

Proposed Reserve Design for
Tejon Ranch
A Threatened California Legacy



Prepared by
Conservation Biology Institute
and
South Coast Wildlands



May 2006



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Tejon Ranch

A Threatened California Legacy

Prepared by



Michael D. White
Jerre Ann Stallcup



Clint R. Cabañero
Kristeen L. Penrod

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The Conservation Biology Institute provides scientific expertise to support conservation and recovery of biological diversity in its natural state through applied research, education, planning, and community service.

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

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1 INTRODUCTION

The 270,750-acre Tejon Ranch is the largest contiguous tract of privately owned land in California and arguably the most valuable conservation property in the state. Tejon Ranch forms an essential landscape feature—serving to connect the Coast Ranges, Sierra Nevada, San Joaquin Valley, and Mojave Desert. It is currently the subject of development proposals that could irretrievably change the landscape that it defines. The purpose of this study is to design a wildland reserve for the Ranch that captures the broad array of landscape functions and conservation values that it supports. This planning effort is intended to be biologically conservative; that is, it is intended to ensure that, in the face of future development outside of the reserve, species and habitats are unquestionably protected, landscape-scale processes can proceed within their natural ranges of variability, and responses to extreme events and long-term climate changes can be accommodated. We did not explicitly consider the effects of the reserve configuration on the viability of species populations or its contribution to the recovery of listed species in the region. Furthermore, while we excluded some areas from the reserve based on their lesser contributions to landscape values, we did not explicitly consider whether these areas are appropriate for development from a regional development planning perspective, potential development constraints or the development suitability of portions of these areas, environmental compliance or endangered species permitting implications of development in these areas, other constraints such as military flight corridors, or economic considerations relating to development or implementation of conservation and management actions on the reserve.

The work herein draws extensively on our previous studies relating to Tejon Ranch (Stallcup et al. 2003, White et al. 2003) and the Tehachapi Mountains region (Penrod et al. 2003, 2005). These studies have been conducted entirely with publicly available information, and the reader is referred to these reports for descriptions of relevant methods, results, and literature reviews. We also convened a technical peer review group to review the draft findings of this study (Attachment A). We revised the approach and document to reflect the input received at the peer review workshop, but these individuals have not necessarily endorsed our results or conclusions.

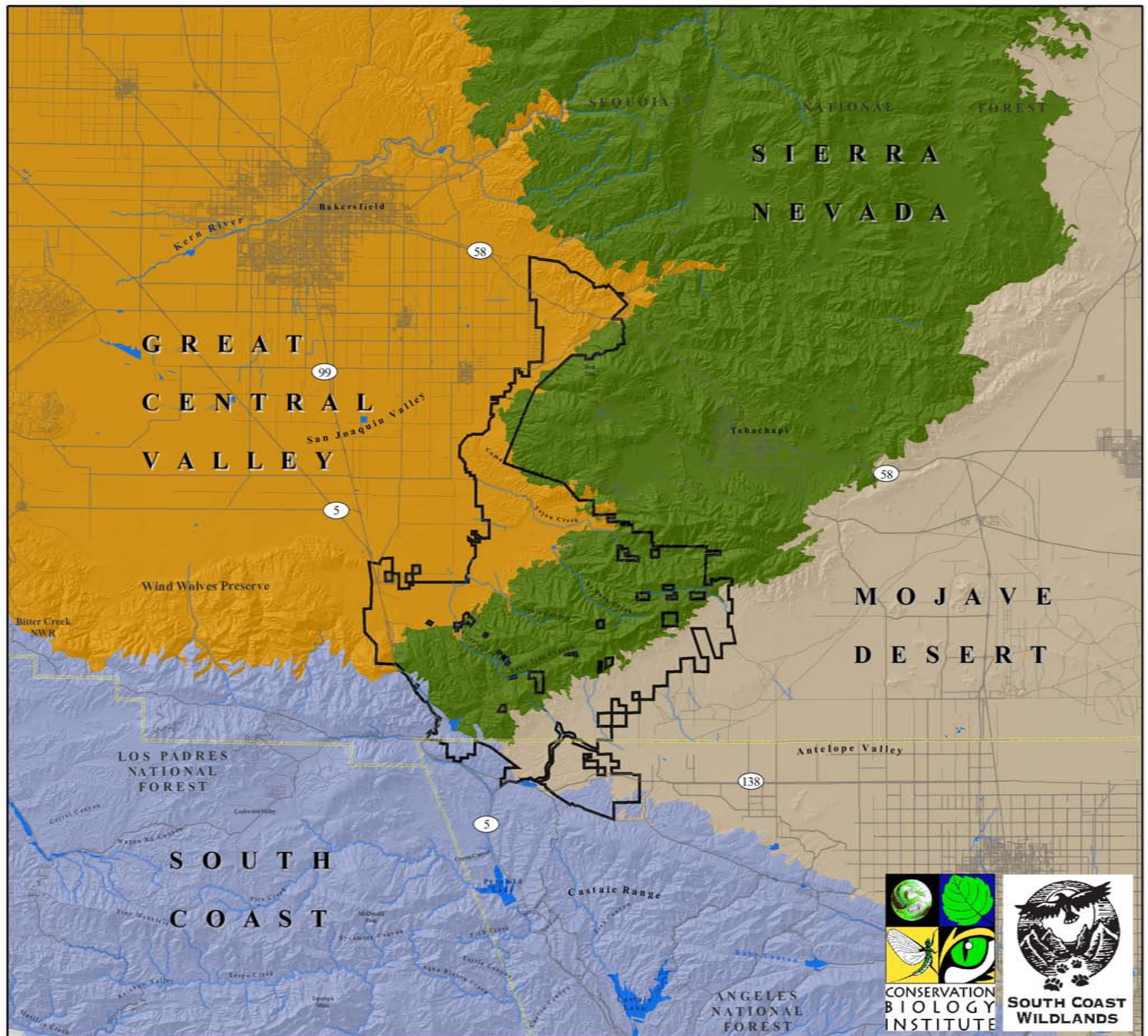
Conservation Values

Tejon Ranch supports a multitude of irreplaceable biological resources, and the melding of these resources in one large, intact landscape makes the Ranch an incomparable regional conservation target. The regional conservation significance of Tejon Ranch is magnified by the increasing threats of adjacent growing metropolitan and agricultural areas—the Los Angeles basin, Bakersfield and the San Joaquin Valley, Tehachapi and Cummings valleys in the Tehachapi Mountains, and Antelope Valley of the Mojave Desert.

Tejon Ranch lies at the confluence of five geomorphic provinces and four floristic ecoregions—Great Central Valley, Sierra Nevada, Mojave Desert, and South Coast—a circumstance unmatched anywhere else in the State of California (Figure 1). Tejon Ranch supports as many as 20 state and federally listed species and over 60 other rare species, including many endemic

Figure 1.
Convergence of
Ecoregions

-  Tejon Ranch
-  Great Central Valley
-  Mojave Desert
-  Sierra Nevada
-  South Coast
-  County Boundaries
-  Roads
-  Rivers & Creeks
-  Lakes & Reservoirs



species or subspecies found nowhere else on earth. It supports several habitat types that are rare and under-protected in the region, including grasslands and significant stands of valley and blue oak woodlands. The Ranch's grasslands, in particular, represent the last opportunity to conserve a connection between grasslands remaining on the western and eastern flanks of the San Joaquin Valley, which are otherwise becoming isolated into non-interacting and therefore diminished ecological communities. The large expanse of native grassland and wildflower fields on the Mojave Valley side of the Ranch is unparalleled in Southern California.

Tejon Ranch is part of a landscape-scale connection between the Coast Ranges and Sierra Nevada and between the San Joaquin Valley and the Mojave Desert—truly a *continental-scale* linkage that is integral to the contiguity and interconnectedness of California's biogeographic regions. It is thus crucial to maintaining the viability of existing conservation investments in the region, such as the Sequoia and Los Padres National Forests, land administered by the Bureau of Land Management (BLM), and The Wildlands Conservancy's Wind Wolves Preserve, which depend on unrestricted movement of the species they support (Figure 2). This is particularly true in the face of global climate change that will surely force alteration of species ranges, which can only occur within unfragmented landscapes.

The extraordinary biological diversity and endemism of Tejon Ranch is a legacy of the dynamic geologic, climatic, and evolutionary history of the region. Tejon Ranch is considered an *evolutionary hotspot*, where the processes and products of evolution can be observed and studied, and a place that exemplifies the evolution of California's exceptional taxonomic diversity. Tejon Ranch played an important historic role in the understanding of the biogeography of California and the western U.S. by serving as the natural laboratory for the work of John Xántus in the mid 19th century, whose voluminous collections still reside at the Smithsonian and other research institutions. Many of the species in these collections represent newly described species first observed at Tejon Ranch.

Tejon Ranch's long history of use as a working ranch and haven for sportsmen has helped to maintain its biological values in the face of California's rapid development and agricultural conversion. The Ranch is, so far, largely roadless and unfragmented by urbanization. It therefore supports something very rare in Southern California—intact, healthy watersheds and streams. Tejon Ranch serves as a core biological resource area—large enough and pristine enough to support such wide-ranging species as mountain lions and California condors and sufficiently vast to accommodate large-scale ecological processes such as natural fire regimes.

State and local agencies and environmental organizations have long recognized the historical significance, unique biological characteristics, and important resource values of Tejon Ranch:

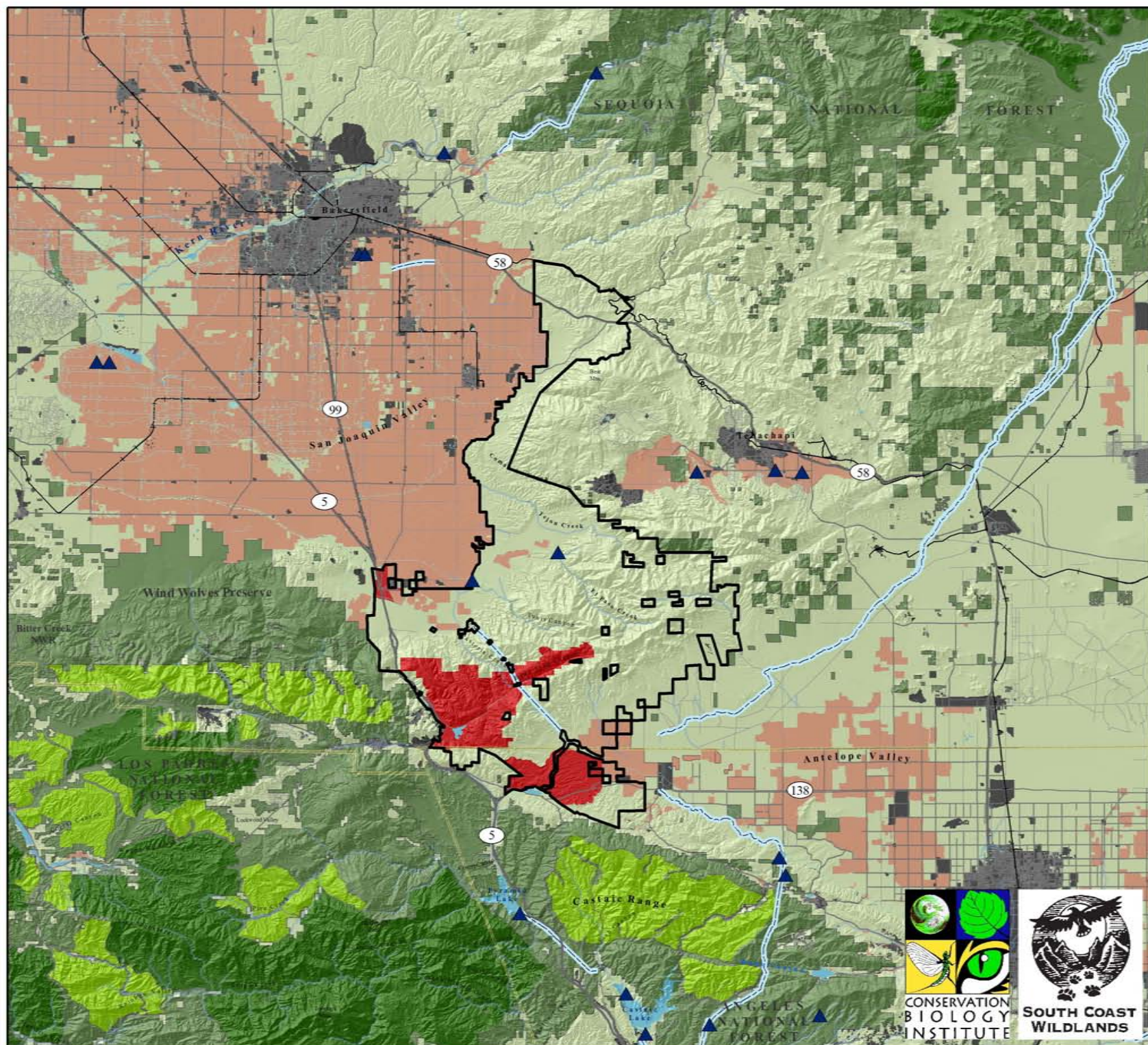
- Tejon Ranch meets nearly all of the *Priority Criteria for Conservation* established by the California Resources Agency.
- The California Wilderness Coalition named Tejon Ranch as one of *California's Ten Most Threatened Wild Places*.
- Audubon California has identified the Tehachapi Mountains around Tejon Ranch as an *Important Bird Area*.

Figure 2.
Existing and Proposed
Development
and
Infrastructure

-  Tejon Ranch
-  Tejon Proposed Developments
-  Protected Lands
-  Urban/Developed
-  Natural Vegetation
-  Agriculture
-  Designated Wilderness
-  Proposed Wilderness
-  County Boundaries
-  Major Highways
-  Roads
-  Railroads
-  Rivers & Creeks
-  Lakes & Reservoirs
-  Canal/Ditch
-  Pipeline
-  Dams



Scale 1:600,000



- Los Angeles County has designated *Significant Ecological Areas* (SEA) on Tejon Ranch and is considering expanding the area of the Ranch under this designation.
- The U.S. Fish and Wildlife Service designated a very large part of Tejon Ranch as *Critical Habitat* for the endangered California condor and as important for recovery of many other endangered San Joaquin Valley species.

Given the size, integrity, and geographic context of Tejon Ranch, and the regional significance of its resources, the consensus of the technical peer review group that reviewed the draft reserve design was that virtually all of Tejon Ranch merits protection. We strongly urge a regional conservation solution for Tejon Ranch that is worthy of its irreplaceable resource values, cultural significance, and heritage of the citizens of California. It is in this spirit that we propose our reserve design for the Ranch.

Threats

Significant urbanization is currently proposed on and around Tejon Ranch, threatening to fragment and degrade this remarkable wildland. Figure 2 shows the existing land uses and infrastructure in the region around Tejon Ranch and the footprints of development projects currently proposed for the Ranch—Tejon Industrial Complex, Tejon Mountain Village Project, and Centennial Project. These Tejon Ranch developments are proposed for areas that support regionally under-protected resources (grasslands and oak woodlands) and that provide habitat for numerous rare, endangered, and endemic species.

The Tejon Industrial Complex is proposed for the San Joaquin Valley floor grasslands—habitat for a host of species that are federally listed as threatened or endangered. Tejon Mountain Village is a sprawling development plan that would cut into the heart of the Ranch’s rugged highlands, including designated Critical Habitat for an icon of California—the California condor. The Centennial Project proposes 23,000 dwelling units within an area supporting an extensive, high quality native grassland community, a resource without equal in Southern California. The locations of these developments also have the potential to significantly compromise habitat connectivity between adjacent protected areas outside the Ranch.

These proposed industrial and residential development projects will introduce significant additional urbanization to one of the last remaining wildlands in a region that has experienced considerable land use changes, particularly along Interstate-5 and within developable valleys (e.g., Tehachapi, Cummings, San Joaquin, and Antelope valleys). Development projects proposed outside the Ranch in the Frazier Park/Lebec area (e.g., Gorman Ranch, Frazier Park Estates) would further urbanize land at the margins of the Ranch, incrementally eliminate high priority natural resources (e.g., native grasslands and wildflower fields), and reduce habitat connectivity between public open space and Tejon Ranch in key areas. Attachment B provides a brief literature review on the adverse biological effects of habitat fragmentation and low density residential development on natural resources functions and values.

2 RESERVE DESIGN PROCESS

This section outlines the conservation targets and processes used to design a reserve that attempts to capture the myriad conservation values and ecosystem functions of Tejon Ranch. We defined *regional conservation objectives* for the Ranch and surrounding undeveloped areas to provide a framework for guiding the reserve design process. We also defined four *landscape units* on Tejon Ranch (Stallcup et al. 2003) to reflect the differential distribution of resource types, ecosystem integrity, and ecosystem functions across the region (Figure 3). We designed the Tejon Ranch reserve by focusing on the protection of targeted resources and conservation values within individual landscape units, and then integrated the reserve designs within each unit to meet our established regional conservation objectives. We did not use the boundaries of various regulatory designations or overlays, such as federally designated Critical Habitat for the endangered California condor or the County of Los Angeles' SEAs. These should be considered, as appropriate, in refining the boundaries of potential development areas.

Regional Conservation Objectives

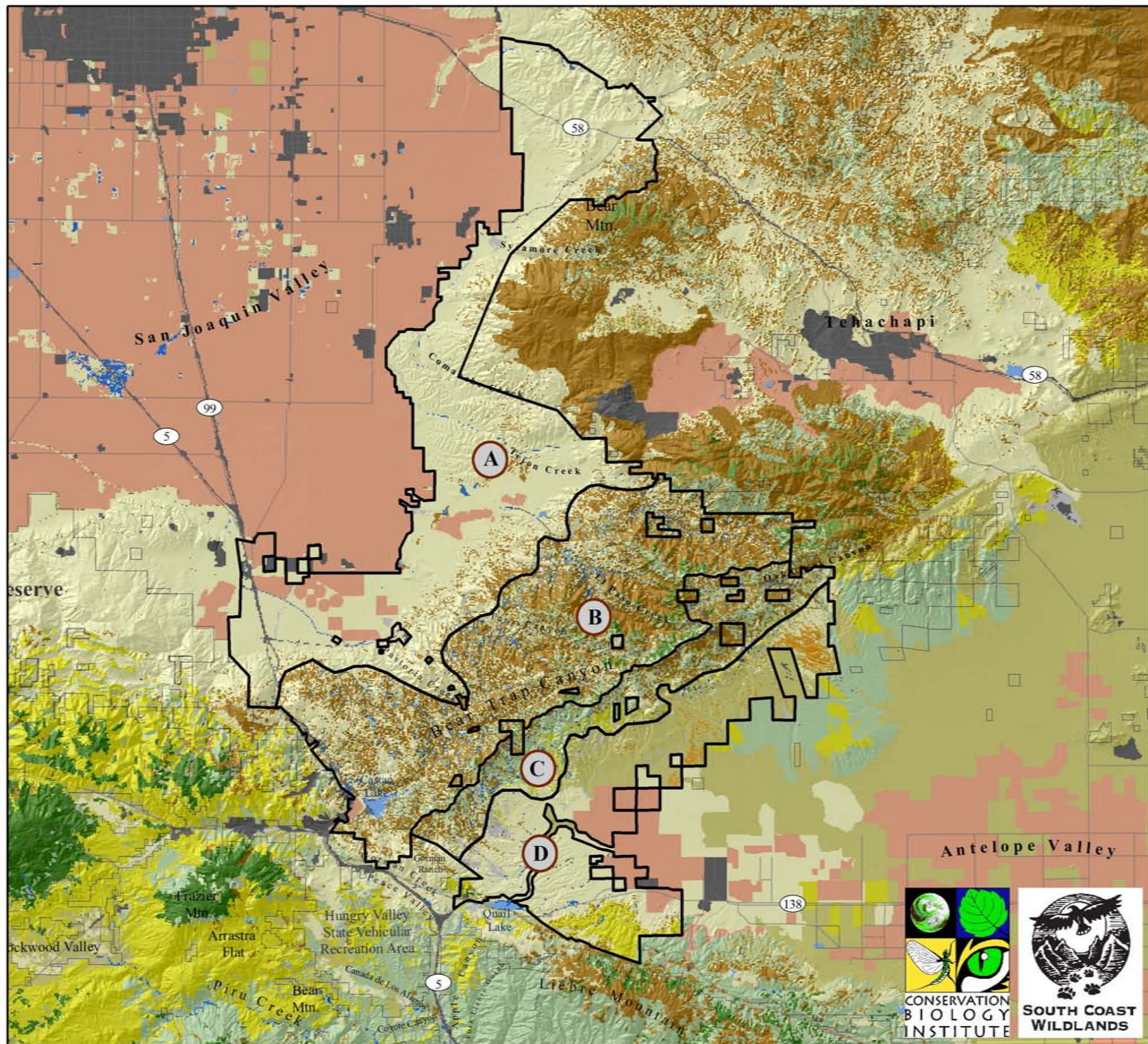
Using the findings of our previous studies of the region (Penrod et al. 2003, 2005; Stallcup et al. 2003, White et al. 2003), we established the following regional conservation objectives, based on generally accepted principles of conservation biology (e.g., Groves 2003, Groves et al. 2000, 2002, Meffe and Carroll 1997, Mittermeier et al. 1998, Noss 1983, 2002, Noss et al. 1997, Soulé and Terborgh 1999):

1. Conserve a large and intact area of natural open space on Tejon Ranch that will continue to provide the significant core landscape-scale functions, ecological processes, and myriad conservation values currently supported by the Ranch. In addition to these core habitat functions provided by the Ranch, the configuration of natural open space on Tejon Ranch must be sufficient to:
 - a. Maintain the regionally significant landscape linkage between the Sierra Nevada and the Coast Ranges formed by the Ranch.
 - b. Maintain the regionally significant landscape linkage between the grasslands on the western and eastern sides of the San Joaquin Valley.
 - c. Maintain the regionally significant landscape linkage between the San Joaquin and Antelope valleys.
2. Avoid habitat fragmentation of the reserve by development, golf courses, and roads to ensure that natural ecological processes can occur unimpeded and to maintain wildland values.
3. Contribute to protection of an adequate representation of the biological diversity in the region, across diverse physical and environmental conditions and ecological gradients, especially focusing on those vegetation communities that are under-represented in regional open space reserves, i.e., grasslands and oak savannas.
4. Protect intact watershed basins to maintain natural hydrological, water quality, and biological functions and processes of stream systems and wetlands.

Figure 3. Landscape Units on Tejon Ranch

Vegetation Communities

-  Grassland
-  Oak woodlands & savanna
-  Conifer
-  Riparian woodlands & forests
-  Chaparral & Coastal scrub
-  Pinyon - Juniper
-  Desert scrub
-  Joshua tree woodland
-  Developed
-  Agriculture
-  Barren
-  Lakes & Reservoirs
-  Landscape Units on Tejon
-  Protected Lands
-  Roads



5. Contribute to the recovery of rare, threatened, and endangered species by protecting both existing and potentially suitable habitats that may support these species throughout their life cycles.
6. Maintain regional habitat connections between open space inside and outside the reserve that is adequate to allow inter-generational dispersal of animals and plants.
7. Enhance existing conservation investments by siting the reserve contiguous with or near existing and targeted protected and public open space and away from existing development and infrastructure.
8. Using principles of *Smart Growth*, identify areas outside the reserve that may be lower priority for conservation and thus potentially more appropriate for non-reserve land uses, such as development, as a result of proximity to existing development and infrastructure.

Landscape Units on Tejon Ranch

Four landscape units—ecological units with a distinguishable structure (Noss 1983)—were defined by the distribution of major vegetation associations and topography of Tejon Ranch (Stallcup et al. 2003). The characteristics and conservation values of these landscape units are described below, along with the unit-specific reserve design objectives used to assemble the reserve. A reserve design for Tejon Ranch must, at a minimum, capture these values while ensuring the maintenance and management of ecological processes within and between landscape units. Similarly, conservation planning must ensure integration and connection of these landscape units with others in the region, along with a regional plan for long-term biological monitoring and management.

Unit A. Lowland grasslands and oak savannas of the San Joaquin Valley

Unit A is the largest of the four landscape units (approximately 107,727 acres), covering about 40% of the Ranch (Figure 3). Unit A supports habitat for the greatest number of listed plants and animals and endemic plants on the Ranch. Although Unit A supports a slightly lower diversity of vegetation communities than the other landscape units, these are largely the high conservation value, under-protected vegetation communities in the region—grasslands and oak savanna habitats (White et al. 2003). Although the grasslands in this unit of the Ranch appear to be dominated by nonnative annual grasses, they still provide functional habitat for rare and endemic species in the region, whose habitat has been substantially reduced in its extent as a result of agricultural and urban development. One-third of Unit A supports high to very high watershed integrity values. Almost half of Unit A supports roadless areas greater than 1,000 acres, but less than 10% of Unit A supports roadless areas greater than 10,000 acres.

Effective conservation of the grasslands in this unit—including conservation of grassland-associated species—was a very high priority of the technical peer review group. Less than 5% of the San Joaquin Valley floor currently remains uncultivated or developed (USFWS 1998), and an even smaller amount is protected. The only major reserve areas that support some of these communities in the region lie to the west of the Ranch—Wind Wolves Preserve, Bittercreek National Wildlife Refuge, and Carrizo Plains National Monument (Figure 2).

The objectives of the reserve design for Unit A are:

- a. Conserve a sufficient area of grassland and oak savanna habitat to support a satellite population of the *San Joaquin kit fox* and habitat for associated species (Figure 4).
- b. Conserve land for *specialty reserves* identified in the valley floor recovery plan (USFWS 1998).
- c. Maintain the *regional linkage* through this portion of the Ranch to offsite areas, including important grasslands on the west and east sides of the San Joaquin Valley and through the foothills into the Sierra Nevada (i.e., the Tehachapi connection, Penrod et al. 2003).

Using these objectives as guidelines, and based on the criteria described below, we developed a reserve design for Unit A that includes 98,483 acres, of which 85,036 acres are grasslands and 1,824 acres are oak savanna (Figure 5). Areas excluded from the reserve currently support agriculture and other land uses that have eliminated or reduced the quality of valley floor habitats. These areas (approximately 9,244 acres) are shown in red in Figure 5d.

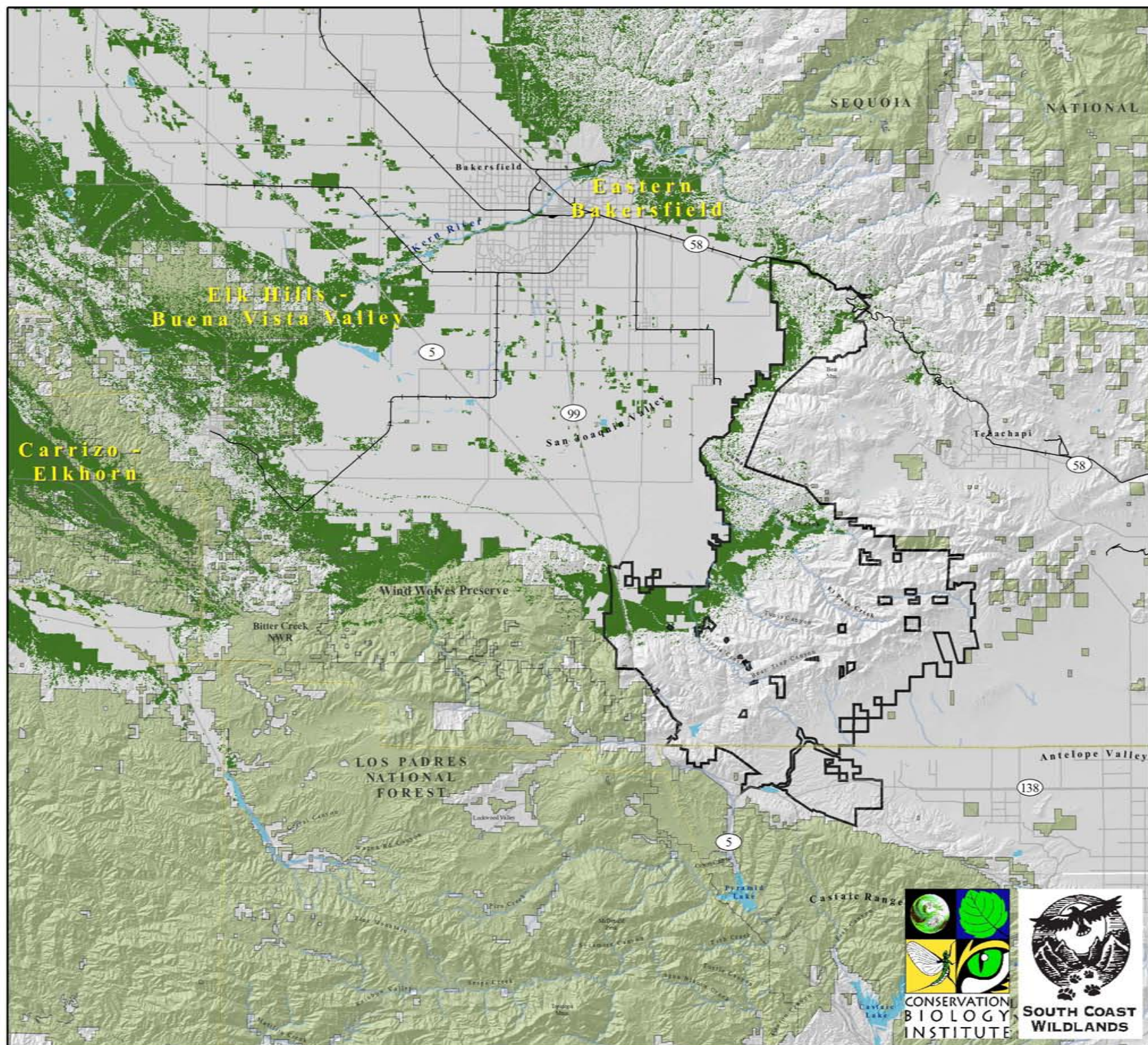
- a. San Joaquin kit fox. In the recovery plan for upland species in the San Joaquin Valley (USFWS 1998), the federally endangered San Joaquin kit fox is considered an umbrella species for the grassland community of the valley floor. Thus, we used kit fox as the focal species in the reserve design for Unit A of Tejon Ranch. In the San Joaquin Valley, this species occurs within a metapopulation structure comprised of *core* or large, source populations and smaller *satellite* populations. Known locations of large populations of kit foxes in the southern San Joaquin Valley—Carrizo Plain-Elkhorn Hills, Elk Hills-Buena Vista Valley, and eastern Bakersfield—are shown in Figure 4. The large, core kit fox populations are connected to one another via two principal routes—(i) trans-valley along the Kern River corridor, and (ii) around the southern end of the valley through Tejon Ranch (Figure 4). Because of ongoing land use modifications, the Kern River corridor's connectivity function for kit fox is rapidly being diminished (Brian Cypher personal communication), thus increasing the importance of the connection through Tejon Ranch. Because the distance between the Carrizo-Elkhorn and eastern Bakersfield populations is at least 70 miles (113 km), we believe that conservation of enough habitat to support a satellite population of kit foxes between these two larger populations is necessary to ensure long-term demographic exchange between them. Thus, Tejon Ranch supports grassland habitat essential to maintaining connectivity between populations of kit foxes on the western and eastern sides of the San Joaquin Valley.

Quality breeding habitat can be a limiting factor in the long-term sustainability of kit fox populations; thus, we used breeding habitat requirements for kit fox to develop the reserve boundary within Unit A. The kit fox occurs in grasslands up to 1,000 m (3,281 ft) in elevation, with slopes <10%. Habitat with slopes <5% are the highest quality, while habitat with 5-10% slopes are considered to be fair quality (Haight et al. 2002). The kit fox has a home range size of 640 acres to 7,600 acres (USFWS 1998), and breeding pairs require a minimum of about 988 acres (4 km²) of good quality habitat and 1,976 acres (8 km²) of fair quality habitat (Haight et al. 2002). We excluded land from the reserve in the northwest portion of Tejon Ranch that is dominated by agriculture or already disturbed, but ensured that the reserve includes a 2-km wide swath of high quality habitat adjacent to this potentially

Figure 4.
Potential Habitat
for
San Joaquin kit fox
(Vulpes macrotis mutica)

- Potential Breeding Habitat*
- Tejon Ranch
- County Boundaries
- Rivers & Creeks
- Lakes & Reservoirs
- Protected Lands
- Roads
- Railroads

*Potential Habitat with < 10% slope



**Figure 5a. San Joaquin kit fox
Potential Breeding Habitat**

- Potential Breeding Habitat (< 10% slope)
- 2 km Buffer
- Landscape Unit A
- Streams

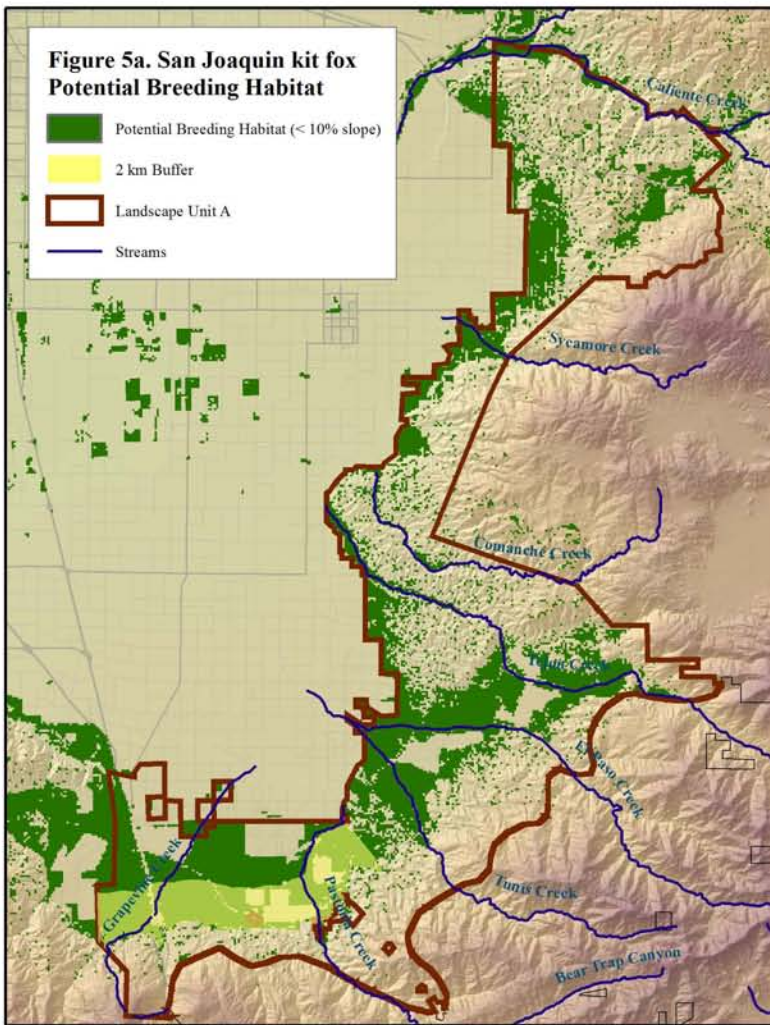


Figure 5b. Specialty Reserves

- Specialty Reserve*
- Landscape Unit A
- Streams

*Data courtesy of CSUS Endangered Species Recovery Program

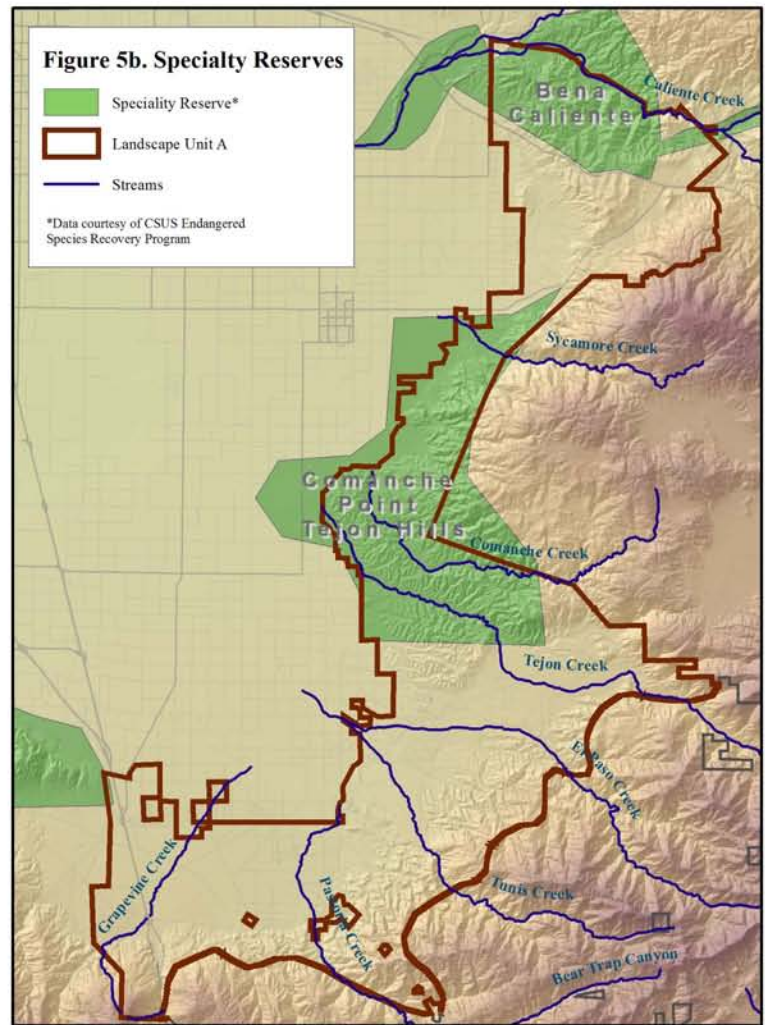
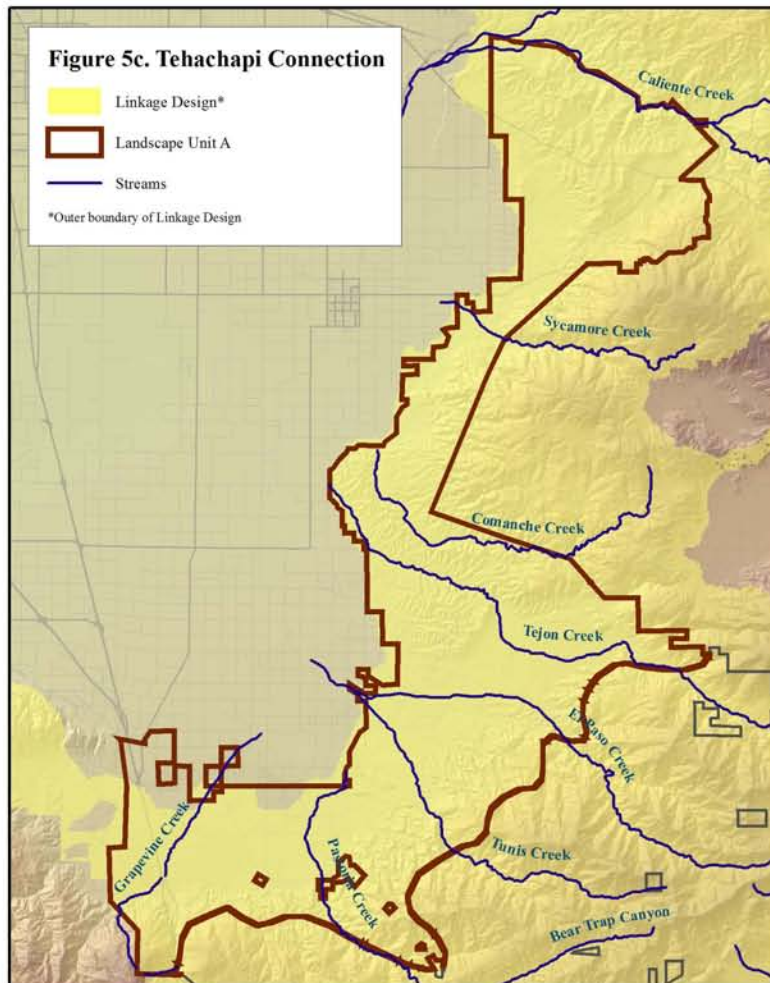


Figure 5c. Tehachapi Connection

- Linkage Design*
- Landscape Unit A
- Streams

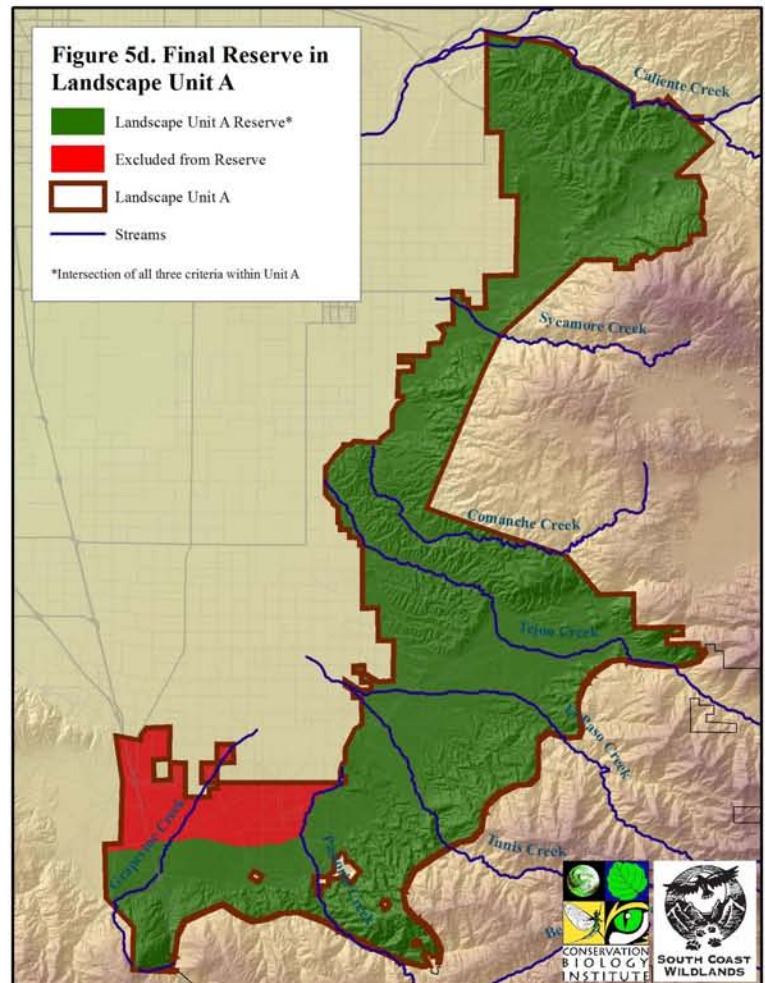
*Outer boundary of Linkage Design



**Figure 5d. Final Reserve in
Landscape Unit A**

- Landscape Unit A Reserve*
- Excluded from Reserve
- Landscape Unit A
- Streams

*Intersection of all three criteria within Unit A



developable area, excluded from the reserve (Figure 5). Thus, the reserve in Unit A includes 18,384 acres and 12,855 acres of high and fair quality kit fox habitat, respectively (Figure 5a). The reserve is assumed to potentially support as many as 25 individuals that would serve as a satellite population between the three large populations adjacent to Tejon Ranch. Such a satellite population on Tejon Ranch is not expected to be completely viable in isolation, but would be supported by, and in-turn would support, demographic exchange between the two adjacent core populations (i.e., Carrizo-Elkhorn and eastern Bakersfield populations). The area of the reserve prioritized for the kit fox also supports habitat important to the San Joaquin antelope squirrel, blunt-nosed leopard lizard, and Tipton kangaroo rat, among other listed species (Stallcup et al. 2003, USFWS 1998).

- b. Specialty reserves. The San Joaquin Valley floor recovery plan identifies specialty reserves important for recovery of listed and endemic species. Two specialty reserves—Comanche Point-Tejon Hills (31,068 acres) and Bena-Caliente Hills (19,297 acres)—occur largely on Tejon Ranch (USFWS 1998) and were targeted to protect Vasek's clarkia, Bakersfield cactus, and Comanche Point layia. These two specialty reserves are included in the Tejon Ranch reserve (Figure 5b). These specialty reserves also support California jewelflower, Tejon poppy, blunt-nosed leopard lizard, short-nosed kangaroo rat, and San Joaquin kit fox, including scattered patches of habitat suitable for kit fox breeding (Figure 5a).
- c. Grassland linkage. The reserve should provide adequate regional connectivity by including key areas within Unit A that connect Tejon Ranch habitats to offsite areas either currently protected or targeted for protection. Over 70% of Unit A supports regional landscape linkages (Penrod et al. 2003). Thus, we included in the reserve those portions of Unit A that are part of the *Tehachapi connection* to the Sierra Nevada—through the Walker Basin and Caliente Creek watersheds north of Tejon Ranch—and between the east and west sides of the San Joaquin Valley grasslands (Penrod et al. 2003). Because Interstate-5 and Highway 58 are significant barriers to movement of grassland species from Tejon Ranch to offsite areas, the ultimate reserve design must also include structural improvements to these roads to facilitate animal movement at these two locations.

Unit B. Oak woodland, montane hardwood, and montane hardwood-conifer communities, northwest slope of Tehachapi Mountains

This is the second largest landscape unit, covering over 30% of Tejon Ranch (approximately 85,302 acres). This landscape unit supports the most intact and biologically diverse part of the Ranch, including regionally under-protected oak woodland communities. Unit B also includes the greatest area (63,968 acres) of high to very high watershed integrity basins, which maintain hydrologic processes and water quality for aquatic and wetland species. Approximately 77% of Unit B is roadless, including the largest area of roadless areas greater than 10,000 acres, illustrating the high intactness of the habitats in this unit. Almost 90% of Unit B supports regional landscape linkages (Penrod et al. 2003). This landscape unit includes the rugged north slope of the Tehachapi Mountains, which supports historic ridge-top foraging and roosting habitat for the endangered California condor, such as Geghus Ridge, Tunis Ridge, and Winters Ridge (D. Clendenen personal communication).

Conservation of Unit B is important for maintaining integrity and landscape functions and thus forms the *core* of the Tejon Ranch reserve. The primary conservation focus in this unit is protection of the large block of intact, diverse habitats in the unit, thereby maintaining natural ecosystem processes (e.g., hydrologic and fire regimes), keeping regional wildlife linkages intact, and protecting key habitat areas for listed and sensitive species. Moreover, Unit B, along with land in Unit C, is part of a regional linkage along the spine of the Tehachapi Mountains to the southern Sierra Nevada. The habitats in this unit support rare and endangered species, including the California condor, California spotted owl, and Tehachapi slender salamander.






The objectives of the reserve design within Unit B are:

- a. Protect a *core* intact block of roadless areas, high diversity habitats, and high-integrity watershed basins to conserve biodiversity, landscape-scale processes, and ecological functions.
- b. Maintain the regional *high-elevation linkage* in this unit to offsite protected areas in the Los Padres and Sequoia National Forests (the Tehachapi connection, Penrod et al. 2003).
- c. Conserve foraging and roosting habitat for *California condor* and other sensitive species.

Using these objectives as guidelines, and based on the criteria described below, we developed a reserve design for Unit B. The reserve includes 77,055 acres of Unit B; an area of approximately 8,247 acres in this unit has been excluded from the reserve (Figure 6).

- a. Core reserve. The reserve design includes the highest-integrity areas of the upper Tejon, El Paso, Tunis, and Pastoria watersheds and the highest diversity habitats on the northern slopes of the Tehachapi Mountains, including mixed oak, conifer, shrub, and riparian communities (Stallcup et al. 2003). Approximately 61,000 acres within the core reserve are roadless; demonstrating the wildland characteristics of this core reserve unit. Our reserve design excludes lower-integrity subbasins of the Castac Lake and Grapevine Creek watersheds (approximately 8,250 acres), adjacent to existing development in the Frazier Park/Lebec area at an off-ramp of Interstate-5 (Figure 6a). However, lower integrity areas that serve regional linkage functions (Penrod et al. 2003) are included in the reserve design (Figures 6c and 6d).
- b. High-elevation linkage. The high-elevation ridge through Tejon Ranch is a continental-scale linkage that connects the Coast Ranges to the Sierra Nevada. This topographic feature is representative of the physiographic and evolutionary changes that have shaped the State of California—it is critical for maintaining the landscape-scale functionality of existing protected areas in the Sierra Nevada and South Coast ecoregions that converge on Tejon Ranch. Landscape-scale connectivity between the Los Padres National Forest and the Wind Wolves Preserve to Tejon Ranch relies on areas both north and south of Castac Lake, and large mammals currently must cross at-grade or use existing culverts under Interstate-5. Penrod et al. (2003) propose a large, bridged undercrossing to enhance wildlife movement in this area; therefore, we include within the reserve that area deemed most topographically suitable for this structure inside the reserve (Figures 6c, 6d). The final conservation boundary of the reserve could be further modified if a regional linkage could be at least partially conserved through the Gorman Ranch property adjacent to Tejon Ranch.

Figure 6a. Existing Development and Infrastructure

-  Landscape Unit B
-  Tejon Ranch
-  Natural Vegetation
-  Urban
-  Agriculture
-  Protected Lands

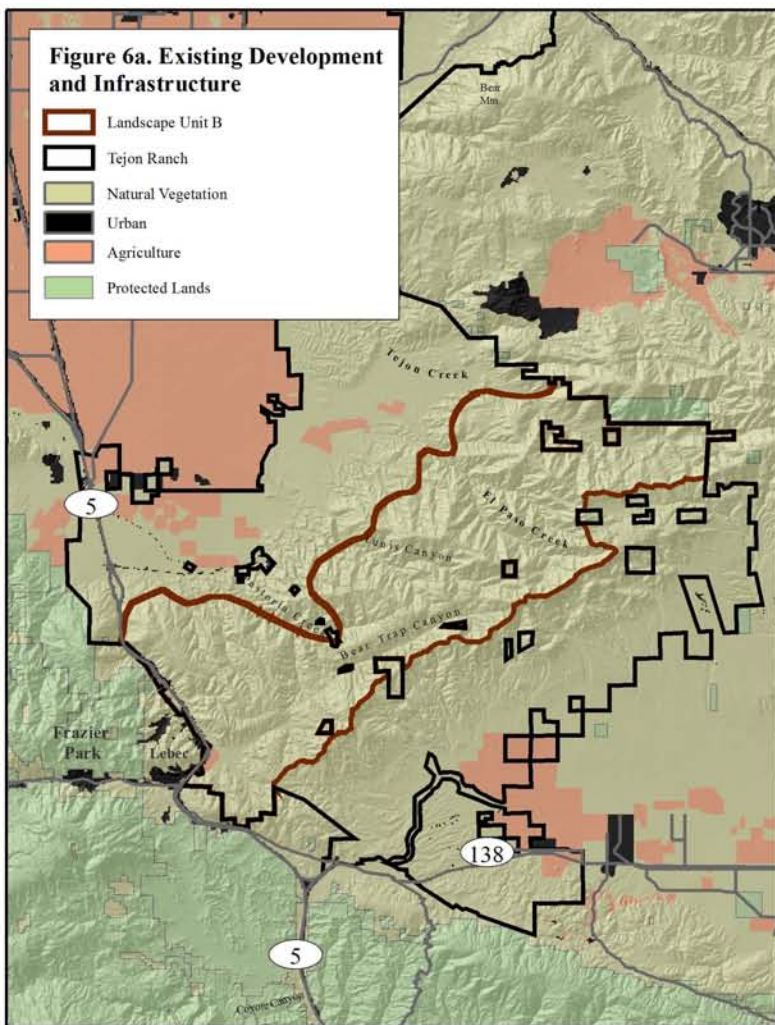









Figure 6b. Watershed Subbasins with Existing Development

-  Lower integrity watershed subbasins
-  Landscape Unit B
-  Tejon Ranch
-  Natural Vegetation
-  Urban
-  Agriculture
-  Protected Lands

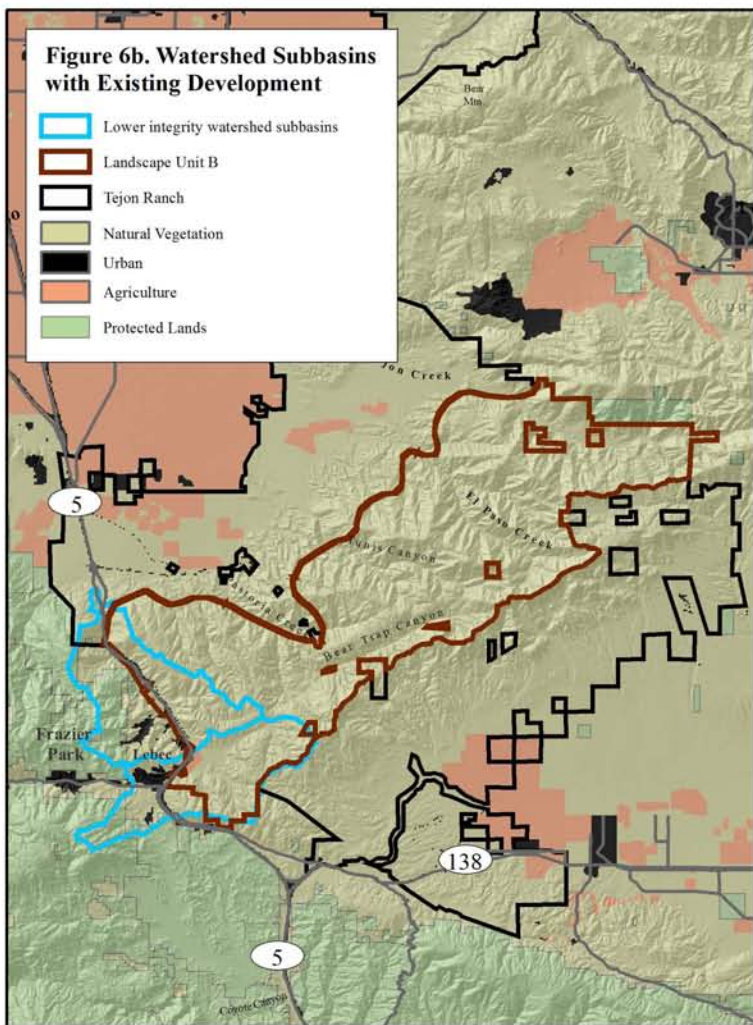










Figure 6c. Intersection of Linkage Design with Watershed Subbasins

-  Linkage Design*
-  Lower integrity watershed subbasins
-  Landscape Unit B
-  Tejon Ranch
-  Protected Lands
-  Natural Vegetation
-  Urban
-  Agriculture

*Outer boundary of Linkage Design

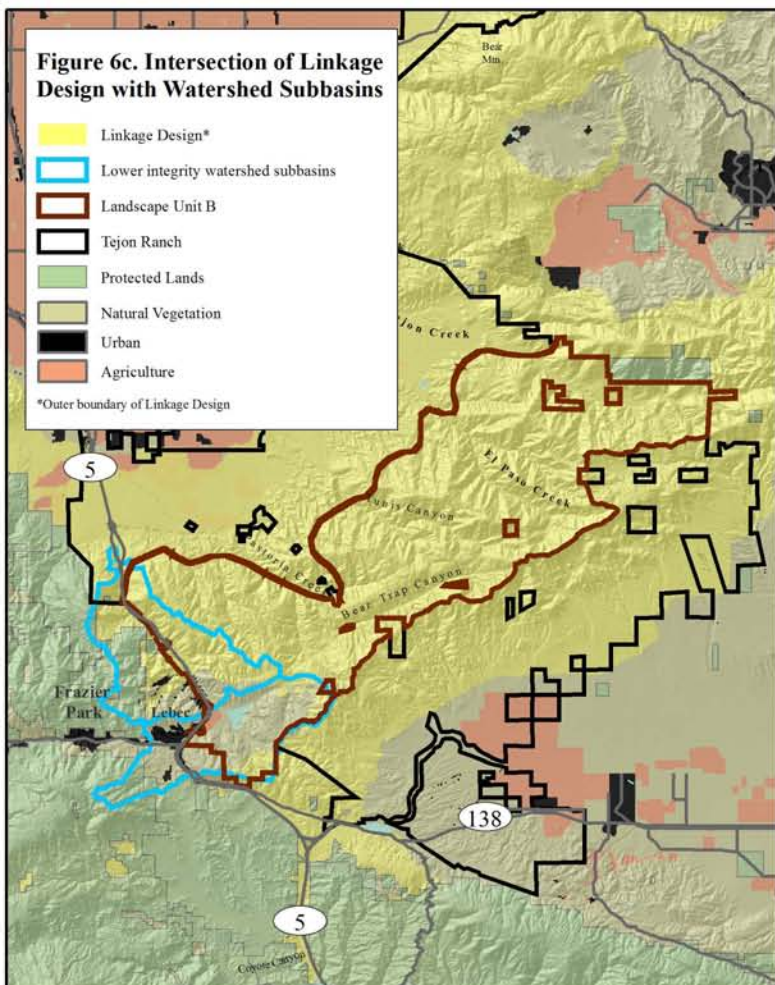
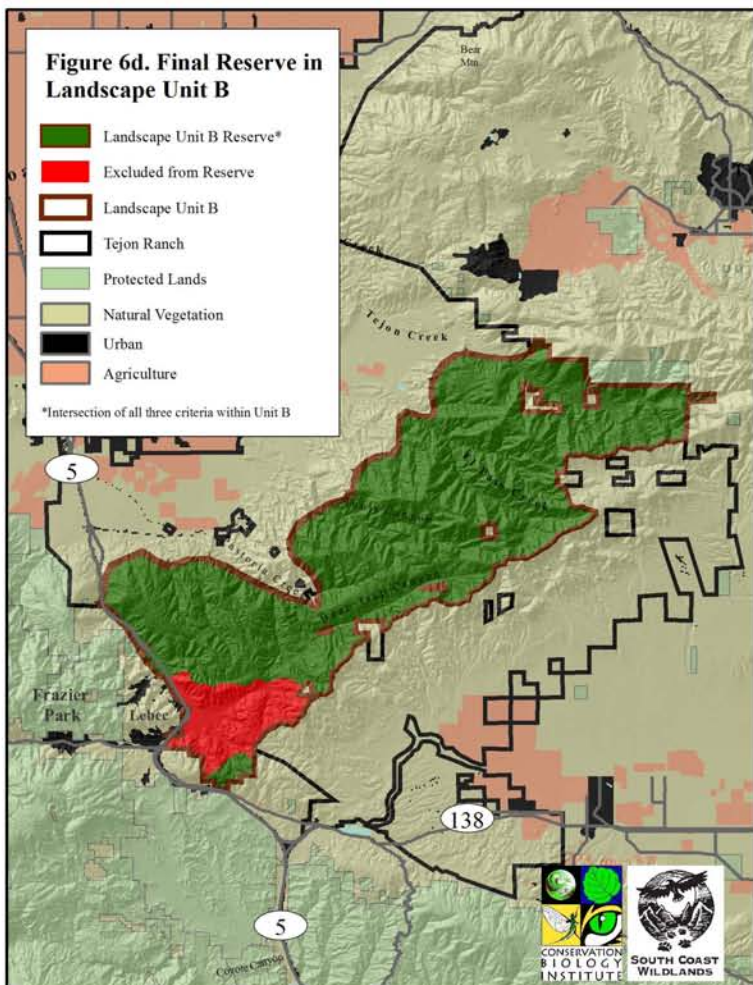


Figure 6d. Final Reserve in Landscape Unit B

-  Landscape Unit B Reserve*
-  Excluded from Reserve
-  Landscape Unit B
-  Tejon Ranch
-  Protected Lands
-  Natural Vegetation
-  Urban
-  Agriculture

*Intersection of all three criteria within Unit B



- c. California condor. The core reserve in Unit B includes 58,255 acres of Critical Habitat on the Ranch for the California condor, including important habitat on Geghus Ridge, Tunis Ridge, and Winters Ridge (Dave Clendenen personal communication). The core reserve also supports habitat for the California spotted owl and Tehachapi slender salamander.

Unit C. Oak woodland, chaparral, and pinyon-juniper communities, southeast slope of Tehachapi Mountains

Unit C is the smallest of the four landscape units (10% of the Ranch or approximately 26,872 acres), including the relatively intact southern slopes of the Tehachapi Mountains. Approximately 60% of Unit C supports high or very high integrity watershed basins. The majority of Unit C supports a high diversity of vegetation communities, but a relatively low percentage of under-protected communities. Approximately 75% of Unit C is roadless, including a high percentage of roadless areas greater than 10,000 acres. This landscape unit is a unique transition area, supporting a distinctive juxtaposition of ecoregional elements and habitat for several sensitive species, including the California spotted owl, threatened Tehachapi slender salamander, endemic yellow-blotched salamander, and endemic Tehachapi pocket mouse. The majority of this unit supports part of a regional landscape linkage (Penrod et al. 2003).










The objectives of the reserve design within Unit C are:

- a. Protect a *core* intact block of roadless areas, high diversity habitats, and high-integrity headwater watershed basins.
- b. Maintain the regional *Tehachapi linkage* to offsite protected areas along the southern slopes of the Tehachapi Mountains (the Tehachapi connection, Penrod et al. 2003).
- c. Conserve habitat for sensitive species, with a focus on the *Tehachapi pocket mouse*.

Conservation values of Unit C are similar to Unit B in that these two units form the *core* of the Tejon Ranch reserve, supporting biologically diverse, high integrity areas that are necessary for the continued functions of the region. Unit C also supports unique higher elevation habitats that transition into lower elevation desert scrub. Using these objectives as guidelines, and based on the criteria described below, we developed a reserve design for Unit C. Given the high integrity of this unit, its unique biodiversity, and importance for regional linkage functions, we believe the entire unit (26,872 acres) should be included as part of the *core* reserve (Figure 7).

- a. Core reserve. The reserve design includes the highest-integrity areas of the upper Cottonwood, Little Oak, Sacatara, Del Gato Montes, Bronco, Los Alamos, and Oso watersheds. Roads and other sources of disturbance (e.g., residential and utility development) provide corridors for invasion by nonnative plant species, can facilitate human entry into undisturbed areas, and alter runoff. Thus, high-integrity areas (i.e., undeveloped and un-roaded areas) generally support more intact native communities and natural ecological processes than do lower integrity areas. Furthermore, watershed basins with lower integrity, and thus less natural hydrology and water quality, can adversely affect hydrology and water quality of down-gradient watershed basins. These high-integrity headwater areas

Figure 7a. Watershed Basins

-  Landscape Unit C
-  Bronco
-  Cottonwood
-  Del Gato Montes
-  Los Alamos
-  La Liebre
-  Little Oak
-  Oso
-  Sacatara

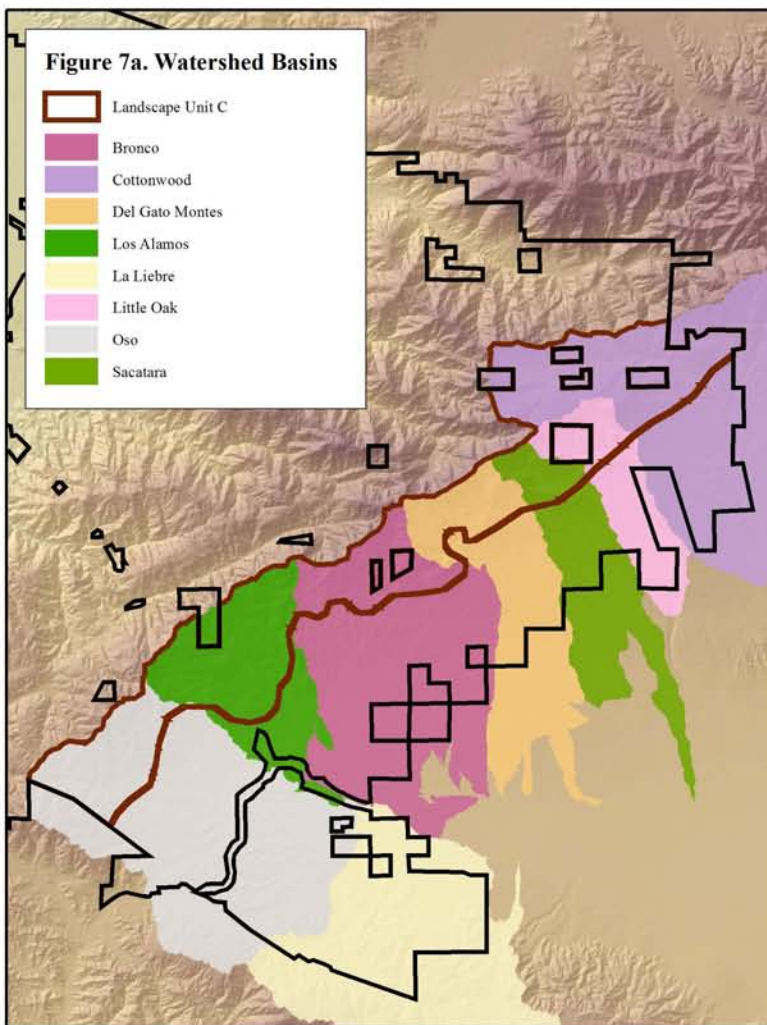


Figure 7b. Tehachapi Connection

-  Linkage Design*
 -  Landscape Unit C
 -  Protected Lands
 -  Roads
- *Outer boundary of Linkage Design

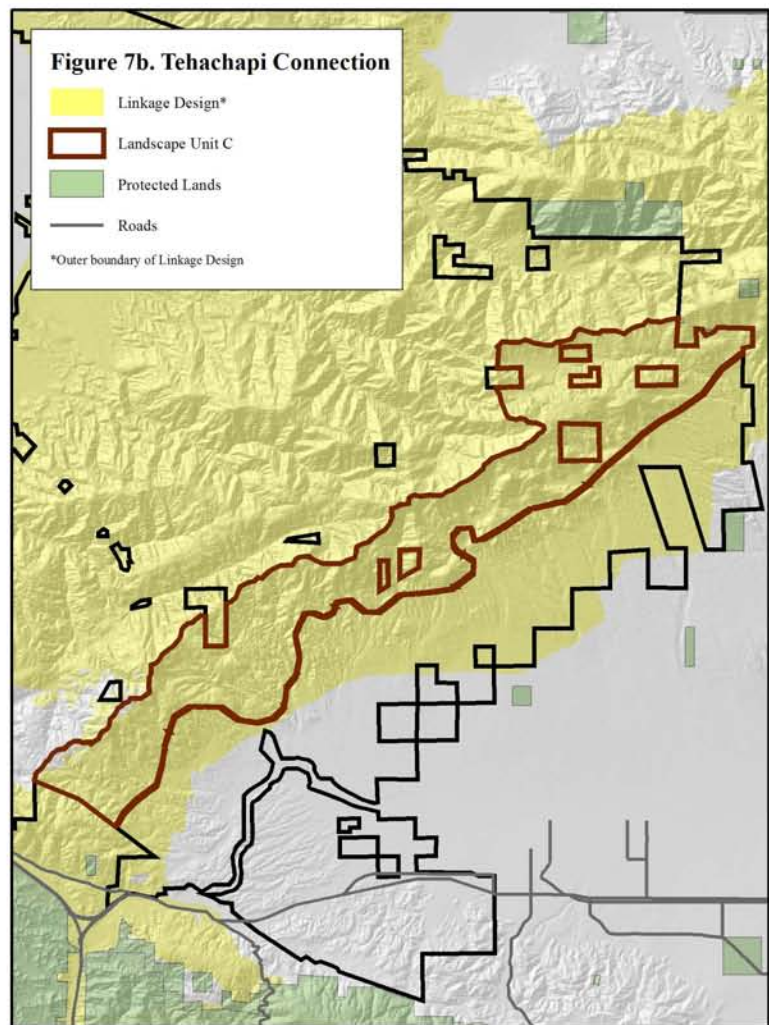


Figure 7c. Tehachapi pocket mouse Potential Habitat

-  Potential Habitat
-  Landscape Unit C
-  Protected Lands
-  Roads

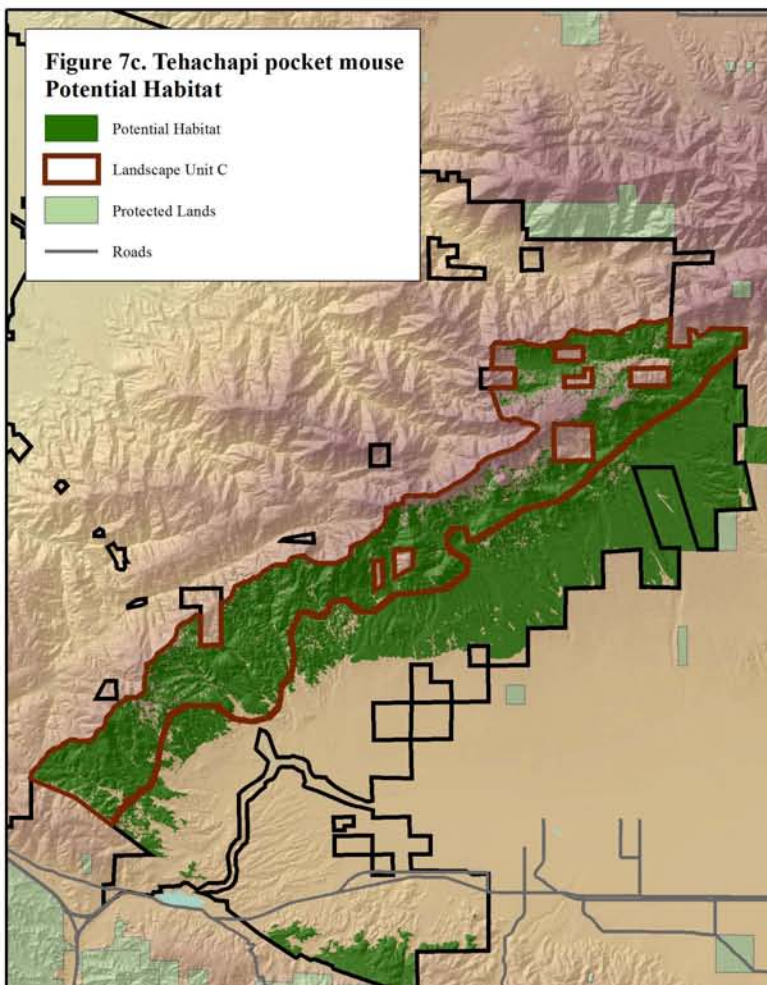



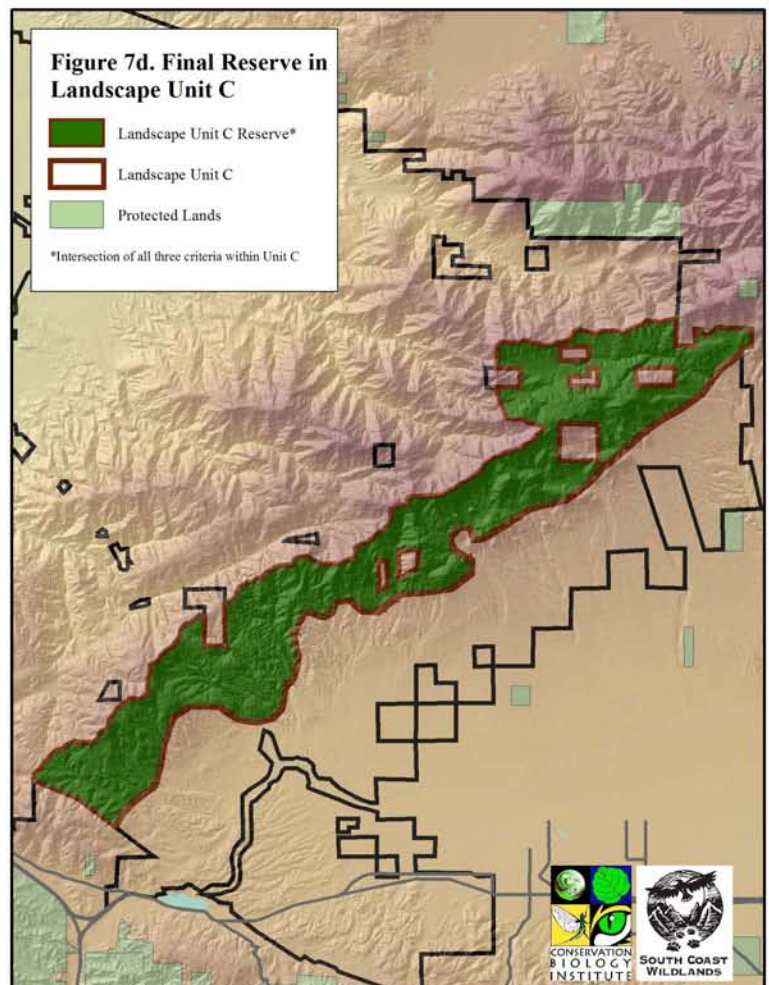


Figure 7d. Final Reserve in Landscape Unit C

-  Landscape Unit C Reserve*
 -  Landscape Unit C
 -  Protected Lands
- *Intersection of all three criteria within Unit C



are critical to maintaining natural ecological processes and support the unique and diverse transitional habitats of the south slopes of the Tehachapis.

- b. Tehachapi linkage. The entire southern slope of the Tehachapi Mountains is an important linkage for a variety of species, including mountain lion, badger, mule deer, western gray squirrel, Tehachapi pocket mouse, California thrasher, acorn woodpecker, coast horned lizard, yellow-blotched salamander, bright blue copper butterfly, callipe fritillary, San Emigdio blue butterfly, and bear sphinx moth (Penrod et al. 2003). Developments have been proposed at the western end of Tejon Ranch (e.g., Gorman Ranch) that would potentially affect the linkage design in this unit. There may be an opportunity to eliminate some land from the reserve in this area for potential development, but planning should be conducted in conjunction with areas off the Ranch to ensure that this linkage and the conservation values it supports are adequately protected.
- c. Tehachapi pocket mouse. The entirety of Unit C is a transition zone between the southern Sierra Nevada, Coast Ranges, and Mojave Desert. This is exemplified by the presence of potential habitat for the Tehachapi pocket mouse, a narrow endemic species (Penrod et al. 2003) that prefers the mix of vegetation communities on the Mojave Desert side of the Ranch (desert scrub, Joshua tree, pinyon-juniper, grasslands, and coniferous forests between 3,500 and 6,000 ft (1,067-1,829 m).

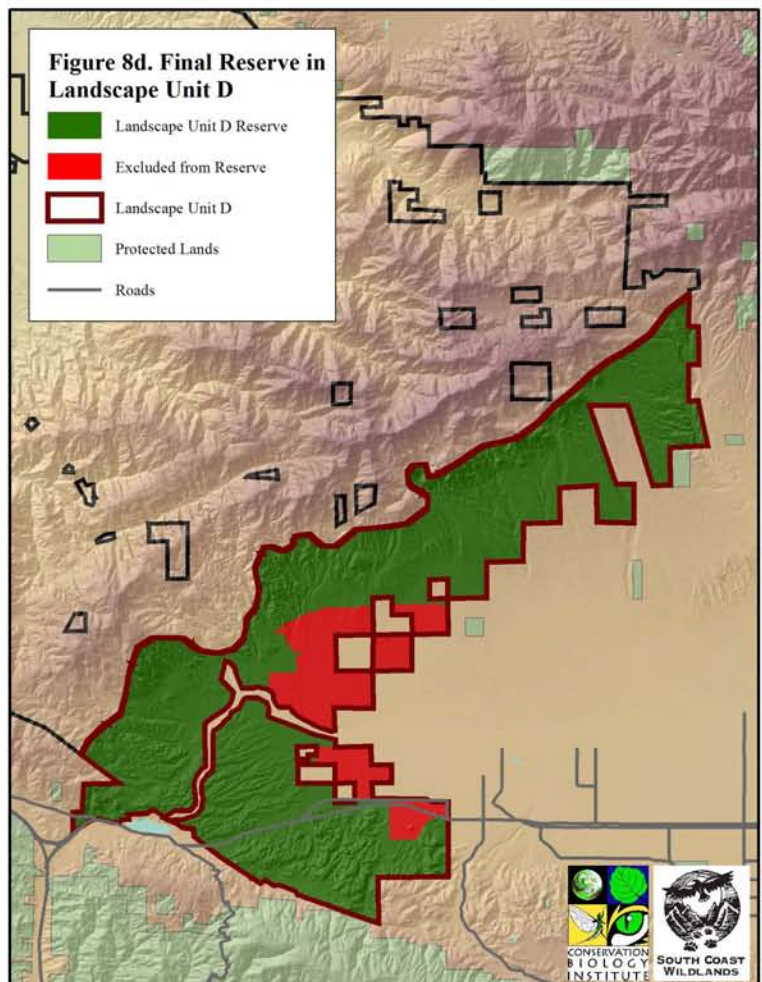
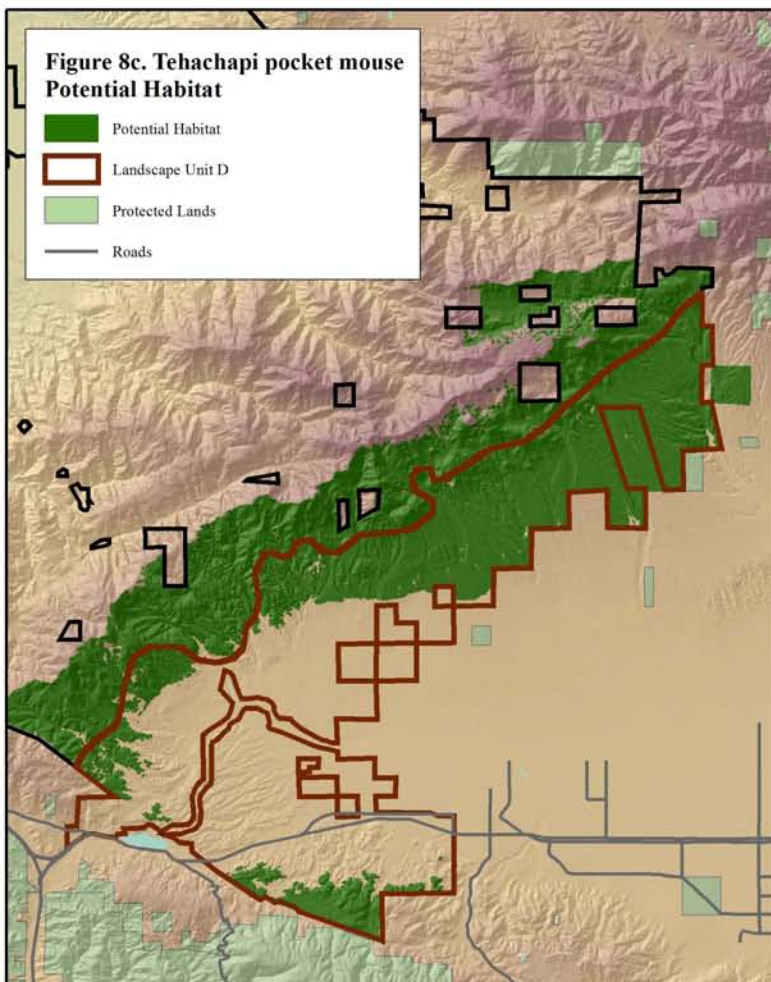
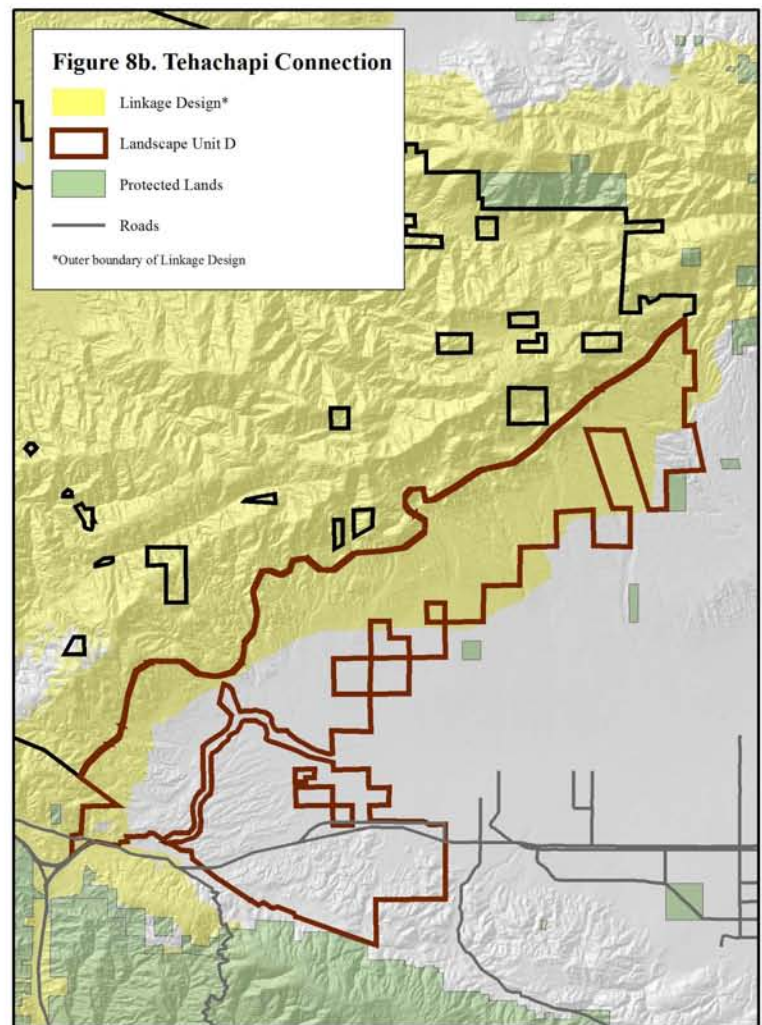
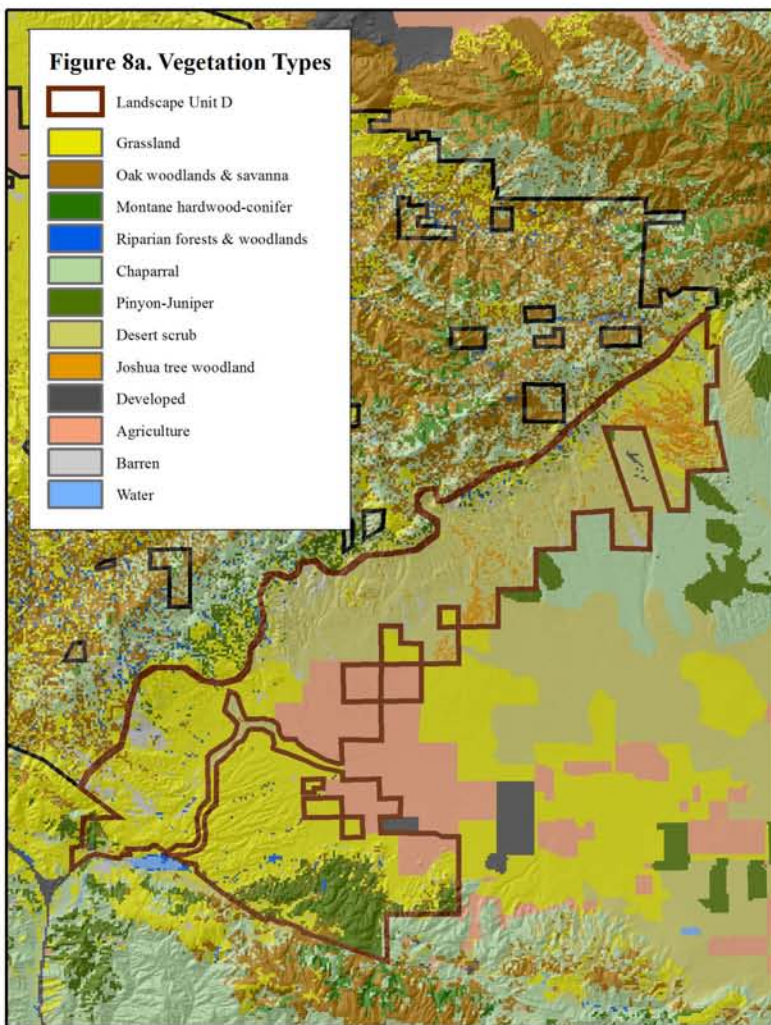
Unit D. Lowland Joshua tree, grassland, and desert scrub communities of the Mojave Desert

Unit D covers about 19% of Tejon Ranch (approximately 50,846 acres). This unit supports a high percentage of under-protected communities (i.e., native grasslands), and it supports diverse communities transitioning to the higher elevation habitats in the Castaic Range south of the Ranch. One-third of Unit D supports high to very high integrity watershed basins, which are generally contiguous with their intact headwater basins in landscape Unit C. Almost half of Unit D is roadless, but less than 10% of these roadless areas are greater than 10,000 acres.

The objectives of the reserve design within Unit D are:

- a. Conserve the large, intact *native grasslands* on the Mojave Desert floor.
- b. Maintain the regional *Tehachapi linkage* in this unit to offsite protected areas along the Mojave Desert floor (the Tehachapi connection, Penrod et al. 2003).
- c. Conserve diverse, transitional habitats, such as those that support the *Tehachapi pocket mouse*.

Using these objectives as guidelines, and based on the criteria described below, we developed a reserve design for Unit D. The existing intact lands supporting high value regional resources and linkages should be included within the reserve (43,972 acres, Figure 8). The eastern portion of this unit (approximately 6,874 acres) has been disturbed by previous land uses and existing agriculture, has access from Highway 138, and is adjacent to existing development, agriculture, and roads in the western Antelope Valley, and we have excluded this area from the reserve.



- a. Native grasslands. The large grassland within this unit (approximately 18,580 acres), much of it within a high quality native grassland complex, supports species such as burrowing owl and badger, as well as native wildflowers and forbs. This regionally significant resource, which is part of a Los Angeles County-designated SEA, is included in the reserve. These grasslands are largely contained within the gently sloping portion of the Oso Creek watershed. Protection of the headwaters area of this watershed from future development is particularly important because of the documented changes to natural hydrologic regimes and associated vegetation communities resulting from watershed urbanization (White and Greer 2006). Any development in this area should be located hydrologically down-gradient from the grasslands. The reserve design in this unit also maintains connectivity with grasslands to the east of Tejon Ranch, along the foot of Liebre Mountain.
- b. Tehachapi linkage. Over half of Unit D supports a regional landscape linkage that provides connectivity between Tejon Ranch and the Sierra Madre Mountains to the west, Castaic Mountains to the south, and southern Sierra Nevada to the northeast (Penrod et al. 2003, 2005). This linkage is included in the reserve because it is particularly important for desert scrub species, such as the badger, Tehachapi pocket mouse, burrowing owl, coast horned lizard, callipe fritillary, Tejon rabbitbrush long-horned borer, and bear sphinx moth (Penrod et al. 2003), using the higher elevations of Antelope Valley along the northern, southern, and eastern portions of this unit. We have included all of the regional linkage design in the reserve. However, the Gorman Ranch development, proposed at the western end of Tejon Ranch, would potentially affect the linkage design in this unit. There may be an opportunity to exclude some land from the Tejon Ranch reserve in this area, but any development onsite must be planned in conjunction with areas off the Ranch to ensure that this linkage and the conservation values it supports are adequately protected.
- c. Tehachapi pocket mouse. The slopes within Unit D are a transition zone between the Mojave Desert, Tehachapi Mountains, and Coast Ranges. This is exemplified by the presence of potential habitat for the Tehachapi pocket mouse, a narrow endemic species (Penrod et al. 2003) that prefers the mix of vegetation communities on the Mojave Desert side of the Ranch (desert scrub, Joshua tree, pinyon-juniper, grasslands, and coniferous forests between 3,500 and 6,000 ft (1,067-1,829 m)).

3 SUMMARY OF CONSERVATION VALUES FOR THE TEJON RANCH RESERVE

We combined the four landscape unit-specific reserve designs into a single unfragmented reserve system for the Ranch, totaling 246,382 acres (Figure 9). The reserve captures the full range of physical and biological diversity of the Ranch and areas important for recovery of listed species. It would maintain intact an area of undeveloped land large enough to allow essential natural processes, such as fire, to occur within their natural range of variability, as well as provide habitat for both wide-ranging species with very large area needs and smaller, less mobile species that require generations to move across landscapes. Thus, the proposed reserve would maintain the irreplaceable regional conservation values the Ranch currently supports.

Figure 9. Tejon Ranch Reserve

- Reserve
- Excluded from Reserve
- Tejon Ranch
- Protected Lands
- Other Large Landowners

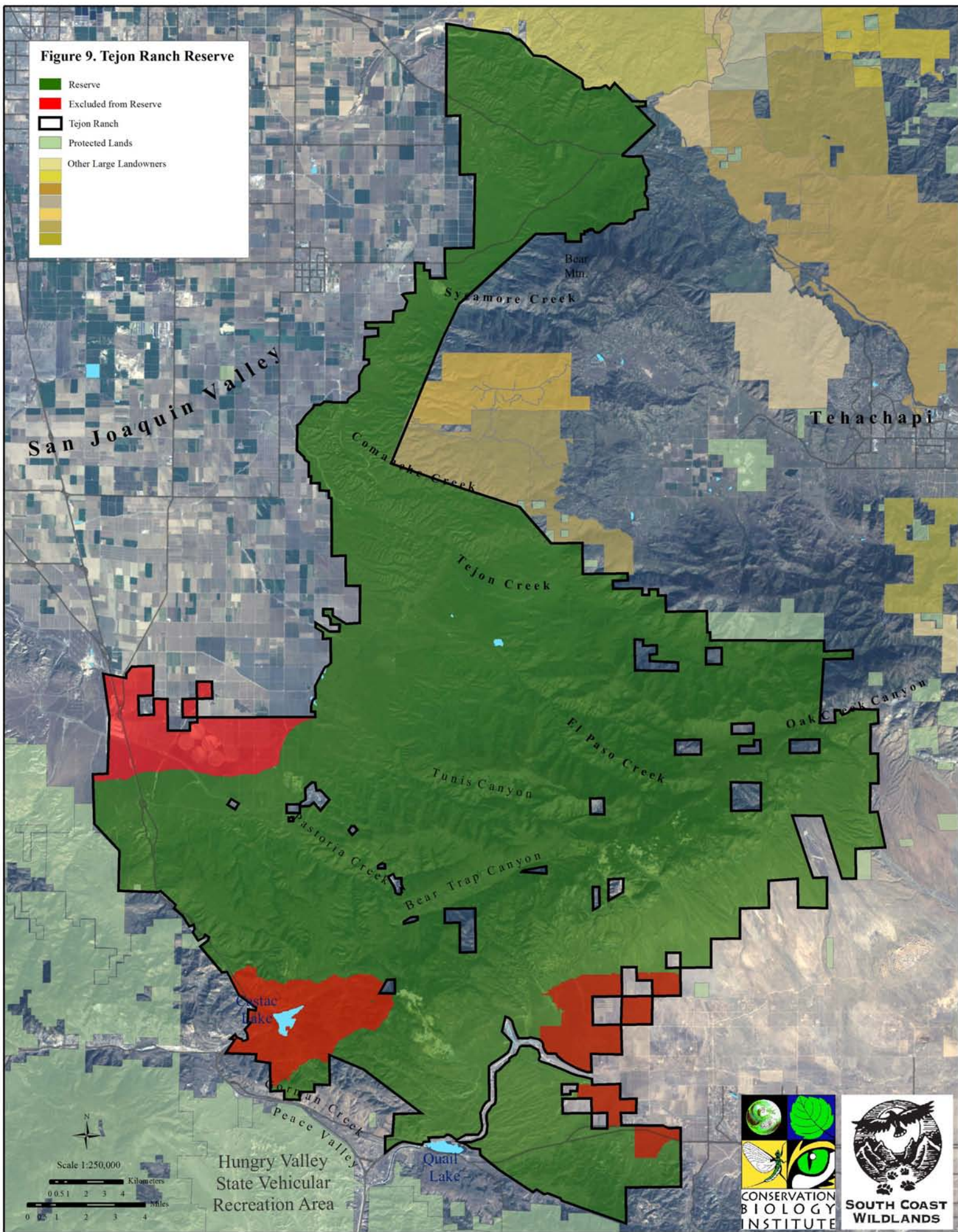


Figure 9 also shows areas on Tejon Ranch that are excluded from the reserve, which may be available for development or other non-reserve land uses such as intensive agriculture. These areas (totaling approximately 24,365 acres) are at the margins of the Ranch near existing development, disturbed areas, and transportation infrastructure: (1) San Joaquin Valley floor adjacent to the community of Grapevine via an exit from Interstate-5, (2) Castac Lake area adjacent to Lebec and Frazier Park via exits from Interstate-5, and (3) western Antelope Valley via access from Highway 138. Loss of natural resources in these excluded areas would not internally fragment the reserve, thus minimizing direct and indirect adverse impacts.

Figure 10 shows the Tejon Ranch reserve in the context of existing regional conservation investments, the linkage design (Penrod et al. 2003, 2005) for the region, as well as selected large, privately owned properties that are candidates for completing the reserve system in the Tehachapi region. The northeastern arm of Tejon Ranch provides both a grassland and oak savanna connection to the eastern San Joaquin Valley and to the foothills of the Sierra Nevada, while the core of the reserve along the spine of the Tehachapis provides connectivity to higher elevation habitats in the southern Sierra. The Tejon Ranch reserve allows connectivity to the protected areas of Sequoia National Forest and BLM land, bypassing the developed and agricultural areas in the Cummings and Tehachapi valleys, and virtually completes connectivity to the Los Padres and Angeles National Forests and Wind Wolves Preserve to the west.

Conservation efforts are currently underway that would complement the proposed Tejon Ranch reserve and complete a contiguous system of conserved lands in this region. In fact, conservation is pending for one of the large properties shown in Figure 10, further emphasizing the importance of the Tejon Ranch reserve for completing the network of conservation lands in this part of California.

The remainder of this section describes the attributes of the proposed reserve with respect to the original regional conservation objectives (Table 1).

1. Conserve a large and intact area of natural open space.

The proposed reserve occupies approximately 246,382 acres of wildlands. Large, intact areas allow natural physical processes and ecological functions to continue, reduce the probability of species extinctions, and require less intensive land management than do smaller and fragmented natural areas. The extent of roadless areas on the Ranch is arguably one of its most significant conservation values. These areas are less accessible to humans and are mostly associated with the rugged terrain of the Tehachapi Mountains, which forms the core of the Tejon Ranch reserve. All roadless areas greater than 5,000 acres in size are included in the reserve, and the majority of roadless areas between 1,000 and 5,000 acres are included.

2. Avoid habitat fragmentation by development, golf courses, and roads.

Habitat fragmentation is associated with a variety of adverse effects on natural resources and landscape-scale ecological processes (Attachment B). For example, fragmentation of natural areas by roads and development is associated with changes in runoff regimes and water quality, alterations of fire regimes, increased invasion of nonnative species, increased abundance of

Figure 10. Tejon Ranch Reserve Context

- Reserve
- Excluded from Reserve
- Tejon Ranch
- Linkage Design
- Protected Lands
- Conservation Pending
- Other Large Landowners
- Roads
- Lakes & Reservoirs

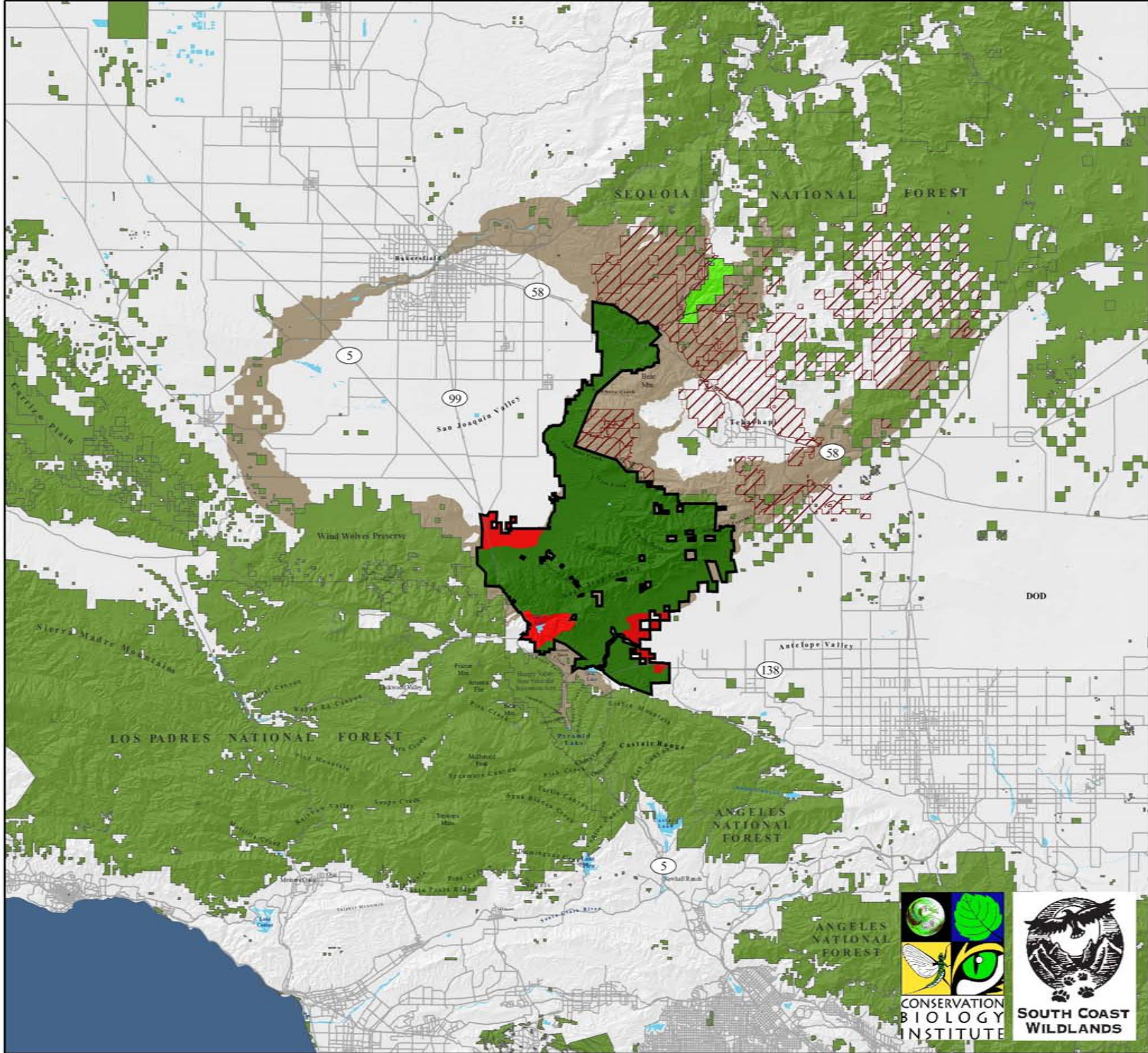


Table 1. Summary of attributes for the Tejon Ranch reserve.

Attribute	Reserve Unit A	Reserve Unit B	Reserve Unit C	Reserve Unit D	Total Reserve	Total Ranch	% of Total
Areas of ecoregions (acres)							
• Central Valley	75,532	155	0	0	75,687	84,931	89%
• Mojave Desert	0	13	5,491	38,149	43,653	50,528	86%
• Sierra Nevada	22,951	74,748	20,571	464	118,734	123,808	96%
• South Coast	0	2,139	810	5,359	8,308	11,483	72%
Total area (acres)	98,483	77,055	26,872	43,972	246,382	270,750	91%
Roadless areas (acres)							
• 1,000-5,000 acres	29,841	20,073	6,473	16,665	73,052	78,061	94%
• 5,000-10,000 acres	14,575	14,414	6,101	3,170	38,260	38,260	100%
• >10,000 acres	7,369	26,523	7,848	3,335	45,075	45,172	100%
Representation (acres)¹							
• Grasslands	85,036	18,892	4,173	18,580	126,681	134,036	95%
• Oak woodlands	1,824	11,662	2,377	291	16,154	25,152	64%
• Sycamore woodlands	414	1,665	77	0	2,156	2,164	100%
• Cottonwood-willow riparian	234	993	658	326	2,211	2,482	89%
No. of vegetation communities (#)	12	13	13	13	15	16	-
Elevational gradient (meters)	126-1,491	485-2,072	993-2,074	909-1,603	126-2,074	126-2,074	-
Watershed integrity (acres)							
• Very high integrity basins	17,636	39,054	4,053	5,997	66,741	68,219	98%
• High integrity basins	18,924	22,203	12,301	9,895	63,323	64,974	97%
Regional linkages (acres)							
• Tehachapi connection	71,173	75,316	26,038	23,963	196,490	204,944	96%
• Sierra Madre-Castaic connection	0	60	0	330	390	390	100%

Attribute	Reserve Unit A	Reserve Unit B	Reserve Unit C	Reserve Unit D	Total Reserve	Total Ranch	% of Total
Rare, threatened, & endangered species (acres)							
• High quality kit fox habitat	18,384	0	0	0	18,385	23,584	-
• Fair quality kit fox habitat	12,855	0	0	0	12,857	13,059	-
• Condor Critical Habitat	35,134	58,255	16,957	7,117	117,463	128,726	-
• Tehachapi pocket mouse potential habitat	0	29	21,132	22,860	44,021	44,036	-
Area excluded from reserve (potentially available for development (acres))	9,244	8,247	0	6,874	24,365	-	-

¹Communities on Tejon Ranch that are considered regionally underprotected (refer to White et al. 2003 for more information).

human-tolerant wildlife species, and decreased abundance of human-intolerant wildlife species. We configured the reserve in a large contiguous block, with no internal fragmentation. Areas excluded from the reserve, potentially available for development, are located at the periphery of the Ranch to avoid habitat fragmentation.

3. Protect an adequate representation of physical and biological diversity.

Existing conservation areas within the region do not protect a full range of physical and natural diversity. In particular, higher elevation habitats are disproportionately included in conserved open space, and lower elevation habitats, such as grasslands and oak savannas, are under-protected in the region. The proposed reserve includes a full range of the physical diversity (e.g., elevation, topography, aspect) and environmental gradients on the Ranch (e.g., biogeographic gradients) and emphasizes inclusion of under-protected communities. Moreover, the reserve includes the majority of the undisturbed portions of the County of Los Angeles' proposed SEAs within the Ranch. These areas are designated by the County to encourage protection of regionally important biodiversity and examples of high quality vegetation communities.

4. Protect intact watershed basins to maintain natural functions and processes.

The integrity of watershed basins in the region, indeed in California as a whole, has been severely compromised by residential and agricultural development, road-building, water diversions and storage, etc. The reserve includes over 130,000 acres (Table 1) of high and very high integrity watershed basins on Tejon Ranch (Stallcup et al. 2003). Potential future development should be allocated to lower integrity watershed basins.

5. Contribute to the recovery of rare, threatened, and endangered species.

A large number of rare, threatened, and endangered species occur in the region, many of which are endemic to the region (White et al. 2003). Tejon Ranch provides important habitat for these species, as well as a unique opportunity to contribute to their conservation and recovery (see Appendix C in White et al. 2003). The reserve captures the majority of known and potential habitat for these species on Tejon Ranch. The reserve design is also consistent with guidance provided by available recovery plans for species that occur on the Ranch, including 117,463 acres of designated Critical Habitat for the California condor (USFWS 1976) and protection of specialty reserves and linkage areas identified in the recovery plan for upland species of the San Joaquin Valley (USFWS 1998).

6. Maintain regional habitat connections inside and outside the reserve.

Tejon Ranch is located within a continental-scale linkage between the Coast Ranges and Sierra Nevada, the western and eastern sides of the San Joaquin Valley grasslands, and the slopes of the Mojave Desert floor. The reserve design maintains the landscape-scale connectivity functions of the Ranch, consistent with recommendations for regional linkages by the South Coast Missing Linkages Project (Penrod et al. 2003, 2005). The reserve also includes connections between the Ranch and Los Padres National Forest and adjacent Wind Wolves Preserve. The design allows for future conservation actions outside of the Ranch to secure connectivity functions to Sequoia

National Forest and land administered by the BLM via a number of large private properties between Tejon Ranch and public lands.

7. Enhance existing conservation investments.

Regional conservation efforts in California have focused on securing adequate landscape-scale connectivity between protected and public lands, where the long-term sustainability of existing conservation investments would be jeopardized unless they are linked within a functional network of reserves. The Tehachapi Range, and the low elevation bands of habitat along either side, is the last intact habitat connection for plants and animals to disperse between the Coast Ranges and the Sierra Nevada and the hundreds of thousands of acres of protected open space these areas support. The convergence of ecosystems in this part of California results in a diversity of habitat types that span and link together a cross-section of the state. Tejon Ranch may serve as a refuge during catastrophic events and periods of changing climatic conditions.

8. Identify areas potentially available for development.

More disturbed and degraded areas of the Ranch, areas adjacent to existing development and infrastructure, and areas within watershed basins with reduced integrity that have been excluded from the Tejon Ranch reserve are potentially appropriate for development. These areas include existing or former agricultural lands on the San Joaquin Valley and Mojave Desert floors, which are adjacent to the proposed Tejon Industrial Complex (and associated infrastructure) and Highway 138, respectively. There is a third potential development area in the vicinity of Castac Lake, adjacent to the communities of Frazier Park and Lebec and an existing off-ramp from Interstate-5. The Castac Lake and Grapevine Creek watershed basins have reduced integrity from these human land uses and immediate access from existing transportation infrastructure. These three potential development areas total approximately 24,365 acres of Tejon Ranch. Areas adjacent to Tejon Ranch were not evaluated but may also be suitable for development.

4. A THREATENED CALIFORNIA LEGACY

Tejon Ranch represents a biogeographic crossroads of many Californias—the Sierra Nevada, the Pacific Coast, the Mojave Desert, and the Great Central Valley. It is the last intact connection for plants and animals of these lands that cannot cross water, intensive agriculture, or urban development. It is a place where we can virtually witness the ongoing evolution of California's geology and biodiversity. It is a geography steeped in the history of our state—at stake in severing or even fragmenting this landscape is an enduring legacy for all of California. This extraordinary property should be treated with the same respect and passion that we have for California's other natural cathedrals—Yosemite, Kings Canyon, Sequoia, Joshua Tree, Headwater Forests, and the Hearst Ranch coastal preserve.

Inappropriate development of Tejon Ranch would irreversibly destroy the ecological integrity of this legacy. Consider the direct and indirect impacts of building a city 3/4 of the area of the City of Santa Clarita, far removed from other major population centers across this landscape! The reserve design presented herein conserves all of the interior of the Ranch, while excluding three potentially developable areas at the margins of the Ranch (totaling approximately 24,365 acres),

with immediate access to existing infrastructure. In contrast, the three developments currently proposed for the Ranch—Tejon Industrial Complex, Tejon Mountain Village Project, and Centennial Project and their associated infrastructure—cover over 41,300 acres—over half the area of the City of Bakersfield—and cut into the wildland core of the Ranch, all but eliminate significant historic condor use areas, and destroy and fragment one of the largest and richest native grasslands in Southern California. Moreover, the indirect impacts of these developments would cause far more insidious adverse effects to the region's natural resources and watershed and other ecosystem processes (Attachment B). Given the unknown fate of the remaining, unplanned areas of the Ranch, its remaining natural resource values may be profoundly jeopardized by future development.

Conservation and development of the Ranch should be planned within a regional context—there is just too much at stake not to take this logical step. We must commemorate California's legacy by preserving the continental grandeur of this region, by celebrating its wilderness values in our urbanizing world, and making this natural laboratory accessible to the citizens of the state. We believe that the 246,000-acre reserve design presented herein begins to meet this challenge.

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ATTACHMENT A

Peer Review Workshop Attendees

The following individuals attended the technical peer review meeting to discuss the draft report. We have attempted to address the input of these individuals in the final report; however, these individuals or their agencies of affiliation do not necessarily endorse the results presented in this report.

NAME	AFFILIATION
Laura Colton	California Department of Fish and Game
Bill Asserson	California Department of Fish and Game
Steve Juarez	California Department of Fish and Game
Jeff Single	California Department of Fish and Game
Mike Josselyn	Wetland Research Associates
David Clendenen	The Wildlands Conservancy
Ron Rempel	Independent biologist
Craig Moritz	U.C. Berkeley
Ellen Cypher	California Department of Fish and Game
Brian Cypher	Endangered Species Recovery Program
Joe Decruyenaere	L.A. County Regional Planning
Ileene Anderson	Center for Biological Diversity
Jerre Stallcup	Conservation Biology Institute
Michael White	Conservation Biology Institute
Wayne Spencer	Conservation Biology Institute
Esther Rubin	Conservation Biology Institute
Kristeen Penrod	South Coast Wildlands
Clint Cabañero	South Coast Wildlands

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ATTACHMENT B

Impacts of Habitat Fragmentation by Low-Density Residential Development

Changing land use patterns in natural areas can have profound effects on the species they support. These effects include habitat loss and fragmentation, loss of native species, increases in nonnative and human-tolerant species, and altered physical processes (e.g., hydrologic regimes and fire cycles) that reduce habitat quality. Many of these effects are indirect impacts of development projects (e.g., increasing light and noise, facilitating invasions of nonnative species, and increasing wildlife-human encounters), which can greatly exceed the magnitude of direct impacts on natural resources. Therefore, even though habitats may not be directly impacted by development, habitat values can be lost from indirect impacts of adjacent development and associated human uses and recreational activities.

Habitat loss and habitat fragmentation—breaking up contiguous natural habitats into small patches that are isolated from intact areas of habitat—are considered the single greatest threat to biodiversity at global and regional scales (Myers 1997, Noss and Csuti 1997, Brooks et al. 2002). Over 80% of imperiled or federally listed species in the U.S. are at risk from habitat degradation and loss (Wilcove et al. 2000), and approximately 32% of California's diverse flora and vertebrate fauna are at risk (Stein et al. 2000). Urban sprawl, defined as encroachment of low-density, automobile-dependent development into natural areas outside of cities and towns, imperils 65% of species listed as Threatened or Endangered in California (Czech et al. 2001).

Habitat fragmentation also produces a habitat *edge*, where natural habitat conditions transition to a human-altered condition; this transition in habitat condition produces what are referred to as *edge effects* (Murcia 1995). Edge effects decrease the net, biologically functional area of habitats left undeveloped within landscapes fragmented by development. Edge effects take on many forms, including physical or structural changes (e.g., moisture levels, vegetation density), plant growth rates, and species interactions (e.g., predation competition, brood parasitism, herbivory, pollination, and seed dispersal) (Murcia 1995, Sauvajot et al. 1998). As the precise nature of edge effects is variable and species- or habitat-specific, the extent of habitat impacts is also variable, usually disappearing within 50 m (160 ft) from the edge (Murcia 1995). However, Wilcove et al. (1986) demonstrated effects that extended as far as 1,600 ft from the development/habitat edge.

Development and other human land uses generally facilitate the invasion of nonnative plant species into adjacent natural habitats, especially in small habitat fragments (McConnaughay and Bazzaz 1987, Tyser and Worley 1992, Brothers and Spingarn 1992, Matlack 1993). Invasive nonnative species in landscaping can become established and spread into the interior of natural open space areas. Construction of roads and other infrastructure (e.g., pipelines and transmission lines) and recreational activities within open space disturb existing vegetation, compact soils, and change natural runoff patterns. These alterations facilitate the invasion of nonnative plants, particularly annual grasses and forbs, by providing points of establishment within the interior of

open space areas, where nonnative species can successfully outcompete native species in the altered physical environment. Clearing native vegetation to reduce fire threat and planting non-native ornamental plants around dwelling units also facilitate establishment of nonnative plant species in habitat areas adjacent to development.

Changes in land cover associated with development can modify physical processes that are integral to ecosystem function and thus can alter the dynamics of adjacent, undisturbed ecosystems (Pickett et al. 2001, Saunders et al. 1991). Poff et al. (1997) discuss the concept of the *natural flow regime* of riverine systems as the critical determinant of their biological composition. Because urbanization can modify the natural flow regime of stream systems, aquatic and riparian communities that depend on a natural flow regime are ultimately affected. Urbanization increases the area of impervious surfaces (Paul and Meyer 2001), which increases storm runoff, peak discharges, and flood magnitudes downstream (Dunne and Leopold 1978, Gordon et al. 1992, Leopold 1994). White and Greer (2006) found that increasing watershed urbanization and the use of landscaping irrigation produced increasing dry-season stream flow, which altered the historic composition of the riparian vegetation community associated with the stream. Impervious surfaces can also decrease the infiltration of precipitation into the soil, thus reducing groundwater recharge of streams and their dry-season baseflow (Klein 1979). Urbanization results in increased nutrient and sediment loads, elevated water temperatures, nonnative species invasions, and, ultimately, reduced abundance of native aquatic and riparian species (Paul and Meyer 2001). Impervious surface cover associated with development can be used as a predictor of degradation of aquatic systems; a threshold of 10% of a watershed basin with impervious surface cover is indicative of degraded systems, and the level of degradation increases with increasing amounts of surface cover (Klein 1979, Booth and Jackson 1994).

Urbanization also alters natural fire cycles, as fuel loads are modified and fires are suppressed to protect human lives and property. Increasing human presence in Southern California has been associated with an increased frequency of wildlife ignition from anthropogenic sources (Keeley and Fotheringham 2001). Even very low density development can greatly change the fire regime of an area, and thus the dynamics of this ecological process, by altering fire frequency and fire suppression/protection requirements, such as fuel modification of native habitats and extinguishing fires that could otherwise be allowed to burn naturally. Fire protection activities change the natural fire regime of areas in the vicinity of development, such that they may no longer sustain natural ecological systems and processes. Therefore, the many species that depend on natural physical processes to maintain suitable habitat can be locally extirpated as an area is developed.

While some species are tolerant of or respond positively to human modifications associated with development (i.e., *synanthropic* species), many native species are not (Soulé et al. 1988, Soulé et al. 1992, Bolger et al. 1991, Blair 1996, Crooks 2002). For example, in a study of forest birds in the Northwest, synanthropic bird species, such as house sparrow, American crow, European starling, and rock dove, and nonnative vegetation tend to increase in abundance in the vicinity of urbanization, whereas native forest species decreased in these areas (Donnelly and Marzluff 2004). Habitat fragmentation from development in Southern California has resulted in the loss of top carnivores from small habitat fragments, thereby allowing smaller *mesopredators* (e.g., opossums, skunks, etc.) to increase in number; this has the cascading effect of increasing

predation rates on other species in the community (Soulé et al. 1988, Crooks 2002). Nest predation rates have been shown to be higher closer to habitat edges in other studies as well (Wilcove 1985, Andrén and Angelstam 1988), presumably from a greater abundance of synanthropic predator species. Harrison (1997) documented changes in gray fox diets and home range characteristics between rural residential and undeveloped areas, with foxes in residential areas consuming a higher frequency of mammal prey and anthropogenic food items than in undeveloped areas. Even human use of recreational trails in reserve areas has been associated with changes in bird species composition and a reduced frequency of nesting in the vicinity of trails (Miller et al. 1998).

The alterations of ecosystems by urbanization have been well documented by ecologists (see review by Pickett et al. 2001) and, like their responses to natural gradients (e.g., climate or productivity gradients), ecosystems also predictably respond to urban-rural gradients (McDonnell and Pickett 1990). Landscape-scale ecosystem studies along an 87-mile urban-rural transect in an eastern oak forest demonstrated significant reductions in forest patch size and increases in urban edge (Medley et al. 1995), as well as altered ecosystem processes resulting in modified physical and chemical environments (McDonnell et al. 1997) as one moved toward the urban end of the transect. Medley et al. (1995) also note that the forest habitats in the suburban region of this transect are much more susceptible to fragmentation and recommend that conservation and management actions should be directed at minimizing fragmentation and maintaining sustainable landscape structures.

Numerous studies have documented decreases in the numbers of native wildlife species and increases in the numbers of nonnative species tolerant of human-modified habitats along development-intensity gradients extending from natural open space to urban areas. In the Sonoran Desert outside of Tucson, Arizona, Germaine et al. (1998) found that housing density best explained changes in bird species richness. In this study, nonnative bird species richness was positively correlated with housing density, while the richness of a group of sensitive bird species was negatively correlated with housing density. This pattern is largely a result of the greater abundance of nonnative plants and anthropogenic food sources in urban settings, which allow nonnative bird species to effectively outcompete native specialist bird species. Consistent with this pattern, Donnelly and Marzluff (2004) found that, in western Washington, species richness of native forest bird communities was always higher in areas of exurban development than in suburban or urban areas, whereas the richness of synanthropic species was higher in suburban and urban areas.

In the oak woodlands of the Palo Alto area, both butterfly and bird communities exhibited responses to land use changes along an urban-wildland gradient (Blair and Launer 1997, Blair 1999). This gradient included a highly developed business district and office park, residential neighborhoods, a golf course, open space used for recreational activities (jogging, dog-walking, hiking, and equestrians), and a biological preserve with access for research and docent-led groups only. Along this gradient, both butterfly and bird species found in the biological preserve (the native oak woodland community) dropped out of the community in sites with increasing urbanization and human activity, including the open space recreational area, suggesting any development or increased human use of an area is detrimental to the integrity of the original species assemblage (Blair and Launer 1997). They also found that golf courses, which are

frequently classified as *open space*, do not function as well as natural open space areas for maintaining native species richness of bird and butterfly communities (Blair 1996, Blair and Launer 1997, Blair 1999). Comparable results were found in oak woodlands in the foothills of the Sierra Nevada (Placer County), where the abundance of native oak woodland species declined and the abundance of synanthropic species (e.g., house finch, western scrub jay) increased with increasing development density (Stralberg and Williams 2002). Native species richness and density in riparian habitats have also been shown to decrease adjacent to development and bridges, whereas the abundance of nonnative species increases (Rottenborn 1999).

A few studies have compared responses of wildlife species associated with specific development densities, which allows inferences regarding the threshold of development density at which adverse effects can be observed. For example, significant changes in lizard species composition in the Sonoran Desert outside of Tucson, Arizona was found at housing densities above 1 dwelling unit (DU)/2 acres (Germaine and Wakeling 2001). In forested areas of Canada, Friesen et al. (1995) demonstrated average bird species diversity and abundance were lower in forest patches with housing densities ranging from 1DU/47 acres to 1DU/141 acres than in comparably sized forest patches with no houses present. In this study, bird species diversity and abundance fell rapidly when housing density increased above 1DU/47 acres.

In a mosaic of shrub-steppe and prairie in Colorado, Maestas et al. (2001) assessed plant, bird, and mammalian carnivore community changes along a gradient of land use intensity from exurban development (1 DU/35-49 acres), to private ranch land, to protected public open space. They found that the most nonnative plant species occurred in areas of exurban development and the fewest on private ranches. Human-tolerant bird species (i.e., black-billed magpie, European starling, Brewer's blackbird, American goldfinch, house wren, broad-tailed hummingbird, and Bullock's oriole) were significantly denser in areas of exurban development than on either private ranches or public open space, whereas no statistical difference was found in their densities on private ranches or public open space. Several human-intolerant species (i.e., vesper sparrow, dusky flycatcher, Savannah sparrow, and lark bunting) either were never seen or were statistically less abundant in areas of exurban development. Domestic dogs and cats were detected significantly more frequently and coyotes less frequently in exurban areas.

In a study of exurban development in a shrub oak-sagebrush community in western Colorado, Odell and Knight (2001) examined how bird and mammal species assemblages responded to two different densities of development relative to undeveloped land and their responses relative to distance from individual houses. In this study, Odell and Knight classified exurban development density in their sample plots as high (average of 1 DU/2.4 acres \pm 1 DU/3.7 acres) or low (1 DU/26 acres \pm 1 DU/30 acres). They found that the density of human-tolerant bird species (i.e., American robin, black-billed magpie, brown-headed cowbird, European starling, house wren, and mountain bluebird) were higher in developed areas than in undeveloped areas, and the density of human-intolerant species (i.e., black-capped chickadee, blue-gray gnatcatcher, black-headed grosbeak, dusky flycatcher, green-tailed towhee, orange-crowned warbler, plumbaceous vireo, and Virginia's warbler) was lower in developed areas than in undeveloped areas. Interestingly, the densities of both human-tolerant and human-intolerant species were generally not significantly different between the high and low development density areas, but low

development density areas were almost always significantly different than the undeveloped areas. Odell and Knight also found that the frequency of detection of mammal species followed a similar pattern, with domestic dogs and cats detected more frequently in developed areas and coyotes and foxes detected much more frequently in undeveloped areas, even when compared to the plots in low development density areas. Thus, even at very low exurban development densities, significant reductions of human-intolerant and significant increases in human-tolerant species densities have been demonstrated.

When examining species responses to distance from individual houses, Odell and Knight (2001) found that the density of human-tolerant bird species was always higher and the density of human-intolerant bird species was lower at 30 m (96 ft) from a house than at either 180 m (576 ft) or 330 m (1,056 ft) from a house. This relationship also held for the detection frequency of mammal species, with detections of domestic dogs and cats decreasing with distance from houses (neither was detected at 330 m from houses) and detections of coyotes and foxes increasing with distance from houses. Therefore, in this study there appears to be a threshold of effect of houses on the density of birds and detection frequency of mammals at a distance between 96 and 576 ft.

In summary, a great deal of research conducted within many different ecosystems documents a very clear negative effect of urbanization intensity on biological communities. Urbanization changes many physical and biological characteristics of adjacent natural areas, either via direct impacts, or perhaps more importantly, via indirect impacts. Indirect impacts to wildlife communities are often expressed as an increase in human-tolerant species at the expense of human-intolerant species. Edge effects have been documented to extend at least 100-160 ft into a patch from the edge, but can extend substantially greater distances in specific situations. Thus, accurate impact calculations for development projects must consider indirect impacts beyond the footprint of the development or individual houses and roads themselves. In addition to documenting adverse effects of urban areas, this research also demonstrates significant biological effects of low density suburban or exurban development. Even development densities as low as 1 DU/40-50 acres have been documented to result in reduced abundances of human-intolerant species and increases in human-tolerant species. It is unclear whether significant effects may occur at densities below this threshold, as we found no published studies that explicitly compared effects to development densities above and below this threshold.

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