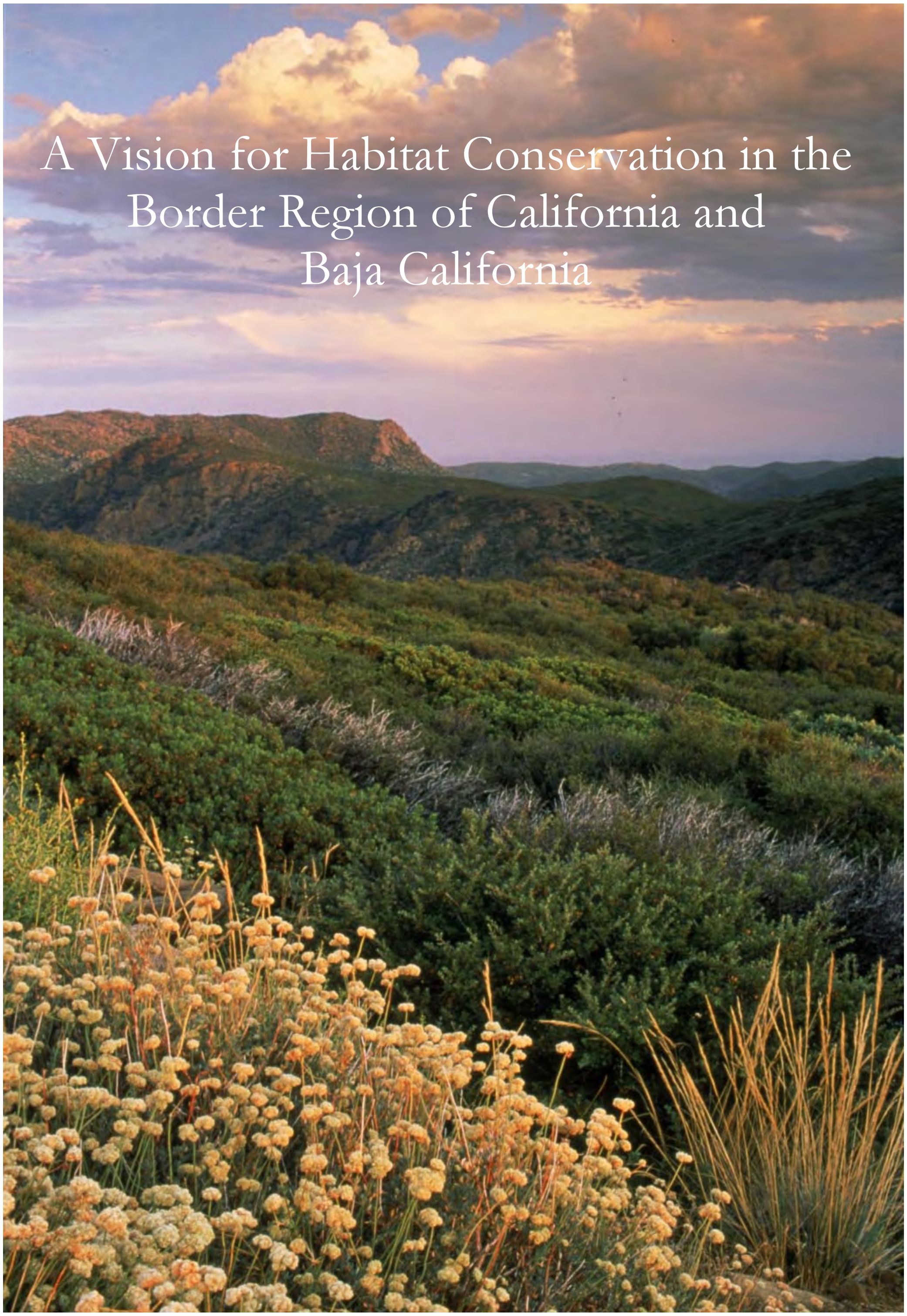
Las Californias Binational Conservation Initiative



September 2004

Las Californias Binational Conservation Initiative

A Vision for Habitat Conservation in the Border Region of California and Baja California

Prepared by

CONSERVATION BIOLOGY INSTITUTE

in partnership with

PRONATURA ASOCIACIÓN CIVIL *and* The Nature Conservancy SAVING THE LAST GREAT PLACES ON EARTH

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-Michael D. White and Jerre Ann Stallcup

1. INTRODUCTION

The Las Californias Binational Conservation Initiative began under the leadership of Pronatura, a nonprofit organization promoting conservation and sustainable development in México. Their objective was to foster the conservation of biodiversity, open space, and *areas rurales productivas* in the border region of Baja California. Pronatura initially conducted studies in the Tijuana River watershed, and ultimately focused on natural resources in the Tijuana-Tecate corridor of Baja California. The Nature Conservancy (TNC) and Conservation Biology Institute (CBI), nonprofit habitat conservation organizations in the United States, joined Pronatura in a binational partnership and expanded the study area to include the Sweetwater and Otay River watersheds in California, the binational Tijuana River watershed, and the Rio Guadalupe watershed in Baja California (Figures 1 and 2). Our collaboration, and our friendships, have sprung from the recognition that conservation of biological resources in this fragile and biologically rich region of over 5 million people must include landscape-scale conservation strategies, sustainable land use planning, and workable long-term management programs. This is an enormous and immediate challenge in the face of rapid regional growth and pressing socioeconomic realities.

This report discusses the biogeographic significance of the California–Baja California border region and proposes a binational conservation network (*enlace conservación*) that recognizes our shared natural resources and our socioeconomic and cultural differences. Our ultimate goal is for U.S. and Méxican governments, academic and research institutions, and nongovernmental conservation organizations to embrace and adopt a shared conservation vision for this border region and to collaborate in its implementation. We hope that this project will provide a framework for launching this process.

Need for the Project

The border region is a biologically diverse and unique landscape, at the center of an internationally recognized biodiversity hotspot (Mittermeier et al. 1999, IUCN 2000). More than 400 species in this region are endangered, threatened, or otherwise sensitive to human impacts. Historically, planning processes on both sides of the border have not recognized the shared natural resources and complementary conservation opportunities in this region. Natural resources and the environmental services they support, such as water quality and water supply protection, flood control, and scenic and recreational resources, function across large landscapes, which are increasingly threatened by expanding human land uses.

Figure 1. Location of study area (hatched) within the South Coast Ecoregion (shaded) of California and Baja California.

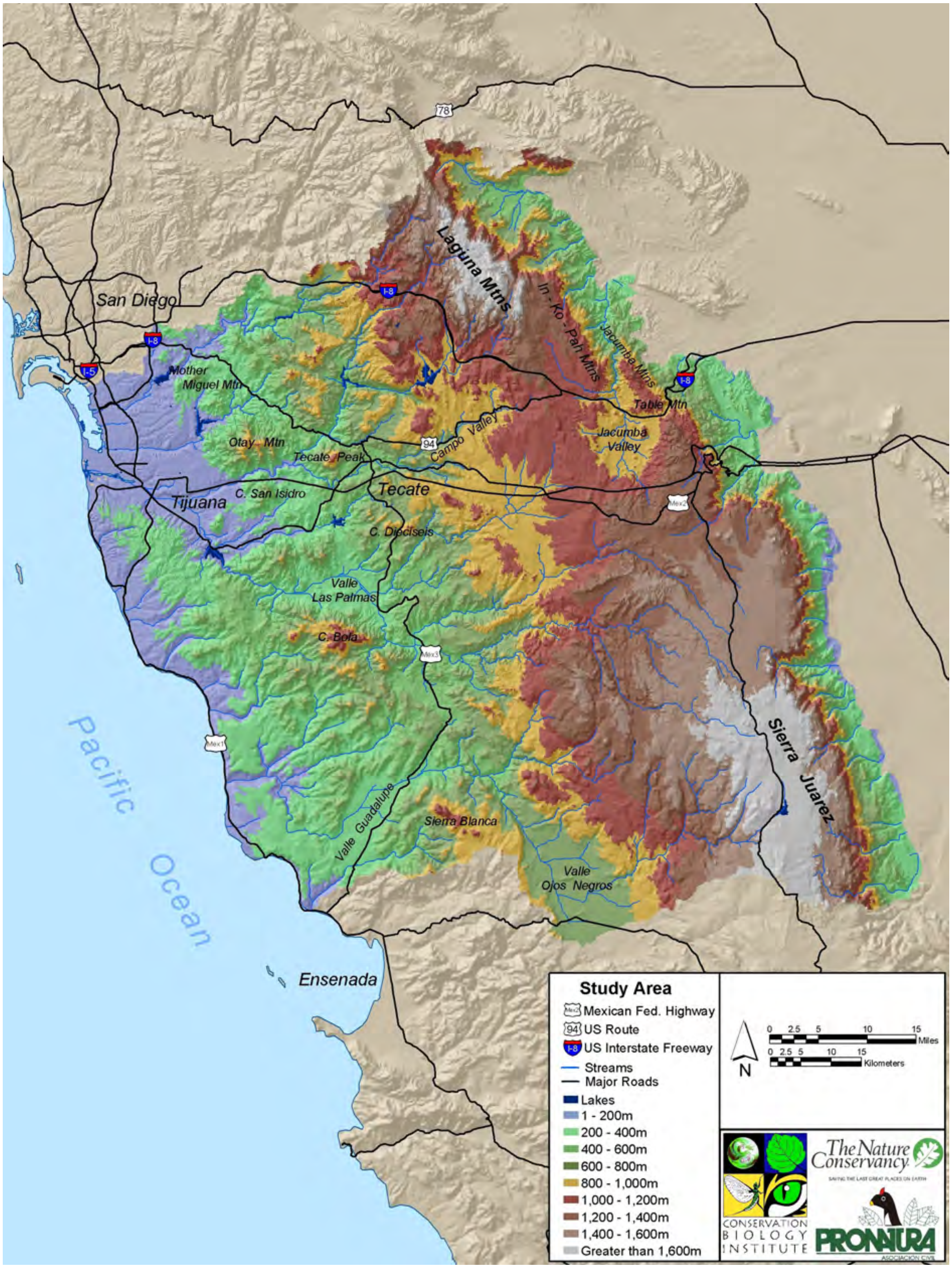

Figure 2. Las Californias Binational Conservation Initiative study area.

Land ownership patterns and available conservation mechanisms differ markedly between California and Baja California, complicating cooperative conservation planning. Within the Las Californias Binational Conservation Initiative study area, the U.S. federal government and State of California have already designated more than 375,000 acres (150,000 ha) as protected, public open space, which is complemented by more than 13,750 acres (5,500 ha) of County and City lands. In contrast, only 14,373 acres [12,350 acres (5,000 ha) at Parque Constitución de 1857 and 2,023 acres (819 ha) at Rancho Cuchumá)] are currently protected within the Baja portion of the study area.

Connectivity between wildland areas is critical to maintaining the values of these existing conservation investments. Historically, species dispersed freely across the international border, but road and highway corridors and associated developments are now major impediments to wildlife movement. Interstate-8 and State Road-94 in California and Highway-2 in Baja California largely sever connectivity between habitats north and south of these roads (Figure 2). Increasing development along these transportation corridors is closing off opportunities for maintaining trans-border habitat linkages. Sand mining in stream channels and riparian habitats, low density rural development of San Diego's backcountry, and agricultural activities on both sides of the border are affecting habitats and water supplies, which could severely impact human, plant, and animal communities. In addition, Native American Indian tribes have proposed new casinos and related projects in southern and eastern San Diego County. Their lands are governed by tribal regulations, which may not consider regional biodiversity protection and habitat connectivity needs outside the reservations.

The urgency of the Las Californias Binational Conservation Initiative is emphasized by the rapid urbanization of the San Diego, Tijuana, and Tecate region and their adjacent suburbs. Population growth and development patterns on both sides of the international border are fragmenting our landscape and quickly compromising our ability to conserve a functional and representative portion of the South Coast Ecoregion in Southern California and Baja California. Largely intact areas with reasonable land values in the eastern portion of the border region present a short-term opportunity to shape binational land protection patterns.

Increased urbanization is coupled with a human need for increased open space, particularly in Baja California where there is very little public land or designated open space. The patterns of ownership, land uses, topography, and biological resources suggest the need for binational conservation areas that represent these patterns. Conservation of habitats along the border, as opposed to allowing these areas to continue to be consumed by urban sprawl, would not only protect ecological integrity but would also symbolize a unified conservation ethic for the two countries and lay the framework for binational cooperation.

Objectives

The Las Californias Binational Conservation Initiative proposes a binational conservation vision for the border region that will:

1. *Encompass biogeographically important and unique natural resources, distributed from the coast, across the mountains, to the desert.*
2. *Identify threats to maintaining an interconnected conservation network and sustaining ecosystem processes.*
3. *Identify large, intact wildlands that represent the region's biodiversity.*
4. *Link protected areas to facilitate wildlife movement and protect existing conservation investments.*
5. *Promote collaboration in implementing land protection strategies that result in secure and sustainable conservation.*
6. *Lay the foundation for a binational park system that connects the Parque Constitución de 1857 in México to wilderness areas, forests, and park land in the United States.*
7. *Heighten the visibility of this little-studied, multi-cultural area and the global importance of implementing a strategy that conserves the integrity and functionality of its ecosystems, while enriching the health, economy, and standard of living of its residents.*

The following sections summarize how the biogeography of the Las Californias border region results in a remarkably diverse and unique flora and fauna, and how this diversity is threatened by human population growth and human land uses. In subsequent sections, we describe how these patterns of biodiversity and human land uses influence our approach for developing a conservation network, and how these patterns, along with various considerations for implementation, ultimately drive decisions on sustainable habitat conservation and sustainable patterns of human growth and land uses.

2. CONSIDERATIONS FOR HABITAT CONSERVATION PLANNING

Biogeography of the Study Area

Geomorphologic diversity

The shape and geologic composition of the landscape of Southern California - Baja California is a product of its long and complicated geologic history. Over the last 150 million years, plate tectonics has produced ancient volcanic islands, intruded vast quantities of magma, uplifted mountains, and dotted the landscape with volcanic flows and cinder cones. Some of these formations have been eroded and buried beneath younger sediments, folded and metamorphosed by the vast pressures of overlying rock, only to be uplifted and exposed again millions of years later. Within the last 5 million years, activity along the San Andreas Fault has pulled the Baja California peninsula away from mainland México, creating the Gulf of California and uplifting the Peninsular Ranges to near their current elevations (Grismer 1994).

This dynamic history has produced a diverse topography with a complex geology (Gastil et al. 1981). In coastal areas, uplifted marine sedimentary rock has formed mesas, whereas more recent volcanic flows have created tablelands in southern and eastern portions of the region. Remnants of Jurassic-age volcanic islands form part of a discontinuous, low mountain range in the coastal zone (Figure 2). These metavolcanic and gabbro peaks, including Otay Mountain, Tecate Peak, Cerro Dieciseis, and Cerro Bola, are rich in mafic minerals such as iron and magnesium. Several large inland valleys, including Valle de Ojos Negros, Valle de las Palmas, Campo Valley, and Jacumba/Jacumé valley, generally separate the coastal mountains from the inland Peninsular Ranges.

The northwest trending mountain ranges—Laguna, In-Ko-Pah, Jacumba Mountains, and Sierra Juárez—are part of the Peninsular Ranges. The Sierra Juárez in Baja California and the Laguna Mountains in California, both reaching elevations of >5,800 ft (1,800 m), are separated by a broad saddle approximately 3,000 ft (1,000 m) in elevation; thus, from a biological viewpoint, these mountains represent high elevation islands of habitat. The Peninsular Ranges are a mixture of igneous and metamorphic rocks that can be distinguished by age and composition into an older (>100 million years) western zone and a younger (<100 million years) eastern zone. The western zone is notable for the occurrence of gabbro peaks, such as Tecate Peak and Cerro Bola. The boundary between these zones, generally trending northwest to southeast, lies to the east of the Laguna Mountains, curves to the west south of the Lagunas, and swings south through the Campo Valley into Baja California (Walawender 2000). This region, from Campo and El Hongo to Jacumba and Jacumé, is extremely diverse in its geological composition and ranges in age from over 300 million years old to less than 20 million years old.

Geologic forces have tilted the foundation rock of the Peninsular Ranges (the Peninsular Ranges Batholith) to the west, producing a relatively gently sloping western slope and a very steep eastern escarpment. Erosion and faulting has produced rolling foothills carved by gentle, westward-draining streams on the western flank of the mountains, whereas the eastern flank is dramatically shear, with steeply incised canyons that drain to the desert floor.

Climate patterns

Climate patterns also shape patterns of floral and faunal diversity. Climate patterns across the border region begin to transition from a Mediterranean climate pattern in the north to a more Sonoran Desert climate pattern in the south, both with a high inter-annual variability (Axelrod 1978, Delgadillo 1998, Western Regional Climate Center 2004). These patterns have shaped the life histories of the species that have evolved here and distinguish this region from adjacent geographic locations.

Annual precipitation increases with increasing elevation, with significant contributions from snowfall at the highest elevations. Summer monsoonal precipitation becomes increasingly more important in the southern portion of the border region, particularly at higher elevations in the Sierra Juárez and coastal range (Delgadillo 1998, Minnich et al. 2000). The Peninsular Ranges produce a rain shadow such that the eastern escarpment of the Laguna Mountains and Sierra Juárez is much drier than the same elevations on their western slopes.

Temperatures rarely ever reach freezing in coastal areas, and daily temperature fluctuations are moderate. Inland from the coast, daily temperatures fluctuate widely, and freezing is common during the winter, particularly at higher elevations. Delgadillo et al. (1995) distinguish four bioclimate zones in the Baja California portion of the study area—*termomediterráneao* (coastal zone), *mesomediterráneao* (foothills), *suprameditterráneao* (mountains), and *mesotropical* (Sonoran Desert on eastern side of the Sierra Juárez)—which also correspond to changes in vegetation community composition.

Hydrography

The border region is defined by major hydrographic units or watersheds that drain both the western and eastern slopes of the Peninsular Ranges (Figure 3). The largest watersheds drain the western slope and include (from north to south) the Sweetwater River, Otay River, Tijuana River, and Rio Guadalupe. Several small, unnamed hydrographic units drain directly to the Pacific Ocean. On the eastern slope, numerous drainages flow to two major hydrographic units—the northern Anza-Borrego, which flows to the Salton Sea, and the southern Laguna Salada.

Historically, there was likely a mix of ephemeral, intermittent, and perennial streams in the region. Ephemeral and intermittent flow is characteristic of low-order tributaries and many of the eastern-flowing streams. Perennial flow typically occurs in drainages with significant contributions from springs or in reaches where underlying geology forces water to the surface. However, current hydrologic regimes have been altered in most of the major drainages as a result of surface impoundments, groundwater pumping, irrigation, and urbanization.

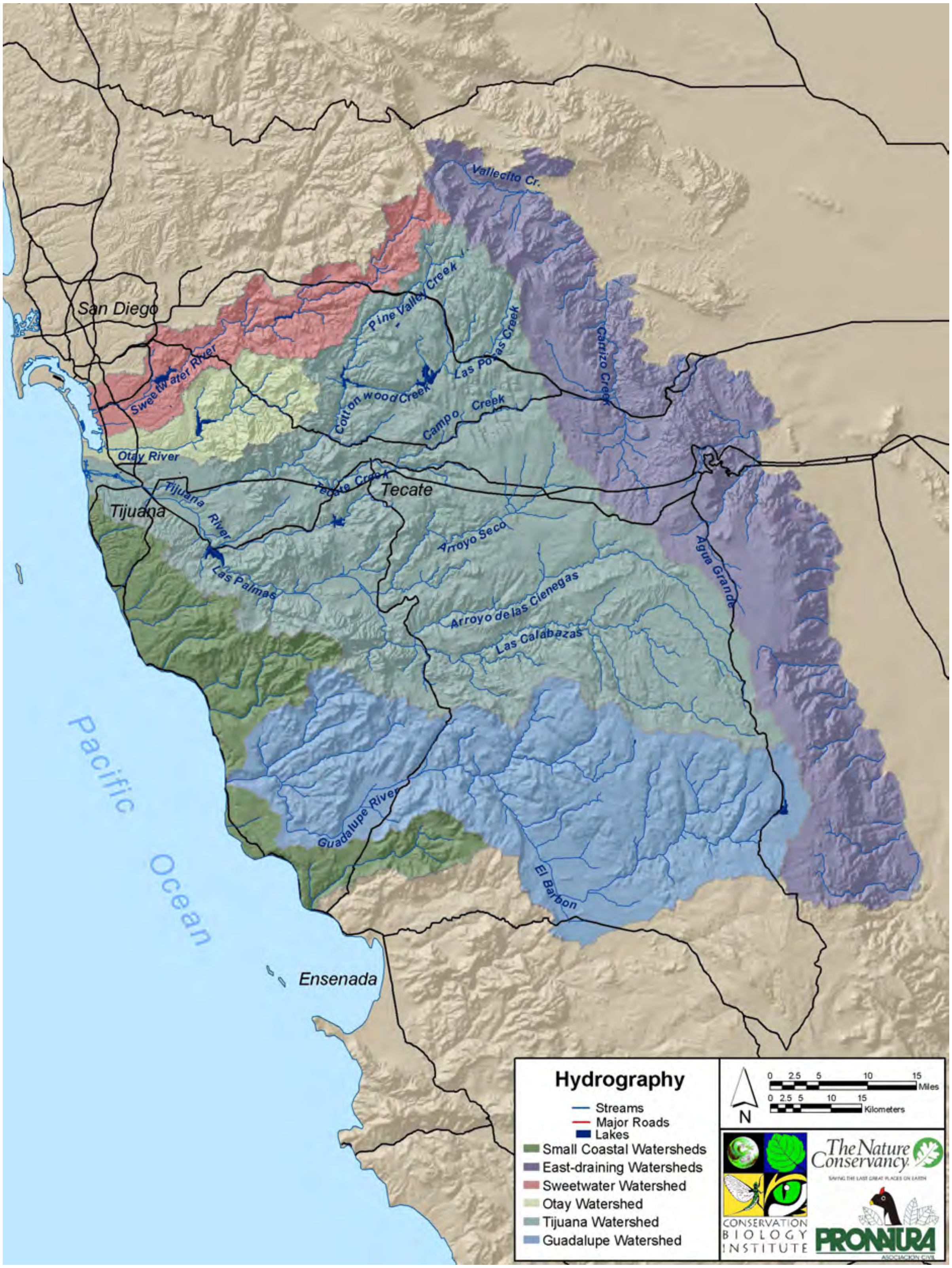

Figure 3. Hydrography.

Floristic regions and plant diversity

Since the concept of identifying biodiversity hotspots was introduced in 1988 (Myers 1988), it has become a common tool for establishing global conservation priorities (Myers 1990, Mittermeier et al. 1998, Mittermeier et al. 1999). Biodiversity hotspots are areas supporting high concentrations of species, particularly endemic species. Conservation International has designated the California Floristic Province, which stretches from Northern California to El Rosario in Baja California, as one of the world's 25 biodiversity hotspots. Although these hotspots comprise less than 1.5% of the Earth's vegetated land surface, they are estimated to contain over 70% of all vascular plant species. Moreover, as measured by species endemic to only a single hotspot, these 25 locations account for 44% of endemic plant species diversity, 35% of terrestrial vertebrate species, and 75% of all terrestrial animal species listed as threatened by the IUCN-World Conservation Union (Mittermeier et al. 1998, Mittermeier et al. 1999).

The border region lies at the center of the South Coast Floristic Region (Figure 1), which is renowned for supporting the highest number of endemic and relict plant species in the California Floristic Province (Stebbins and Major 1965, Raven 1988, Hickman 1996). Thus, the South Coast Region represents a unique portion of the overall biodiversity for which the California Floristic Province is recognized (Mittermeier et al. 1998, Myers et al. 2000, Stein et al. 2000). The border region also includes one of two distinct centers of relict plant species frequency in California (Stebbins and Major 1965, Raven and Axelrod 1978), including numerous endemic plant species, many of which are associated with unique or restricted soil or habitat types (Appendix A).

The border region historically has been divided into three phytogeographic regions based on climate, topography, and species composition—Californian, Coniferous Forest, and a small portion of Colorado (Microphyllous) Desert (Munz and Keck 1959, Wiggins 1980). Delgadillo et al. (1995) subdivide the Coniferous Forest into two bioclimate zones, restricting coniferous forests to the highest elevations (*suprameditерráneao*). Within these phytogeographic regions, a rich mosaic of vegetation communities reflects the variability of physical and climatic factors at fine geographic scales (Figure 4). Vegetation community mapping within the California portion of the study area has identified 84 native community types (Appendix B), although undoubtedly there are many more unique species associations (i.e., vegetation series, associations, or unique stands, Sawyer and Keeler-Wolf 1995) that are yet to be described. Three general communities are representative of large portions of the border region—coastal sage scrub, chaparral, and coniferous forests—and provide good examples of its importance with respect to plant community biogeography.

Coastal sage scrub is a low-growing, partially drought deciduous, vegetation community that occurs along the coastal zone from the northern California border to El Rosario, Baja California (Axelrod 1978). In Southern California and northern Baja California, it is greatly restricted relative to its original distribution and highly threatened by development. The coastal sage scrub community has been variously divided into major geographic divisions based on species composition (Axelrod 1978, Westman 1983, Zippen and Vanderwier 1994). Each division supports distinct elements of the overall biogeographic diversity of this community type. Three

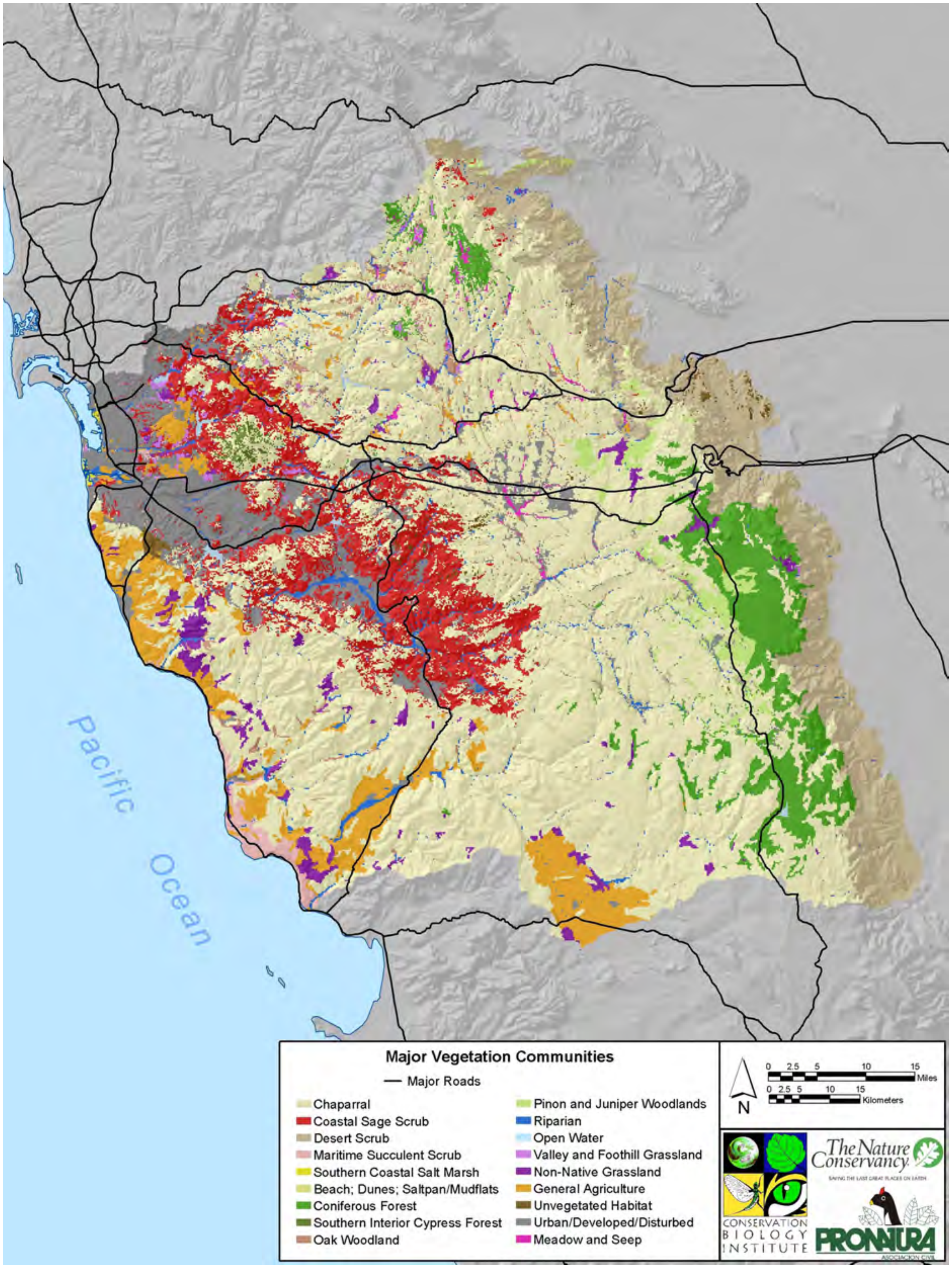

Figure 4. Major vegetation communities

coastal sage scrub divisions—Diegan sage scrub along the coast, Riversidian sage scrub to the east, and Martirian succulent scrub to the south (Westman 1983)—occur in the border region. Martirian succulent scrub differs from the other two communities by supporting an increased abundance of stem-succulent species [e.g, dudleyas (*Dudleya* spp.), Shaw's agave (*Agave shawii* ssp. *shawii*), velvet cactus (*Bergerocactus emoryi*), coast barrel cactus (*Ferocactus viridescens*), sour pitaya (*Stenocereus gummosus*), fishhook cactus (*Mammillaria dioica*), coastal prickly pear (*Opuntia littoralis*), chollas (*Cylindropuntia* spp.)], and other species indicative of the transition to Sonoran Desert communities further to the south (Westman 1983, Zippen and Vanderwier 1994, Delgadillo 1998).

Chaparral is comprised of dense thickets of hard-leaved (sclerophyllous) shrubs 4-12 ft (1-4 m) tall (Hanes 1965, Keeley 2000). The chaparral community is often classified relative to the dominant species (e.g., chamise chaparral, red shank chaparral, etc.), which vary according to soil conditions, aspect, elevation, and climate. California has a high diversity of chaparral types or communities; for example, Hanes (1965) identified 10 chaparral types, whereas Holland (1986) identified 36 unique communities within California alone! The border region supports 19 chaparral communities (Holland 1986) as a result of variable physical and climatic conditions, extending from the coast to the desert transition zone. Southern mixed chaparral commonly occurs from the coastal zone to the western foothills of the Peninsular Ranges, where it transitions to northern mixed chaparral, semi-desert chaparral, and montane chaparrals. The higher plateaus of the Sierra Juárez, in particular (Delgadillo 1998, Minnich and Franco Vizcaìno 1998), support the red shank chaparral (*Adenostoma sparsifolium*) community, which is unique to Southern California and northern Baja California (Hanes 1965).

Coniferous forest communities or species associations are also classified on the basis of dominant species (Delgadillo 1998, Holland 1986, Sawyer and Keeler-Wolf 1995), many of which are at or near the edges of their ranges within the border region (Minnich 1986, Minnich 1987, Delgadillo 1998). Closed-coned pine forests are represented by stands of knobcone pine (*Pinus attenuata*) in the coastal Sierra Blanca of Baja California. This population is disjunct from the next closest population in the Santa Ana Mountains of Southern California (Vogl 1973, Vogl et al. 1988) and is presumably a relict from times when cooler and moister climate conditions prevailed. Cypress forests are represented by Tecate cypress (*Cupressus forbesii*), which occurs in small, isolated groves on the archipelago of metavolcanic and gabbro peaks in the coastal range. Tecate cypress groves on Otay Mountain, Tecate Peak, and Guatay Mountain in San Diego County represent the northern limit of an extensive distribution of this species that extends south 100 miles (160 km) into northern Baja California (Minnich 1987).

Pine forests in the region are dominated by Jeffrey pine (*Pinus jeffreyi*), with a few small stands of incense cedar (*Calocedrus decurrens*) occurring near streams (Minnich 1987) and small stands of Coulter pine (*Pinus coulteri*) (Beauchamp 1986, Minnich and Franco Vizcaìno 1998). The Laguna Mountains and Sierra Juárez support two of the southernmost high-elevation islands of Jeffrey pine forest (the southernmost is in the Sierra San Pedro Mártir) within a more extensive and continuous distribution to the north. Pinyon and juniper woodlands also occur above 3,000 ft (1,000 m) in the northern Sierra Juárez and Jacumba Mountains and are dominated by Parry pinyon (*Pinus quadrifolia*), singleleaf pinyon (*Pinus monophylla*) on the drier eastern escarpment of the Peninsular Ranges, California juniper (*Juniperus californica*), and various chaparral species (Minnich 1987, Minnich and Franco Vizcaìno 1998).

Patterns of faunal diversity

The distribution of fauna in the border region can be grouped into biotic provinces that generally correspond to phytogeographic regions—Californian (Northwestern Coastal Slope), Coniferous Forest (Vancouverian), and Lower Colorado Valley (Sonoran or Colorado Desert) (Truxal 1960, Erickson and Howell 2001, Grismer 2002). Like plant species, the distributional patterns of animal taxa are a product of millions of years of geologic, climate, and evolutionary change. Grismer (1994, 2002) described historical biogeographic patterns to explain distributions of related herpetofauna taxa on and adjacent to the Baja California peninsula. Grismer's research provides insight into the derivation of faunal diversity and its complex evolutionary dynamics in the border region. For example, this area supports species whose closest kin are in mainland México, who rafted into their present position and evolved into new species as Baja California pulled away from the mainland. Many species show a taxonomic affinity to more northerly distributed species, their ancestors presumably invading the border region from habitats to the north. Some species evolved from taxa that were formerly widely distributed in Southwestern North America but were split by the northernmost extension of the ancestral Gulf of California about 3 million years ago. This allowed genetic divergence of populations on either side of the Gulf and subsequent recontact of these differentiated populations once the Gulf retreated to its present position. Several species were formerly more widespread in their distributions when climates were wetter, but have become restricted to higher elevations and stream courses with the onset of drying in the Pleistocene.

Among many bird species, the border region is a vulnerable point along dispersal routes between the two countries, further emphasizing the need for landscape-scale protection strategies. At least 12 long-distance migrants circumvent crossing the Gulf of California by moving through the border region (Unitt personal communication). The ranges of coniferous woodland species, if not reaching their southern limits here, have a distributional gap straddling the border; for example, the mountain chickadee (*Parus gambeli*) and dark-eyed junco (*Junco hyemalis*) are both divided into different subspecies in the California and Baja portions of the study area. The distribution of oak woodlands in the border region is patchy, thus forming bottlenecks in the ranges of many species [e.g., western wood peewee (*Contopus sordidulus*), acorn woodpecker (*Melanerpes formicivorus*), lazuli bunting (*Passerina amoena*), Hutton's vireo (*Vireo huttoni*), white-breasted nuthatch (*Sitta caroleninsis*)] (San Diego Bird Atlas 2004). Several riparian or freshwater birds reach the southern end of their breeding distribution near the border. For two declining species, the gray vireo (*Vireo vicinior*) and sage sparrow (*Amphispiza belli*), the extensive chaparral along the border between Otay Mountain and Jacumba likely serves as an important dispersal corridor (Unitt personal communication). Habitat specialists, such as the grasshopper sparrow (*Ammodramus savannarum*), are especially sensitive to habitat fragmentation and urbanization and need landscape integrity for dispersal.

Dramatic geologic and climate dynamics over millions of years drove evolutionary change and diversification of species within the border region, and evolutionary dynamics continue today. The distributions of fine-scale climate patterns (e.g., coastal-mountain-desert rainfall and temperature gradients), parent rock types and soils (e.g., clay soils derived from metavolcanic and gabbro rocks), and unique and isolated habitats (e.g., vernal pools, closed-cone pine forests) provide unique biophysical conditions that continue to fuel evolutionary processes. The large number of taxa that are endemic to the border region or with ranges in contact within the border region (Appendix A) affirm its importance as a *staging ground for evolution* (Jockusch and Wake 2002). The only way to ensure that evolution can continue innovating, and keeping pace with climatic and other anthropogenic changes in the region, is to conserve large, intact, and connected landscapes where ecological and evolutionary processes can continue at a grand scale.

Threats and Vulnerability

Many of the unique natural resources of the border region have already been lost to development, and ecological processes that sustain these resources have been altered by human land uses. The greatest loss has been in the coastal zone, where urban development and roads are most dense. Further inland, human threats are defined more by rural residential settlements, industrial and agricultural uses, and associated infrastructure. However, there are still large patches of habitat that are not currently altered by human uses. This section describes the potential impacts of human land uses to natural resources and how these issues should be considered in habitat conservation planning in the region.

Habitat fragmentation by development and roads

The loss and fragmentation of habitats is 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). It has been estimated that 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). Within an area defined as the Southern California Mountains and Valleys region, the most commonly cited endangerment factors are residential and industrial development, introduction of exotic species, agricultural development, heavy equipment, and grazing (Flather et al. 1998).

The border region provides a textbook example of the effects of habitat fragmentation. Road construction and conversion of land to urban and intensive agricultural land uses have fragmented and isolated natural habitats, particularly in the coastal zone. The remaining habitat fragments, lying within a matrix of altered land cover, experience edge effects in the form of altered physical conditions (Saunders et al. 1991, Pickett et al. 2001) and fire regimes (Keeley and Fotheringham 2001), increased invasions by exotic plant and animal species (Suarez et al. 1998, Brothers and Spingarn 1992), changes in vegetation structure (Pickett et al. 2001), loss of top predators and changes in interspecific interactions (Bolger et al. 1991, Crooks 2002), and altered population dynamics (Soulé et al. 1992). Roads have even broader geographic impacts, serving as sources of pollution, altering hydrologic patterns, disrupting migration patterns, and causing direct mortality via road kill (Beier 1995, Trombulak and Frissell 2000).

Modifications to watershed processes

Poff et al. (1997) discuss the concept of the *natural flow regime* of riverine systems as the critical determinant of their biological composition. The natural flow regime can be described by five key characteristics—magnitude, frequency, duration, timing, and rate of change of discharge (Poff et al. 1997). Because land use changes, such as urbanization and agriculture, can modify the natural flow regime of stream systems, aquatic and riparian communities that depend on a natural flow regime are ultimately affected. Agriculture and some urban land uses can deplete groundwater supplies and surface flow in streams. 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). Importing water into an urban watershed for landscape irrigation may also increase dry-season base flows and can cause intermittent streams to become perennially flowing, thereby altering the composition of riparian vegetation communities (White and Greer in press). Urbanization and agricultural development produce other adverse changes to watersheds and stream systems, including increasing nutrient and contaminant loads, elevating water temperatures, facilitating invasion by nonnative aquatic species, and, ultimately, reducing the abundance of native aquatic and riparian species (Paul and Meyer 2001).

Climate change

Conservation scientists are concerned with the implications of global climate change for native biodiversity (Peters and Darling 1985, Kareiva et al. 1992, Malcolm et al. 2001). Climate models suggest that Southern California will experience increased winter precipitation, hotter and drier summers, and more severe El Niño events (Field et al. 1999). One consequence of these changes will likely be shifts in the distribution of vegetation communities and species ranges. It has been suggested that areas with high physical heterogeneity will allow species greater *choices* in the face of changing conditions (Meffe and Carroll 1997). Therefore, protecting contiguous habitat areas with broad elevational and other environmental gradients is critical to accommodating these shifts in species distributions.

3. APPROACH FOR DEVELOPING A CONSERVATION NETWORK

Different standards and criteria have been used to assess conservation values and develop conservation priorities (Pressey et al. 1993, Noss et al. 1997, Soulé and Terborgh 1999, Groves et al. 2000, 2002; Noss 2002, Groves 2003, Margules and Pressey 2000, Carroll et al. 2001). Conservation assessments generally focus on specific conservation objectives, depending on the information available and the ultimate implementation strategies. For example, assessments may prioritize protection of endemic or imperiled species or species requiring large areas for survival (focal species analysis), conservation of biogeographically unique or representative resources (representation analysis), conservation of areas exhibiting high landscape integrity or connectivity, protection of open space for human quality of life, or some combination of these. Because each set of conservation targets will likely have a unique distribution, different conservation approaches may prioritize different areas of the landscape.

Because there is not comprehensive data on species distributions for the study area, we used digital land cover information (vegetation communities, land uses, and roads) to identify areas with the following characteristics:

1. High ecosystem integrity, to maintain viability of resources and ecological processes, such as natural fire and stream flow regimes (e.g., Noss 1983, Poiani et al. 2000).
2. Representative of regional diversity patterns, i.e., including vegetation community types across the full range of biophysical conditions and climate gradients (Scott et al. 2001).
3. Support irreplaceable resources that are unique or highly restricted in their distribution (e.g., stands of knobcone pine, tecate cypress groves, Martirian succulent scrub) (Pressey et al. 1993).
4. Matrix lands between these areas that are compatible with human land uses and can be managed as working landscapes (Margules and Pressey 2000, Lindenmayer and Franklin 2002).

Vegetation Communities Map

Constructing a seamless, composite vegetation data set for the entire 2,846,052-acre (1,151,761-ha) study area required merging data from five different sources with variable resolutions and vegetation classification systems (refer to Appendix B for more detail). Relatively detailed data sets were available for San Diego County (San Diego Association of Governments and Anza-Borrego Desert State Park) and the binational Tijuana River watershed (CESAR 1995). The INEGI (1997) vegetation data for Baja outside of the Tijuana River watershed are of lower resolution and used a very different vegetation classification system. We used other non-digital data sources to assist in characterizing different portions of the region (e.g., Minnich and Franco Vizcaìno 1998). The data limitations encountered in this project emphasize the need for additional input and research by experts to document and fully understand the overall biodiversity, ecological functions, and ecosystem processes in the region.

Technical Approach—SPOT

The Spatial Portfolio Optimization Tool (TNC 2003) allows us to identify places within the border region that optimize achieving biodiversity conservation goals, in the most intact portions of the landscape, with the least amount of fragmentation. SPOT uses digital data layers as inputs to derive conservation portfolios that describe the biological integrity of the area (i.e., the *cost surface*, Figure 5), the distribution of biological resource targets (in this case, vegetation communities), and conservation goals for these targets. SPOT provides an objective way to identify priority conservation areas, which can be replicated by others to validate our results and modified as finer resolution data and additional information become available. Appendix B describes the inputs to SPOT (i.e., cost surface, biological targets, and goals), the approach used to derive the conservation network from the SPOT outputs, and constraints and other issues that influence our results.

Biological integrity of the landscape

Human modifications of the landscape are the largest threats to the integrity of biological resources and ecosystem functions. Therefore, we used the distribution of urbanization, agriculture, and roads as a measure of the human modification of the landscape in constructing the cost surface used by SPOT (Figure 5). The cost surface was also used to assess the integrity of watershed subbasins—i.e., the degree to which a watershed unit has not been altered by human activities and thus may retain intact watershed processes—and to assist in identifying priority conservation areas.

Biological resource targets and conservation goals

We relied on vegetation communities as biological resource targets for use in SPOT. This *coarse-filter* approach to identifying priority conservation areas (Groves 2003) potentially overlooks important conservation targets, such as individual species or unique physical habitats. We attempted to compensate for shortcomings in our data, as well as differences in data classification and resolution, by stratifying the study area based on known climate and biodiversity gradients (Figure 6). Thus, we forced SPOT to identify conservation portfolios in all portions of the study area, presumably increasing the potential for capturing diverse community types and the species they support.

We defined conservation goals as percentages of each vegetation community that should be included in portfolios within each stratum (Table B-3, Appendix B). These numerical targets are consistent with those used in other conservation planning exercises [e.g., Natural Community Conservation Planning (NCCP) programs in California, TNC ecoregional planning, Groves 2003]. To test the sensitivity of SPOT outputs, we evaluated a range of goal sets, representing a range of conservation objectives. For example, Goal set 1 prioritized irreplaceability (in this case, vegetation communities that are rare or restricted in distribution), while Goal set 5 used uniformly low goals among vegetation communities to emphasize habitat intactness.

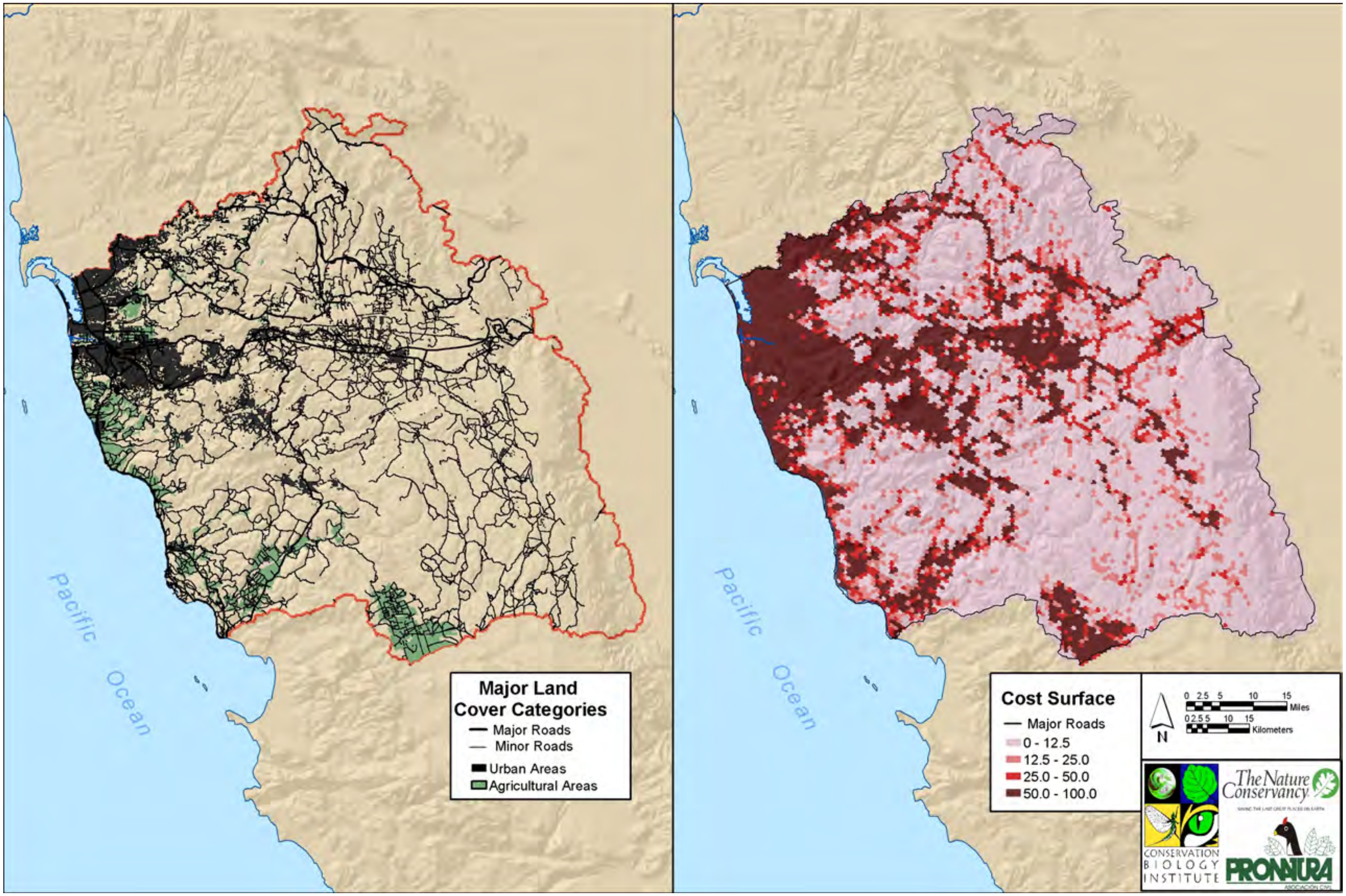

Figure 5. Cost surface for SPOT.

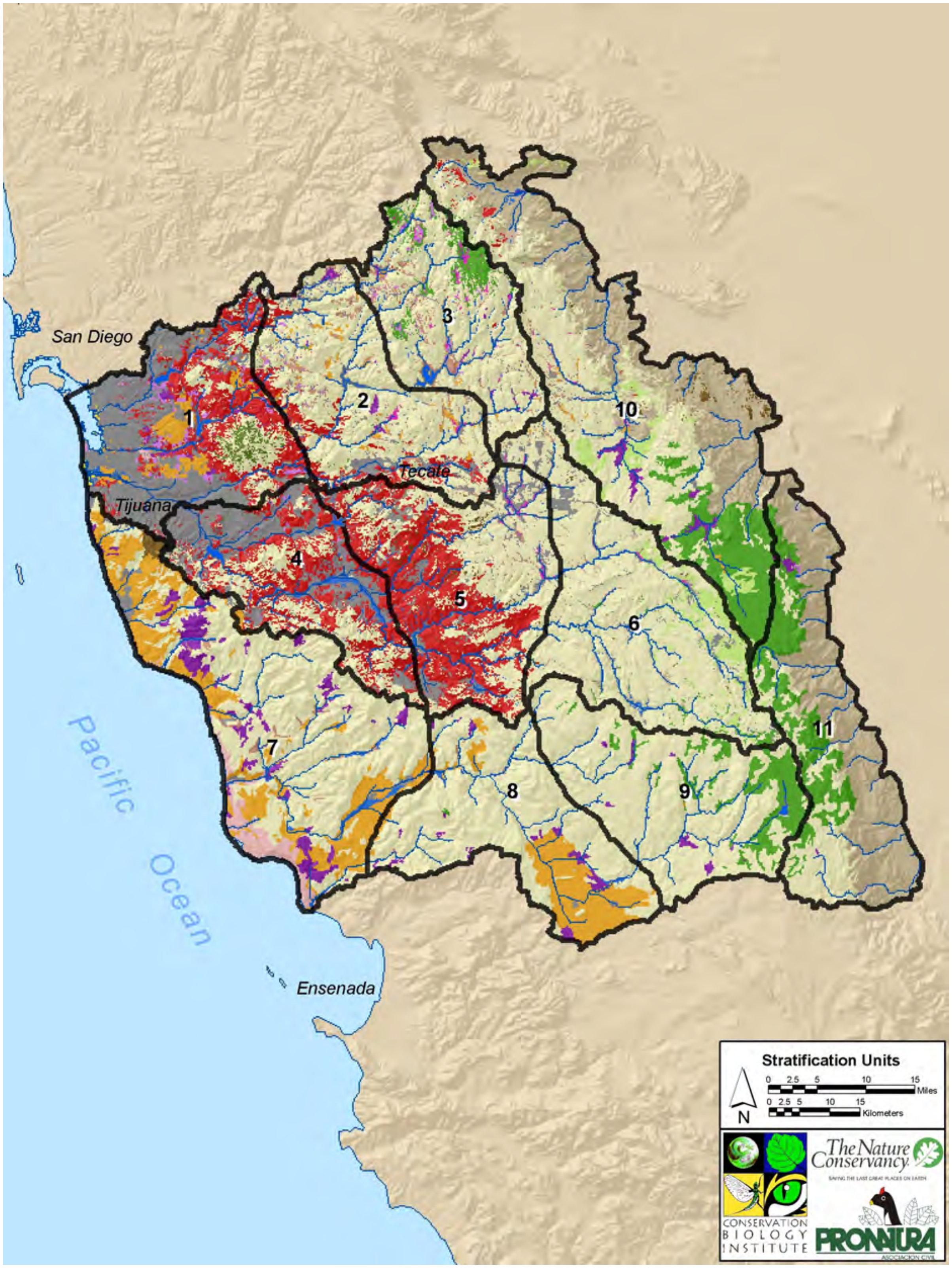

Figure 6. Stratification.

Refining SPOT outputs

To account for the random element in the generation of portfolios by SPOT, we ran SPOT ten times for each set of goals and determined the frequency of cells selected in each of the ten sets of portfolios. Cells selected in all ten SPOT runs indicate that they are the highest priority for achieving that set of goals. Figure 7 shows SPOT results using Goal sets 1 and 5, depicting the frequency of selection in each of the ten respective SPOT runs. We used the combinations of these SPOT portfolios to categorize the entire study area relative to different conservation objectives or functions by identifying groups of cells that were selected with different frequencies:

- Category A—nodes of regional biodiversity that meet both integrity criteria and vegetation conservation goals.
- Category B—intact habitat areas that meet some vegetation conservation goals (but to a lesser degree than Category A areas) and that buffer and provide connectivity between Category A areas.
- Category C—natural areas that are fragmented by roads and human uses, but which support isolated, high value resources (e.g., vernal pools) and serve as habitat linkages.
- Category D—areas dominated by urban communities and intensive agriculture (e.g., orchards, dairies, vineyards).

We then refined the boundaries of these conservation categories by referring to more detailed sources, including:

- Phase I studies in the Tijuana-Tecate corridor (Pronatura 2004)
- Cross-border linkage studies (CBI 2003)
- Multiple Species Conservation Program (MSCP)
- Existing literature, museum and other species records from experts
- Studies of existing protected areas (Figure 8)
- Watershed boundaries and topography
- Human modifications to the landscape (e.g., new development, roads)

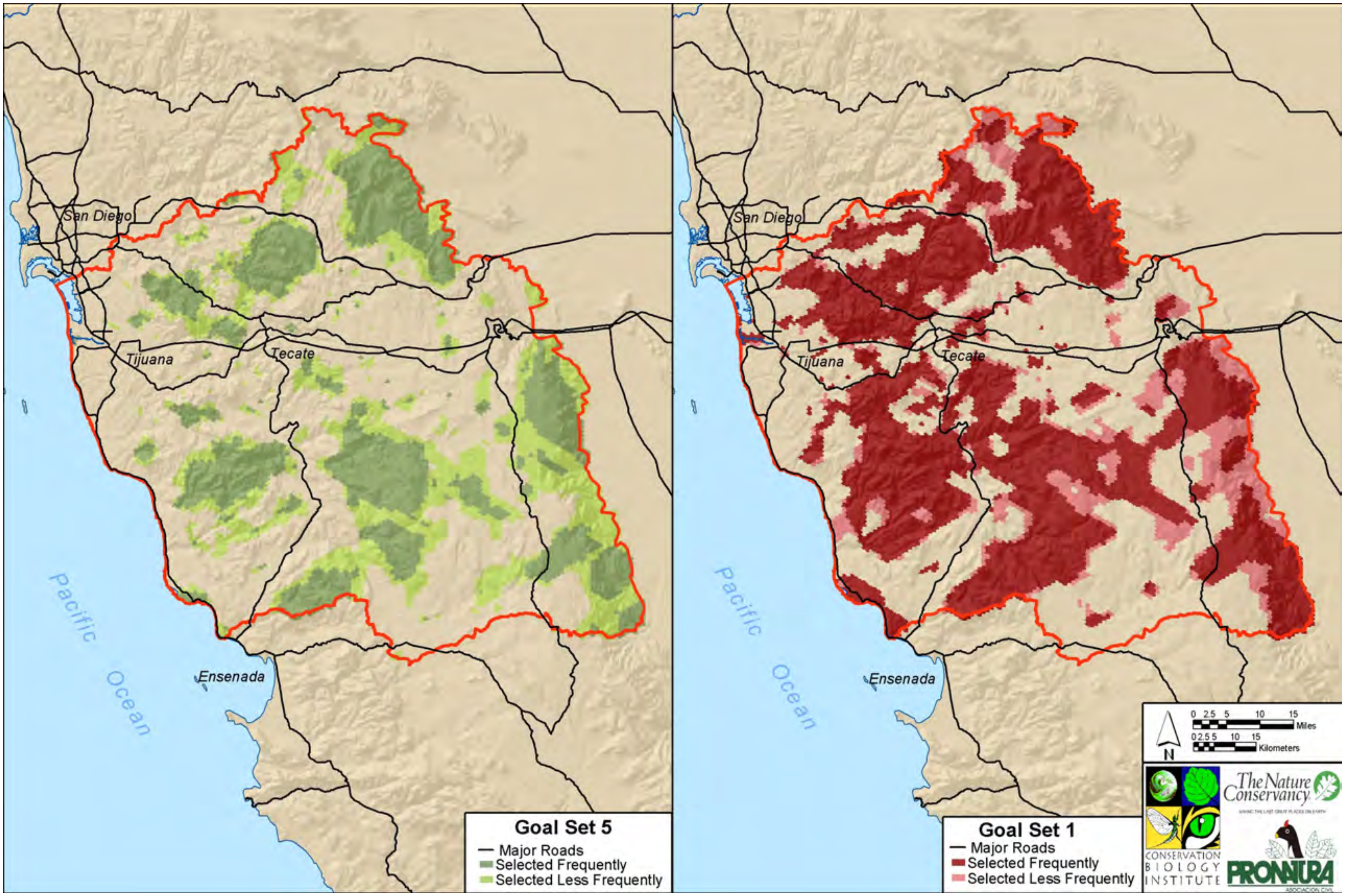

Figure 7. SPOT outputs.

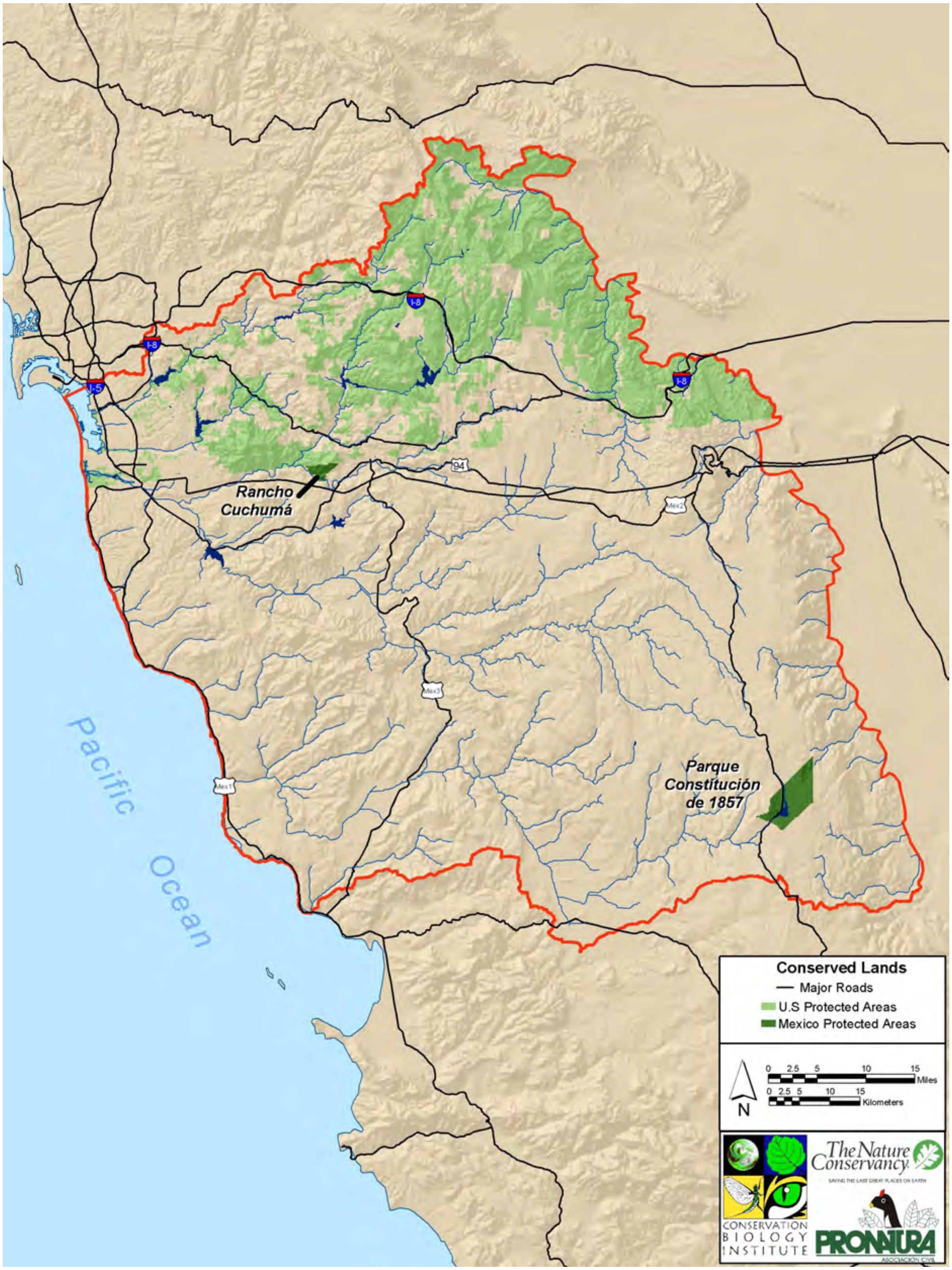

Figure 8. Existing conserved lands.

4. LAS CALIFORNIAS BINATIONAL CONSERVATION NETWORK

The Las Californias region supports a rich, yet fragile, landscape that ranges from intact wildlands to areas dominated by human land uses. Conservation values and objectives differ across this integrity gradient, ranging from protection of biological resources and ecosystem processes in areas removed from urban centers, to maintaining habitat connectivity and habitat quality for resources less sensitive to human alterations, to promoting open space and riverine greenbelts in urban areas for sustaining human health and quality of life. Our conservation vision for this landscape is a network of nodes of biodiversity that are buffered and interconnected by relatively intact land, embedded in a matrix of lands that have undergone varying degrees of human modification and whose current resource values may be more compatible with human land uses. Each of these components of the network supports conservation values that contribute to the region's character and the tapestry of biodiversity for which the region as a whole is renowned.

Conservation and Management Objectives

Figure 9 represents our conservation vision for the border region that encompasses a range of conservation objectives and functions within distinct conservation categories:

- *Category A—Protect large, intact habitat blocks to conserve irreplaceable resources and to maintain natural ecological processes, such as fire and stream flow regimes that require large landscapes to function.*

- *Category B—Require land uses and management that maintain habitat integrity and allow natural ecological processes to continue.*

- *Category C—Promote sustainable land uses and maximize biological resource values by preserving the rural character of the backcountry through low-density residential development and extensive agriculture (e.g., grazing), providing parkland and open space, protecting isolated high value resources (e.g., vernal pools), and maintaining a landscape permeable to wildlife movement.*

- *Category D—Focus conservation and management efforts on riparian greenbelts and other open spaces that improve air and water quality, enhance human health and quality of life, and protect isolated resources (e.g., vernal pools) and local wildlife.*

- *Critical Opportunity Areas—Specific locations where conservation values are imminently threatened if conservation actions are not initiated in the short-term.*

The following sections describe the biological resources of the geographic areas corresponding to these conservation objectives, generally organized by three major bioclimatic zones—coastal zone, inland zone, and montane zone (including the escarpment and transition to desert

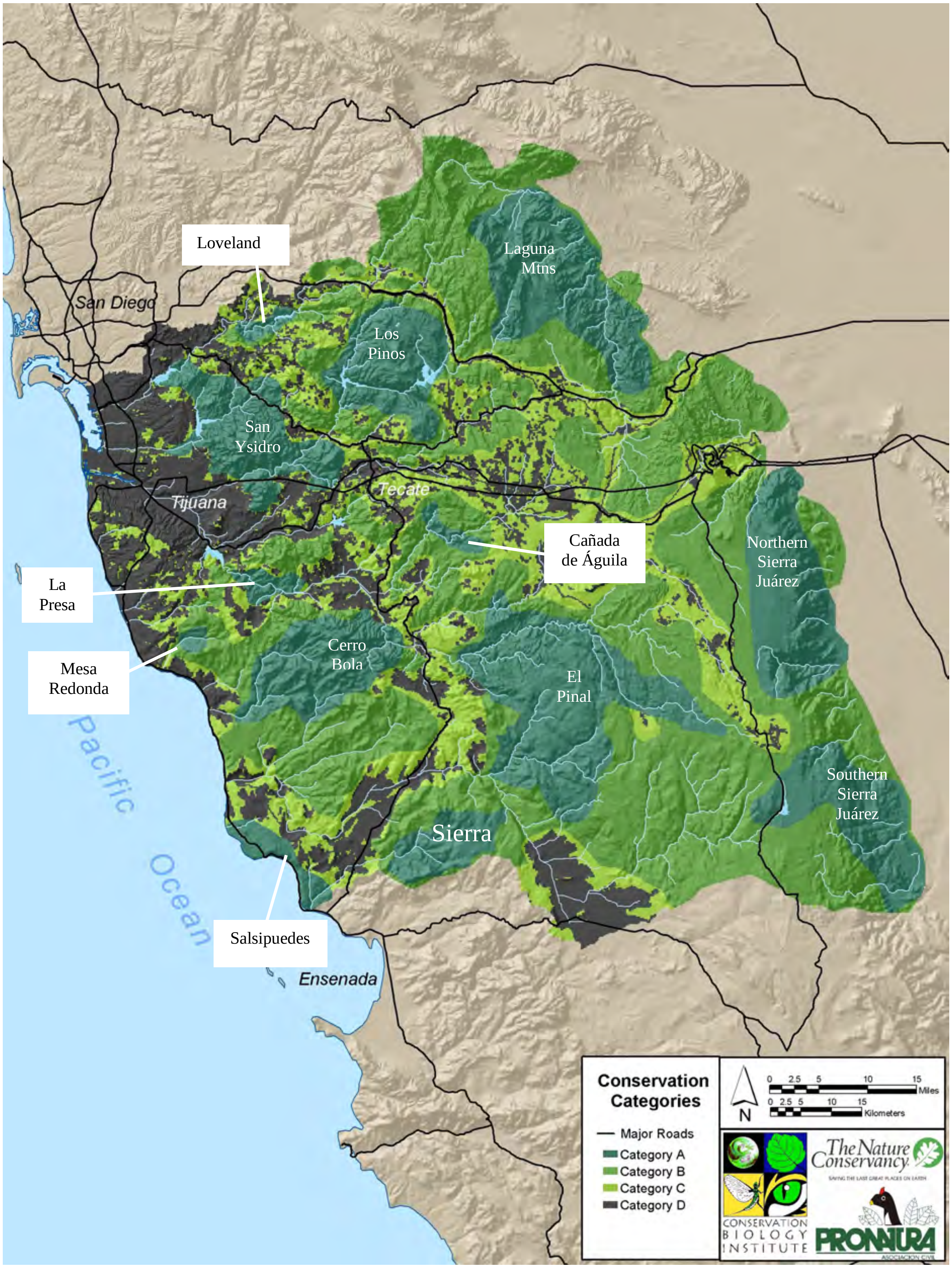

Figure 9. Las Californias binational conservation network.

communities on the eastern side of the Peninsular Ranges). However, the border region is surprisingly understudied, considering it resides between two academic and research centers—San Diego (e.g., San Diego State University, University of California, San Diego) and Ensenada (e.g., UABC, CICESE, COLEF). Most of these areas, especially in Baja California, have not been comprehensively surveyed, and there is minimal, often anecdotal, information on the biological resources that characterize them. Field investigation is essential in this rapidly developing region, lest important conservation and management needs not be recognized until conservation opportunities have been foreclosed. We emphasize the need for focused field studies to further define the biological characteristics and conservation values in the border region.

Coastal Zone

Loveland

This unit includes land protected as a result of the Multiple Species Conservation Program (MSCP) in San Diego County, including one of the last remaining intact patches of Diegan coastal sage scrub in the California portion of the study area, a resource that has largely been lost to development along the coast. This area is at an elevation of about 1,500 ft (470 m). The Sweetwater River corridor supports arroyo toads (*Bufo californicus*), least Bell's vireos (*Vireo bellii pusillus*), southwestern willow flycatchers (*Empidonax traillii extimus*), and other neotropical migrant bird species, and is adjacent to coastal sage scrub habitat occupied by California gnatcatchers (*Polioptila californica*). Except for the Sweetwater River corridor, which connects Loveland to the inland valley and ultimately to the Laguna Mountains, this unit is largely surrounded by development and has relatively little Category B lands as a buffer. It is separated from San Ysidro by Lyons Valley and Lawson Valley (Category C), which are rural landscapes important for species dispersal.

San Ysidro

This unit includes Otay Mountain, Cerro San Isidro, San Miguel Mountain, and Tecate Peak, which are gabbroic or metavolcanic in composition. Elevations in the unit range from less than 500 ft to over 3,000 ft (150-1,000 m) at the tops of Tecate Peak, Otay Mountain, and Cerro San Isidro. This area supports some of the largest remaining intact patches of Diegan coastal sage scrub (including coastal sage scrub with abundant cactus patches) in the border region, supporting core populations of California gnatcatchers and coastal cactus wrens (*Campylorhynchus brunneicapillus couesi*). This unit also supports mafic chaparral communities, important riparian habitat along the Tijuana and Tecate rivers, and vernal pools on the mesa tops. The San Ysidro unit supports concentrations of sensitive and endemic plant species [e.g., Tecate cypress, Jennifer's monardella (*Mondardella stoneana*), Baja California bird bush (*Ornithostaphylos orcuttii*), coast barrel cactus (*Ferocactus viridescens*), small-leaved rose (*Rosa minutifolia*), variegated dudleya (*Dudleya variegata*), Mexican flannelbush (*Fremontodendron mexicanum*), Cedros Island oak (*Quercus cedrosensis*), Otay mesa mint (*Pogogyne nudiuscula*), prostrate navarretia (*Navarretia fossalis*), San Diego button-celery (*Eryngium aristulatum* var. *parishii*)]. The Thorne's hairstreak butterfly (*Mitoura thornei*) is an endemic species here, whose larvae are obligate to Tecate cypress. Jesus Maria Mesa, on the southwestern flank of Cerro San Isidro, supports vernal pools and a population of Quino checkerspot butterfly (*Euphydryas editha quino*) that uses habitat on both sides of the border and is likely important to recovery of the species (USFWS 2000).

The San Ysidro unit includes the Otay Mountain Wilderness Area and Cerro Cuchumá (Tecate Peak), which is protected by a historic Mexican private lands conservation easement. It also supports the San Diego National Wildlife Refuge lands around Sweetwater Reservoir and lands administered by the Bureau of Land Management (BLM), U.S. Fish and Wildlife Service, California Department of Fish and Game, City of San Diego, California Department of Forestry, and County of San Diego.

San Ysidro is surrounded on the north, west, and south by development (Category D areas). Cottonwood Creek, which supports arroyo toads, provides an important hydrographic and habitat linkage between San Ysidro and Los Pinos to the east. State Road-94 and Honey Springs Road bisect Category B lands that buffer the eastern side of the San Ysidro unit. Proposed *areas verdes* and other open spaces identified by Pronatura (2004) in Tijuana provide open space and restoration opportunities (see Critical Opportunity Areas and Appendix C).

Mesa Redonda and La Presa

These units range in elevation from less than 1,000 ft to nearly 2,000 ft (300-650 m) at the tops of Mesa Redonda and the small peaks in these units (e.g., Cerro la Avena). Mesa Redonda and La Presa support Diegan coastal sage scrub, including patches of Nuttall's scrub oak (*Quercus dumosa*). La Presa is associated with the canyon upstream of Presa Rodriguez on the las Palmas drainage. Presa Rodriguez supports foraging by waterfowl, herons, egrets, and golden eagles (*Aquila chrysaetos*) (Pronatura 2004). This unit also supports some stands of Tecate cypress and other irreplaceable resources in the coastal zone.

These two Category A units are virtually isolated by encroaching coastal development around Tijuana and Rosarito. Category B lands connect and buffer these units and connect La Presa to Cerro Bola to the south. Roads and associated development separate La Presa from Cañada de Águila to the east and San Ysidro unit to the north. This represents a critical opportunity area (see below).

Cerro Bola

The Cerro Bola unit includes the metavolcanic peaks of Cerro Bola and Cerro Gordo and volcanic tablelands to the south. Elevations in this unit range from less than 1,000 ft to over 4,200 ft (300-1,300 m) at the top of Cerro Bola. The western portion of this unit supports the largest patch of intact Diegan coastal sage scrub in the Baja portion of the border region. The Cerro Bola unit also includes a large area of mafic chaparral that supports many rare and endemic plant species [e.g., Bola ceanothus (*Ceanothus bolensis*) and Bola manzanita (*Arctostaphylos bolensis*), Gander's pitcher sage (*Lepechinia ganderi*), Tecate cypress] (Wells 1992, Boyd and Keeley 2002). Vernal pools on the clay terraces of Valle de las Palmas support rare and endemic plant species [e.g., prostrate navarretia, little mousetail (*Myosurus minimus* ssp. *apus*), San Diego button-celery], including a potentially undescribed species of mesa mint

(*Pogogyne* sp. *nova*) (Oberbauer personal communication). Arroyos draining the eastern side of Cerro Bola (e.g., Cañada las Palmas) support the westernmost population of California fan palms (*Washingtonia filifera*), which is the only population of this species on the western side of the Peninsular Ranges divide. This unit straddles three watersheds—Las Palmas, El Bajio (Cañon El Descanso), and the downstream end of the Rio Guadalupe watershed.

Cerro Bola is largely surrounded and buffered by Category B areas. Roads and development along the coast and Highway-3 and agriculture in the Valle Guadalupe separate Cerro Bola from other units. The Category C areas along Highway-3 between Cerro Bola and El Pinal represent a critical opportunity area, where maintaining landscape permeability is important.

Salsipuedes

Salsipuedes supports the only sizeable patch of Martirian succulent scrub, a unique division of coastal sage scrub with a significant component of stem succulents, semi-succulents [e.g., cliff spurge (*Euphorbia misera*), yuccas (*Yucca* spp.)], and shrubs typical of coastal sage scrub [e.g., sages (*Artemisia* spp.), flat-topped buckwheat (*Eriogonum fasciculatum*), jojoba (*Simmondsia chinensis*)]. Buckeye (*Aesculus parryi*) reaches its northernmost distribution here. This unit supports irreplaceable resources and is highly threatened by encroaching development on all sides. The Tijuana-Ensenada tollroad bisects it. Salsipuedes will require protection and focused management efforts to maintain its conservation value.

Sierra Blanca

This unit includes Sierra Blanca, Cerro Miracielo, Cerro Blanco, Cerro Venado Macho, and Cerro Apodaca. The Sierra Blanca unit ranges in elevation from less than 1,000 ft to over 4,200 ft (300-1,300 m) at the top of Sierra Blanca. This unit supports a coastal chaparral community that includes rare and endemic plant species such as manzanita (*Arctostaphylos incognita*), Moran manzanita (*Arctostaphylos moranii*), Tecate cypress, wart-stemmed ceanothus (*Ceanothus verrucosus*), Cedros Island oak, and Baja California bird bush (Minnich 1987, Wells 1992, Keeley et al. 1997). There are also relict populations of Coulter pine and knobcone pine (Minnich 1987), which persist because of the high winter rainfall that occurs in the Sierra Blanca (Minnich et al. 2000).

While connected to El Pinal to the north, development associated with the outskirts of Ensenada is encroaching from the south. Highway-1, Valle Guadalupe, and Highway-3 separate Sierra Blanca from Salsipuedes and Cerro Bola, respectively (critical opportunity areas).

Inland Zone

Los Pinos

This unit includes Los Pinos Mountain, Corte Madera Mountain, Long Valley Peak, and Hauser Mountain. Elevations range from about 1,500 ft to over 4,200 ft (500-1,300 m). Los Pinos and Corte Madera Mountains are comprised of gabbroic rocks and support a diversity of chaparral communities, including mafic mixed chaparral, northern mixed chaparral, chamise chaparral, scrub oak chaparral, and red shank chaparral. Isolated stands of Coulter pines occur on Corte Madera Mountain. Pine Valley Creek and Cottonwood Creek flow through the U.S. Forest Service Pine Creek Wilderness Area and the BLM Hauser Mountain Wilderness Area, respectively, and represent largely intact hydrologic units. Arroyo toads occur in Pine Valley Creek and Cottonwood Creek, upstream of Morena Reservoir. This unit represents the only core habitat area in the inland zone of the California border region. It is largely public land administered by the U.S. Forest Service, BLM, and City of San Diego Water Department.

Interstate-8, State Road-94, and Buckman Springs Road and associated development separate Los Pinos from the Laguna Mountains unit. Pine Valley Creek and associated habitat serve as a linkage, via the Pine Valley Creek bridge on Interstate-8. In the Campo area east of Los Pinos, the La Posta Linkage (critical opportunity area) has been identified as the last remaining connection between National Forest lands to the north and habitats in Baja California (CBI 2003). Other Category C lands, including the areas around Potrero, Lyons Valley, Engineer Springs, El Hongo, and Tecate, may also serve to maintain habitat connectivity between the Laguna Mountains and Baja California. This critical opportunity area to the south and east of Los Pinos warrants immediate conservation actions (Appendix C).

Cañada de Águila

This unit consists of a ridge in the foothills of the Peninsular Ranges, which range in elevation from about 2,500 ft to over 3,500 ft (800-1,300 m). Portions of this unit are gabbroic in composition (Gastil et al. 1975). The Cañada de Águila unit supports Diegan sage scrub, chamise and mixed chaparral, and oak woodlands (Minnich and Franco Vizcaìno 1998). Category B lands connect Cañada de Águila to El Pinal to the south. Highway-2 and associated development between Tecate and El Hongo are a barrier to the north. Cañada de Águila and isolated Category B lands surrounding Presa Carrizo to the west represent centrally located *stepping stones* of intact habitat that is important for maintaining habitat connectivity in both north-south and east-west directions. Thus, the entire region around Cañada de Águila is a critical opportunity area.

El Pinal

El Pinal is located on the west slope of the Sierra Juárez and ranges in elevation from about 2,000 ft to over 4,800 ft (650-1,500 m). Gabbroic rock occurs in two locations within this unit—in the west near San Antonio Las Minas and La Hiedra, and in the east at Cerros Corte de Madera and Cerro El Alamar (Gastil et al. 1975). El Pinal supports chamise and red shank chaparral, oak woodland, mountain meadow, and patches of Jeffrey pine forest at its highest elevations (Minnich and Franco Vizcaìno 1998). It also includes a largely intact hydrologic unit associated with Las Calabazas drainage in Cañada El Testerazo. Arroyo toads have been documented at the lower end of Las Calabazas (Lovich et al. in preparation). El Pinal is buffered and connected to Sierra Blanca and Southern Sierra Juárez by Category B lands; however, Category C and D lands along Highway-3 (critical opportunity area) separate it from Cerro Bola.

Montane Zone

Laguna Mountains

The Laguna Mountains unit is comprised of the Laguna, Jacumba, In-Ko-Pah, and Tierra Blanca mountains. Elevations in this unit range from 5,500 ft at the crest to about 1,600 ft (1,800-525 m) at the base of the eastern escarpment. As the montane zone includes the eastern side of the Peninsular Ranges, this unit includes the transition from montane to Sonoran Desert communities, including montane chaparral, Jeffrey pine and mixed conifer forests, pinyon and juniper woodland, and Sonoran Desert scrub. It also includes watercourses that drain both slopes of the Peninsular Ranges. Eastern drainages support California fan palm oases. Big Laguna Lake is a large ephemeral pond, surrounded by extensive wet meadows. This unit supports the southernmost U.S. population of the Peninsular bighorn sheep, which is currently isolated from the Méxican population in the Sierra Juárez. Carrizo Gorge is a crucial desert water supply and supports an important bighorn sheep lambing area. This is the only core habitat unit in the montane zone of the California border region. It is largely public land administered by BLM and Anza-Borrego Desert State Park.

Category C and D lands associated with development in Boulevard, El Hongo, Jacumba, Jacumé, and La Rumorosa, along Interstate-8, Highway-94, and Highway-2, are barriers to habitat connectivity. The Jacumba Wilderness is an important stepping stone between the Laguna Mountains and Northern Sierra Juárez. The Category C and D lands along the highways represent critical opportunity areas (Appendix C).

Northern Sierra Juárez

This unit lies on the plateau of the northern Sierra Juárez, generally at an elevation range of 3,800 to 4,400 ft (1,250-1,400 m), but also includes parts of the eastern escarpment down to elevations less than 1,000 ft (300 m). California fan palm oases occur along the canyons of the eastern escarpment, including Cañon Tajo. Vegetation communities include red shank chaparral, oak woodland, pinyon and juniper woodland, scattered mountain meadows, and Sonoran Desert scrub (Minnich and Franco Vizcaìno 1998). This unit supports the northernmost Méxican population of Peninsular bighorn sheep, which is currently isolated from the U.S. population.

Category B lands connect the Northern Sierra Juárez unit with the Southern Sierra Juárez. The Mexican highway from El Condor to El Coyote separates the Northern Sierra Juárez from El Pinal; La Rumorosa, Interstate-8, and Highway-2 separate it from the Laguna Mountains, as discussed above (critical opportunity areas).

Southern Sierra Juárez

The Southern Sierra Juárez includes the Parque Constitución de 1857, which is one of two state parks in Baja California. It supports red shank and montane chaparral, canyon oak woodland, mixed pinyon forest, and Jeffery pine forest, with scattered isolated stands of Coulter pines (Minnich 1987, Minnich and Franco Vizcaìno 1998). The stands of Coulter pines represent the northernmost limit of this species in Baja California (Minnich 1987). The northern reported limit of Cuyamaca cypress (*Cupressus stephensonii*) (Minnich 1987) in Baja California is immediately south on Mesa Huicual, and it is likely that Cuyamaca cypress occurs within the southern portion of this unit as well. Laguna Juárez is a large ephemeral lake surrounded by mountain meadows. California fan palm oases line the canyons of the eastern escarpment. Peninsular bighorn sheep also are supported in this unit.

Category C and D lands along Highway-3, from Ojos Negros to Colonia Lázaro Cárdenas outside the study area, abut this area on the south.

Critical Opportunity Areas—Maintaining Regional Connectivity

Human development is quickly compromising our ability to maintain regional habitat connectivity in portions of the border region. We have identified several critical opportunity areas, where conservation values of existing habitat blocks are imminently threatened unless focused conservation actions are taken. This is particularly evident along the international border, where coordinated conservation actions on both sides of the border are needed to allow species dispersal and large-scale ecological processes (e.g., natural fire and stream flow regimes) to continue and thus to protect the values of previous conservation investments. Both north-south and east-west habitat connectivity is important to support the variety of plants and wildlife that converge along this coastal-mountains-desert transect and low elevation to high elevation habitat gradient.

Appendix C spotlights three major groupings of critical opportunity areas along the international border within each of the three bioclimatic zones described above (Figure 10). These areas have been the focus of recent conservation planning efforts by Pronatura, in the Tecate-Tijuana corridor, and by the Missing Linkages project conducted by the South Coast Wildlands Project and its partners. Conservation actions may range from maintaining low-density rural land uses and conducting community education programs, to facilitating localized wildlife movement over or under highways, to developing conservation or agricultural leases, to strategic, focused acquisitions.

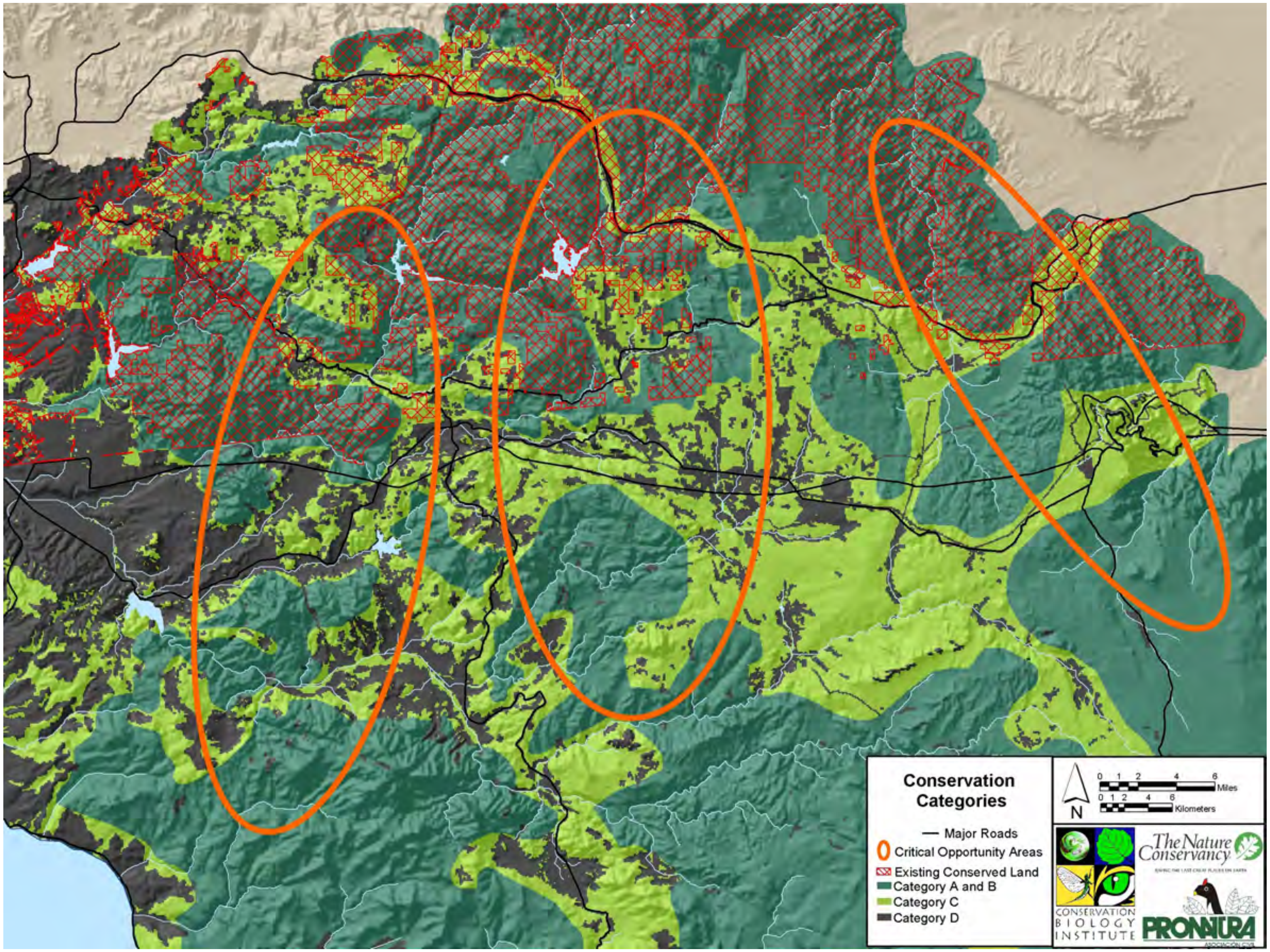

Figure 10. Critical opportunity areas along the U.S.-México border.

5. CONSIDERATIONS FOR IMPLEMENTING A BINATIONAL CONSERVATION VISION

The Las Californias vision represents an optimal open space configuration for biodiversity conservation in the border region. As such, it highlights a shared dependence on natural resources and thus conservation implementation across borders. Institutions on both sides of the border are grappling with the challenge of meeting the needs of an ever-burgeoning human population, improving (or at least maintaining) standards of living and quality of life, and sustaining economic growth in the region. The Las Californias vision is largely compatible with fulfillment of these goals. The sustainable conservation goals of the Las Californias vision complement efforts to protect open space and watersheds, create recreational and educational growth opportunities, cultivate tourism and business investment, and preserve a rich agricultural and cultural heritage. This complementarity of diverse interests presents opportunities for advancing a common conservation vision.

This section addresses some of the societal elements that will influence implementation strategies—land ownership and conservation patterns, land use regulations, and economic challenges—and presents some suggested approaches that rely on multiple partners and programs and the development of a new paradigm for regional planning that recognizes the global importance of the Las Californias vision.

Land Ownership and Conservation Patterns

California and Baja California are at very different stages of implementing the conservation vision. In California, public lands—which can serve as building blocks of a reserve network—represent approximately 61% of undeveloped land in the border region. Most of these federal, state, and locally-administered lands have been set aside as conserved or multi-use open space (Figure 8):

- Federal. The largest area of protected land in the California portion of the border region is under federal ownership (approximately 324,287 acres [129,715 ha]). These lands include the Cleveland National Forest (encompassing Pine Creek Wilderness and Hauser Wilderness), National Wildlife Refuges administered by the U.S. Fish and Wildlife Service, and other properties administered by BLM such as Otay Mountain Wilderness, Sawtooth Mountains Wilderness, Carrizo Gorge Wilderness, and Jacumba Wilderness.
- State. The State of California administers 103,855 acres [41,542 ha] in the border region. The Department of Fish and Game manages Ecological Reserves and Wildlife Management Areas, while the Department of Parks and Recreation manages Anza-Borrego Desert State Park, the largest state park in California (including Sombrero Peak Wilderness and Carrizo Canyon Wilderness), Cuyamaca Rancho State Park in the Cuyamaca Mountains, and Border Field State Park on the coast. The Department of Forestry and Fire Protection administers a single property on the border, Tecate Peak.
- Local. The City of San Diego, City of Chula Vista, and County of San Diego own MSCP lands, which are conserved as mitigation for development impacts in the region. The

City of San Diego Water Department also owns watershed lands around Otay Lakes, Barrett, and Morena reservoirs, which are protected to prevent degradation of the municipal water supply.

In contrast, <1% of undeveloped land in the Baja border region is in public ownership. The Parque Constitución de 1857, encompassing approximately 12,350 ac (5,000 ha), is the only government-decreed protected area in the region (Figure 8). The conservation easement (*servidumbre ecológica*) that Pronatura developed with Fundación la Puerta for Rancho Cuchumá represents the only other designated conservation area in the region.

Land Use Regulations

In California, a suite of federal, state, and local land use regulations and conservation programs provide some protection of biological resources on private lands. Development projects are subject to environmental review under the California Environmental Quality Act and must comply with a host of other environmental regulations and permitting requirements. Projects that may cause significant adverse impacts to natural resources or jeopardize the continued existence of state-listed endangered or threatened species must mitigate these impacts by modifying the project or by providing long-term conservation and management of natural resources that would be affected by the project. For example, land developers and other project proponents often purchase land or establish conservation easements on land as mitigation for project-related biological impacts. Historically, open space mitigation was accomplished on a project-by-project basis; the result was a fragmented patchwork of conserved land that cannot sustain biological resources over the long term. In 1991, California adopted the Natural Community Conservation Planning (NCCP) Act, which allows local jurisdictions to plan for conservation of ecosystems and ecosystem processes while allowing for economic growth. NCCP plans have resulted in a significant amount of open space conservation in San Diego County and are an important conservation tool for local governments.

In Baja California, federal, state, or municipal government agencies can define natural protected areas (*áreas naturales protegidas*) by decree. However, private land owners within natural protected areas often have not been compensated for economic losses associated with the decreed land use limitations (although this may be changing through incentives and land expropriation). Consequently, these private lands may not be managed in a manner consistent with the protection of natural resource values. State and municipal plans regulate and control land use and production activities, provide for environmental protection, and allow for preservation and sustainable use of natural resources. For example, scientists from the Universidad Autónoma de Baja California are assisting the City of Tijuana with the identification of important natural resource areas (*áreas verdes*) as part of the *ordenamiento ecológico* for the city. The *ordenamiento* will be used to guide land development within Tijuana. In addition to *planes de ordenamiento*, federal and state environmental laws (*Ley General del Equilibrio Ecológico y la Protección al Ambiente* and *Ley de Protección al Ambiente para el Estado de Baja California*) require an environmental impact study (*manifestación de impacto ambiental*) for any development project. If the project will have negative environmental consequences, the developer is required to take mitigation actions to minimize impacts and/or restore natural conditions.

The Importance of Private and Communal Lands to Fulfilling the Conservation Vision

Perhaps the greatest difference in implementing mechanisms between California and Baja California is the availability in California of financial compensation and incentives for imposing land use restrictions. However, nongovernmental organizations in México are working to change this by exploring mechanisms to transfer land use rights for the purpose of conserving natural resources on private lands (Gutiérrez Lacayo et al. 2002). Legal conservation tools that allow landowners to voluntarily restrict the type and amount of development to protect natural resources are relatively new in Mexico. The conservation easement (*servidumbre ecológica*) that Pronatura developed for Rancho Cuchumá is a good example of this effort. The *servidumbre ecológica* is a voluntary legal agreement between two or more property owners in which the land use rights of one are restricted and provided to another, with the objective of preserving natural resources, scenic beauty, or historical and cultural values of the land for a designated period of time or in perpetuity. The *servidumbre* stays with the land and not with the property owner. *Servidumbres ecológicas* can be used to conserve areas of biological richness, protect endangered species, allow use as wildlife movement corridors, or maintain sustainable land use practices. Restrictions that may be placed on properties can vary by property and include policies forbidding hunting, cutting, or clearing trees and other vegetation, impeding wildlife movement, burning, construction, subdividing the property, or increasing housing density.

Although the extensive mosaic of public lands north of the border provides a substantial anchor for conservation work on both sides of the border, there is nonetheless important work required there to fulfill the biodiversity protection goals of the Las Californias vision. Private inholdings, for example, are interspersed throughout the public lands mosaic north of the border; those that compromise the viability of the surrounding natural habitats must be identified and prioritized for conservation action. Fragmentation by development or roads is an ongoing concern for maintaining connectivity for species and natural processes and, thus, viability and value of conserved lands. Management and monitoring of public lands will continue to pose significant scientific, political, and financial challenges.

The continued ecological function of private lands within the border region is an integral component of the Las Californias vision. Yet, rural traditions on both sides of the border face considerable economic challenges. In Baja California, collectives (*ejidos*) own a majority of the undeveloped land; land use decisions are made by the members of the collective (*ejidatarios*). In general, the lack of financial resources and incentives for private and social landowners to land uses supportive of conservation goals has constrained resource protection efforts. Both sides of the border are experiencing the subdivision of large ranches. In general, smaller and smaller lot sizes can be found as one moves towards the coast or the border, or inward toward the urban centers. Subdivision frustrates conservation—lands become more expensive, biodiversity values more compromised, landscapes less permeable, and social challenges more complex. A necessary strategy to implement the vision must focus on private or communal lands to ensure that they support the mosaic of public and private lands that will protect the irreplaceable conservation value of the region.

Strategies for Implementation

Implementation of this binational conservation vision will face many cultural, institutional, legal, and socioeconomic obstacles. Differences in legal mechanisms and available financial resources for achieving land conservation in the two countries (see White et al. 2004 for a review of the constraints to conservation in the border region) underscore the importance of a multifaceted approach to implementation—with different conservation actors, implementing different conservation strategies, appropriate for different portions of the border region, that vary based on ownership, land use, socioeconomic factors, and level of participation by government and nongovernmental organizations and community groups.

The following outlines examples of potential strategies for achieving the myriad conservation objectives in the border region. This list is not intended to be exhaustive or complete, but rather to be illustrative of the diversity of strategies necessary to achieve the vision's goals.

1. *Establish a public policy framework that supports and provides incentives for conservation.*

a. Ensure that the following support and reinforce the goals of the binational conservation vision:
   - San Diego County General (Zoning) Plan 2020
   - East County Subarea of the San Diego MSCP
   - Tijuana, Tecate, and Ensenada *ordenamiento ecológicos*

b. Ensure that the Las Californias vision is integrated into state and federal maps in Baja California (e.g., maps showing *áreas naturales protegidas*).

c. Develop intergovernmental Memoranda of Understanding to raise the visibility of conservation efforts and to maximize efficient use of funds.

2. *Develop and implement new mechanisms to protect lands.*

a. Promote the establishment of an International Peace Park.

b. Foster the development of U.S. Homeland Security and Border programs that are synergistic with conservation (e.g., increased conservation of open space in the border region could facilitate border enforcement, without the need for extensive physical barriers that may preclude wildlife movement).

c. Promote establishment of a United Nations Educational, Scientific, and Cultural Organization (UNESCO) Biosphere Reserve and possible World Heritage Site status.

d. Create a Las Californias program within the California Resources Agency, and include Baja California representatives on the California Biodiversity Council.

e. Support Binational Watershed Management Agreements for the Tijuana River Watershed.

f. Explore potential conservation incentives through North American Free Trade Agreement (NAFTA) programs.

g. Continue to develop, through strategic application, *servidumbres ecológicas.*

h. Explore the interface of sustainable community development and conservation.
   - Promote ecotourism projects.
   - Use the Management and Sustainable Use of Wildlife policy under México's General Law of Wildlife, which provides for conservation of managed species while improving quality of life for local communities (Cariño 2004; e.g., *Unidades de Manejo y Aptovechamiento de la Vida Silvestre*, or UMAs, could be applied to bighorn sheep conservation.).

i. Develop support for a Binational Wildlife Corridor (Parque-to-Park Binational Corridor).

j. Explore focused programmatic pre-mitigation programs for large infrastructure developments in California.

k. Explore the potential for mitigating impacts of California development in Baja California.

l. Develop mechanisms in Baja California to require and enforce meaningful mitigation for environmental impacts of industrial development.

3. Secure adequate funding for conservation initiatives.

a. Establish a privately-funded and managed Las Californias Ventures Fund to seed border region conservation strategies, seize and create opportunities, and leverage public spending.

b. Encourage state and federal delegations to support the Las Californias vision (e.g., through funding support of NCCP, National Wildlife Refuge, BLM, and Forest Service acquisition and land management budgets as well as Méxican conservation programs).

c. Work with government and nongovernmental partners to undertake strategic acquisition and management programs in the border region.

d. Investigate the potential for BLM land swaps to secure and maximize the conservation value of holdings along the border.

e. Coordinate with government agencies to ensure acquisition priorities support the Las Californias vision.

f. Support propositions that authorize bonds for conservation and management of natural open space, water resources, and park lands.

g. Develop presentations and organize field trips to generate interest and funding.

4. Develop public education and outreach that fosters understanding and appreciation of Las Californias vision goals.

a. Support public education and outreach by community groups and institutions.

b. Include programs within federal, state, and local agencies that emphasize the interdependence of resources in the border region.

5. *Foster conservation-compatible land use practices for private lands, working landscapes, and rural communities.*

a. Support private lands conservation initiatives that maintain conservation values in the border region.

b. Promote preservation of agricultural communities and sensitive land management practices.

c. Develop and implement legal and policy tools that encourage working landscapes and rural communities that are compatible with conservation values.

d. Work with the Natural Resources Conservation Service and nongovernmental organizations to secure easements and funds for farmers and ranchers that use sensitive land management practices.

6. *Foster scientific research and exploration in the border region.*

a. Promote geographically and taxonomically comprehensive field surveys so as to fill data gaps and ground-truth the land categorization in the conservation vision.

b. Support an update of this Las Californias vision as changes in land use and data availability/quality warrant.

c. Cultivate future, local conservation scientists and practitioners through the support of university student biologists.

d. Update state and federal endangered species lists on both sides of the border.

e. Develop science-based management and monitoring programs, and create an infrastructure to implement them.

f. Encourage analyses to evaluate target species' viability in Conservation Category A and B areas.

g. Use tracking studies of large mammals to inform locations of regional wildlife movement corridors.

7. *Conduct focused (e.g., parcel-level) planning, especially in critical opportunity areas.*

a. Investigate and resolve land tenure in the Baja California portion of the border region.

b. Initiate parcel-level land use planning, particularly in critical opportunity areas, to ensure that future land uses are compatible with existing conservation functions.

c. Conduct parcel-level planning in selected critical opportunity areas to identify specific needs to restore wildlife corridor functions for target species (e.g., vegetated road overpasses, road undercrossings, etc.).

8. *Advance regional coordination in land management and monitoring.*

a. Expand existing binational coordination efforts (e.g., fire-fighting programs) to address natural resources issues.

b. Use the Rancho Cuchumá/Tecate Peak binational conservation area as a staging ground for binational cooperation on land management and monitoring by developing a coordinated monitoring program for the border region.

c. Increase monitoring efforts for species that are of binational concern (e.g., bighorn sheep, mountain lion, etc.).

9. *Develop Urban Greening programs.*

a. Identify candidate areas for establishing urban green-spaces (*áreas verdes*).

b. Develop community partnerships to plan and implement green-space development in existing developed areas.

c. Integrate green-space projects into new development.

d. Link upland green-spaces with riparian greenbelts.

10. Build an effective Border Coalition to strengthen conservation capacity and coordination.

a. Convene Border Roundtables to foster communication and coordination among conservation practitioners, government agencies, scientists, and stakeholders.

b. Build land management and land trust capacity on both sides of the border.

c. Improve effectiveness of nongovernmental organizations through capacity-building, training, and mentorship.

d. Develop partnerships and strategic alliances.

- Build administrative *sister park* relationships between Parque Constitución de 1857 in México and state and federal lands in the U.S.
- Build relationships with indigenous communities to support preservation of historic and cultural resources through implementation of the Las Californias vision.

6. SUMMARY

The border region of California and Baja California—Las Californias—lies at the center of one of the world's biodiversity hotspots, harboring ecosystems and species that occur nowhere else on earth. It is also a growing, multi-national metropolitan area of more than 5 million people. The integrity and functionality of ecosystems in the border region, as well as the health, economy, and standard of living of its residents, depend on a system of open space reserves that are interconnected across the international border. The urgency of this need cannot be overstated, as the ever-growing human footprint of development is beginning to preclude opportunities for protecting a functional open space system.

However, there are institutional and political constraints to a binational conservation effort in this region. There is a tremendous difference in land ownership and conservation patterns in the two countries, with a far greater percentage of both public ownership and conserved land in California than in Baja California. Moreover, differences in legal mechanisms and available financial resources for achieving land conservation in the two countries complicate coordination.

Creating a Las Californias Binational Conservation Initiative vision takes a systematic, phased approach to conservation in the border region. The planning phase uses a science-based approach, with uniform conservation targets and goals, to identify significant natural resource areas. The objective of the planning phase is to identify areas that must be linked to conserve representative biodiversity, functional ecological processes, and wildlife movement across the region. The long-term goal for the initiative is for U.S. and México governments, academic and research institutions, and nongovernmental conservation organizations to embrace and adopt a shared conservation vision for the region, and to refine this vision over time with focused research and planning.

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APPENDIX A

SELECTED SENSITIVE AND ENDEMIC PLANT AND ANIMAL SPECIES IN THE LAS CALIFORNIAS STUDY AREA

Common Name	Scientific Name	Status	Notes
PLANTS			
San Diego thorn-mint	*Acanthomintha ilicifolia*	FT, CE, MSCP	Restricted to San Diego County and northern Baja California
Shaw's agave	*Agave shawii* ssp. *shawii*	MSCP	Northern limit of range in study area
San Diego bur-sage	*Ambrosia chenopodiifolia*		Endemic to study area
Ragweed	*Ambrosia flexuosa*		Endemic to study area
San Diego ambrosia	*Ambrosia pumila*	FE, MSCP	Major populations in study area
Moran's manzanita	*Arctostaphylos moranii*		Endemic to Sierra Blancas
Cerro Bola manzanita	*Artcostaphylos bolensis*		Endemic to Cerro Bola area
Manzanita	*Artcostaphylos incognita*		Endemic to Sierra Blancas
Otay manzanita	*Arctostaphylos otayensis*	MSCP	Majority of distribution in study area
Dean's milk vetch	*Astragalus deanei*		Rare; majority of distribution in study area
Encinitas baccharis	*Baccharis vanessae*	FT, CE	Southern limit of range in study area
Golden snake cactus	*Bergerocactus emoryi*		Northern limit of range in study area
Mexican blue palm	*Brahea armata*		Northern limit of range in study area

Common Name	**Scientific Name**	**Status**	**Notes**
Orcutt's brodiaea	*Brodiaea orcuttii*	MSCP	Southern limit of range in study area
Incense cedar	*Calocedrus decurrens*	*A*	Populations in Laguna Mountains and Sierra Juárez
Dunn's mariposa lily	*Calochortus dunnii*	CR, MSCP	Restricted to study area
Cerro Bola ceanothus	*Ceanothus bolensis*		Endemic to Cerro Bola area
Otay Mountain ceanothus	*Ceanothus otayensis*		Endemic to San Ysidro Mountains
Wart-stemmed ceanothus	*Ceanothus verrucosus*	MSCP	Majority of distribution in study area
Salt marsh bird's-beak	*Cordylanthus maritimus* ssp. *maritimus*	FE, CE, MSCP	Significant loss of salt marsh habitat
Orcutt's bird's beak	*Cordylanthus orcuttianus*	MSCP	Northern limit of range in study area
Tecate cypress	*Cupressus forbesii*	MSCP, *Pr*	Isolated populations on gabbroic and metavolcanic peaks in Southern California and northern Baja California
Cuyamaca cypress	*Cupressus stephensonii*		Isolated populations in Sierra Juárez
Snake cholla	*Cylindropuntia californica* var. *californica*		Majority of distribution in study area
Wolf's cholla	*Cylindropuntia wolfii*		Endemic to study area
Otay tarplant	*Deinandra conjugans*	FT, CE, MSCP	Restricted to study area; only 1 known occurrence in Baja
Tecate tarplant	*Deinandra floribunda*		Northern limit of range in study area
Variegated dudleya	*Dudleya variagata*	MSCP	Majority of known distribution in study area
Laguna Mountains goldenbush	*Ericameria cuneata* var. *macrocephala*		Restricted to Laguna Mountains and Corte Madera Mountain
Palmer's goldenbush	*Ericameria palmeri* ssp. *palmeri*	MSCP	Majority of known distribution in study area

Common Name	**Scientific Name**	**Status**	**Notes**
San Diego button-celery	*Eryngium aristulatum* ssp. *parishii*	FE, CE, MSCP	Restricted to vernal pools
Coast barrel cactus	*Ferocactus viridescens* var. *viridescens*	MSCP, *A*	
Palmer's frankenia	*Frankenia palmeri*		Northern limit of range in U.S. portion of study area
Ash	*Fraxinus trifoliata*		Northern limit of range in study area
Mexican flannelbush	*Fremontodendron mexicanum*	FE, CR	Northern limit of range in U.S. portion of study area
	Geraea viscida		Northern limit of range in study area
Orcutt's hazardia	*Hazardia orcuttii*	CT	Southern limit of range in study area
Graceful tarplant	*Holocarpha virgata* ssp. *virgata*		Southern limit of range in study area
Ramona horkelia	*Horkelia tuncata*		Majority of known distribution in study area
Baja California ipomopsis	*Ipomopsis effusa*		Northern limit of range in study area
Slender-leaved ipomopsis	*Ipomopsis tenuifolia*		Northern limit of range in study area
California juniper	*Juniperus californica*	*Pr*	
Pride-of-California	*Lathyrus splendens*		Endemic to study area
Gander's pitcher sage	*Lepechinia ganderi*	MSCP	Endemic on gabbroic or metavolcanic soils in study area
	Linanthus melingii		Northern limit of range in study area
Otay Mountain lotus	*Lotus crassifolius* var. *otayensis*		Known only from Otay Mountain and 1 occurrence in Baja
Sierra Juárez biznaga	*Mammillaria* var. *deherdtiana deherdtiana*	*Pr*	Endemic to Sierra Juárez

Common Name	**Scientific Name**	**Status**	**Notes**
Sierra Juárez biznaga	*Mammillaria* var. *deherdtiana dodsoni*	*A*	Endemic to Sierra Juárez
Low bush monkeyflower	*Mimulus aridus*		Majority of distribution in study area
Jennifer's monardella	*Monardella stoneana*		Endemic to canyons in San Ysidro Mountains
Little mousetail	*Myosurus minimus* ssp. *apus*	MSCP	Endemic to vernal pools in S. California and northern Baja California
Spreading navarretia	*Navarretia fossalis*	FT, MSCP	Endemic to vernal pools in S. California and northern Baja California
Chaparral nolina	*Nolina cismontana*	*Pr*	Southern limit of range in study area
Dehesa beargrass	*Nolina interrata*	CE, MSCP, *Pr*	Endemic on gabbroic or metavolcanic soils in study area
California Orcutt grass	*Orcuttia californica*	FE, CE	
Baja California bird bush	*Ornithostaphylos oppositifolia*	CC	Northern limit of range at U.S.-México border
Knobcone pine	*Pinus attenuata*	*Pr*	Isolated population in Sierra Blancas
Coulter pine	*Pinus coulteri*	*Pr*	Isolated populations in Laguna Mountains, Sierra Juárez, Sierra Blancas, Corte Madera Mtn., and Los Pinos Mtn.
Jeffrey pine	*Pinus jeffreyi*	*Pr*	
Parry pinyon pine	*Pinus quadrifolia*	*Pr*	
Otay mesa mint	*Pogogyne nudiuscula*	FE, CE, MSCP	Endemic to vernal pool complexes on Otay Mesa
Cedros Island oak	*Quercus cedrosensis*		Northern limit of range near U.S.-México border
Nuttall's scrub oak	*Quercus dumosa*		Rare
Engelmann oak	*Quercus engelmannii*		Southern limit of range in study area

Common Name	**Scientific Name**	**Status**	**Notes**
	Quercus peninsularis		Northern limit of range in study area
Santa Catalina Island currant	*Ribes viburnifolium*		Majority of mainland distribution in study area
Small-leaved rose	*Rosa minutifolia*	CE, MSCP	Northern limit of range at U.S.-México border
Gander's butterweed	*Senecio ganderi*	CR	Endemic to San Diego County on metavolcanic soils
	Sideroxylon leucophyllum		Northern limit of range in study area
California fan palm	*Washingtonia filifera*		Only population on west slope of Peninsular Ranges divide is on eastern flanks of Cerro Bola
ANIMALS			
Quino checkerspot butterfly	*Euphydras editha quino*	FE	Study area supports habitat complexes important to the recovery of this species (e.g., Jesus Maria Mesa)
Thorne's hairstreak	*Mitoura thornei*	MSCP	Larvae obligate to Tecate cypress
Hermes copper	*Lycaena hermes*	CSC	Extremely limited and highly localized endemic
Salt marsh skipper	*Panoquina errans*	MSCP	Highly localized; restricted to estuarine and coastal salt marsh habitats; probably occurs at mouth of Rio Guadalupe
Riverside fairy shrimp	*Streptocephalus woottoni*	FE, MSCP	Southern limits of range likely in study area
San Diego fairy shrimp	*Branchinecta sandiegonensis*	FE, MSCP	Southern limits of range likely in study area
Southern steelhead (Southern California ESU)	*Oncorhynchus mykiss*	FE	Trout stock from upper Sweetwater River currently being evaluated for genetic relationship to steelhead; historically in Tijuana River and Sweetwater River watersheds
Arboreal salamander	*Aneides lugubris*	*Pr*	Records for this species extend only as far south as Santo Tomas
Ensatina	*Ensatina eschscholtzii*	*Pr*	Southern limit of *E. e. eschscholtzii* range in Sierra Juárez; population in coastal Rio Guadalupe

Common Name	**Scientific Name**	**Status**	**Notes**
Western spadefoot	*Spea hammondii*	CSC	Breeds in vernal pools and other wetlands
Arroyo toad	*Bufo californicus*	FE, CSC, MSCP	Populations in Sweetwater R., Cottonwood Ck., coastal Rio Guadalupe, and La Misión; southern third of range in northern Baja
California red-legged frog	*Rana aurora draytonii*	FE, CSC	Possible in Sierra Juárez (upper Rio Guadalupe)
Alligator lizard	*Elgaria multicarinata*	*Pr*	
San Diego horned lizard	*Phrynosoma coronatum blainvillei*	CSC, MSCP, *A*	
Sagebrush lizard	*Sceloporus graciosus*	*Pr*	
Black-tailed brush lizard	*Urosaurus nigricaudus*	*A*	Northern limit of range just crosses border
Orange-throated whiptail	*Cnemidophorus aspidosceles beldingi*	CSC, MSCP, *A*	
Silvery legless lizard	*Anniella pulchra pulchra*	CSC, *Pr*	
Granite night lizard	*Xantusia henshawi*		Majority of range in study area
Baja leopard lizard	*Gambelia copeii*		Northern extent of range in study area
Coastal banded gecko	*Coleonyx variegatus abbotti*	*Pr*	Very uncommon
Baja California collared lizard	*Crotaphytus vestigium*		Isolated population on Tecate Peak
Western rattlesnake	*Crotalus viridis*	*Pr*	
Speckled rattlesnake	*Crotalus mitchellii*	*Pr*	
Red diamond rattlesnake	*Crotalus ruber*	*Pr*	
Night snake	*Hypsiglena torquata*	*Pr*	

Common Name	**Scientific Name**	**Status**	**Notes**
Rosy boa	*Charina trivirgata*	*A*	A major phylogenetic break (California-Arizona clade vs. Baja California clade) of this species occurs at the U.S.-México border
Mountain kingsnake	*Lampropeltis zonata*		Disjunct populations in Sierra Juárez (*L.z. agalma*) and Lagunas (*L.z. pulchra*)
Baja coachwhip	*Masticophis flagellum fuliginosus*	*A*	Endemic to Baja peninsula
Two-striped garter snake	*Thamnophis hammondii*	CSC, *A*	
Southwestern pond turtle	*Emys marmorata pallida*	CSC, MSCP	Petitioned for listing
California brown pelican	*Pelecanus occidentalis*	FE, CE, MSCP	
Golden eagle	*Aquila chrysaetos*	CSC, CFP, MSCP, *A*	
Bald eagle	*Haliaeetus leucocephalus*	FT, CE, CFP, MSCP	
Cooper's hawk	*Accipiter cooperii*	CSC, MSCP, *Pr*	
Sharp-shinned hawk	*Accipiter striatus*	CSC, *Pr*	
Northern harrier	*Circus cyaneus*	CSC, MSCP	Uncommon coastal breeder in Southern California; regular at La Misión Estero
White-tailed kite	*Elanus leucurus*	CFP	
Swainson's hawk	*Buteo swainsoni*	CSC, MSCP, *Pr*	
Prairie falcon	*Falco mexicanus*	CSC, *A*	
American peregrine falcon	*Falco peregrinus anatum*	CE, CFP, MSCP, *Pr*	
California black rail	*Laterallus jamaicensis coturniculus*	CT, CFP	
Light-footed clapper rail	*Rallus longirostris levipes*	FE, CE, MSCP	Tijuana River estuary

Common Name	**Scientific Name**	**Status**	**Notes**
California least tern	*Sterna antillarum browni*	FE, CE, MSCP	
Western snowy plover	*Charadrius alexandrinus nivosus*	FT, CSC, MSCP	
Burrowing owl	*Speotyto cunicularia*	CSC, MSCP	Likely in coastal foothills between Tijuana and Ensenada
Long-eared owl	*Asio otus*	CSC, *Pr*	
California spotted owl	*Strix occidentalis occidentalis*	CSC, *A*	Disjunct populations in Lagunas and Sierra San Pedro Mártir
Southwestern willow flycatcher	*Empidonax traillii extimus*	FE, MSCP	
Purple martin	*Progne subis*	CSC	Regular at Laguna Juárez, La Rumorosa (breeds); suffered from habitat reductions and competition with European starlings
Least Bell's vireo	*Vireo bellii pusillus*	FE, CE, MSCP, *A*	Major populations along Tijuana and Sweetwater rivers
Gray vireo	*Vireo vicinio*	CSC	Occurs at La Rumorosa and Laguna Juárez; probably occurs on western slopes of Sierra Juárez
Coastal cactus wren	*Campylorhynchus brunneicapillus couesi*	CSC, MSCP	Major populations in Loveland and San Ysidro units
Coastal California gnatcatcher	*Polioptila californica*	FT, CSC, MSCP, *A*	Major populations in Loveland and San Ysidro units
Rufous-crowned sparrow	*Aimophila ruficeps lambi (=canescens)*	CSC, MSCP	Occurs from Santa Barbara to south of San Quintìn; suffered habitat loss along coast and coastal foothills of study area
Bell's sage sparrow	*Amphispiza belli belli*	CSC	In Baja, only found in northwest; suffered loss of chaparral and sage habitats along coast and coastal foothills
Belding's Savannah sparrow	*Passerculus sandwichensis beldingi*	CE, MSCP, *A*	Tijuana River estuary
Tricolored blackbird	*Agelaius tricolor*	CSC, MSCP	Observed at Cantamar and El Descanso on coast, north of Ensenada
California leaf-nosed bat	*Macrotus californicus*	CSC	Potential in mine fields south of El Condor
Mexican long-tongued bat	*Choeronycteris mexicana*	CSC, *A*	Winter migrant to study area; northern range limit in study area

Common Name	**Scientific Name**	**Status**	**Notes**
Spotted bat	*Euderma maculatum*	CSC	Very rare; usually associated with high elevations
Townsend's big-eared bat	*Corynorhinus townsendii*	CSC	Few records from study area: Dulzura, Julian, Barrett Lake; usually associated with caves or abandoned mines
Pallid bat	*Antrozous pallidus*	CSC	Records within study area: Chula Vista, Jamacha, Jacumba
Western mastiff bat	*Eumops perotis californicus*	CSC	Rare; most records from U.S. side of study area
Dulzura pocket mouse	*Chaetodipus californicus femoralis*	CSC	Majority of range in study area; records from Laguna Hanson, El Rayo, Dulzura
Northwestern San Diego pocket mouse	*Chaetodipus fallax fallax*	CSC	Records from throughout study area
Southern grasshopper mouse	*Onychomys torridus ramona*		Southern end of range in study area; very rare in recent decades
Pacific pocket mouse	*Perognathus longimembris pacificus*	FE	Historically found in coastal portion of study area (Tijuana River mouth), but currently thought extirpated south of Camp Pendleton
Little pocket mouse	*Perognathus longimembris internationalis*		Endemic to study area?
Antelope ground squirrel	*Spermophilus beecheyi*		Study area is transition area between subspecies
Black-tailed jackrabbit	*Lepus californicus bennettii*		Study area is transition area between subspecies
Bighorn sheep	*Ovis canadensis nelsoni*	FE, CT, *Pr*	Southernmost extent of U.S. range in Jacumba Mtns; northernmost extent of México range in Northern Sierra Juárez

México (Norma Oficial Mexicana NOM-059-ECOL-2001)
P = En peligro de extinción
A = Amenazada
E = Probablemente extincta en el medio silvestre
Pr = Sujeta a protección especial

MSCP = species covered by Multiple Species Conservation Program

United States
FE = federally listed as Endangered
FT = federally listed as Threatened
CE = California listed as Endangered
CT = California listed as Threatened
CR = California listed as Rare
CC = California candidate for listing
CFP = California fully protected species
CSC = California Species of Concern

APPENDIX B
DATA SOURCES AND METHODS

Assembling the Database

Assembling a seamless, comprehensive database for the study area was one of the project's greatest challenges. Despite the size of the human population, the presence of two academic and research centers—San Diego (e.g., San Diego State University, University of California, San Diego) and Ensenada (e.g., UABC, CICESE, COLEF)—and the concentration of globally unique biological resources, comprehensive natural resources data are not available for the study area, particularly species-level distributional data. Thus, we were forced to use vegetation community distributions as our primary source of biological information and human-modified land cover as a measure of habitat integrity. Vegetation data for the study area were derived from multiple sources, which differed with respect to classification system and resolution, requiring us to cross-walk the various data sources to a common classification system and accept generalized vegetation maps for portions of the study area in Baja California.

Data sources

Table B-1. Digital data sources

Name	Type	Scale	Date	Source
National boundary—México	Polygon	1:250,000	2003	CONABIO
State boundaries—México	Polygon	1:250,000	2003	CONABIO
City boundaries	Polygon	varies	2000	CESAR-SDSU
Ecoregions	Polygon	unknown	?	TNC
Roads—San Diego County	Line	1:24,000	1993	SANDAG
Roads— México	Line	1:50,000	1999	INEGI
Roads—California	Line	1:100,000	1995	USGS
Vegetation—San Diego County	Polygon	1:1,200 to 1:24,000	1995	SANDAG
Vegetation—Anza-Borrego Desert State Park	Polygon	1:24,000	1998	Anza-Borrego Desert State Park
Vegetation—California	Polygon	2.5 acre mmu	2003	FRAP
Vegetation—Tijuana River Watershed	Polygon	0.5 acre mmu	2000	CESAR-SDSU
Vegetation— México	Polygon	1:250,000	1997	INEGI

Name	Type	Scale	Date	Source
Fine filter targets	Point	varies	2003	TNC, CONABIO
Gabbro soils	Paper map	unknown	1975	Gastil et al. 1975
Sensitive species	Points, polygons	varies	1995, 2004	SANDAG, CNDDB
Vernal pools—San Diego County	Polygon	1:24,000	varies	SANDAG
Vernal pools—Baja California	Point	1:50,000	2003	Pronatura Noroeste
Satellite imagery Landsat 7 ETM+	Raster	30m	varies	EROS Data Center
Digital Elevation Model— México	Raster	85m	1994	INEGI—GEMA
Digital Elevation Model—California	Raster	30m	varies	USGS
Watershed boundaries—San Diego Co.	Polygon	1:24,000	1994	SANDAG
Watershed boundaries— México	Polygon	1:100,000	1998	CONABIO
Watershed boundaries—Tijuana River watershed	Polygon	unknown	2000	CESAR-SDSU
Land use—San Diego County	Polygon	unknown	2003	SANDAG
Protected areas—U.S.	Polygon	varies		CBI—PAD 2001
Protected areas—Baja California	Polygon	1:50,000	2003	Pronatura Noroeste
Areas Naturales Protegidas	Polygon	1:50,000	2003	Comisión Nacional de Áreas Naturales Protegidas

CBI—PAD = Conservation Biology Institute—Protected Areas Database
CESAR-SDSU = Center for Earth Systems Analysis Research, San Diego State University
CNDDB = California Natural Diversity Data Base
CONABIO = Comisión Nacional para el Conocimiento y Uso de la Biodiversidad
FRAP = California Department of Forestry and Fire Protection
INEGI = Instituto Nacional de Estadística, Geografía e Informática
INEGI–GEMA = Geomodelos de Altimetría del Territorio Nacional
SANDAG = San Diego Association of Governments
TNC = The Nature Conservancy
USGS = U.S. Geological Survey

Study area boundary

The project's study area boundary was created using: (1) the Pacific Ocean coastline as the western boundary, (2) Rio Guadalupe watershed as the primary southern boundary, (3) Sweetwater River watershed as the primary northern boundary, and (4) TNC's California South Coast Ecoregion boundary to the east. Using 2001 and 2002 Landsat 7 imagery and on-screen digitizing in ArcView 8.3, the eastern boundary was adjusted to follow the eastern edge of the Sierra Juárez in Baja California. At the northeastern edge of the study area, the ecoregion boundary was modified to match the derived 500 km^2 catchment boundaries.

Hydrography

The 85m DEM from INEGI (México) and 30m DEM from USGS were re-sampled into an 80m DEM, using ArcInfo. ArcHydro was used to derive water catchments and drainages from the created 80m DEM with thresholds of $13.5km^2$, $30km^2$, $50km^2$, and $500km^2$.

Stream slope was calculated using the following steps in ESRI's Spatial Analyst:

1. An ESRI grid of the $13.5km^2$ drainages was created using Convert Feature to Raster command and the Reclassify command (0 = non-stream, 1 = streams).
2. Percent slope was derived from the 80m DEM and reclassified into categories of 0-8%, 8-30%, and >30%.
3. Slope and drainage grids were combined using Raster Calculator, which provided a grid of slope by stream segments.
4. The stream_slope grid was converted to polyline vector feature.

Vegetation

We used available vegetation community mapping from five different sources, with different mapping conventions, classifications, and resolutions, to develop a seamless vegetation coverage for the entire 2,846,052-acre (1,151,761-ha) study area. The five data sources were San Diego County (SANDAG), San Diego State University-CESAR Tijuana River watershed project (for the portion of the Tijuana River watershed within Baja California), Anza-Borrego Desert State Park, California Department of Forestry Fire and Resources Protection (FRAP), and INEGI (Figure B-1). Two of these data sets (San Diego County, SDSU-CESAR) used a modified Holland (1986) classification system, and one (Anza-Borrego Desert State Park) was classified at a more detailed alliance level (Sawyer and Keeler-Wolf 1995) but was cross-walked to the Holland system. We, therefore, elected to use a modified Holland system for our composite vegetation map, and we cross-walked the FRAP and INEGI vegetation data to the Holland system (Table B-2).

However, not all of these data sets could be cross-walked to the same level in the hierarchical classification system. For example, San Diego County regional vegetation data describe numerous chaparral communities (e.g., southern mixed chaparral, chamise chaparral, red shank chaparral, etc.), whereas the SDSU-CESAR Tijuana River watershed and INEGI data map chaparral as a single community. Thus, for use in SPOT, we simplified all of the vegetation data to a single chaparral category to eliminate potential biases that would be created in geographic areas with more detailed vegetation data.

Minnich and Franco Vizcaìno (1998) created a vegetation map for Baja California that distinguishes chaparral communities. We elected not to use this data set because it does not have

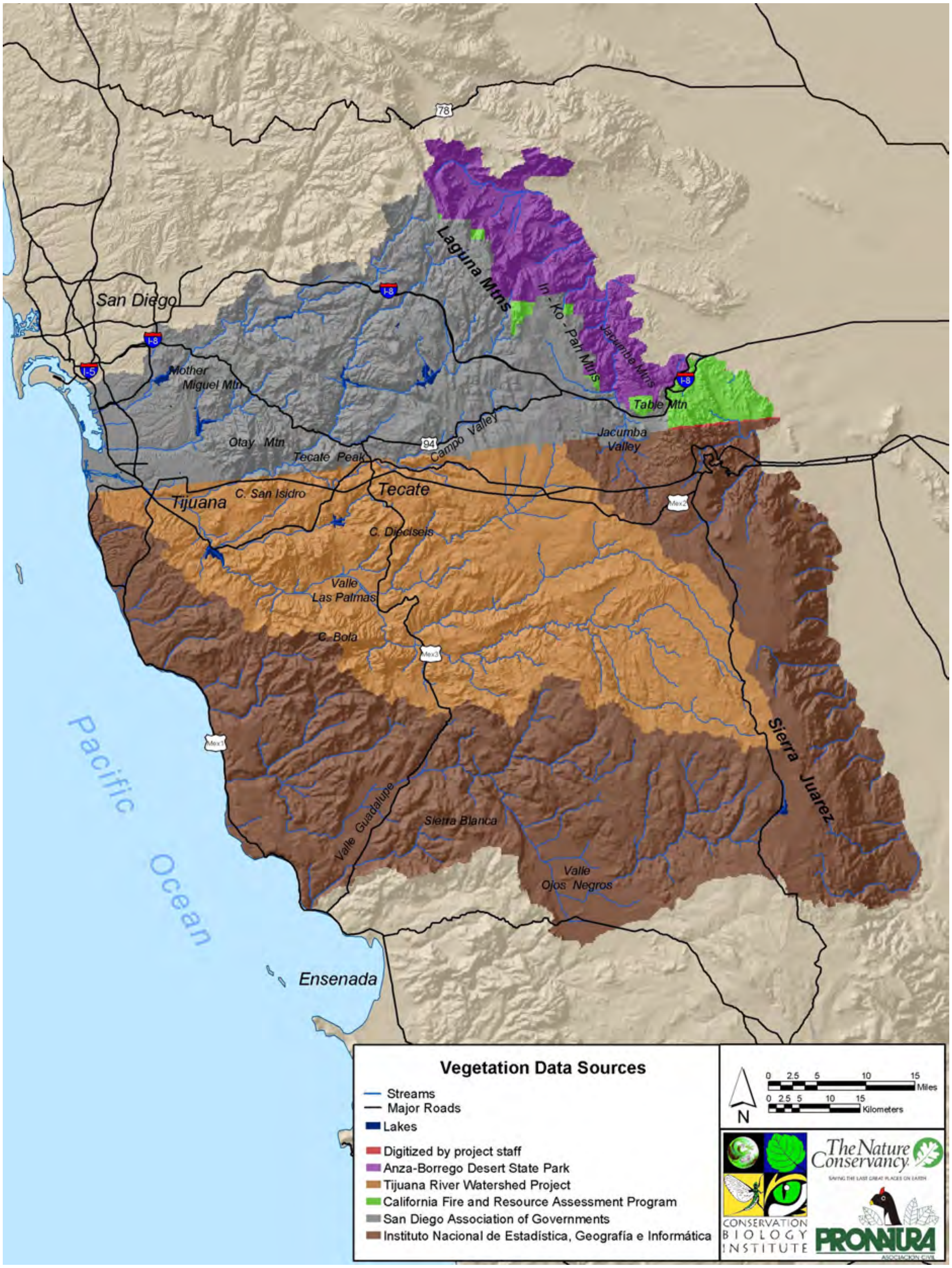

Figure B-1. Digital vegetation data sources.

Table B-2. Vegetation Classification Crosswalk

SPOT Veg Code	SPOT Vegetation Class	Modified Holland Code	Modified Holland Class	San Diego County	Anza-Borrego State Park	Anza-Borrego Series	Imperial County (FRAP)	Tijuana River Watershed	INEGI	Digitized
11100	Eucalyptus Woodland	11100	Eucalyptus Woodland	11100						
11200	Disturbed Wetland	11200	Disturbed Wetland	11200						
11300	Disturbed Habitat	11300	Disturbed Habitat	11300				Disturbed Habitat (240)		
12000	Urban/Developed	12000	Urban/Developed	12000	XXX			Developed (250)	Zona Urbana (ZU)	
13000	Unvegetated Habitat	13000	Unvegetated Habitat				BA	Bare Rock (230)	Area sin Vegetacion (DV)	
							NY			NYM13000
13100	Open Water	13100	Open Water					Open Water (200)	Cuerpo de Agua (H2O)	
		13111	Marine-Subtidal	13111						
		13121	Deep Bay	13121						
		13122	Intermediate Bay	13122						
		13123	Shallow Bay	13123						
		13130	Estuarine	13130						
13140	Freshwater	13140	Freshwater	13140						
13200	Non-Vegetated Channel, Floodway, Lakeshore Fringe	13200	Non-Vegetated Channel, Floodway, Lakeshore Fringe	13200	13200	Sandy-Cobbly Wash Bottom (9990001)		Natural Floodchannel / Streambed (220)		
13300	Saltpan/Mudflats	13300	Saltpan/Mudflats	13300						
13400	Beach	13400	Beach	13400						
18000	General Agriculture	18000	General Agriculture	18000					Area Agricola; riego (RA)	
									Area Agricola; riego (permanente) (RAP)	
									Area Agricola; riego (RP)	
									Area Agricola; riego (RPA)	
									Area Agricola; temporal (TA)	
									Area Agricola; temporal (permanente) (TPA)	
		18100	Orchards and Vineyards	18100						
		18200	Intensive Agriculture	18200						
		18300	Extensive Agriculture	18300						
		18310	Field/Pasture	18310						
		18320	Row Crops	18320						
21230	Southern Foredunes	21230	Southern Foredunes	21230						
29000	Acacia Scrub	29000	Acacia Scrub	29000	29000	Catclaw Acacia				
32400	Maritime Succulent Scrub	32400	Maritime Succulent Scrub	32400					Matorral Rosetofilo Costero (E-MRC/Vsa)	
									Matorral Rosetofilo Costero (subinerme) (MRC/MB)	
									Matorral Rosetofilo Costero (Inerme (MRC/MI)	
									Matorral Rosetofilo Costero; veg sec arbus (MRC/Vsa)	
32000	Coastal Scrub	32500	Diegan Coastal Sage Scrub	32500				Coastal Sage Scrub (30)		
								Coastal Sage Scrub - Disturbed (31)		
		32710	Riversidian Upland Sage Scrub		32710	CA Buckwheat-White Sage				
						Deerweed (*Lotus scoparius*)				
32720	Alluvial Fan Scrub	32720	Alluvial Fan Scrub	32720						

Table B-2. Vegetation Classification Crosswalk, cont'd

SPOT Veg Code	SPOT Vegetation Class	Modified Holland Code	Modified Holland Class	San Diego County	Anza-Borrego State Park	Anza-Borrego Series	Imperial County (FRAP)	Tijuana River Watershed	INEGI	Digitized
33000	Sonoran Desert Scrub	33100	Sonoran Creosote Bush Scrub			Creosote Bush-Burrobush				
						Ocotillo				
		33200	Sonoran Desert Mixed Scrub		33200		DX		Matorral Desertico Microfilo (subin (MDM/MB)	
							HS		Matorral Desertico Microfilo (espin (MDM/ME)	
							SE		Matorral Desertico Microfilo (ineme (MDM/MI)	
							NY			NYM33200
										MDM/MI
										MDM/MB
		33210	Sonoran Mixed Woody Scrub	33210	33210	Desert Sunflower				
						Nolina				
		33230	Sonoran Wash Scrub	33230	33230	Desert Lavender				
		33300	Colorado Desert Wash Scrub	33300	33300					
		33600	Encelia Scrub	33600	33600					
33220	Sonoran Mixed Woody and Succulent Scrub	33220	Sonoran Mixed Woody and Succulent Scrub	33220	33220				Matorral Desertico Rosetofilo (MDR/MB)	
										MDR/MB
34000	Mojavean Desert Scrub	34000	Mojavean Desert Scrub		34000					
		34300	Blackbush Scrub		34300					
35000	Great Basin Scrub	35000	Great Basin Scrub					Great Basin Sagebrush (350)		
		35200	Sagebrush Scrub	35200						
		35210	Big Sagebrush Scrub	35210	35210					
36110	Desert Saltbush Scrub	36110	Desert Saltbush Scrub	36110	36110					
37000	Chaparral	37000	Chaparral	37000	37000			Chaparral (50)	Chaparral (E-ML/Vsa)	ML/VSa
								Chaparral - Disturbed (51)	Chaparral (E-ML)	
									Chaparral (ML)	
									Chaparral (ML/V sa)	
		37120	Southern Mixed Chaparral	37120						
		37121	Granitic Southern Mixed	37121						
		37130	Northern Mixed Chaparral	37130	37130		CQ			
		37131	Granitic Northern Mixed	37131	37131					
		37200	Chamise Chaparral	37200			CA			
		37210	Granitic Chamise Chaparral	37210	37210					
		37300	Red Shank Chaparral	37300			CR			
		37400	Semi-Desert Chaparral	37400	37400		CZ			
		37500	Montane Chaparral	37500						
		37510	Mixed Montane Chaparral				CX			
		37520	Montane Manzanita	37520	37520					
		37530	Montane Ceanothus	37530						
		37540	Montane Scrub Oak	37540	37540					
		37800	Upper Sonoran Ceanothus		37800					
		37900	Scrub Oak Chaparral	37900			CS			
		37A00	Interior Live Oak Chaparral	37A00	37A00					
		37G00	Coastal Sage-Chaparral	37G00				Coastal Sage Scrub / Chaparral (72)		
		37K00	Flat-topped Buckwheat	37K00	37K00					

Table B-2. Vegetation Classification Crosswalk, cont'd

SPOT Veg Code	SPOT Vegetation Class	Modified Holland Code	Modified Holland Class	San Diego County	Anza-Borrego State Park	Anza-Borrego Series	Imperial County (FRAP)	Tijuana River Watershed	INEGI	Digitized
37122	Mafic Southern Mixed Chaparral	37122	Mafic Southern Mixed Chaparral	37122						
37132	Mafic Northern Mixed Chaparral	37132	Mafic Northern Mixed Chaparral	37132						
37220	Mafic Chamise Chaparral	37220	Mafic Chamise Chaparral	37220						
39000	Upper Sonoran Subshrub Scrub	39000	Upper Sonoran Subshrub Scrub	39000	39000					
42000	Valley and Foothill Grassland	42000	Valley and Foothill Grassland	42000				Grasslands (80)		
		42100	Native Grassland	42100					Pastizal Natural (PN)	
		42110	Valley Needlegrass	42110						
		42120	Valley Sacaton Grassland	42120						
		42300	Wildflower Field	42300						
		42400	Foothill/Mountain Perennial	42400						
42200	Nonnative Grassland	42200	Nonnative Grassland	42200	42200				Pastizal Inducido (E-PI)	
									Pastizal Inducido (PI)	
45000	Meadow and Seep	45000	Meadow and Seep					Alkali Seep or Meadow (530)		
		45100	Montane Meadow	45100	45100					
		45110	Wet Montane Meadow	45110						
		45120	Dry Montane Meadow	45120						
		45300	Alkali Meadow and Seep	45300						
		45320	Alkali Seep	45320	45320					
		45400	Freshwater Seep	45400						
46100	Badlands/Mudhill Forbs	46100	Badlands/Mudhill Forbs		46100					
52120	Southern Coastal Salt Marsh	52120	Southern Coastal Salt Marsh	52120						
52310	Cismontane Alkali Marsh	52310	Cismontane Alkali Marsh	52310						
52400	Freshwater Marsh	52400	Freshwater Marsh	52400				Freshwater Marsh		
		52410	Coastal and Valley	52410						
60000	Riparian and Bottomland Habitat	60000	Riparian and Bottomland	60000						
		61000	Riparian Forests	61000			NR	Riparian Forest (110)		
								Riparian Forest - Disturbed (111)		
		61300	Southern Riparian Forest	61300						
		61310	Southern Coast Live Oak Riparian Forest	61310				Oak Riparian Forest (280)		
		61320	Southern Arroyo Willow Riparian Forest		61320					
		61330	Southern Cottonwood-Willow Riparian Forest	61330						
		61510	White Alder Riparian Forest	61510						
		62000	Riparian Woodlands					Riparian Woodland (120)		
		62200	Desert Dry Wash Woodland	62200	62200		UX			
61800	Colorado Riparian Forest	61810	Sonoran Cottonwood-Willow		61810					
		61820	Mesquite Bosque		61820		UM	Mesquite Woodland (290)		
62300	Desert Fan Palm Oasis Woodland	62300	Desert Fan Palm Oasis Woodland		62300					

Table B-2. Vegetation Classification Crosswalk, cont'd

SPOT Veg Code	SPOT Vegetation Class	Modified Holland Code	Modified Holland Class	San Diego County	Anza-Borrego State Park	Anza-Borrego Series	Imperial County (FRAP)	Tijuana River Watershed	INEGI	Digitized
62400	Southern Sycamore-Alder Riparian Woodland	62400	Southern Sycamore-Alder Riparian Woodland	62400	62400					
63000	Riparian Scrub	63000	Riparian Scrub					Riparian Scrub (130) Riparian Scrub - Disturbed (131)		
		63300	Southern Riparian Scrub	63300					Vegetacion de Galleria (VG)	
		63310	Mule Fat Scrub	63310	63310					
		63320	Southern Willow Scrub	63320						
		63410	Great Valley Willow Scrub		63410					
		63810	Tamarisk Scrub	63810	63810					
70000	Woodland	70000	Woodland	70000						
		71000	Cismontane Woodland		71000					
		71100	Oak Woodland	71100				Oak Woodland (140)	Bosque de Encino (BQ)	
		71120	Black Oak Woodland	71120						
		71160	Coast Live Oak Woodland	71160						
		71161	Open Coast Live Oak	71161				Oak Woodland - Sparse Phase (160)		
		71162	Dense Coast Live Oak	71162						
		77000	Mixed Oak Woodland	77000						
		78000	Undifferentiated Open Woodland	78000						
71180	Engelmann Oak Woodland	71181	Open Engelmann Oak	71181						
		71182	Dense Engelmann Oak	71182						
72000	Pinyon and Juniper Woodlands	72000	Pinyon and Juniper Woodlands					Pinyon-Juniper Forest (300)		
		72300	Peninsular Pinyon and Juniper	72300						
		72310	Peninsular Pinyon Woodland		72310					
		72320	Peninsular Juniper Woodland and Scrub		72320		JC		Bosque de Tascate; veg sec arbor, sin erosion aprec (BJ)	
75100	Elephant Tree Woodland	75100	Elephant Tree Woodland		75100					
80000	Forest	81100	Mixed Evergreen Forest	81100				Coniferous Woodland (310)		
		81310	Coast Live Oak Forest	81310	81310					
		81320	Canyon Live Oak Forest		81320		QC			
		81340	Black Oak Forest	81340	81340					
		84000	Lower Montane Coniferous Forest							
		84230	Sierran Mixed Coniferous	84230						
		84500	Mixed Oak/ Coniferous/ Bigcone/ Coulter	84500						
		85100	Jeffrey Pine Forest	85100	85100				Bosque de Pino (BP) Bosque de Pino; Veg sec arbor; sin erosion aprec (BP/VSA)	
83230	Southern Interior Cypress Forest	83230	Southern Interior Cypress Forest	83230				Southern Interior Cypress Forest (180)		

the detailed spatial resolution that the SDSU-CESAR data have for the Tijuana River watershed portion of the study area, and the scanned map available for our use could not be adequately georeferenced. We referred to the Minnich and Franco Vizcaìno vegetation map when characterizing the study area and specific conservation areas.

INEGI uses a very different vegetation classification system than the other data sets, using physiognomic characteristics rather than communities defined by species associations. Thus, the INEGI data required cross-walking to a classification system consistent with the other data sets. However, in the INEGI data, communities such as coastal sage scrub and chaparral are not differentiated and thus could not be distinguished in the cross-walk. The INEGI vegetation mapping was developed at a much coarser resolution than any of the other data sets. Consequently, some communities were not distinguished. For example, narrow riparian areas and small wetlands were not mapped. To compensate, we added a new vegetation category to our database by intersecting it with our stream coverage. Streams were assigned a width of 20m to create a vegetation polygon that we named *Riparian Stream* in the database. The Riparian Stream category replaced upland vegetation communities where it overlapped with them, but did not replace mapped wetland communities. Thus, the Riparian Stream category was not necessarily intended to define true riparian and wetland communities, but was used to help SPOT differentiate areas that likely possessed different biophysical characteristics (e.g., more mesic-adapted communities along drainages).

The project's final vegetation coverage was derived using the following steps in ArcInfo and ArcView 8.3.

<u>California</u>

1. Clip the San Diego County vegetation data to the study area boundary.
2. Clip the Anza-Borrego Desert State Park vegetation data to the study area boundary and to the edge of the San Diego County vegetation data.
3. Clip the FRAP vegetation data to the study area boundary and to the edge of either the San Diego County vegetation or the Anza-Borrego Desert State Park, and interpret/assign vegetation classes to *not yet mapped* polygons using surrounding vegetation data and Landsat 7 imagery.
4. Merge all three data layers to create the California vegetation data layer (.shp).

<u>Baja California</u>

5. In Baja California, clip the SDSU-CESAR Tijuana River watershed vegetation data to the edge of the merged California vegetation data layer (i.e., we used the SDSU-CESAR data only for the Baja portion of the Tijuana River watershed).
6. Clip the INEGI vegetation data to the study area boundary and to the edge of the Tijuana River watershed.
7. Merge both data layers and on-screen digitize small vegetation data gaps at the border, using Landsat imagery to create the Baja vegetation data layer.

Study area

8. Merge California and Baja California vegetation layers and use the ELIMINATE command to absorb any polygon less than 0.5 acre.
9. Cross-walk all vegetation to the modified Holland classification scheme per Table B-2.

Protected areas

Protected areas were derived from four data sources using ESRI's ArcView 8.3:

California

1. Select the following classes from the 2003 SANDAG Land Use and Ownership layers.

Land Use (LU)	**Definition:**
7603	Open space reserves, preserves
Ownership (OWN)	**Definition:**
32	California State Parks
33	California Dept. of Fish and Game
43	U.S. Forest Service
44	Bureau of Land Management
46	U.S. Fish and Wildlife Service

2. Select those polygons from the CBI Protected Areas Database within the study area boundary and outside the San Diego County Land Use and Ownership layer.
3. Merge above layers to create protected lands within California (.shp).

Baja California

4. Select those polygons from the *Areas Naturales Protegidas* that lie within the study area, and add the Rancho Cuchumá conservation easement polygon from Pronatura to create protected lands in Baja (.shp).

Study Area

5. Merge California and Baja California protected areas for final data layer.

Spatial Portfolio Optimization Tool (SPOT)

SPOT (TNC 2003) allows us to identify places within the study area that optimize achieving biodiversity conservation goals, in the most intact portions of the landscape, with the least amount of fragmentation. SPOT uses digital data layers that describe the biological integrity of the study area (i.e., the cost surface, Figure 5), the distribution of biological resource targets (in this case, vegetation communities), and conservation goals for these targets as inputs to derive conservation portfolios within an ArcView 3.x GIS platform. In each run, SPOT forms and analyzes millions of conservation portfolios, while searching for the most efficient portfolio. The most efficient portfolio is one that meets conservation goals established by the user with the minimum area, least fragmentation, and lowest cost (as measured by the cost surface). While the algorithms used by SPOT to select conservation portfolios are complicated, it provides an objective method of identifying priority conservation areas, which can be replicated by others to validate our results and modified as finer resolution data and additional information become available.

This section describes the inputs to SPOT (i.e., cost surface, biological targets, and goals), how we stratified the study area to compensate for data limitations, the approach we used to derive the conservation network from the SPOT outputs, and how we refined the SPOT outputs to derive the conservation network.

Units of analysis

To use SPOT, the study area is broken into a set of cells or selection units (Groves 2003), to which attributes describing the conservation targets and cost are assigned. Although watershed subbasins were originally considered as the unit of analysis, we were not able to create uniform watersheds of small enough size with the 80m DEM. Therefore, we used grids of hexagons of various sizes, before settling on 250ac (100ha) hexagons as optimal for dealing with computer processing capacity and limitations of SPOT. Each cell in the grid assumes the attributes of the vegetation communities that it overlays in the vegetation data layer. Cost assigned to each cell is derived from the cost surface in the same way, and is a measure of the biological integrity of the conservation targets contained within each cell.

Biological integrity of the landscape—the cost surface

Human modifications of the landscape are the largest threats to integrity of biological resources and ecosystem function. Therefore, we used the distribution of urbanization, agriculture, and roads as a measure of the human modification of the landscape to construct the cost surface. The distribution of urbanization, agriculture, major roads, and small roads is shown in Figure 5. We constructed the cost layer from these data as follows:

- *Major roads* were buffered by 80ft (25m) on each side, for a total footprint of 160ft (50m). The *major roads* footprint was merged with the Developed and Disturbed categories from the vegetation database to create the *urban* layer.
- The *minor roads* layer was created by buffering minor roads by 32ft (10m) on each side for a total footprint of 64ft (20m).
- Agriculture categories from the vegetation database were extracted and defined as the *agriculture* layer.
- We assigned costs to these layers:
  - *Urban* = 5 points/ha
  - *Minor roads* = 5 points/ha
  - *Agriculture* = 1 point/ha
  - The grid of 250ac (100ha) hexagonal cells was overlaid on these layers, and the corresponding cost values assigned to each cell. Maximum cost for each cell was capped at 100 points.

We also assessed the integrity of watershed subbasins within the study area. Watershed integrity is a measure of the degree to which a watershed unit has not been altered by human activities and thus retains intact watershed processes. We used the presence of development, roads, and agriculture as a measure of the degree to which watershed integrity has been compromised. We were unable to evaluate factors such as amount of groundwater extraction, number of surface water impoundments, and amount of flow regulation, which can also substantially degrade hydrologic processes. We used the same procedure described above, but assigned cost values to $14.5km^2$ watershed subbasins rather than grid cells.

Biological resource targets

Vegetation communities and fine-filter targets (e.g., palm oases, gabbro soils, vernal pools, locations of sensitive species; see Table B-1) were used for various SPOT runs. However, the final SPOT runs used only vegetation communities as biological resource targets, primarily because the available species distributional data were not comprehensive for the study area. Because of scale and resolution, the gabbro soils data and non-digital data from other sources were not used in the SPOT runs, but rather were used to characterize the areas prioritized by SPOT.

Compensating for vegetation data limitations—stratification of the study area

We were concerned that the significant differences in classification and resolution of vegetation community types in different portions of the study area, and the lack of detail on the distribution of certain vegetation community types (e.g., coastal sage scrub and chaparral communities), would bias the portfolios derived by SPOT. Therefore, we stratified the study area to compensate for this issue. Figure 6 shows the stratification units we used to achieve three primary goals:

1. Separate the INEGI data from other data sets, as the INEGI data differed in resolution and mapping conventions. Thus, the southern and eastern boundaries of the Tijuana River watershed served as stratification unit boundaries between the SDSU and INEGI vegetation data.
2. Increase goals for chaparral within Stratum 7, to prioritize the coastal sage scrub community where chaparral and coastal sage scrub were not differentiated in the vegetation database.
3. Force SPOT to select portfolios in all biogeographically important areas (e.g., coastal, inland, and montane zones), in both California and Baja California, to achieve the established goals. We grouped the Sweetwater River watershed, Otay River watershed, and the Tecate Creek basin of the Tijuana River watershed into a northern stratum, used the Las Palmas basin of the Tijuana River watershed as a central basin, and grouped the Rio Guadalupe watershed and the small coastal watersheds into a southern stratum. We used general elevation zones to subdivide these strata into smaller units, creating a total of 11 strata.

As SPOT tries to optimize its efficiency while meeting its goals, it selects areas in each stratum where it can achieve multiple goals (i.e., selects the most intact areas that support multiple vegetation communities). SPOT also searches beyond each stratum to build an overall portfolio that is most efficient. Thus, SPOT tries to reduce fragmentation of the portfolio by grouping areas selected in adjacent strata.

Setting conservation goals

SPOT uses conservation goals to determine how much of each conservation target should be included in each portfolio. For this study, goals were defined as percentages of each vegetation community within each stratum. Thus, SPOT used these goals to develop portfolios that would include the targeted percentage of each community type available in each stratum in the most efficient manner. The selection of conservation goals is somewhat arbitrary, although consistent with conservation goals that have been used in other conservation planning exercises (e.g., NCCP programs in California, TNC ecoregional planning, Groves 2003). As the portfolios produced by SPOT vary depending on the goals used, we used different sets of goals to evaluate the sensitivity of the SPOT results. Table B-3 shows the five sets of vegetation goals used in this study. For example, if the goal for coastal sage scrub is set at 25%, SPOT selects portfolios that include 25% of the coastal sage scrub present within each individual stratum. Several land cover categories, including Urban, Agriculture, Disturbed (no vegetation), Nonnative Vegetation, Open Water (reservoirs), and Beaches, were assigned a 0% goal.

We conducted SPOT runs using five different categories of vegetation goals (Table B-3), ranging from goals classifications that prioritized rare vegetation communities (Goal sets 1, 2, and 3) to classifications that treated all vegetation communities equally (Goal sets 4 and 5). Goal set 1 uses three quartile percentages (75%, 50%, 25%) for communities that we consider to be high sensitivity or irreplaceable (most threatened in terms of extent and distribution), moderate sensitivity, and low sensitivity (least threatened in terms of extent and distribution), respectively. Goal set 2 used high (75%) and low (30%) values for high sensitivity and moderate to low sensitivity communities, respectively. Goal set 3 values were derived by dividing Goal set 1 values in half, to decrease the overall area that SPOT includes in the portfolio. Goal sets 4 and 5 used constant, minimal values of 30% and 25%, respectively, for all communities. Goals can also be varied among stratification units. For example, we set a higher goal for chaparral in Stratum 7, where the INEGI vegetation data did not differentiate between coastal sage scrub and chaparral. The main difference between portfolios generated using different goals is that overall portfolio size increases as goals increase (e.g., using Goal set 1 vs. Goal set 5). We also assessed the frequency that cells were selected (out of 10 runs) for each set of goals to determine areas that were consistently selected by SPOT.

Selecting conservation portfolios

To account for the random element in the generation of portfolios by SPOT, we ran SPOT ten times for each set of goals and determined the frequency of cells selected in each of the ten sets of portfolios. Cells that are selected in all ten SPOT runs are indicative of the highest priority areas for achieving goals. This is particularly true when groups of cells are selected for all sets of goals considered by SPOT.

Table B-3. Vegetation community goals

Vegetation Community	Goal set 1	Goal set 2	Goal set 3	Goal set 4	Goal set 5
Eucalyptus Woodland	0%	0%	0.0%	0%	0%
Disturbed Habitat	0%	0%	0.0%	0%	0%
Urban/Developed	0%	0%	0.0%	0%	0%
Unvegetated Habitat	0%	0%	0.0%	0%	0%
Open Water	0%	0%	0.0%	0%	0%
Freshwater	0%	0%	0.0%	0%	0%
Non-Vegetated Channel, Lake Fringe	25%	30%	12.5%	30%	25%
Saltpan/Mudflats	75%	75%	37.5%	30%	25%
Beach	0%	0%	0.0%	0%	0%
General Agriculture	0%	0%	0.0%	0%	0%
Southern Foredunes	75%	75%	37.5%	30%	25%
Acacia Scrub	25%	30%	12.5%	30%	25%
Coastal Scrub	75%	75%	37.5%	30%	25%
Maritime Succulent Scrub	75%	75%	37.5%	30%	25%
Alluvial Fan Scrub	50%	30%	25.0%	30%	25%
Sonoran Desert Scrub	25%	30%	12.5%	30%	25%
Sonoran Mixed Woody/Succulent Scrub	75%	75%	37.5%	30%	25%
Mojavean Desert Scrub	25%	30%	12.5%	30%	25%
Great Basin Scrub	25%	30%	12.5%	30%	25%
Desert Saltbush Scrub	25%	30%	12.5%	30%	25%
Chaparral	25%	30%	12.5%	30%	25%
Chaparral STRATUM 7	50%	30%	25.0%	30%	25%
Mafic Southern Mixed Chaparral	75%	75%	37.5%	30%	25%
Mafic Northern Mixed Chaparral	75%	75%	37.5%	30%	25%
Mafic Chamise Chaparral	75%	75%	37.5%	30%	25%
Upper Sonoran Subshrub Scrub	25%	30%	12.5%	30%	25%
Valley and Foothill Grassland	75%	75%	37.5%	30%	25%
Nonnative Grassland	50%	30%	25.0%	30%	25%
Meadow and Seep	75%	75%	37.5%	30%	25%
Badlands/Mudhill Forbs	50%	30%	25.0%	30%	25%
Southern Coastal Salt Marsh	75%	75%	37.5%	30%	25%
Cismontane Alkali Marsh	75%	75%	37.5%	30%	25%
Freshwater Marsh	75%	75%	37.5%	30%	25%
Riparian and Bottomland Habitat	75%	75%	37.5%	30%	25%
Colorado Riparian Forest	75%	75%	37.5%	30%	25%
Desert Fan Palm Oasis Woodland	75%	75%	37.5%	30%	25%
So. Sycamore-alder Riparian Woodland	75%	75%	37.5%	30%	25%
Riparian Scrubs	75%	75%	37.5%	30%	25%
Riparian Stream	75%	75%	37.5%	30%	25%
Woodland	50%	30%	25.0%	30%	25%
Engelmann Oak Woodland	75%	75%	37.5%	30%	25%
Pinyon and Juniper Woodlands	50%	30%	25.0%	30%	25%
Elephant Tree Woodland	75%	75%	37.5%	30%	25%
Forest	50%	30%	25.0%	30%	25%
Southern Interior Cypress Forest	75%	75%	37.5%	30%	25%

SPOT also provides an option of mandating that certain cells (e.g., existing protected areas) be included in a conservation portfolio. We performed SPOT runs that included *locking in* protected areas in both California and Baja California, but found that the large amount of protected land in California overwhelmed the results. We also wanted to determine which public lands SPOT would select when protected status was not considered. Because there are so few natural protected areas in the Baja portion of the study area (Rancho Cuchumá and Parque Constitución de 1857), we *locked in* these two areas so that SPOT would consider these areas as building blocks of the conservation portfolio. The results of two SPOT runs, using Goal sets 1 and 5, are shown in Figure 7. The portfolios generated by these two goal sets were used to initially formulate a conservation network.

Identifying and Refining Areas of Conservation Value

We used the two extreme sets of goals [i.e., a minimum representation goal of 25% for all native vegetation communities in the study area (Goal set 5, Table B-3) and goals that were more aggressive for communities considered sensitive or irreplaceable (Goal set 1, Table B-3)] and locked in existing natural protected areas in Baja California (Rancho Cuchumá and Parque Constitución). Therefore, the resulting portfolios were focused on the most intact habitats to meet conservation goals and were *anchored* by existing protected areas in Baja California (Figure 7). These portfolio results were used as the starting point for categorizing land in the study area based on conservation objectives. In general, areas that were selected most frequently for both sets of goals were designated Category A conservation areas; cells that were selected less frequently were designated Category B conservation areas; and areas selected rarely or not at all were classified as Category C or D conservation areas. As Categories A and B are defined as the most intact habitats, we refined the boundaries of these categories using the cost surface. Thus, groups of cells with high costs were excluded from Category A or B areas, and groups of cells with low costs that were not frequently included by SPOT in portfolios were included in Category B areas.

We then used previous studies of the area [e.g., Phase I studies in the Tijuana-Tecate corridor (Pronatura 2004), cross-border linkage studies (CBI 2003)], Multiple Species Conservation Program (MSCP), knowledge of site-specific resources not represented in the database, existing protected areas (Figure 8), watershed boundaries, topography, and known human modifications to the landscape (e.g., new development, roads) to refine conservation boundaries and classification.

APPENDIX C

IMPLEMENTATION STRATEGIES FOR SELECTED CRITICAL OPPORTUNITY AREAS

Human development is quickly compromising our ability to maintain regional habitat connectivity in portions of the border region. We have identified several critical opportunity areas where conservation values of existing blocks of Category A and B lands are threatened unless focused conservation actions are taken in intervening Category C and D areas. This is particularly evident along the international border, where coordinated conservation actions on both sides of the border are needed to maintain habitat connectivity and to allow species dispersal through these Category C and D areas. Both north-south and east-west habitat connectivity is important to support the variety of plants and wildlife that converge along this coastal-mountains-desert transect and low elevation to high elevation habitat gradient.

Appendix C spotlights three major groupings of critical opportunity areas along the international border within each of the three bioclimatic zones—coastal, inland, and montane (Figure 10). These areas have been the focus of recent conservation planning efforts by Pronatura, in the Tecate-Tijuana corridor, and by the Missing Linkages project conducted by the South Coast Wildlands Project and its partners. A variety of conservation actions, by multiple partners, will be needed to achieve conservation objectives in these critical opportunity areas, ranging from maintaining low-density rural land uses and conducting community education programs, to facilitating localized wildlife movement over or under highways, to establishing conservation or agricultural leases, to strategic, focused acquisitions.

Coastal Zone

Category A and B conservation areas in this zone include the Los Pinos, San Ysidro, La Presa, and Cerro Bola units. In California, development along State Road-94 (e.g., Dulzura, Engineer Springs, Barrett Junction, Potrero) is fragmenting the landscape between San Ysidro and Los Pinos. Restricting residential densities in this area is important for maintaining permeability of the landscape between these units. The Tijuana-Tecate corridor in Baja California is characterized by dense residential, commercial, and industrial development that has massively altered the natural landscape and has all but severed a cross-border coastal sage scrub linkage, between Otay Mountain, Cerro San Isidro, La Presa, and Mesa Redonda. In addition, development, agriculture, and mining along Rio Las Palmas are degrading habitat integrity between Cerro Bola and units to the north. Pronatura (2004) has identified areas in this corridor that are important for maintaining the conservation values of lands within and between San Ysidro and La Presa, as well as natural lands within urban areas that are important as public open space.

Existing conservation investments

The Los Pinos unit is largely comprised of U.S. Forest Service land, including the Pine Creek and Hauser Wilderness Areas, with the Bureau of Land Management (BLM) administering the Hauser Mountain portion of the unit. The San Ysidro unit has a mixed ownership and administration, with the bulk of this unit being land protected within the MSCP, including Otay Mountain Wilderness, Rancho Jamul Ecological Reserve, Hollenbeck Canyon Wildlife Management Area, Tecate Peak/Rancho Cuchumá, and the Otay-Sweetwater National Wildlife Refuge. There are also significant BLM-administered lands adjacent to the Cottonwood Creek corridor below Barrett Reservoir, and the City of San Diego Water Department owns land around Barrett Reservoir and along Cottonwood Creek for protection of the municipal water supply.

Threats and connectivity issues

Development along State Road-94, Lyons Valley Road, Lawson Valley Road, and Deerhorn Valley Road in California is fragmenting the landscape, impeding connectivity between San Ysidro and Los Pinos, and threatening to isolate the San Ysidro unit from other core habitat areas. Likewise, development in the Tijuana-Tecate corridor has virtually isolated the San Ysidro unit from other units in Baja California. State Road-94 in California and Highway-2 in Baja California pose significant barriers to movement of animals, particularly as traffic volumes increase to support increasing populations in these areas. The new Toyota plant, and associated development, could irretrievably alter the landscape in this part of Baja California if conservation or mitigation actions are not undertaken immediately.

Conservation goals

1. Link the Los Pinos and San Ysidro units, using BLM-administered land between McAlmond Canyon and Tecate Peak and City of San Diego Water Department land adjacent to Cottonwood Creek as building blocks.
2. Link the San Ysidro unit to the La Presa and Cañada de Águila units and adjacent Category B areas. [Pronatura (2004) has identified undeveloped land west of Tecate important for maintaining connectivity between these units.]
3. Provide east-west habitat linkages for species whose distributions extend between lower elevation coastal areas and higher elevation inland areas.
4. Protect stepping stones of habitats through the urbanized coastal plain to maintain north-south habitat connectivity for species such as California gnatcatcher and Quino checkerspot butterfly.
5. Protect oak woodlands and riparian habitats along streams and drainages.
6. Protect high value resources in and adjacent to Category C and D areas (e.g., vernal pools at Colonia Ejido Matamoros and Otay Mesa).
7. Manage fire regimes to prevent unnaturally high fire frequencies.

Conservation priorities

Priorities in this zone include privately owned properties in California along and adjacent to Cottonwood Creek and between McAlmond Canyon and Tecate Peak. Priorities in Baja California include the land between Tijuana and Tecate and in the Valle de Las Palmas.

Conservation strategies

U.S. Forest Service—Land on the south side of Hauser Canyon is proposed for addition to the Hauser Wilderness in the California Wild Heritage Wilderness Act. There are other public lands adjacent to these proposed additions that are also candidates for inclusion in the Wilderness Area. Acquisition of inholdings in the Cleveland National Forest would facilitate management of this unit to maintain ecological integrity. The integrity and habitat value of Cleveland National Forest lands would also benefit from conservation of landscape linkages that extend to BLM lands in the San Ysidro unit and other Category A areas in Baja California.

Bureau of Land Management—Conserve privately owned parcels between McAlmond Canyon and Tecate Peak to connect the San Ysidro and Los Pinos units. The property at the State Road-94 bridge over Cottonwood Creek is particularly important to ensure movement of large mammals through the area. Consider exchanges of BLM land in areas of the border region that are not a priority for conservation.

City of San Diego Water Department—Conserve and manage privately owned properties that function as watershed lands around Barrett Reservoir and Cottonwood Creek.

County of San Diego—The existing County General Plan designates private property (identified as conservation priority areas in this zone) as General Agriculture, 1 dwelling unit (du)/10, 40 acres, or Multiple Rural Use, 1 du/2, 8, 20 acres. The proposed land use designation (Residential Baseline Map) in the General Plan 2020 update for all private properties in the area is Rural Lands (RL-40), 1 du/40 acres. The densities proposed in General Plan 2020 are more compatible with achieving many conservation objectives.

Within the next year, the County of San Diego plans to initiate development of a NCCP program for the eastern parts of the county as part of the East San Diego County MSCP. Ensuring the maintenance and management of landscape linkages between existing conserved open space is one of the goals of NCCP programs, which is consistent with the conservation vision for this area.

As part of any planned upgrades to Lyons Valley Road, Lawson Valley Road, and Deerhorn Valley Road, create and enhance wildlife undercrossings and install wing fencing to prevent wildlife from crossing the road at-grade.

Private land trusts and community groups—Community groups (e.g., Back Country Land Trust, Pronatura) can help educate residents about the unique natural values of the area and ways to protect and restore them, including use and management of private properties, whether they are residential lots or grazing lands. Community groups should also work with the County Department of Planning and Land Use and local property owners in both states to ensure that new development, and associated impacts, in the community do not compromise the ability to conserve critical linkages, water resources, and other important natural resources. In light of the rapid growth of the planning area, strategic use of acquisition funds in vulnerable areas is warranted, particularly in the Cottonwood Creek corridor.

<u>Caltrans and federal government in México</u>—There are at least three ways that road and righs-of-way improvements can contribute to conservation efforts in this area:

1. Remove riprap from creek banks to allow greater wildlife use.
2. Maintain State Road-94 rights-of-way at the crossings of Cottonwood, Grapevine, and Potrero creeks and Highway-2 right-of-way at the crossing of Tecate Creek to ensure the underpasses don't become too densely vegetated.
3. As part of any planned upgrades to State Road-94 and Highway-2, enhance wildlife undercrossings and install wing fencing to prevent wildlife from crossing the road at-grade.

<u>Culturally important lands</u>—Land on the flank of White Mountain to the east of Cottonwood Creek has been identified as having cultural significance (Phaler personal communication). This area is important for native Indian ceremonies, given its proximity to and view of Cerro Cuchamá/Tecate Peak. Protecting the cultural value of these lands would also protect biological resource values.

<u>Working landscapes and easements</u>—Several properties along Cottonwood Creek and along the border have existing residential developments or agriculture. Conservation or agricultural easements are potential tools to maintain land uses in this area in their existing condition. Conservation groups such as The Trust for Public Land, Environmental Defense, and The Nature Conservancy, as well as the County of San Diego, should work with landowners to maintain landscape permeability in these linkages.

<u>Toyota Motor Corporation</u>—As mitigation for the new assembly plant and associated development, conserve lands that will enhance the quality of life of local citizens as well as maintain and enhance landscape permeability for wildlife, consistent with the Las Californias binational conservation vision.

Inland Zone

Category A and B units in this zone include the Laguna Mountains and Los Pinos in California and Cañada de Águila and El Pinal in Baja California. These areas are generally separated by Category C areas of rural residential and agricultural development. Interstate-8, State Road-94, and Highway-2 are barriers to movement of some species and accommodate increased density developments. This is particularly true for Interstate-8, where there are only three underpasses through this area where wildlife can avoid crossing the freeway at-grade. Cañada de Águila and Category B lands around Campo are important stepping stones of habitat in the Inland Zone, facilitating both north-south and east-west species dispersal. Although isolated BLM parcels may facilitate habitat connectivity, some of these should be evaluated for their potential use in strategic land swaps. Establishing and maintaining north-south connectivity across the border, through the area between Tecate and El Hongo, should be a focus in this zone (CBI 2003).

Existing conservation investments

The U.S. Forest Service and BLM have the largest conservation investments in this zone. The Forest Service administers the bulk of the public land in the Los Pinos and Laguna Mountains units. The La Posta Microwave Station property, administered by the Department of Defense as a U.S. Navy SEAL training facility, is surrounded by a patchwork of BLM lands. BLM also administers thousands of acres along the border, including rugged canyons through the Campo Valley area. South of the border, there are no protected or public lands, but conservation priorities include the perennial springs and vernal pools around Neji and the watershed lands of Cañada del Testerazo, as well as habitats in the central portion of the valley that would maintain a landscape linkage across the border.

Threats and connectivity issues

The Campo and El Hongo valleys support ranchette-type development and agriculture, and new residential housing projects are threatening. Interstate-8, State Road-94, and both Highway-2 roads (toll road and free road) are significant barriers to wildlife movement, and increasing development along these roads is exacerbating the problem. Also, sand mining in Campo Creek, Miller Creek, and Las Calabazas drainage and agricultural consumption of water are significantly depleting stream and riparian habitats.

Conservation goals

1. Create at least two areas of unfragmented core habitat in the California planning area:
   a. BLM lands around the La Posta Microwave Station property.
   b. Hauser Mountain across State Road-94 to BLM lands on the border (contiguous with the Hauser Wilderness Area and National Forest lands to the north).
2. Link Laguna Mountains and Los Pinos (Hauser Mountain) with Cañada de Águila:
   a. Use BLM land on the border, including La Gloria and Smith canyons and Schockey Truck Trail, and key private properties to create a system of open space connecting Category B areas near the border through Clover Flats, Miller Creek, Brian's Creek, and Denlinger valley to National Forest land to the north.
   b. Connect BLM land on the border north along Campo Creek to Hauser Mountain and Star Ranch valley.
   c. Maintain existing uses on private properties at La Posta Creek, Kitchen Creek, and Cottonwood Creek to allow wildlife access to Interstate-8 underpasses.
3. Conserve oak woodlands along riparian corridors in this zone.
4. Conserve grasslands and meadows, which are under-represented in conserved open space in this zone and which are vulnerable to development.

5. Provide foraging for large area-dependent species in this zone (e.g., spotted owl, deer, and mountain lion).
6. Conserve a representative sample of vegetation communities unique to this zone, including the inter-mountain transition between coastal and desert communities.

Conservation priorities

Priorities in this area include privately-owned properties along State Road-94, lands bordering Campo Creek and Miller Creek, properties adjacent to the La Posta Microwave Station, and properties abutting Hauser Mountain on the east, south, and north. Private inholdings and lands that serve to link public lands (e.g., under Interstate-8) are also critical.

Conservation strategies

<u>U.S. Forest Service</u>—The integrity and habitat value of Cleveland National Forest lands would benefit from conservation of landscape linkages that extend to BLM lands on the border and into Baja California. The Forest Service could contribute to conservation through acquisition or designation of conservation easements and/or management agreements with property owners of private inholdings in the National Forest. These privately owned lands are also the locations of the three Interstate-8 undercrossings and thus represent chokepoints in the linkage. The majority of these lands are currently being used for grazing, which can be compatible with wildlife movement across these properties. Continued managed grazing in these areas would help to maintain habitat integrity. As an alternative to acquisition in these areas, conservation easements and/or management agreements could be developed to maintain the habitats in all or a portion of (1) Cottonwood Valley, along Buckman Springs Road, east and west of Interstate-8, and (2) Cameron Valley, along La Posta Creek, north and south of Interstate-8.

<u>U.S. Navy</u>—The U.S. Navy and BLM are discussing withdrawal of BLM land uses from BLM lands adjoining the La Posta Microwave Station property. Our understanding is that the proposed land use by the Navy (i.e., SEAL training) would be compatible with use by wildlife. Conservation of private inholdings adjacent to Navy and BLM lands would best be accomplished through acquisition.

<u>Bureau of Land Management</u>—BLM could contribute to conservation through acquisition of private inholdings and other adjacent parcels along Campo Creek. Hauser Mountain is designated as a wildlife habitat management area. If a portion of the private lands east of Hauser Mountain also were acquired (Star Ranch valley), the land could be leased for grazing allotments (current use). BLM should also consider targeted acquisition of properties in Smith and La Gloria canyons.

<u>County of San Diego</u>—The private lands along both sides of State Road-94 comprise one of the chokepoints in the *La Posta Linkage* (CBI 2003), especially along a 4-mile stretch (approximately 2 miles both east and west of La Posta Road). Proposed General Plan designation of Rural Lands (RL-40), 1 du/40 acres, or Rural Lands (RL-80), 1 du/80 acres, could allow some use of remaining habitat by wildlife. Higher densities along this portion of State Road-94, such as allowed in the existing General Plan, would severely restrict crossing the road

in this area. Much of the area south of State Road-94 is within the Campo Creek floodplain and would not be suitable for residential development. Some of this area is currently being used for grazing, which can be compatible with use of the area as a linkage.

The General Plan 2020 also proposes the Clover Flat/Miller Creek area and the Star Ranch valley, east of Hauser Mountain and west of Cameron Corners, for densities of 1 unit per 40 acres. Higher densities in these areas, such as allowed in the existing General Plan, would restrict use of these areas for wildlife movement. Portions of these areas would not be suitable for residential development or sand mining because of floodplain restrictions, the presence of wetland habitats, and the potential to support arroyo toads (Miller Creek).

Within the next year, the County of San Diego plans to initiate development of a NCCP program for the eastern parts of the county as part of the East San Diego County MSCP. Ensuring the maintenance and management of landscape linkages between existing conserved open space is one of the goals of NCCP programs, which is consistent with the conservation vision for this area.

As part of any planned upgrades to Buckman Springs Road and La Posta Road, create and enhance wildlife undercrossings and install wing fencing to prevent wildlife from crossing the road at-grade.

<u>City of San Diego Water Department</u>—Conserve and manage privately owned properties that function as watershed lands around Morena Reservoir and upstream on Cottonwood Creek.

<u>Private land trusts and community groups</u>—Community groups [e.g., Mountain Empire Resources Information Taskforce (MERIT)] can help educate residents about the unique natural values of the area and ways to protect and restore them, including use and management of private properties, whether they are residential lots or grazing lands. Community groups should also work with the County Department of Planning and Land Use and local property owners in both states to ensure that new development, and associated impacts, in the community do not compromise the ability to conserve critical linkages, water resources, and other important natural resources. In light of the rapid growth of this area, strategic use of acquisition funds in vulnerable areas is warranted, particularly along a 4-mile stretch of State Road-94 (about 2 miles east and 2 miles west of La Posta Road, north and south of State Road-94). In addition, conservation easements could be placed over Miller Creek, Campo Creek, La Posta Creek, Kitchen Creek, Cottonwood Creek, and Tecate Creek in strategic areas. A greenbelt concept along Tecate Creek is being discussed as a way to enhance quality of life and natural resource values (Comer personal communication).

<u>Caltrans and federal government in México</u>—There are at least three ways that road and right-of-way improvements can contribute to conservation efforts in this area:

1. Remove riprap from creek banks within the linkage area to allow greater wildlife use.
2. Maintain the rights-of-way along Campo Creek under State Road-94, south of Hauser Mountain, and along Highway-2 to ensure the underpasses don't become too densely vegetated.
3. As part of any planned upgrades to State Road-94 and Highway-2, construct wildlife underpasses or bridges to facilitate wildlife crossing and reduce mortality caused by

wildlife crossing the roads at-grade. This will become particularly important as development and traffic increase along these roads.

Working landscapes and easements—On grazing or agricultural lands in both California and in Baja California, conservation may best be achieved in the form of working landscapes, with some strategic restrictions or conservation easements (e.g., along streams, floodplain areas, at highway underpasses). Conservation groups such as The Trust for Public Land, Environmental Defense, and The Nature Conservancy, as well as the County of San Diego, should work with landowners to maintain landscape permeability across El Hongo and Campo valleys.

Montane Zone

Category A lands in this area include the Laguna Mountains and Northern Sierra Juaréz. These units are separated by Interstate-8, State Road-94, and Highway-2. Therefore, Category C lands in this area are important for maintaining north-south connectivity, including relatively small areas of private land from Oasis to Boulder Park and at the headwaters of Carrizo Creek. The concept of a binational Peace Park, dubbed the Parque-to-Park, recognizes the potential to connect the Parque Constitución de 1857 in Baja California, through Anza-Borrego Desert State Park, to Palomar Mountain State Park in California as a way of formally establishing an interconnected conservation network in this area.

Existing conservation investments

BLM and California State Park lands represent huge blocks of public lands that stretch across the Tecate Divide. BLM administers the Carrizo Gorge Wilderness and Jacumba Wilderness, the In-Ko-Pah Area of Critical Environmental Concern (ACEC), and Table Mountain ACEC, as well as smaller parcels of land directly along the international border. Anza-Borrego Desert State Park is the largest state park in California and the largest desert state park in the contiguous U.S., two-thirds of which is designated as Wilderness Areas.

Threats and connectivity issues

While most of the conserved land is mountainous and rugged, much of the private land along the international border, south of Interstate-8, is relatively gentle and thus vulnerable to development (e.g., Jacumba Valley Ranch, Boulevard, El Hongo, Jacumé, La Rumorosa). Consumption of surface and ground waters as a result of new development is a significant threat to habitats and wildlife. Interstate-8 and State Road-94 in California and Highway-2 (toll road and free road) in Baja are barriers to wildlife movement and sources of mortality. There are only two habitat undercrossings of Interstate-8 across this area between Boulevard and the Jacumba Wilderness, a distance of about 10 miles. These two bridges, over Carrizo Creek and Boulder Creek, allow animals to move through habitat under the freeway rather than crossing the freeway at-grade. However, both undercrossings are on private land.

Conservation goals

1. Link the Jacumba and In-Ko-Pah Mountains with the Sierra Juárez:
   a. Connect Anza-Borrego Desert State Park Jacumba Mountain Wilderness Area with BLM Jacumba Wilderness Area by protecting land along Interstate-8, particularly at locations of underpasses (e.g., Boulder Creek in Imperial County and Myer Creek in San Diego and Imperial counties).
   b. Connect Anza-Borrego Desert State Park (e.g., Carrizo Canyon and Jacumba Mountain Wilderness Areas) and BLM border lands (Jacumba Wilderness and Table Mountain ACEC) to Category A and B areas in Baja California through private lands in California (e.g., in the Carrizo Gorge watershed) and Baja California. Connectivity for large mammals, which may require an overpass over the highway in each country, may not be appropriate at this time because of concerns over livestock diseases that may affect bighorn sheep (Rubin personal communication).
   c. Connect the Carrizo Gorge watershed with the Northern Sierra Juárez.
2. Provide east-west habitat linkages or stepping stones for species whose distribution ranges across coastal, trans-montane, and desert habitats (i.e., Campo Valley across Tecate Divide to Jacumba).
3. Conserve habitat integrity and water resources in the Carrizo Gorge, Myer Creek, Boulder Creek, and Agua Grande watersheds.
4. Provide foraging for large area-dependent species, with particular focus on habitats that support seasonal migrations of bighorn sheep.
5. Conserve a representative sample of vegetation communities unique to the area, including Sonoran mixed woody scrub communities on old cinder cones, riparian communities and desert washes, and alkali meadows and seeps.

Conservation priorities

Priorities in this area include the Jacumba Valley Ranch (Specific Plan Area in San Diego County) in the upper watershed of the Carrizo Gorge and private inholdings important to the State Park (e.g., Inner Pasture) and BLM (e.g., private land along the San Diego-Imperial County line between Table Mountain and the Jacumba Wilderness). Private inholdings along Interstate-8 may be important to maintaining a linkage through this area. Conservation priorities identified to date in Baja California include the areas around Jacumé and Vallecitos and linkages to the Northern Sierra Juárez.

Conservation strategies

Bureau of Land Management—BLM could contribute to conservation through acquisition of private inholdings and other adjacent parcels through outright purchase or through land swaps. For example, there are many small, scattered BLM parcels along the border, south of Manzanita, Boulevard, and Bankhead Springs. Exchanging these lands for parcels bordering the BLM

Jacumba Wilderness on the west would consolidate its ownership and provide a habitat linkage between the Wilderness Areas.

<u>Anza-Borrego Desert State Park and State Lands Commission</u>—Acquisition and management of watershed lands and lands with ground water and surface water resources should be a priority to protect the enormous existing conservation investments and habitat values for desert wildlife. Planned human development in the desert communities is competing for these resources.

<u>County of San Diego</u>—The Jacumba Valley Ranch is designated as a Specific Plan Area (SPA) in both the existing General Plan and the proposed General Plan 2020. The proposed General Plan 2020 densities for this SPA are 1.7 du/1 ac, with residential development concentrated in two areas on the property. Permitting future build-out at this level would have severe consequences to water resources in the Carrizo Gorge watershed and potential negative impacts to bighorn sheep and other wildlife. Other private lands along the border have proposed General Plan designations of Rural Lands (RL-40), 1 du/40 acres, Rural Lands (RL-80), 1 du/80 acres, which could allow some use of remaining habitat by wildlife. Higher densities, such as allowed in the existing General Plan (1 du per 2, 4, and 8 acres), would severely impact habitat integrity and connectivity in this area.

Within the next year, the County of San Diego plans to initiate development of a NCCP program for the eastern parts of the county as part of its East San Diego County MSCP. Ensuring the maintenance and management of landscape linkages between existing conserved open space is one of the goals of NCCP programs, which is consistent with the conservation vision for this area.

<u>Private land trusts and community groups</u>—Community groups (e.g., Anza-Borrego Foundation) can help educate residents about the unique natural values of the area and ways to protect and restore them, including use and management of private properties, whether they are residential lots or grazing lands. Community groups should also work with the County Department of Planning and Land Use and local property owners in both states to ensure that new development, and associated impacts, in the community do not compromise the ability to conserve critical linkages, water resources, and other important natural resources. In light of the rapid growth in this area, strategic use of acquisition funds in vulnerable areas is warranted, particularly in the Carrizo Gorge watershed (e.g., Jacumba Valley Ranch) and Boulder Creek chokepoint along Interstate-8. Alternatively, conservation easements could be placed over Carrizo Creek, Boulder Creek, Myer Creek, and Agua Grande in strategic areas.

<u>Caltrans and federal government in México</u>—There are at least three ways that road and right-of-way improvements can contribute to conservation efforts in this area:

1. Remove riprap from creek banks to allow greater wildlife use.
2. Maintain the rights-of-way of Interstate-8, State Road-94, and Highway-2 along Carrizo Creek, Boulder Creek, Myer Creek, and Agua Grande to ensure the underpasses don't become too densely vegetated.
3. As part of any planned upgrades to Interstate-8 and Highway-2, construct a wildlife bridge (overpass) to facilitate bighorn sheep crossing and reduce mortality caused by

wildlife crossing the road at-grade. This will become particularly important as development and traffic increase along these roads.

Working landscapes and easements—On grazing or agricultural lands in both California and in Baja California, conservation may best be achieved in the form of working landscapes, with some strategic restrictions or conservation easements (e.g., along streams, desert washes, at highway underpasses). Conservation groups such as The Trust for Public Land, Environmental Defense, and The Nature Conservancy, as well as the County of San Diego, should work with landowners to maintain landscape permeability through the area along the border.

Culturally important lands—Petroglyphs at Vallecitos have been identified as having cultural significance for native Indian tribes. Protection of the cultural value of these lands would also protect the biological resource values.