine Fisheries Service, and California Department of Fish and Game to design culverts, stream crossings, bridges that facilitate movement of aquatic species (USFWS 1998). Use strategies identified in Guidelines for Salmonid Passage at Stream Crossings (McElhany et al. 2000), including information on preferred crossings, designing new culverts, retrofitting or replacing culverts, general recommendations, post construction evaluation, maintenance, and long term assessment.

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

Figure 35. Concrete trash guards at both entrances to largest pipe along Rainbow Canyon Road.

- Install appropriate fencing to direct wildlife to crossing structures. Wildlife fencing along I-15 should be installed to guide animals to crossing structures and keep them off the road. Install escape structures, such as earthen ramps, that allow animals to escape if they get trapped on the freeway. On other paved roads, use fine mesh fencing to guide small vertebrates to crossing structures.

- For all large crossing structures, place branches or living plants along the sides of the passageway for the length of the structure to provide cover for smaller prey species.

- Minimize artificial night lighting, and direct the light onto the roadway and away from adjacent wildland.

- Alert rural communities to the movement needs and roadkill concerns of wildlife and sensitive species in their backyards. Work with CalTrans or the Department of Public Works to install catchy signage.

- Discourage the construction of additional roads in the linkage area and reduce road speeds where possible. In particularly sensitive areas, conduct road surveys to understand types and levels of use, and consider restrictions that reduce or eliminate vehicle travel, such as rerouting through-traffic, emergency vehicle access only, and road closures.

- Work with local Resource Conservation Districts to adopt Best Management Practices for dirt roads in the Linkage Design area.

Barriers in Streams

Wetland and riparian habitats occupy less than 1% of the total land area in the western U.S., yet are used by up to 80% of terrestrial vertebrate species (Kreuper 1992). The ninth annual report of the U.S. Council on Environmental Quality (1978) states, "no ecosystem is more essential than the riparian system to the survival of the nation's fish and wildlife" (Horwitz 1978, Faber et al. 1989). Despite their importance to biological communities, over 90% of the historic wetland and riparian vegetation in Southern California has been eliminated or severely altered by urban and agricultural activities (Peters and Noss 1995). Coastal watersheds, in particular, have suffered due to dams, diversions, channelization, development, livestock grazing, and land disturbance (Dennis et al. 1984, Bell 1997). This extensive loss of habitat has resulted in declines in wildlife and plant populations that depend wholly or in part on riparian systems (Faber et al. 1989).

Terrestrial organisms moving through rugged landscapes also often use riparian areas. Some butterflies preferentially move through streamside areas (USGS 2002a, Orsack 1977). Some species of frogs are restricted to streamside movements (Kay 1989). While southwestern pond turtles are capable of overland movements of up to 0.5 km (0.3 mi)(Holland 1991), they preferentially move along stream courses (Bury 1972). Even large, mobile vertebrates, such as mountain lions, have shown preferences for moving through areas with moderate slopes, such as riparian corridors or ridgelines (Beier 1995, Dickson et al. 2004).

For plants and animals associated with streams or riparian areas, impediments are presented by dams, road crossings, exotic species, increased scouring of native vegetation by urban runoff, water recharge basins, dumping and runoff of agricultural waste and fertilizers, farming in streambeds, gravel mining, and concrete structures that stabilize stream banks and streambeds. Increased urban and agricultural runoff also can 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).

Examples of Mitigation for Stream Barriers: The primary goal of many restoration projects has been to restore habitat for targeted species; however, few restoration projects have focused on the natural dynamics of the systems on which these species depend (Bell 1997). In riparian systems, annual floods are a major component of ecosystem function. Many riparian plants are considered pioneer species, and have developed adaptations such as rhizomes, stolons, and wind- and water-disseminated seeds, that allow seedlings to become quickly established on newly deposited soils (Ohmart 1994). Because of the adaptation and resilience of riparian plants to high-disturbance regimes such as floods, revegetation can be a natural process if threats (i.e. invasive species) are removed from the system and physical processes are restored (i.e. dams and diversions are mitigated or removed).

Continuity between upland and riparian vegetation types is also a key component of viable riparian ecosystems. Many species commonly found in riparian areas depend on upland habitats during some portion of their cycle. These species include butterflies that use larval host plants in upland habitat and drink as adults, western pond turtles that lay their eggs in sandy upland habitats, and western toads that summer in upland burrows. Most fish feed on the aquatic larvae of insects that depend on terrestrial habitats as adults. While the width of upland habitats needed beyond the streams edge has rarely been estimated for these species, information on the western pond turtle suggests that a 1-km (0.6-mi) upland buffer (i.e., 0.5 km to either side of the stream) (Holland 1991) is needed to sustain populations of this species.

Stream Barriers in the Linkage Design Area: The Linkage Design area encompasses a potential connection for aquatic and riparian species that runs along the Santa Margarita River crosses under the I-15, and continues up Temecula Creek and across Vail Lake to the Cleveland National Forest Palomar Ranger District via the Arroyo Seco, Kolb, and Temecula creek drainages. Other riparian areas, although not providing a direct habitat connection between the Core Areas, are crucial for sustaining populations of water-dependent species (e.g., western pond turtle, California quail, California tree frog) in the Linkage Design area. These riparian drainages include creeks in the Santa Margarita (De Luz, Sandia, Rainbow, Stone, Pechanga) and San Luis Rey watersheds (Pala, Trujillo, Gomez, and Agua Tibia creeks).

Historically runoff from the Palomar Mountains supported riparian and aquatic habitat between the Santa Ana and Palomar ranges. Historic aerial photos of Temecula Creek in April 1939 (Figure 36) show a well-developed though discontinuous riparian forest canopy that joins with vegetation on Murrieta Creek from the Santa Ana Mountains to create dense multi-layered canopy of oak riparian forest, southern cottonwood–willow riparian forest and mulefat scrub (ACOE 2000) along the main stem of the Santa Margarita River. The presence of broad sandy washes suggests that flows may have been seasonal along some stretches but close enough to the surface to sustain riparian vegetation. The continuous stands of sycamore and cottonwood riparian forest, willow woodland and riparian scrub provided avenues for riparian and aquatic species to move between the Santa Ana and Palomar Ranges. Winter rains likely facilitated fish dispersal (Moyle 1976, Finney and Edmondson, no date) and allowed arroyo chub to move among their current locations in Temecula Creek and the main stem of the

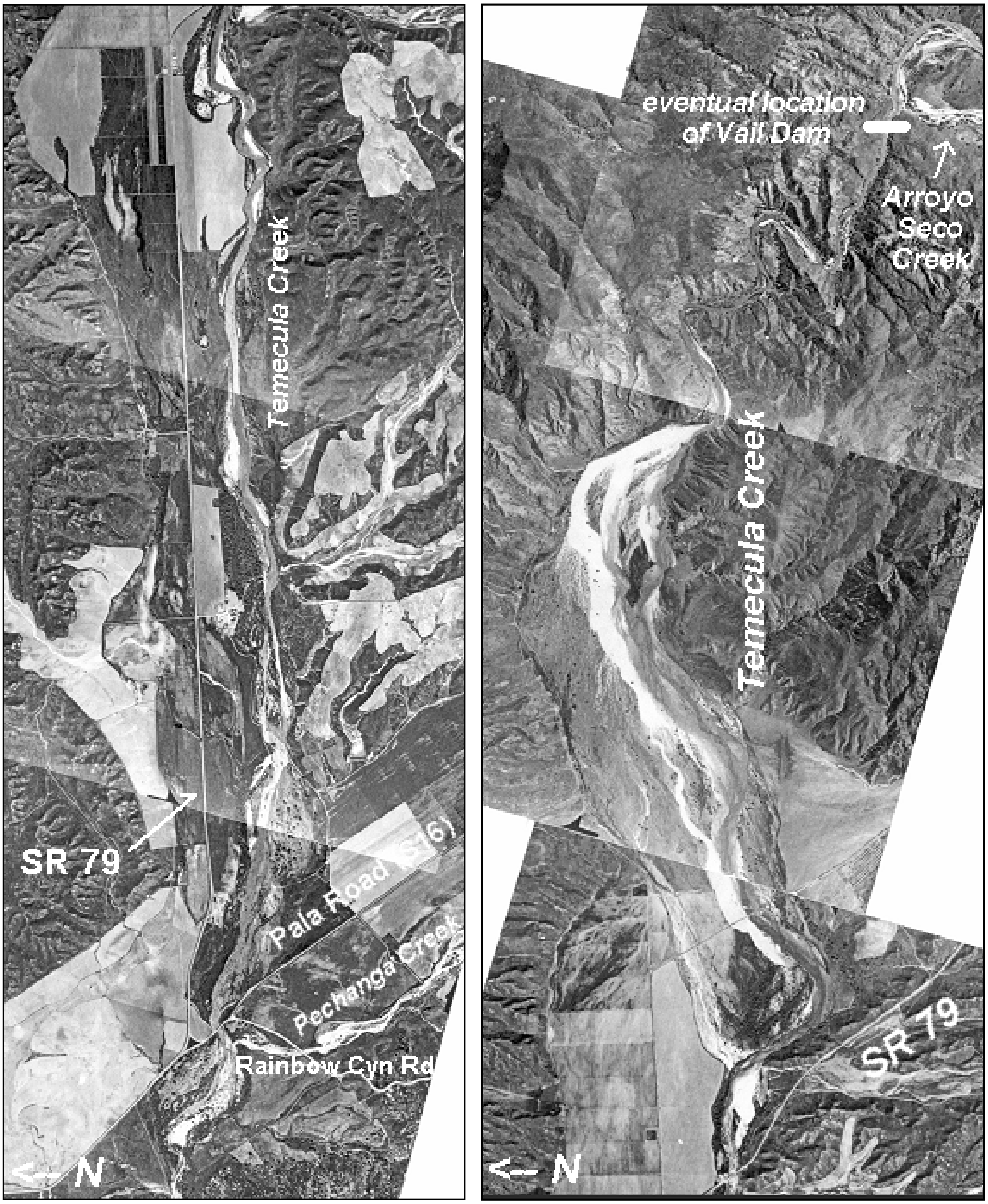


Figure 36. Aerial photographs of Temecula Creek in April 1939 from the main stem of the Santa Margarita River to the SR 79 crossing (left) and from SR 79 crossing to the eventual location of Vail Dam (right). Photos show a well-developed though discontinuous riparian canopy (dark areas) along Temecula Creek. Extensive agriculture (light areas) is apparent on lower portion of the Creek (lef). Photographs from Fairchild Aerial Photography Collection at Whittier College. Photos from left to right (4/16/39, Flight C-5750, Frames 205:31, 205:32, 205:95, 4/18/39, Flight C-5750, Frames 210:70, 210:62).

river, and steelhead to make journeys up the river to spawn in perennial sections of the river.

Figure 37. Rancho California Water District recharge site on the Santa Margarita River at the confluence of Temecula and Murrieta creeks. Base flows are maintained at 6 cfs.

Base flows (and consequently much of the vegetation) on the Santa Margarita River have been largely protected by water rights litigation between upstream utility districts (Rancho California Water District) and downstream entities (Fallbrook Public Utility District and Camp Pendleton MCB), and are currently maintained by disgorging imported water from the Colorado River and San Joaquin Delta into Temecula Gorge (Figure 37, Jenks 2002). Water quality on the main stem has, however, been impaired by intensive agriculture on most of its tributaries. A 27-km (17-mi) stretch of the upper Santa Margarita River was listed as impaired under Section 303(d) of the Clean Water Act due to excessive phosphorus and total dissolved solids (TDS) in 2002. Total dissolved solids are measure of the amount of material that is dissolved in water and can include carbonate, bicarbonate, chloride, sulfate, phosphate, nitrate, calcium, magnesium, sodium, organic ions, and other ions. Other recent listings include the Santa Margarita estuary, Rainbow Creek, Murrieta Creek, and Sandia Creek. These listings make these riparian stretches eligible for the development of intensive management plans called Total Maximum Daily Load (TMDL) plans. TMDLs are implemented by the Regional Water Quality Control Board, which evaluates the cause of water quality deterioration and then enacts an implementation plan to return water quality to targeted values.

The hydrology of Temecula Creek has been drastically altered by dam construction, ground water pumping, and habitat conversion associated with the urbanization of the City of Temecula. A dam at Vail Lake was originally built in 1942 to improve water supplies for cattle at Vail Ranch and today is used to recharge the Temecula aquifer, which provides domestic water to homeowners throughout the valley. Ground water pumping of the lower aquifer in the Temecula Basin to support tract home developments in the 1980s drew the water table down (Jenks 2002) and likely triggered the substantial reduction in riparian vegetation. Further historical analysis of aerial photos to determine the cause of riparian habitat loss is needed. Aquifer levels are currently maintained through recharge from Vail Lake at approximately 12 m (40 ft) below their historic levels (Joe Jackson, pers. comm., Jenks 2002).

Figure 38. Temecula Creek between I-15 and SR 79 crossing. Photo on right shows recent disturbance at the Pala Road Bridge looking southwest towards the Santa Ana Mountains.

Today, the lower stretch of Temecula Creek from I-15 to the SR 79 crossing is channelized and riparian vegetation is significantly reduced (Figure 38). The broad stands of willow and cottonwood at the I-15 crossing generally become narrower and more herbaceous as the vegetation nears the SR 79 crossing. Vegetation in this reach is apparently supported by urban runoff from homes and the Red Hawk golf course. Along this reach, we found bleached puma scat in areas with good vegetative cover, indicating that this level of vegetation can provide cover for some species. Trails, garbage, intrusion by off-road vehicles, and pets were common is this region.

Between the SR 79 crossing and Vail Dam, riparian vegetation is virtually absent. Bulldozer activity and construction, including several horse corrals and vineyards, has greatly altered and infringed upon the stream channel. Vail Dam is constructed across a narrow canyon and is owned and operated by the Rancho California Water District. Vail Lake was closed for 15 years but reopened in 1993 as Sundance Meadows, a members-only facility (www.vaillake.com). The reservoir is stocked with non-native fish, including bass, bluegill, catfish, and crappie for recreational fishing and is open for a variety of motorboat activities. Upland areas on the south side of the lake have been developed for housing, camping, golf, tennis, and horseback riding. Other upland habitat around the lake is dominated by chaparral and coastal sage scrub.

Two main tributaries drain the Palomar Mountains from the Palomar Ranger District to Vail Lake: Arroyo Seco and upper Temecula creeks. Vegetation along these drainages is a mixture of oak woodland, willow scrub, mulefat and cottonwood depending on the availability of water along these creeks. Riparian and upland vegetation is these areas are largely unimpacted, except for a large mining operation in the riparian zone just upstream and downstream from the SR 79 crossing at Temecula Creek. A concrete drop structure at this site prevents upstream migration of exotic basses and sunfishes and is probably helping protect arroyo chub populations upstream (Swift, pers comm.)

Recommendations to Mitigate the Effects of Streams Barriers in the Linkage Design Area: To enhance species use of riparian habitat in all areas of the Linkage Design and to restore a significant riparian connection 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 National Marine Fisheries Service, California Department of Fish and Game, Riverside County Department of Public Works, Water Districts, watershed groups and others to investigate the historic flow regimes and develop a surface and groundwater management program to restore and recover properly functioning aquatic/riparian conditions based on parameters developed by NFMS (1996). Priority should be given to Temecula Creek, where a more natural hydrology is needed to restore a continuous riparian connection between the Santa Margarita River and the drainages above Vail Lake.

- Determine the feasibility of dam removal, or installation of fish passages, and vegetated causeways, to restore habitat connectivity for steelhead, arroyo chub, and other species preferring to move through riparian areas. Two dams currently occur on the Santa Margarita River and Temecula Creek: Lake O'Neill Dam operated by Camp Pendleton MCB on the main stem and Vail Dam operated by Rancho California Water District on Temecula Creek. Modifications to the diversion weir at Lake O'Neill have now made fish passage possible (USFWS 1998). Vail dam should be analyzed in cooperation with the Army Corps of Engineers, National Marine Fisheries Service, Camp Pendleton MCB, Rancho California Water District, and other pertinent agencies, to determine the feasibility of installing fish passages and riparian vegetation connections around the dam (McEwan and Jackson 1996).

- Mitigate the effects of road crossings in riparian zones. Coordinate with the California Department of Transportation, National Marine Fisheries Service, and California Department of Fish and Game to evaluate existing stream crossings and upgrade culverts, stream crossings, bridges, and roads that impede fish movement (USFWS 1998). Use strategies identified in *Guidelines for Salmonid Passage at Stream Crossings* (NFMS 2000), including information on preferred crossings, designing new culverts, retrofitting or replacing culverts, general recommendations, post construction evaluation, maintenance and long term assessment. Install specialized culverts and bridges in streams for improved fish passage to address outfall height, water velocities, and water depth for adequate upstream fish passage (Carey and Wagner 1996, Evink 2002).

- Restore riparian vegetation in all drainages and upland vegetation within 1 km (0.6 mi) to either side of streams and rivers. These areas may restrict plant or animal movements and compromise water quality by increasing erosion and non-point sources of pollution. If restored, these areas would support aquatic and semi-aquatic species and enhance movement through both aquatic and riparian habitats. Discourage the construction of concrete-banked streams and other channelization projects. In particular, develop protocols that would sustain a vegetated riparian corridor along Temecula Creek below and above Vail Dam. In addition, protect and restore a continuous riparian corridor for tributaries to Temecula Creek that drain lands from the Cleveland National Forest Palomar Ranger District (Arroyo Seco, Kolb, Pechanga, and upper Temecula Creek). The Pechanga Creek project will involve restoring vegetation at the confluence of Temecula and Pechanga creeks, working with the Red Hawk Golf Club to restore at least a 35 m (115 ft) wide strip along the creek, and working with members of the Pechanga Tribal Council, and the Bureau of Indian Affairs to maintain high-quality riparian connections.

- Remove exotic aquatic plants and animals from streams, rivers, and Vail Lake. Work with the Santa Margarita and San Luis Rey Weed Management Area, SDSU Field Station Programs, Biological Resources Division at USGS, and other relevant agencies to survey streams and drainages for invasive species and develop a comprehensive removal strategy. The survey and removal should document and recommend how to deal with ephemeral drainages that are becoming increasingly perennial due to agricultural runoff, and supporting exotic fish and bullfrogs.

- Enforce existing regulations protecting streams and stream vegetation from alteration, manure dumping, and vegetation removal. Agencies and regulations with applicable jurisdiction include California Department of Fish and Game, Streambed Alteration Agreements, Army Corps of Engineers, Clean Water Act, Native Plant Protection Act and Oak Tree Ordinances. In high-abuse areas, post signs that prevent vehicles from driving in the creek bottom. Review existing regulations relative to linkage goals and develop additional restrictions or recommend closures in sensitive areas.

- Increase and maintain high water-quality standards in the Santa Margarita Watershed. Work with the Resource Conservation District to help establish use of Best Management Practices for all agricultural operations in the watershed, including alternatives to the standard practices of fertilizer use. Work with Regional Water Quality Control Board and the Total Maximum Daily Load (TMDL) process to reduce nutrient levels in impaired reaches of the watershed. Current estuary conditions are not sufficient to support over-summer rearing of steelhead (USFWS 1998).

- Support the protection of riparian and adjacent upland habitats on private lands. Continue to insure the incorporation of the linkage in the NCCP planning process and work with the county NCCP efforts to acquire lands from willing sellers. Offer conservation easements to interested lands owners. Pursue cooperative programs with landowners to improve conditions in riparian and upland habitats on private land in the Linkage Design.

Urban Barriers

Urban, industrial and suburban areas make particularly inappropriate landscapes for movements of most plants and animals (Marzluff and Ewing 2001). Apart from the direct loss of habitat caused by the construction of buildings and associated infrastructure, urban developments have negative effects far beyond the boundaries of the construction footprint. These effects, known as edge effects, can significantly reduce plant and animal populations and impede ecosystem functions in surrounding areas. Most terrestrial mammals that move at night will avoid areas that have artificial night lighting (Beier, in press). Pet cats can hunt in a 3 ha area (Hall et al. 2000) and significantly depress populations of small vertebrates (Churcher and Lawton 1987, Crooks 1999, Hall et al. 2000). Irrigation of landscapes surrounding homes can encourage 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 with habitat disturbance from human use show decreases in bird and small mammal populations (Sauvajot unpubl.).

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 with willing landowners will have the greatest effect on preserving linkage function. Mitigation for existing urban developments focuses on designing buffers that reduce penetration of undesirable effects into natural areas (Marzluff and Ewing 2001). These buffer areas can be targeted for management actions that reduce the effects of urban activities. These include fencing in pets, reducing human traffic in sensitive areas or constriction points, limiting noise and lighting, reducing traffic speeds, minimizing use of irrigation, minimizing the use of pesticides, poisons and other harmful chemicals, and increasing enforcement of existing regulations.

Urban Barriers in the Linkage Design Area: Urban developments comprise 14% of the Linkage Design area. The most significant area of urban encroachment is along I-15 and Pala Temecula Rd in southern Temecula. The City boundaries extend into both upland and riparian habitat components of the Linkage Design in this area. Existing developments in the city boundaries include tract homes, a golf course, agriculture and primary access to a new Indian gaming casino on the Pechanga Indian Reservation that lies immediately south of the city boundary. Scattered urban development extends from these areas in a narrow band along most of Pala Temecula Road. Urban and commercial developments extend along Temecula Creek for approximately 10 km (6 mi) east of I-15 on both sides of this riparian connection.

The remainder of the Linkage Design area is mostly zoned as rural residential on 5-10 acre lots. Private homes extend along existing roads into the Linkage Design area from the south (Fallbrook and Rainbow) and perforate natural connections on ridgelines and drainages (De Luz). Although home construction is relatively minor in many areas, the regional practice of clearing natural habitat to plant avocado groves has removed significant acreage of natural habitat in the Linkage Design area. Due to the common association between home building and agriculture, low density urban development has a much greater impact here than in other regions where private lands are more commonly left in a natural state.

Recommendations for Mitigating the Effects of Urban Barriers in the Linkage Design Area: We provide the following initial recommendations regarding urban, suburban, and rural developments in the Linkage Design area:

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

- Develop a public education campaign, such as the On The Edge program developed by the Mountain Lion Foundation, which encourages residents at the urban wildland interface to become active stewards of the land by reducing penetration of undesirable effects into natural areas. Such voluntary cooperation is essential to preserving linkage function. Education topics should include fencing in pets, constructing predator-safe enclosures for livestock, reducing human traffic in sensitive areas or constriction points, limiting noise and lighting, reducing traffic speeds, minimizing use of irrigation, minimizing the use of pesticides, poisons and other harmful chemicals, and effective reporting of violations.

- Work with San Diego and Riverside County on their 2020 General Plan updates to encourage zoning of rural areas of the Linkage Design to larger lot sizes (e.g., 40-80 acres).

- Discourage major new residential or urban developments. Where development of single residences or small subdivisions do occur, we recommend restrictions that limit edge effects (above). A few estates on large lots (such as 50 acres or larger) left in natural condition may be compatible with the linkage. However, the total extent of any development should be limited. As a condition of such new subdivisions, the developer should implement a mechanism whereby purchasers of lots accept loss of pets and livestock to wild predators without demanding compensation or a depredation permit. The Mountain Lion Foundation has also worked to developed predator safe domestic livestock enclosures and works with several ranchers and farmers to help keep livestock safe, with the ultimate goal of reducing the number of depredation permits issued for mountain lions.

- Work with Fire Safe Councils and California Department of Forestry and Fire Protection to develop fire preparedness plans that do not compromise linkage function.

- Work with the San Diego and Riverside counties to implement their Natural Communities Conservation Plans (NCCP). The Multi-Species Conservation Plan in San Diego County encompasses the linkage and the Multi-Species Habitat Conservation Plan in Riverside County has designated portions of the Linkage Design in their county as a Special Area.

Agricultural Barriers

Agricultural practices remove native vegetation, require significant water resources, increase nutrient runoff into streams, and facilitate invasions by exotic species. Waters draining from agricultural areas show elevated levels of nutrients and particles. Many drainages that were once ephemeral become perennial near avocado orchards (Fisher and Crooks 2001) and are capable of supporting exotic species such as exotic fish, bullfrogs and giant reed. In addition, the pattern of agricultural developments can have a significant affect on species movements.

Examples of Mitigation for Agricultural Barriers: As with urban developments, acquisition or conservation easements with willing landowners, will have the greatest effect on preserving linkage function from agricultural impacts. For existing developments, a variety of Best Management Practices are available through federal Resource Conservation District offices that can reduce nutrient runoff and erosion. These include the timing and types of nutrient use, use of native vegetation to absorb surface and subsurface runoff, and soil management. Restoring agriculture to native vegetation in key areas is also an option. In areas where agricultural developments have constricted natural habitat to narrow isthmuses of habitat, orchards in key areas can be removed and the habitat restored.

Agricultural Barriers in the Linkage Design Area: Avocado orchards are the dominant agriculture type in the Linkage Design area, comprising roughly 7% of the Linkage Design. They are relatively easy to grow and harvest and have become a lucrative activity for many of the landowners in rural areas of the Linkage Design. The ability to grow avocados on virtually any slope or soil in the region has made this activity a significant threat to linkage function. Orchards are scattered throughout the linkage in the communities of De Luz, Fallbrook, and Rainbow and are the dominant vegetation type north of the Linkage Design area in the Santa Rosa Community Service District. Focal species analyses (see Appendix C) indicate that orchards adjacent to the southwestern boundary of the Santa Margarita Ecological Reserve prevent species with short dispersal distances from moving between patches of chaparral in this area and may prevent movement through the Linkage Design.

Recommendations to Mitigate the Effects of Agricultural Barriers in the Linkage Design Area: We provide the following initial recommendations to prevent or mitigate the effects of agriculture in the Linkage Design area:

- Discourage further agricultural development in the Linkage Design area by purchasing lands with natural vegetation, or developing conservation easements with willing landowners. Runoff from avocado orchards has resulted in listing the upper Santa Margarita River, Santa Margarita estuary, Rainbow Creek, Murrieta Creek, and Sandia Creek as impaired water bodies under the Clean Water Act. Furthermore, many ephemeral streams north of the Linkage Design have become perennial due to agricultural runoff and support exotic species that may impair linkage function for native species (Fisher and Crooks 2001).

- Restore agricultural lands to pre-development conditions in areas of the Linkage Design where natural habitats have been severely constricted by agricultural development. Where possible, restore a 2-km (1.2-mi) wide isthmus of habitat through adjacent agricultural developments. Focal species analyses indicate that the area adjacent to the southwestern boundary of the Santa Margarita Ecological Reserve should be targeted for restoration.
- Work with local Mission Resource Conservation District and the Elsinore-Murrietta Resource Conservation District to help local farmers to adopt Best Management Practices that reduce the effects of agricultural activities on the environment.

- Work with the Regional Water Quality Control Board's TMDL program to evaluate the cause of water quality deterioration and enact an implementation plan to return water quality to targeted water quality values.

- Encourage research on agriculture that specifically identifies solutions to elevated nutrient runoff, erosion, and effects of perennializing streams.

- Work with the San Diego and Riverside counties to implement their Natural Communities Conservation Plans (NCCP). The Multi-Species Conservation Plan in San Diego County encompasses the linkage and the Multi-Species Habitat Conservation Plan in Riverside County has designated portions of the Linkage Design in their county as a Special Area.

Recreation and Other Types of Potential Land Use Barriers

Land management policies in the Core Areas and the Linkage can have substantial impact on habitat and movements of species through the Linkage Design area. It is essential to work with major land-management entities, including Camp Pendleton Marine Corps Base, Fallbrook Naval Weapons Station, and US Forest Service to integrate the results of the linkage planning effort into their existing policies and regulations. Additional work will be needed to determine how Linkage Design needs can be integrated with military training needs. In this report, we limit our discussion to recreational activities in the Core and Linkage Design areas, but encourage collaborative investigations regarding how other land use practices may affect linkage function.

Examples of Mitigation for Recreation: Recreational use is not inherently incompatible with wildlife movement through the Linkage Design. However, Intense recreational activities have been shown to cause significant impacts to wildlife and plants (Knight and Gutzwiller 1995). Even such relatively low-impact activities as wildlife viewing, hiking, and horseback riding can 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), with potentially devastating effects. 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.

Recreation in the Linkage Design Area: Areas currently available for recreation include the US Forest Service lands in the Core Areas, and Fallbrook Public Utility District (FPUD) and County of San Diego lands along the Santa Margarita River in the Linkage Design area. The contiguous County and FPUD lands contain riparian scrub and woodlands along the Santa Margarita River and a narrow band of adjacent chaparral and sage scrub habitats that are flanked by a growing number of homes and orchards. A Memorandum of Understanding between Fallbrook Land Conservancy and FPUD, allows the Conservancy to develop and maintain trials for hiking and horseback riding on FPUD lands. The level of recreational use is unrestricted. The FPUD and County lands form a particularly critical portion of the Linkage Design area, supporting both riparian and upland species movements through an already constricted portion of the linkage.

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

- Monitor trail development and recreational use on FPUD, US Forest Service, and San Diego County lands to provide a baseline for decisions regarding levels, types, and timing of recreational use.

- Work with regional monitoring programs, such as the State's Natural Communities Conservation Planning or Resource Assessment Program, to collect information on special status species, species movements, and vegetation disturbance in areas of high recreational activity.

- Enforce existing regulations on types of recreational use currently established in areas of recreational use.

Land Protection & Stewardship Opportunities

A variety of planning efforts addressing the conservation and use of natural resources are currently underway in the Linkage Design area. In this section, we provide information on planning efforts, agencies, and organizations in the region that may represent potential collaborative opportunities for conserving the Santa Ana – Palomar Mountains Linkage. While this list is not exhaustive, it is meant to provide a starting point for persons interested in becoming involved in preserving and restoring linkage function. We provide first a description of the Linkage Planning sponsors and then an alphabetical list of other activities and organizations in the Linkage Design area.

San Diego State University Field Station Programs: The SDSU Field Station Programs provides lands and facilities for the purposes of research and education on natural ecosystems. The Santa Margarita Ecological Reserve, one of four SDSU Field

Stations, lies between the Santa Ana and Palomar Mountains. A wide variety of ecological studies have been conducted on the reserve since its establishment in 1962. As part of Field Station Programs conservation planning initiative, the reserve engages in regional planning to preserve ecosystem functions and exports significant research results to address management concerns in the region. SDSU Field Station Programs is Linkage Manager for the Santa Ana – Palomar Linkage planning effort, developing and coordinating conservation planning in the linkage. Field Station Programs are a partner in the South Coast Missing Linkages project and the South Coast Conservation Forum effort.

South Coast Wildlands: South Coast Wildlands is a non-profit group established to create a protected network of wildlands throughout the South Coast Ecoregion and is the key administrator and coordinator of the South Coast Missing Linkages Project. For all 15 priority linkages in the Ecoregion, South Coast Wildlands supports and enhances existing efforts by providing information on regional linkages critical to achieving the conservation goals of each planning effort. They are a partner in the Santa Ana – Palomar Mountains Linkage planning effort, South Coast Missing Linkages project, and the South Coast Conservation Forum effort.

***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, The Wildlands Project, California Wilderness Coalition, and the Zoological Society of San Diego Center for Reproduction of Endangered Species.

****

Bureau of Land Management: BLM sustains the health, diversity and productivity of the public lands for the use and enjoyment of present and future generations. BLM owns several key parcels in the Linkage Design Area. Their South Coast Resource Management Plan designates all BLM parcels in the Santa Ana – Palomar Mountain linkage as “Land Not Available for Disposal,” and establishes acquisition priorities in the Linkage Design area. BLM parcels inside the Santa Margarita Ecological Reserve are a designated as an Area of Critical Environmental Concern for the purposes of research and education (BLM 1996).

Bureau of Reclamation: Reclamation's Southern California Area Office (SCAO) is located in Temecula. SCAO is responsible for water conservation, reclamation and reuse projects to enhance water management practices throughout southern California. Reclamation holds three water rights permits totaling 228 million cubic meters (185,000 acre-feet) of the Santa Margarita River that were originally obtained as part of a proposed dam project. The dam was never built, and, under California

Water Rights Law, these permits must be perfected (i.e., demonstrated to be put to beneficial uses) by 2007 or the water rights may be lost. Reclamation is interested in identifying and implementing a functional equivalent to the dams and surface impoundment that would involve the discharge of treated water into the watershed. Since the success of such a project will depend on the ability for the watershed to assimilate nutrients, Reclamation is undertaking a collaborative effort with local entities to develop an effective water quality monitoring plan in the watershed that will accurately identify impaired water bodies (pursuant to section 303(d) of the Clean Water Act), support the development of water quality recovery plans (Total Maximum Daily Load plans), and estimate the assimilative capacity for nutrients in the Santa Margarita River system. A central part of this monitoring effort is the WARMF model (Watershed Analysis Risk Management Framework), a watershed model that supports decision-making by estimating the effects of a variety of land use practices on water quality.

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. CDFG holds lands administered by SDSU Field Station Programs as part of the Santa Margarita Ecological Reserve, and recently acquired management authority for the Santa Rosa Plateau Ecological Reserve, a key land holding north of the Linkage Design Area. CDFG has also expressed commitment to completing acquisitions in the Tenaja Corridor, a habitat linkage between the Santa Rosa Plateau Ecological Reserve and US Forest Service lands in the Cleveland National Forest Trabuco Ranger District. Acquisition dollars for CDFG projects are authorized through the Wildlife Conservation Board as part of their Concept Area Protection Plan (CAPP) process. See below under Wildlife Conservation Board for more information.

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 are eager to spend their mitigation dollars on the most important linkage areas; they 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.

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. 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 and is a key partner in the South Coast Missing Linkages effort. CSP was a co-sponsor of the statewide Missing

Linkages conference (Penrod et al. 2001) and has made habitat linkages a priority in their land acquisition plans.

California Wild Heritage Campaign: CWHC is a coalition comprised of local, regional and national conservation organizations, faith groups, and businesses. Their mission is to ensure the permanent protection of California's public lands and rivers and they are active in supporting wilderness and wild & scenic river designations.

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 (Penrod et al. 2001). They listed the Santa Ana – Palomar Mountains Linkage in 2001 and the Santa Ana Range in 2002 as one of the top 10 threatened areas in California (California Wilderness Coalition 2002).

Camp Pendleton Marine Corps Base: Camp Pendleton Marine Corps Base provides training facilities for reserve Marines, Army and Navy units, as well as national, state and local agencies. Camp Pendleton contains the largest remaining block of coastal habitat within the South Coast Ecoregion. Natural resource management and planning is an on-going process on Camp Pendleton. The base lies within the coastal foothills of the Santa Ana Mountains, sharing it northwestern boundary with the San Mateo Wilderness in the Cleveland National Forest. Together these lands form the Santa Ana Mountain Core Area, a significant block of contiguous habitat within the Santa Ana Mountains and coastal zone. The majority of the Linkage Design area connects to the northwestern boundary of the Base.

The Integrated Natural Resource Management Plan (INRMP) is the base's reference and management tool to prescribe resource management programs and initiatives with planned actions and sets the agenda for managing natural resources over 5-year periods (2002-2007). The 2003 Defense Authorization Bill authorized U.S. military training operations to acquire property that could relieve future environmental restrictions that interfere with anticipated military activities (see South Coast Conservation Forum).

Coal Canyon Biological Corridor: The Coal Canyon Biological Corridor was a significant public conservation investment designed to link the Chino Hills (Chino Hills State Park) to the Santa Ana Mountains (Cleveland National Forest). California State Parks, Caltrans, The Wildlands Conservancy, and Hills for Everyone recently held an asphalt-breaking ceremony. Caltrans plans to close the Coal Canyon interchange to traffic and use the existing bridge as a wildlife underpass; plans include the removal of asphalt, habitat restoration, and installation of fencing to guide wildlife to the underpass (Transportation Research Board 2002). Mountain lions regularly use the Coal Canyon Biological Corridor and their long-term presence in the Santa Ana Mountains is dependent on preservation of the Santa Ana – Palomar Mountains Linkage.

County of Riverside: The County of Riverside is presently involved in regional planning in the Linkage Design area for its Riverside County Integrated Plan (RCIP) which includes environmental, transportation, housing and development guidelines based on estimates of a doubling of the human population. The Western Riverside Multi-Species Habitat Conservation Plan (MSHCP)) serves as a Habitat Conservation Plan (HCP) and well as an NCCP document. It is designed to protect over 150 species and conserve over 500,000 acres. The Western Riverside MSHCP recognized the value of connecting natural areas within the planning area to the Santa Ana Mountains (7 corridors are currently identified that link to the Santa Ana Mountains). The Linkage Design is proposed as a "Special Area" in the Western Riverside MSHCP.

County of San Diego: The County of San Diego is presently involved in regional planning in the Linkage Design area for its General Plan 2020. The plan incorporates NCCP (North County Multi-Species Conservation Plan (MSCP)) conservation planning efforts and establishes zoning and transportation goals to the year 2020. The North County MSCP identifies portions of the Linkage Design in San Diego County for acquisition from willing sellers. Acquisition of targeted parcels supports San Diego planning efforts by providing regional connections that serve ecosystem goals. The County of San Diego also owns lands in the Linkage Design area along the Santa Margarita River. They are a partner in the South Coast Conservation Forum effort. The MSCP Subregional Plan and Final Environmental Impact Statement/Environmental Impact Report (EIS/EIR) were adopted by the San Diego Association of Governments Board of Directors in March 2003. The North County Subarea Plan, including portions of the Santa Ana – Palomar Mountains linkage is being prepared.

Fallbrook Land Conservancy: The Fallbrook Land Conservancy (FLC) is a private, nonprofit, tax-exempt organization dedicated to preserving and enhancing the rural lifestyle and natural beauty of Fallbrook. FLC owns small reserves south of the Linkage Design area and develops and maintains trails for recreational use of Fallbrook Public Utility lands in the Linkage Design area.

Fallbrook Naval Weapons Station: The Fallbrook Naval Weapons Station is located in the Santa Ana Core Area, immediately adjacent to the eastern border of MCB Camp Pendleton. The Weapons Station is a weapons storage facility, transferring ammunition to boats on coast. Several endangered or threatened species, including the Stevens kangaroo rat, the California gnatcatcher and the cactus wren occur on the base and are managed under a variety of USFWS approved plans.

Fallbrook Public Utility District: FPUD provides Fallbrook with a reliable water supply and wastewater disposal with optimal use of recycled water in the most efficient and economical means possible. FPUD owns 7.7 km (4.8 mi) along the main stem of the Santa Margarita River. These lands were taken by eminent domain to build a dam that could provide water for the people of Fallbrook. Today the construction of a dam is no longer planned, and FPUD lands are managed for recreational use under a cooperative agreement with the Fallbrook Land Conservancy. FPUD is still interested in using these lands to perfect an existing water right to the Santa Margarita River (i.e., demonstrate that withdrawn waters are put to beneficial uses), by entering into a joint water development project with Camp Pendleton Marine Corps Base. This project would allow FPUD to gain access to ground water under the base and Camp Pendleton to use FPUD lands as mitigation for base projects. Under this mitigation, FPUD lands would be managed in their natural state.

Friends of the Foothills: Friends of the Foothills seeks to protect South Orange County's quality of life by permanently preserving South Orange County's remaining open space, stopping the extension of the Foothill-South Toll Road, and keeping creeks and surf clean. They are active in preventing the construction projects that could compromise the viability of the Santa Ana Core Area.

Mountain Lion Foundation: The Mountain Lion Foundation is a nonprofit conservation and education organization dedicated to protecting the mountain lion and their wild habitat to ensure that wildlife heritage endures for future generations. The Foundation educates communities, agencies and community members about mountain lion behavior and management, and lobbies to provide funding, laws, regulations and policies that support mountain lion populations. They also provide speakers, information displays, educational exhibits, lectures and workshops.

Orange County: Orange County is engaged in Natural Community Conservation Planning (NCCP). Two plans in progress cover approximately 340,000 acres. The Southern Orange County NCCP is noteworthy because this region still includes large, relatively undeveloped sections of coastal sage scrub habitat.

Palomar Mountain State Park: This state park is location on southern boundary of the Cleveland National Forest’s Palomar Ranger District in the Palomar Core Area. The State Park’s mission is to provide 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. These management practices are compatible with preservation of the Core Area.

Pechanga, Pala, and Pauma Indian Reservations: The Pechanga, Pala and Pauma Indian Reservation lands constitute the majority of lands in the eastern portion of the Santa Ana – Palomar Mountains Linkage Design area.

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. Region 9 of the San Diego RWQCB oversees waters in the Linkage Design area. Rainbow Creek, a tributary to the Santa Margarita River, is one of the first Total Maximum Daily Load (TMDL) planning efforts undertaken in the state to identify sources of pollutants and restore water quality for an impaired water body. Other impaired water body listings in the Santa Margarita Watershed include the upper Santa Margarita River, the Santa Margarita River estuary, and Sandia Creek.

Resource Conservation Districts (RCD): The federal district has two offices with responsibilities in the Linkage Design area: The Mission RCD and the Elsinore-

Murrietta RCD. These non-profit agencies support 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 do not enforce regulations but instead serve the interests of local residents and businesses.

Santa Ana Mountains Task Force: The Santa Ana Mountains Task Force works to protect the Santa Ana Mountains for current and future users. They are undertaking four major campaigns at present: (1) block construction of a trans Santa Ana Mountain Highway and work with local state officials to maximize the capacity of the 91 transportation corridor, (2) stop a hydro-electric project and keep projected electric transmission lines out of the Cleveland National Forest, (3) support a Conservation Alternative for the Cleveland National Forest, and (4) promote the creation of new Wilderness in the Trabuco District and the creation of the Trabuco Protected Area.

Santa Margarita River and San Luis Rey Watersheds Weed Management Area: The SMRSRLW Weed Management Area provides support, coordination and funding for management of invasive non-native plants and restoration of native riparian habitat within the Santa Margarita and San Luis Rey watersheds in San Diego and Riverside Counties. They are funded through a diversity of grant sources through the Missing Resource Conservation District. The management area has coordinated and carried out a successful multi-year removal program for giant reed in the Santa Margarita Watershed (http://smslrwma.org/).

Santa Margarita River Watershed Proposition 13 Watershed Management Plan: With partial funding from the State Water Resources Control Board (Costa-Machado Water Act of 2000 = Prop 13), the County of San Diego is developing a watershed management plan to restore and protect water quality in the Santa Margarita Watershed. To keep stakeholders informed of developments and status of the program, the County is holding public workshops on plan development. The WMP is being developed in cooperation with the county of Riverside, Camp Pendleton MCB and the Cities of Temecula and Murrieta. Project Manager for the WMP is Joe DeStefano in the Department of Land Use, County of San Diego.

Santa Margarita Water Quality Managers Group**:** This working group is comprised of representatives from Camp Pendleton, Fallbrook Public Utility District, Eastern Municipal Water District, Murrieta Water District, the Regional Water Quality Control Board, Mission Resource Conservation District, Elsinore-Murrieta Resource Conservation District, Riverside County Flood Control District, and SDSU Field Station Programs. This group has spawned a number of planning efforts to better understand water quality needs in the watershed. The current project to build a watershed model (WARMF), is collaboratively funded and spearheaded by the Bureau of Reclamation. The model will be used to better understand how land use affects water flow and quality. Watershed planning efforts such as this may provide opportunities for restoration of natural water flow and riparian vegetation in the linkage.

***Santa Rosa Community Service District*:** The SRCSD is located on the northern margins of the Linkage Design area. Its mission is to enhance the community by providing quality roads, law enforcement, environmental, and ancillary services. SRCSD may be helpful in linkage conservation by helping to enforce existing regulations and developing road design that conserve species movement.

Santa Rosa Plateau Ecological Reserve: The SRPER, located just north of the Linkage Design, is an 8,500-acre reserve dedicated to recreational use and scientific exploration. The Nature Conservancy and California Department of Fish and Game are conserving a key habitat connection, the Tenaja Corridor, for mountain lions to move between the reserve and the Santa Ana Mountains. These multi-million dollar efforts were undertaken to ensure that mountain lions and the ecosystem functions they represent remain a significant part of natural community dynamics. Should the Santa Ana – Palomar Mountains linkage be severed, mountains lions are predicted to become extinct with the range (Beier 1993), compromising the considerable conservation investment already made in this area.

Save Our Forests and Ranchlands: SOFAR is a membership-based watchdog group committed to defending the San Diego backcountry against urban sprawl & working toward the adoption and implementation of a plan to preserve rural resources. They have several projects in the Linkage Design or Core Areas.

Sierra Club: To achieve its conservation goals, the Sierra Club works to influence policies and decisions affecting the environment of North America and the rest of the world. The Angeles and San Diego Chapters have active programs affecting activities in the Santa And and Palomar Core areas and the Linkage Design, including the Santa Ana Mountains Task Force (see above).

***South Coast Conservation Forum*:** The 2003 Defense Authorization Bill authorized U.S. military training operations to acquire easements that could relieve future environmental restrictions that interfere with anticipated military activities. The South Coast Conservation Forum, a consortium of agencies and non-governmental organizations, strategically identifies priority lands for this program around Camp Pendleton. Representatives of the Forum include Camp Pendleton, U.S. Forest Service, Bureau of Land Management, USFWS, CDFG, San Diego County, Riverside County, Trust for Public Land, The Nature Conservancy San Diego State University Field Station Programs, South Coast Wildlands, and others. The approval of Senate Bill 1468 (Knight) reinforces the Defense Authorization Act by requiring that all counties in California address the effects of land use zoning on military base encroachment. SB 1468 specifically requires counties to "define open-space land to include areas adjacent to military installations, military training routes, and restricted airspace."

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. The Nature Conservancy has undertaken significant conservation planning efforts in the linkage planning area, including conserving properties along the main stem of the Santa Margarita River (they currently own land administered by SDSU Field Station Programs as part of the Santa Margarita

Ecological Reserve), establishing the Santa Rosa Plateau Ecological Reserve (SRPER), and working to conserve the Tenaja Corridor that connects SRPER to the Trabuco Ranger District of the Cleveland National Forest. Recently the California Department of Fish and Game agreed to take over management of the SRPER and complete the conservation of the Tenaja Corridor through their Conceptual Area Protection Plan process. Conservation of the Santa Ana – Palomar Mountains Linkage supports the Tenaja effort by ensuring that the Santa Ana Core Area remains a viable ecosystem for the connection. TNC provided monetary support for Santa Ana – Palomar Mountains Linkage Design workshops, and is a partner in the South Coast Missing Linkage Project and the South Coast Conservation Forum effort.

Trust for Public Land: The Trust for Public Land conserves land for people to enjoy as parks, gardens and other natural places, ensuring livable communities for generations to come. TPL is presently involved in conservation actions in the linkage as part of the South Coast Conservation Forum.

The Wildlands Conservancy: The Wildlands Conservancy is a non-profit, member-supported organization dedicated to land preservation, river preservation, trail development and environmental stewardship through education. Their Save the Saints Program brings together multiple land trusts and conservancies to identify key lands for acquisition within National Forest boundaries and lands contiguous with the Forests in the Santa Ana, San Gabriel, San Jacinto, and San Bernardino Mountains. TWC is a partner in the South Coast Missing Linkages project, which compliments their Save the Saints campaign.

US Army Corps of Engineers: The mission of the ACOE is to provide quality, responsive engineering services for planning, designing, building and operating water resources and other civil works projects (Navigation, Flood Control, Environmental Protection, Disaster Response, etc.). They are currently involved in Special Area Management Plan for the Santa Margarita Watershed. This plan involves an assessment of watershed processes and riparian system integrity. The goals of the project are to involve state, federal, and local stakeholders in establishing programmatic permits (for activities regulated under 404 permitting process) and protection and management areas. These activities are in coordination with NCCP and HCP planning.

US Fish and Wildlife Service: The U.S. Fish & Wildlife Service works with others 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. USFWS has developed recovery plans with designated or proposed critical habitat for 5 threatened or endangered species in the Linkage Design area: Quino checkerspot butterfly (*Euphydreas editha quino*), arroyo toad (Bufo microscaphus), California gnatcatcher (*Polioptila californica californica*), southwestern willow flycatcher (*Empidonax traillii extimus*) and least Bell's vireo (*Vireo belli pusillus*). The Santa Margarita River is also listed as potential recovery watershed for southern steelhead trout. 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.

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) are in the process of jointly revising their Resource Management Plans. The biological importance and feasibility of connecting the four forests to the existing network of protected lands in the region is being evaluated in the Draft Environmental Impact Statement. The Forest Service is taking a proactive role in habitat connectivity planning in the region: they are a partner in the South Coast Missing Linkages project.

US Geological Survey: The Western Ecological Research Center at the San Diego Field Station is dedicated to using science to address management challenges in the region. Scientists at the office have conducted a variety of studies in the Linkage Design area including tracking studies of large carnivores, small-vertebrate pit-fall array studies, bird sampling, and roadkill surveys.

Wildlife Conservation Board: The Wildlife Conservation Board administers capital outlay for wildlife conservation and related public recreation for the State of California and is within the Department of Fish and Game (DFG). DFG has strong interests in the linkage and has previously purchased lands along the Santa Margarita River as part of a Conceptual Area Protection Plan (CAPP). CAPPs are internal DFG documents used to help determine acquisition priorities for parcels. Four CAPPs are currently delineated with the Linkage Design Area.

(this page intentionally left blank)

Summary

A Scientifically Sound Plan for Conservation Action

In the South Coast Ecoregion, humans have become significant agents of biogeographic change, converting habitat to urban and agricultural uses and altering the movements of organisms, nutrients, and water through the ecosystem. The resulting fragmentation of natural landscapes threatens to impede the natural processes needed to support one of the world's greatest biological warehouses of species diversity.

The interaction among human development and unparalleled biodiversity is one of the great and potentially tragic experiments of our time. It creates a unique challenge for land managers and conservation planning efforts – to mitigate catastrophic changes to a once intact ecosystem. Many local and regional planning efforts, such as California Natural Communities Conservation Planning, have taken up this challenge, identifying the need for protected reserves and connections among them. The Santa Ana – Palomar Mountains Linkage conservation plan supports these efforts by identifying larger-scale ecosystem processes that must be conserved if these individual local efforts are to succeed in protecting the region's biodiversity.

The Santa Ana – Palomar Mountains Linkage reaches between the Santa Ana Mountains and its coastal lowlands to the Palomar Mountains and inland ranges of San Diego County, and constitutes the only remaining habitat connection to other large protected areas for these coastal lands. The prioritization of this linkage for conservation and the demarcation of lands requiring protection in the linkage are based on the best available conservation techniques and expertise of biologists working in the region. The project, spearheaded by the SDSU Field Station Programs and South Coast Wildlands, provides a strong biological foundation and quantifiable, repeatable conservation design approach that can be used as the basis for successful conservation action. By identifying landscape-level conservation priorities necessary to sustain local biodiversity, the Santa Ana – Palomar Mountains Linkage Plan serves as a common vision for collaboration among a wide variety of conservation groups and projects.

Next Steps

This Linkage Design Plan acts as a scientifically sound starting point for conservation implementation and evaluation. It serves a resource:

- For conservation and restoration action. A variety of projects will be needed to address road, stream, urban, agricultural, and recreational barriers. Recommended tools include road renovation, construction of wildlife crossings, watershed planning, habitat restoration, conservation easements, zoning, acquisition, public education (see below) and others. These recommendations are not exhaustive, but are meant to serve as a starting point for persons interested in becoming involved in preserving and restoring a functional landscape. 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, and to work within this framework to develop a wide variety of restoration options for maintaining linkage function. To this end, we provided a list of organizations, agencies and regional projects that provide collaborative opportunities for implementation

- For setting land management goals. This plan provides information for regional land managers to understand their critical role in sustaining biodiversity and ecosystem processes, both locally and in the South Coast Ecoregion. Existing conservation investments in the linkage are already extensive including lands managed by the Camp Pendleton Marine Corps Base, California State Parks, Fallbrook Naval Weapons Station, US Forest Service, Bureau of Land Management, San Diego State University, California Department of Fish and Game, The Nature Conservancy, and the County of San Diego. Other major landholders include the Pala, Pechanga, and Pauba Indians and Fallbrook Public Utility District. Each holding lies within Core Areas or the linkage itself and serves a unique role in preserving some aspect of the connection. Incorporating relevant aspects of this plan into individual land management plans provides an opportunity to jointly implement a regional conservation strategy.

- For developing education programs. Public education and outreach is vital to the success of this effort – both to change land use activities that threaten species existence and movement in the linkage and to generate an appreciation and support of the conservation effort. Public education can encourage residents at the urban-wildland interface to become active stewards of the land and to generate a sense of place and ownership for local habitats and processes. Such voluntary cooperation is essential to preserving linkage function. The biological information, figures and tables from this plan are ready materials for interpretive programs. We have also prepared two types of visual journey through each linkage. The flyover animation consists of color aerial photographs draped over a digital elevation map. The interactive map is the USGS 1:24000 topographic map with the LD superimposed; arrows on the map are hyperlinked to digital photographs taken from the point on the ground indicated by the base of the arrow in the direction of the arrow. These materials are available at our websites (www.fs.sdsu.edu and www.scwildands.org) and on CD-ROM.

- For identifying research and monitoring studies. Successful conservation efforts are reiterative, incorporating and encouraging the collection of new biological information that can increase understanding of linkage function. We strongly support the development of a monitoring and research program that addresses movement (of individuals and genes) and resource needs of species in the

Linkage Design area. The suite of predictions generated by the GIS analyses conducted in this planning effort provides a starting place for designing monitoring programs. In addition, the facilities, databases, and protected lands at San Diego State University's Santa Margarita Ecological Reserve serves as a focal point for further study and to attract and encourage research in the linkage.

The remaining wildlands of the South Coast Ecoregion 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 agricultural 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. Development is sure to continue in southern California. With this linkage conservation plan, the outcome of land use changes can be altered to assure the greatest protection for our natural areas at the least cost to our human endeavors. If we act now, we can choose a future where wildland areas are still wild, and natural areas remain alive with movements of all of our native species.

(this page intentionally left blank)

Literature Cited

AOU (American Ornithologists' Union). 1998. Check-list of North American birds. 7th ed. American Ornithologists' Union, Washington D.C.

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

Ahlborn, G. 1999. California quail, *Callipepla californica*. In: Volume II: Birds. California wildlife habitat relationships system, edited by D.C. Zeiner, W.F. Laudenslayer Jr., KE Mayer, and M. White. California Department of Fish and Game, California Interagency Wildlife Task Group, Sacramento, California.

Aker, C.L. 1982. Spatial and temporal dispersion patterns of pollinators and their relationship to the flowering strategy of *Yucca whipplei* (Agavaceae). Oecologia 54:243-252.

Aker, C.L. and D. Udovic. 1981. Oviposition and pollination behavior of the Yucca Moth, *Tegeticula maculata* (Lepidoptera: Prodoxidae), and it relation to the reproductive biology of *Yucca whipplei* (Agavaceae). Oecologia 49:96-101.

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.

Andrews, R.D. and E.K. Boggess. 1978. Ecology of coyotes in Iowa. In: Coyotes: biology, behavior, and management, edited by M. Bekoff. Academic Press, New York, New York.

Archibold, O.W. 1995. Ecology of world vegetation. Chapman & Hall, New York, New York.

ACOE (Army Corps of Engineers). 2000. General Investigations. Flood control, environmental restoration and recreation. Final feasibility report. U.S. Army Corps of Engineers Los Angeles District, Los Angeles, California.

Apps, C.D., N.J. Newhouse, and T.A. Kinley. 2002. Habitat associations of American badgers in southeastern British Columbia. Canadian Journal of Zoology 80:1228-1239.

Arnold, R.A. 1985. Geographic variation in natural populations of *Speyeria callippe* (Boisduval)(Lepidoptera: Nymphalidae). Pan-Pacific Entomologist 61:1-23.

Atsatt, P.R. and T. Ingram. 1983. Adaptation to oak and other fibrous, phenolic-rich foliage by a small mammal, *Neotoma fuscipes*. Oecologia 60:135-142.

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

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. California Riparian Habitat Joint Venture and The Wildlife Society, Sacramento, California.

Beecham, J.J. and M.N. Kocher. 1975. Breeding biology of the golden eagle in southwestern Idaho. Wilson Bulletin 87:506-513.

Beedy, E.C. 1975. Avifaunal complexity and forest structure in the Sierra Nevada of California. Masters thesis. University of California Davis, Davis, California.
Beer, J.R., L.D. Frenzel, and N. Hansen. 1956. Minimum space requirements of some nesting passerine birds. Wilson Bulletin 68:200-209.
Beier, P. 1993. Determining minimum habitat areas and habitat corridors for cougars. Conservation Biology 7:94-108.
Beier, P. 1995. Dispersal of juvenile cougars in fragmented habitats. Journal of Wildlife Management 5:228-237.
Beier, P. 1996. Metapopulation models, tenacious tracking, and cougar conservation. In: Metapopulations and wildlife conservation, edited by D. R. McCullough. Island Press, Covelo, California.
Beier, P. and R. Barrett. 1993. The cougar in the Santa Ana Mountain Range, California. Final report for Orange County Cooperative Mountain Lion Study. Department of Forestry and Resource Management, University of California, Berkeley, California.
Beier, P. and S. Loe. 1992. A checklist for evaluating impacts to wildlife movement corridors. Wildlife Society Bulletin 20:434-440.
Beier, P. and Noss, R.F. 1998. Do habitat corridors provide connectivity? Conservation Biology 12:1241-1252.
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, C. Personal communication. Reserve Manager. Santa Rosa Plateau Ecological Reserve, Riverside County, California.
Bell, G P. 1997. Ecology and management of *Arundo donax*, and approaches to riparian habitat restoration in southern California. In: Plant invasions: studies from North America and Europe edited by J.H. Brock, M. Wade, P. Pysek and D. Green. Backhuys Publications, Leiden, The Netherlands.
Belt, G.H., J. O'Laughlin, and T. Merrill. 1992. Design of forest riparian buffer strips for the protection of water quality: analysis of scientific literature. Report No. 8, Idaho Forest, Wildlife and Range Policy Analysis Group. Wildlife and Range Sciences, University of Idaho, Moscow, Idaho.
Benninger, M.C. 1989. Trails as conduits of movement for plant species in coniferous forests of Rocky Mountain National Park, Colorado. Masters thesis, Miami University, Oxford, Ohio.
Benninger-Truax, M., 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. Landscape Ecology 6:269-278.
Bent, A.C. 1946. Life histories of North American jays, crows, and titmice. U.S. National Museum Bulletin 191. United States Government Printing Office, Washington D.C.
Bent, A.C. 1953. Life histories of North American Wood Warblers. National Museum Bulletin 203. United States Government Printing Office, Washington D.C.
Bittner, D. Personal communication. Wildlife Research Institute, Ramona, California.
Bleich, V.C. 1973. Ecology of rodents at the United States Naval Weapon Station, Seal

Beach, Fallbrook Annex, San Diego County, California. Masters thesis. California State University, Long Beach, California.
Bloom, P. Personal communication. Research biologist. Western Foundation of Vertebrate Zoology. Santa Ana, California.
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.
Bolger, D.T., T.A. Scott, and J.T. Rotenberry. 2001. Use of corridor-like landscape structures by bird and small mammal species. Biological Conservation 102:213-224.
Bounds, D.L. and W.W. Shaw 1997. Movements of suburban and rural coyotes at Saguaro National Park, Arizona. The Southwestern Naturalist 42:94-121.
Bowen, W.D. 1982. Home range and spatial organization of coyotes in Jasper National Park, Alberta. Journal of Wildlife Management 46:201-216.
Boyd, S. and D. Banks. 1995. A botanical assessment of the Aqua Tibia Wilderness Area, Cleveland National Forest, California. Rancho Santa Ana Botanic Garden, Claremont, California.
Brattstrom, B.H. and D.F. Messer. 1988. Current status of the southwestern pond turtle, *Clemmys marmorata pallida* in southern California. Final report for California Department of Fish and Game. Contract C-2044. California State University, Fullerton, California.
Brown, T. Personal communication. California State University San Marcos. San Marcos, California.
Brown, L. and D. Amadon. 1968. Eagles, hawks and falcons of the world. 2 Vols. Country Life Books, London.
Brylski, P. 1988-1990. Dusky-footed woodrat, *Neotoma fuscipes*. In: Volume III: Mammals. California wildlife habitat relationships system, edited by D.C. Zeiner, W.F. Laudenslayer Jr., K.E. Mayer, and M. White. California Department of Fish and Game, California Interagency Wildlife Task Group, Sacramento, California
Bureau of Land Management. 1996. South Coast resource management plan and record of decision. United States Department of the Interior Bureau of Land Management, South Coast Resource Area, California Desert District, Palm Springs, California.
Bury, R.B. 1972. Habits and home range of the Pacific pond turtle, *Clemmys marmorata*, in a stream community. Ph.D. Dissertation. University of California, Berkeley.
Bury, R.B. 1979. Population ecology of freshwater turtles. In: Turtles: research and perspectives, edited by M. Harless and H. Morlock. John Wiley and Sons, New York.
Bury, R.G. and J.H. Wolfheim. 1973. Aggression in the free-living pond turtle (*Clemmys marmorata*). Bio-Science 23:659-662.
Cahalane, V.H. 1961. Mammals of North America. The MacMillan Company, New York.

Cain, A.T. 1999. Bobcat use of highway crossing structures and habitat use near a highway expansion in southern Texas. M.S. thesis, Texas A&M University, Kingsville, Texas.

CDFG (California Department of Fish and Game). 1999. Rare find: California natural diversity database. California Department of Fish and Game, Sacramento, California.

CDFG (California Department of Fish and Game). 2000. Steelhead rainbow trout in San Mateo Creek, San Diego County, California. Report prepared for National Marine Fisheries Service. California Department of Fish and Game, Native Anadromous Fish and Watershed Branch and South Coast Region, Sacramento, California.

California Trout, Inc. 1996. California steelhead trout: essential information regarding species recovery. California Trout Incorporated, San Francisco, California.

California Wilderness Coalition. 2002. Our natural heritage at risk: California's 10 most threatened wild places. California Wilderness Coalition, Davis, California.

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.

Churcher, J.B. and J.H. Lawton. 1987. Predation by domestic cats in an English village. Journal of Zoology (London) 212:439-456.

Clevenger, A.P. and N. Waltho. 2000. Factors influencing the effectiveness of wildlife underpasses in Banff National Park, Alberta, Canada. Conservation Biology 14:47-56.

Clevenger, A.P. and N. Waltho. 1999. Dry drainage culvert use and design considerations for small- and medium-sized mammal movement across a major transportation corridor. 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.

Clevenger, A.P., B. Chruszez, and K. Gunson. 2001. Highway mitigation fencing reduces wildlife vehicle collisions. Wildlife Society Bulletin 29:646-653.

Collopy, M.W. 1984. Parental care and feeding ecology of golden eagle nesting. Auk 101:753-760.

Cooperrider, A.Y., R.J. Boyd, and H.R. Stuart (eds.). 1986. Inventory and monitoring of wildlife habitat. U.S. Department of the Interior, Bureau of Land Management, Denver, Colorado.

Corn, S., E. Muths, and S. Haire. 2001. Project description for examining an intact "metapopulation" of boreal toads (*Bufo boreas*): use of habitat and large scale movements. <http://www.mesc.usgs.gov./research/5003080.asp> (22 December 2003).

Craighead, A.C., E.A Roberts, and F.L. Craighead. 2001. Bozeman Pass wildlife linkage and highway safety study. International conference on ecology and transportation. September 2001. Craighead Environmental Research Institute, Bozeman, Montana <http://www.wildlands.org/research.html> (22 December 2003).

Cranford, J.A. 1977. Home range and habitat utilization by *Neotoma fuscipes* as determined by radiotelemetry. Journal of Mammalogy 58:165-172.
Crooks, K. 1999. Mammalian carnivores, mesopredator release, and avifaunal extinctions in a fragmented system. Ph.D. Dissertation. University of California Santa Cruz, California.
Crooks, K. and M. Soule 1999. Mesopredator release and avifaunal extinctions in a fragmented system. Nature 400:563-566.
Crooks, K.R., A.V. Suarez, D.T. Bolger, and M. Soule. 2001. Extinction and colonization of birds on habitat islands in urban Southern California. Presentation at Society of Conservation Biology Conference, Fragmented Habitats and Bird Conservation Session, Hilo, Hawaii.
Currier, M.J.P. 1983. *Felis concolor*. Mammalian Species 200:1-7. American Society of Mammalogists, Michigan.
Dale, N. 2000. Flowering plants. The Santa Monica Mountains. Coastal and chaparral regions of Southern California. California Native Plant Society, Sacramento, California.
Davenport, K. Personal communication. Independent consulting biologist, Bakersfield, California.
Debinski, D.M. and R.D. Holt. 2000. A survey and overview of habitat fragmentation experiments. Conservation Biology 14:342-355.
DeGraaf, R.M., V.E. Scott, R.H. Hamre, L. Ernst, and S.H. Anderson. 1991. Forest and rangeland birds of the United States: Natural history and habitat use. Agriculture Handbook 688. U.S. Department of Agriculture, Forest Service. Washington DC.
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.
Dennis, N.B., D. Ellis, J.R. Arnold, and D.L. Renshaw. 1984. Riparian surrogates in the Sacramento/San Joaquin and their habitat values. In: California riparian systems: ecology, conservation and productive management, edited by R.E. Warner and K.M. Hendrix. University of California Press, Berkeley, California.
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, B.G. and P. Beier. 2002. Home range and habitat selection by adult cougars in southern California. Journal of Wildlife Management 66:1235-1245.
Dickson, B.G., J.S. Jenness, and P. Beier. 2004. Influence of vegetation, roads, and topography on cougar movement in southern California. Journal of Wildlife Management 68:in press.
Dixon, J.B. 1937. The golden eagle in San Diego County, California. Condor 39:49-56.
Dixon, K.L. 1949. Behavior of the plain titmouse. Condor 51:110-136.
Dixon, K.L. 1954. Some ecological relations of chickadees and titmice in central California. Condor 56:113-124.
Dixon, K.L. 1956. Territoriality of and survival in the plain titmouse. Condor 58:169.
Dunstan, T.C. 1989. The golden eagle. Audubon Wildlife Report: 1989/1990:499-511.

Ehrlich, R., D.S. Dobkin, and D. Wheye. 1988. The birder's handbook. A field guide to the natural history of North American birds. Simon & Schuster Inc, New York, New York.
Emmel, T.C. and J.F. Emmel. 1973. The butterflies of Southern California. Natural History Museum of Los Angeles County. Science Series 26.
Ernest, H. 2002. Genetic structure of mountain lion populations in California and Nevada. Carnivores 2002: from the mountains to the sea, a conference on predator biology and conservation. November 17-20, 2002. Monterey, California.
Evink, G.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.
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.
Ficken, M.S. and R.W. Ficken. 1966. Notes on mate and habitat selection in the yellow warbler. Wilson Bulletin 78:232-233.
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.
Finney, K. and J. Edmondson. No date. Swimming upstream: restoring the rivers and streams of coastal Southern California for Southern Steelhead and other fishes. Prepared for the Southern California Steelhead Recovery Coalition. http://www.socalsteelhead.org/frames/steelhead.pdf (22 December 2003).
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.
Fisher, R. and C. Swift. 1998. Preliminary survey of the fish of the Santa Margarita River Watershed, San Diego and Riverside counties, California. Department of Biology, San Diego State University, San Diego, California.
Fitch, H.S. and H.W. Shirer. 1971. A radiotelemetry study of spatial relationships in some common snakes. Copeia 1971:118-128.
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 37:1489-1508.
Fleishman, E.R., C. Ray, P. Sjogren-Gulve, C.L. Boggs, and D.D. Murphy. 2002. Assessing the roles of patch quality, area, and isolation in predicting metapopulation dynamics. Conservation Biology 16:706-716.
Forman, R.T.T. 1995. Land mosaics: the ecology of landscapes and regions. Cambridge University Press, Cambridge, England.
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., 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.
Francis, W.J. 1970. The influence of weather on population fluctuation in California quail. Journal of Wildlife Management 34:249-266.
Garth, J.S. and J.W. Tilden. 1986. California butterflies. University of California Press, Berkeley, California.
Garrett, K. and J. Dunn. 1981. Birds of Southern California: status and distribution. Los Angeles Audubon Society, Los Angeles, California.
Gier, H.T. 1975. Ecology and behavior of the coyote (*Canis latrans)*. In: The wild canids, edited by M.W. Fox. Van Nostrand Reinhold, New York, New York.
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.
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.
Green, M. 1999. Yellow warbler (*Dendroica* petechia). In: Volume II: Birds. California wildlife habitat relationships system, edited by Zeiner, D.C., W.F. Laudenslayer Jr., KE Mayer, and M. White. California Department of Fish and Game, California Interagency Wildlife Task Group, Sacramento, California.
Haines, L. 1941. Variation in*Yucca whipplei*. Madrono 6:33-45.
Hall, E. R. 1981. The mammals of North America. 2nd ed. Vol. 2. John Wiley and Sons. New York, New York.
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 64:19-28.
Hanski, I. and M. Gilpin. 1991. Metapopulation dynamics: brief history and conceptual domain. Biological Journal of the Linnean Society 42:3–16.
Harris, L.D. 1984. The fragmented forest: island biogeography theory and the preservation of biotic diversity. University of Chicago Press, Chicago, Illinois.
Harris, L. D. and P. B. Gallagher. 1989. New initiatives for wildlife conservation: the need for movement corridors. In: Preserving communities and corridors, edited by G. Mackintosh. Defenders of Wildlife, Washington, D.C.
Harris, R.T. 1975. Seasonal activity and microhabitat utilization in *Hyla cadaverina* (Anura: Hylidae). Herpetologica 31:236-239.
Harrison, R.L. 1992. Toward a theory of inter-refuge corridor design. Conservation Biology 6:293-295.
Hertz, P.E., J.V. Remsen, and S.I. Zones. 1976. Ecological complementarity of three sympatric parids in a California oak woodland. Condor 78:307-316.
Higgins, P. 1991. Southern California steelhead recovery assessment: San Mateo Creek, Santa Margarita River. A wider role for Trout Unlimited in protection and

recovery. Report to the South Coast chapter of Trout Unlimited, Berkeley, California.
Holland, D.C. 1985. An ecological and quantitative study of the western pond turtle (*Clemmys marmorata*) in San Luis Obispo County, California. Master's Thesis. California State University, Fresno, California.
Holland, D.C. 1991. A synopsis of ecology and status of the Western Pond Turtle (*Clemmys marmorata*) in 1991. Prepared for the US Fish and Wildlife Service, National Ecology Research Center, San Simeon Field Station, California.
Horwitz, E.L. 1978. Our nation's wetlands: an interagency task force report. Council on Environmental Quality, Washington D.C.
Hunt, A., H.J. Dickens, and R.J. Whelan. 1987. Movement of mammals through tunnels under railway lines. Australian Zoologist 24:89-93.
Jackson, S.D. and C.R. Griffin. 2000. A strategy for mitigating highway impacts on wildlife. In: Wildlife and highways: seeking solutions to an ecological and socio-economic dilemma, edited by T.A. Messmer and B. West. The Wildlife Society, Bethesda, Maryland.
Jenks, J.S. 2002. Santa Margarita River Watershed annual watermaster report. Water year 2000-2001. United States of America v. Fallbrook Public Utility District, et al. Civil No. 1247-SD-T. Fallbrook, California.
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.
Kay, D.W. 1989. Movements and homing in the canyon tree frog (*Hyla cadaverina*). The Southwestern Naturalist 34:293-294.
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.
Keeley, J.E. and A. Massihi. 1994. *Arctostaphylos rainbowensis*, a new burl-forming manzanita from northern San Diego County, California. Madrono 41:1-12.
Kendeigh, S.C. 1941. Birds of a prairie community. Condor 43:165-174.
Klauber, L. M. 1972. Rattlesnakes: their habits, life histories, and influence on mankind. 2nd Ed. University of California Press, Berkeley, California.
Knight, R.L. and D.N. Cole. 1995. Wildlife responses to recreationists. In: Wildlife and recreationists, coexistence through management and research, edited by R.L. Knight and K.J. Gutzwiller. Island Press, Washington D.C.
Knight, R.L. and K.J. Gutzwiller (eds.) 1995. Wildlife and recreationists, coexistence through management and research. Island Press, Washington D.C.
Kreuper, D.J. 1992. Effects of land use on western riparian ecosystems. In: Status and Management of Migratory Birds, edited by D.M. Finch and P.W. Stangel. U.S.D.A. Forest Service General Technical Report RM-229.
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.

Kucera, T. 1999-1990. Oak titmouse, *Baeolophus inornatus*. In: Volume II: Birds. California wildlife habitat relationships system, edited by D.C. Zeiner, W.F. Laudenslayer Jr., K.E. Mayer, and M. White. California Department of Fish and Game, California Interagency Wildlife Task Group, Sacramento, California.
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.
Lang, J.S., B.F. Oppenheim, and R.N. Knight 1998. Southern steelhead *Oncorhynchus mykiss* habitat suitability of the Santa Margarita River, San Mateo, and San Onofre creeks on Marine Corps Base Camp Pendleton. Coastal California Fish and Wildlife Office, U.S. Fish and Wildlife Service, Arcata California.
Lathrop, E.W. and C.D. Osborne. 1990. From acorn to tree: ecology of the Engelmann Oak. Fremontia 18:30-35.
Lawson, D., L. Seiger, and P. Zedler. 2001. Long term monitoring of coast live oak and Engelmann Oak populations in San Diego County: 10 years of change. Abstract 53. Oaks in California's Changing Landscape. Fifth Symposium on Oak Woodlands October 22-25, 2001, San Diego, California.
Leopold, A.S. 1977. The California quail. University of California Press, Berkeley, California.
Leopold, A.S., M. Erwin, J. Oh, and B. Browning. 1976. Phytoestrogens: adverse effects on reproduction in California quail. Science 191:98-100.
Levins, R. 1970. Extinction. In: Some mathematical questions in biology. Lectures on mathematics in the life sciences, Vol. 2, edited by M. Gerstenhaber. American Mathematical Society, Providence, Rhode Island.
Ligon, J.D and P.B. Stacey. 1996. Land use, lag times and the detection of demographic change: the case of the acorn woodpecker. Conservation Biology 10:840-846.
Lindsdale, J.M. and L.P. Tevis, Jr. 1971. The dusky-footed woodrat. University California Press, Berkeley.
Lindzey, F.G. 1978. Movement patterns of badgers in northwestern Utah. Journal of Wildlife Management 42:418-422.
Lindzey, F. 1987. Mountain lion. In: Wild furbearer management and conservation in North America, edited by M. Novak, J. Baker, M.E. Obbard, and B. Mllock. OntarioTrappers Association, North Bay, Ontario.
Long, C.A. 1973. Taxidea taxus. Mammalian Species 26:1-4.
Long, C.A. and C.A. Killingley. 1983. The badgers of the world. Charles C. Thomas Publishing, Springfield, Illinois.
Longcore, T. 2000. Ecological effects of fuel modification on arthropods and other wildlife in an urbanizing wildland. In: National Congress on Fire Ecology, Prevention and Management Proceedings, No. 1, edited by L.A. Brennan et al. Tall Timbers Research Station, Tallahassee, Florida.
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.

Lovich, J. and K. Meyer. 2002. The western pond turtle (*Clemmys marmorata*) in the Mojave River, California, USA: highly adapted survivor or tenuous relict? Journal of Zoology London 256:537-545.
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 913:19-22.
Luke, C. Personal communication. Director Santa Margarita Ecological Reserve, San Diego State University Field Station Programs, San Diego, California.
Lyon, L.J. 1983. Road density models describing habitat effectiveness for elk. Journal of Forestry 81:592-5.
MacArthur, R.H., and E.O. Wilson. 1967. The theory of island biogeography. Princeton University Press, Princeton, New Jersey.
Maehr, D.S. 1992. Florida panther: *Felis concolor coryi*. In: Rare and endangered biota of Florida. Mammals: Volume 1, edited by S.R. Humphrey. Florida Game and Fresh Water Fish Commission, Naples, Florida.
Marlow, W. 1988-1990. Red diamond rattlesnake: *Crotalus ruber*. In: Volume I: Amphibians and reptiles. California wildlife habitat relationships system, edited by D.C. Zeiner, W.F. Laudenslayer, Jr., K.E. Mayer, and M. White. California Department of Fish and Game. California Interagency Wildlife Task Group, Sacramento, California.
Marr, D.L., J. Leebens-Mack, L. Elms, and O. Pellmyr. 2000. Pollen dispersal in *Yucca filamentosa* (Agavaceae): the paradox of self-pollination behavior by *Tegeticula yuccasella* (Prodoxidae). American Journal of Botany 87:670-677.
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.
Matchett, M.R. and B.W. O'Gara. 1991. Golden eagles and the livestock industry: an emotionally charged issue. Western Wildlands 17:18-24.
McElhany, P., M.H. Ruckelhaus, M.J. Ford, T.C. Wainwright, and E.P. Bjorkstedt. 2000. Viable salmond populations and the recovery of evolutionarily significant units. U.S. Department of Commerce, NOAA Technical Memorandum. NMFS-NWFSC-42.
McEwan. D. and T.A. Jackson. 1996. Steelhead restoration and management plan for California. California Department of Fish and Game. Sacramento, California.
McGahan, J. 1968. Ecology of the golden eagle. Auk 85:1-12.
McMillan, I.I. 1964. Annual population changes in California quail. Journal of Wildlife Management 28:702-711.
Messick, J.P. and M.G. Hornocker 1981. Ecology of the badger in southwestern Idaho. Wildlife Monographs 76:1-53.
Miller, R.R. 1968. Records of some native freshwater fishes transplanted into various waters of California, Baja California, and Nevada. California Fish and Game 54:170-179.
Miller, A.H. and R.C. Stebbins. 1964. The lives of desert animals in Joshua Tree National Monument. University of California Press, Berkeley, California.

Mills, L. S., and P. E. Smouse. 1994. Demographic consequences of inbreeding in remnant populations. American Naturalist 144:412-431.
Mittermeier, R.A., N. Myers, J.B. Thomsen, G.A.B. de Fonceca, and S. Olivieri. 1998. Biodiversity hotspots and major tropical wilderness areas: approaches to setting conservation priorities. Conservation Biology12:516-520.
Mittermeier, R.A., N. Myers, and C.G. Mittermeier (eds.). 1999. Hotspots: earth's biologically richest and most endangered terrestrial ecosystems. CEMAX, Mexico City.
Morey, S. 1988-1990a. Western toad, *Bufo boreas*. In: Volume I: amphibians and reptiles. California wildlife habitat relationships system, edited by D.C Zeiner, W.F. Laudenslayer Jr., KE Mayer, and M. White. California Department of Fish and Game, California Interagency Wildlife Task Group, Sacramento, California.
Morey, S. 1988-1990b. California Chorus Frog. In: Volume I: amphibians and reptiles. California wildlife habitat relationships system, edited by D.C. Zeiner, W.F. Laudenslayer Jr., KE Mayer, and M. White. California Department of Fish and Game, California Interagency Wildlife Task Group, Sacramento, California.
Morey, S. 1988-1990c. Western Pond Turtle. In: Volume I: amphibians and reptiles. California wildlife habitat relationships system, edited by D.C. Zeiner, W.F. Laudenslayer Jr., KE Mayer, and M. White. California Department of Fish and Game, California Interagency Wildlife Task Group, Sacramento, California.
Morse, D.H. 1966. The context of songs in the yellow warbler. Wilson Bulletin 78:444-455.
Moyle, P. 1976. Inland fishes of California. University of California Press, Berkeley, California.
Moyle, P.B., R.M. Yoshiyama, J.E. Williams, and E.D. Wikramanayake. 1995. Fish species of special concern in California. 2nd Edition. Inland Fisheries Division, California Department of Fish and Game, Rancho Cordova, California.
Moyle, P. 2002. Inland fishes of California. University of California Press, Berkeley.
Munz, P.A. 1974. A flora of southern California. University of California Press, Berkeley, California.
Murcia, C. 1995. Edge effects in fragmented forests: implications for conservation . Tends in Ecology and Evolution 10:58-62.
National Marine Fisheries Service. 1996. Status review of west coast steelhead from Washington, Idaho, Oregon and California. NOAA Technical Memorandum. NMFS-MNFSC-27.
Norton, D.A. 2002. Edge effects in a lowland temperate New Zealand rainforest. DOC Science Internal Series 27. Department of Conservation, Wellington.
Nosil, P., B.J. Crespi and C.P. Sandoval. 2002. Host-plan adaptation drives the parallel evolution of reproductive isolation. Nature 417:440-443.
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.
Noss, R.F. 1991. Landscape linkages and biodiversity. W. E. Hudson, Washington, D.C.

Noss, R.F. 1992. The Wildlands Project: land conservation strategy. Wild Earth (Special Issue) 1:10-25.
Noss, R.F. and A.Y. Cooperrider. 1994. Saving nature's legacy: protecting and restoring biodiversity. Island Press, Washington, D.C.
Noss, R.F., C. Carole, K. Vance-Borland, and G. Wuerthner. 2002. A multi-criteria assessment of the irreplaceability and vulnerability of sites in the greater Yellowstone ecosystem. Conservation Science 16:895-908.
Nussbaum, R.A., E.D. Brodie, Jr., and R.M. Storm. 1983. Amphibians and reptiles of the Pacific Northwest. University Press of Idaho, Moscow, Idaho.
Ohmart, R. D. 1994. The effects of human-induced changes on the avifauna of western riparian habitats. Studies in Avian Biology 15:273-285.
Olson, D.H. 1992. Ecological susceptibility of amphibians to population declines. In: Proceedings of the symposium on biodiversity of northwestern California,1991 October 28-30, Santa Rosa, California. technically coordinated by R.R. Harris, D.C Erman, and H.M. Kerner. Report 29, Wildland Resources Center, Division of Agriculture and Natural Resources, University of California, Berkeley, California.
Orsak, L.J. 1977. The butterflies of Orange County, California. Center for Pathobiology Miscellaneous Publication 3. University of California Press, New York, New York.
Osborne, C.D. 1989. Early establishment of *Quercus engelmannii* (Fagaceae) on the Santa Rosa Plateau, Riverside County, California. Ph.D. Dissertation. Loma Linda University, Riverside, California.
Ozoga, J.J. and E.M. Harger. 1966. Winter activities and feeding habits of northern Michigan coyotes. Journal of Wildlife Management 30:809-818.
Page, L. M. and B. M. Burr. 1991. A field guide to freshwater fishes of North America north of Mexico. The Peterson Field Guide Series, Vol. 42, Houghton Mifflin Company, Boston, Massachusetts.
Palmer, R.S. (ed.) 1988. Handbook of North American birds. Vol. 5. Yale University Press, New Haven, Connecticut.
Pavlik, B.M., P.C. Muick, S.G. Johnson, and M. Popper. 1991. Oaks of California. Cachuma Press Inc., Olivos, California.
Penrod, K., A. Atkinson, P. Beier, C. Luke, and W. Spencer. 2001. Procedures for prioritizing for linkages in the South Coast Ecoregion. Unpublished report. South Coast Wildlands Project, Idyllwild, California.
Penrod, K., M. Bond, and H. Wagenvoord. 2002. A Conservation alternative for the four southern forests (Los Padres, Angeles, San Bernardino, Cleveland). Center for Biological Diversity, Idyllwild, California.
Penrod, K, R Hunter, and M. Marrifield. 2001. Missing Linkages: restoring connectivity to the California landscape. South Coast Wildlands Project in collaboration with California Wilderness Coalition, The Nature Conservancy, US Geological Survey, Center for Reproduction of Endangered Species, and California State Parks, Idyllwild, California.
Peters, R.L. and R.F. Noss. 1995. America's Endangered Ecosystems. Defenders of Wildlife. <http://www.defenders.org/amee03.html> (22 December 2003).
Peterson, R.T. 1990. Western birds. Peterson Field Guides. Houghton Mifflin Company, Boston, Massachusetts.

Peugegnat, W.E. 1951. The biota of the Santa Ana Mountains. Journal of Entomology and Zoology (Pomona) 82:1-84.
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.
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.
Pratt, G. Personal communication. Department of Entomology, University of California, Riverside, Riverside, California.
Proctor, M., P. Yeo and A. Lack. 1996. The natural history of pollination. Timber Press, Portland, Oregon.
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.
Quinn, T. 1995. Using public sighting information to investigate coyote use of urban habitat. Journal of Wildlife Management 59:238-245.
Quinn, T. 1997. Coyote (*Canis latrans*) habitat selection in urban areas of western Washington via analysis of routine movements. Northwest Science 71:289-297.
Rathburn, G., N. Siepel, and D. Holland. 1992. Nesting behavior and movements of western pond turtles, *Clemmys marmorata*. Southwestern Naturalist 37:319-324.
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.
Reese, D.A. and H.W. Welsh. 1997. Use of terrestrial habitat by western pond turtles, *Clemmys marmorata*: implications for management. In: Conservation, restoration and management of turtles and tortoises – an international conference, edited by J. Van Abbema. State University of New York, New York, New York.
Reiser, C.H. 1994. Rare plants of San Diego County. Aquifer Press, San Diego, California.
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.
Ries, L. and D.M. Debinski. 2001. Butterfly responses to habitat edges in the highly fragmented prairies of Central Iowa. Journal of Animal Ecology 70:840-852.
Riverside County Integrated Project (RCIP). 2000. Multi-species habitat conservation plan species accounts. Prepared for Riverside County. Dudek and Associates, Encinitas, California.
Robbins, C.S., B. Bruun, and Herbert S. Zim. 1966. Birds of North America. Golden Press, New York, New York.
Roberts, R. 1995. Illustrated guide to the oaks of the southern floristic province: the oaks of coastal southern California and northwestern Baja California. F.W. Roberts Publications, Encinitas, California.

Rodriguez, A., G. Crema and M. Delibes. 1996. Factors affecting crossing of red foxes and wildcats through non-wildlife passages across a high speed railway. Ecography 20:287-94.
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.
Rosell, C., J. Parpal, R. Campeny, S. Jove, A. Pasquina, and J.M. Velasco. 1997. Mitigation of barrier effect on linear infrastructures on wildlife. In: Habitat Fragmentation and Infrastructure, edited by K. Canters. Public Works and Water Management, Ministry of Transport, Delft, Netherlands.
Salt, G.W. 1957. An analysis of avifaunas in the Teton Mountains and Jackson Hole, Wyoming. Condor 59:373-393.
Sandoval, C. and B. Crespie. 1999. Speciation and radiation in the *Timema* walking stick. In: 1998-1999 Annual report, James Reserve and Oasis de los Osos, edited by Mike Hamilton. UC Natural Reserve System, <http://www.jamesreserve.edu/9899arpt/narrative.html> (22 December 2003).
Sandoval, C., D.A. Carmean, and B Crespi. 1998. Molecular phylogenetics of sexual and parthenogenic *Timema* walkingsticks. Proceedings of the Royal Society of London, Series B 265:589-595.
Suarez, A.V., D.T. Bolger and T.J. Case 1998. Effects of fragmentation and invasion on native ant communities in coast southern California. Ecology 79:2041-2056.
Sauvajot, R.M., M. Buechner, D. Kamradt, and C. Schonewald. 1998. Patterns of human disturbance and response by small mammals and birds in chaparral near urban development. Urban Ecosystems 2: 279-297.
Schonewald-Cox, C.M. 1983. Conclusions. Guidelines to management: A beginning attempt. In: Genetics and conservation: A reference for managing wild animal and plant populations, edited by C.M. Schonewald-Cox, S.M. Chambers, B. MacBryde, and W.L. Thomas. Benjamin/Cummings, Menlo Park, California.
Scott, J.A. 1986. The butterflies of North America: A natural history and field guide. Stanford University Press, Stanford, California.
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 63:51.
Scott, T.A. 1990. Conserving California's rarest white oak: the Engelmann oak. Fremontia 18:26-29.
Scott, T.A. 1991. The distribution of Engelmann Oak (*Quercus engelmannii*) in California. In: Proceedings of the symposium on oak woodland and hardwood rangeland management, technically coordinated by R.B. Standiford. U.S. Forest Service General Technical Report PSW-126.
Scott, T., S. Mensing, and R. Minnich. 2001. The demography and distribution of the Engelmann Oak. Abstract 66. Oaks in California's Changing Landscape. Fifth Symposium on Oak Woodlands October 22-25, 2001, San Diego California.
Shaffer, M.L. 1981. Minimum population sizes for species conservation. BioScience 31:131-134.
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. U.S. Forest Service, Pacific Northwest Research Station, Research Paper PNW-RP-549.
Skagen, S.K., C.P. Melcher, W.H. Howe and F.L. Knopf. 1998. Comparative use of riparian corridors and oases by migrating birds in southeast Arizona. Conservation Biology 1:896-909.
Smith, D.G. and J.R. Murphy. 1973. Breeding ecology of raptors in the eastern Great Basin of Utah. Provo Science Bulletin Biological Series 18 No. 3, Brigham Young University, Provo Utah.
Smith, F.A. 1997. *Neotoma cinerea.* Mammalian Species 564:1-8.
Sork, V.L., F.W. Davis, and P.E. Smouse. 2001. Where have all the fathers gone? Contemporary pollen movement in California Valley Oak, *Quercus lobata*. Abstract 39. Oaks in California's Changing Landscape. Fifth Symposium on Oak Woodlands October 22-25, 2001, San Diego California.
Soule, M.E. (ed.) 1987. Viable populations for conservation. Cambridge University Press, Cambridge.
Soulé, ME, and J Terborgh (eds.) 1999. Continental conservation: scientific foundations of regional reserve networks. Island Press, Washington, D.C.
Spencer, W. Consulting biologist. Conservation Biology Institute, San Diego, California.
Stauffer, D. F. and L. B. Best. 1980. Habitat selection by birds of riparian communities: evaluating effects of habitat alteration. Journal of Wildlife Management 44:1-15.
Stebbins, R.C. 1954. Amphibians and reptiles of western North America. McGraw-Hill Book Company, Inc., New York.
Stebbins, R.C. 1985. A field guide to western reptiles and amphibians. 2nd Ed., revised. Houghton Mifflin, Boston, Massachusetts.
Stein, B.A., L.S. Kutner, and J.S. Adams (eds.) 2000. Precious heritage: the status of biodiversity in the United States. Oxford University Press, New York, New York.
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. Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture, Albany, California.
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.
Stokes, D. and P. Morrison. 2003. GIS-based conservation planning: a powerful tool to be used with caution. Conservation in Practice 4:38-41.
Storer, T.I. 1930. Notes on the range and life-history of the Pacific fresh-water turtle, *Clemmys marmorata.* University of California Berkeley Publications in Zoology 32: 429-441.
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, Janet. 1994. Bufo boreas. In: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory, Fire Effects Information System, http://www.fs.fed.us/database/feis/2002 (22 December 2003).

Sullivan, Janet. 1996. *Taxidea taxus*. In: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory, Fire Effects Information System, http://www.fs.fed.us/database/feis/ (22 December 2003).
Swift, C.C. 2001. The Santa Ana sucker in the Santa Ana River: distribution, relative abundance, spawning areas, and impact of exotic predators. Submitted to the Santa Ana Water Project Authority, Riverside, California.
Swift, C.C., T. Hadlund, M. Ruiz, and R. Fisher. 1993. Status and distribution of freshwater fishes of southern California. Bulletin of Southern California Academy of Sciences 92:101-167.
Swift, C.C., R.N. Fisher, and M. Warburton. 2000. Status and distribution of fishes in the Santa Margarita River drainage. Report for the Nature Conservancy, Newport Beach, California.
Taylor, A. D. 1990. Metapopulation structure in predator-prey systems: an overview. Ecology 71:429-433.
Tesky, J.L. 1994. *Aquila chrysaetos*. In: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory, Fire Effects Information System, http://www.fs.fed.us/database/feis/ (22 December 2003).
Tesky, J.L. 1995. *Felis concolor*. In: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory, Fire Effects Information System, <http://www.fs.fed.us/database/feis/> (22 December 2003).
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. Proceedings of the National Academy of Sciences 99:12923-12926.
Titus, R.G., D.C. Erman, and W.M. Snider 1994. History and status of steelhead in California coastal drainages south of San Francisco Bay. Department of Fish and Game, Environmental Services. Sacramento, California
Tracey, J. 2000. Movement of red diamond rattlesnakes (*Crotalus ruber ruber)* in heterogeneous landscapes in coastal Southern California. Masters Thesis. University of California, San Diego, La Jolla, California.
Trombulak, S.C. and C.A. Frissell. 2000. Review of ecological effects of roads on terrestrial and aquatic communities. Conservation Biology 14:18-30.
Udovic, D. Personal communiation. Department of Biology and Environmental Studies, University of Oregon, Eugene, Oregon
Udovic, D. 1981. Determinants of fruit set in *Yucca whipplei*: reproductive expenditure vs. pollinator availability. Oecologia 48:389-399.
USFS. 1986. Final environmental impact statement. Land and resource management plan Cleveland National Forest, U.S. Department of Agriculture, Forest Service.
USGS. 2002a. Butterflies of North America, Butterflies of California. California Sister (*Adelpha bredowii*). Northern Prairie Wildlife Research Center, U.S. Geological Survey, < http://www.npwrc.usgs.gov> (22 December 2003).
USGS. 2002b. Pale Swallowtail (*Papilio eurymedon*). Butterflies of California. Northern Prairie Wildlife Research Center, <http:www.npwrc.usgs.gov> (22 December 2003).

Vaughan, T.A. 1954. Mammals of the San Gabriel Mountains of California. University of Kansas Museum of Natural History Publication 7:513-582.
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.
Verbeek, N.A.M. 1973. The exploitation system of the yellow-billed magpie. University of California Publications in Zoology 97:339-350.
Verner, J. and A.S. Boss (tech. cords.) 1980. California wildlife and their habitats: western Sierra Nevada. General Technical Report PSW-37. Pacific Southwest Forest and Range Experiment Station, U.S. Department of Agriculture, Forest Service, Berkeley, California.
Ver Steeg, B. and R.E. Warner. 1995. American badgers in Illinois. In: our living resources: a report to the nation on the distribution, abundance and helth of U.S. plants, animals and ecosystems, edited by E.T. LaRoe, G.S. Farrris, C.E. Puckett, P.D. Doran, J.J. Mac. U.S. Department of the Interior, National Biological Service, Washington D.C.
Walker, R. and L. Craighead. 1997. Analyzing wildlife movement corridors in Montana using GIS. Presented at the 1997 ESRI User Conference and published in the proceedings on CD-ROM, http://www.grizzlybear.org/ (22 December 2003).
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.
Warburton, M.L. Personal Communication. US Geological Survey, San Diego, California.
Warburton, M.L., C. Swift, and R. Fisher. 2001. Dramatic effects of rainfall on species distributions in the Santa Margarita River. Abstract. Society for Conservation Biology 15th Annual Meeting, 2001 University of Hawai'i, Hilo Hawai'i.
Wassink, J. 1991. Birds of the central Rockies. Mountain Press Publishing. Missoula, Montana.
Wells, J.W. and A.S. Diana. 1975. Survey of the freshwater fishes and their habitats in the coastal drainages of southern California. Report submitted to California Department of Fish and Game Inland Fish Branch, Los Angeles County Museum of Natural History, Los Angeles, California.
Wilcove, D.D., D. Rothstein, J. Dubow, A. Phillips, and E. Losos. 1998. Quantifying threats to imperiled species in the United States. BioScience 48:607-615.
Wilcox, B.A., and D.D. Murphy. 1985. Conservation strategy: the effects of fragmentation on extinction. American Naturalist 125:879-887.
Willson, 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.
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.
Zink, T.A. and M.F. Allen. 1998. Disturbance corridors as invasion pathways. Restoration and Management Notes 13:132-133.

Appendices

Appendix A: Special Status Species in the Core Areas and Linkage Planning Area

Table A-1. Documented occurrences of special status species in the Core Areas and Linkage Planning Area. Occurrence data are from the 2002 California Natural Diversity Data Base, 2003 California Native Plant Society (by topo quad), Santa Margarita Ecological Reserve species lists, and Fisher and Crooks (2001).

Scientific Name	Common Name	Federal Status	State Status	Other Status	Santa Ana Core Area	Linkage	Palomar Core Area
PLANTS							
Apiaceae							
Eryngium aristulatum var *parishii*	San Diego button celery	FE	SE	1B	x	x	
Eryngium pendletonensis	Pendleton button-celery			1B	x		
Asteraceae							
Ambrosia pumila	San Diego ambrosia	FE		1B		x	
Baccharis vanessae	Encinitas baccharis	FT	SE	1B	x		
Centromadia parryi ssp *australis*	southern tarplant			1B			x
Centromadia pungens laevis	Smooth tarplant	C2		1B	x	x	
Chaenactis glabriuscula var. *orcuttiana*	Orcutt's pincushion			1B	x	x	
Chaenactis parishii	Parish's chaenactis			1B			x
Coreopsis maritima	sea dahlia			2	x		
Deinandra mohavensis	Mojave tarplant		SE	1B		x	x
Ericameria palmeria ssp *palmeri*	Palmer's goldenbush			2			x
Hulsea californica	San Diego sunflower			1B		x	x
Lasthenia glabrata ssp *coulteri*	Coulter's goldfields			1B	x	x	
Lessingia glandulifera var *tomentosa*	Warner Springs lessingia			1B			x
Senecio ganderi	Gander's butterweed	FSC	Rare	1B		x	x
Berberidaceae							
Berberis nevinii	Nevin's barberry			1B		x	x
Brassicaceae							
Lepidium virginicum var *robinsonii*	Robinson's pepper-grass			1B	x		x
Sibaropsis hammittii	Hammitt's clay-cress			1B	x	x	
Campanulaceae							
Githopsis diffusa ssp. Filicaulis	Mission canyon bluecup			3			
Chenopodiaceae							
Atriplex coulteri	Coulter's saltbush			1B			x
Atriplex pacifica	south coast saltscale			1B	x		

Table A-1 (cont.) Documented occurrences of special status species in the Core Areas and Linkage Planning Area.

Scientific Name	Common Name	Federal Status	State Status	Other Status	Santa Ana Core Area	Linkage	Palomar Core Area
PLANTS Cont.							
Crassulaceae							
Dudleya blochmaniae ssp *blockmaniae*	Blochman's dudleya			1B	x		
*Dudleya cymosa*ssp *ovatifolia*	Santa Monica Mountains dudleya			1B	x		
Dudleya multicaulis	many-stemmed dudleya	FSC		1B	x	x	x
Dudleya viscida	sticky-leaved dudleya	FSC		1B	x	x	
Cupressaceae							
Cupressus forbesii	Tecate cypress			1B	x		
Ericaceae							
Comarostaphylis diversifolia ssp. diversifolia	summer holly	FSC		1B	x		
Arctostaphylos rainbowensis	Rainbow manzanita			1B	x	x	x
Euphorbiaceae							
Tetracoccus dioicus	Parry's tetracoccus	FSC		1B	x	x	x
Fabaceae							
Astragalus brauntonii	Braunton's milk-vetch	FE		1B	x		
Astragalus oocarpus	San Diego milk-vetch			1B			x
Astragalus pachypus jaegeri	Jaeger's locoweed	FSC		1B		x	x
Astragalus tener var *titi*	coastal dunes milk-vetch	FE	SE	1B	x		
Lotus nuttallianus	Nuttall's lotus			1B	x		
Thermopsis californica var *semota*	velvety false lupine			1B			x
Fagaceae							
Quercus engelmannii	Englemann oak			4	x	x	x
Geraniaceae							
Erodium macrophyllum	round-leaved filaree			2	x		
Hydrophyllaceae							
Phacelia stellaris	Brand's phacelia			1B	x		
Phacelia suaveolens ssp *keckii*	Santiago Peak phacelia			1B	x	x	x
Lamiaceae							
Lepechinia cardiophylla	heart-leaved pitcher sage			1B	x		
Monardella hypoleuca ssp *lanata*	felt-leaved monardella			1B	x	x	x

Table A-1 (cont.) Documented occurrences of special status species in the Core Areas and Linkage Planning Area.

Scientific Name	Common Name	Federal Status	State Status	Other Status	Santa Ana Core Area	Linkage	Palomar Core Area
PLANTS Cont.							
Monardella macrantha ssp *hallii*	Hall's monardella			1B	x	x	x
Monardella nana ssp. *leptosiphon*	San Felipe monardella			1B			x
Satureja chandleri	San Miguel savory			1B	x	x	
Scutellaria bolanderia ssp austromontana	southern skullcap			1B	x	x	x
Lilaceae							
Allium munzii	Munz's onion	FE	ST	1B	x	x	
Brodiaea filifolia	thread-leaved brodiaea	FT	SE	1B	x	x	
Brodiaea orcuttii	Orcutt's brodiaea	FSC		1B	x	x	x
Calochortus weedii v. intermedius	intermediate mariposa lily			1B	x	x	x
Calochortus dunnii	Dunn's mariposa lily		Rare	1B		x	x
Calochortus plummerae	Plummer's mariposa lily			1B	x		
Lilium parryi	lemon lily			1B			x
Nolina cismontana	chaparral nolina			1B	x	x	
Limnanthaceae							
Limnanthes gracilis ssp *parishii*	Parish's meadowfoam		SE	1B	x	x	x
Loasaceae							
Mentzelia tridentata	felt-leaved blazing star			1B			x
Nyctaginaceae							
Abronia villosa v. aurita	chaparral sand verbena			1B	x	x	x
Onagraceae							
Camissonia lewisii	Lewis's evening-primrose			3	x	x	x
Clarkia delicata	delicate clarkia			1B			x
Poaceae							
Hordeum intercedens	vernal barley			3	x		
Orcuttia californica	California Orcutt grass	FE	SE	1B	x	x	
Poa atropurpurea	San Bernardino blue grass	FE		1B			x
Polemoniaceae							
Linanthus orcuttii	Orcutt's linanthus			1B		x	x
Naverretia fossalis	spreading navarretia	FT		1B	x		
Navarretia prostrata	prostrate navarretia			1B	x	x	

Table A-1 (cont.) Documented occurrences of special status species in the Core Areas and Linkage Planning Area.

Scientific Name	Common Name	Federal Status	State Status	Other Status	Santa Ana Core Area	Linkage	Palomar Core Area
PLANTS Cont.							
Polygonaceae							
Chorizanthe parryi var. parryi	Parry's spineflower	FSC		3		x	x
Chorizanthe polygonoides ssp. longispina	long-spined spineflower	FSC		1B	x	x	x
Chorizanthe xanti var *leucotheca*	white-bracted spineflower			1B	x		
Dodecahema leptoceras	slender-horned spineflower	FE	SE	1B	x	x	x
Eriogonum foliosum	leafy buckwheat			1B			x
Nemacaulis denudata var *denudata*	coast woolly-heads			1B	x		
Nemacaulis denudata var *gracilis*	slender woolly-heads			2	x		
Pottiaceae							
Tortula californica	California screw-moss			1B	x		
Ranunculaceae							
Delphinium hesperium spp. *cuyamacae*	Cuyamaca larkspur		Rare	1B		x	x
Myosurus minimus ssp. *Apus*	little mousetail			3	x	x	
Rhamnaceae							
Ceanothus cyaneus	Lakeside ceanothus			1B		x	x
Ceanothus ophiochilus	Vail Lake ceanothus	FT	SE	1B		x	x
Rosaceae							
Horkelia truncata	Ramona horkelia			1B	x	x	x
Horkelia cuneata ssp. Puberula	mesa horkelia			1B	x		
Saxifragaceae							
Heuchera rubescens var. *versicolor*	San Diego County alumroot			2			x
Scrophulariaceae							
Penstemon californicus	California beardtongue			1B			x
Selaginellaceae							
Selaginella eremophila	desert spike-moss			2	x		
Sphaerocarpaceae							
Sphaerocarpos drewei	bottle liverwort			1B	x	x	

Table A-1 (cont.) Documented occurrences of special status species in the Core Areas and Linkage Planning Area.

Scientific Name	Common Name	Federal Status	State Status	Other Status	Santa Ana Core Area	Linkage	Palomar Core Area
PLANTS Cont.							
Thelypteridaceae							
Thelypteris puberula var. *sonorensis*	Sonoran maiden fern			2			x
Violaceae							
Viola aurea	golden violet			2		x	x
INVERTEBRATES							
Branchinecta lynchi	Vernal pool fairy shrimp	FT				x	
Danaus plexippus	monarch butterfly	FSC			x		
Streptocephalus woottoni	Riverside fairy shrimp	FE			x	x	
Euphydryas editha quino	Quino checkerspot butterfly	FE				x	
Euphyes vestris	Harbison's dune skipper	FSC				x	
FISH							
Gila orcutti	arroyo chub	FSC	CSC	FSS	x	x	
Oncorhynchus mykiss irideus	Southern steelhead trout	FT			x	x	
Eucyclogobius newberryi	Tidewater goby	FE	CSC		x		
AMPHIBIANS							
Salamandridae							
Taricha torosa torosa	coast range newt		CSC, P		x	x	
Pelobatidae							
Scaphiopus hammondii	western spadefoot toad	FSC	CSC, P			x	
Bufonidae							
Bufo microscaphus californicus	Arroyo southwestern toad	FE	CSC, P		x	x	x
Ranidae							
Rana aurora draytoni	California red-legged frog	FT	CSC, P			x	
Rana muscosa	mountain yellow-legged frog	FE	CSC			x	
REPTILES							
Emydidae							
Clemmys marmorata pallida	Southwestern pond turtle	FSC	CSC, P	FSS	x	x	x
Gekkonidae							
Coleonyx variegatus abbotti	San Diego banded gecko	FSC				x	

Table A-1 (cont.) Documented occurrences of special status species in the Core Areas and Linkage Planning Area.

Scientific Name	Common Name	Federal Status	State Status	Other Status	Santa Ana Core Area	Linkage	Palomar Core Area
REPTILES Cont.							
Iguanidae							
Phrynosoma coronatum blainvilli	San Diego horned lizard	FSC	CSC, P	FSS	x	x	x
Scincidae							
Eumeces skiltonianus interparietalis	Coronado skink	FSC	CSC		x	x	
Teiidae							
Cnemidophorus hyperythrus	orange-throated whiptail	FSC	CSC, P		x	x	x
Cnemidophorus tigris multiscutatus	coastal western whiptail	FSC			x	x	
Boidae							
Lichanura trivirgata	rosy boa	FSC			x	x	
Colubridae							
Diadophis punctatus similis	San Diego ring-necked snake	FSC	CSC		x	x	
Lampropeltis zonata pulchra	San Diego mountain kingsnake		P	FSS	x		
Salvadora hexalepis virgultea	coast patch-nose snake	FSC	CSC		x	x	
Thamnophis hammondii	two-striped garter snake	FSC	CSC, P	FSS	x	x	
Viperidae							
Crotalus ruber ruber	Northern red-diamond rattlesnake	FSC	CSC		x	x	x
BIRDS							
Rallidae							
Rallus longirostris levipes	light-footed clapper rail	FE	SE, P		x		
Charadriidae							
Charadrius alexandrinus nivosus	western snowy plover	FT, MNBMC	CSC	PIFWL	x		
Laridae							
Sterna antillarium browni	California least tern	FE, MNBMC	SE, P		x		
Accipitridae							
Accipiter cooperii	Cooper's hawk (nesting)	FSC	CSC			x	
Accipiter striatus	sharp-shinned hawk (nesting)		CSC			x	
Aquila chrysaetos	golden eagle		FP	CDFS	x	x	x

Table A-1 (cont.) Documented occurrences of special status species in the Core Areas and Linkage Planning Area.

Scientific Name	Common Name	Federal Status	State Status	Other Status	Santa Ana Core Area	Linkage	Palomar Core Area
BIRDS Cont.							
Buteo regalis	ferruginous hawk		CSC			x	
Circus cyaneus	northern harrier (nesting)		CSC		x	x	
Elanus caeruleus	white-tailed kite (nesting)	MNBMC	FP		x	x	
Cuculidae							
Coccyzus americanus occidentalis	western yellow-billed cuckoo	MNBMC	SE			x	
Strigidae							
Athene cunicularia hypugea	western burrowing owl	FSC, MNBMC	CSC			x	
Tyrranidae							
Empidonax traillii extimus	southwestern willow flycatcher	FE	SE			x	
Contopus borealis	olive-side flycatcher (nesting)	MNBMC		AWL		x	
Alaudidae							
Eremophila alpestris actia	California horned lark		CSC			x	
Hirundinidae							
Riparia riparia	bank swallow		ST		x		
Troglodytidae							
Campylorhynchus brunneicapillus	coastal cactus wren		CSC		x	x	
Muscacapidae							
Polioptila californica californica	California gnatcatcher	FT	CSC		x	x	
Mimidae							
Toxostoma bendirei	Bendire's thrasher		CSC			x	
Laniidae							
Lanius ludovicianus	loggerhead shrike	FSC, MNBMC	CSC	AWL		x	
Vireonidae							
Vireo bellii pusillus	least Bell's vireo	FE, MNBMC	SE	PIFWL	x	x	x
Thraupidae							
Piranga rubra	Summer tanager		CSC			x	

Table A-1 (cont.) Documented occurrences of special status species in the Core Areas and Linkage Planning Area.

Scientific Name	Common Name	Federal Status	State Status	Other Status	Santa Ana Core Area	Linkage	Palomar Core Area
BIRDS Cont.							
Emberizidae							
Aimophila ruficeps canescens	southern California rufous-crowned sparrow	FSC	CSC, P	FSS	x	x	
Ammodramus savannarum	grasshopper sparrow (nesting)	MNBMC				x	
Amphispiza belli belli	Bell's sage sparrow (nesting)	FSC, MNBMC	CSC	PIFWL, AWL		x	
Passerculus sandwichensis beldingi	Beldings savannah sparrow	S3			x		
Dendroica petechia brewsteri	California yellow warbler		CSC			x	
Icteria viren	yellow-breasted chat		CSC			x	
Spizella passerina	chipping sparrow (nesting)			CNDDB		x	
Fringillidae							
Carduelis lawrencei	Lawrence's goldfinch (nesting)	MNBMC		PIFWL, AWL		x	
MAMMALS							
Vespertillionidae							
Antrozous pallidus	pallid bat		CSC	FSS		x	
Myotis ciliolabrum	small-footed myotis	FSC				x	
Myotis yumanensis	Yuma myotis	FSC	CSC			x	
Molossidae							
Eumops perotis	western mastiff bat	FSC	CSC			x	
Nyctinomops (=Tadarida) femorosaccus	pocketed free-tailed bat		CSC			x	
Leporidae							
Lepus californicus bennettii	San Diego black-tailed jackrabbit	FSC	CSC			x	
Heteromyidae							
Chaetodipus californicus femoralis	Dulzura pocket mouse	FSC	CSC		x	x	x
Chaetodipus fallax fallax	northwestern San Diego pocket mouse	FSC	CSC		x	x	
Perognathus longimembris brevinasis	Los Angeles pocket mouse	FSC	CSC	FSS		x	

Table A-1 (cont.) Documented occurrences of special status species in the Core Areas and Linkage Planning Area.

Scientific Name	Common Name	Federal Status	State Status	Other Status	Santa Ana Core Area	Linkage	Palomar Core Area
MAMMALS Cont.							
Dipodomys stephensi	Stephens' kangaroo rat	FE	ST		x	x	x
Cricetidae							
Neotoma lepida intermedia	San Diego desert woodrat	FSC	CSC		x	x	
Mustelidae							
Taxidea taxus	badger		CSC		x	x	x
Felidae							
Felis concolor	mountain lion		P		x	x	x

Key

Federal Listings
- FT = federally threatened
- FE = federally endangered
- FSC = federal candidate
- MNBMC = Migratory Nongame Birds of Management Concern

State Listings
- ST = state threatened
- SE = state endangered
- CSC = species of special concern
- P = protected
- FP = fully protected
- S1 = less than 809.4 ha (2,000 ac) remaining
  - S1.1 = very threatened
  - S1.2 = threatened
- S2 = 809.4 to 4,047 ha (3,000 to 10,0000 ac) remaining
  - S2.1 = very threatened
- S3 = 4,047 to 20,235 ha (10,000 to 50,000 ac) remaining
  - S3.1 = very threatened
  - S3.2 = threatened
  - S3.3 = no current threats known
- S4 = apparently secure within California but some concerns exist

Other Listings
- AWL = Audubon Society's State watch list for California
- CDFS = California Department of Forestry and Fire Protection Sensitive species
- CNDDB = California Natural Diversity Data Base tracks occurrences of this species
- FSS = US Forest Service Sensitive species
- NMFE = National Marine Fisheries Endangered
- PIFWL = Partners in Flight watch list
- 1B = CNPS: rare or endangered in California or elsewhere
- 2 = CNPS: rare or endangered in California and common elsewhere
- 3 = CNPS: plants for which we need more information
- 4 = CNPS: plants of limited distribution watch list

Appendix B. Workshop Attendees and Agendas

Table B1. Connectivity Planning Workshop participants. Workshops were held at the Santa Margarita Ecological Reserve on March 23 and September 14, 2001 and sponsored by SDSU Field Station Programs, The Nature Conservancy, South Coast Wildlands, and U.S. Geological Survey.

Name	Affiliation	E-Mail
Anderson, Allison	US Fish and Wildlife Service	Alison_Anderson@r1.fws.gov
Ballmer, Greg	University of California Riverside	ballmer@ucrac1.ucr.edu
Balk, Michelle	Dudek Associates	mbalk@dudek.com
Ballmer, Greg	University of California Riverside	ballmer@ucrac1.ucr.edu
Barrows, Cameron	Center for Natural Lands Management	cbarrows@cnlm.org
Baxter, Ron	Center for Natural Lands Management	cnlmbax@aol.com
Baumberger, Rolf	University of Zurich	baumberg@systbot.unizh.ch
Beach, Andrea	TRS Consultants	abeach@trs-sandiego.com
Beck, Peter	US Fish and Wildlife Service	peter_beck@ews.gov
Beier, Paul	Northern Arizona University	Paul.Beier@nau.edu
Bell, Carole	The Nature Conservancy	bellfam@iinet.com
Bieber, Deborah	Camp Pendleton	bieberdj@cpp.usmc.mil
Bittner, Dave	Wildlife Research Institutute	lbittn1@hallmark.com
Bittner, Leigh	Wildlife Research Institutute	lbittn1@hallmark.com
Bohonak, Andrew	San Diego State University	Bohonak@sciences.sdsu.edu
Bornyasz, Margaret	University of California Riverside	maborn@citrus.ucr.edu
Braun, Hans-Werner	UCSD San Diego Supercomputer Center	hwb@nlanr.net
Bucey, Karen	TRS Consultants	kbucey@trs-sandiego.com
Bruch, Kimberly	UCSD San Diego Supercomputer Center	kbruch@sdsu,edu
Burford, Bill	The Nature Conservancy	bburford@tnc.org
Carlson, Barbara	UC Riverside - Emerson Oaks Reserve	bcarlson@citrus.ucr.edu
Carlson, Larry	Camp Pendleton	carlsonle@mail.cpp.usmc.mil
Carter, Jim	Environmental Land Solutions	jimcarter@fastwave.net
Chester, Tom	SDSU Docent Program	tom@tchester.org
Cleury-Rose, Karin	US Fish and Wildlife Service	Karin_Cleary-Rose@fws.gov
Cobb, Beth	Volunteer	charliebeth@tFb
Compton, Andrea	SDSU Field Stations Programs	acompton@sciences.sdsu.edu
Crowley, Caroline	San Diego State University	crowley@rohan.sdsu.edu
Delia, Jesse	US Fish and Wildlife Service	jesse_delia@fws.gov
Dempsey, Heather	National Fish and Wildlife Fund	hdempsey@nfwf.org
Diffendorfer, Jay	San Diego State University	jdiffen@sunstroke.sdsu.edu
Duggan, Jenny	San Diego State University	jennyduggan@excite.com
Dugger, Aubrey	Green Info Network	aubrey@greeninfo.org
Ferguson, Corey	US Department of Agriculture Forest Service	cferguson01@fs.fed.us
Fisher, Robert	US Geological Survey	rfisher@sciences.sdsu.edu
Flanagan, Pat	San Diego Natural History Museum	pflanagan@sdnhm.org
Scott Fleury	TAIC	scottfleury@taic.net
Gonzales, Paul	Caltrans	Paul_Gonzales@dot.ca.gov

Table B1 (cont.) Connectivity Planning Workshop participants.

Name	Affiliation	E-Mail
Haas, Chris	US Geological Survey	cdhaas@prodigy.net
Hanley, Maeve	San Diego County	MHANLEPL@co.san-diego.ca.us
Hovey, Tim	California Department of Fish and Game	THovey@dfg.ca.gov
Hund, Geary	California State Parks	ghund@parks.ca.gov
Hushen, Timothy	San Diego State University - Foundation	thushen@foundation.sdsu.edu
Hussman, Julie	The Nature Conservancy	jhussman@tnc.org
Jackson, Joe	Fallbrook Public Utility District	Joe@fpud.com
Jenny, Michelle	SR Community Service District	srcsd@cpl.net
Johnson, Melissa	South Coast Wildlands	brianandmel@earthlink.net
Kiester, Ross	USDA Forest Service	Ross@krait.fsl.orst.edu
Kiriakos, Peter	Sierra Club,	p.kiriakos@verizon.net
Lawson, Dawn	U.S. Navy	LawsonDM@efdsw.navfac.navy.mil
Lovich, Rob	MCB Camp Pendleton	LovichRE@pendleton.usmc.mil
Lovio, John	U.S. Navy	loviojc@efdsw.navfac.navy.mil
Luke, Claudia	SDSU Field Stations Programs	cluke@sciences.sdsu.edu
Mallett, Cynthia	Mission Resource Conservation District	Cynthia_Mallet@ca.nacdnet.org
Maloney-Rames, Robin	California Department of Fish and Game	rmaloney@dfg.ca.gov
Marriott, Adrienne	San Diego State University – Field Station Programs	marriott@rohan.sdsu.edu
Miller, Will	US Fish and Wildlife Service	William_B_Miller@fws.gov
Oberbauer, Thomas	County of San Diego	toberbpl@co.san-diego.ca.us
Oechel, Walt	San Diego State University	oechel@sunstroke.sdsu.edu
Opdycke, Jeff	Center for Reproduction of Endangered Species	jopdycke@sandiegozoo.org
Ortega, Brock	Dudek Associates	bortega@dudek.com
Pavelka, Mark	US Fish and Wildlife Service	Mark_Pavelka@fws .gov
Penrod, Kristeen	South Coast Wildlands	scwildlands@juno.com
Phillips, Jamie	Eddy Foundation	jphill82@aol.com
Pratt, Gordon	University of California Riverside	Euphilotesa@aol.com
Principe, Zachary	The Nature Conservancy/San Diego State University	zprincip@gte.net
Pryor, Gary	San Diego County	Egoodmpl@co.san-diego.ca.us
Scott Quinnell	Caltrans	Scott_Quinnell@dot.ca.gov
Schultz, Joel	Bureau of Land Management	j1schult@ca.blm.gov
Scott, Tom	University of California Riverside	tomscott@citrus.ucr.edu
Shapiro, Sedra	SDSU Field Stations Programs	sshapiro@sciences.sdsu.edu
Smith, Glenn	Smith Properties	
Smith, Trish	The Nature Conservancy	trish-smith@tnc.org
Spencer, Wayne	Conservation Biology Institute	wdspencer@consbio.org
Stallcup, Jerre	Conservation Biology Institute	jastallcup@consbio.org
Swarts, Maria	San Diego State University	mswarts@projects.sdsu.edu

Table B1 (cont.) Connectivity Planning Workshop participants.

Name	Affiliation	E-Mail
Swift, Camm	Natural History Museum L.A. County	cammswift@aol.com
Takata, Eileen	South Coast Wildlands	eileents@earthlink.net
Thomas, Mary L.	Cleveland National Forest	mlthomas@fs.fed.us
Todt, Iovanka	San Diego County	itodtxpw@co.san-diego.ca.us
Tucker, Karen	Fallbrook Land Conservancy/ SDLCC	wktucker@sd.znet.com
Tucker, Wallace	Fallbrook Land Conservancy/ SDLCC	wktucker@sd.znet.com
Turschak, Greta	US Geological Survey	gturschak@hotmail.com
Udovic, Dan	University of Oregon	udovic@oregon.uoregon.edu
VanScoy, Mark	SDSU Field Stations Programs	mvanscoy@sciences.sdsu.edu
Warburton, Manna	US Geological Survey	warburto@sunstroke.sdsu.edu
Weaver, Ken	San Diego County Bird Atlas	kweaver@tfb.com
Wells, Jeff	US Department of Agricuture - Forest Service	jmwells@fs.fed.us
White, Mike	Conservation Biology Institute	mdwhite@consbio.org
Wiehe, Maria	San Diego State University – Field Station Programs	mwiehe@sciences.sdsu.edu
Winchell, Clark	US Fish and Wildlife Service	clark_winchell@fws.gov
Winter, Kirsten	Cleveland National Forest	Kwinter@fs.fed.us
Withey, Alison	UCSD San Diego Supercomputer Center	awithey@SDSC.edu
York, Julie	US Fish and Wildlife Service	Julie-York@fws.mail
Zimmer, Jim	San Diego State University	jzimmer@sunstroke.sdsu.edu

Connectivity Planning Workshop
Santa Ana – Palomar Mountains Linkage

Agenda I: Biological Perspectives
March 23, 2001 Santa Margarita Ecological Reserve

8:30	Check-in at Santa Margarita Ecological Reserve
9:00	Sedra Shapiro – SDSU Field Station Programs – Welcome and workshop context
9:10	Dr. Claudia Luke - SDSU Santa Margarita Ecological Reserve – Workshop goals
9:20	Dr. Tom Scott – UC Riverside – Connectivity issues and ideas
9:40	Dr. Ross Kiester – US Forest Service – Alternative futures based on the Department of Defense study for the Camp Pendleton region
10:20	BREAK
10:40	Dr. Paul Beier - Northern Arizona University - Corridor monitoring concepts and mountain lion movement patterns
11:00	Dr. Gordon Pratt – U.C. Riverside - Connectivity for butterflies.
11:20	Dr. Robert Fisher - U.S. Geological Survey – Connectivity for vertebrates
11:50	Tom Oberbauer - San Diego Co, Department of Planning – Connectivity for plants and potential habitat modeling using GIS
12:10	Dr. Claudia Luke - SDSU Field Station Programs - Preparation for working groups
12:20	LUNCH (Will Be Provided)

TAXONOMIC WORKING GROUPS
(Groups: Plants, Insects, Fish/Amphibians/Reptiles, Birds, Mammals)

1:20	Design corridors for representative species
4:00	Workgroup leaders report on workgroup findings
5:00	Summary remarks and next steps
5:30	Adjourn

Connectivity Planning Workshop
Santa Ana – Palomar Mountains Linkage

Agenda II: Conservation Design: "Merging Biological Needs with Economic and Social Realities"
March 23, 2001 Santa Margarita Ecological Reserve

8:30 Check-in at the Santa Margarita Ecological Reserve

INTRODUCTION

9:00 Welcome
Sedra Shapiro, Interim Executive Director, SDSU Field Station Programs
Kristeen Penrod, Executive Director South Coast Wildlands

9:05 Biological foundations for conservation design in the Santa Ana – Palomar Mountains Linkage
Dr. Claudia Luke - Conservation Scientist, SDSU Field Station Programs

REGIONAL PLANNING INITIATIVES AFFECTING LINKAGE

9:20 General Plan revision for San Diego County
Gary Pryor – Director of Planning and Land Use, San Diego County

9:40 North San Diego County MSCP Sub-area Plan
Pat Atchison - Project Manager, TAIC
Dr. Scott Fleury - Conservation Biologist, TAIC

10:00 Riverside County's proposed Conservation Plan
Jerry Jolliffe - Administrative Manager, Riverside County Transportation and Land Management Agency

10:20 Riverside MSHCP planning and the Santa Ana - Palomar Mountains Linkage
June Collins - Project Manager, Dudek and Associates

BREAK

~~11:00~~ **Travel Cancellation:** Land management and planning on Pechanga Tribal lands in the Santa-Ana – Palomar Mountains Linkage
John Gomez – Pechanga Cultural Committee

11:00 Cal Trans projects and wildlife crossings
Paul Gonzales – Environmental Branch Chief for Habitat Conservation and Mitigation Banking for the Southern Region, CalTrans District 8

11:20 Land Management Plan revisions for the Southern California National Forests

Tom White - Cleveland National Forest

11:40 A history of conservation planning in the Santa Ana - Palomar Mountains Linkage
Julie Hussman - Santa Ana Mtns Project Director, The Nature Conservancy

LUNCH (will be provided)

WORKING GROUPS

1:00 Participants break into workgroups to prioritize conservation needs based on biological information and regional planning efforts

4:30 Workgroup leaders report on workgroup findings

5:00 Summary remarks and next steps

5:30 Adjourn

Appendix C. Patch Size and Configuration Analyses

This appendix contains patch size configuration analyses for focal species not included in the main body of the report. In these analyses, modifications to the Least-Cost Union were not needed to accommodate species movements. Species for which recommendations were made to modify the boundaries of the Least-Cost Union are included in the body of the report.

Justification for Selection: Habitat fragmentation at a landscape scale is best analyzed relative to the needs of large mammalian carnivores (Noss 1991, Soule and Terborgh 1999) that require large tracts of land for persistence (Beier 1996). Loss of the dispersal corridor between the Santa Ana and Palomar Mountains may to lead to local extinctions of mountain lions in the Santa Ana Mountains (Beier 1993). Mountain lions are listed as State protected.

Distribution: Mountain lions are widely distributed throughout the western hemisphere (Currier 1983, Maehr 1992, Tesky 1995). Historically, they ranged from northern British Columbia to southern Chile and Argentina and from the west to east coast of North American continent (Currier 1983). The subspecies *F. c. californica* occurs in southern Oregon, California, and Nevada (Hall 1981) and occurs between 590 and 1,780 m (1,980 and 5,940 ft)(Ahlborn 1988). Approximately 20 mountain lions sustain territories in the Santa Ana Mountains (Beier and Barrett 1993).

Habitat Associations: Mountain lions are habitat generalists. In California, they occur primarily in brushy stages of woodland and scrub habitats (Ahlborn 1988). In the Santa Ana Mountains, they commonly occur in oak woodlands, chaparral and other habitats with good cover (Dickson and Beier 2002). Within these habitats, mountain lions prefer vegetation or topography that provide cover when hunting prey (Dickson and Beier 2002), which is primarily mule deer, *Odocoileus hemionus* (Lindzey 1987, Beier and Barrett 1993). Vegetated stream courses and areas of relatively gentle topography are used as travel corridors and hunting routes. Mountain lions avoid urban developments, disturbed habitats, and areas with a high density of paved roads, and traveling individuals tend to minimize crossing paved roads (Dickson et al. 2004).

Home Range and Core Area Sizes: Home range size varies by sex, age, and prey distribution. A recent study in the Sierra Nevada documented annual home range sizes between 250 and 817 km^2 (96 and 315 mi^2)(Pierce et al. 1999). Home ranges in the Santa Ana Mountains 93 km^2 (s.d. = 50) (36 mi^2, s.d. =19) for 12 adult female and 363 km^2 (s.d. = 63) (140 mi^2, s.d. = 24) for 2 adult male cougars (Dickson and Beier 2002). Male home ranges appear to reflect the density and distribution of females (Maehr 1992). Males occupy distinct areas and are tolerant of transients of both sexes, while the home range of females may overlap completely (CDFG 1990, Beier and Barrett 1993). Regional population counts have not been conducted but in the Santa Ana Mountain Range, Beier (1993) estimated about 1.05-1.2 adults per 100 km^2 (38 mi^2).

Dispersal: Mountain lions are capable of making long-distance movements, and can have multiple strategies of migration that allow them to take advantage of changing densities of prey (Pierce et al. 1999). In the Santa Ana Mountains, mountain lions moved 6 km (4 mi) per night (Beier et al. 1995) and dispersed up to 65 km (40 mi)(Beier 1995). Dispersal plays a crucial role in cougar population dynamics because recruitment into a local population occurs mainly by immigration of juveniles from adjacent populations, while the populations own offspring emigrate to other areas (Beier 1995, Sweanor et al. 2000). Juvenile dispersal distances average 32 km (20 mi) (range 9-140 km (6-87 mi)) for females and 85 km (53 mi) (range 23-274 km (14-170 mi)) for males (Anderson et al. 1992). Dispersing lions may cross large expanses of nonhabitat, though they prefer not to do so (Logan and Sweanor 2001). To allow for dispersal of juveniles and the immigration of transients, lion management should be on a regional basis (Sweanor et al. 2000).

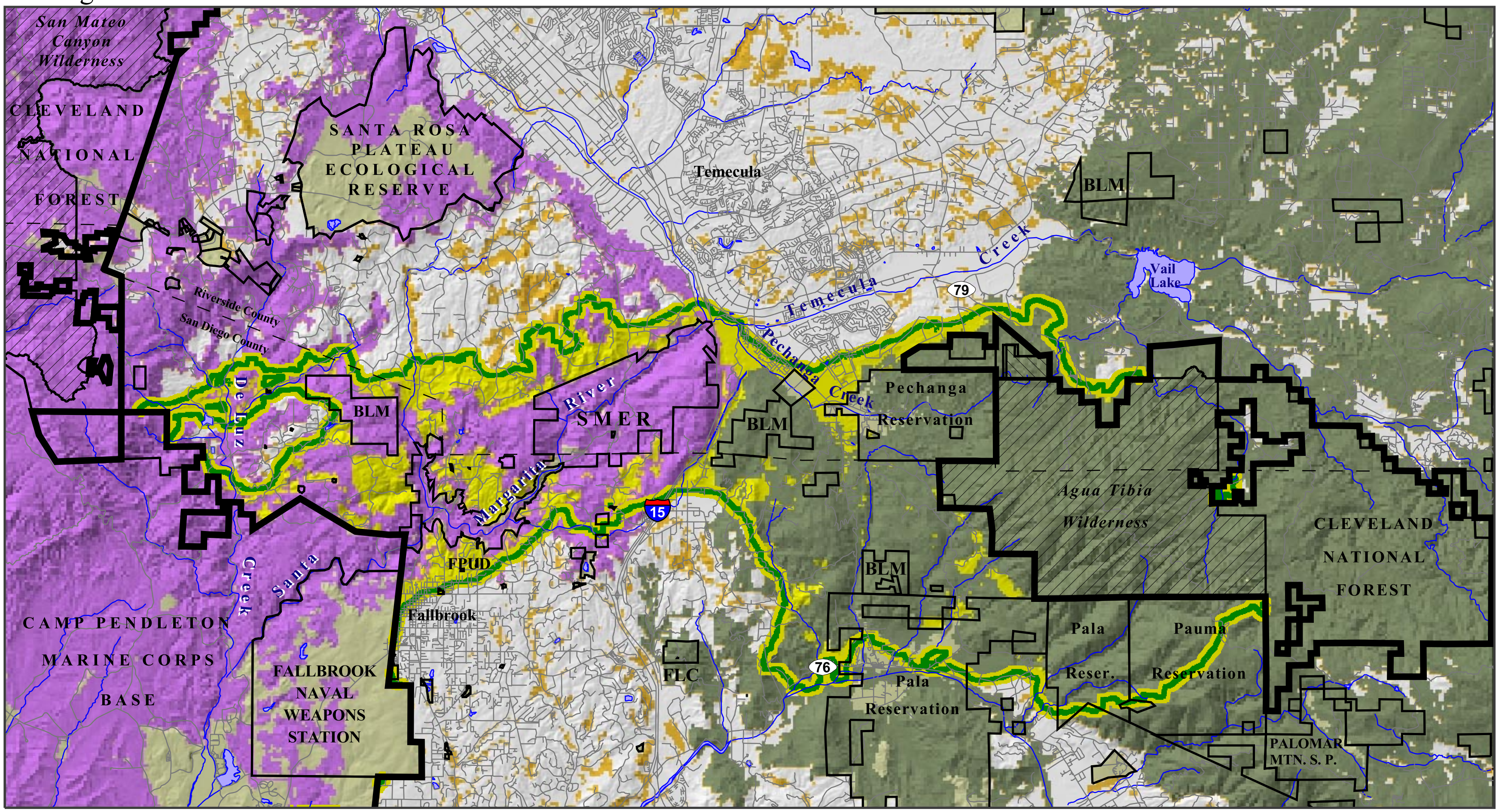
Conceptual Basis for Model Development: The best suitable habitat for mountain lions is characterized by good cover (forests, woodlands and chaparral). Minimum patch size is 93 km^2, the average territory size needed to support a breeding female. Core Area size is 2,325 km^2, the area needed to support 50 individuals or 25 breeding pairs. Dispersal distance is 130 km, twice the maximum recorded dispersal distance for a dispersing juvenile.

Results and Discussion: The 538 km^2 (208 mi^2) of protected lands in Palomar Ranger District of the Cleveland National Forest are too small to support mountain lion populations in perpetuity, but connections to other large blocks of habitat in the San Diego and San Jacinto ranges make this area a potential source population (Figure C1). Remaining natural habitats in the Santa Ana Mountains and coastal lowlands of Camp Pendleton Marine Corps Base areas and are not large enough (1,179 km^2 (455 mi^2) to support mountain lion populations in perpetuity (Beier 1991) and are isolated from other blocks of habitat (except through the Least-Cost Union). The long-term survival of these populations is dependent on immigration from the Palomar Mountains and inland ranges. Most of the Least-Cost Union provides suitable habitat for lions.

All core areas and patches of potential suitable habitat are within the species' dispersal distance suggesting that mountains lions could theoretically access all habitat within the planning area. Actual barriers on the ground, however, limit mountain lion movement. Interstate 15 has been identified a barrier to gene flow among populations in the Santa Ana and Palomar Mountains (Ernest 2002).

While the Least-Cost Union serves the movement needs of this species, habitat additions recommended for other species would benefit mountain lions. The De Luz addition would widen the narrowest sections of the corridor to 2 km (1.2 mi). Although this is still markedly less than the minimum width of 6.8 km (4.2 mi) that Harrison (1992) recommended for a species with a home range of 93 km^2 (36 mi^2), Harrison's recommendations were for linkages designed to provide live-in habitat. Mountain lions avoid areas of human activity and would benefit from this broader area of protected habitat. Habitat additions that would also provide avenues of movement for mountain lions are the Rainbow and Temecula creek additions. Mountain lions prefer to move along vegetated stream courses and through areas of relatively gentle topography such as those provided in these areas.

Figure C1. Cores and patches of potential suitable habitat for mountain lion *(Felis concolor).*
Cores (dark green) are large enough to support 50 or more individuals (> 2,325 km^2). Patches (purple) are large enough to support 2 to 49 individuals (93 km^2 < x < 2,325 km^2). Orange areas are too small to support 2 individuals (< 93 km^2). All cores and patches are less than the species' maximum dispersal distance (130 km) apart. See text for assumptions regarding model inputs. BLM = Bureau of Land Management, FLC = Fallbrook Land Conservancy, FPUD = Fallbrook Public Utility District, SMER = Santa Margarita Ecological Reserve.



Legend

- Least-Cost Union
- cores of suitable habitat
- patches of suitable habitat
- < patch
- paved roads
- county line
- Santa Ana and Palomar Core Areas
- major landholders*
- designated wilderness
- proposed wilderness
- hydrography
- lakes & reservoirs

*land management varies by ownership.

N

5 0 5 Kilometers

5 0 5 Miles

SDSU San Diego State University FIELD STATION PROGRAMS

SOUTH COAST WILDLANDS

Map produced by:
SDSU Field Station Programs
February 9, 2004
http://fs.sdsu.edu

SDSU San Diego State University FIELD STATIONS

SOUTH COAST WILDLANDS

Justification for Selection: Badgers are area-dependent grassland specialists that are sensitive to habitat fragmentation and loss. Movement needs represented by badger that guided linkage design include: movement through a wide variety of natural habitats, very long dispersal distances, large home range size, terrestrial locomotion, and sensitivity to road barriers. The primary mortality factors for this species are collisions with vehicles and predator control activities (Long 1973, CDFG 1999). Badgers are listed as a Species of Special Concern by the State of California.

Distribution: Badgers occur throughout North America from central Alberta south to central Mexico and from the Pacific coast to the Great Lake States (Long and Killingley 1983). Although usually found at lower elevations (Long and Killingley 1983), they may occur at elevations up to 12,000 feet (3,600 m) but are usually found at lower elevations (Long and Killingley 1983). Badgers have been recently observed at the Santa Rosa Plateau (C. Bell, pers. comm.) and are occasionally observed on Marine Corps Base Camp Pendleton, but they are becoming increasingly rare in the Santa Ana Mountains region, probably due to habitat fragmentation (P. Bloom and W. Spencer, personal communications).

Habitat Associations: Badgers occur throughout North America from central Alberta south to central Mexico and from the Pacific coast to the Great Lake States (Long and Killingley 1983). Although usually found at lower elevations (Long and Killingley 1983), they may occur at elevations up to 3,600 m (12,000 feet) but are usually found at lower elevations (Long and Killingley 1983). Badgers have been recently observed at the Santa Rosa Plateau (C. Bell, pers. comm.) and are occasionally observed on Marine Corps Base Camp Pendleton, but they are becoming increasingly rare in the Santa Ana Mountains region, probably due to habitat fragmentation (P. Bloom and W. Spencer, personal communications).

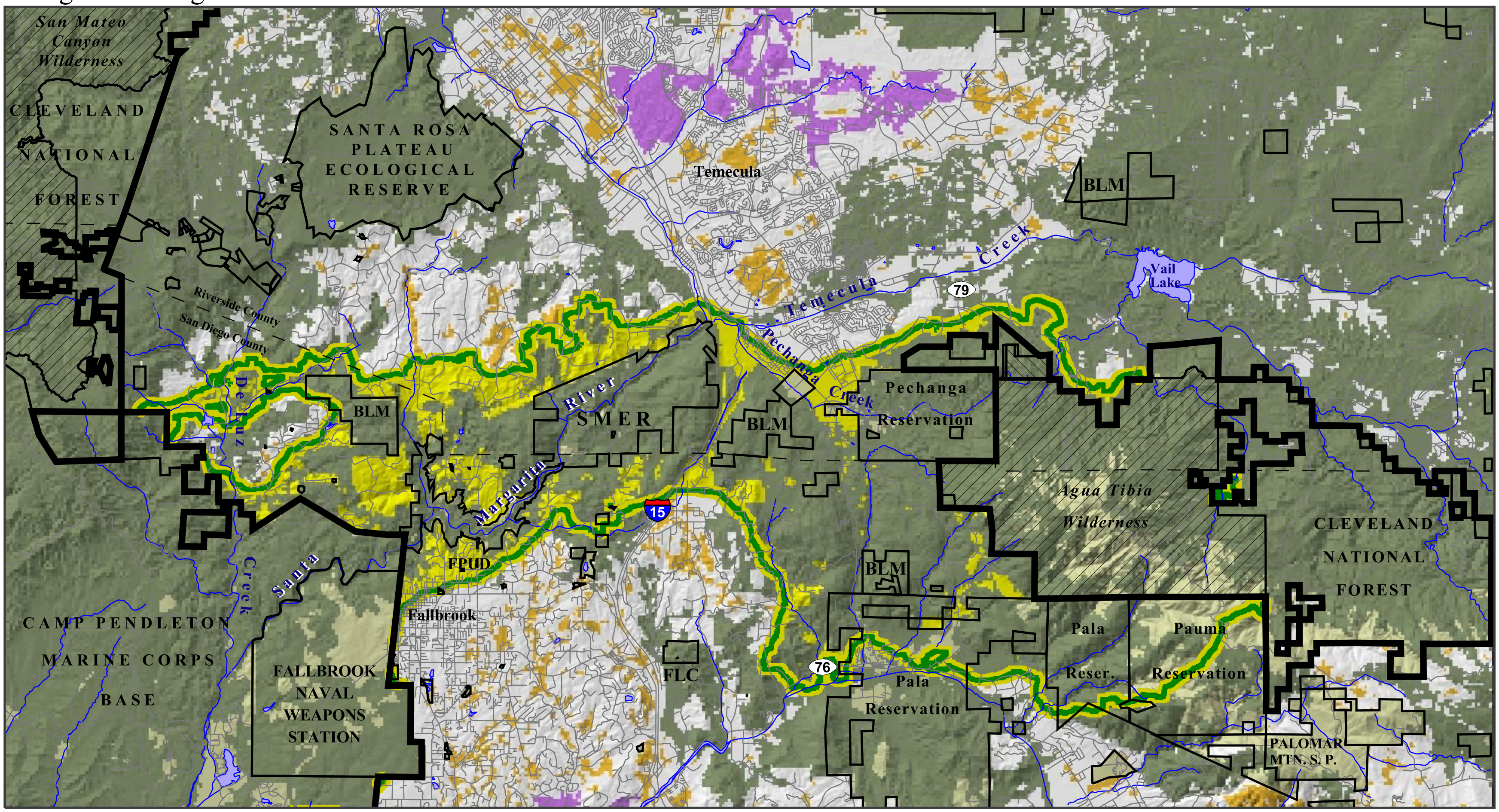
Home Range and Core Area Sizes: Males and females have overlapping home ranges. Home ranges of male badgers have been estimated at 240-850 ha (600-2,100 ac) and females at 137-725 ha (338-1,790 ac) (Long 1973, Lindzey 1978, Messick and Hornocker 1981). Population density in Utah scrub-steppe was 1 badger per 2.6 km^2 (1.0 mi^2)(Long 1973).

Dispersal: Maximum natal dispersal distance is estimated at 110 km (68 mi) for one male and 51 km (32 mi) for one female (Lindzey 1978).

Conceptual Basis for Model Development: Badgers prefers grasslands, meadows, scrubs, riparian, desert washes and open woodland communities. The minimum patch size was defined as the home range of a male badger, using the smallest recorded range (240 ha). Core Areas containing 25 badgers are equal to or greater than 6,000 ha in size (240 ha x 25). Maximum dispersal distance for male badgers is 220 km, twice the measured dispersal distance of 110 km.

Results and Discussion: Core areas of habitat for badger are widely distributed throughout both the Santa Ana and Palomar Mountain Core Areas and comprise approximately ¾ of the Least-Cost Union (Figure C2). Much of the area mapped as suitable habitat, however, is too steep, rocky, and vegetated by dense chaparral and oak woodland to be used frequently by badgers. However, the long dispersal distances of this species may allow it to disperse through these habitats between the Core Areas if barriers to movement, such as I-15, were mitigated. The Temecula Creek, Rainbow Creek and De Luz additions to the Least-Cost Union that were recommended to support other focal species would also benefit badger by providing additional protected areas for movement through upland and riparian habitats.

Figure C2. Cores and patches of potential suitable habitat for American badger *(Taxidea taxus)*.
Cores (dark green) are large enough to support 50 or more individuals (> 220 km^2). Patches (purple) are large enough to support 2 to 49 individuals (2.4 km^2 < x < 220 km^2) (none shown). Orange areas are too small to support 2 individuals (< 2.4 km^2). All cores and patches are less than the species' maximum dispersal distance (220 km) apart. See text for assumptions regarding model inputs.
BLM = Bureau of Land Management, FLC = Fallbrook Land Conservancy, FPUD = Fallbrook Public Utility District, SMER = Santa Margarita Ecological Reserve.



Legend

- Least-Cost Union
- cores of suitable habitat
- patches of suitable habitat
- < patch
- paved roads
- county line
- Santa Ana and Palomar Core Areas
- major landholders*
- designated wilderness
- proposed wilderness
- hydrography
- lakes & reservoirs

*land management varies by ownership.

N

5 0 5 Kilometers

5 0 5 Miles

SDSU San Diego State University FIELD STATION PROGRAMS

SOUTH COAST WILDLANDS

Map produced by:
SDSU Field Station Programs
February 9, 2004
http://fs.sdsu.edu

Justification for Selection: Dusky-footed woodrat was chosen as a surrogate for many small mammals. Movement needs represented by woodrats that guided linkage design include: movement through a wide variety of natural habitats, short dispersal distances, small home range sizes, and sensitivity to road barriers. *N. f. intermedia* is listed as Federal candidate and State Species of Special Concern.

Distribution: Dusky-footed woodrats range from the Columbia River in Washington southward through California west of the Sierra Nevada to northwestern Baja California (Miller and Stebbins 1964). Woodrats are common and often abundant in Santa Ana and Palomar Mountain core areas and in the linkage. Woodrats mostly occur below 2150 m (7000 ft) (Brylski 1988).

Habitat Associations: Dusky-footed woodrats occur in woodland and forest habitats with a moderate canopy and a moderate to dense understory (Brylski 1988). They build stick houses at base of trees, bushes or hills, and feed mainly on oak leaves and acorns (Atsatt and Ingram 1983), but also eat maple, coffeeberry, alder and elderberry (Lindsdale and Tevis 1951) as well as deer brush, Oregon myrtle Douglas fir, crab apple fruit, Christmas berry (*Photina*), mountain mahogany, honeysuckle, rose, dewberry, cottonwood, madrone, manzanita, kidneywort, hazel, willow, poison oak, buckthorn, currant, snowberry, vetch and monkey flower (Cahalane 1961). They are generally absent from cultivated land and open grasslands in the Central Valley (Brylski 1988), but can tolerate rural low-density residential housing. In chaparral habitat, density was report to reach 18.8/ha (Bleich 1973). Capture rates for this species were lower in narrow strips of remnant habitat along highways than other habitat patches (Bolger et al. 2001).

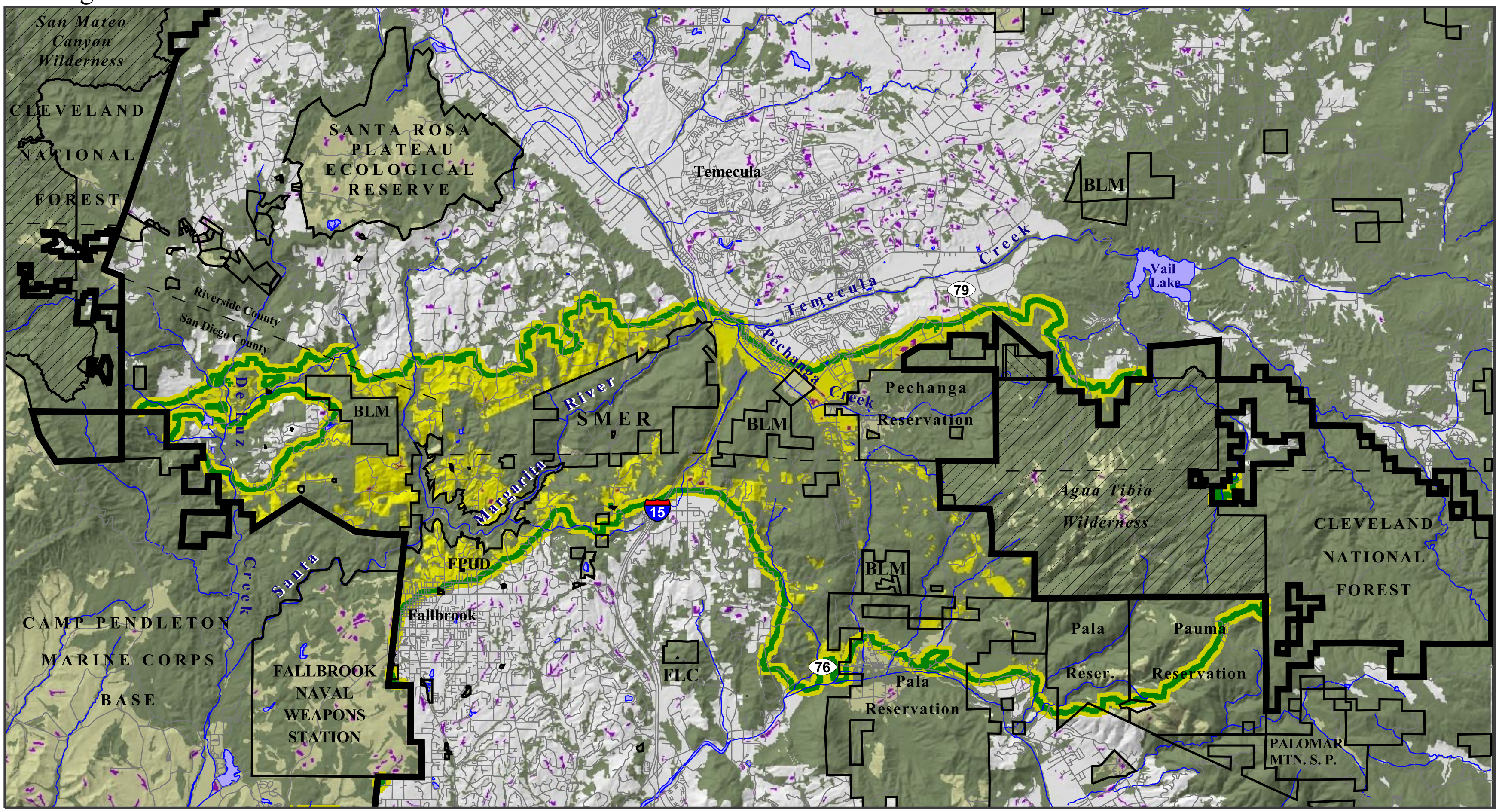
Home Range and Core Area Sizes: In Sonoma County, home ranges average 0.23 ha for males, 0.19 ha for females and 0.17 ha for juveniles (Cranford 1977). In chaparral habitat, density was reported to reach 18.8/ha (Bleich 1973).

Dispersal: Individuals in the genus (species not reported) have returned home after being released 0.4 km (0.25 mi) away (Cahalane 1961). A congeneric species, *N. cinerea* was recorded with a maximum natal dispersal distances of 2.2 km (1.4 mi) (Smith 1997).

Conceptual Basis for Model Development: The best suitable habitat for woodrats is coastal scrub, chaparral, oak woodland and riparian forest habitat types. Minimum patch size is 0.23 ha, the average size of a territory for male with potential overlap into a female territory. Core area size is 5.8 ha, the size of 25 average males territories (with potential to overlap 30 female territories). Dispersal distance is 4.4 km, the maximum natal dispersal distance reported for a congener.

Results and Discussion: Suitable core habitat is well-distributed in the Santa Ana and Palomar Mountain Core Areas and within the Least-Cost Union (Figure C3). All patches are within the presumed dispersal distance for this species, although numerous barriers to movement may exist between suitable habitat patches. We conclude that the Least-Cost Union meets the needs of this species for movement among populations in the Core Areas. Note that the Rainbow Creek, De Luz and Temecula Creek habitat additions that were recommended for other focal species would also benefit woodrats by providing additional suitable habitat.

Figure C3. Cores and patches of potential suitable habitat for dusky-footed woodrat *(Neotoma fuscipes)*.
Cores (dark green) are large enough to support 50 or more individuals (> 5.8 km^2). Patches (purple) are large enough to support 2 to 49 individuals (0.23 km^2 < x < 5.8 km^2). Orange areas are too small to support 2 individuals (< 0.23 km^2). All cores and patches are less than the species' maximum dispersal distance (4.4 km) apart. See text for assumptions regarding model inputs. BLM = Bureau of Land Management, FLC = Fallbrook Land Conservancy, FPUD = Fallbrook Public Utility District, SMER = Santa Margarita Ecological Reserve.



N

5 0 5 Kilometers

5 0 5 Miles

Legend

- Least-Cost Union
- cores of suitable habitat
- patches of suitable habitat
- < patch
- paved roads
- county line
- Santa Ana and Palomar Core Areas
- major landholders*
- designated wilderness
- proposed wilderness
- hydrography
- lakes & reservoirs

*land management varies by ownership.

SDSU San Diego State University FIELD STATION PROGRAMS

SOUTH COAST WILDLANDS

Map produced by:
SDSU Field Station Programs
November 17, 2003
http://fs.sdsu.edu

SDSU San Diego State University FIELD STATIONS

SOUTH COAST WILDLANDS

Justification for Selection: Yellow warblers have substantially declined in lowland areas of southern California (Green 1999). As riparian specialists, their presence in the linkage is an indication of habitat quality and hydrological conditions. To support this and other riparian species, linkage design must maintain large areas of riparian habitat.

Distribution: The yellow warbler breeds throughout the United States, with the exception of parts of the southeast (Robbins et al. 1966). Although a small number overwinter in southern California lowlands (Garrett and Dunn 1981), the majority migrates to central South America (AOU 1998).

Habitat Associations: Yellow warblers in southern California prefer lowland and foothill riparian woodlands that are dominated by cottonwoods, alders or willows and have abundant shrubs or small trees (Bent 1953, Morse 1966; Stauffer and Best 1980). They can also breed in montane chaparral, open ponderosa pine and mixed conifer with abundant brush (Green 1999). Warblers inhabit thickets, marshes, swamp edges, aspen groves, and willows (Salt 1957). In southern California, they are typically found in riparian forests that contain cottonwoods, sycamores, willow, or alders (Stephenson and Calcarone 1999). In summer, the yellow warbler is usually found in riparian deciduous habitats with cottonwood, willow, and alder.

Home Range and Core Area Sizes: Home range and territory sizes measured in Iowa, Minnesota, Illinois and New York varied from 0.03 ha to 0.36 ha (Ficken and Ficken 1966, Kendeigh 1941, Beer et al. 1956). In southeast Arizona, densities reached 48 birds per hectare (Skagen et al. 1998).

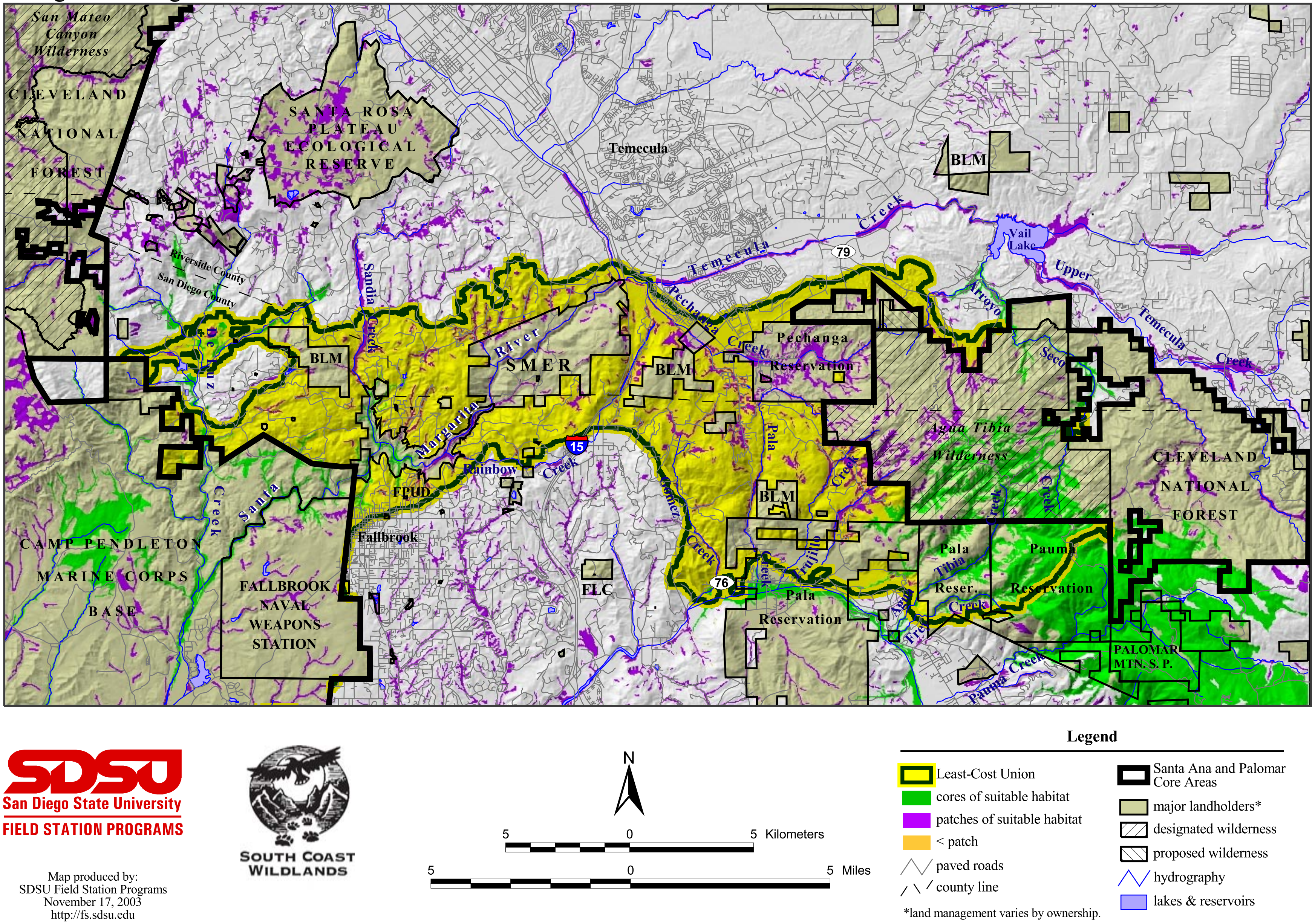
Dispersal: Although a small number of birds overwinter in southern California (Garrett and Dunn 1981), the majority of yellow warblers migrates to central South America in October and return in April. Little is know about their site tenacity. They can move up to 488 m to feed. In some areas, birds move upslope to middle elevations after breeding (Beedy 1975).

Conceptual Basis for Model Development: The best suitable habitat for warblers are riparian forest and woodland habitat types. Minimum patch size is 0.4 ha, the largest territory size reported for a mated pair. Minimum core area is 4 km^2, the area needed to sustain 25 territories (or 50 birds). Dispersal is 1 km, twice the maximum distance reported for an individual to move while on breeding grounds. The dispersal distance used here is highly conservative, and is used solely to determine whether habitat distribution allows movement among breeding areas during the breeding season. Yellow warblers are strong fliers and capable of flying thousands of kilometers.

Results and Discussion: Core habitat for yellow warbler occurs in both Core Areas (Figure C4): along the Santa Margarita River and DeLuz Creek in Camp Pendleton MCB and along a variety of drainages (e.g., Arroyo Secco and Pala creeks) in the Palomar Mountains. The majority of suitable habitat in the Least-Cost Union does not occur in large enough patches to support viable populations of over 50 individuals except on the western portion of the Santa Margarita River and along DeLuz Creek. All patches are within the presumed dispersal distance for this species, although some barriers to movement among breeding areas may exist between suitable habitat patches.

We conclude that the Least-Cost Union supports habitat for this species. Because this species is migratory and a strong flyer, habitat in the Least-Cost Union is probably not likely to affect connectivity among populations in the Santa Ana and Palomar Mountains. The Least-Cost Union does, however, provide habitat for yellow warbler and other riparian species. Habitat additions to the Least-Cost Union in DeLuz, Rainbow Creek and Temecula Creek would also benefit yellow warbler by providing additional suitable riparian habitat for breeding.

Figure C4. Cores and patches of potential suitable habitat for yellow warbler *(Dendroica petechia).*
Cores (dark green) are large enough to support 50 or more individuals (> 4 km^2). Patches (purple) are large enough to support 2 to 49 individuals (0.004 km^2 < x < 4 km^2). Orange areas are too small to support 2 individuals (< 0.004 km^2). All cores and patches are less than the species' maximum dispersal distance on breeding grounds (1 km) apart. See text for assumptions regarding model inputs. BLM = Bureau of Land Management, FLC = Fallbrook Land Conservancy, FPUD = Fallbrook Public Utility District, SMER = Santa Margarita Ecological Reserve.



San Diego State University
FIELD STATION PROGRAMS

SOUTH COAST WILDLANDS

Map produced by:
SDSU Field Station Programs
November 17, 2003
http://fs.sdsu.edu

SDSU San Diego State University FIELD STATIONS

SOUTH COAST WILDLANDS

Justification for Selection: Golden eagles have shown pronounced declines throughout southern California (Tesky 1994). The Santa Ana-Palomar Mountains linkage contains portions of the territories of 4 of 10 remaining breeding pairs in coastal San Diego County (D. Bittner pers. comm.). To support this and other top-predators in the linkage, the linkage design must maintain large blocks of natural habitats and protect breeding areas from recreational use and other disturbances. Golden eagles are listed as Federally protected and a California Department of Forestry and Fire Protection sensitive species.

Distribution: Golden eagles occur throughout the northern hemisphere. In North America, they breed from northern Alaska to northern Mexico (DeGraaf et al. 1991, Dunstan 1989).

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

Home Range and Core Area Sizes: Territory size averages 57 km^2 (22 mi^2) in Idaho (Beecham and Kocher 1975), 171-192 km^2 (66-74 mi^2) in Montana (McGahan 1968), 23 km^2 (8 mi^2) in Utah (Smith and Murphy 1973), 124 km^2 (48 mi^2) in northern California (Smith and Murphy 1973), and 93 km^2 (36 mi^2) in southern California (Dixon 1937). During the nesting season, eagles usually forage within 7 km (4 mi) of the nest (Cooperrider et al. 1986).

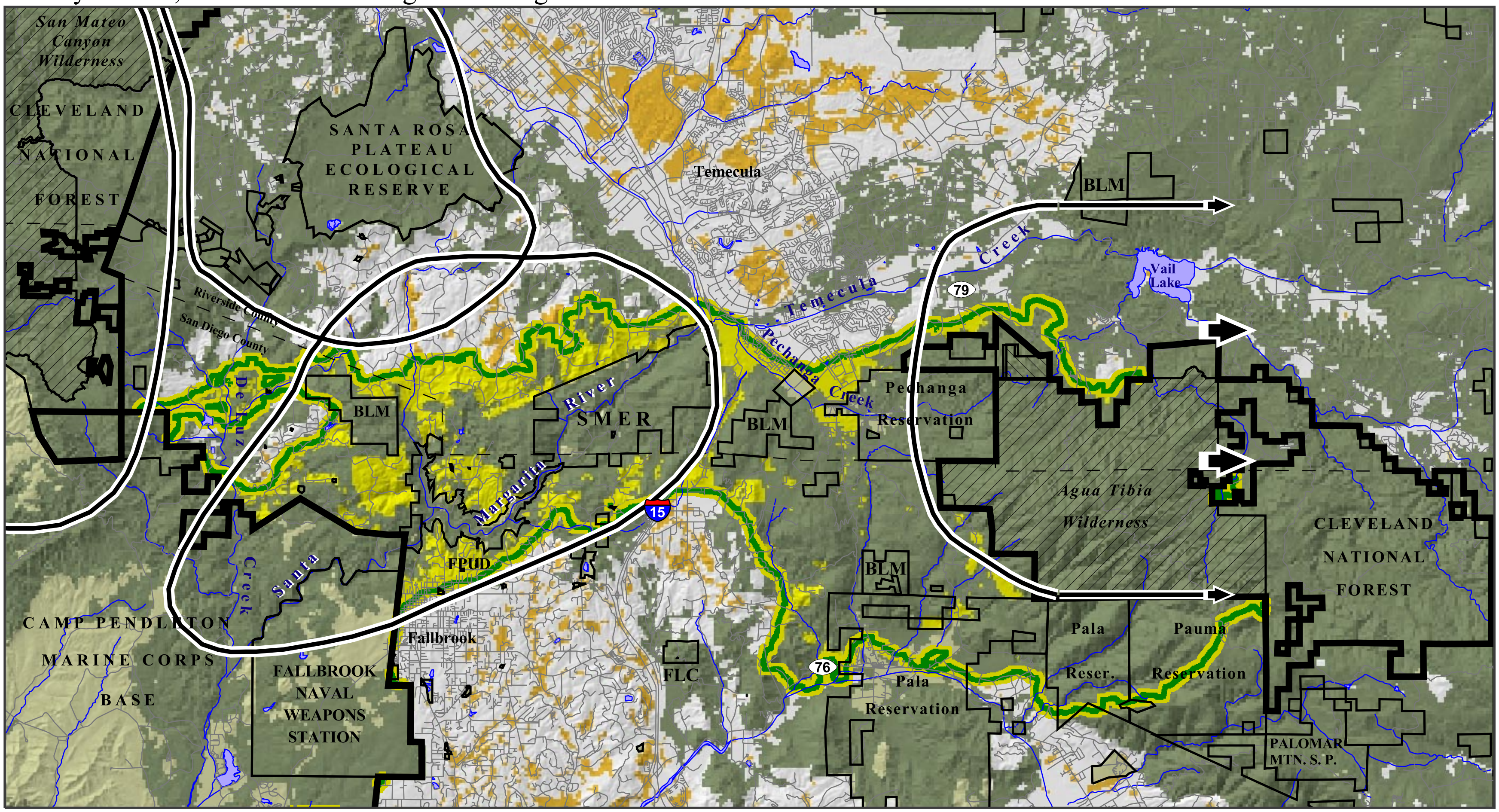
Dispersal: Little is known about natal dispersal distance for resident golden eagle populations. The young often visit their natal nesting site the following year (Brown and Amadon 1968), suggesting that immediate dispersal is not common for immature birds. Although populations in southern California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

Conceptual Basis for Model Development: The best suitable habitat for golden eagles is grass, shrub and non-riparian woodlands. Minimum patch size is 93 km^2, the average size of golden eagle territories measured in southern California. Minimum core area size is 2,325 km^2, the area needed to sustain 25 golden eagle territories (i.e., 50 individuals). Dispersal distance adopted for the model is 120 km, 3 times the length of the planning area.

Results and Discussion: Despite the presence of apparently large blocks of suitable core habitat in both ranges, only a few breeding pairs of golden eagles are known from coastal areas of San Diego and Orange counties (D. Bittner pers. comm.). This discrepancy between the suitable habitat model and known occurrences of self-sustaining populations emphasizes the need to confirm habitat modeling with field studies.

Occupied golden eagle territories exist in each of the Core Areas on Camp Pendleton and CNF Trabuco Ranger District and on CNF Palomar Ranger Districts (Figure C5). The Least-Cost Union covers roughly 2/3 of the territory used by a nesting pair, the remainder is predominantly planted as avocado groves with some small fragments of hunting habitat. This territory has been occupied since 1972 but has not successfully fledged young in the past few years (D. Bittner pers. comm.). We conclude that while the Least-Cost Union is not needed to sustain movement needs among populations of eagles, it serves a critical function of preserving this top predator in the linkage. The Least-Cost Union serves to protect the majority of hunting habitat for the nesting pair in the linkage. The Temecula Creek, Rainbow Creek and De Luz additions to the Least-Cost Union that were recommended to support other focal species would also benefit golden eagle by providing additional protected areas for hunting.

Figure C5. Cores and patches of potential suitable habitat for golden eagle *(Aquila chrysaetos)*.
Cores (dark green) are large enough to support 50 or more individuals (> 2,325 km^2). Patches (purple) are large enough to support 2 to 49 individuals (93 km^2 < x < 2,325 km^2). Orange areas are too small to support 2 individuals (< 93 km^2). All cores and patches are less than the species' maximum dispersal distance (120 km) apart. See text for assumptions regarding model inputs. Territory outlines are from D. Bittner (pers. comm.). BLM = Bureau of Land Management, FLC = Fallbrook Land Conservancy, FPUD = Fallbrook Public Utility District, SMER = Santa Margarita Ecological Reserve.



N

5 0 5 Kilometers

5 0 5 Miles

Legend

- Least-Cost Union
- cores of suitable habitat
- patches of suitable habitat
- < patch
- known golden eagle territories
- paved roads
- county line
- Santa Ana and Palomar Core Areas
- major landholders*
- designated wilderness
- proposed wilderness
- hydrography
- lakes & reservoirs

*land management varies by ownership.

SDSU San Diego State University FIELD STATION PROGRAMS

SOUTH COAST WILDLANDS

Map produced by:
SDSU Field Station Programs
January 28, 2004
http://fs.sdsu.edu

Justification for Selection: California quail is a resident species that is sensitive to habitat fragmentation (Crooks and Soule 1999). Movement needs represented by quail that guide linkage design include: movement through a wide variety of natural habitats, short dispersal distances, weak flight or terrestrial locomotion, and sensitivity to road barriers. To support a multi-generational crossing of the linkage, linkage design must maintain diverse blocks of natural habitat of sufficient size to support quail coveys and address mortality due to roadkill and hunting.

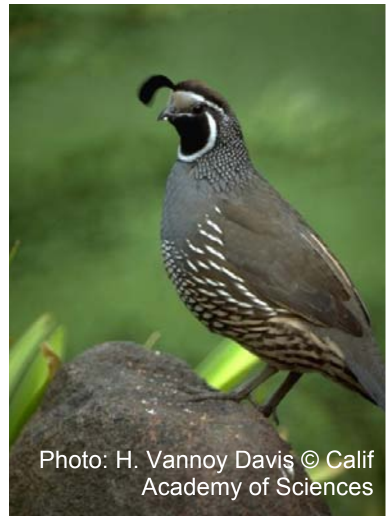


Photo: H. Vannoy Davis © Calif Academy of Sciences

Distribution: California quail range from southern British Columbia south to the Baja California peninsula and eastward into Idaho, Nevada and Utah (Peterson 1990). They are common in the planning area (C. Luke pers. obs.).

Habitat Associations: California quail require a mosaic of habitat types with low, brushy vegetation, grass/forb openings, taller shrubs and trees, and surface water (Ahlborn 1999). They occur in scrub and brush habitats (e.g., coastal sage, chaparral) and open conifer and open woodlands (e.g., oak), near the margins of grasslands and croplands (Leopold 1977). Numbers and breeding success are affected by rainfall, with high numbers following hears of high winter rainfall (McMillan 1964, Francis 1970, Leopold et al. 1976). Population productivity can be best estimated as a function of April soil moisture, the proportion of breeding females > 1 year old, and September to April rainfall (Francis 1970).

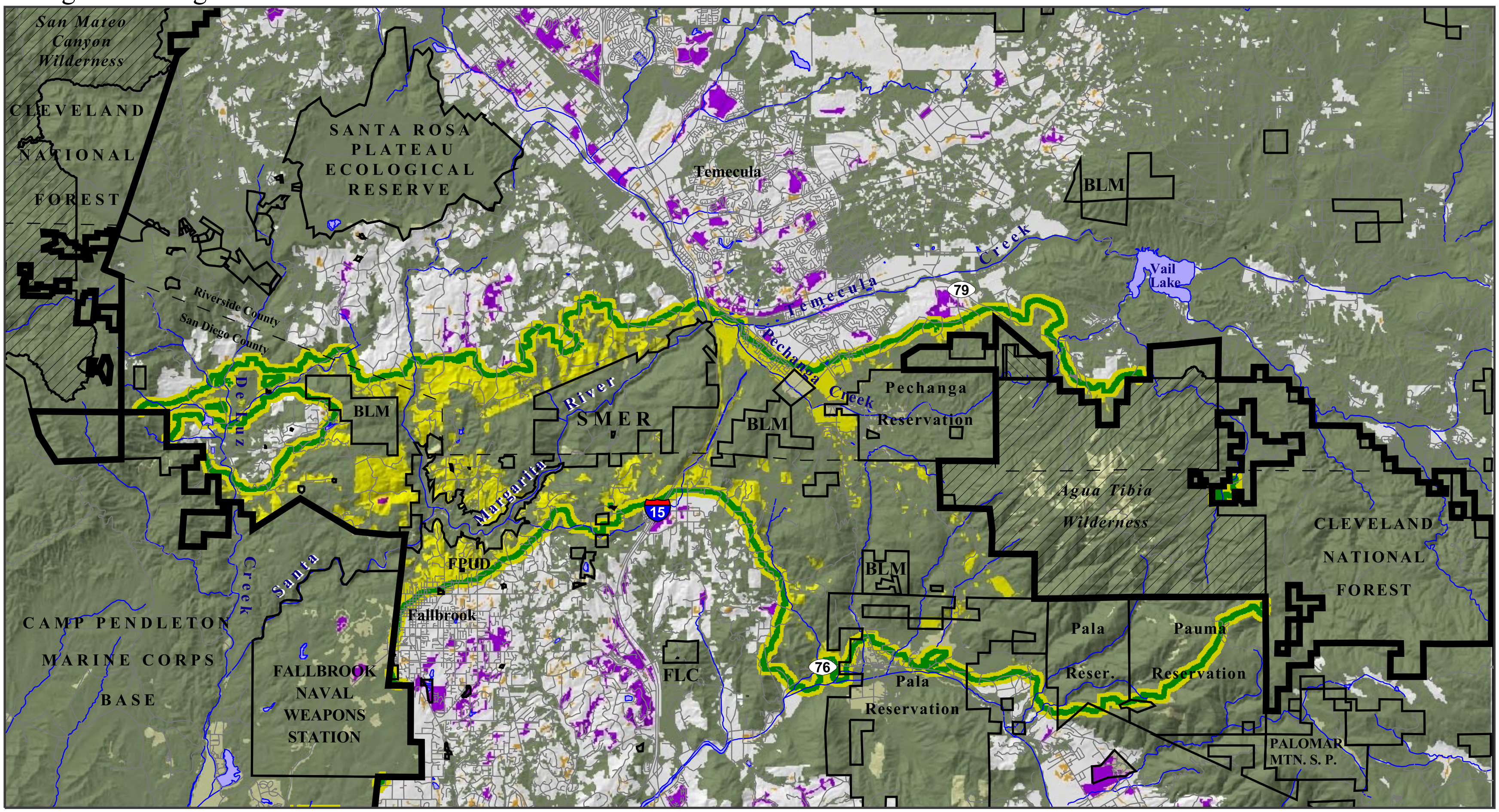
Home Range and Core Area Sizes: In California, the winter home range of 4 coveys averaged 10.5 ha (26 ac) and varied from 6.9 to 18 ha (17-45 ac). Habitat fragments without coyotes, those usually less than 1 km^2 (247 ac) in size, lack quail populations (Crooks and Soule 1999).

Dispersal: A mated pair can move 1.6 km (1 mi) from the nesting site to the brood range (Ahlborn 1999).

Conceptual Basis for Model Development: The best suitable habitat for quail is grassland, coastal scrub, chaparral, oak woodland and riparian habitat types. Minimum patch size is 6.9 ha, the minimum winter home range size reported for a covey. Core area size is 1 km^2, the size of a habitat patch needed to support use by coyotes. Dispersal distance is 3.2 km, twice the reported distance for movements of a mated pair and their young.

Results and Discussion: California quail habitat is well represented in both Core Areas and in the Least-Cost Union. The majority of the gaps in suitable habitat in the Least-Cost Union (Figure C6) is due to agricultural and urban development. All patches are within the presumed dispersal distance for this species, although numerous barriers to movement may exist between suitable habitat patches. We conclude that the Least-Cost Union currently serves population connectivity needs for California quail between the Santa Ana and Palomar Mountains. The Temecula Creek, Rainbow Creek and De Luz additions to the Least-Cost Union that were recommended to support other focal species would also benefit quail by providing additional suitable habitat and areas for movement through upland and riparian habitats.

Figure C6. Cores and patches of potential suitable habitat for California quail *(Callipepla californica)*.
Cores (dark green) are large enough to assure use by coyotes (> 1 km^2)(see text). Patches (purple) are large enough to support the winter home range size for one covey (0.069 km^2 < x < 1 km^2). Orange areas are too small to support one covey (< 0.069 km^2). All cores and patches are less than the species' maximum dispersal distance (3.2 km) apart. See text for assumptions regarding model inputs.
BLM = Bureau of Land Management, FLC = Fallbrook Land Conservancy, FPUD = Fallbrook Public Utility District, SMER = Santa Margarita Ecological Reserve.



Legend

- Least-Cost Union
- cores of suitable habitat
- patches of suitable habitat
- < patch
- paved roads
- county line
- Santa Ana and Palomar Core Areas
- major landholders*
- designated wilderness
- proposed wilderness
- hydrography
- lakes & reservoirs

*land management varies by ownership.

N

5 0 5 Kilometers

5 0 5 Miles

SDSU San Diego State University FIELD STATION PROGRAMS

SOUTH COAST WILDLANDS

Map produced by:
SDSU Field Station Programs
February 23, 2004
http://fs.sdsu.edu

SDSU San Diego State University FIELD STATIONS

SOUTH COAST WILDLANDS

Justification for Selection: Oak titmice are local residents. Movement needs represented by titmice that guide linkage design include: movement through oak woodland, riparian, and chaparral habitats and moderate dispersal distances. To support a multi-generational crossing of the linkage, linkage design must maintain blocks of oak woodland habitat of sufficient size to support populations of titmice.

Distribution: The oak titmouse ranges from Humboldt County south along the Sierra Nevada and Coast Ranges to northern Baja California (Peterson 1990) and seldom ranges above 1100 m (3500 ft) (Bent 1946).

Habitat Associations: Oak titmice are a common, year-round resident in a variety of habitats but prefer open woodlands with oak and pine/oak (Kucera 1999). They occur in montane hardwood-conifer, montane hardwood, blue, valley and coastal oak woodlands, and montane and valley foothill riparian habitats in cismontane California (Kucera 1999). They sometimes forage and breed in riparian habitats and can occur in residential areas (Kucera 1999). Oak titmice tend to remain in the canopy where food (insects, spiders, berries, seeds, and acorns are readily available (Ehrlich et al. 1988).

Home Range and Core Area Sizes: In Alameda County, territories ranged from 3.3 to 12.5 acres (Dixon 1949, 1954, 1956). In San Mateo County, territories averaged 0.8 ha (2.0 ac) (Hertz et al. 1976).

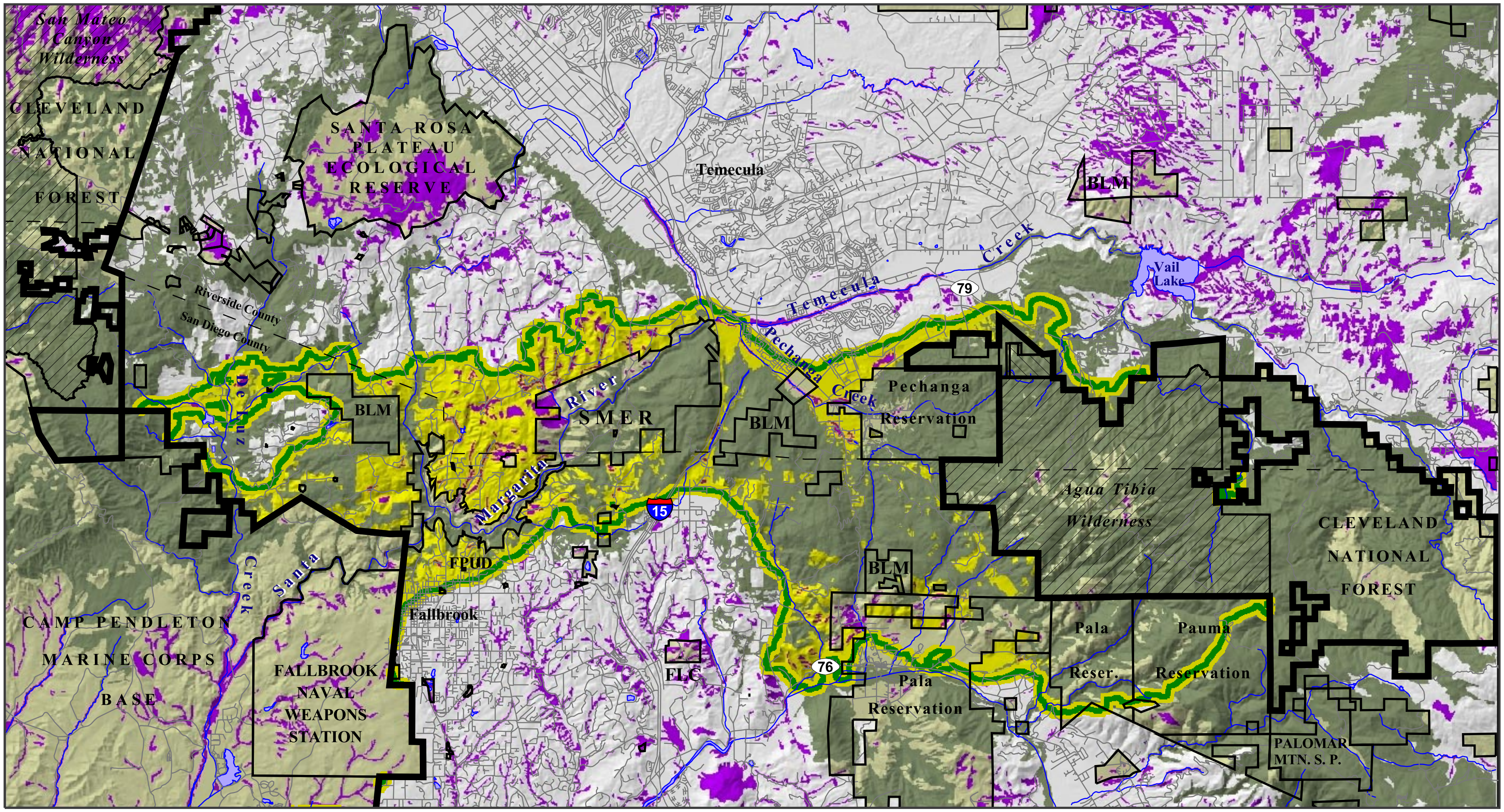
Dispersal: Four of 7 birds established territories in their natal area, and the median distance of dispersal was approximately 600 m (1950 ft)(Dixon 1949). Dispersal distances into new breeding areas have not been reported. Oak titmice may occasionally join mixed-species flocks in the non-breeding season (Ehrlich et al. 1988, Kucera 1999).

Conceptual Basis for Model Development: The best suitable habitat for titmice is chaparral, oak woodland, and riparian habitat types. Minimum patch size is 2 ac (0.008 km^2 (0.003 mi^2)), the average territory size needed to support a breeding pair. Core Area size is 15.8 km^2 (3906 ac), the area needed to support 50 individuals or 25 breeding pairs. Dispersal distance is 1200 m, twice the maximum recorded dispersal distance for a breeding individual.

Results and Discussion: Oak titmouse habitat is well represented in both Core Areas and in the Least-Cost Union (Figure C7), and all patches are within the presumed dispersal distance for this species, although numerous barriers to movement may exist between suitable habitat patches. Abundant suitable habitat exists in the eastern part of the linkage. Core areas of suitable habitat in the middle of the linkage is limited to a narrow band of woodland and chaparral along the Santa Margarita River on Fallbrook Public Utility District lands. The majority of the gaps in the suitable habitat in the Least-Cost Union in this area are due to agricultural and urban development.

The Least-Cost Corridor still provides connectivity for oak titmouse, although additional habitat fragmentation within the linkage could isolate populations in the Core Areas. The Temecula Creek, Rainbow Creek and De Luz additions to the Least-Cost Union that were recommended to support other focal species would also benefit titmice by providing additional suitable habitat and areas for movement through upland and riparian habitats.

Figure C7. Cores and patches of potential suitable habitat for oak titmouse *(Baeolophus inornatus)*.
Cores (dark green) are large enough to support 50 individuals (> 15.8 km^2). Patches (purple) are large enough to support 2 to 49 individuals (0.008 km^2 < x < 15.8 km^2). Orange areas are too small to 2 individuals (< 0.008 km^2). All cores and patches are less than the species' maximum dispersal distance (1.2 km) apart. See text for assumptions regarding model inputs. BLM = Bureau of Land Management, FLC = Fallbrook Land Conservancy, FPUD = Fallbrook Public Utility District, SMER = Santa Margarita Ecological Reserve.



Legend

- Least-Cost Union
- cores of suitable habitat
- patches of suitable habitat
- < patch
- paved roads
- county line
- Santa Ana and Palomar Core Areas
- major landholders*
- designated wilderness
- proposed wilderness
- hydrography
- lakes & reservoirs

*land management varies by ownership.

N

5 0 5 Kilometers

5 0 5 Miles

SDSU San Diego State University FIELD STATION PROGRAMS

SOUTH COAST WILDLANDS

Map produced by:
SDSU Field Station Programs
February 24, 2004
http://fs.sdsu.edu

SDSU San Diego State University FIELD STATIONS

SOUTH COAST WILDLANDS

Justification for Selection: This reptile is endemic to southern California and in decline. Movement needs represented by red diamond rattlesnakes for developing the linkage design include: movement through chaparral and other brushy habitats, slow-moving terrestrial locomotion, and very short dispersal distances. To support a multi-generational crossing of the linkage, linkage design must maintain continuity among chaparral habitats, and address species that are preferentially killed by humans and those frequently killed while crossing roads. Red diamond rattlesnakes are listed as Federal Candidates and State Species of Special Concern.

Distribution: Red diamond rattlesnakes range from southern San Bernardino County south along both desert and coastal sides of the Peninsular Ranges to coastal San Diego County (Peugegnat 1951, Stebbins 1985, Marlow 1988). They range from sea level to 1,520 m (0 to 4,990 ft) (but are more commonly encountered below 1,200 m (3900 ft) (Klauber 1972). They occur within the project area and are commonly encountered in the Santa Margarita Ecological Reserve (C. Luke, pers. obs.). They were recently recorded in the western portion of the linkage area as well (Fisher and Crooks 2001).

Habitat Associations: Red diamond rattlesnakes prefer sage scrub and chaparral habitats with heavy brush and large boulder and rock outcroppings (RCIP 2000, Klauber 1972) and avoid open areas (Tracey 2000). They are most abundant in areas with rock cover and vegetation height between 0.5 and 1.5 m (1.6 to 4.9 ft) (Tracey 2000). Woodrat middens are favorite microhabitats as well as crevices or under rocks (Tracey 2000). Rattlesnakes are good climbers and swimmers (Klauber 1972).

Home Range and Core Area Sizes: Home range sizes are greater for male than female snakes and range between 0.005 and 0.05 km^2 (1.2 and 12 ac) (Tracey 2000). Home ranges of males and females can overlap (T. Brown pers. comm.).

Dispersal: The only reported movement distances are for adults on their home ranges: males can move 400-700 m (0.3-0.4 mi) from den sites (Tracey 2000). Fitch and Shirer (1971) measured average daily movements for adults at 45 m; 10% percent of these movements are distances greater than 150 m. Juveniles are more likely to disperse long distances but no movement data are available for this life stage (Tracey 2000).

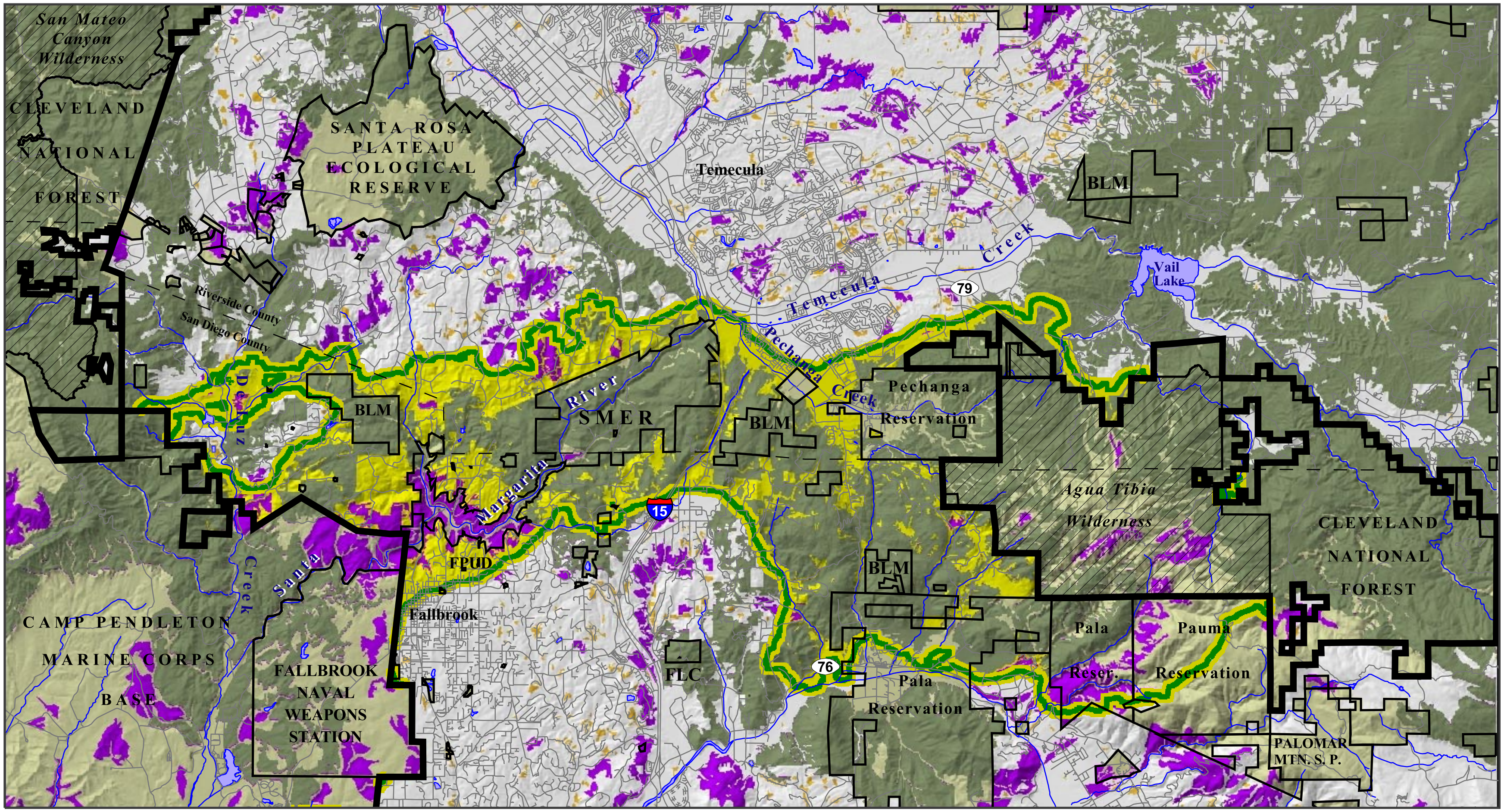
Conceptual Basis for Model Development: The best suitable habitat for red diamond rattlesnakes are chaparral and coastal scrub habitat types below 1,200 m. Minimum patch size is 0.10 km^2 (twice the maximum reported home range size). Core Area is

2.5 km^2 (50 x maximum home range size). Dispersal distance is 1400 m (twice the maximum recorded movement for an adult).

Results and Discussion: Red diamond rattlesnake habitat is well represented at mid-elevations in both Core Areas. In the Least-Cost Union, suitable habitat is fragmented along the Santa Margarita River, occurring in patches large enough to contain rattlesnakes but not large enough to sustain a population in the long-term. A second tenuous habitat connection occurs from the Santa Margarita Ecological Reserve, over Gavlin Mountain and through the BLM parcel to Camp Pendleton. The majority of the gaps in the suitable habitat in the Least-Cost Union (Figure C8) is due to agricultural and some urban development. Despite the relatively short dispersal distance adopted for the model, all patches inside the Least-Cost Union are within the presumed dispersal distance for this species (Figure C9). Numerous barriers to movement, such as roads, may exist between suitable habitat patches.

We conclude that the Least-Cost Corridor still provides connectivity for red diamond rattlesnakes, although, due the relatively short dispersal distance of this species, additional habitat fragmentation within the linkage could isolate populations in the Core Areas. The barriers of Interstate 15 and other major roads are not addressed by the model and most likely already have already caused isolation of populations on either side of the road. The Rainbow Creek and De Luz additions to the Least-Cost Union that were recommended to support other focal species would also benefit red diamond rattlesnakes by providing additional suitable habitat and areas for movement through upland and riparian habitats.

Figure C8. Cores and patches of potential suitable habitat for red diamond rattlesnake *(Crotalus ruber)*.
Cores (dark green) are large enough to support 50 individuals (> 2.5 km^2). Patches (purple) are large enough to support 2 to 49 individuals (0.10 km^2 < x < 2.5 km^2). Orange areas are too small to 2 individuals (< 0.10 km^2). See text for assumptions regarding model inputs. BLM= Bureau of Land Management, FLC = Fallbrook Land Conservancy, FPUD = Fallbrook Public Utility District, SMER = Santa Margarita Ecological Reserve.



Map produced by:
SDSU Field Station Programs
February 24, 2004
http://fs.sdsu.edu

N

5 0 5 Kilometers

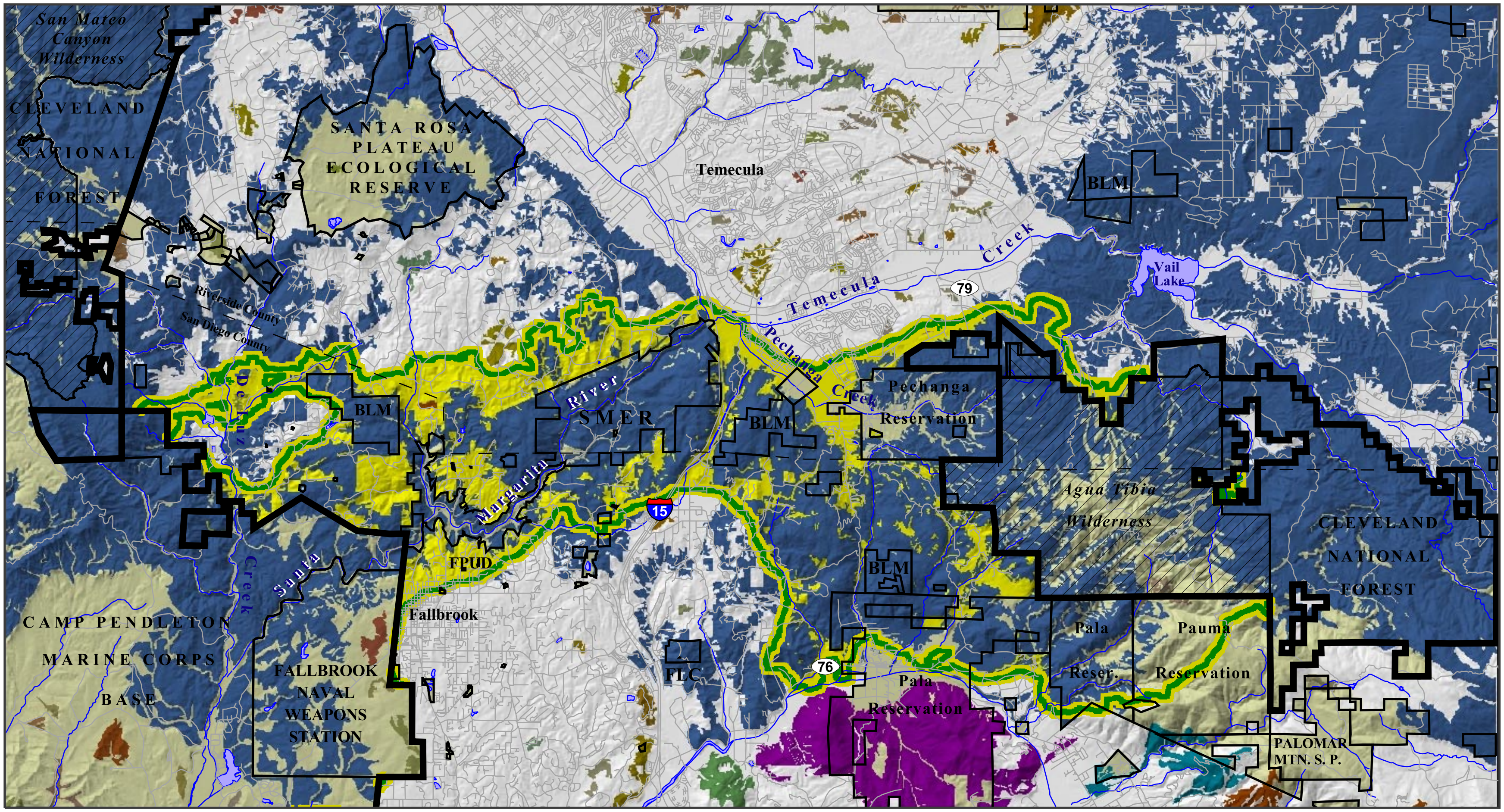
5 0 5 Miles

Legend

- Least-Cost Union
- cores of suitable habitat
- patches of suitable habitat
- < patch
- paved roads
- county line
- Santa Ana and Palomar Core Areas
- major landholders*
- designated wilderness
- proposed wilderness
- hydrography
- lakes & reservoirs

*land management varies by ownership.

Figure C9. Distances among cores and patches of potential suitable habitat for red diamond rattlesnake *(Crotalus ruber)*. Suitable habitat polygons that are farther apart than the species' dispersal distance (0.14 km) are shown in different colors. See text for assumptions regarding model inputs. BLM = Bureau of Land Management, FLC = Fallbrook Land Conservancy, FPUD = Fallbrook Public Utility District, SMER = Santa Margarita Ecological Reserve.



Legend

- Least-Cost Union
- Various Colors: Each color represents suitable habitat polygons within the species' dispersal distance.
- Paved Roads
- County Line
- Santa Ana and Palomar Core Areas
- major landholders*
- designated wilderness
- proposed wilderness
- hydrography
- lakes & reservoirs

*Land management varies by ownership.

N

5 0 5 Kilometers

5 0 5 Miles

SDSU San Diego State University FIELD STATION PROGRAMS

SOUTH COAST WILDLANDS

Map produced by:
SDSU Field Station Programs
February 25, 2004
http://fs.sdsu.edu


Photo: Chris Brown

Justification for Selection: Movement needs represented by western toads for developing the linkage design include: movement through a variety of upland habitats, slow-moving terrestrial locomotion and moderate dispersal distances. To support a multi-generational crossing of the linkage, linkage design must maintain continuity between high-quality slow-moving aquatic and upland habitats. The species is one of the most commonly killed species on roads in the linkage area (Fisher and Crooks 2001).

Distribution: The western toad ranges from western British Columbia and southern Alaska south through Washington, Oregon, and Idaho to northern Baja California, and east to Montana, western and central Wyoming, Nevada, high elevation areas in Utah, and western Colorado (Stebbins 1985). In the linkage planning area, relatively high densities of toads occur on MCB Camp Pendleton, the Santa Rosa Plateau Ecological Preserve, Tenaja Corridor, and along the Santa Margarita River (Fisher and Crooks 2001).

Habitat Associations: In California, western toads occur up to 3000 m (10,000 ft) elevation in most habitats except deserts (Morey 1988a, Sullivan 1994). Upland habitats in the planning area include grasslands, coastal scrub, chaparral, and oak and riparian woodlands. Aquatic habitats include lakes, ponds, vernal pools, roadside ditches, irrigation canals, permanent and intermittent streams, and rivers (Morey 1988a). Eggs are laid in water 6 to 12 inches (30 cm) in depth (Olson 1992, Stebbins 1954).

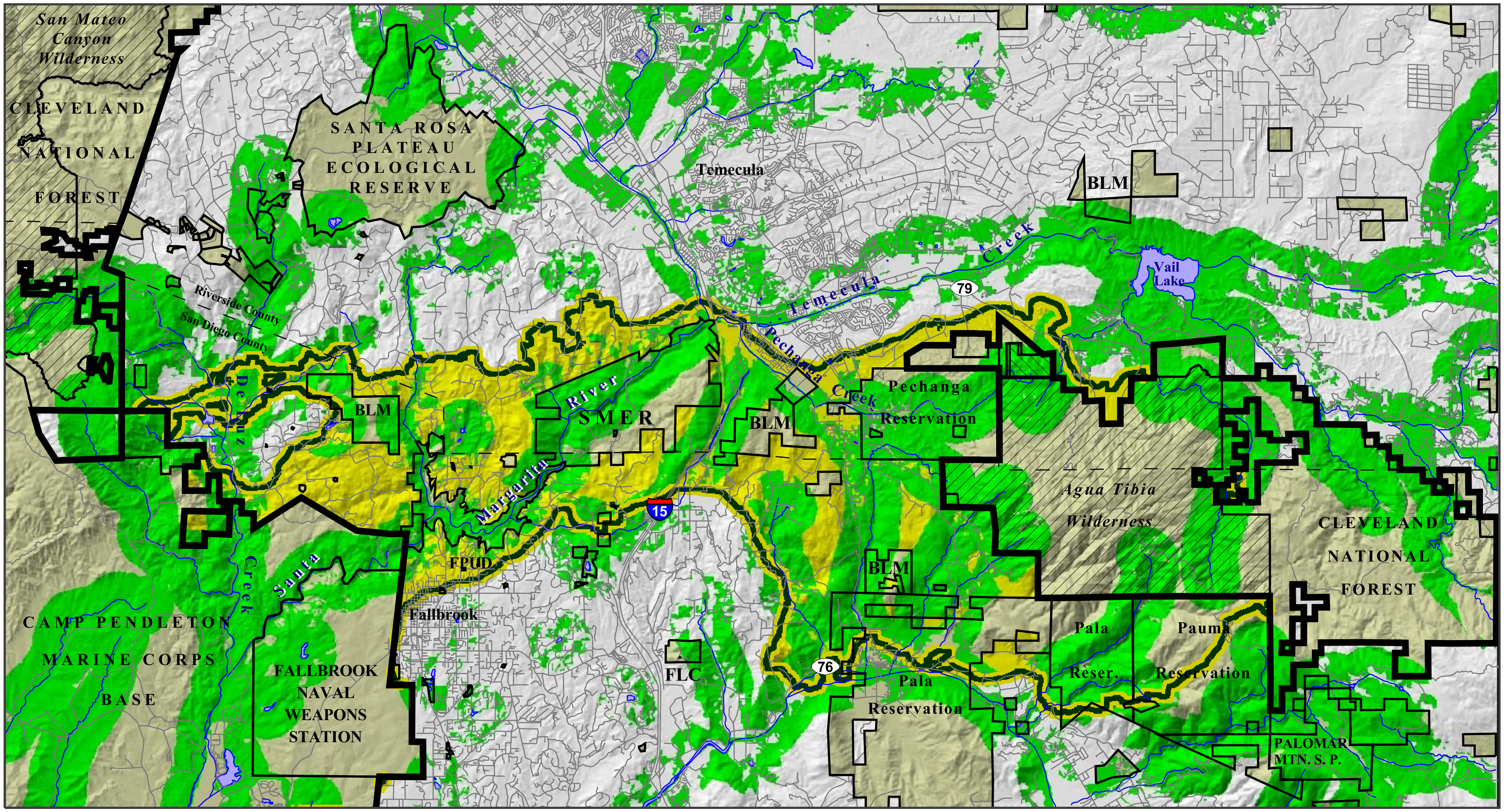
Home Range and Core Area Sizes: While there is substantial variation in home range, individuals living in low elevation areas are occasionally encountered up to 1000 m (0.62 mi) from potential breeding sites, and some have been tracked through a wide range of habitats up to 5 km (3 mi) from their breeding areas (Morey 1988a, Corn et al. 2001).

Dispersal: Dispersal distances among breeding sites has not been measured. After breeding, adult toads move up to 1 to 5 km (0.6 to 3 mi) through wide range of potentially inhospitable habitats (Morey 1988a, Corn et al. 2001). Tadpole dispersal is probably not significant: breeding adults in a population tend to lay their eggs at the same location (Sullivan 1994) and their tadpoles clump in large masses until they metamorphose (Nussbaum et al. 1983).

Conceptual Basis for Model Development: Western toads prefer grassland, coastal scrub, chaparral, and oak and riparian woodland habitats types within 1 km (0.6 mi) of perennial or ephemeral surface water. Aquatic habitat without adjacent native vegetation was not considered suitable. Minimum patch size needed for 2 toads is less than the 30-m minimum mapping unit. Because habitat quantity is a poor predictor of population density in western toads, we did not designate a minimum core area size, but included all suitable habitat as potential core habitat. Dispersal distance used is 10 km (6 mi)(twice the maximum reported distance an individual moved from a breeding site).

Results and Discussion: Large areas of suitable habitat exist for western toad populations in the Core Areas and in the Least-Cost Union (Figure C10). All patches are within the presumed dispersal distance for this species, although numerous barriers to movement may exist between suitable habitat patches. The primary avenue for movement among populations in the Core Areas is the Santa Margarita River and Pechanga Creek. The Temecula Creek, Rainbow Creek and De Luz additions to the Least-Cost Union that were recommended to support other focal species would also benefit western toads by providing additional suitable habitat and areas for movement through upland and riparian habitats.

Figure C10. Potential suitable habitat for western toad *(Bufo boreas)*.
All suitable habitat polygons are less than the species' maximum dispersal distance (10 km) apart. See text for assumptions regarding model inputs. BLM= Bureau of Land Management, FLC = Fallbrook Land Conservancy, FPUD = Fallbrook Public Utility District, SMER = Santa Margarita Ecological Reserve.



SDSU San Diego State University FIELD STATION PROGRAMS

SOUTH COAST WILDLANDS

Map produced by:
SDSU Field Station Programs
February 25, 2004
http://fs.sdsu.edu

N

5 0 5 Kilometers

5 0 5 Miles

Legend

- Least-Cost Union
- suitable habitat
- paved roads
- county line
- Santa Ana and Palomar Core Areas
- major landholders*
- designated wilderness
- proposed wilderness
- hydrography
- lakes & reservoirs

*land management varies by ownership.

Justification for Selection: Pale swallowtails are chaparral specialists and local extinctions have been attributed to urban and agricultural developments (Emmel and Emmel 1973). To insure continued existence of this species in the linkage, linkage design must allow movement among chaparral habitats, juxtaposition of a diversity of habitat features (e.g. hilltops, drainages, host plants), and provide for long-distance dispersal through natural habitats.

Distribution: Pale swallowtails range from southern British Columbia east to Montana and south to New Mexico, California and Baja California (USGS 2002b). They occur throughout the Santa Ana Mountains (Orsack 1977).

Habitat Associations: Pale swallowtails are found in open hilly areas, often in open woodlands and chaparral (USGS 2000b, Emmel and Emmel 1973). They are found flying along undisturbed watercourses or in moist canyons (Orsack 1977). Adults feed on flower nectar from thistle (Orsak 1977) and are attracted to moist sandbars and soils (Garth and Tilden 1986). Caterpillar host plants are trees and shrubs in the Rosaceae, Rhamnaceae and Betulaceae, including holly-leafed cherry (*Rhamnus ilicifolia*), California lilac (*Ceanothus spp.*), coffeeberry (*Rhamnus crocea* and *R. californica*) and ash *(Fraxinus sp.)*(USGS 2000b, Orsak 1977, Garth and Tilden 1986). Adults commonly hilltop on higher peaks. They are attracted to moist sandbars.

Home Range and Core Area Sizes: No home range or density estimates exist for this species.

Dispersal: Dispersal and movements have not been measured in this species. The large body size of this species suggests that it is capable of making long-distance flights. When western swallowtail (*P. zelicaon*) males, a congener of similar size, were displaced 5 km (3 mi) from hilltops, they returned the site of capture (Scott 1986).

Conceptual Basis for Model Development: Adults prefer chaparral, woodlands, and undisturbed watercourses and hilltops. 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 mi) (twice the reported return distance reported for a congener).

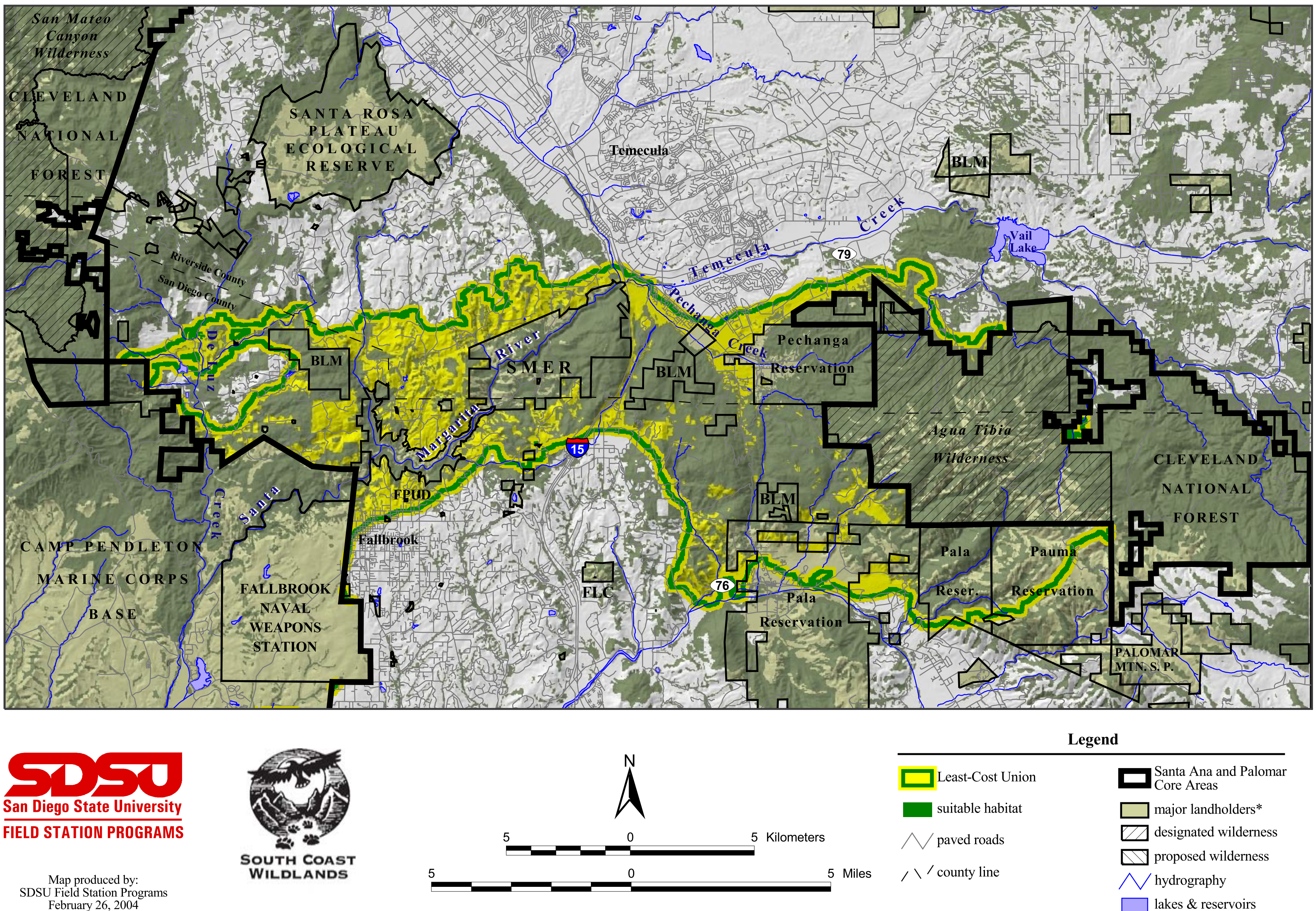
Results and Discussion*:* The Least-Cost Union will likely serve this species. Core areas of habitat for pale swallowtail are widely distributed throughout both Santa Ana and Palomar Mountain Core areas and comprise approximately ½ of the Least-Cost

Union (Figure C11). All patches are within the presumed dispersal distance for this species, although numerous barriers to movement may exist between suitable habitat patches. We conclude that the Least-Cost Union could provide adequate habitat protection for this species to preserve connections between the Core Areas. The Temecula Creek, Rainbow Creek and De Luz additions to the Least-Cost Union that were recommended to support other focal species would also benefit pale swallowtails by providing additional suitable habitat and areas for movement through upland and riparian habitats.

SDSU
San Diego State University
FIELD STATIONS

SOUTH COAST WILDLANDS

Figure C11. Potential suitable habitat for pale swallowtail *(Papilio eurymedon).*
All suitable habitat polygons are less than the species' maximum dispersal distance (10 km) apart. See text for assumptions regarding model inputs. BLM= Bureau of Land Management, FLC = Fallbrook Land Conservancy, FPUD = Fallbrook Public Utility District, SMER = Santa Margarita Ecological Reserve.



SDSU
San Diego State University
FIELD STATION PROGRAMS

SOUTH COAST WILDLANDS

Map produced by:
SDSU Field Station Programs
February 26, 2004
http://fs.sdsu.edu

Photo: Dale Clark

Justification for Selection: To insure existence of this widely-dispersing oak woodland specialist species in the linkage, linkage design must allow movement among oak woodland habitats, protect a diversity of habitat features (e.g. drainages, host plants), and provide for long-distance dispersal through natural habitats.

Distribution: The California sister ranges from southwestern Washington to Baja California and east to Nevada, Arizona and Colorado (Orsak 1977, Emmel and Emmel 1973). It is found throughout California's Coast ranges, including the Santa Ana Mountains (Orsak 1977) and oak woodland belt of the Transverse, Sierra Nevada and Cascade Ranges (Garth and Tilden 1986).

Habitat Associations: The California Sisters occur in oak woodlands and stream valleys (USGS 2002a) in middle- and low-elevation mountains. Its larval food plants are oaks, especially the canyon oak (*Quercus chrysolepis*) and coast live oak (*Q. agrifolia*) (Garth and Tilden 1986). They fly close to streams and cluster on moist sandy banks (Orsack 1977).

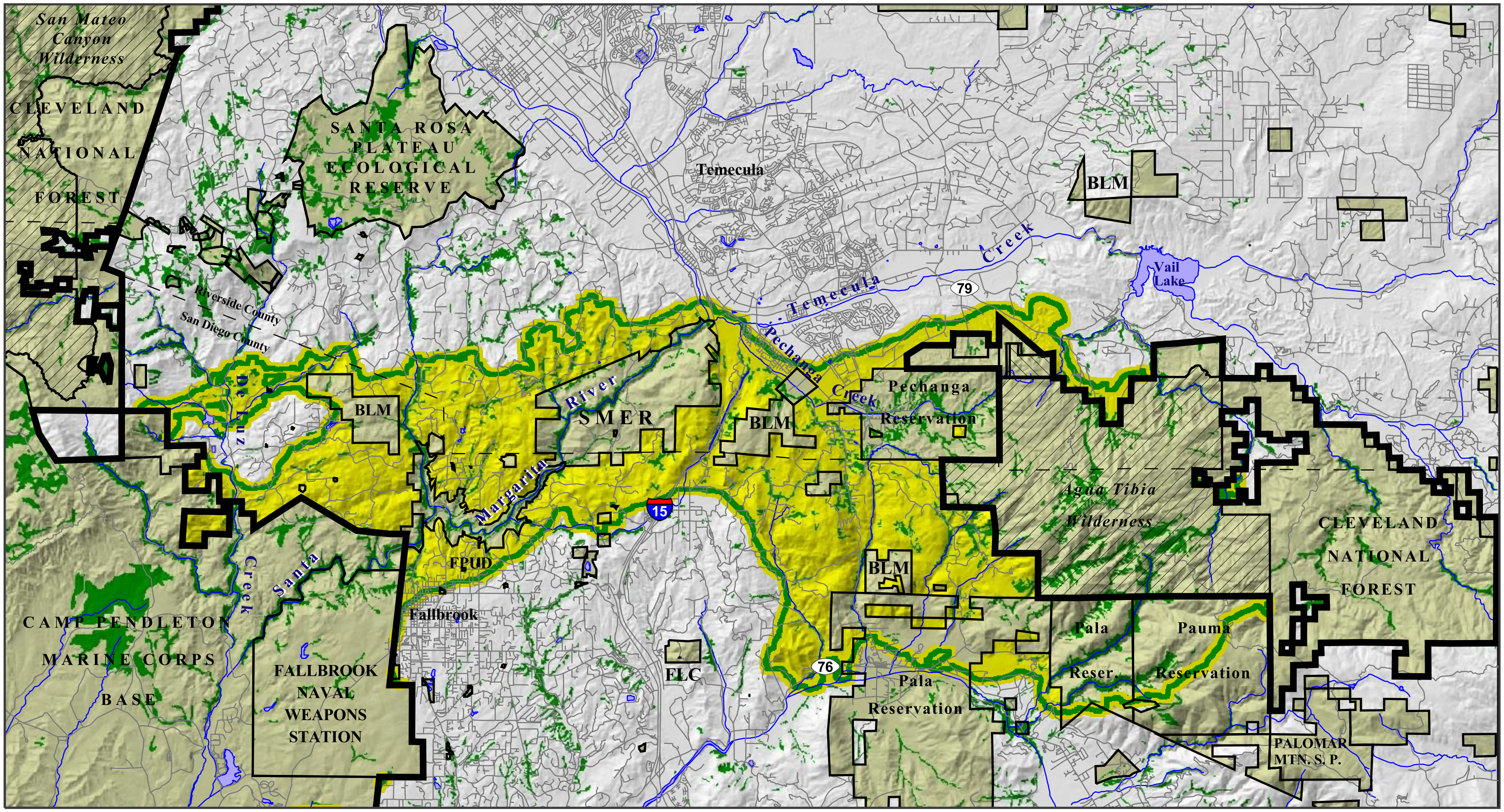
Home Range and Core Area Sizes: Home range and core area sizes are unknown.

Dispersal: Little is known about dispersal of this species. They are often seen gliding among high branches of oak trees or close the ground near streams and moist soils (Orsak 1977). They are reported to be strong flyers and commonly travel up to 8 km (5 mi), occasionally traveling up 80 km (50 mi) to the nearest oak (G. Pratt pers. comm.)

Conceptual Basis for Model Development: Oak woodlands, riparian forests and canyons with native vegetation and perennial water are preferred habitats for these butterflies. 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 160 km (twice the reported maximum dispersal distance).

Results and Discussion: The Least-Cost Union likely provides adequate habitat connections for this species. Core areas for California Sister are patchily distributed throughout both Santa Ana and Palomar Mountain Core Areas and in the Least-Cost Union (Figure C12). All patches are within the presumed dispersal distance for this species, although numerous barriers to movement may exist between suitable habitat patches. The Temecula Creek, Rainbow Creek and De Luz additions to the Least-Cost Union, recommended for other focal species, would benefit California sister by providing additional suitable habitat and riparian movement areas.

Figure C12. Potential suitable habitat for California sister *(Adelpha bredowii)*.
All suitable habitat polygons are less than the species' maximum dispersal distance (160 km) apart. See text for assumptions regarding model inputs. BLM= Bureau of Land Management, FLC = Fallbrook Land Conservancy, FPUD = Fallbrook Public Utility District, SMER = Santa Margarita Ecological Reserve.



Legend

Least-Cost Union
suitable habitat
paved roads
county line
Santa Ana and Palomar Core Areas
major landholders*
designated wilderness
proposed wilderness
hydrography
lakes & reservoirs

*land management varies by ownership.

N

5 0 5 Kilometers

5 0 5 Miles

SDSU
San Diego State University
FIELD STATION PROGRAMS

SOUTH COAST WILDLANDS

Map produced by:
SDSU Field Station Programs
February 26, 2004
http://fs.sdsu.edu

Comstock's Fritillary (*Speyeria callippe comstocki*)


Photo: Clark Thompson

Justification for Selection: This species is sensitive to habitat alteration from urban development (Orsack 1977) and may be a good indicator of climate change since they require moist sites. To insure continued existence of this species in the linkage, linkage design must allow juxtaposition of a diversity of habitat features (e.g. hilltops, drainages, host plants, moist hillsides), allow low-flying insects to cross roads, and provide for long-distance dispersal through natural habitats.

Distribution: Comstock's Fritillary ranges from southern British Colombia to southwestern Manitoba, south to central and southern California, Nevada, and southern Colorado. It is common in the Santa Ana Mountains (Orsak 1977). The species was recently collapsed into the subspecies *S. c. callippe* (Arnold 1985).

Habitat Associations: This species occurs in open pine woodlands, sagebrush, chaparral and grasslands on hillsides and in canyons (Emmel and Emmel 1973). Adults visit thistle blossoms. The larvae feed on Johnny Jump-Up (*Viola pedunculata)* and possibly other members of the genus that occur in moist places in the foothills, especially on sheltered rocky outcroppings (Orsak 1977). Males seek hilltops and ridges to attract mates (Orsak 1977, Scott 1986).

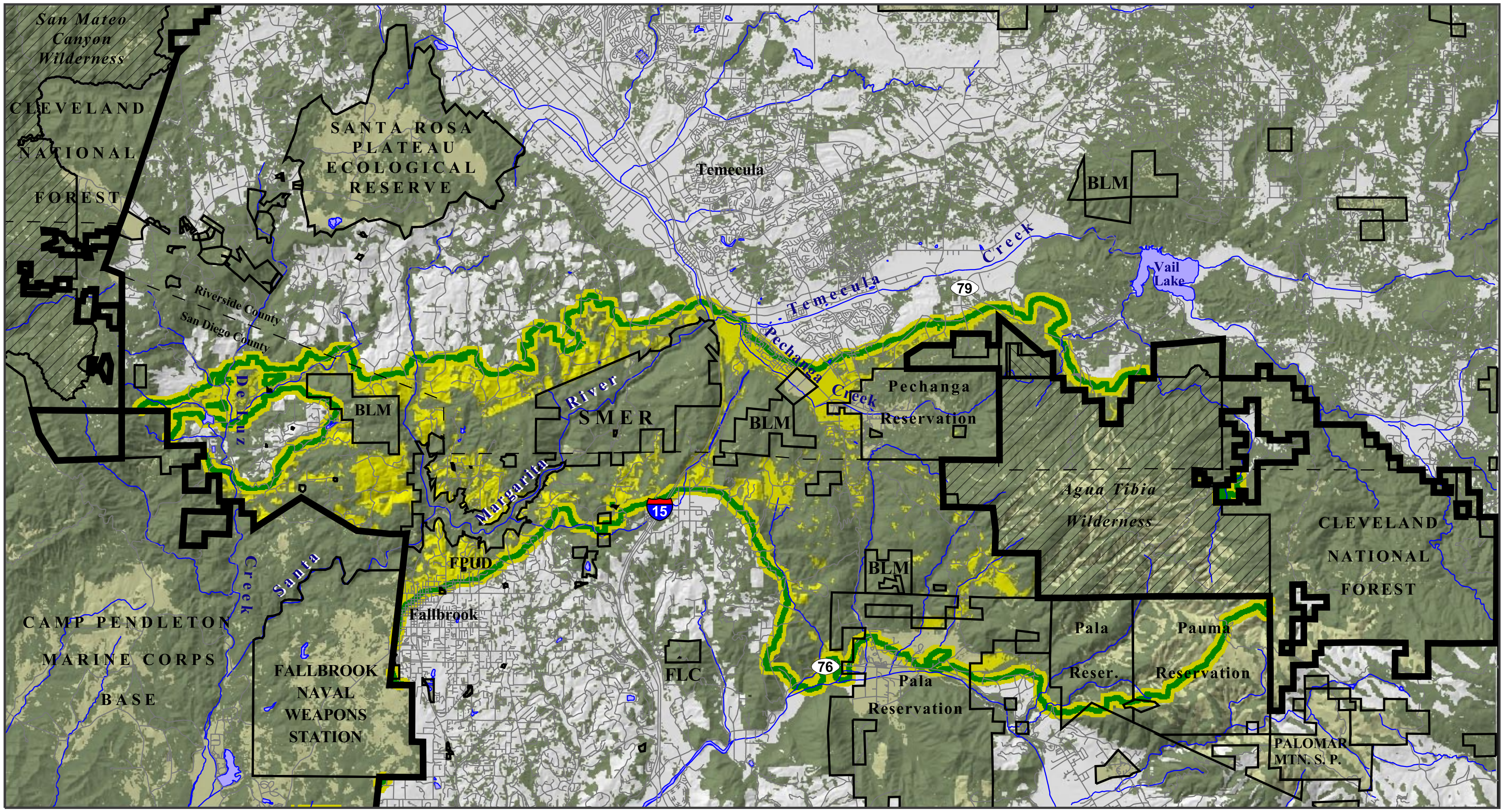
Home Range and Core Area Sizes: No home range or density estimates exist for this species but in three other members of the genus abundance was positively correlated with the abundance of the *Viola* host plants (Fleishman et al. 2002).

Dispersal: Adults are low but fast flyers (Emmel and Emmel 1973) capable of 48-km (30-mi) movements (K. Davenport and G. Pratt pers. comm.). Rapid increases on host plants in wet years (Emmel and Emmel 1973) suggest that individuals are good dispersers and quickly colonize host plant populations. Other species in this genus, also show this propensity where density is best modeled as a consequence of habitat quality rather than patch area or degree of isolation (Fleishman et al. 2002). Other habitat specialists in the genus have also been observed to preferentially avoid crossing habitat edges into other habitat types, including crops and roads (Ries and Debinki 2001).

Conceptual Basis for Model Development: The best suitable habitats are oak and riparian woodlands, chaparral, coastal sage, and grasslands occurring on slopes and in canyons, and undisturbed hilltops. 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 is 98 km, twice the maximum reported movement for this species.

Results and Discussion: The Least-Cost Union will likely serve this species. Core areas of habitat for Comstock's Fritillary are widely distributed throughout both Santa Ana and Palomar Mountain Core areas and comprise approximately ¾ of the Least-Cost Union (Figure C13). All patches are within the presumed dispersal distance for this species, although numerous barriers to movement may exist between suitable habitat patches. The Temecula Creek, Rainbow Creek and De Luz additions to the Least-Cost Union that were recommended to support other focal species would also benefit California fritillary by providing additional suitable habitat and areas for movement through upland and riparian habitats.

Figure C13. Potential suitable habitat for Comstock's fritillary *(Speyeria callippe comstocki)*.
All suitable habitat polygons are less than the species' maximum dispersal distance (96 km) apart. See text for assumptions regarding model inputs. BLM= Bureau of Land Management, FLC = Fallbrook Land Conservancy, FPUD = Fallbrook Public Utility District, SMER = Santa Margarita Ecological Reserve.



N

5 0 5 Kilometers

5 0 5 Miles

Legend

- Least-Cost Union
- suitable habitat
- paved roads
- county line
- Santa Ana and Palomar Core Areas
- major landholders*
- designated wilderness
- proposed wilderness
- hydrography
- lakes & reservoirs

*land management varies by ownership.

San Diego State University
FIELD STATION PROGRAMS

SOUTH COAST WILDLANDS

Map produced by:
SDSU Field Station Programs
February 26, 2004
http://fs.sdsu.edu

SDSU San Diego State University FIELD STATIONS

SOUTH COAST WILDLANDS

Justification for Selection: Timema walkingsticks are wingless chaparral specialists with low dispersal capabilities. Movement needs represented by this species and addressed by linkage design include movement among chaparral habitats and extremely short dispersal distances. All gaps in the chaparral, including those produced by dirt roads are very difficult for walkingsticks to traverse making this species a good indicator or habitat continuity.

***Photo: Timema* sp.**

Distribution: Timema walkingstick occurs in southern portion of the Coast Ranges and Sierra Nevada and continues south through the Transverse Ranges to the mountainous regions of coastal California and into the extreme northern portion of Baja (Sandoval et al. 1998).

Habitat Associations: Timema walkingstick populations in the San Jacinto mountains specialize on either *Ceanothus leucodermis* or *Adenostoma fasciculatum* (Sandoval and Crespie 1999) and this may be true for the species throughout its range.

Home Range and Core Area Sizes: The core area size needed to sustain this species in perpetuity is unknown. Fifty individuals could easily be found on one or two host plant bushes. However, the relatively high abundance and low dispersal distance of this species suggest that populations may persist for long periods on small habitat fragments.

Dispersal: Walkingsticks are slow-moving. Like the closely related *T. cristinae, T. podura* is polymorphic for color, and body size (Sandoval and Crespie 1999). In *T. cristinae,*, differences in body size, shape, host plant preference, and behavior in green and brown color morphs have been explained by low rates of gene flow (caused by intense predation) among animals on different host plants (*Ceanothus spinosus* and *Adenostoma fasciculatum*) (Nosil et al. 2002). Phylogenetic analyses further showed a high degree of genetic divergence among 8 populations living within the Santa Ynez Valley, even for populations specializing on the same host plant (Nosil et al. 2002). Although dispersal has never been measured in this or related species, we assume that lifetime movements of individuals may be extremely low (on the order of tens of meters).

Conceptual Basis for Model Development: Ideal habitat for Timema walkingsticks is chaparral containing its host plants, *Ceanothus* and *Adenostoma*. Both minimum patch size (area needed to support 2 individuals) and minimum core area (area needed to support 50 individuals) are less than the 30-m minimum mapping unit. Therefore, no habitat patches were excluded from the analysis. Without adequate information on this species, a dispersal distance of 50 m was adopted, a distance slightly larger than the minimum mapping unit.

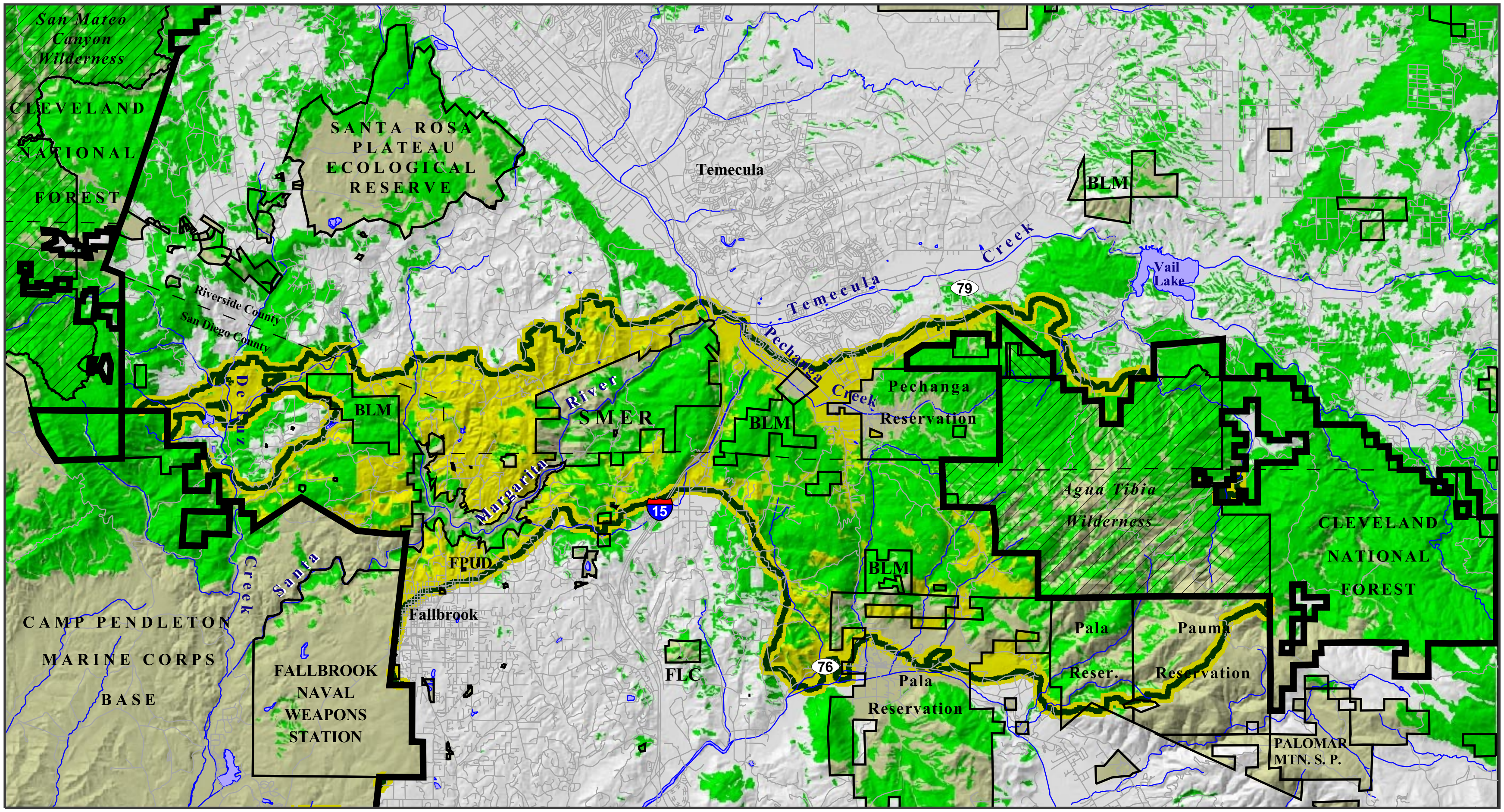
Results and Discussion: Habitat for Timema walkingstick is widespread throughout the Santa Ana and Palomar Mountain Core areas and in the Least-Cost Union (Figure C14). Polygons of suitable habitat in the center of the Least-Cost Union are separated by distances greater than the dispersal distance for this species (i.e., suitable habitat polygons represented in blue and pink, Figure C15). In this area (just west of the Santa Margarita Ecological Reserve boundary), the combination of orchards and naturally occurring coastal scrub habitats form a barrier to movements between populations in the Santa Ana and Palomar Core Areas.

Restoration of lands within the Least-Cost Union are needed to restore and protect habitat connections for Timema walkingstick and other chaparral specialists with short dispersal distances between the Santa Ana and Palomar Mountain Core Areas. We recommend that:

- agricultural areas adjacent to the western boundary the Santa Margarita Ecological Reserve be restored to preserve connections among chaparral habitats, and
- artificial barriers, such as roads, be modified to allow for small animal movement.

The Rainbow Creek and De Luz habitat additions to the Least-Cost Union that were recommended for other focal species would also benefit Timema walkingsticks. Both of these additions would provide additional suitable habitat for this species.

Figure C14. Potential suitable habitat for Timema walkingstick *(Timema podura)*.
Suitable habitat is predominantly chaparral vegetation types. See text for assumptions regarding model inputs. BLM= Bureau of Land Management, FLC = Fallbrook Land Conservancy, FPUD = Fallbrook Public Utility District, SMER = Santa Margarita Ecological Reserve.



Map produced by:
SDSU Field Station Programs
February 27, 2004
http://fs.sdsu.edu

SDSU San Diego State University FIELD STATION PROGRAMS

SOUTH COAST WILDLANDS

N

5 0 5 Kilometers

5 0 5 Miles

Legend

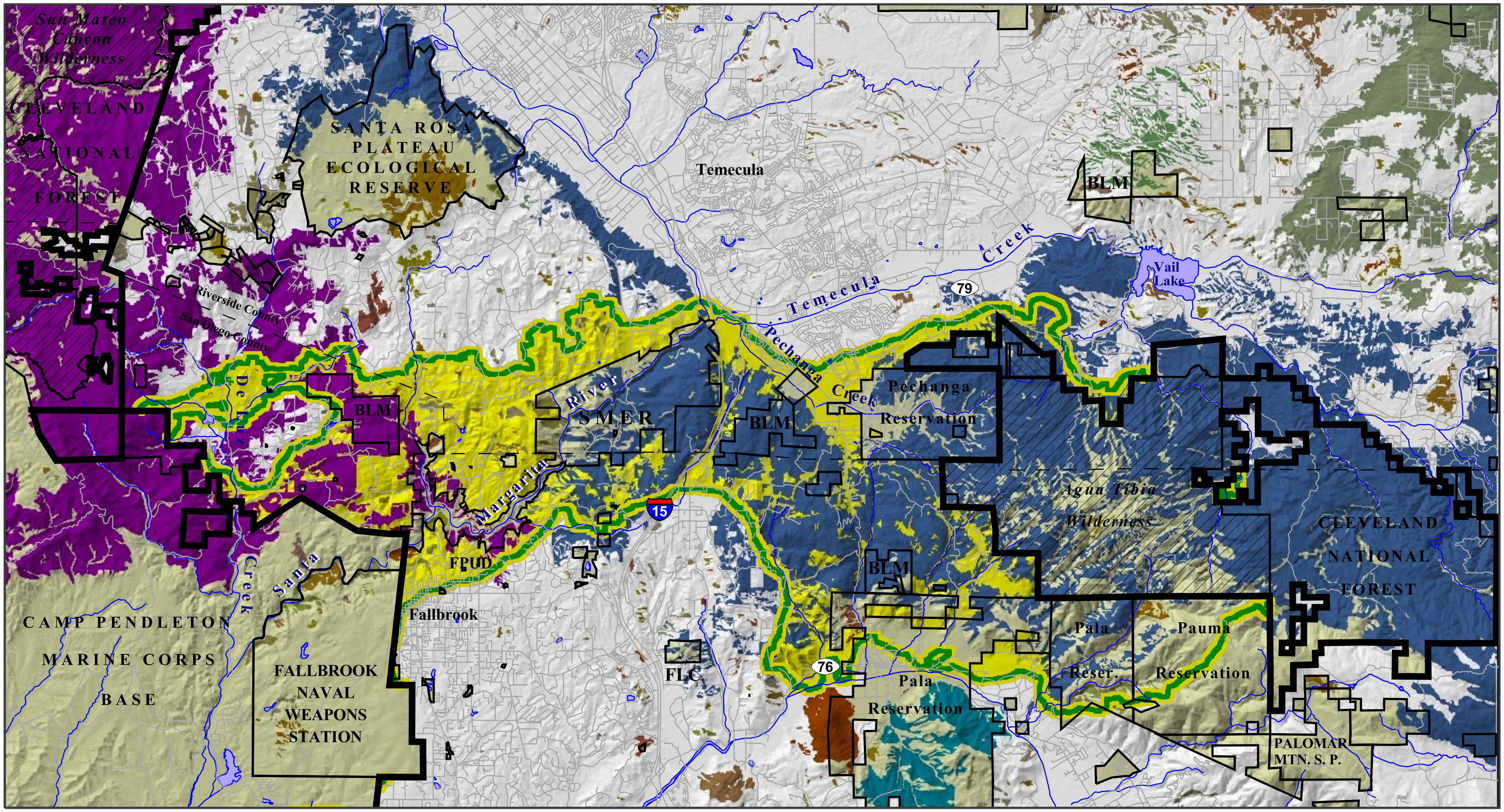
- Least-Cost Union
- suitable habitat
- paved roads
- county line
- Santa Ana and Palomar Core Areas
- major landholders*
- designated wilderness
- proposed wilderness
- hydrography
- lakes & reservoirs

*land management varies by ownership.

SDSU San Diego State University FIELD STATIONS

SOUTH COAST WILDLANDS

Figure C15. Distances among potential suitable habitat polygons for Timema walkingstick *(Timema podura).*
Suitable habitat polygons that are farther apart than the species' dispersal distance (50 m) are shown in different colors. See text for assumptions regarding model inputs. BLM= Bureau of Land Management, FLC = Fallbrook Land Conservancy, FPUD = Fallbrook Public Utility District, SMER = Santa Margarita Ecological Reserve.



Legend

- Least-Cost Union
- Various Colors: Each color represents suitable habitat polygons within the species' dispersal distance.
- Paved Roads
- County Line
- Santa Ana and Palomar Core Areas
- major landholders*
- designated wilderness
- proposed wilderness
- hydrography
- lakes & reservoirs

*Land management varies by ownership.

N

5 0 5 Kilometers

5 0 5 Miles

SDSU San Diego State University FIELD STATION PROGRAMS

SOUTH COAST WILDLANDS

Map produced by:
SDSU Field Station Programs
March 2, 2004
http://fs.sdsu.edu

SDSU San Diego State University FIELD STATIONS

SOUTH COAST WILDLANDS

Justification for Selection: Engelmann oaks are long-lived trees restricted to the South Coast Ecoregion. Significant populations occur in the Core Areas and Linkage (Reiser 1994, Scott 1991) and the linkage may be important for maintaining gene flow among the 3 largest remaining stands of this species. Movement needs represented by this species and addressed by linkage design include movement through oak woodland and riparian habitats, wind-dispersed pollen, animal-dispersed seed, short to moderate dispersal distances, and long generation time. Engelmann oaks are on the California Native Plant Society plants of limited distribution watch list.

Distribution: Engelmann oaks occur from eastern Los Angeles County to northwestern Baja California (Roberts 1995). The highest known elevation for this species is 1310 m (4,300 ft)(Pavlik et al. 1991). Ninety-three percent of the remaining stands are in San Diego County, with only 6% in Riverside County and 0.5% in Orange County (Scott 1991, Stephenson and Calcarone 1999). The majority of stands in Riverside County are in the linkage planning are in a 373 km^2 (144 mi^2) area around the Santa Rosa Plateau and scattered populations in the Gavilan Hills (Scott 1990). A large stand of oaks is also known from Camp Pendleton (Reiser 1994, RCIP 2000).

Habitat Associations: Engelmann oaks occur in southern oak woodlands with 10 to 50% canopy cover and riparian/oak woodlands with closed canopy along canyon bottoms and watercourses (Scott 1990). Stands are also expanding into abandoned dry-farms and grazing lands (Scott et al. 2001). Engelmann oaks are most abundant on deep, loamy clay soils (RCIP 2000), but also occur on rocky or shallow soils with summer moisture (Pavlik et al. 1991). The degree of available shade is critical for germination: some studies report that seedlings have greater survivorship where there are gaps in densely canopied areas (Lawson et al. 2001), others report that seedlings occur no more than 3 m (10 ft) from the outside of the closest canopy (Osborne 1989, Lathrop and Osborne 1990).

Home Range and Core Area Sizes: The area needed to support a viable population of Engelmann oaks has not been studied. However, the core area must be large enough to support viable populations of common dispersers, such as scrub jays and common predators of acorn predators, such as coyote, bobcat and fox.

Dispersal: Engelmann oaks are wind pollinated (Proctor et al. 1996). Pollen movement in this species has not been studied, although the species is known to hybridize with scrub oak (*Quercus dumosus*) in the western portion of its range (Scott et al. 2001).

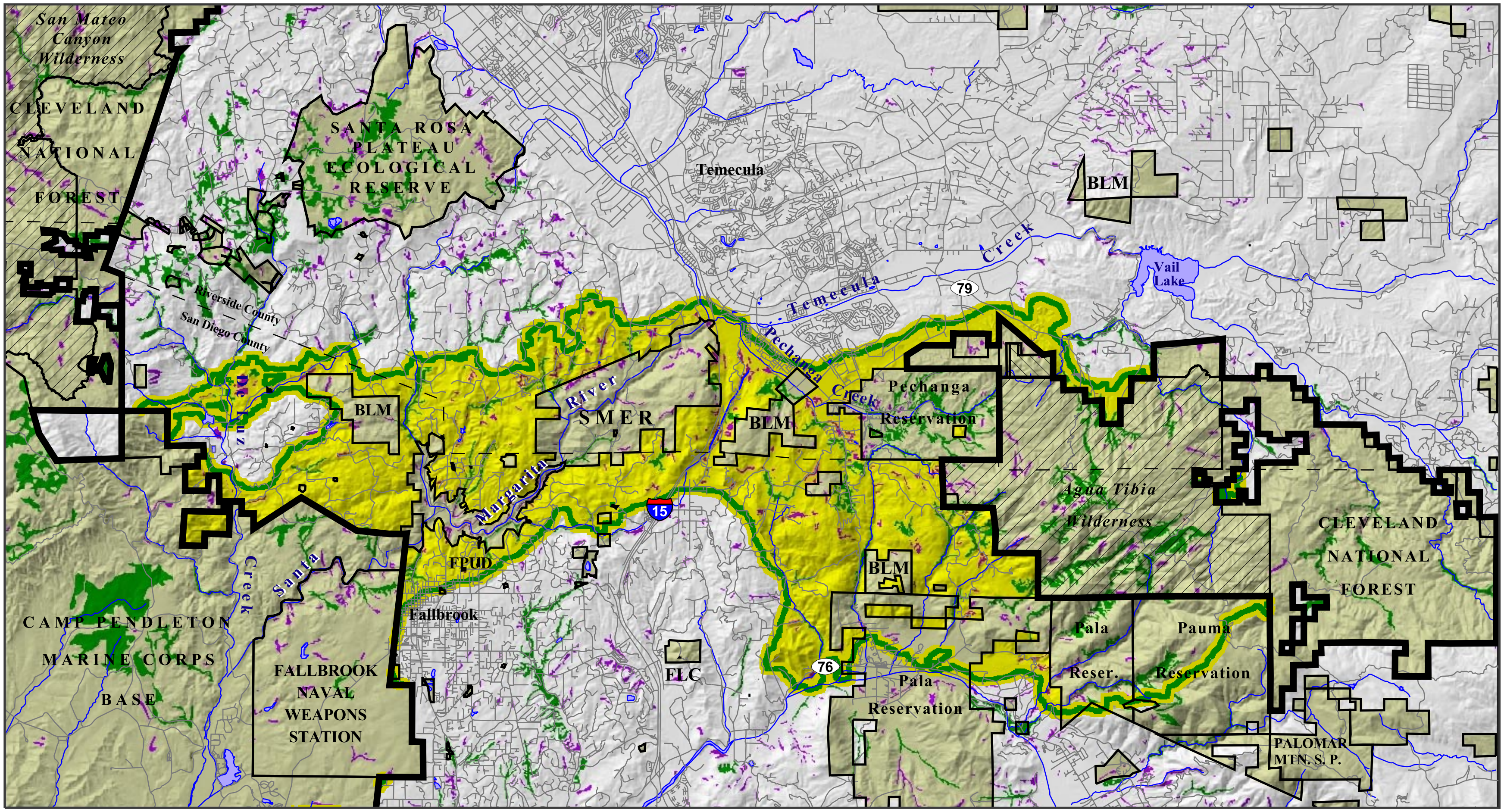
Studies of California Valley Oak (*Quercus lobata*) show that pollen movement can be restricted in oaks: average pollen dispersal distance is 60 m (200 ft) (Sork et al. 2001).

Acorns are often transported and buried by western scrub jays (*Aphelocoma californicus*)(Bent 1946). Burying acorns increases seed survivorship (Lathrop and Osborne 1990). Jays usually stay within their territories when burying acorns for future retrieval. In coastal California, scrub jay territories are roughly 3 ha (7.5 acres)(Verbeek 1973). A territory of this size corresponds to circle with diameter of roughly 200 m.

Conceptual Basis for Model Development*:* The best suitable habitat for Engelmann oak is oak woodland, including those in riparian areas. Since two mature trees can easily exist with the minimum mapping unit of 30 m, no habitat patches were excluded from the analysis. Minimum core area is a grouping of 50 mature oaks standing an average distance of 60 m apart (allowing the exchange of pollen) = 0.11 km^2. Dispersal distance used in the model is 400 m, twice the average diameter of a scrub jay territory.

Results and Discussion: The Least-Cost Union will likely serve this species. Core habitat for Engelmann oak is scattered throughout the Santa Ana and Palomar Mountain Core Areas and Least-Cost Union. Particularly large blocks of habitat occur on Camp Pendleton, the Santa Rosa Plateau and Tenaja Corridor, and in the Agua Tibia Wilderness in the Palomar Mountains (Figure C16). Most of the core areas identified are larger than the minimum core area size. Numerous habitat patches, large enough to support between 2 and 50 oaks are scattered throughout the Least Cost Union. The short presumed dispersal distance for this species limits potential acorn movement among habitat patches and much of the habitat occurs in isolated patches (Figure C17). However, adding additional habitat to the Least-Cost Union will improve connectivity between the Core Areas for this species. We conclude that, if preserved and restored, the Least-Cost Union can support connectivity for Engelmann oak between the populations on Camp Pendleton and Palomar Mountain, but that gaps among patches of suitable habitat within the Least-Cost Union be further evaluated to determine whether restoration may improve connectivity. The Temecula Creek, Rainbow Creek and De Luz additions to the Least-Cost Union that were recommended to support other focal species would also benefit Engelmann oaks by providing additional suitable habitat and areas for movement through riparian areas.

Figure C16. Cores and patches of potential suitable habitat for Engelmann oak *(Quercus engelmannii)*.
Cores (dark green) are large enough to sustain pollen exchange among 50 individuals (> 0.11 km^2). Patches (purple) are large enough to support 1 to 49 individuals (< 2.5 km^2). See text for assumptions regarding model inputs. BLM= Bureau of Land Management, FLC = Fallbrook Land Conservancy, FPUD = Fallbrook Public Utility District, SMER = Santa Margarita Ecological Reserve.



Legend

- Least-Cost Union
- cores of suitable habitat
- patches of suitable habitat
- paved roads
- county line
- Santa Ana and Palomar Core Areas
- major landholders*
- designated wilderness
- proposed wilderness
- hydrography
- lakes & reservoirs

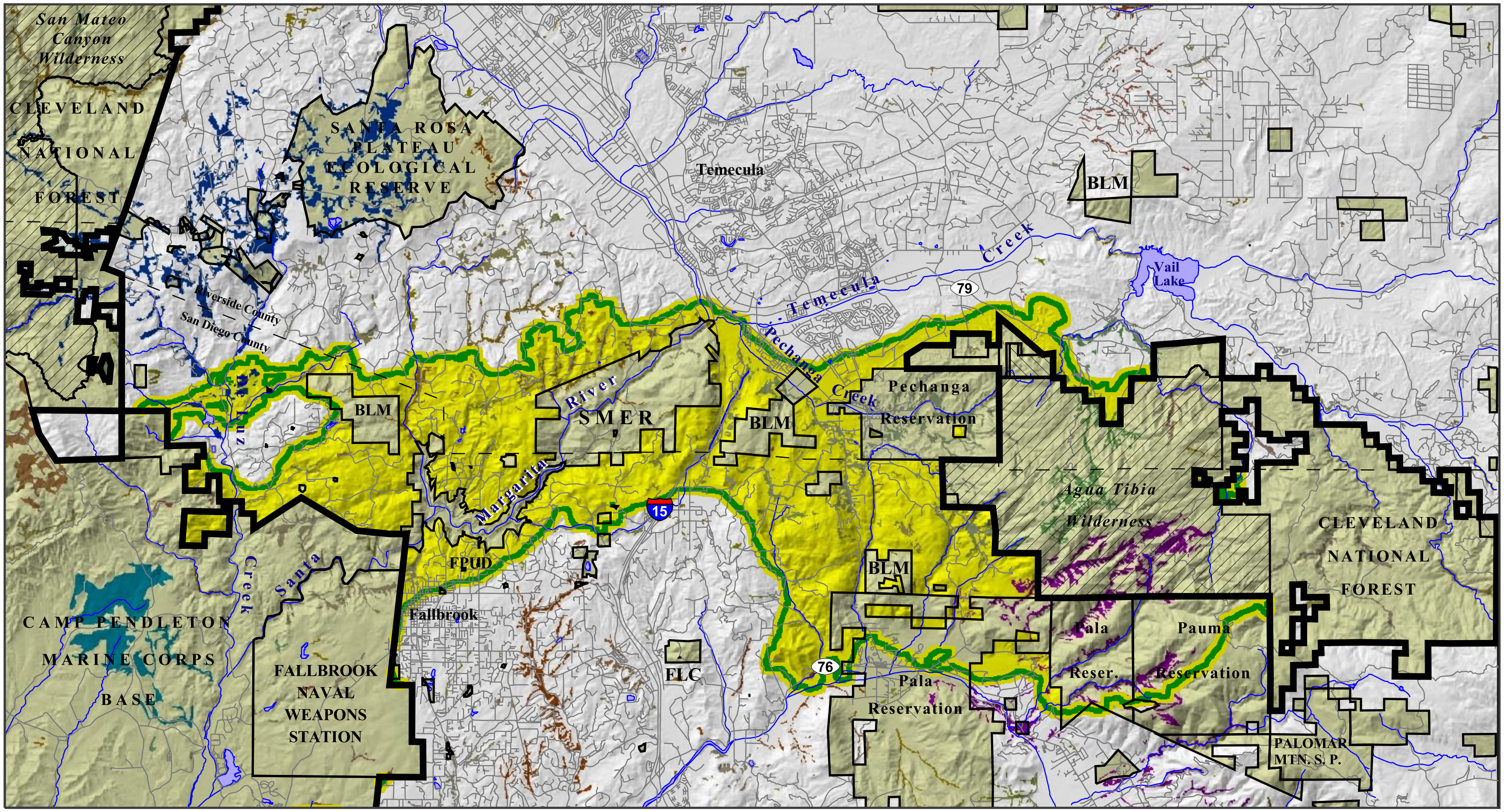
*land management varies by ownership.

SDSU San Diego State University FIELD STATION PROGRAMS

SOUTH COAST WILDLANDS

Map produced by:
SDSU Field Station Programs
March 2, 2004
http://fs.sdsu.edu

Figure C17. Distances among potential suitable habitat polygons for Engelmann oak *(Quercus engelmannii).*
Suitable habitat polygons that are farther apart than the species' dispersal distance (400 m) are shown in different colors. See text for assumptions regarding model inputs. BLM= Bureau of Land Management, FLC = Fallbrook Land Conservancy, FPUD = Fallbrook Public Utility District, SMER = Santa Margarita Ecological Reserve.



Legend

- Least-Cost Union
- Various Colors: Each color represents suitable habitat polygons within the species' dispersal distance.
- Paved Roads
- County Line
- Santa Ana and Palomar Core Areas
- major landholders*
- designated wilderness
- proposed wilderness
- hydrography
- lakes & reservoirs

*Land management varies by ownership.

N

5 0 5 Kilometers

5 0 5 Miles

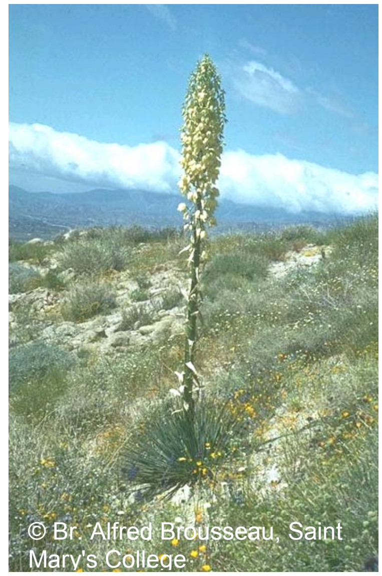
San Diego State University
FIELD STATION PROGRAMS

SOUTH COAST WILDLANDS

Map produced by:
SDSU Field Station Programs
May 28, 2004
http://fs.sdsu.edu

SDSU San Diego State University FIELD STATIONS

SOUTH COAST WILDLANDS



Justification for Selection: Our lord's candle predominantly occurs in coastal scrub, a habitat that has shown widespread intensive decline and fragmentation throughout the Ecoregion. Movement needs represented by this species and addressed by linkage design include movement through coastal scrub and chaparral habitats, insect-dispersed pollen, gravity-dispersed seed, short dispersal distance, and moderate generation time. Movement of pollen is dependent on one species of moth pollinator. Population movement likely requires broad expanses of habitat.

Distribution: Our Lord's candle occurs from coastal southern California across portions of the Mojave Desert southward into Mexico and northeast to New Mexico (Udovic 1981). *H. w. whipplei* occurs from Riverside and Orange counties southward into Mexico and grows between 30 and 1,500 m (100-4,920 ft) elevation (Munz 1974). The species is common in the planning area.

Habitat Associations: Our Lord's candle occurs in coastal sage and chaparral communities (Haines 1941, Munz 1974). This subspecies mostly grows on dry, stony slopes (Aker 1982, Munz 1974).

Home Range and Core Area Sizes: A high-density population studied in coastal scrub habitat at the Santa Margarita Ecological Reserve occurs at densities of 1 plant per 10 m^2 (D. Udovic pers. comm.). Flowering is dependent on rainfall, with approximately 5 to 12% of the population flowering per year (D. Udovic pers. comm.). At the more commonly observed 5% flowering frequency, blooming individuals occur at roughly 1 individual per 200 m^2 (D. Udovic pers. comm.).

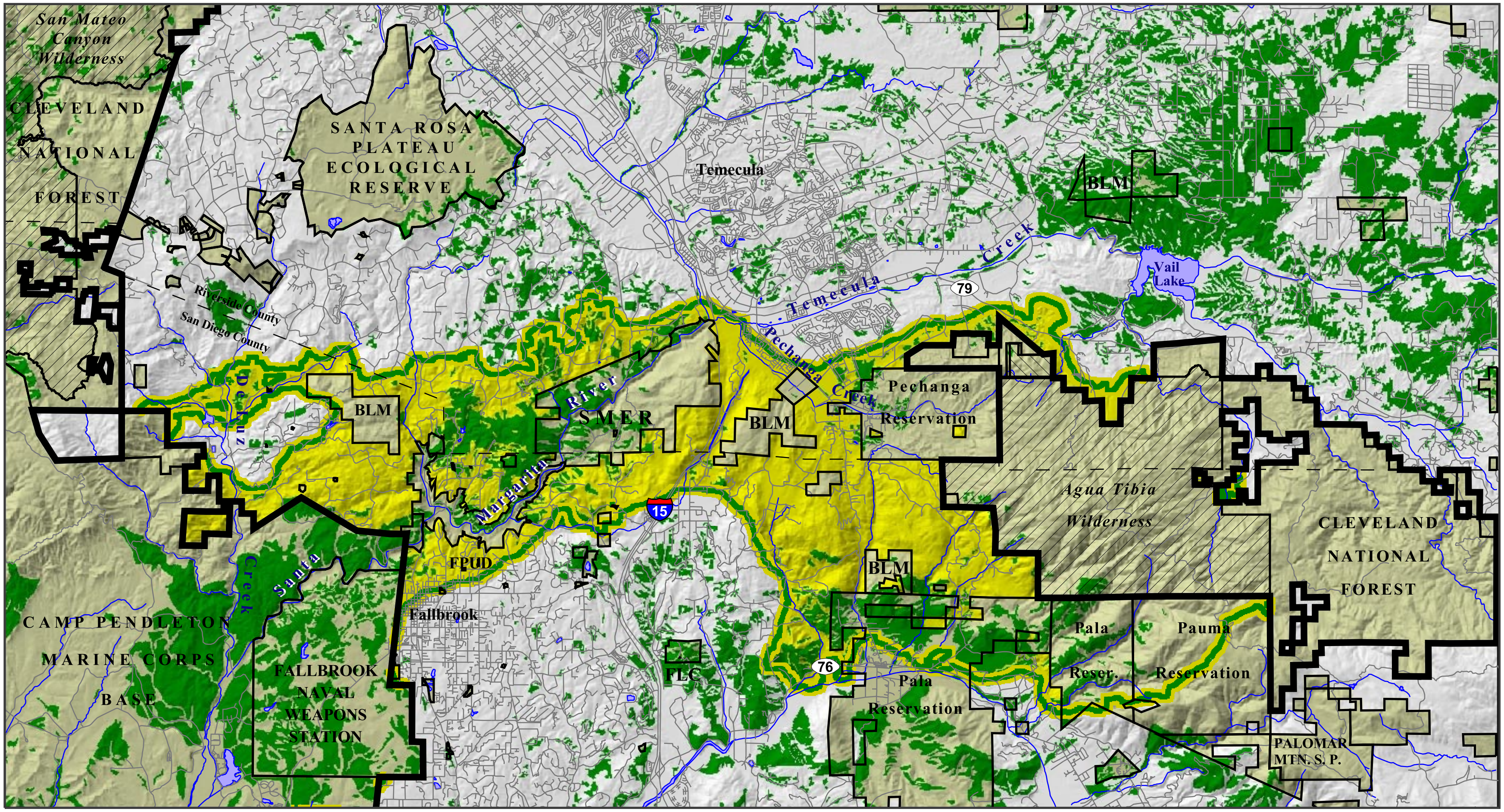
Dispersal: The sole pollinator of this species is female Yucca moths (*Tegeticula maculata*)(Aker and Udovic 1981). Moths collect pollen from a single flower on the influorescence and immediately fly in a random direction (Aker and Udovic 1981) until they encounter another flowering plant (Aker 1982). Dispersal distance in this species has not been documented. A closely related species, *T. yuccasella*, is capable of moving pollen from *Yucca filimentosa* up to 51 m, with most pollen transfers occurring within 5 m (15 ft) (Marr et al. 2000). Seeds are heavy and largely wind dispersed (Udovic pers. comm.). Seed dispersers are unknown.

Conceptual Basis for Model Development: The best suitable habitat for this species in the planning area is coastal scrub. Minimum patch size is the minimum area required to support 2 plants (fruits produced by selfing are often aborted). Two individuals can occur in patch sizes less than the 30-m minimum mapping unit used in the GIS model and no habitat patches were identified as too small to support this species. Minimum core area size is 0.01km^2 (2.5 ac) the area needed to support 50 flowering individuals when 5% of the population is blooming. Dispersal distance used in the model is twice the reported distance that pollen was moved by a conspecific (= 102 meters).

Results and Discussion: The Least-Cost Union will likely serve this species. Core habitats for this species extend from Camp Pendleton through the western portion of the Least-Cost Union to Interstate 15. Palomar Mountains Core Area is notably lacking in suitable habitat; the coastal scrub habitats preferred by this species are found at lower elevations on Bureau of Indian Affair lands in the eastern portion of the linkage, and private lands surrounding Vail Lake (Figure C18). The Patch Configuration analysis (Figure C19) shows that many of the best habitat patches and core areas in the Least-Cost Union are isolated from each other. Agricultural developments are found in many of the gaps between these isolated patches and probably are barriers to pollen dispersal. Figure C19, however, also overestimates isolation; our lord's candle can occur in low densities in chaparral habitats, which were not mapped as suitable habitat in this analysis. When the analysis is rerun including chaparral communities, no isolation of habitat patches is observed.

We conclude that the Least-Cost Union serves to connect populations of our lord's candle in Camp Pendleton to those in the eastern portion of the linkage. We recommend that collaborative management options be pursued with the Pala Reservation to insure the protection of coastal sage scrub habitats in this area. This analysis has highlighted the potential importance of low density our lord's candle populations that occur in chaparral communities to preserve genetic connections among populations. The Rainbow Creek and De Luz additions to the Least-Cost Union that were recommended to support other focal species would also benefit our lord's candle by providing additional suitable habitat and pollen movement areas in upland habitats.

Figure C18. Cores and patches of potential suitable habitat for our Lord's candle *(Hesperoyucca whipplei).*
Cores (dark green) are large enough to support 50 flowering individuals (> 0.01 km ^{2}). Patches (purple) are large enough to support 1 to 49 individuals (< 0.01 km ^{2}). See text for assumptions regarding model inputs. BLM= Bureau of Land Management, FLC = Fallbrook Land Conservancy, FPUD = Fallbrook Public Utility District, SMER = Santa Margarita Ecological Reserve.



Legend

- Least-Cost Union
- cores of suitable habitat
- patches of suitable habitat
- paved roads
- county line
- Santa Ana and Palomar Core Areas
- major landholders*
- designated wilderness
- proposed wilderness
- hydrography
- lakes & reservoirs

*land management varies by ownership.

SDSU San Diego State University FIELD STATION PROGRAMS

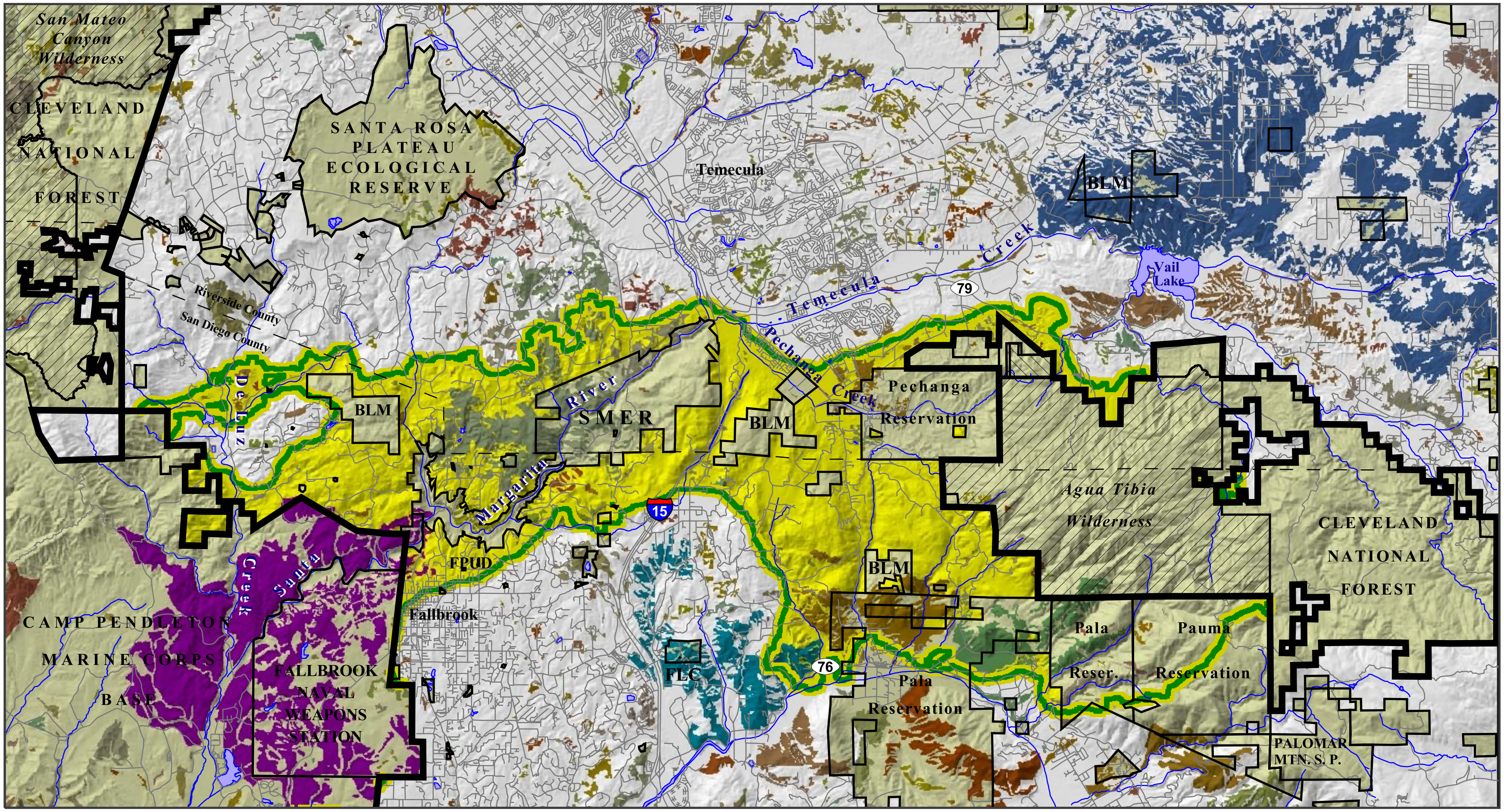
SOUTH COAST WILDLANDS

Map produced by:
SDSU Field Station Programs
March 2, 2004
http://fs.sdsu.edu

SDSU San Diego State University FIELD STATIONS

SOUTH COAST WILDLANDS

Figure C19. Distances among cores and patches of potential suitable habitat for our Lord's candle *(Hesperoyucca whipplei)*. Suitable habitat polygons that are farther apart than the species' dispersal distance (0.102 km) are shown in different colors. A separate configuration analysis that included chaparral as suitable habitat found that all cores and patches are less than the species' maximum dispersal distance apart. See text for assumptions regarding model inputs. BLM= Bureau of Land Management, FLC = Fallbrook Land Conservancy, FPUD = Fallbrook Public Utility District, SMER = Santa Margarita Ecological Reserve.



Legend

Least-Cost Union	Santa Ana and Palomar Core Areas
Various Colors: Each color represents suitable habitat polygons within the species' dispersal distance.	major landholders*
Paved Roads	designated wilderness
County Line	proposed wilderness
	hydrography
	lakes & reservoirs

*Land management varies by ownership.

SDSU San Diego State University FIELD STATION PROGRAMS

SOUTH COAST WILDLANDS

Map produced by:
SDSU Field Station Programs
March 3, 2004
http://fs.sdsu.edu

SDSU San Diego State University FIELD STATIONS

SOUTH COAST WILDLANDS

Justification for Selection: The range of this species is coincident with the linkage planning area (Keeley and Massihi 1994) and linkage loss will fragment the species into isolated populations or cause extinction. Movement needs represented by this species and addressed by linkage design include movement through chaparral habitats, animal-dispersed seeds, relatively long dispersal distance, and moderate generation time. Rainbow manzanita is listed as rare or endangered (List 1B) by the California Native Plant Society.

Distribution: Rainbow manzanita is restricted to northwestern San Diego County north of the San Luis Rey River, and southern Riverside County south of Pauba Valley (Keeley and Massihi 1994). The entire species' distribution is about 75 km^2 (29 mi^2)(Keeley and Massihi 1994) within the planning area east of the Agua Tibia range and west of the Santa Margarita Mountains between 300 and 600 m (980 to 1950 ft)(Keeley and Massihi 1994). It is known from the Santa Rosa Plateau and Santa Margarita Ecological Reserve (RCIP 2000).

Habitat Associations: Rainbow manzanita occurs in chaparral, principally on gabbro soils or those rich in ferro-magnesium minerals (Boyd and Banks 1995). It is the sole *Arctostaphylos* species throughout the majority of its range, but does co-occur and hybridize with *A. glandulosa* on the western and eastern boundaries of its range (Keeley and Massihi 1994).

Home Range and Core Area Sizes: Density estimates for this species are not published and the minimum core area size for the long-term survival of Rainbow manzanita has not been estimated. While many individuals can occur at great density in a small area (C. Luke personal observation), larger areas are needed if the processes that sustain movements of pollen and seeds are to be protected. Coyotes, a common disperser of manzanita seed, are reliably found on habitat fragments > 1 km^2 (0.4 mi^2) in size, but become increasingly scarce as fragment size decreases (Crooks 1999).

Dispersal: Dispersal mechanisms and distances for this species are unknown. However, humans, bears, and coyotes are all known to feed on the fruit of *Arctostaphylos* species (Dale 2000) and it is likely that coyotes are dispersers for *A. rainbowensis* as well. The ability of coyotes to move *Arctostaphylos* seeds depends upon rates of passage through the digestive tract while the animals are traveling. How far animals move between meal and defecation sites, and the proportion of seeds germinating after ingestion have not been measured. Average daily travel for coyotes has been estimated at roughly 4 km (2.4 mi)(Ozoga and Harger 1966). In southern

California, coyotes commonly move up to 1 km (0.6 mi) through the urban matrix to visit habitat patches (Crooks 1999).

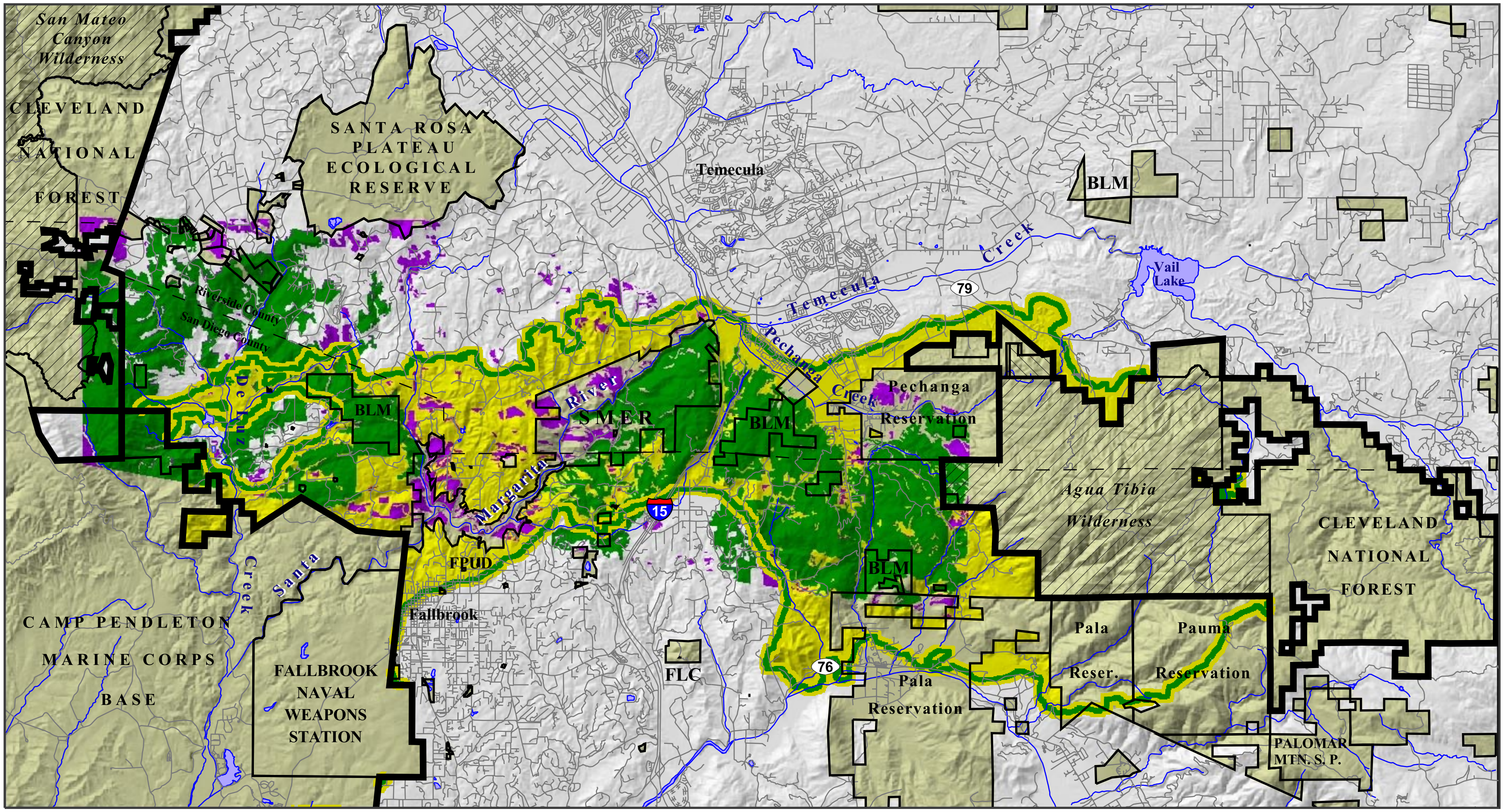
Dispersal distances are much greater. Young coyotes disperse in the fall and winter, moving up to 80-160 km (50–99 mi) (Gier 1975). Observation of 125 coyotes in Iowa provided maximum natal dispersal estimates of 176.0 km (109.4 mi) for males and 232.2 km (144.3 mi) for females (Andrews and Boggess 1978). Median natal distances have been estimated at 16.6 km (10.3 mi) for males and 42.2 km (26.2 mi) for females (Bowen 1982) in Canada. Coyotes can move through developed areas to gain access to patches of natural habitat (Crooks 1999, Quinn 1995, 1997, Bounds and Shaw 1997).

Conceptual Basis for Model Development: Chaparral vegetation communities are the best suitable habitat for rainbow manzanita within its range. Minimum patch size for this species is an area large enough to support two individuals. This size is less than the 30 m minimum mapping unit used in this GIS analysis and therefore no habitat patch was considered excluded from the model as too small to support this species. Minimum core area size is the area needed for a patch to be assured of visits by coyotes (=1 km^2). Dispersal distance used in the model is twice the commonly reported daily movement rates for coyote (= 2 km).

Results and Discussion: The Least-Cost Union will likely serve this species. Roughly 2/3 of the species' range is encompassed by the Least-Cost Union boundaries; 1/3 of the range in the De Luz valley is unprotected (Figure C19). Only small portions of the range extend into the Santa Ana and Palomar Mountain Core Areas. Suitable habitat is highly fragmented in the central part of the distribution in and adjacent to FPUD lands. Considerable habitat along the Santa Margarita on FPUD lands has been converted to agricultural use and only a few small fragments remain in this area.

Of the habitat that occurs within the Least-Cost Union, most is large enough to assure visitation by coyotes, a probable disperser of manzanita seed. All patches are within the presumed dispersal distance for this species, although numerous barriers to movement may exist between suitable habitat patches. The ability of coyotes to move long-distances among patches, both through natural habitats and rural developments, suggests that plants occurring in these patches likely still are able to distribute seed. Coyote visitations to these patches may, however, be reduced. Interstate 15 is likely the most significant barrier to coyote movement and may reduce gene flow between populations on either side of the highway. We recommend that coyote movements be restored across I-15. The Rainbow Creek and De Luz additions to the Least-Cost Union that were recommended to support other focal species would also benefit Rainbow manzanita by providing additional suitable habitat and areas for dispersers to carry seeds.

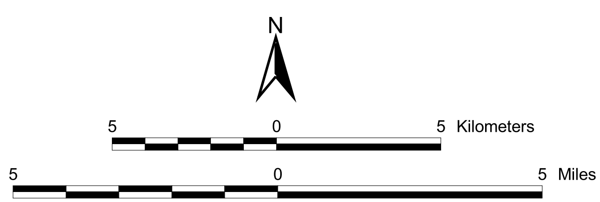
Figure C20. Cores and patches of potential suitable habitat for Rainbow manzanita *(Arctostaphylos rainbowensis)*. Cores (dark green) are large enough to sustain visitation by seed dispersers (> 1 km ^{2}). Patches (purple) are smaller than cores (< 1 km ^{2}). All cores and patches are less than the seed disperser's maximum seed dispersal distance (2 km) apart. See text for assumptions regarding model inputs. BLM= Bureau of Land Management, FLC = Fallbrook Land Conservancy, FPUD = Fallbrook Public Utility District, SMER = Santa Margarita Ecological Reserve.



SDSU San Diego State University FIELD STATION PROGRAMS

SOUTH COAST WILDLANDS

Map produced by:
SDSU Field Station Programs
March 5, 2004
http://fs.sdsu.edu



Legend

- Least-Cost Union
- cores of suitable habitat
- patches of suitable habitat
- paved roads
- county line
- Santa Ana and Palomar Core Areas
- major landholders*
- designated wilderness
- proposed wilderness
- hydrography
- lakes & reservoirs

*land management varies by ownership.