

A Framework for Effective Conservation Management of the Sonoran Desert in California


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Prepared for

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EXECUTIVE SUMMARY

The Sonoran Desert of southern California has long been a region of under-appreciated natural significance. For most, the term “desert” evokes images of a bleak and lifeless wasteland—a place of unforgiving heat, sun, sand, and rocks. Throughout history, the Southwest’s deserts have been avoided or they presented a challenging obstacle on the way to a greener place. In the 19th century, during the era of exploration and migration, the desert was seen as an area to be crossed as quickly as possible. Even today, the Sonoran Desert remains one of the least populated areas in California. Historically and recently, many who ventured into the desert did so for utilitarian purposes—for activities such as mining, military training, farming, off-highway vehicle (OHV) recreation and, more recently, for energy production. In general, however, there has been a lack of awareness of the special and uniquely diverse species and ecosystems found in the region, leading to an unfortunate under-appreciation for what is truly an area of incredible natural significance.

The Sonoran Desert has been recognized by scientists for its great biological wealth, including its large species diversity, unique geology, and diverse plant communities. In fact, the Sonoran Desert has been identified as one of the top 200 ecoregions worldwide that deserve special conservation attention. The Sonoran Desert in California, with its coastal influence, rich geological history, presence of the Colorado River, and the dynamic Salton Sea, lives up to this reputation, with an amazing diversity of habitats including marshes and pupfish ponds, ephemeral playas, open desert washes, wind-formed sand dunes, alluvial fans, rugged mountain slopes, steep-walled canyons, flowing streams, and hidden palm oases. These habitats support a wide variety of species, including water and neotropical migratory birds, uniquely adapted reptiles and amphibians, dozens of mammal species, hundreds of plant taxa, countless invertebrates, and even fish. A number of these species are Federally or State listed, and some are found no place else on Earth.

In California, the Sonoran Desert comprises a large portion of the 25-million acre California Desert Conservation Area (CDCA) which, in turn, is included in the National Landscape Conservation System, established in 2000 with the mission of conserving, protecting, and restoring nationally significant landscapes. In addition, portions of California’s Sonoran Desert are designated as a biosphere reserve by the United Nations Educational, Scientific and Cultural Organization (UNESCO), and a large number of wilderness areas have been designated in the region by various State and Federal agencies.

Today, however, California’s Sonoran Desert is at increased risk from development, habitat fragmentation, water diversion and overdraft, global climate change, invasive nonnative species, nitrogen deposition, a modified fire regime, and a myriad of land use impacts. Although the Sonoran Desert in California has been one of the most sparsely populated areas in California, its population is growing rapidly, with a predicted human population of 222,600 in 2020, doubling in size since 1990. It is therefore urgent that conservation of this area is managed and enhanced appropriately, to assure the long-term viability of its unique ecosystems and species. Although protected areas exist and many conservation efforts are underway, existing efforts have been hindered by fragmented ownership, diverse missions and mandates among landowners, and a lack of a region-wide conservation vision.

Our goal in this report is to propose a framework for effective conservation management that encompasses a regional perspective in addressing threats, and that will allow participating land managers to increase effectiveness and efficiencies in the face of limited funding and increasing conservation challenges. The objectives of this framework are to:

1. Summarize conservation values and targets.
2. Summarize existing conservation and management emphases and stewardship roles.
3. Describe current threats and conservation challenges facing the region.
4. Identify gaps in existing management and conservation efforts relative to current threats and protection of biodiversity, ecological processes, and focal species.
5. Identify and describe opportunities for improved management and protection of the desert ecosystem, via enhanced unilateral actions of public and private landowners, as well as collaborative conservation management among stakeholders.

To guide our identification of conservation opportunities, we identified multiple conservation targets and used these, in concert with an evaluation of landscape integrity, to divide the study area into four broad categories of landscape integrity and conservation value. Within these land categories, conservation objectives were established, and opportunities to address conservation challenges and increase conservation effectiveness were identified.

Our assessments were informed by review of pertinent literature, reports, and maps regarding the conservation, management, and ecology of the Sonoran Desert, in particular its California extent. In addition, we met with numerous individuals, organizations, and agencies involved in management and conservation of the region, to obtain their input on conservation priorities and threats, management challenges, selection of targets, data availability, as well as existing and planned management protocols.

Conservation Opportunities

The Sonoran Desert in California is a diverse landscape in terms of its physical features, biodiversity, natural (ecosystem) functions, and in degree of human impact. As a result, a range of conservation opportunities and appropriate strategies exist across this landscape. To assess current conservation conditions and identify conservation opportunities, we categorized the study area into the following four classes:

Category A: Lands that have a high level of landscape integrity (low or no fragmentation) and satisfy at least one of our two conservation goals of irreplaceability and ecosystem representation.

Category B: Lands that have a high level of landscape integrity or satisfy at least one of our two conservation goals of irreplaceability or ecosystem representation. As such, lands in this category may have high target value but have compromised integrity, or they may have high integrity and lower target value.

Category C: Natural areas or open space that are fragmented by roads, sparse rural residential communities, or other human uses, but which may nonetheless contain conservation targets, provide potential habitat linkages, or provide a buffer around Category A and B lands.

Category D: Lands that are dominated by urban communities and agriculture, but which may contain isolated conservation targets or provide habitat for some wildlife species.

These four categories recognize the differences that exist across the conservation landscape of the region, and allowed us to define the following unique conservation objectives for each category:

Category A: Protect large, intact habitat blocks to conserve irreplaceable biological resources, support natural ecological processes (e.g., fire and water-flow regimes), and maintain habitat connectivity. Prevent agents of fragmentation (e.g., development, roads), invasion of exotic species, and other direct and indirect human impacts from occurring in these areas.

Category B: Promote land uses and management practices that maintain or improve landscape integrity and protect conservation targets. Promote restoration of habitat connectivity, natural vegetation communities, and ecological processes (e.g., water-flow regimes, eolian processes).

Category C: Encourage sustainable land uses that minimize impacts to natural resources, allow protection of sensitive species and isolated high value native ecosystems, and maintain landscape permeability to wildlife movement.

Category D: Focus conservation and management efforts on natural areas (e.g., open spaces, riparian habitats, canyons) that support local wildlife, improve air and water quality, recharge groundwater aquifers, and otherwise improve human quality of life. Promote management of agricultural landscapes to support key wildlife resources (e.g., birds at the Salton Sea).

To identify regional conservation opportunities, we examined distribution of the four land categories, assessed how well conservation objectives were met by existing conservation efforts and land management, and evaluated the potential effects of identified threats and challenges on them. We identified six groupings of Category A and B lands, which we termed *landscape units*, that represent areas with the highest integrity and conservation values and serve as the core units of our conservation vision. In addition to specific recommendations for each of the six landscape units, we recommend the following strategies for the four land categories:

For the six landscape units (Category A and B lands), general recommendations include:

- Avoid land conversion and fragmentation. Land uses that result in fragmentation or conversion, for example, urban development and renewable energy production and transport facilities, should be sited within Category D lands when possible, and within

Category C lands when necessary.

- Increase effective conservation of Category A and B lands by enhancing management policies and actions to improve natural resource protection on public lands, and promote habitat protection on private lands via acquisition of key properties (e.g., inholdings), conservation easements, or enhanced zoning that emphasizes natural resource values.
- Improve landscape integrity within landscape units lands by closing, and possibly restoring, unnecessary dirt roads, and by increasing wildlife permeability across critical sections of paved roads, canals, and railroad tracks via construction of over- and under-passes.
- Maintain or restore connectivity among landscape units, as feasible, as well as connectivity to adjacent protected and intact lands outside of the study area. Maintenance of landscape integrity that includes complete watersheds flowing into the Sonoran Desert will protect ecosystems within the study area.
- Limit off-route (cross-country) OHV use, reduce open routes in sensitive areas, increase enforcement and rider education programs to reduce trespass into closed areas, and support restoration of OHV-damaged areas.
- Protect and maintain health of watersheds and groundwater basins by avoiding water-consuming developments and by increasing protection of watersheds.
- Eliminate or control non-native invasive plants.

In addition, key recommendations for individual units are summarized here:

<u>Landscape Unit 1</u>: This unit is located at the western edge of the Sonoran Desert, extends from the Jacumba and In-Ko-Pah mountains at the US-Mexico border north to the San Jacinto mountains, and includes the U.S. portion of the Peninsular Ranges. This unit provides important landscape connectivity, supports a diversity of vegetation communities, and provides habitat for a focal species such as bighorn sheep, flat-tailed horned lizards, Peirson's milk-vetch, triple-ribbed milk-vetch, and least Bell's vireo. Key conservation actions for this unit include maintaining and re-establishing habitat connectivity, enhancing conservation on private lands, especially along the eastern slopes of the Santa Rosa and San Jacinto mountains in the Coachella Valley, reducing groundwater overdraft, and increasing OHV enforcement and education programs on public lands, primarily along the unit's eastern and southern extents.

<u>Landscape Unit 2</u>: This unit includes a narrow arc of land stretching from the southern edges of the San Bernardino Mountains at the north end of the Coachella Valley, along the southern edges of the Little San Bernardino Mountains and the Indio Hills, to the Eagle and Coxcomb mountains. The unit adjoins large blocks of protected land to the north, helps maintain intact landscapes along an elevational gradient and ecoregional transition zone, supports diverse habitat such as dunes, playas, desert dry wash woodlands, and alluvial fans containing both Mojavean and Sonoran creosote bush scrub, and provides habitat for sensitive species such as desert tortoise and flat-tailed horned lizard. Because land conversion for development and energy production are significant threats, conservation goals include increasing protection of private

land along the eastern slopes of the Coachella Valley, along the Interstate 10 corridor, and inholdings within Joshua Tree National Park, via conservation easement or acquisition, and enhanced conservation of public lands along the Interstate 10 corridor and within the San Gorgonio River, Whitewater River, and Mission Creek watersheds. Energy development projects should be located in adjacent Category C and D lands.

Landscape Unit 3: This unit, which extends from State Route 62, near the Calumet Mountains and Cadiz Valley, east to include the Iron Mountains, the Ward and Chemehuevi valleys, and the Whipple Mountains, includes important transition lands between the Sonoran and Mojave deserts. The area supports some of the region's most extensive undeveloped areas, including desert dry wash woodlands, sand dunes, and playas, and is home to desert bighorn sheep, desert tortoises, and rare saguaros. Key conservation goals for this area include enhanced protection of public lands, particularly the large valleys that link wilderness areas typically found in more mountainous terrain, from land conversion for solar and geothermal energy production, and from adverse impacts of inappropriate OHV use, and enhanced conservation of selected mountainous areas that have high potential for wind energy production. Energy development projects should be located in adjacent Category C and D lands. Enhanced conservation of private and Tribal lands, in collaboration with the Lower Colorado River Multi-Species Conservation Program, would also benefit the Colorado River and its associated riparian habitats.

Landscape Unit 4: This unit, located between State Route 62, State Route 177, Interstate 10, and the Colorado River, includes the Palen, Granite, McCoy, Big Maria, and Riverside mountains, and expansive undeveloped areas such as the Rice Valley and Palen Dry Lake. This area supports playas, sand dunes, desert dry wash woodlands, large expanses of Sonoran creosote bush scrub, and historic and currently occupied bighorn sheep habitat. Conservation goals for this landscape unit rely heavily on enhanced conservation of public lands. In particular, lands with potential for wind energy (e.g., in the Granite, Little Maria, and McCoy mountains) and those with potential for solar (e.g., Palen Dry Lake and gentle terrain northwest of Blythe), should be carefully managed to protect sensitive ecosystems, native species, and habitat connectivity. Increased protection of private lands at Palen Dry Lake, in the vicinity of Federal wilderness, and scattered inholdings, especially those within wilderness, would help maintain landscape integrity and protect key resources.

Landscape Unit 5: This unit is located south of Interstate 10, and extends from the Coachella and Imperial valleys east to Blythe, with its southern extent including the Algodones Dunes. It includes the Chuckwalla, Palo Verde, Orocopia, and Chocolate mountains, Mecca Hills, Milpitas Wash, and the Algodones Dunes. This area supports key resources such as extensive dry wash woodlands, sand dunes, fan palm oases, pupfish habitat, saguaros, bighorn sheep, flat-tailed horned lizard, Peirson's milk-vetch, and desert tortoise critical habitat. Conservation goals for this unit include enhanced protection of private lands, especially in the Milpitas Wash and eastern slopes of the Chocolate Mountains (which would provide the added benefit of buffering military lands), increasing effective conservation of existing protected core areas such as the Chuckwalla and Orocopia mountains (via protection of private lands, enhanced management of public lands, and avoidance of additional fragmentation), and increased OHV enforcement and educational programs primarily at the southern extend of this unit.

Landscape Unit 6: This unit is found at the southeastern corner of the study area, where it is bound on the east by the Colorado River, on the south by Interstate 8 and the city of Yuma, Arizona, and on the west by State Highway 78 and State Route 34. This unit includes extensive desert dry wash habitats, and habitats for rare species such as saguaros, desert pupfish, flat-tailed horned lizards, desert tortoises, and bighorn sheep. It also supports important riparian habitats along the Colorado River which provide diverse wildlife habitat and recreational opportunities. Primary conservation goals for this unit include enhanced protection of BLM lands from conversion and fragmentation related to solar and wind energy development, OHV enforcement and education programs, primarily at the southwestern portion of the unit, and invasive plant removal and habitat restoration programs along the Colorado River. Energy development projects should be located in adjacent Category C and D lands. The Lower Colorado River Multi-Species Conservation Program provides a conservation framework for enhancing conservation values of the Colorado River and its associated riparian habitats.

For Category C lands, primary recommendations include:

- Promote protection of sensitive species and isolated sensitive native ecosystems (e.g., pupfish habitat).
- Eliminate or control non-native invasive plants.
- Implement water conservation programs to contribute to the State's goal of reducing use of Colorado River water, and to reduce overdraft of local groundwater basins.
- Plan future renewable energy production and transport facilities such that they:
  - do not threaten sensitive plants or animals.
  - do not threaten sensitive habitats (e.g., playas, sand dunes, pupfish ponds).
  - do not disrupt wildlife habitat permeability.
  - do not create an additional strain on the desert's limited water supply.
  - are sited near energy use areas, thereby reducing the need for transport facilities.
- Promote connectivity among landscape units by managing Category C lands to promote wildlife permeability and, as feasible, natural processes such as water flows and sand transport:
  - Conduct a habitat connectivity assessment to determine where important linkages exist
- Increase enforcement of existing land use regulations , especially those beneficial to desert conservation efforts in adjacent landscape units (e.g., enforcement of OHV use regulations).
- Improve facilities and rider experience at designated OHV use areas, to help reduce trespass into closed areas.

For Category D lands, primary recommendations include:

- Manage and/or restore agricultural lands to benefit native species in collaboration with Salton Sea restoration efforts. This should involve collaboration with private land owners, farmers, and ranchers, and be coordinated with mitigation programs associated with the water conservation and transfer activities being conducted by the Imperial Irrigation District.
- Implement water conservation programs to contribute to the State's goal of reducing use of Colorado River water, and to reduce overdraft of local groundwater basins.
- Protect open spaces such as parks, greenbelts, and riparian areas that support wildlife.
- Eliminate or control non-native invasive plants.
- Promote strong enforcement of air and water quality regulations, as well as regulations to reduce nitrogen deposition.
- Encourage energy conservation and use of local generation of renewable power (e.g., rooftop solar) in land planning and development.
- For commercial renewable energy production, emphasize Category D lands as the recommended location. Plan future facilities such that they:
    - do not threaten sensitive plants or animals
    - do not threaten sensitive habitats (e.g., pupfish ponds).
    - do not create an additional strain on the desert's limited water supply.
- Promote programs that reduce indirect impacts on adjacent wildlands (e.g., programs that address night lighting, use of pesticides, roaming pets, planting of invasive plants).

Integrated into the above recommendations for the four land categories and six landscape units, we stress the importance of maintaining and restoring landscape connectivity. Maintenance of landscape integrity is key to effectively conserving the Sonoran Desert landscape by maintaining connectivity among communities and habitats, preserving the functionality of ecosystem processes and the long-term viability of wildlife populations, maintaining resilience to global climate change, reducing the potential for exotic species invasions, and protecting air and water quality. Maintaining and restoring landscape integrity at multiple scales is an overarching conservation objective for this region, and we thus stress the maintenance of integrity within and among landscape units. Equally important is maintenance of connectivity between the California Sonoran Desert and adjacent regions. This includes connectivity to the South Coast ecoregion, the Mojave ecoregion, and to Mexico.

Protection of habitats in the Sonoran Desert of California also contributes to landscape connectivity at far larger scales. Protection of the Salton Sea and neighboring agricultural lands and the Colorado River corridor provides crucial foraging and resting areas for migratory birds along the Pacific Flyway. Without conservation of these Sonoran Desert resources, a significant global migration pattern could be significantly impacted. Similarly, the Colorado River is a crucial source of freshwater, sediment and nutrients to the northern Gulf of California and its delta, and protecting the conservation functions of this river system is key to conserving the biodiversity of the entire Gulf of California ecosystem.

Implementing the Vision

Our vision for conservation of the Sonoran Desert in California relies greatly on enhanced conservation of existing conservation investments to protect them from increasing threats and challenges. Highly significant investments have been, and are continuing to be made in the California's Sonoran Desert. Yet, these large conservation investments are potentially jeopardized by the threats discussed in this report, and they, and ultimately the long-term sustainability of the entire California Sonoran ecosystem, must be protected via a number of general strategies. First and foremost, more attention and resources should be dedicated to protecting this incredibly special place. However, resources will always be limiting, so we need to increase the efficiency of our conservation actions through coordination and collaborations. Finally, we must seek to reduce the existing threats to this landscape today, as they will only become worse and more costly to address in the future, by acquiring strategic inholdings, improving enforcement of existing regulations and land uses, and minimizing fragmentation of intact areas. Securing and protecting the existing integrity of the California Sonoran Desert is the most effective conservation strategy available to land managers.

In addition to protecting existing investments, effective conservation will require building *on* existing investments. Our assessment has identified many areas of the region that are critical to the long-term maintenance of its regional conservation values, and many of these areas need increased protection and conservation to protect existing conservation investments. For example, many existing protected lands are associated with "islands" of mountainous terrain, separated from each other by extensive lands with lower protective status. Building on these existing investments by linking these protected lands will be necessary for maintaining and restoring landscape integrity and landscape processes, which tie the desert's species and communities together. Although much of our conservation vision is focused on the six large landscape units, we stress that effective protection of California's Sonoran Desert must involve improved management of all lands within this region, including those classified as Category C and D lands.

Given that conservation pressures are growing in the face of limited resources, collaborative efforts are one means of increasing efficiency and effectiveness. Although past conservation efforts and achievements have been significant, the most effective conservation efforts in the region will likely be collaborative because of the vastness of the landscape, the multitude of land managers, and the landscape-scale immensity of some management issues and conservation challenges. In this report, we recommend the following collaborative efforts:

- Continue and expand activities of the Desert Managers Group as a means of increasing cooperative management among agencies.
- Promote a regional approach for conservation of California's desert by pursuing a collaborative effort to retain the CDCA in the National Landscape Conservation

System.

- Encourage partnerships between public land managers and conservation organizations working in the region to acquire fee title or conservation easements on key inholdings and buffers zones. For example, develop and promote collaborations between the Department of Defense, other Federal and State agencies, and conservation groups, to encourage military land buffering as a means of protecting both military training missions and natural resources.
- Consider formation of a land trust to acquire and protect the multiple small inholdings scattered throughout (Category A and B) landscape units.
- Develop and promote collaborative relationships with private land owners to maximize the conservation value of private lands.
- Develop collaborative programs for long-term sustainability of groundwater basins.
- Establish collaborative programs to maintain and restore watershed health.
- Look for opportunities to build on existing regional conservation programs (e.g., the Lower Colorado River Multi-Species Conservation Program and the Coachella Valley Multiple Species Habitat Conservation Plan).
- Establish and continue collaborative programs to control non-native invasive plants.
- Consider establishing a collaborative program to restore and enhance habitat for migratory birds at the Salton Sea and in adjacent agricultural lands.
- Establish and continue collaborative efforts to maintain landscape connectivity. For example, work with partners in the U.S. and Mexico to promote connectivity to Baja, and conduct a landscape connectivity analysis to identify key linkage areas among landscape units within California's Sonoran Desert.
- Promote transportation and land management measures that reduce nitrogen deposition.

These efforts will require increased coordination and specific allocation of funds. Reaffirming a commitment to working groups of the Desert Managers Group may facilitate some of these efforts. Joint management planning will be needed, ideally within an established framework to ensure long-term follow-through. Ideally all agencies would contribute funding, or joint fund-raising efforts could be undertaken.

With this framework, our intent is to promote a shared ecoregional vision for conservation management of the Sonoran Desert in California, and we suggest that this vision includes an important role for everyone who cares for this desert. Our hope is that the recommendations herein can be used by multiple partners as a framework for improved protection and management of California's Sonoran Desert.

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1. INTRODUCTION

1.1. A Region of Under-Appreciated Natural Significance

For most, the term "desert" evokes images of a bleak and lifeless wasteland; a harsh inhospitable place of extreme heat, sun, sand, and rocks. Throughout American history, the desert has been avoided by many, or has presented a challenging obstacle on the way to a greener place. In southern California, the deserts were a primary challenge for explorers and pioneers on their journeys to the west coast, and Spanish explorer, Juan Bautista de Anza, named the deserts of southern California "The Land of the Dead," due to extensive losses and grim survival in this harsh environment (Bureau of Land Management [BLM] 1999).

Today, the Sonoran Desert of southern California remains one of the least populated areas in California (Bunn 2007). Yet impacts from human activities have been substantial. Although this arid land has a relatively small human population, it has attracted human activities for years, often for utilitarian purposes. For some, the desert is a place to enjoy off-road vehicle use, for others it provides valuable military training grounds, a growing ground for agriculture, a valuable source of mined materials, an ideal location for energy production facilities, prisons, or an unpleasant landfill. In short, the desert is often seen as an ideal site for activities and facilities not desirable in more populated areas. For many, it represents nothing more than a long hot drive on the way to the casinos of Las Vegas or to recreational activities on the Colorado River.

But beyond the forbidding and harsh first impression of the desert, there exists an incredible diversity of life--unique ecosystems and species that have inherent value and play important roles in this sensitive and special environment. In fact, the Sonoran Desert has been identified as one of the top 200 ecoregions worldwide that deserve special conservation attention (Olson and Dinerstein 1998). In 1976, the U.S. Congress designated the 25-million acre (10.1-million hectare) California Desert Conservation Area (CDCA), through the Federal Land Policy and Management Act (FLPMA), in recognition of the area's special values and the need for a comprehensive management plan (BLM 2008a). The CDCA, in turn, is included in the National Landscape Conservation System, a system established in 2000 with the mission of conserving, protecting, and restoring nationally significant landscapes recognized for their outstanding cultural, ecological and scientific values (BLM 2008b). In addition, portions of California's Sonoran Desert were designated as a biosphere reserve by the UNESCO (UNESCO 1984) to promote ecological conservation of a constellation of areas in the Mojave and Colorado Deserts.

The Sonoran Desert of southern California is home to 481 vertebrate species, including 282 bird species, 82 mammals, 66 reptiles, 16 amphibians, and 35 fish species that inhabit this region at some point in their life cycles (Bunn et al. 2007). The diversity of invertebrates is so great that it is impossible to accurately estimate species numbers, but 15 invertebrate taxa are on California's Special Animals List (Bunn et al. 2007). Numerous rare desert-adapted plants occur in this region, 12 of which are State or Federally listed. A number of species, including the Coachella Valley fringe-toed lizard, the sandstone night lizard, the Palm Springs pocket mouse, Carlson's dune beetle, and the Coachella Valley milk-vetch, are found no place else on Earth. This great diversity of species is possible due to an incredibly wide range of habitat types, from flowing streams, hidden palm oases, marshes, ephemeral playas, and pup-fish ponds, to open desert washes, alluvial fans, rugged mountain slopes, steep-walled canyons, and wind-formed sand dunes. Although the remarkable natural resources of California's Sonoran Desert are found within an easy drive of Los Angeles and San Diego, they are not well known or appreciated. It is likely that this under-appreciation stems from a lack of exposure and education rather than from a lack of unique and exceptional qualities. Because those who do get to know the desert are drawn back to it, enchanted by its harsh yet delicate wonders, and quickly recognize that the desert is a special place like no other.

1.2. The Need for a Conservation Framework

In spite of, and perhaps because of, this general lack of public awareness of the desert's natural resource and recreation values, California's Sonoran Desert is at increased risk from urban development, habitat fragmentation, water diversion and overdraft, and a myriad of land use impacts such as off-highway vehicle use, energy production and transportation, and mineral extraction (Lovich and Bainbridge 1999). Although the Sonoran Desert in California has been one of the most sparsely populated area in California, its population is growing rapidly, with a predicted human population of 222,600 in 2020; doubling in size since 1990 (Stewart 1997).

These threats are exacerbated by the fragmented ownerships across this vast landscape. Multiple agencies and organizations administer land in the Sonoran Desert of California, with differing missions and mandates for environmental protection, management, and public uses. In the face of increasing threats and limited management resources, the planning and implementation efforts of individual agencies will likely be enhanced by taking advantage of the potential for coordinated or complementary conservation opportunities on neighboring lands administered by other stakeholders. Our goal in this report is to propose a framework for conservation management that encompasses a regional and multijurisdictional perspective of the Sonoran Desert in California to help participating land managers increase the efficiencies of their efforts. This framework recognizes and builds upon previous planning efforts across this ecoregion. These include:

- Bureau of Land Management (BLM) plans for the long-range management of the 25-million acre CDCA, of which BLM administer less than half.
- An ecological analysis of conservation priorities in the Sonoran Desert of Arizona, California, and Mexico (Marshall et al. 2000).
- A conservation vision for the Colorado and Sonoran Deserts of California (Mojave Desert Land Trust 2006).
- Planning documents of individual stakeholders which guide management on their respective lands.

This framework focuses on the Sonoran ecoregion of southern California, within Imperial, Riverside, San Bernardino, and San Diego counties, but also addresses connectivity to the South Coast ecoregion, the Mojave ecoregion, and Sonoran ecoregion in Arizona and Mexico (Figure 1-1; Appendix A).

The objectives of this framework are:

1. Describe the physical, land use, and landowner characteristics of the study area (Section 2).
2. Summarize conservation values and targets (Section 3).
3. Summarize existing conservation and management emphases and stewardship roles (Section 4).
4. Describe current threats and challenges facing the conservation of biodiversity (Section 5).
5. Identify gaps in existing management and conservation efforts relative to current threats and protection of biodiversity, ecological processes, and focal species (Section 6; Appendix B).
6. Identify and describe opportunities for improved management and protection of the desert ecosystem, via enhanced unilateral actions of public and private landowners, as well as collaborative conservation management among stakeholders (Section 6).

> Biodiversity: *The natural variety and variability among living organisms, the ecological complexes in which they naturally occur, and the ways in which they interact with each other and the natural environment* (Redford and Richter 1999).

1.3. Overview of Project Approach

To address the objectives of this framework, we first described the study area and its conservation values (Sections 2 and 3), summarized existing conservation and management activities (Section 4), and described conservation threats and challenges (Section 5). To guide identification of conservation opportunities, we selected multiple conservation targets (Section 3; Appendix B) and used these, in concert with an evaluation of landscape integrity, in an objective conservation reserve selection procedure, to divide the study area into four broad categories of conservation functions and values (Appendix B; Section 6). We identified conservation objectives for each of the four categories, recognizing that all lands, including urban and agricultural lands, have conservation value and play a role in protecting the Sonoran Desert (Section 6). We identified opportunities to increase the effectiveness of conservation management in the Sonoran Desert, realizing that implementation strategies will vary according to the conservation functions and management objectives of the landscape. In some cases, enhancing the effectiveness of conservation management will rely on the independent actions of individual landowners, but in other cases will be best accomplished by improving coordination and collaboration among stakeholders. Fundamental to our thinking is that large, intact landscapes are more resilient to adverse changes, easier and more efficient to manage, and thus should be a focus of protection and resource investments.

Our assessments were informed by review of pertinent literature, reports, and maps regarding the conservation, management, and ecology of the Sonoran Desert, in particular its California extent. In addition, we met with numerous individuals, organizations, and agencies involved in management and conservation of the region (Appendix B, Table B-1) to obtain their input on conservation priorities and threats, management challenges, selection of targets, data availability, as well as existing and planned management protocols.

This report is accompanied by several appendices that provide additional details for the reader. Appendix A provides additional detail on opportunities to maintain and restore connectivity to Baja California, Appendix B describes the methods we used in developing this framework, Appendix C presents an overview of the cultural values of this region, Appendix D lists scientific names of species, Appendix E provides added detail on existing management, and Appendix F defines acronyms used in this report.

2. THE STUDY AREA

In California, the Sonoran Desert encompasses 7,212,605 acres (2,918,838 hectares). This part of the Sonoran Desert is also referred to as the Colorado Desert or the Lower Colorado River Valley because of its association with the Colorado River (MacMahon 1992; Dimmitt 2000a). The Colorado Desert subdivision, representing the westernmost part of the Sonoran Desert, includes the southeastern portions of California and the northeastern portions of the Mexican state of Baja California, along the northwestern margin of the Sea of Cortez (Dimmitt 2000a).

For the purpose of this framework, we adopted the Sonoran Desert ecoregion boundary described by W. L. Jepson (Baldwin et al. 2002; Figure 2-1; Appendix B). In California, the Sonoran Desert ecoregion is bounded to the north by the Mojave Desert and to the west by the higher elevations of the Peninsular Ranges in the South Coast ecoregion. Although we focused our study on Jepson's Sonoran Desert ecoregion, we expanded our study area to include watersheds that run into the Sonoran Desert, recognizing that influences from outside the ecoregion, such as watershed processes, can impact the health of this ecoregion. We refer to this as the Transboundary Study Area (Figure 2-1). For selected assessments of connectivity to areas outside of our study area, we further extended our assessment to protected areas to the north and west (e.g., Joshua Tree National Park and Forest Service lands) and into the Sonoran Desert of Arizona and northern Mexico.

2.1. Geomorphology

The Sonoran Desert in California is a dynamic and diverse geological landscape formed by millions of years of rich geological history of plate tectonics and activity of multiple earthquake faults, mixed with intermittent flooding and continuous erosion. A key feature in this landscape is the Salton Trough, which is dominated by the San Andreas Fault that borders the northeastern side of the trough. The San Jacinto Fault zone borders the southwest. Over millions of years, plate tectonics have pulled the Baja California peninsula away from mainland Mexico, creating the Gulf of California and uplifting the Peninsular Ranges (Sharp1994). The Salton Trough, essentially an extension of the Gulf of California extending northwestward towards San Gorgonio Pass, has been isolated from the Gulf of California by alluvial sediments deposited in the delta of the Colorado River.

Along the western boundary of the Sonoran Desert, the Peninsular Ranges geomorphic province consists of a large complex of batholithic rocks that extend from Baja California northward to the Transverse Ranges, where the San Andreas Fault truncates the two mountain ranges (California State Parks 2005). East of the Peninsular Ranges, multiple and complex fault lines have created a landscape of elongated valleys and ridges, complete with unique stratified formations and deep-cut canyons, known as the Basin and Range Province. Near the south end of the Salton Trough, recent volcanic knobs, hot brine wells, erosion and intermittent flooding of the Colorado River, shifting sand dunes, and an ancient sea bottom that now reveals itself as badland habitat, contribute to the geologic diversity of the area (Sharp 1994, California State Parks 2005).

Much of the land lies below 1,000 feet (304 meters) elevation, with the lowest point at 275 feet (84 meters) below sea level at the bottom of the Salton Sea, while some peaks in the Peninsular Ranges reach over 10,000 feet (3,048 meters). This mosaic of mountains, washes, valleys, badlands, bajadas, dunes, dry lake beds, and delta plains, all with different microclimate conditions, in turn supports an incredible variety of habitats and species that are uniquely adapted to surviving in this environment.

2.2. Climate

The region's climate is shaped by global weather patterns and regional topography. Rainfall is bimodal, with most rain (approximately 70% of annual totals) falling during widespread winter storms, and the remainder falling during localized, and sometimes violent, thunderstorms in mid-summer (National Oceanic and Atmospheric Administration 1962-2007). Winter rains originate in the north Pacific Ocean, while summer storms typically come from southern Mexico (California State Parks 2005). While the vast Peninsular Ranges block coastal moisture from moving east into the region, resulting in the desert of southeastern California being the hottest and driest portion of the Sonoran Desert, they also capture summer monsoonal moisture moving northwest from the subtropics. In some of the driest sites, annual rainfall may average less than 76 mm (3 inches), and rapid evaporation of this limited moisture results from intense sun and high temperatures (Dimmitt 2000a). Summer temperatures may exceed 120°F (49°C), while winter temperatures occasionally dip below freezing (Dimmitt 2000a). In addition to wide seasonal temperature ranges, large fluctuations in daily temperatures created special challenges for all life forms in this region.

2.3. Hydrology

Water plays an important role in shaping the land and supporting unique habitats in this arid region. The two most prominent water features in the region are the Salton Sea and the Colorado River (Figure 2-2). The Salton Sea lies in the Salton Sink, a small portion of the Salton Trough, which has a long and dynamic history. Several million years ago, during the Pliocene, the Salton Trough was essentially the northern extent of the Gulf of California (Durham and Allison 1960). As silt from the Colorado River accumulated, water in the Salton Sink became separated from the Gulf of California, forming what is now referred to as the ancient Lake Cahuilla (Blake 1914, cited in Patten et al. 2003). The lake eventually dried up, but was then periodically re-filled by floodwaters of the Colorado River, as the river's mouth shifted with time. In 1901, irrigation canals were built to bring Colorado River water to farmlands in the Imperial Valley within the Salton Trough. Four years later, the present-day Salton Sea was created when heavy rains and snowmelt caused the Colorado River to break through the banks of these canals, filling the lower portions of the Salton Trough once again. Instead of drying up, as it had in previous years, the modern day Salton Sea is maintained primarily by run-off from agricultural irrigation in the Imperial and Coachella Valleys (Patton et al. 2003, Salton Sea Authority, no date). The sea is essentially an agricultural sump, used to store agricultural tail water. Since it is a closed basin with no outlet, sea salinity has risen as salts entering via agricultural runoff are concentrated by evaporation. The Salton Sea supports important habitat for wildlife, in particular migratory water birds, and once supported a considerable sport fishing industry (primarily for orangemouth corvina, gulf croaker, sargo, and tilapia), yet the health of this ecosystem presents a complex management challenge (California Regional Water Quality Control Board 2005, see also Section 5).

The Colorado River, demarcating the boundary between California and Arizona, traverses the entire eastern length of the Sonoran Desert in California and supports extensive riparian habitats and species. The river has been dramatically altered over the years by dams built for hydroelectric power generation and diversions of water for agriculture and increasing urban use. Prior to the mid-20th century, the Colorado River Delta supported extensive riparian wetlands and rich estuarine marshland as it entered the north end of the Gulf of California. The Colorado River was also an important source of nutrients to the northern Gulf of California that has diminished as the river has been controlled and diverted. The Delta and northern Gulf of California, although greatly altered and now fairly desiccated due to water diversion, is nonetheless an important ecological resource, and has been established as a Biosphere Reserve by the Mexican government that is recognized by UNESCO’s Man and Biosphere Programme. Two other rivers, the New River and the Alamo River, running north from Mexico into the Salton Sea, collect irrigation and other discharge along the way and face serious pollution problems.

In addition to these primary water bodies, numerous watersheds are found in the region, with most draining into the Salton Trough or towards the Colorado River. In this arid environment, many streams are ephemeral or seasonally intermittent, but several perennial streams, such as Deep, Coyote, and San Felipe creeks, are maintained by groundwater springs, rainfall, and runoff from higher elevations. Water flowing through these stream systems supports and shapes a variety of water-dependent habitats, such as marshes, ephemeral playas, desert washes, and springs. Permanent oases (e.g., palm oases) may be supported where there are fissures in the bedrock, allowing groundwater to pool near the surface.

Groundwater basins, or aquifers, are recharged when water, coming mostly from higher elevations in the mountains, reaches the low-elevation, often alluvium-filled valleys. Recharge of these basins is mainly from percolation of streams as they flow across the valleys (California State Parks 2005). Habitats dependent on ground water, such as mesquite bosques, and those shaped by heavy rainfall, such as dry desert washes and ephemeral playas, occur in these valleys.

2.4. Land Use

Although the Sonoran Desert remains one of the least populated areas in California, and much of the region remains undeveloped, humans have used the area for many years. Native Americans have inhabited the area for centuries, with a number of tribes calling this region home (Appendix C). During the 1800s, small numbers of cattlemen, miners, and explorers settled in the region, and livestock grazing and mining were primary land uses. Growth in the area remained slow until the late 19th century, when this remote region became connected to other areas by road and rail. The San Diego and Arizona Railway, connecting Yuma, Arizona to San Diego, was completed in 1919 (California State Parks 2005), increasing the economic potential of the area. Although livestock grazing has decreased substantially in recent years, mining activities have continued to this day, including extractions for calcite, tungsten, strontium, uranium, precious metals such as gold, gem quality non-metals, and building materials such as gypsum, decorative rock, and gravel (BLM 1999, California State Parks 2005).

The region experienced an incredible increase in activity when irrigation water arrived from the Colorado River in the early 1900s, causing a wave of agriculture, ranching, and town building (BLM 1999). Control over the Colorado River, development of pumping technology to extract groundwater, fertile soil, and mild winters quickly made the Imperial Valley in the southern portion of the region one of the most productive agricultural regions in the world, with approximately 500,000 acres (202,343 hectares) of farmland currently under cultivation (Marshall et al. 2000, Legislative Analyst's Office 2008). Imperial Valley farmers plant, cultivate, and harvest a wide variety of crops throughout the year, generating more than $1 billion in cattle and field, vegetable, and permanent crops in 2006 (California Farm Bureau Federation, no date).

The advent of affordable and reliable air conditioning in homes, businesses, and vehicles changed the desert from a seasonal destination or work location, to a place of year-round occupancy. In the early to mid 1900's the newly formed Salton Sea became a mecca for retirement, recreation, and development. Although areas immediately adjacent to the Salton Sea became less desirable in subsequent years, primarily due to the environmental challenges of water quality, decline of the sea's fisheries, and fluctuating water levels, areas north of the sea, in the Coachella Valley continued to grow. In these areas, at the northwestern edges of the Sonoran Desert, areas that had previously supported productive agriculture have given way to rapidly expanding urban developments, golf courses, and resorts in communities such as Palm Springs, Palm Desert, Indian Wells, and La Quinta. These areas continue to grow at a rapid pace today, with the population in the Coachella Valley more than doubling between 1980 and 2000 (Coachella Valley Association of Governments 2007). Urban development has also increased in recent years, although at a much slower rate, along the Colorado River, such as near the towns of Blythe and Lake Havasu City, and in the Imperial Valley, near El Centro and Calexico.

Land uses in less developed parts of the region include military training (in the Chocolate Mountains) and recreation in many of the public lands owned by the Bureau of Land Management (BLM) and California Department of Parks and Recreation.

2.5. Land Ownership

The Sonoran Desert in California has a large number of owners, including Federal, State, and local governments, Native American tribes, non-governmental land trusts, and numerous private entities. The BLM is by far the region's largest land manager, with about 3.7 million acres (51% of the region; Figure 2-3, Table 2-1). The Department of Defense (DOD) administers 528,735 acres (7%) encompassing nearly the entire Chocolate Mountains. Other Federal lands are administered by the U.S. Fish and Wildlife Service (USFWS), the Bureau of Reclamation, the U.S. Forest Service, and the National Parks Service (with approximately one half of Joshua Tree National Park, or approximately 340,000 acres, within the Sonoran Desert region). The California Department of Parks and Recreation (CDPR) is the second largest single landowner, administering 654,703 acres (9% of the region). Other State landowners include the California Department of Fish and Game (CDFG) and the State Lands Commission. Non-governmental organizations such as The Nature Conservancy and land trusts own approximately 25,000 acres (<1%). Private lands and Indian tribal lands represent 1.6 million (23%) and 118,733 (1.7%) acres of the Sonoran Desert in California, respectively.

Table 2-1. Land ownership in the study area

Land Owner/Manager	**Sonoran Ecoregion in California**			**Transboundary Study Area**		
	Acres	**Hectares**	**% of Area**	**Acres**	**Hectares**	**% of Area**
Bureau of Land Management	3,698,373	1,496,684	51.28	4,526,724	1,831,908	46.19
Department of Defense	528,735	213,972	7.33	528,735	213,972	5.40
National Park Service	119,515	48,366	1.66	610,568	247,089	6.23
U.S. Fish and Wildlife Service	78,419	31,735	1.09	80,984	32,773	0.83
Bureau of Reclamation	72,248	29,238	1.00	72,212	29,224	0.74
U.S. Forest Service	21,964	8,889	0.30	126,108	51,035	1.29
California Department of Parks and Recreation	654,703	264,950	9.08	713,973	288,936	7.29
State Lands Commission	118,347	47,894	1.64	136,328	55,170	1.39
California Department of Fish and Game	18,364	7,432	0.25	32,495	13,150	0.33
Other State Lands	6,909	2,796	0.10	6,975	2,823	0.07
Private Landowner (in U.S.)	1,635,408	661,826	22.67	1,890,731	765,152	19.29
Mexican Ownership (type undetermined)				796,678	322,404	8.13
American Native Indians	118,733	48,050	1.65	118,733	48,050	1.21
Portions of Salton Sea not agency-owned	102,356	41,422	1.42	102,356	41,422	1.04
Non-governmental Organizations and Conservancies (other than TNC)	23,581	9543	0.33	36,254	14,671	0.37
Local Government	12,593	5,096	0.17	16,247	6,575	0.17
The Nature Conservancy	1,827	739	0.03	3,028	1,225	0.03
Other	529	214	0.01	870	352	0.01
Total Area	7,212,605	2,918,837		9,800,000	3,965,919	

3. CONSERVATION VALUES OF CALIFORNIA'S SONORAN DESERT

The Sonoran Desert is known for its incredible variety of life-forms and ecosystems and may have the highest biodiversity of any desert in the world (Nabhan 2000). The Sonoran Desert in California, with its coastal influence, rich geological history, presence of the Colorado River, and the dynamic Salton Sea, lives up to this reputation, with an amazing diversity of habitats, species, and cultural resources. These characteristics collectively comprise the conservation values of the region, which must be targeted for protection by an effective conservation strategy for California's Sonoran Desert.

3.1. Plant Diversity and Sensitive Plant Species

California's Sonoran Desert, the most arid of the Southwest's deserts, presents plants with unique survival challenges, which have resulted in a diversity of forms and life history strategies. In addition, the wide variety of microclimates, including shifting sand dunes, streambeds and flood-prone washes, intermittently flooded playas, marshes, canyon bottoms, arroyos and adjacent terraces, and seeps and springs in rocky mountain slopes in the region have resulted in diverse plant assemblages. The desert's geographic location, at the junction of North America's deserts with the South Coast Region of the California Floristic Province to the west, and to the Neotropic ecozone to the south, has also contributed to the presence of many endemic and rare plant forms. The number of unique vegetation communities depends on the resolution of vegetation mapping; however, one vegetation map limited to Anza-Borrego Desert State Park (ABDSP) differentiated 96 vegetation series (Keeler-Wolf et al. 1998). These include communities as diverse as palm oases, ciénagas, microphyll woodlands, and pinyon-juniper woodlands.

Within these diverse vegetation communities, California's Sonoran Desert supports an extraordinary assortment of plant species, with 932 plant taxa belonging to 387 genera in 98 families documented within Anza-Borrego Desert State Park alone (California State Parks 2005). The study area is home to a number of species that are endemic to the Sonoran Desert, including but not limited to Borrego Valley pepper-grass, Algodones dunes sunflower, Munz cholla, Gander's cryptantha, triple-ribbed milk-vetch, Coachella Valley milk-vetch, Peirson's milk-vetch, Parry's spineflower, and Orocopia sage. Six species, including the above three milk-vetch species, are Federally listed. The Sonoran Desert of California also supports the extreme edges or limited distributions of several species, such as elephant trees, saguaros, and crucifixion thorn.

Climate patterns differentiate the Sonoran Desert from other deserts, including the Mojave Desert. In addition to being hotter and drier, it rarely experiences frost, and experiences two rainy seasons per year (while the Mojave Desert typically only has winter rains). Although the region supports numerous perennial species, such as creosote, lavender, ocotillo, and a wide variety of cacti, more than half of the region's plant species are herbaceous annuals, which reveal themselves only during incredible spring blooms (and some during summer blooms) in years of suitable precipitation and temperature conditions.

3.2. Faunal Diversity and Sensitive Animal Species

The natural vegetation communities of the Sonoran Desert support a surprisingly large diversity of animal species that are adapted to survival in this harsh environment. In the California section of the Sonoran Desert alone, there are 481 vertebrate species that inhabit this region at some point of their lives (Bunn et al. 2007). These include 282 birds, 82 mammals, 66 reptiles, 16 amphibians, and 35 fish species. Invertebrate species are so numerous that an accurate estimate is not available, but 15 invertebrates are considered California Species at Risk (Bunn et al. 2007).

Among vertebrates, 84 bird taxa, 34 mammalian taxa, 21 reptilian taxa, five amphibian taxa, and four fish taxa are included on the California Special Animals List. Several sites within the region have been designated as “Globally Important Bird Areas” or as “Important Bird Areas” by the American Bird Conservancy and Audubon California, respectively. Four vertebrate species (the desert slender salamander, the Palm Springs pocket mouse, the Coachella Valley fringe-toed lizard, and the sandstone night lizard) and eight invertebrate species (including Carlson’s dune beetle, Hardy’s dune beetle, the white desert snail, and California McCoy snail) are endemic to this region (Bunn et al. 2007). Most species have morphological, physiological, or behavioral adaptations that allow their existence in the arid and hot desert environment. While some species such as desert bighorn sheep and mountain lions range across diverse habitats in response to varying seasonal and environmental conditions, other species rely on access to a particular vegetation community. For example, western yellow bats are closely associated with palm oases, primarily for roosting, while fringe-toed lizards are restricted to sand dunes. Some branchiopods (e.g., fairy shrimp) and desert pupfish are even further limited in their distribution by characteristics (e.g., water quality, quantity, and temporal availability) of their unique habitats (ephemeral playas and permanent pools, respectively).

3.3. Landscape-scale Ecological Processes

A number of ecological processes shape the physical conditions of the Sonoran Desert ecosystem and thus are integral to maintaining its vegetation communities and species. Conservation and management efforts must therefore recognize that functional landscape-scale processes of this ecosystem transcend jurisdictional and ownership boundaries as well as physiographic features. Indeed, maintaining the integrity of this landscape, both within the desert ecosystem and connections to adjacent areas, is critical for long-term survival of the ecosystem.

3.3.1. Ecological Integrity and Ecosystem Services

Intact ecosystem services (e.g., provision of clean water, regulation of carbon sequestration, availability of scenic and recreational resources, and preservation of biodiversity) tend to be associated with landscapes with high ecological integrity (i.e., low habitat fragmentation). High integrity landscapes tend to be more resilient to disturbance events and surrounding land use changes, and are better able to accommodate ecosystem adaptations to long-term changes, for example, those associated with climate change. Large portions of the Sonoran Desert in California support high integrity landscapes and these areas are critical to maintaining the health of the unique desert ecosystem as well as to providing ecosystem services that are key to the well-being of the region's residents and visitors, including humans and wildlife.

Animals move throughout their habitat and between habitat patches to find food, shelter, and mates, and plants disperse their seeds to areas of suitable growing conditions. Movement of individuals between patches of habitat allows gene flow, pollination, seed dispersal, and mutualistic relationships to occur between populations, helps boost small populations with addition of individuals (Brown and Kodric-Brown 1977), accommodates energy flow and nutrient cycling, and supports the long-term viability of populations and species (Levins 1969). Patches of suitable habitat vary among species, thus landscape integrity must exist at multiple scales and across a variety of habitat types. For example, bighorn sheep live primarily in habitat "islands" of mountainous terrain surrounded by flat terrain, fringe-toed lizards occupy patches of sand dunes surrounded by a sand-less landscape, and least Bell's vireos occupy patches of riparian habitats surrounded by arid lands. Conserving the habitat connections between these species' preferred habitats, i.e., conserving an intact landscape that is not fragmented by development and roads, etc., will allow individual movements and multi-generational dispersal, thereby increasing long-term species viability.

Maintaining landscape integrity across elevational gradients and transition zones (e.g., where the desert merges with coastal communities) also increases the ecosystem's resilience to long-term environmental changes, such as a changing climate. Conserving wide swaths of protected areas that span the complete range of elevations will allow desert species and vegetation communities to shift their distributions (e.g., north or to higher elevations) in response to a changing climate (Pitelka et al. 1997, Warren et al. 2001; see also Section 5.7). Maintaining connectivity to other ecoregions (e.g., the Mojave Desert and the South Coast ecoregion) and to other portions of the Sonoran Desert (e.g., in Baja California) are key for long-term ecosystem resilience and evolutionary adaptation (Section 6.2.2, and Appendix A).

In addition to protecting native species and communities, intact landscapes also provide diverse ecosystem services to humans. Intact landscapes provide superior recreational opportunities, providing the opportunity to experience the desert's expansive and remote wildness and natural wonders, and benefiting the communities and agencies who gain from these tourist investments. Soils in intact desert landscapes are less prone to erosion than soils in fragmented areas, thus maintaining healthy air quality for residents in the region. Intact landscapes also protect water quantity and quality, which are critical to urban and agricultural consumers. They maintain natural fire regimes and other natural processes, such as the dynamics of sand dunes, to the benefit of humans, plants, and animals (see following sections). Perhaps most importantly, intact landscapes are more efficient and cost effective to manage than fragmented landscapes, which is a critical consideration in these times of limited management resources.

3.3.2. Water and Watersheds

Surface and groundwater shape desert communities in ways that are not immediately apparent. For example, sand dunes are indirectly dependent on water when their sand source is a river bed. Mesquite bosques, possibly miles from surface water, are dependent on subsurface water.

Smoke trees and other inhabitants of desert dry wash woodlands are dependent on periodic flooding and scouring for recruitment of new individuals. Numerous water-related habitats, such as pupfish ponds and ciénagas, are dependent on intact water systems. Resources in California's Sonoran Desert are adapted to the unique hydrologic regimes of the area, and natural hydrologic processes are associated with high integrity watersheds (Poff et al. 1997). In addition, desert communities rely on intact watersheds and groundwater basins for clean and adequate water supplies. Therefore, maintaining the integrity of watersheds is critical to effective conservation.

3.3.3. Eolian Processes and Sand Deposition

California's Sonoran Desert supports several areas that satisfy the following prerequisites for dune formation: (1) a source of sand, often from a dry lake bed or river bed devoid of vegetation, (2) wind that can lift and transport this sand, and (3) an area where the wind loses momentum due to topography or some other obstacle, and the sand particles settle, collect, and form sand dunes. Active sand dunes are dynamic, with ever-changing shape and location as a result of a continuous sand source. Sand dune characteristics depend on the geology of the sand source, as this determines the size, shape, and color of the sand particles, and on the speed and direction of the wind. They are thus a direct product of the eolian system that created them and their existence depends on replenishment of wind-blown sand.

Three primary sand dune areas within the Sonoran Desert in California are the Coachella Valley Dunes, with only 5-10 percent (<8,000 acres [3238 hectares]) of their original size remaining, the Superstition Hills (also known as West Mesa) encompassing approximately 100,000 acres (40,469 hectares), and the Algodones Dunes (also known as the Imperial Dunes) with approximately 160,000 acres (64,750 hectares; Bunn et al. 2007). Sand dunes account for only 6% of the surface area of North American deserts, and the Algodones Dunes, found in the southern portion of our study area, is one of the largest sand dunes remaining in the United States. These rare dune systems provide habitat for a number of uniquely adapted species found nowhere else on Earth (Section 3.5).

3.3.4. Fire Regimes

Historically, fires were not frequent or widespread in the Sonoran Desert, due to limited biomass, wide spacing between shrubs, and sparse ground cover (Humphrey 1949, Rogers 1986, Brown and Minnich 1986). It has been suggested that Sonoran Desert plants are not fire-adapted (Rogers 1986), and that even rare fires may have long-term impacts on the structure and composition on communities such as creosote bush scrub (Brown and Minnich 1986). Several studies have demonstrated that recovery may depend on fire intensity and season (e.g., Rogers and Steele 1980, O'Leary and Minnich 1981, Brown and Minnich 1986). For example, mortality and re-sprouting rates among creosote bushes appears to be related to fire intensity, duration, and season of burning (Brown and Minnich 1986). In general, however, long-lived perennials such as creosote bush, catclaw acacia, teddy-bear cholla, and desert lavender recovery slowly (or not at all) while short-lived shrubs such as brittle-bush may recover more quickly and persist after fire (Brown and Minnich 1986). Brown and Minnich (1986) suggested that the rapid transformation of perennial cover and floristic composition of creosote scrub communities after fires in the northern portions of the Coachella Valley suggests that these communities are poorly adapted to recurrent burning (see also Section 5.6).

Some vegetation communities of the Sonoran Desert may, however, have historically experienced more frequent fires, as a result of fires set by Native American Indians. Davis et al. (2002) suggested that ciénagas of the Sonoran Desert may have been burned seasonally to harvest animals and to promote agriculture. Similarly, palm oases of southern California are believed to have been burned, perhaps as frequently as every four years, to increase fruit production, to reduce insect pests, and to reduce understory brush (Parish 1909, Vogl and McHargue 1966, Miller 1983).

Vegetation communities such as chaparral and forest communities found at the western edges of the Sonoran desert, along the eastern flanks of the Peninsular Ranges, appear to be more fire-adapted than true desert communities (Brown and Minnich 1986). Historically, fires moving through these communities would stop when they reached desert communities such as creosote bush scrub, presumably due to limited fuels, with the possible exception of years following high rainfall (followed by high production of annuals; Brown and Minnich 1986). This resulted in long inter-fire intervals in these communities, permitting the re-establishment of long-lived perennials (Brown and Minnich 1986). Today, invasions of exotic plants, in particular Saharan mustard and exotic grasses, often result in a continuous blanket of vegetation (fuel) within native desert plan communities, allowing fires to spread more readily (see Section 5.4.1). Increased ignition rates and fuels have resulted in more frequent and more extensive fires (see Section 5.6). Exotic plant populations are often associated with areas of low landscape integrity such as near roads and at edges of developed areas, thus high landscape integrity can serve to maintain natural (historically low) fire frequencies.

3.4. Cultural Resources

Although our report focuses on the natural biodiversity of the Sonoran Desert in California, it is important to acknowledge the rich cultural resources that exist in this region. Humans have been a part of this region for many years, calling it home and making use of its many natural resources. Humans have also influenced the desert, from early manipulation of palm groves, to influences on water flows and persistence of the Salton Sea, to today's influences of development, recreation, and use of the desert's resources (Section 2.4).

Many historical and archeological sites, such as Native American Indian village sites and traditional areas important to Native Americans, are found in association with the natural resources that we focus on in this report, reflecting the close ties that Indian cultures had with the desert and its natural communities. Appendix C summarizes these relationships and provides examples of important archeological and historical sites. Because of the close geographic association of cultural sites with conservation targets chosen for our assessment, it is our hope that conservation efforts intended to protect natural resources will also benefit protection of culturally important sites.

3.5. Conservation Targets

Our overarching conservation objective for California's Sonoran Desert is to maintain a functioning system containing all of the natural resource elements present in the region, with a particular focus on ensuring that rare resources and key ecological processes are adequately protected. To achieve this objective, we identified a series of conservation targets for our analysis (Table 3-1). These conservation targets included major vegetation communities (Figure 3-1) and special desert elements (i.e., specific microhabitats not well captured by vegetation communities; Figures 3-2 and 3-3). Appendix B provides details on selection of the following targets as well as methods used to evaluate them:

Table 3-1. Conservation targets

Vegetation Communities	
1. Desert dry wash woodlands	Washes, or arroyos, and their adjacent channel terraces represent the desert's stream channels and floodplains. These dynamic environments, shaped and scoured by intense floods, are dry most of the year but may convey ephemeral surface water after heavy rainfall. Many plant species, often characterized by deep roots and tolerance to flash floods, are found only in this environment and some, such as the smoke tree, are dependent on the scouring action that occurs during floods (Baldwin et al. 2002). Other perennial desert wash species include desert willow, cheesebush, desert lavender, honeybean mesquite, screwbean mesquite, ironwood, catclaw acacia, and blue palo verde. These species comprise what is also referred to as microphyll woodlands, a vegetation community which offers shade, structure, shelter, and nutrient cycling important to the desert ecosystem (BLM 1999). Washes provide important habitat for a number of animals including desert tortoises, they supply quality forage for bighorn sheep, and many have been designated as Important Bird Areas by Audubon California.
2. Mojavean pinyon and juniper woodland 3. Peninsular pinyon and juniper woodland	Pinyon-juniper woodlands are found at the upper elevations of our study area, primarily in the Peninsular Ranges, above elevations of approximately 3,937 feet (1,200 meters; Ryan 1968). In this region, this community often represents the westernmost sections of the desert, where desert vegetation transitions into montane vegetation communities such as chaparral and coniferous forest at higher elevations (Ryan 1968). Because they represent a transition zone, occur at moderately high elevations, and occur in the rain shadow of the Peninsular Ranges (resulting in cooler temperatures and higher precipitation than at lower elevations), these woodlands support a unique plant assemblage uncommon in the Sonoran Desert. Mojavean and Peninsular pinyon and juniper woodlands differ in their dominant pine species and in the composition and density of their understory species.
4. Mojave creosote bush scrub	Desert scrub, in the form of creosote bush scrub or mixed scrub, is the most widespread vegetation community in the Sonoran Desert of California. It occupies vast expanses of the desert floor, alluvial fans, lower elevation hills and slopes, and xeric mountains, and includes plants such as creosote bush,

5. Sonoran creosote bush scrub 6. Sonoran desert mixed scrub	ocotillo, Mojave yucca, ephedra, burrobush, brittle bush, desert sunflower, cholla cactus, and barrel cactus (California State Parks 2005). In spring, these areas often host stunning wildflower displays. Creosote bushes and Mojave yucca are exceptionally long-lived perennial plants that form a “clonal ring” as one genetic individual spreads from a center point. Individual living yucca plants have been aged at 2,250 years old, while individual creosote bushes have been aged at 11,700 years old, making them the oldest life forms known to man (Vasek 1995). These three scrub communities, which occur in areas of slightly different terrain variability and moisture availability, are differentiated from each other by their species composition and diversity, and differences in succulent diversity, abundance, and composition.
Special Desert Elements	
1. Pupfish habitat	Desert pupfish depend on the persistence and quality of rare water habitats in the desert. In California, pupfish are found in two natural tributaries (San Felipe and Salt creeks, and their associated wetlands), some shoreline pools along the Salton Sea, and irrigation drainages leading into the Salton Sea. They can survive in fresh water as well as in water with salinity greater than sea water, and can endure water temperatures over 100°F (38°; Ivanyi 2000). Yet, desert pupfish populations have declined precipitously and are Federally listed as endangered, threatened primarily by habitat destruction, water diversion, water pollution, climate change, and exotic species invasions (USFWS 1986).
2. Palm oases	California fan palm oases establish at permanent water sources, such as springs or seeps, or at fault lines where groundwater is forced to the surface by movement of hard, impermeable rock. Palm oases create a unique micro-climate that provides habitat for numerous species including western screech-owls, hooded orioles, and the giant palm-boring beetle--a species endemic to this unique habitat. For years, palm oases supplied Native Americans with water and food (in the form of palm fruit), and today provide a cool and refreshing refuge for the desert hiker and explorer.
3. Mesquite bosques	Mesquite woodlands or “bosques” may be found near surface water or in areas where surface water is rarely seen but groundwater is relatively high. The deep rooting system of mesquite trees (primarily honey and screwbean mesquite, but also velvet mesquite) allow them to use subsurface water not available to other plants, thereby allowing their survival where other trees are not found, but also making them susceptible to depletion of groundwater basins. Mesquite bosques provide shade, shelter, and roosting sites for many species, including Coachella Valley round-tailed ground squirrel populations, a California Species of Special Concern. Because they are a nitrogen-fixing legume, they provide an important function for cycling nutrients through the desert ecosystem.
4. Saguaros	Although widely distributed and quite common in other parts of the Sonoran Desert, only a small number of saguaros exist on the west side of the Colorado River in California’s Sonoran Desert. Saguaros are the largest species of cacti in the United States (Dimmitt 2000b), and add an element of

	vertical structure often limited in the desert. They provide a source of food, roosting spots, and particularly excellent nesting places for many birds. Gila woodpeckers and gilded flickers excavate nest holes in the fleshy stems, and these holes may subsequently be used by other cavity nesting birds. Because of the saguaro's massive size, temperatures inside these nests are greatly stabilized compared to ambient temperatures (Dimmitt 2000b). Saguaros are slow growing, first reproducing when they are 50-100 years of age (Drezner 2008), and have high seedling mortality as a result of drought, frost, and herbivory (Steenbergh and Lowe 1969, Dimmitt 2000b). Because saguaro growth and regeneration rates tend to be lowest in the northern and western extents of their range (Drezner 2005), it is possible that the California population is particularly vulnerable to any human impacts that reduce their survival or recruitment.
5. Ephemeral playas (dry lakes)	Playas, or dry lakes, are found in low-elevation areas, typically in large flats of clay soil with a slight concave depression. Dry for many months or even years, the clay soils of these areas catch water from runoff or heavy rains and become short-lived shallow lakes. Each playa may support a unique assemblage of plants and animals, influenced by its unique chemical and physical environmental conditions such as water chemistry, depth, and duration (Eng et al. 1990, Erikson and Belk 1999, California State Parks 2005). Some aquatic invertebrates may survive in the form of cysts or resting eggs. Cysts or resting eggs remain dormant until the playa fills with water, when they develop, mature, and breed (Hathaway and Simovich 1996). Playas also support specially-adapted plants, such as Borrego Valley peppergrass, and provide habitat for migrating waterbirds. Playas are susceptible to vehicular and foot traffic because they can break up soils, making them susceptible to wind erosion, and by dispersing branchiopod cysts to areas where they will not survive.
6. Ciénagas	Ciénagas, or marshes, are rare desert communities formed by ponding of surface water in areas where the water table is high. Ciénagas are home to hydrophytic plants adapted to growing in water or very wet environments (California State Parks 2005). Ciénagas support species such as cottonwoods, willows, bulrushes, and cattails, and may play an important role in dispersing powerful desert floods (BLM 1999, California State Parks 2005). These productive communities are important to a variety of wildlife species, such deer, foxes, raccoons, and numerous birds.
7. Sand dunes	Sand dunes are dynamic, ever-changing ecosystems that are created and maintained by wind-blown sand. They require a source of sand, winds sufficient for moving sand from source to the dunes, and terrain that allows sand transport and dune migration. Although sand dunes are characterized by harsh conditions of shifting sand, high temperatures, limited water availability, low nutrients, and limited vegetation for cover or forage, they support many rare and sensitive species of plants and animals. Uniquely-adapted species that are found in this environment include fringe-toed lizards, Peirson's milk-vetch, sand food, Algodones Dunes sunflower, flat-tailed

	horned lizard, Andrew's dune scarab beetle, and at least 9 endemic beetles. Dunes represent a rare habitat type, accounting for only 6% of the surface of North American deserts (MacMahon 1992).
8. Water-related habitats	In the desert, any vegetation community associated with water is a limited and precious resource. In addition to water-related habitats mentioned above (pupfish habitat, palm oases, playas, and ciénagas), additional water-related habitats are found along intermittent and perennial streams, rivers, lakes, seeps, and springs, and support a diverse assemblage of plants, such as cottonwoods, sycamores, and willows that are dependent on the presence of surface, subsurface, permanent, or temporary water. These plants and water, in turn, provide a limited and special habitat for numerous animal species. Riparian habitats support more bird species than any other habitat in California (Faber et al. 1989), with some species, such as Yuma clapper rails and southwestern willow flycatchers, restricted to these communities. Although water-related habitats are widely recognized as sensitive and valuable communities worthy of protection (BLM 1999, California State Parks 2005, Bunn et al. 2007, Desert Managers Group 2007), they are at continued risk from numerous human impacts, including water diversion, overdraft of groundwater basins, and climate change.

In our assessment, we also considered the following landscape-scale ecological processes (Section 3.3):

- Watershed integrity and health
- Ecological (habitat) connectivity
- Eolian processes and sand deposition
- Fire regimes

Although not used as conservation targets, we considered a small set of focal species (Figures 3-4, 3-5, 3-6) in our discussion of conservation opportunities (Section 6.2.2). Appendix B provides expanded descriptions of the following focal species (or groups of species):

- <u>Flat-tailed horned lizard</u>: a California State Species of Concern that relies on undisturbed low elevation desert lands, including creosote scrub and some dune habitats, and is threatened by habitat loss, fragmentation, and other human activities.
- <u>Desert tortoise</u>: a Federally listed species that inhabits desert dry washes, alluvial fans, and flats, and is threatened by habitat loss, fragmentation, and other human activities.
- <u>Bighorn sheep</u>: a wide-ranging species that inhabits mountainous terrain and requires unobstructed desert lands for long-term population persistence. One population in the study area is Federally listed as endangered.
- <u>Birds of the Salton Sea (as a group)</u>: a multi-species group that utilizes the Salton Sea, its shoreline, and adjacent agricultural lands. This group includes a number of

sensitive or listed species and many migratory species, most of which are sensitive to loss of wetland habitats.

- Least Bell's Vireo: a Federally listed species that inhabits and relies on desert wetland habitats, particularly riparian woodlands habitats along riverine systems. It is threatened by habitat modification and loss, and parasitism by brown-headed cowbirds.
- Triple-ribbed milk-vetch: a Federally listed perennial herb endemic to California, which is found in limited locations along sandy and gravelly soils in dry washes, at the base of canyon slopes, and on steep scree slopes of decomposed granite.
- Peirson's milk-vetch: a Federally listed perennial endemic to the Algodones Dunes and eastern portions of the Borrego Valley, and uniquely adapted to survival in a dune environment. It is primarily threatened by off-highway vehicle (OHV) use.

4. EXISTING MANAGEMENT AND CONSERVATION EFFORTS

4.1. Existing Management and Conservation Efforts

California's Sonoran Desert is administered and managed by a large set of public agencies, organizations, and individuals (Table 2-1, Figure 2-3), resulting in a large and diverse range of land use mandates, conservation efforts, and management protocols. The diversity of these mandates, efforts, and protocols has the potential to produce management inefficiencies or conflicts to the detriment of regional conservation values, and understanding this diversity is key to establishing an effective conservation and management framework. In this section we outline the various conservation goals and approaches of these various entities to document the existing management and conservation landscape in California's Sonoran Desert. Appendix E provides additional detail on these existing efforts.

4.1.1. Federal Lands

The vast majority of Federal lands in the study area are administered by the BLM, while other Federal land managers include the DOD, National Park Service, the Forest Service, and the USFWS, each with a unique mission or mandate in relation to desert conservation (Table 4-1, Appendix E). Other Federal agencies responsible for management and conservation of lands in this region include the Bureau of Reclamation and the Bureau of Indian Affairs. The U.S. Geological Survey collects and provides environmental data to guide management of public lands.

Federal lands managed primarily for conservation values in the study area are administered by BLM, National Park Service, Forest Service, and USFWS. Lands with the highest levels of protection include Wilderness Areas, Wilderness Study Areas, Areas of Critical Environmental Concern (ACEC), National Monuments, and National Wildlife Refuges (Figure 4-1). The remaining Federally administered lands outside of these designations have varying levels of natural resources protection, and some land use mandates may be potentially incompatible with natural resources protection. Conservation values of these lands are therefore at risk from a variety of land uses.

Table 4-1. Federal agency mandates

Agency:	Mission, stated purpose, or goals:
Bureau of Land Management	The California Desert Conservation Area (CDCA) Plan directs BLM to "…provide for the immediate and future protection and administration of the public lands in the California Desert within the framework of a program of multiple use and sustained yield, and the maintenance of environmental quality" (BLM 1999).
National Park Service (Joshua Tree National Park)	The mission of Joshua Tree National Park is as follows: "The National Park Service at Joshua Tree National Park preserves and protects a representative area of the Colorado and Mojave Deserts and the natural and cultural resources for the benefit and enjoyment of present and future generations. The park strives to maintain its rich biological and geological diversity, cultural history, recreational resources, and outstanding opportunities for scientific study" (National Park Service 2001).
Forest Service	The Forest Service's mission, "… to sustain the health, diversity, and productivity of the nation's forests and grasslands to meet the needs of present and future generations", is now carried through with a renewed emphasis on *condition of the land* rather than *outputs of the land* (U.S. Forest Service 2005b).
Department of Defense	The mission of the U. S. Department of Defense (DOD) is to provide the military forces needed to deter war and to protect the security of our country. While the DOD's primary goal is military readiness, the department's long-term management goals also include safeguarding native environments and species that rely on them.
Fish and Wildlife Service	The mission of the U. S. Fish and Wildlife Service (USFWS) is to conserve, protect, and enhance the nation's fish and wildlife and their habitats for the continuing benefit of people.

4.1.2. State Lands

The California Department of Parks and Recreation (CDPR) is the largest State land owner in the Sonoran Desert in California, followed by the State Lands Commission, the CDFG, and the Coachella Valley Mountains Conservancy (Table 2-1, Figure 2-3). Mandates of these agencies are also diverse (Table 4-2). Other State lands are administered by the University of California and the Department of Transportation.

State lands managed primarily for conservation values in the study area are administered by CDPR, CDFG, the Coachella Valley Mountains Conservancy, and the University of California.

State lands with the highest levels of protection include Wilderness Areas, Natural Reserves, Ecological Reserves, and State Wildlife Areas (Figure 4-1). The remaining State-owned lands have varying levels of natural resources protection, due to various land use mandates that do not necessarily focus on natural resources protection.

Table 4-2. State agency mandates

Agency:	Mission, stated purpose, or goals:
California Department of Parks and Recreation (CDPR)	The mission of the CDPR is to provide for the health, inspiration, and education of the people of California by helping to preserve the State's extraordinary biological diversity, protecting its most valued natural and cultural resources, and creating opportunities for high-quality outdoor recreation.
California Department of Fish and Game (CDFG)	The mission of the CDFG is to manage California's diverse fish, wildlife, and plant resources, and the habitats upon which they depend, for their ecological values and for their use and enjoyment by the public.
California State Lands Commission	The California State Lands Commission's mission is to manage approximately 4.5 million acres (1.8 million hectares) of land held in trust for the people of California. The State holds these lands "for all the peoples of the State for the public trust purposes of water related commerce, navigation, fisheries, recreation, and open space". The Public Trust Doctrine originally required that land and water be maintained for "commerce, navigation, and fisheries". Subsequent revisions added hunting, fishing, swimming, recreational boating, and "preservation of those lands in their natural state" in order to protect scenic and wildlife habitat values to the list of requirements (California State Lands Commission 2008).
The Coachella Valley Mountains Conservancy	The purpose of the Coachella Valley Mountains Conservancy is to acquire and hold, in perpetual open space, mountainous lands surrounding the Coachella Valley and natural community conservation lands within the Coachella Valley.

4.1.3. The Salton Sea

The Salton Sea has long been recognized as a valuable natural and recreational resource with a highly threatened future. The ownership, use, and management of the sea is under the jurisdiction of multiple State, Federal, and local agencies, which has complicated restoration efforts. As a result of the Quantification Settlement Agreement (QSA) of 2003, the State of California has assumed the lead in restoration of the Salton Sea (Legislative Analyst's Office 2008; Section 5.3.3). As a result of the QSA, the State is required to implement a restoration project for the Salton Sea with the following objectives:

- Restoration of long-term stable aquatic and shoreline habitat for the historic levels and diversity of fish and wildlife.
- Elimination of air quality impacts from restoration projects.
- Protection of water quality.

Many agencies including Federal and local governments are involved in the restoration effort, and the process is advised by the Salton Sea Advisory Committee, with the California Department of Water Resources (CDWR) and CDFG playing lead roles in preparing a restoration plan (see Appendix E for more details).

4.1.4. Native American Lands

The Sonoran Desert in California includes the ancestral and present-day homes of a number of Native American tribes. The distribution of Tribal land in the study area is shown in Figure 2-3. The Federal government maintains a special trust relationship with Indian tribes, as a result of various treaties, statutes, Executive Orders, judicial decisions, and other legal instruments (USFWS 2008c). This relationship creates an enforceable fiduciary responsibility to Indian tribes to protect their lands and resources. Indian lands are, however, not Federal public lands or part of the public domain, and are therefore not directly subject to Federal public land laws (USFWS 2008c). The Bureau of Indian Affairs (BIA), within the U.S. Department of the Interior, is responsible for the administration and management of land held in trust by the U.S. government for Native American Indians. Land protection related to development on forests and rangelands, leasing assets on these lands, protection of water and land rights, and direction of agricultural programs are components of the bureau's responsibilities. Although Indian lands are exempt from a number of laws, involvement by the BIA in such land management situations triggers selected Federal laws such as the National Environmental Policy Act (NEPA).

Within the framework of applicable laws, Tribal lands are managed by individual tribes according to tribal goals and objectives (USFWS 2008c), and management may differ from tribe to tribe. For example, the Agua Caliente Band of Cahuilla Indians recently released for public review its draft Tribal Habitat Conservation Plan (THCP), which would apply only to the tribe's lands near Palm Springs.

4.1.5. Regional and Local Government Lands

In addition to Federal and State lands, the Sonoran Desert in California includes a large number of jurisdictions at the city and county level, resulting in a diverse set of land use plans and management goals. In some cases, planning is coordinated among jurisdictions to address long-term habitat and species recovery goals and land management strategies.

In the Coachella Valley, the Coachella Valley Association of Governments (CVAG) is lead agency on the recently approved Coachella Valley Multiple Species Habitat Conservation Plan (HCP). Participants include Riverside County, at least 8 cities, the Coachella Valley Water District, and the Imperial Irrigation District. To the south, the County of San Diego is lead on San Diego County's East County Multiple Species Conservation Program Plan, currently under development (County of San Diego 2008). In addition, the Imperial Irrigation District has developed a Natural Community Conservation Plan (NCCP) and is developing an HCP to address water conservation and transfer activities (Imperial Irrigation District, no date). To the east, along the border of Arizona and Nevada, the U.S. Bureau of Reclamation is the lead agency responsible for implementing the Lower Colorado River Multi-Species Conservation Program (LCRMSCP) plan. The LCRMSCP plan includes the goal of protecting, enhancing, or creating more than 8,100 acres (3,278 hectares) of riparian, marsh, and backwater habitat for six listed species and 20 other native species at numerous locations along the river between Lake Mead and the U.S.-Mexico border. When the above conservation plans are all complete, they will establish important regulatory frameworks for implementing conservation actions within important portions of the Sonoran Desert of California. In addition to the above planning efforts, each county has a general plan which addresses land use issues, including protection of natural resources, and numerous cities have their own environmental goals and plans, with some but not all incorporated into one of the abovementioned HCPs.

4.1.6. Non-governmental Organization Lands

A number of non-governmental organizations are dedicated to the protection of open space, natural habitats, and biodiversity in the Sonoran Desert in California. Although not all of the following are long-term land stewards, all work to acquire or otherwise protect natural area lands for the purpose of protecting sensitive and rare habitats and species, and for maintaining linkages between ecological preserves, parks and other wildlife refuges:

- Anza-Borrego Foundation and Institute
- California Wilderness Coalition
- The Nature Conservancy
- The Riverside Land Conservancy
- The Wilderness Land Trust
- The Wildlands Conservancy

4.1.7. Private Lands

Over one and a half million acres of the Sonoran Desert in California are in private ownership (Figure 2-3, Table 2-1). Private lands have no formal protection status and management of privately owned land is diverse and unpredictable. The type of use may range from a highly managed status on a voluntary basis to high-density industrial and urban development. As described in Section 2.4, land use patterns in the Sonoran Desert of California have evolved towards increased intensity of use, primarily as a result of water importation and transportation improvements in the region. As southern California's human population grows, it is likely that greater development, agricultural, recreation, and energy production and transport demands will be placed on the desert.

Many private lands do, however, support conservation values, and they can be managed to protect natural desert habitats and to provide benefits to wildlife. Conservation management can be accomplished via the volunteer efforts of private land owners, either individually or through collaborative efforts, conservation dedications via mitigation programs, or through financial incentives such as purchase of development rights or dedication of conservation easements for tax benefits. Private land does not necessarily have to be maintained in a pristine state to support important conservation values. Beneficial management of private lands may include protection of important natural areas or buffers on portions of the property, low intensity land uses that provide permeability to wildlife and maintain habitat connectivity, and working landscapes that support wildlife habitats. An important example of the latter is the management of agricultural lands near the Salton Sea in the Imperial Valley to provide vital foraging and roosting areas for migratory birds (see Section 6.2.2).

4.2. Management Challenges

Although tremendous conservation efforts are underway in the Sonoran Desert of California, extensive areas are currently under elevated protection (Figure 4-1), and a large number of agencies and organizations are involved in protecting biodiversity of this spectacular ecoregion, there are a number of management challenges that currently hinder the full potential of these collective efforts.

4.2.1. Multiple Mandates and Constraints

The many agencies and entities managing lands in this region each have their own mission and set of mandates. Although conservation efforts would be most effective if coordinated among agencies and organizations, divergent missions and mandates often create a different set of long-term goals and on-the-ground management strategies. For example, while one agency might be mandated to provide for recreational opportunities or extraction of resources, another may be mandated to provide complete protection of native ecosystems, creating constraints on how closely their on-the-ground strategies can be coordinated. Similarly, even slight differences in missions can result in divergent management protocols such as fire management policies (California State Parks 2005).

4.2.2. Lack of Coordinated Management

Management strategies are frequently not coordinated among agencies and organizations, which can hinder effective conservation management. For example, when a watershed is owned and managed by multiple agencies and private owners, a land manager with a conservation emphasis can be adversely affected by an upstream land manager with a resource extraction emphasis. Agency mandates to provide intensive recreational opportunities may adversely affect adjacent lands managed to protect high conservation values. Lack of coordination is often related to the various mandates of the agencies and organizations, and a lack of time and resources available for coordination.

Formation of the Desert Managers Group (DMG), an interagency group formed in 1994 to jointly address desert-wide conservation, visitor services, and public safety efforts (Desert Managers Group 2007), has helped to increase coordination by increasing communication and providing a forum for sharing information and discussion of issues of common concern. The DMG is involved in collaborative management such as weed management (Desert Managers Group 2007), and has a number of working groups that jointly address a wide range of conservation issues, including desert tortoise management, desert lands restoration, and protection of cultural resources; however, many of these working groups are currently inactive (Desert Managers Group 2008).

Designation of the CDCA in 1976 by the U.S. Congress provided a geographic delineation for a coordinated conservation effort. Currently, however, only the BLM is mandated to manage their lands as part of this conservation area (BLM 1999). Although the missions and mandates of multiple governmental agencies and non-governmental organizations promote conservation of this area, there is no mandate requiring them to work in a coordinated fashion within the CDCA.

Some conservation goals, such as connectivity to portions of the Sonoran Desert in Baja California, are further complicated by the different land use policies of the U.S. and Mexican governments, as well as the socioeconomic differences between the two countries. Although exceptional efforts to promote binational conservation in the Sonoran Desert are required to achieve success, the potential conservation gains in this region are large (Appendix A).

4.2.3. Lack of Resources in a Vast Landscape

A lack of sufficient funding and resources can hinder the effectiveness of conservation and management even when existing goals and mandates are clearly defined. In our discussions with land mangers, a lack of sufficient personnel such as wardens and rangers was cited as a serious hindrance to effective protection of natural resources, especially as related to recreational OHV use. In addition, a lack of funding, personnel, and equipment can make habitat management activities such as invasive species control or restoration of damaged lands infeasible. Recently, a lack of State funding even threatened to close 48 California State Parks sites, including three in the Sonoran Desert ecoregion (Los Angeles Times 2008). Although referred to as “closures”, this lack of State funding would have resulted in a very real threat to natural resources because, in reality, a vast desert State park can not be locked as if it were a building. Actual use, impacts, and threats would likely have continued, but less staff would have been present to manage them. While a lack of resources is a challenge for conservation efforts worldwide, they become especially daunting in the vast landscape of California’s deserts.

4.2.4. Diversity of Interests in the Desert

California’s Sonoran Desert is becoming an increasingly popular location for recreation, development, agriculture, and power generation (Sections 2.4 and 5.1). Those with interests in the desert are a diverse group, which includes farmers, ranchers, developers, power companies, mining companies, OHV recreationists, golfers, equestrians, families seeking affordable and safe neighborhoods, tourists seeking wildflowers, researchers and others with natural resource interests, and those simply seeking to experience the calm beauty and serenity of the desert. These diverse interests have different needs and their activities can result in a wide range of impacts on the desert. Many are not compatible with each other and some have goals not consistent with strategies for conserving biodiversity. This therefore creates a large challenge for land and natural resources managers who must address these different interests, while at the same time striving to protect the integrity and natural resources of the desert ecosystem.

4.2.5. Knowledge Gaps

The ability to effectively manage and conserve desert lands is often hindered by a lack of information. Existing information gaps which are impacting effective conservation of California's Sonoran Desert include, but are not limited to:

- Incomplete locational data and inventories on sensitive species and vegetation communities
- Incomplete knowledge regarding control of invasive plant species
- Incomplete knowledge regarding control and the indirect impacts of invasive animal species
- Incomplete understanding of future climate change
- Incomplete understanding of ground water systems
- Incomplete understanding of the inter-relationships among nitrogen deposition, fire ecology, and invasive plant ecology
- A lack of linkage (habitat connectivity) planning in California's deserts

5. THREATS AND CONSERVATION CHALLENGES

The unique and fragile desert ecosystems of southern California's desert face a number of conservation challenges and threats, which come in a wide range of shapes and forms. While some threats are quite obvious, other are subtle and their impacts are not immediately apparent. What is clear, however, is that the following challenges will have to be addressed by a diverse and creative set of conservation measures to effectively conserve this unique landscape.

5.1 Land Conversion

Habitat loss is the single most important cause of species extinctions (May 1990, Brooks et al. 2002), and it threatens entire ecosystems, the species that depend on them, and the biodiversity that they represent. The majority (> 80% in 2000) of imperiled or Federally listed species in the U.S. are at risk of extinction due to habitat loss and degradation (Wilcove et al. 2000). Flather et al. (1998) identified the Sonoran Desert of California as part of a national hotspot of species endangerment. This hotspot, referred to by Flather et al (1998) as the Sonoran Basin and Range, rated in the 95th percentile in the United States in terms of number of endangered species, and the most cited causes of species endangerment were residential, agricultural, and industrial development, introduction of exotic species, water diversion, and surface mining (Flathers et al. 1998). Land conversion presents a large threat to this region, and it continues rapidly, primarily in the Coachella Valley, near Blythe, and in southeastern Imperial County. Additionally, recent efforts to rapidly increase renewable energy production increases the risk of land conversion on both private and public lands throughout the study area (Section 5.3.1).

The GAP Analysis Program (U. S. Geological Survey 2008) has established a ranking system to characterize the natural resources management emphasis and risk of conversion of lands in the U.S. (Table 5-1). Approximately 27% of the region is rated as GAP 4, defined as an area that "generally allows conversion to unnatural land cover throughout" while 40% is rated as GAP 3 and could be impacted by uses such as renewable energy production (U.S. Geological Survey 2008; Table 5-1, Figure 5-1, Appendix B). Converted lands can also adversely affect adjacent unconverted lands via "edge effects" (Meffe and Carroll 1994), thus a substantial amount of land in the region is at risk from the adverse effects of land conversion.

Table 5-1. Acres and percentage of GAP categories within the U.S. portion of the study area

GAP	Acres	Percent	GAP Category Definition
1	1,717,526	23.8%	An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a natural state within which disturbance events (of natural type, frequency, intensity, and legacy) are allowed to proceed without interference or are mimicked through management.
2	666,657	9.2%	An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a primarily natural state, but which may receive uses or management practices that degrade the quality of existing natural communities, including suppression of natural disturbance.
3	2,905,610	40.3%	An area having permanent protection from conversion of natural land cover for the majority of the area, but subject to extractive uses of either a broad, low-intensity type (e.g., logging) or localized intense type (e.g., mining). It also confers protection to Federally listed endangered and threatened species throughout the area.
4	1,922,812	26.7%	There are no known public or private institutional mandates or legally recognized easements or deed restrictions held by the managing entity to prevent conversion of natural habitat types to anthropogenic habitat types. The area generally allows conversion to unnatural land cover throughout.

5.2. Habitat Fragmentation

Habitat integrity is important for the viability of populations and species, as well as for the long-term health of ecosystems and functionality of ecological processes. Additionally, habitat fragmentation can cause a variety of adverse direct and indirect effects (MacArthur and Wilson 1967, Noss 1987, Hanski and Gilpin 1991, Mills and Smouse 1994, Forman 1995; Section 3.3.2). In the Sonoran Desert in California, habitat fragmentation has occurred as a result of physical barriers such as urban development, highways, canals, and fences (Figure 5-1; Appendix B). These barriers can also impact sand dune habitats by disrupting eolian processes and sand deposition (Bunn et al. 2007). For some populations or species, habitat fragmentation may be caused by less apparent impacts, such as zones of disturbance that may be avoided by individual animals, thereby causing a break in connectivity, or zones of modified habitat that no longer support reproducing plants, resulting in discontinuity in a species' or population's range. Water diversions and alterations to water systems may also leave populations (e.g., those associated with riparian systems) isolated from each other (Martin and Wilcox 2004). Fragmentation along elevational gradients (such as along slopes of desert mountains) may become increasingly detrimental in the face of future climate change, because it can eliminate the ability of animal and plant species to shift their distributions either up or down slope in response to changing climate (Sections 3.3.2 and 5.7). In addition, fragmentation of habitats can interfere with the potential for long-term northward movement by species and habitats in response to climate change.

In addition to fragmenting habitats and landscapes, agents of fragmentation (e.g., urban development, roads, canals) are often accompanied by a host of indirect threats as they spread into pristine desert areas. In addition to increased roadkill of native species, invasive exotic species, such as cats and non-native ant species may be promoted (Section 5.4.2). Other species, such as ravens, may be subsidized by anthropogenic resources and tend to occur in greater densities near urban areas, with increased negative impacts on native species such as desert tortoises (Kristan and Boarman 2003). Invasive plant density and fire risk, as well as light, noise, and air pollution, are higher near urban areas and roads, and natural eolian and water systems may be disrupted by development and flood-control structures. Collectively, agents of fragmentation can impact native species and ecosystems in a variety of ways, in addition to the immediate impacts of habitat or landscape fragmentation.

5.3. Land Use Impacts

A variety of land use activities can have negative impacts on native species and ecosystems even when the land is under public ownership and is technically protected from conversion (by development, for example). Many of the land uses discussed below have historically occurred in California's Sonoran Desert or are increasingly becoming a conservation concern in the region.

5.3.1. Power Generation

In the face of climate change and the need to reduce dependency on fossil fuels, Californians have become increasingly interested in generation of renewable energy such as solar, wind, and geothermal developments. California has long been a recognized leader in the field of renewable energy, and its deserts have been identified by many as a region of productive renewable energy development due to abundant sunshine, strong winds, and geothermal resources, with a number of potential energy production sites in the Sonoran Desert (Figure 5-2).

In 2002, California established the goal of increasing the percentage of renewable energy in the State's overall electricity mix to 20% by 2017. In 2003, the California Energy Commission recommended that efforts be increased to reach that goal by 2010, and the State's 2004 Energy Report Update recommended increasing the target to 33% by 2020 (California Energy Commission 2008). More recently, Governor Schwarzenegger proposed a long-term goal of reducing 2050 greenhouse gas emissions to 80 percent below 1990 emission levels (California Energy Commission and California Public Utilities Commission 2008). The State's 2008 update to the 2005 Energy Action Plan continues to support these goals for reducing greenhouse gas emissions (California Energy Commission and California Public Utilities Commission 2008). In response to a recent Executive Order (13212, *Actions to Expedite Energy-Related Projects*) and the Energy Policy Act of 2005, BLM and the Department of Energy (DOE) are preparing a Solar Energy Development Programmatic Environmental Impact Statement (PEIS) to evaluate potential impacts of utility-scale solar energy development on BLM-administered lands in seven western states, with many of these sites located in the Sonoran Desert in California (U.S. Department of Energy 2008).

Despite the importance and long-term benefits of renewable energy development, precautions must be taken in choosing locations and types of facilities. Improper placement of facilities and energy transportation corridors can damage, destroy, and fragment important habitats, as well as disrupt animal movement corridors, thereby harming sensitive plants and animals. In addition to damaging sensitive soils, grading of natural areas destabilizes soils and can lead to increased particulate air pollution. Energy production also requires water, and can therefore have large impacts such as alterations to water flow patterns, water diversion, and groundwater overdraft. In solar production, various technologies have vastly different water needs. Selection of facility sites influences the need for additional powerlines necessary for transporting energy to users. It is therefore imperative that environmental considerations, including both site selection and water consumption, are fully integrated into the early stages of site and transmission evaluation, assessments of impacts to the region, and into the economic valuation of renewable energy options.

5.3.2. Mining

The desert has a long history of extractive mining, dating back at least two hundred years. Historic mines, most much smaller than today's operations, included extractions for calcite, tungsten, strontium, uranium, precious metals such as gold, gem quality non-metals, and building materials such as gypsum, decorative rock, and gravel (BLM 1999, California State Parks 2005). Today, existing mineral and energy sources in California's desert remain extensive, and include large gypsum, decorative rock, gravel, and gold mines.

The CDCA is considered one of the most diverse geologic regions of the United States, and its mineral and energy resources are judged to be "…vitally important in national and international economics" (BLM 1999). In California, most active mines are on GAP 3 and 4 lands (Table 5-1), on private land and on lands leased from BLM (California State Parks 2005), with a smaller portion on U.S. Forest Service lands (Figure 5-1). On BLM lands, management goals include (1) assuring the availability of known mineral resource lands for exploration and development, (2) encouraging the development of mineral resources in a manner which satisfies national and local needs and provides for economically and environmentally sound exploration, extraction and reclamation processes, and (3) developing a mineral resource inventory, GEM [geology, energy, mineral] database, and professional, technical, and managerial staff knowledgeable in mineral exploration and development (BLM 1999). Similarly, the U.S. Forest Service states as a goal to "administer minerals and energy resource development while protecting ecosystem health".

If not planned or managed properly, mining operations have the potential to destroy sensitive plants and habitats, damage desert soils and soil stabilizers, modify water-flow patterns, cause erosion, and reduce air quality via increased dust. They may also damage cultural resources, create dust and noise pollution, harm sensitive wildlife, and destroy important bat roost sites (California State Parks 2005). Open pit mines, such as those for gold, may also create a significant pollution source if cyanide processing is used, and access roads into mines create additional fragmentation.

5.3.3. Water Diversion and Groundwater Pumping

In California's Sonoran Desert, historic increases in human populations, urban development, and agriculture have all been associated with increased availability of water, via the diversion of water from the Colorado River and pumping of groundwater. In recent years, however, an expanding demand for water, in combination with rapid population growth and climate change, has led to serious concern over the future water supplies, and implications for development, agriculture, and vulnerable natural ecosystems. Based on a survey of experts, Marshall et al. (2000) reported that extraction of groundwater and diversion or impoundment of surface water were identified as major stressors at 40 of 100 conservation sites throughout the entire Sonoran Desert. The Sonoran Desert in California is no exception, with increasingly limited water supplies, a growing human population, increased urban and agricultural development, and the threat of climate change. In fact, water diversion was one of the five most commonly cited causes of species endangerment in this region (Flather et al. 1998).

Water in the region comes from two primary sources: the Colorado River and groundwater basins that are fed by precipitation in local watersheds. The Colorado River runs along approximately 230 miles along California's eastern edge, through agricultural areas in the Palo Verde and Bard valleys, urban centers near Needles, Blythe, and Winterhaven, and many small recreational communities (California Regional Water Quality Control Board [CRWQCB] 2005). The river has a long history of water diversion that has greatly altered its course and structure (Pitt 2001). Before it reaches California, large amounts of water have already been diverted and apportioned according to the Law of the River (CRWQCB 2005). Near Parker Dam, additional water is diverted for export through the Colorado River Aqueduct to coastal counties, at the Palo Verde Diversion Dam water is diverted for irrigation, and at the Imperial Dam water is diverted to the All-American Canal for transport to agricultural lands in Imperial and Coachella valleys (CRWQCB 2005). Since the 1970s, a portion of the river's water has also been used to recharge groundwater basins in the upper portions of the Coachella Valley, via the California Aqueduct (CRWQCB 2005). Excess water not used from these diversions mostly drains to the Salton Sea, and the remaining river water, much reduced from historical levels, makes its way to the Gulf of California in Mexico. Due to this extensive diversion, the river's flow and sedimentation patterns have been greatly impacted (Pitt 2001). Many of its floodplains were converted from native riparian vegetation to large-scale agricultural production (Marshall et al. 2000), and wetlands at the delta of the Gulf of California have been reduce to about 10% of their original two million acres (Pitt 2001).

Water diverted for agricultural use eventually finds its way to the Salton Sea, along with water from the New and Alamo rivers, and these water sources maintain water levels in the sea. The Salton Sea was a popular recreational attraction in its early years, primarily during the 1940s and 1950s, but in recent years it has become a large conservation challenge as water quality declines. Since its formation, salinity and concentrations of various chemicals and elements, including pesticides, heavy metals, and elements, have increased, as the water level is maintained by a balance between runoff and evaporation (Patton et al. 2003, CRWQCB 2005). The New River causes a serious threat to the Salton Sea, as it delivers agricultural runoff, raw sewage, and industrial effluent (Patton et al. 2003). The Whitewater and Alamo rivers carry mainly agricultural runoff into the sea (Patton et al. 2003). Salinity of the sea is currently 25-30 percent higher than that of the Pacific Ocean, and may increase as water evaporates and salt continues to be leached from soils (Patton et al. 2003). It is estimated that even small increases in salinity could make the Salton Sea uninhabitable to fish (Patton et al. 2003). While the sea once supported a thriving sport-fishing industry, tilapia are the only remaining fish species found in significant numbers, and their numbers are only 10% of the mid-1990s population estimate (Legislative Analyst's Office 2008). Occasional fish die-offs have occurred during the sea's history, but die-offs have become both larger and more frequent in recent years (Patton et al. 2003, see Appendix B). Although some bird species would still be able to use the Salton Sea without any fish being present, a complete fish die-off would certainly cause a tremendous reduction in bird biodiversity.

In response to increased water demands across the State, and the QSA of 2003, which was intended to reduce the State's use of Colorado River water to its Federally apportioned 4.4 million acre-feet/year, increased amounts of water will be transferred from agricultural use to urban areas, including the Coachella Valley (Legislative Analyst's Office 2008; Section 4.1.2). To offset this transfer, water conservation measures are being developed in agricultural areas, including irrigation efficiency measures and lining of canals with concrete (Bunn et al. 2007). While benefiting water conservation efforts and limiting California's diversion of water from the Colorado River, there will be negative implications for health of the Salton Sea and nearby irrigation-fed agricultural bird habitat (see Section 3.2 and 4.1.2).

Although a great percentage of agriculture in the Imperial and Coachella valleys is supported by Colorado River water, much of the desert's usable water comes from groundwater basins. Groundwater, which originates mainly from precipitation, is critically important to a healthy desert ecosystem. Springs, seeps, ciénagas, lakes, and riparian habitats are intimately tied to groundwater levels, and depend on them for renewed water sources, while at the same time collecting rainwater that percolates back into the groundwater basins (Brown et al. 2007). Groundwater helps stabilize temperature fluctuations within water bodies and their ecosystems, it supports vegetation communities such as mesquite bosques miles from surface water (Brown et al. 2007), and it is necessary for viability of desert wetlands (Stromberg et al. 1996, Deacon et al. 2007, Patten et al. 2007). Groundwater is also an important water source for humans, representing 97% of unfrozen fresh water on earth (Dunne and Leopold 1978). It provides 75% of municipal water use, and provides drinking water for over one half of the United States population (Zektser et al. 2005). There are worries, however, that many groundwater sources are not sustainable at current use rates, and that numerous aquifers, including several in the Sonoran Desert in California, are being depleted and contaminated, creating serious water shortages as well as health risk for humans and natural environments (Brown et al. 2007). For example, phreatophytes, such as mesquite trees, are threatened by ground-water depletion, placing entire mesquite bosques and the species they support at risk (Section 3.5).

Diversion of Colorado River water has also impacted recharge of groundwater sources; in many riparian areas along the river, groundwater levels have receded from historical levels of less than 3 feet (0.9 meter) to more than 10 feet (3.1 meters) below the surface (Bunn et al. 2007). This change, along with changes to sediment and flooding regimes has put native communities such as riparian cottonwood and willow habitats at risk, and favored establishment of invasive tamarisk (Poff et al. 1997, Briggs and Cornelius 1998). In the Borrego Valley, negative consequences arising from the depletion of local groundwater are perhaps most apparent in mesquite bosque habitat. Mesquite bosques that once thrived have begun to die off, in correlation with declining groundwater levels (California State Parks 2005).

Presence of urban development, agriculture, roads, and canals can all contribute to the impairment of watersheds due to their use, diversion, and contamination of water. It is beyond the scope of this project to assess aquifer capacity and recharge rates, but our preliminary assessment based on the relative percentage of roads, urban areas, and agriculture in each watershed and above each ground water basin, suggest that a number of watersheds and basins in the study area are at risk of impairment (Figure 5-3; Appendix B). Our preliminary assessment is consistent with determinations by the California Department of Water Resources, which monitors groundwater in the State, and determined that overdraft of groundwater in the Coachella Valley is one of two primary challenges in the Colorado River Hydrologic Region (the other being leaking underground storage tanks; California Department of Water Resources 2003). Other groundwater basins reported to be of concern are Desert Hot Springs, Lucerne Valley, Yucca Valley, and Blythe (CRWQCB 2004). The California Regional Water Quality Control Board monitors condition of waterways in this region and listed the following waterways as "impaired": New River, Alamo River, Imperial Valley drains, Salton Sea, Palo Verde outfall drain, and Coachella Valley storm water channel (CRWQCB 2004). Along the northwest edges of the study area, the U.S. Forest Service reports a brighter picture of watershed health, with all watersheds on the Forest within the Sonoran Desert to be "functioning", with the exception of the Lucerne and San Gorgonio watersheds, which were rated as "at risk" (U.S. Forest Service 2001). This may be expected, however, since Forest Service lands are mostly at higher elevations, where watershed health may be less impacted.

5.3.4. Recreational OHV Use

The use of OHVs has become a popular recreational activity throughout the Southwest, and is rapidly increasing. Nationally, there were approximately 44.4 million OHV participants in 2005-2007 (Cordell et al. 2008), and in California, the number of registered OHV users increased by 108% between 1985 and 2002 (California Department of Parks and Recreation 2002). The use of OHVs has become a concern due to multiple potential impacts on sensitive species and their environment, as well as on human health. OHV use can directly destroy and kill native plants and animals (e.g., Vollmer et al. 1976), it can damage and destroy soil stabilizers such as biological soil crusts and natural desert pavement (Wilshire 1983, Lovich and Bainbridge 1999), and it can change soil structure by causing soil compaction, changing water runoff patterns, and promoting erosion (Iverson 1980, Adams et al. 1982). Once disrupted, soils are increasingly susceptible to wind and water erosion (BLM 1999). Wind erosion of disturbed soils can increase human health risks by reducing air quality (due to increased particulate matter) and increasing the risk of valley fever, caused by the fungus *Coccidioides* sp., which is found in desert soils (Nakata et al. 1976, Gill 1996, Valley Fever Center for Excellence, no date). OHV use also promotes the spread of invasive plant species, and is a source of noise pollution (Brattstrom and Bondello 1983). Several studies have documented reduced diversity, density and biomass of reptiles and small mammals, as well as reduced plant density and cover, in OHV use areas versus in control sites (e.g., Bury et al. 1977, Lathrop 1983, Groom et al. 2007).

Extensive and serious negative impacts of OHV use have recently led the BLM to close 55,000 acres (22,258 hectares) of the Sonoran Desert National Monument in Arizona to the use of OHVs, citing environmental damage as the sole reason for the closure (Federal Register 2008, Associated Press 2008). Although desert soils and ecosystems may take centuries to recovery from disturbance from OHV use, and restoration activities will likely be expensive, research in the western Mojave Desert has demonstrated that protection from disturbance can result in measurable improvements in vegetation biomass, seed biomass, cover of perennial shrubs, and rodent density and diversity (Brooks 1995).

In California's Sonoran Desert, OHV use is a popular and widespread activity, focused primarily on lands owned by BLM, the California Department of Parks and Recreation, and private lands (Figure 5-4; Appendix B). Because of the difficulties of regulating a popular and widespread activity in a vast desert landscape (Section 4.2.3), the potential for OHV trespass is a large management challenge, and the potential for impacts due to inappropriate OHV use is wide-spread across the study area (Figure 5-4). Proximity to growing metropolitan areas such as Los Angeles, San Diego, and the Inland Empire, as well as increased enforcement of trespass OHV activities in their suburbs, will likely increase OHV use in the Sonoran Desert. To address the need for legal OHV recreational opportunities, a number of desert areas, both State and Federally owned, have been established as legal OHV use areas. Although the management of these areas varies, and management challenges such as insufficient enforcement and inadequate rider education still remain, they collectively provide opportunities for open, trail only, and special uses. Their establishment has allowed enhanced protection of other important natural resource areas.

5.4. Invasive Non-native Species

Invasive non-native species come in many taxonomic forms, including plants, mammals, fish, insects, amphibians, and reptiles. Non-native species can have a myriad of negative impacts, direct and indirect, because they can modify native plant and animal communities, endanger native species, alter ecological processes such as hydrological systems and fire regimes, threaten agricultural crops, and cause human health concerns. Next to habitat loss, non-native species are considered the second most common cause of U.S. species being listed as threatened or endangered (Randall 1996). It is beyond the scope of this project and report to discuss all the potential invasive non-native species that threaten the Sonoran Desert. Rather, we address them and their impacts in general, and present selected examples as case examples. Other sources, such as Tellman (2002) provide more complete discussions.

5.4.1. Plants

Sixty-two non-native plant species found in the Sonoran Desert are considered to be fully-established, generally widespread, reproducing, and of primary concern (Wilson et al. 2002). An additional 70 species are classified as a slightly lesser risk. Wilson et al. (2002) suggested that, in many cases, humans have facilitated the spread of invasive non-native species, either through purposeful planting (e.g., iceplant, tamarisk, fountain grass) or by modifying habitats of native species in such a way that invasive non-native species have a competitive advantage. Environmental changes such as soil disturbance, changes in soil invertebrates, or other soil alterations have often made conditions more favorable for non-native invasive species. Global climate change may benefit invasive species because increased levels of atmospheric CO_2 are known to enhance production of species such as alien annual grasses and forbs (Brooks and Berry 1999). In addition, increased nitrogen levels, such as from air pollutants, can benefit non-native plants, especially in desert environments, because desert soils are usually low in nitrogen. Even small increases in nitrogen have been associated with increased density and biomass of non-natives and decreased density, biomass, and diversity of native annuals (Brooks 2003, also see Section 5.5).

Although many non-native invasive plant species threaten the Sonoran Desert (Van Devender et al. 1997, Wilson et al. 2002), some of the most prominent invaders of the Sonoran Desert in California can be assigned to the following three broad categories, which have very different invasion patterns but each pose a serious threat to biodiversity in the region:

<u>Grasses</u>: Invasive grasses can spread rapidly, increase plant cover, increase fire frequency and size, can survive in dry years, and have transformed plant communities in some parts of the region. Examples of non-native grass species with high invasive potential include red brome, cheatgrass, ripgut brome, and cape rye grass (California Invasive Plant Council, no date). Bufflegrass, which has become a serious invader in Arizona and parts of Sonora, Mexico, poses a risk to California's deserts as well.

<u>Forbs</u>: Non-native invasive forbs can suppress and out-compete native annuals, may deplete soils of important nutrients and decrease soil moisture, and can increase fire frequency and size. The forb of most concern in California's Sonoran Desert is Saharan mustard.

<u>Riparian and Aquatic Species</u>: Non-native riparian and aquatic species threaten some of the most spatially-limited habitat types in the desert. They may change hydrological processes, usurp tremendous amounts of water, and outcompete native riparian plant communities, thereby altering habitat for a number of riparian-dependent animal species. Examples of invasive non-native riparian and aquatic species include giant Salvinia, hydrilla, scarlet wisteria, arundo, and tamarisk (California Invasive Plan Council, no date).

Saharan mustard and tamarisk may be two of the most serious invaders threatening biodiversity in the Sonoran Desert of California, and we provide additional discussion of these two species:

Tamarisk:

Tamarisk or "salt cedar" is a rapidly growing and invasive riparian shrub that threatens native riparian systems. Tamarisk may have been introduced into North America by the Spaniards, but didn't became widely distributed until the 1800s, when it was planted as an ornamental plant, as windbreaks, and for shade; it is now found throughout nearly all western and southwestern states (Lovich 2000). Tamarisk is a concern because its dense and rapid growth allows it to out-compete native plant species, it is extremely resistant to drought, has high fecundity, produces salts that inhibit the germination and growth of native species, alters fire regimes, and usurps great amounts of water (California State Parks 2005). It impacts native wildlife by changing the composition of forage plants, changing the structure of native riparian systems, and causing surface water sources to dry up. It has, for example, been reported to have negative impacts on native pupfish species (Kennedy et al. 2005). Along streambeds, tamarisk often spreads from the edges to the middle, thereby narrowing the stream channel and increasing the potential for flood damage (California State Parks 2005), it has been found to alter the breakdown of organic materials in desert streams (Kennedy and Hobbie 2004), and it creates large deposits of salt above and below the ground that inhibits other plants (Sudbrock 1993). Tamarisk tolerates a wide range of soil types, but is most commonly found in soils that are seasonally saturated at the surface (Brotherson and Field 1987). A mature saltcedar can produce hundreds of thousands of seeds that are easily dispersed by wind and water (Sudbrock 1993). Seeds have been known to germinate while still floating on water, and seedlings may grow up to a foot per month in early spring (Sudbrock 1993). Areas most threatened by tamarisk include riparian habitats, washes, and playas (Figure 5-5; Appendix B).

Saharan Mustard:

Saharan mustard, also from the Old World, is considered by many to be one of the most dangerous plants invading the Sonoran Desert, and has the potential to be found in most parts of our study area (Figure 5-5; Appendix B). It was first documented in the Coachella Valley in 1927, and was widely spread throughout the low- and mid-elevations of the Sonoran Desert by the 1970s (Minnich and Sanders 2000). As recently as the 1980s, it was found primarily along roadsides and in disturbed ground, but it has since spread extensively to undisturbed desert lands, and has even been found along rocky slopes in Anza-Borrego Desert State Park. Saharan mustard is a fast-growing drought-tolerant winter annual that prefers sandy soils, and is tolerant of saline soils. Flowers are apparently self-pollinating so there is nearly 100% fruit set on most plants (Van Devender et al. 1997, Minnich and Sanders 2000). Thousands of seeds may be produced and spread in the wind, singly or as the entire plant, after drying out, is tumbled across the landscape by the wind. When wet, the seeds become sticky and can be spread long distances by animals and vehicle tires. Seeds can live for many years, allowing Saharan mustard to endure long dry periods.

Saharan mustard is a concern because it grows rapidly, smothering native herbaceous plants and competing with shrubs for light and moisture. In the desert, where vegetation is typically sparsely distributed, the presence of Saharan mustard can increase fuel loads and contribute to the spread of fire (Section 5-6). Saharan mustard also threatens sand dune habitats because it tends to stabilize the otherwise dynamic wind-blown dunes and, because it has a high oxalic acid content, it is potentially toxic to desert tortoises and other native herbivores (Arizona-Sonora Desert Museum, no date). It also impacts wildlife through changes in forage plants and in structure of native plant communities (Sánchez-Flores 2007). There is currently a lack of management tools for controlling this species. Because Saharan mustard is related to commercial crop species, biocontrol of this invader is not a viable management option. Saharan mustard can be found in sandy lowland habitats including low dunes, inter-dune troughs, sandy flats, and sandy-gravely washed with well-drained soils (Van Devender et al. 1997), and it is especially common in wind-blown sediments and in disturbed sites such as along roadsides and abandoned fields. Predictive modeling suggests that areas near human settlements, roads, railroad tracks, and unpaved roads and trails may be at greatest risk of invasion (Sánchez-Flores 2007), consistent with field data, which also indicates that washes are at elevated risk (Brooks 2005). As in the case for many non-native invasive plant species, the invasion of mustard appears to be promoted by nitrogen deposition (Brooks and Berry 1999, Brooks 2003; Section 5.5).

5.4.2. Animals

The Sonoran Desert is also threatened by a number of non-native, invasive animal species. Some of these, such as cattle, goats, domestic sheep, horses, and burros, are large herbivores that were historically introduced and managed. Although free-ranging goats, domestic sheep, and horses have, for the most part, been removed from California's Sonoran desert, cattle and feral burros still exist, and are discussed individually below. Other non-native species include bullfrogs, crayfish, sailfin molly, and western mosquitofish, all of which negatively impact native aquatic species (USFWS 1986, Ivanyi 2000, California State Parks 2005, USGS no date). Terrestrial invaders include European starlings, wild turkeys, European honeybees, and brown-headed cowbirds (Unitt 2004). All of these have had some level of impact on native species and their habitat via competition, predation, or parasitism. Other non-native invasive animals, often associated with urban areas and other human-dominated landscapes and documented to threaten native species, include domestic dogs and cats, Argentine ants (Holway 2005), and fire ants (Forys et al. 2002). Domestic cats are considered an especially damaging species, because they can persist in relatively high subsidized densities, and prey on a variety of birds, desert rodents, and lizards. These non-native animal species, along with plant species associated with roads and human developments, impact the desert as indirect byproducts of development and fragmentation (see Sections 5.1 and 5.2).

Livestock: Cattle, goats, and domestic sheep were raised in this region since the 1800s, with up to 4000-5000 head of cattle grazing the Borrego Valley in some years (California State Parks 2005), and estimates of 60,000 domestic sheep and 67,000 cattle in the Imperial Valley in 1920 (Lovich and Bainbridge 1999). Feral goats and domestic sheep have, for the most part, been removed from the region, but free-range cattle grazing still exists, primarily via grazing permits or special-use authority on grazing allotments administered by the BLM and the Forest Service (Figure 5-5; Appendix B). Although the negative impacts of overgrazing have long been recognized (Bentley 1989, cited in Lovich and Bainbridge 1999), cattle grazing can be managed to benefit some native ecosystems. The threats and virtues of cattle grazing have been controversial (e.g., Brown and McDonald 1995, Curtin 2002), and certainly the risks and benefits of cattle grazing depend on management protocols and the setting in which grazing occurs. For this reason, grazing on public lands has been judged to be a major Federal action requiring an environmental impact statement mandated by the National Environmental Policy Act (NEPA;

BLM 1999). The impact of livestock grazing on desert environments is not well understood, because of the lack of long-term studies and the rarity of undisturbed "control" sites (Lovich and Bainbridge 1999). Desert environments, where forage and water are naturally limited, maybe be especially sensitive to cattle grazing, and impacts in the Sonoran Desert in California, one of the most arid North American deserts, may be greater than impacts in other parts of the southwest. If not properly managed, cattle grazing can alter plant cover, biomass, composition, and structure of desert vegetation communities, can impact sensitive plants and native species that rely on them, and can cause extensive erosion and damage to sensitive soils. Soil damage can, in turn, impede nutrient cycling, such as nitrogen fixation of cryptobiotic crusts (Belnap et al. 1994), and modification of native vegetation communities can impact terrestrial and aquatic animal species. In arid desert environments, cattle often congregate in and near riparian habitat and can influence stream channel morphology, water quality, and structure of streamside soils (Kaufman and Krueger 1984; Platts 1981, quoted in Fleischner 1994). Because riparian systems are a rare habitat type in the Sonoran Desert and support a large component of the desert's biodiversity (see Section 3.1), concentration of cattle in these areas can magnify their impacts on the desert. Research in the western Mojave Desert has demonstrated that protection from disturbance such as livestock grazing and OHV use, by protective fencing, can result in measurable improvements in vegetation biomass, seed biomass, cover of perennial shrubs, and rodent density and diversity (Brooks 1995).

Burros: As large grazers, burros can have similar environmental impacts as cattle. If left unmanaged, they can overgraze desert vegetation communities, especially riparian habitats, they can damage sensitive soils and cause erosion, and they can compete with native mule deer and bighorn sheep (Seegmiller and Ohmart 1981, Marshall et al. 2000). However, aspects of their behavior and physiology likely make their potential impacts on the desert environment unique in relation to impacts from cattle. Although both species are dependent on water, the digestive systems of burros differ from those of ruminant cattle, allowing them to go without water for longer time periods (Dill et al. 1980). Burros are also more agile and better able to negotiate rugged terrain. Both of these attributes make it likely that burros will disperse greater distances and have a wider impact on desert lands (Figure 5-5; Appendix B).

In the Grand Canyon, long-term grazing by burros was reported to cause the near extinction of burrobush, a species which acts as an important "nurse plant" for other plants such as barrel cacti and saguaros (Webb and Bowers 1993). Loss of burrobush due to grazing was hypothesized, in turn, to have impeded recruitment of barrel cacti, causing an observed discontinuity in age structure (Bowers 1997). Burros may be particularly damaging to desert riparian habitat, where they frequently congregate, by increasing sedimentation in water sources and competition for water with native wildlife such as bighorn sheep (Bunn et al. 2007). Indeed, studies have found evidence of competition between burros and bighorn sheep in desert environments (Marshal et al. 2008), and burros have been documented to negatively impact recreational sites and the recreational experience of park visitors at Picacho State Recreation Area along the Colorado River. Burros are protected under the Wild Horse and Burro Act, and although target management numbers were established by the Bureau of Land Management prior to 1980 as part of an effort to limit their numbers, current population sizes still exceed established targets (BLM 1999, Bunn et al. 2007).

5.5. Nitrogen Deposition

Increasing amounts of nitrogen entering the atmosphere from automobiles, agriculture, and industrial emissions has, in turn, increased the amount of nitrogen deposited across the landscape (i.e., nitrogen deposition). Nitrogen deposition has increased in recent years, and is recognized as a serious threat to natural ecosystems and biodiversity (Fenn et al. 2003). Nitrogen deposition can negatively impact native desert ecosystems through three primary mechanisms: (1) direct toxicity to plants (e.g., 100% of sagebrush seedlings died when grown experimentally in soils with nitrogen levels similar to soil levels measured near Riverside, California), (2) changes in composition of native plants, and (3) enhancement of invasive species (Weiss 2006, Brooks 2003, Section 5.4.1). Elevated nitrogen also impacts air quality and contributes to impaired visibility, thereby impacting the aesthetic value of open spaces and wildlands (Fenn et al. 2003).

Because deserts are naturally nitrogen limited, even small additions of nitrogen may benefit non-native plants (Brooks and Berry 1999, Brooks 2003), and very small increases in available nitrogen levels, such as 3.2 $g/m^2/yr$, can result in increases of alien plants and decreases in native annuals (Brooks 2003). Nitrogen deposition rates have been reported to be as high as 4.5 $g/m^2/yr$ in the Los Angeles Basin (Brooks and Berry 1999). Nitrogen deposition therefore creates a risk to desert vegetation communities such as desert scrub, sand dunes, and alkali sinks (Weiss 2006), and contributes indirectly to altered fire regimes (see Section 5.6), which further promote type-conversion, loss of native plant species, and negative impacts on native animals species due to changes in habitat quality.

Of 11 western states tested, California had by far the highest nitrogen deposition levels (Fenn et al. 2003). There is a need for additional research and monitoring of nitrogen deposition in California's desert regions (Adams 2003, Fenn et al. 2003); however, several monitoring studies suggest that the Sonoran Desert in California could be experiencing especially high deposition rates, and model results suggest that areas adjacent to urban areas in southern California represented one of several hotspots for total nitrogen deposition (Fenn et al. 2003). Although actual field testing has been limited, data collected in California indicate that the south-facing slopes of the San Gabriel Mountains and the western and southern edges of the San Bernardino Mountains experience high deposition rates (Fenn et al. 2003).

In western states, primary nitrogen emission sources are, in declining order of importance, transportation, agriculture, industry and power plants, and an unknown amount of nitrogen comes across the Pacific Ocean from Southeast Asia (Fenn et al. 2003). Deposition rates are likely to be highest downwind of large urban areas, but may also be high in non-urban areas downwind of agricultural sources (Tonnesen et al. 2007). In most parts of the West, deposition due to transportation and agriculture have increased; however, transportation sources are projected to decrease slightly in coming years due to new emission standards, while agricultural sources, which are not regulated, are expected to increase (Fenn et al. 2003).

5.6. Modified Fire Regimes

Fire regimes in California's deserts have been altered by two primary influencing factors: (1) increased ignition rates, and (2) an increase in biomass (fuels). Although fires in the desert were historically caused by lightning, an increase in ignition rates during 1980 and 1995 was due to an increase in human-caused fires (Brooks and Esque 2002). Increased amounts of fuels, which can increase fire intensity and size, are mainly a result of invasions of exotic plant species. As described in Section 3.3.4, most of the desert's natural vegetation communities, including the prominent creosote bush scrub communities, are not considered to be fire adapted. Historically, fires in these vegetation communities were rare and did not travel great distances because of limited biomass (fuel), wide spacing between plants, and sparse ground cover (Humphrey 1949, Rogers 1986, Brown and Minnich 1986). Today, however, invasions of exotic plants, in particular Saharan mustard and exotic grasses, provide additional biomass which often forms a continuous blanket of vegetation that allows fires to spread more readily. Increased ignition rates and fuels have resulted in more frequent and more extensive fires. In the Mojave Desert, for example, estimates of historical inter-fire intervals range from 30 to > 100 years, while current inter-fire intervals are as short as 5 years in some areas (Brooks et al. 1999). This change in fire frequency has dramatically increased the risk to long-lived perennials such as creosote, lavender, and cholla cactus, because they have low post-fire recovery rates (Brown and Minnich 1986). It can also result in permanent changes or "type-conversion" of native vegetation communities, often to stands of exotic plant species (Brooks et al. 1999), or reduce the occurrence of "nurse" plants, woody plants, and succulents (Alford et al. 2005, Bock and Block 2005). Increased fire frequency and size can negatively impact native animal species, such as desert tortoise, by killing them and reducing habitat quality (Brooks et al. 1999) by altering species composition of the vegetation community (Simons 1991, Esque et al. 2003).

Although fires are a natural process and can play beneficial roles in some ecosystems, such as chaparral or forested areas, this is not the case in most of the Sonoran Desert's vegetation communities, and it has been suggested that in these areas risk of fire should be reduced through removal of exotic plants and suppression of fires in most cases (Brooks et al. 1999, Brooks and Esque 2002). Bock and Block 2005 echoed this suggestion and stated that although prescribed fires should be increased in some regions of the southwestern United States, desert scrub and riparian woodlands of the Sonoran Desert are an exception due to susceptibility to fire. Measures to maintain and restore natural fire regimes are therefore important conservation actions in this region (Mojave Desert Land Trust 2006).

Mapping altered fire regimes was beyond the scope of this project; however, it is likely that altered fire regimes are linked to fragmentation (the presence of roads and urban developments) and presence of exotic species such as Saharan mustard (Figures 5-1 and 5-5; Appendix B).

5.7. Climate Change

The burning of fossil fuels such as coal and oil, along with extensive deforestation throughout the world, has resulted in increased concentrations of heat-trapping "greenhouse gases" in our atmosphere. The heat trapped by gases such as carbon dioxide has caused a gradual increase in global temperatures. It is anticipated that, along with increased temperatures, the earth will experience additional climatic changes such as more intense heat waves, new wind patterns, worsening drought in some areas, and more precipitation in others (United Nations Environment Programme 2008). Although it is not known how much our climate will change, or what the exact effects will be, it has been predicted that 20-30 percent of plant and animal species will be at increased risk of extinction (United Nations Environment Programme 2008). Increased risk of extinction may result from vegetation community changes due to altered precipitation and temperature patterns, disruption of pollinator-host plant relationships (such as relationships between butterflies and their host plants), reduction or alteration of water-related habitats, and changes to processes such as wildfires, flooding, disease, and pest outbreaks (Field et al. 1999).

A great deal of uncertainty exists in predicting impacts of climate change in California due, in part, to difficulties in predicting future trajectories of greenhouse gas emissions, and the difficulty of predicting minor shifts in stormtracks given California's location between the very wet Northwest and the very dry Southwest (Lenihan et al. 2006). However, significant changes are likely. Even subtle climate changes may have large impacts on ecosystems, and these changes may be especially notable in desert ecosystems, where species are living in extreme conditions of heat and aridity. Elevated temperatures and altered rainfall patterns may cause valuable water sources to dry up seasonally or altogether, and may alter stream flow and recharge of groundwater basins. Small changes in water temperature may impact the viability of desert pupfish or Salton Sea fish populations. Studies suggests that summer thunderstorms in the deserts may increase in number and/or intensity (Dessens 1995), which could cause significant changes in plant phenology, flooding patterns, and fire frequency. Other studies suggest that climate change will alter the distribution of grasslands in relation to desert vegetation communities; however the direction of this change depends on still uncertain precipitation scenarios (Lenihan et al. 2006). Such vegetation changes will also likely have large influences on desert fire regimes (see Section 5.6). Changes in seasonal precipitation totals and patterns can impact vegetation communities and individual species such as saguaros, because their growth is tied to summer precipitation (Drezner 2005). In addition, increased levels of atmospheric carbon dioxide may alter the competitive relationships between native and exotic species, through influences on plant productivity (Ziska 2008), while changes in fire regimes may promote invasion of non-native plants. Epps et al. (2004) found that populations of desert bighorn sheep living in lower, drier mountain ranges may be more susceptible to extinction than those living in higher, moister mountain ranges. Thus, climate change could present a very real challenge to desert bighorn sheep populations, and probably numerous less-studied species that share their habitats.

Plant and animal species may shift their distribution in response to climate change (Field et al. 1999), and it has been speculated that these shifts may be northward or to higher elevations. Given the desert's varied topography, a shift to higher elevations may, in some cases, require moving in a southward path (Loarie et al. 2008). Predicting if and how species will shift is difficult, because many factors, such as topography, soils, water and nutrient availability, and dispersal abilities will influence their distribution. For example, plants dispersing to higher elevations and more northerly latitudes will only be successful if they are able to survive on the soils in these new habitats. The rapid speed with which anthropogenically-induced climate chance occurs may not provide enough time for slow moving or short-distance dispersers to reach new suitable habitat. An important point, therefore, is that the ability of habitats and species to adjust in response to climate change will depend on the availability of large intact and interconnected landscapes (Section 3.3.2). Species living in a fragmented landscape are at increased risk of extinction if they can not move from one location to another to track changes in climate.

6. A FRAMEWORK FOR CONSERVATION MANAGEMENT

6.1. Describing the Current Conservation Landscape

The Sonoran Desert in California is a diverse landscape, in terms of physical features, natural biodiversity and function, and degree of human impact. As a result, a range of conservation conditions, which determine opportunities and implementation strategies, exist across this landscape. To assess current conservation conditions, we categorized lands in the study area based on their ecological integrity and presence of conservation targets (Section 3.5; Appendix B). We then defined conservation objectives for each conservation category, and identified conservation opportunities to achieve these objectives in relation to existing ownership patterns, management activities, and threats and challenges.

6.1.1. Biological Integrity of the Landscape

Habitat fragmentation and the associated direct and indirect impacts can have serious impacts on biological resources and ecosystem function (Sections 3.3.1 and 5.2). A fundamental premise of our approach in this framework is that high integrity landscapes are more effectively and efficiently managed for conservation values. Thus one objective of our analysis was to identify high integrity areas remaining in the Sonoran Desert of California and to determine to what extent these intact areas adequately supported our conservation targets for the region. We used the extent and distribution of land cover changes, e.g., urbanization, agriculture, and roads, as an index of fragmentation (Figure 5-1; Appendix B), and defined landscape integrity as the inverse of fragmentation. We used the fragmentation index as one criterion for identifying intact landscapes (i.e., areas of low fragmentation) that achieved established goals for our conservation targets (Section 6.1.2 and Appendix B), and for assessing risk of watershed impairment risk (Appendix B).

6.1.2. Identifying Areas of High Conservation Value

We used the conservation reserve selection program Marxan (Ball and Possingham 2000, Possingham et al. 2000) to guide our understanding of the landscape's conservation patterns in relation to our conservation goals for our identified conservation targets. Marxan provides an objective procedure for characterizing the contribution of portions of the landscape to achieving conservation goals in the most efficient manner (i.e., within the smallest area possible) and with the least "cost". In the Marxan analysis, the landscape is broken into a set of selection units or cells that are assigned attributes describing conservation targets (e.g., target community acreages) and cost. Marxan creates a conservation "portfolio" by selecting the smallest set of cells that satisfy the established conservation goals with the least cost and fragmentation. We used the fragmentation index (i.e., the inverse of landscape integrity; Section 6.1.1) to determine the cost surface used by the Marxan analysis, such that higher levels of fragmentation resulted in a higher relative "cost" of conserving each cell (Figure 6-1; Appendix B). We defined conservation goals as percentages of each vegetation community and special desert element that should be included in each of the Marxan portfolios. Similar approaches have previously been used to guide conservation planning in southern California (e.g., Natural Community Conservation Planning [NCCP] programs, and the Las Californias Binational Conservation Initiative, Conservation Biology Institute 2004).

We defined two goal sets: Goal Set 1 prioritized irreplaceability by increasing conservation goals for targets that are rare or have limited distribution, while Goal Set 2 prioritized ecosystem representation and integrity by selected a uniform percentage of all targets (Appendix B). Using Goal Set 1, Marxan is forced to include areas supporting rare and irreplaceable conservation targets in a portfolio even if these areas are relatively costly. Whereas using Goal Set 2, Marxan has greater latitude to select a portfolio comprised of lower cost areas, which translates to areas of higher landscape integrity. Thus, the relative contributions of different portions of California's Sonoran Desert landscape to achieving our various conservation objectives can be evaluated by examining the differences between the portfolios obtained under these two goal sets.

6.1.3. The Current Conservation Landscape

To account for the random element of the Marxan analyses, we performed ten runs for each of the two goal sets and determined the frequency with which portions of the landscape were included in the resulting Marxan portfolios. We evaluated the extent to which portions of the study area met the two Marxan conservation goal sets and the spatial relationship of these portfolio areas to areas outside of the portfolios that supported high landscape integrity, and then categorized the study area into four conservation categories (Figures 6-1 and 6-2, Appendix B):

Category A: Lands that have a high level of landscape integrity (low or no fragmentation) and satisfy at least one of our two conservation goals of irreplaceability and ecosystem representation.

Category B: Lands that have a high level of landscape integrity or satisfy at least one of our two conservation goals of irreplaceability or ecosystem representation. As such, lands in this category may have high target value but have compromised integrity, or they may have high integrity and lower target value.

Category C: Natural areas or open space that are fragmented by roads, sparse rural residential communities, or other human uses (i.e., areas with relatively low integrity), but which may nonetheless contain conservation targets, provide potential habitat linkages, or provide a buffer around Category A and B lands.

Category D: Lands that are dominated by urban communities and agriculture, but which may contain isolated conservation targets or provide habitat for some wildlife species, and can contribute to the quality of life of regional residents.

6.2. A Vision for Enhanced and Effective Conservation Efforts

Building on the current conservation landscape, we offer a regional vision for enhanced future conservation and management of the Sonoran Desert in California (Figure 6-2). We recognize that a gradient of conservation values, ranging from high integrity areas that support significant conservation targets to areas dominated by human land uses, exists across the landscape. Our vision for the region is a network of high integrity areas supporting high conservation values that are buffered and interconnected by land that is relatively intact or supports important conservation values, contained within a matrix of increasingly human-altered land. Regional conservation objectives, and thus conservation and management opportunities and implementation strategies, vary according to the distribution of landscape integrity and conservation values and the various threats identified for the region.

6.2.1. Conservation and Management Objectives

The four conservation categories defined in Section 6.1.3 recognize the differences in integrity and conservation values that currently exist across the landscape of California's Sonoran Desert. We defined a range of conservation objectives for lands within the four conservation categories, which help articulate our regional conservation vision (Figure 6-2):

Category A: Protect large, intact habitat blocks to conserve irreplaceable biological resources, support natural ecological processes (e.g., fire and water-flow regimes), and maintain habitat connectivity. Prevent agents of fragmentation (e.g., development, roads), invasion of exotic species, and other direct and indirect human impacts from occurring in these areas.

Category B: Promote land uses and management practices that maintain or improve landscape integrity and protect conservation targets. Promote restoration of habitat connectivity, natural vegetation communities, and ecological processes (e.g., water-flow regimes, eolian processes).

Category C: Encourage sustainable land uses that minimize impacts to natural resources, allow protection of sensitive species and isolated high value native ecosystems, and maintain landscape permeability to wildlife movement.

Category D: Focus conservation and management efforts on natural areas (e.g., open spaces, riparian habitats, canyons) that support local wildlife, improve air and water quality, recharge groundwater aquifers, and otherwise improve human quality of life. Promote management of agricultural landscapes to support key wildlife resources (e.g., birds at the Salton Sea).

6.2.2. Conservation Opportunities

To identify regional conservation opportunities, we examined how lands within the four conservation categories were distributed within the study area. Nearly 73% of the study area was categorized as Category A or B lands, while 13.9% was classified as Category C lands and 13.6% was classified as Category D lands. We identified six groupings of land within conservation Categories A and B, which we termed *landscape units*, that represent the portions of the study area with the highest integrity and conservation values and serve as the core units of our conservation vision (Figure 6-2). These landscape units support many of the conservation targets and priorities previously identified by other conservation analyses (Marshall et al. 2000, Mojave Desert Land Trust 2006) and by individuals in our interviews for this project (Appendix B). For each of the six landscape units we assessed how well the specific conservation objectives were met by existing conservation efforts and land management practices, how identified threats and conservation challenges potentially impacted them, and how enhanced efforts could be used to achieve conservation objectives. We then considered how conservation and management objectives could be achieved in Category C and D lands.

Landscape Units

A large portion of land within the six identified landscape units is already under some level of protection, with 42.5 percent classified as receiving high levels of protection from conversion and a focus on natural resources management (i.e., GAP 1 or 2 lands, Table 5-1). However, many areas remain at risk from various threats and challenges identified for the region, and some lands also remain at risk of land conversion. We provide the following general recommendations for achieving conservation objectives within landscape units comprised of Category A and B lands, and then provide specific recommendations for individual landscape units:

- Avoid land conversion and fragmentation. Land uses that result in fragmentation or conversion, for example, urban development and renewable energy production and transport facilities, should be sited within Category D lands when possible, and within Category C lands when necessary (see Category C and D recommendations).
- Increase effective conservation of Category A and B lands by enhancing management policies and actions to improve natural resource protection on public lands, and promote habitat protection on private lands via acquisition of key properties (e.g., inholdings), conservation easements, or enhanced zoning that emphasizes natural resource values (see also Section 6.3.1).
- Improve landscape integrity within Category A and B lands by closing, and possibly restoring, unnecessary dirt roads, and by increasing wildlife permeability across critical sections of paved roads, canals, and railroad tracks via construction of over- and under-passes.
- Maintain or restore connectivity among landscape units, as feasible, as well as connectivity to adjacent intact and protected lands outside of the study area. Maintenance of landscape integrity that includes complete watersheds flowing into the Sonoran Desert will protect ecosystems within the study area.
- Limit off-route (cross-country) OHV use, reduce open routes in sensitive areas, increase enforcement and rider education programs to reduce trespass into closed areas, and support restoration of OHV-damaged areas (also see recommendations for individual landscape units).
- Protect and maintain health of watersheds and groundwater basins. Although many

watershed and groundwater basin impacts originate in Category C and D lands (and must therefore be addressed in their management; see specific recommendations for Category C and D lands), management decisions in relation to Category A and B lands can benefit watersheds and water basins. This includes avoidance of water-consuming developments, and increased and proactive protection of watersheds (including areas where they extend beyond the study area; see also Section 6.3.1).

- Eliminate or control non-native invasive plants (see also Section 6.3.1).

Landscape Unit 1

Landscape Unit 1, located at the western edge of the Sonoran Desert, extends from the Jacumba and In-Ko-Pah mountains at the US-Mexico border north through the Vallecito, San Ysidro, Santa Rosa, and San Jacinto mountains, collectively forming the U.S. portion of the Peninsular Ranges (Figure 6-2). Peaks in the San Jacinto Mountains rise from the desert floor to over 3,048 meters (10,000 ft), representing one of the steepest escarpments in the contiguous United States. This landscape therefore supports a diversity of vegetation communities, ranging from sand dunes and ephemeral playas to pinyon juniper woodlands. It includes intact lands along elevational gradients and along a north-south orientation, which can provide native species and vegetation communities some resilience to future climate change by giving them the opportunity to shift elevationally or latitudinally. This landscape unit also provides crucial opportunities for habitat connectivity to the San Bernardino Mountains to the north, to Baja California, Mexico to the south, and to protected lands at higher elevations to the west. Important watersheds in this area include Snow, Coyote, Borrego Palm Canyon, San Felipe, Fish, and Carrizo creeks. These and other watersheds support palm oases, perennial and intermittent streams, playas, and ciénagas, and ultimately supply water to the Salton Sea and local groundwater basins. The landscape is replete with numerous historic and cultural sites, and includes significant Tribal lands. It also provides important habitat for Federally listed bighorn sheep, flat-tailed horned lizards, Peirson's milk-vetch, triple-ribbed milk-vetch, and least Bell's vireo.

Anza-Borrego Desert State Park provides protection for much of this landscape, with significant lands protected as State Wilderness. Extensive lands are also administered by BLM, with many lands designated as Federal Wilderness and as ACECs. Along the upper elevation western edge, lands are administered by the Forest Service, with many designated as Federal Wilderness, while additional lands are protected under administration by CDFG. Conservation planning for this area includes the San Diego East County Multiple Species Conservation Plan, the Coachella Valley Multiple Species HCP, and the Agua Caliente Tribal HCP, all of which are currently in draft form.

Despite the existence of extensive land protection and ongoing conservation planning, this landscape unit is threatened by a number of conservation challenges, and requires additional conservation efforts. Increasing protection of private lands within this unit, particularly along the slopes of the Santa Rosa and San Jacinto mountains, in the Borrego Valley, and near Jacumba should be targeted to maintain landscape integrity, protect a key elevational gradient, help buffer wilderness areas within the Santa Rosa and San Jacinto Mountains National Monument and in Anza-Borrego Desert State Park, and increase protection of species such as flat-tailed horned lizards, bighorn sheep, Peirson's milk-vetch, and least Bell's vireo, as well as numerous cultural resources. Preventing additional land conversion would also reduce further degradation of watersheds and groundwater basins. The eastern slopes of the Santa Rosa and San Jacinto mountains represent a significant portion of the planning area of the Coachella Valley Multiple Species HCP. Increased protection of private lands in this area would therefore support the goals of this planning effort and protect key natural resources within the Coachella Valley (Coachella Valley Association of Governments 2007).

Some public lands, in particular BLM lands in the southern portion of the unit, also remain at risk of conversion, for example, for energy development and mining. The potential for solar and geothermal energy development is greatest in gentle terrain at the southeastern portions of this landscape unit, where it would threaten flat-tailed horned lizard habitat as well as playas and dune habitats (Figures 3-2, 3-3, 3-4, 5-2). Wind energy development is most likely in mountainous terrain at the south end of the unit, where it would threaten landscape integrity and species such as bighorn sheep (Figures 3-5, 5-2). Increasing the level of protection of public lands is key to achieving conservation objectives in this landscape unit, and enhanced protection of these lands should be targeted by public land managers by working with development interests to locate their projects in adjacent Category C and D lands.

Integrity of this landscape unit has been impacted by a number of roads, including Interstate 8, State Highways 74 and 78, and several county roads which cut through the landscape. These roads, in particular Interstate 8 and State Highways 78 and 74, should be targeted for wildlife passage improvement to facilitate wildlife movement from south to north through the unit. This would help facilitate the natural movement patterns of species such as bighorn sheep, deer, mountain lions, and flat-tailed horned lizards, making them more resilient to climate change. In addition, participating in the implementation of existing linkage plans developed by SC Wildlands[1] (Penrod et al. 2005a, 2006a, 2006b) will help maintain/re-establish connectivity to protected lands to the west and the north, while working to implement the Las Californias Binational Conservation Initiative will promote connectivity to the South Coast ecoregion and Mexico (CBI 2004; Appendix A).

The integrity and conservation value of this landscape unit would also benefit greatly from modifying public land use practices such as limiting cross-country OHV travel and extent of open routes in sensitive areas, accompanied by increased OHV enforcement, rider education programs, and programs to repair OHV-damaged areas. Livestock trespass into Category A and B lands should be eliminated. In addition, Coyote Creek and the combination of San Felipe, Fish, and Carrizo creeks should be recommended as candidates for Wild and Scenic River status, based on their value for wildlife, recreation, and cultural resources. Increased protection of these and other watersheds in this unit (e.g., via land protection and removal of invasive species) should be targeted to help to achieve conservation objectives for this landscape unit. Although watersheds of this landscape unit benefit from presence of adjacent protected lands (GAP 1 and 2) along its western extent (Figure 6-2), some headwaters such as near McCain Valley, at the unit's southern edge, remain vulnerable to land conversion and deserve increased protection. Although the entire study area is at risk of nitrogen deposition, altered fire regimes, and non-

[1] These include 1) A Linkage Design for the San Bernardino-San Jacinto Connection, 2) A Linkage Design for the Palomar-San Jacinto/Santa Rosa Connection, and 3) A Linkage Design for the Peninsular-Borrego Connection.

native plant invasions, these threats are amplified in the northern portion of this landscape unit due to high density urban areas and major transportation corridors, and this therefore merits targeted restoration efforts and invasive species removal programs in that area (see also Category C and D recommendations).

Landscape Unit 2

Landscape Unit 2 is represented by a chain of relatively small slices of land within the Sonoran Desert ecoregion. These lands form a wide arc, from the southern edges of the San Bernardino Mountains at the north end of the Coachella Valley, along the southern edges of the Little San Bernardino Mountains and the Indio Hills, and then along the Eagle Mountains and Coxcomb Mountains. Interstate 10 roughly defines the southern edge of this landscape unit, while State Route 177 is found at its eastern edge. These lands support extensive alluvial fans of Mojavean and Sonoran creosote bush scrub and desert dry wash woodlands. They also include important dune habitats, playas, and palm oases, and provide habitat for triple-ribbed milk-vetch, flat-tailed horned lizards, bighorn sheep, as well as critical habitat for desert tortoises.

Although representing a small proportion of our study area, these lands border extensive protected lands to the north and west, and therefore represent an important part of a large intact landscape that joins the Sonoran and Mojave ecoregions, as well as elevational gradients that support diverse habitats and provide ecological resilience to climate change. This landscape includes Joshua Tree National Park and Wilderness administered by the National Park Service, Big Morongo Canyon and White Water Canyon ACECs, administered by the BLM, and San Gorgonio Wilderness, administered by the Forest Service. In addition, three preserves (Mission Creek Preserve, Whitewater Canyon Preserve, and Pioneertown Mountains Preserve) owned by The Wildlands Conservancy contribute to protection of this large landscape. Watersheds in this landscape unit feed groundwater basins of the Coachella Valley, and the Whitewater River watershed also serves as a primary sand source for dune habitats downwind.

Some lands within this landscape unit are protected within Joshua Tree National Park and BLM's Coachella Valley Fringe-toed Lizard ACEC; however, many are privately owned. These private lands are at great risk of development, especially given their close proximity to the Interstate 10 corridor and growing urban centers of the Coachella Valley. Along the Interstate 10 corridor east of the Coachella Valley, gentle terrain in these lands is at risk of solar energy development and wind energy development, although the highest potential for future wind development is at the western extent of this landscape unit, where extensive wind energy plants already exist. Conservation strategies for this area should aim to increase protection of private lands via acquisition or conservation easement, particularly for inholdings within the National Park and wilderness areas, or parcels that buffer these areas, to secure landscape integrity within this unit, protect sand sources, and to buffer existing protected lands. Increased protection of public lands is also needed, in particular along the Interstate 10 corridor east of the Coachella Valley, and within the San Gorgonio River, Whitewater River, and Mission Creek watersheds. Increased protection of lands at the western extent of this landscape, near the Banning Pass, will protect unique plant assemblages and hybrids (such as unique intergrades of desert and coastal reptiles) found at this desert-coastal transition zone. Lands in the western half of this landscape unit fall within the planning area of the Coachella Valley Multiple Species HCP and some, such as portions of Mission Creek and the East Indio Hills, have been targeted as priority conservation areas in that plan (Coachella Valley Association of Governments 2007). Increased protection of these lands would therefore protect key natural resources within the Coachella Valley.

Conservation efforts should promote connectivity between this landscape unit and other large landscape units. Lands near Pinkham Wash and Thermal Canyon should be targeted for improved habitat connectivity across Interstate 10 to the Mecca Hills, Orocopia Mountains, and Chocolate Mountains in Landscape Unit 5, benefiting native species including desert tortoises and bighorn sheep. At the western edge of Landscape Unit 2, successful implementation of SC Wildlands' linkage design for the San Bernardino-San Jacinto connection (Penrod et al. 2005a) will promote connectivity to Landscape Unit 1. At its eastern and northeastern edges, Landscape Unit 2 is separated from Landscape Units 3 and 4 by State Route 62 and Route 177, respectively, and future planning should address means of maintaining connectivity across these highways. Habitat integrity within this landscape unit will also benefit from implementation of SC Wildlands' linkage designs for the San Bernardino-Little San Bernardino connection (Penrod et al. 2005b). Additional overpasses should be considered to facilitate wildlife crossing over the Colorado River Aqueduct within this landscape.

Conservation strategies on public lands should also include designating the Whitewater River as a Wild and Scenic River, primarily due to its value for wildlife habitat, contribution to sand sources, and support of habitat for rare species such as triple-ribbed milk-vetch. In addition, although the entire study area is at risk of nitrogen deposition, altered fire regimes, and non-native plant invasions, the western portion of this landscape is at increased risk of these threats due to high density urban areas and major transportation corridors, and should therefore be targeted for restoration efforts and invasive species removal programs (see also Category C and D recommendations). Sensitive resources in this landscape will also benefit from increased enforcement of OHV regulations, in particular near the interface with Category C and D lands.

Landscape Unit 3

Landscape Unit 3 extends from State Route 62, near the Calumet Mountains and Cadiz Valley, east to include the Iron Mountains, the Ward Valley, the Turtle Mountains, the Chemehuevi Valley, and the Whipple Mountains (Figure 6-2). State Route 62 roughly forms the southern extent of this landscape unit, the Colorado River forms its eastern edge, and the unit's northern and western edges are formed by the Sonoran Desert's border with the Mojave Desert. This area supports some of southern California's most extensive undeveloped areas, characterized by broad sweeping valleys, alluvial fans, and dry lakes, interspersed with remote mountain ranges. This landscape unit includes desert dry wash woodlands, sand dunes, playas, and rare California saguaros, and is home to desert bighorn sheep and desert tortoises. Indian tribal lands and significant cultural sites are found here, particularly along the eastern portions of the landscape near the Colorado River.

This landscape represents an extensive and intact stretch of the Sonoran Desert-Mojave Desert transition zone. Beyond the Sonoran ecoregion, this landscape is connected to protected areas within the Mojave Desert, including the Cleghorn Lakes Wilderness, the Sheephole Valley Wilderness, the Cadiz Dunes Wilderness, the Old Woman Mountains Wilderness, the Stepladder

Wilderness, and the Chemehuevi Mountains Wilderness. This landscape unit is therefore important to providing the long-term protection of this desert transition zone, and for maintaining an intact landscape that will give desert species and vegetation communities much-needed resilience in the face of climate change.

Within the Sonoran ecoregion, most of this landscape unit is administered by the BLM, and several large areas are protected as wilderness in the Old Woman Mountains Wilderness, the Turtle Mountains Wilderness, and the Whipple Mountains Wilderness. Smaller areas are protected as ACECs (e.g., the Whipple Mountain ACEC). Habitat management along the Colorado River is guided by the Lower Colorado River Multi-Species Conservation Program (Lower Colorado River Multi-Species Conservation Program 2004).

Increasing the level of protection of public lands is key to achieving conservation objectives in this landscape unit. Although many mountainous areas are protected as wilderness, much of the low elevation gentle terrain remains vulnerable to land use changes, including solar and geothermal energy production and inappropriate OHV use. In general, intact valleys and areas of gentle terrain should be considered important potential linkages between mountains, especially in the face of potential climate change. Intact valleys between protected mountains, such as the Ward and Chemehuevi valleys, should be targeted for enhanced natural resource management to maintain their intact condition. Increased protection of BLM-owned desert tortoise critical habitat, located primarily in low elevation gentle terrain, possibly to ACEC status, would provide more secure protection for this species. It would also protect important connectivity between mountain ranges for bighorn sheep. The potential for wind energy development is highest in several mountainous areas, including the Chemehuevi Valley and the Iron and Whipple mountains (Figure 5-2), and these areas should be targeted for increased protection, and energy development projects should be located in adjacent Category C and D lands. Increased protection of the Iron Mountains, as well as the valleys around them, would protect bighorn sheep, while protection of Danby Playa (Dry Lake), Cadiz Playa (Dry Lake), and nearby sand dunes would further promote biodiversity of this area. In the Whipple Mountains, trespass of burros (and their impact on plants such as saguaros) should be reduced by increased adherence to BLM burro population target goals, while grazing allotments in the upper Ward Valley and near the southern end of the Turtle Mountains (Figure 5-5) should be retired when possible.

Although the vast majority of this landscape unit is administered by the BLM, the area is dotted with inholdings under private ownership or belonging to the State Lands Commission. Along the Colorado River, extensive lands are under Tribal and private ownerships, with the communities of Lake Havasu City and Parker being the main nearby urban centers, and additional lands are found along the State Route 62 corridor. Increased protection of private lands via acquisition, conservation easements, or voluntary conservation efforts would contribute to the long-term conservation objectives for this landscape unit. In addition, the Colorado River and its associated riverside habitats would benefit from enhanced protection of private and Tribal lands in this landscape unit, with collaborative efforts between public agencies, Tribal Nations, and private land owners likely being most effective (Section 6.3.2).

Integrity of this area is currently impaired by U.S. Route 95, which runs from Vidal Junction north to Needles, the Arizona & California Railroad, and several isolated roads bisecting the landscape. Additional crossing structures such as over- or under-passes should be considered to increase wildlife permeability across these roads and the railroad.

Landscape Unit 4

Landscape Unit 4 is located between State Route 62 to the north, State Route 177 to the west, Interstate 10 to the south, and the Colorado River to the east. It includes the Palen and Granite mountains, the McCoy Mountains, the Big Maria Mountains, and Riverside Mountain, and expansive open areas such as the Rice Valley and Palen Dry Lake. This landscape unit supports ephemeral playas, sand dunes, desert dry wash woodlands, and large expanses of Sonoran creosote bush scrub. It also includes historic and currently occupied bighorn sheep habitat. Multiple cultural sites are found here, in particular along the unit's southern and eastern edges, such as in the Big Maria Mountains (Appendix C).

The majority of this landscape is administered by the BLM, with the exception of scattered private (and State Lands Commission) inholdings, a large private inholding at Palen Dry Lake, and private lands along the State Route 62 corridor and northwest of Blythe. Protected lands include the Federally-designated Palen/McCoy, Rice Valley, Big Maria, and Riverside Mountains wilderness areas, and two small ACECs (Palen Dry Lake ACEC and the nearby Desert Lily Preserve ACEC). Habitat management along the Colorado River is guided by the Lower Colorado River Multi-Species Conservation Program (Lower Colorado River Multi-Species Conservation Program 2004).

Achieving conservation objectives in this landscape unit will rely on increased protection of public lands. Extensive public lands outside of wilderness areas are, for example, at risk of energy development. Wind energy development is a possibility in the Granite and Little Maria Mountains, and in portions of the McCoy Mountains, while the potential for solar energy development is highest in the vicinity of Palen Dry Lake and in gentle terrain northwest of Blythe. Increased protection of BLM lands (possibly to ACEC or wilderness status) in the Granite Mountains area, north of the McCoy Mountains, south of the Palen/McCoy Wilderness, and in the area of Palen Dry Lake, would provide additional needed protection for conservation targets such as sand dunes and playas, and protect landscape intactness. In addition, increased protection of lands in the McCoy Wash area, northwest of Blythe, between the McCoy Mountains and the Big Maria Mountains, would protect watersheds and ground water basins from future land conversion, water diversion, and increased water use. Increased protection of public lands in this unit would also provide protection for sensitive resources, such as sand dunes and playas, from OHV use; however, increased enforcement of existing regulations remains necessary, in particular near access points along open roads and near private property. An existing cattle-grazing allotment in the Rice Valley area should be retired.

Conservation strategies for this landscape should attempt to increase protection of private lands in the vicinity of existing protected areas via acquisition or conservation easement. In particular, increased protection of private lands in the Palen Dry Lake area would increase protection of playas and sand dunes habitats, while increased protection of inholdings between the McCoy and Big Maria mountains would help maintain landscape integrity and reduce further degradation of watersheds and groundwater basins in the area.

This landscape unit faces an increasing risk of isolation from other large intact landscapes, especially as traffic and development increase along the transportation corridors that border it on three sides. Within the unit, landscape integrity is impaired by numerous dirt roads and the Arizona & California railroad. Integrity of this landscape would benefit from closure of unnecessary roads, and from crossing structures such as over- or under-passes that would facilitate wildlife permeability across the railroad, in particular between the McCoy and Big Maria mountains and in the Rice Valley area. Long-term planning should also identify the most likely future areas of connectivity between this landscape and areas to the north (Landscape Unit 4), the west (Landscape Unit 3), and to the south (Landscape Unit 5) to facilitate future wildlife habitat connectivity.

<u>Landscape Unit 5</u>

Landscape Unit 5 is bordered on the north by Interstate 10, on the west by Category C and D lands of the Coachella and Imperial valleys, on the south by the U.S.-Mexico border, and on the east by State Highway 78 and State Route 34. This is perhaps the largest area of relatively intact lands in California's Sonoran Desert. It includes the Chuckwalla Mountains, the Palo Verde and Mule mountains, the Orocopia Mountains, the Mecca Hills, and the massive range of the Chocolate Mountains. Near its center, this area includes the extensive Milpitas Wash area, while the Algodones Dunes are found at its southern end. In addition to desert dry wash woodlands and sand dunes, this landscape unit supports fan palm oases, pupfish habitat, saguaros, bighorn sheep, flat-tailed horned lizard, Peirson's milk-vetch, and extensive desert tortoise critical habitat. Multiple cultural sites and lands significant to Native American Indians are also found in this area (Appendix C).

Most of this landscape is administered by the BLM and by the Department of Defense. However, extensive checkerboards of public and private lands exist, particularly in the Milpitas Wash area, along the north side of the Orocopia Mountains, and along the western edges of the Chocolate Mountains. Additional scattered inholdings of State Commission Land parcels and private lands occur primarily in the northern and eastern portions of the unit. Protected lands include the Mecca Hills, Orocopia Mountains, Chuckwalla Mountains, Little Chuckwalla Mountains, Palo Verde Mountains, and North Algodones Dunes wilderness areas. In addition, over a dozen, most relatively small, ACECs occur in the area, including the Dos Palmas, Mule Mountains, Chuckwalla Bench, and East Mesa ACECs. The DOD protects natural resources on its lands from some human impacts but the area is used for military training exercises that can be in conflict with conservation objectives for the region. As has happened around other military installations in the U.S., future development on private property adjacent to DOD land could potentially cause conflicts with military training.

Achieving conservation objectives for this landscape unit will require expanded measures to increase effective conservation on private lands. Within the Milpitas Wash area, for example, numerous private inholdings, scattered residences, and multiple dirt roads connecting them threaten the integrity of this area. Targeting these lands for increased protection would protect the area from further loss of habitat integrity, for example by reducing ready access points for illegal OHV use into existing protected areas, and it would protect important desert dry wash woodlands and species such as desert tortoises that rely on them. Private lands along the low western slopes of the Chocolate Mountains should also be targeted for acquisition or protection via conservation easement to preserve and buffer a critical portion of this intact landscape. In this area, protection of private lands should especially target areas that are key for maintaining landscape intactness along the elevational gradients of the Chocolate Mountains, thereby also protecting watersheds and downslope ground water basins, or those within habitat of sensitive species. For example, lands along the low elevation western slopes of the Chocolate Mountains provide south-north habitat connectivity for flat-tailed horned lizards. Increased protection of these lands will also reduce access points for OHV trespass onto military lands. Many private lands within this landscape unit are also at increased risk of conversion for energy production, and thus merit additional protection. These include gentle terrain within the Milpitas Wash area (for solar energy production), upper Milpitas Wash (for wind energy production), and the western low slopes of the Chocolate Mountains (for geothermal energy production). The location of these lands adjacent to a large military installment in the Chocolate Mountains and the potential for conflicts with military training, make them ideal candidates for DOD land buffering programs, possibly as part of the DOD's Readiness and Environmental Protection Initiative (REPI), which would also help to address the conservation needs in this landscape unit.

Public lands in this landscape unit also need increased protection from land use practices and potential conversion. Public lands at increased risk of conversion for renewable energy production include areas southwest of the Chuckwalla Mountains and on either side of the Algodones Dunes (for solar energy development), portions of the Chuckwalla and Chocolate mountains (for wind power generation), and the western slopes of the Chocolate Mountains and both sides of the Algodones Dunes (for geothermal energy production; Figure 5-2). These areas should be targeted for increased conservation to protect existing conservation investments within this unit, and to enhance its integrity and conservation value. For example, the Chuckwalla and Orocopia mountains represent a core of important protected lands within this unit (Figure 4-1), but their integrity, connectivity to other areas, and overall conservation value are compromised by nearby threats of land conversion, habitat fragmentation, and various land uses. Enhanced conservation efforts in this area should build on these existing investments, and proposed energy developments should be sited in adjacent Category C and D lands to maintain the integrity of this landscape unit.

Inappropriate recreational OHV use presents a significant threat to natural resources in this landscape unit, in particular to important desert dry wash woodlands and sand dune habitats. Protection of desert dry wash woodlands and their many inhabitants, such as desert tortoises, should be increased by controlling cross-country OHV travel, restricting OHV use to appropriate areas, evaluating routes for possible closure, increasing restoration of damaged lands, and by increasing enforcement resources. Existing protection of the Algodones Dunes should, at the very least, be maintained to protect this sensitive natural community and species such as the Peirson's milk-vetch that rely on it. Expansion of closed areas (or establishment of additional closed areas) would benefit the natural eolian processes crucial to this ecosystem, it would more effectively protect sensitive dune species, and it would provide this ecosystem added resilience to climate change. Whether closed areas are expanded or simply maintained, enforcement and educational programs should be increased to avoid OHV trespass into closed areas.

Protection of resources within DOD lands in the Chocolate Mountains should be targeted to meet conservation objectives for Category A and B lands. Conservation actions on DOD lands should include protection of conservation targets (native vegetation communities and special desert elements), focusing on both rare targets as well as representation of all targets, and provide protection for sensitive species and natural landscape processes. Increased protection of lands outside of current DOD lands would also likely benefit DOD environmental goals, by buffering DOD lands from conversion and other land uses, and providing connectivity to protected lands.

Integrity of this area is threatened by presence of multiple dirt roads, the Coachella Canal, railroad tracks, energy lines (with associated service routes), and, at the south end, the presence of State Highway 78 and Interstate 8. Landscape integrity should be maintained and restored by reducing unnecessary dirt roads, such as in the Milpitas Wash area, and by promoting wildlife permeability across roads, canals, and railroad tracks, particularly between the Orocopia and Chocolate mountains and between the Orocopia and Chuckwalla mountains. To maintain connectivity to other landscapes, connectivity should also be promoted across Interstate 10 to the north, as discussed for Landscape Unit 2, and across Highway 78, to connect to Landscape Unit 6.

Landscape Unit 6

Landscape Unit 6 is found at the southeastern corner of California's Sonoran Desert. It is bound on the east by the Colorado River, on the south by Interstate 8 and the city of Yuma, Arizona, and on the west by Category C lands along State Highway 78 and State Route 34. This landscape includes the southeastern tip of the Chocolate Mountains and the Cargo Muchacho Mountains, extensive wash habitats such as Vinagre Wash, and miles of river edge habitats. The area supports desert dry wash woodlands, rare saguaros, pupfish ponds, flat-tailed horned lizards, desert tortoises, bighorn sheep, and multiple significant cultural sites. It also supports important riparian habitats along the Colorado River that provide diverse wildlife habitat and recreational opportunities.

Most of this landscape unit is administered by the BLM, with some scattered inholdings of private land and State Lands Commission parcels. Extensive Tribal lands and some private lands are located outside of Yuma. The USFWS and CDPR both administer lands along the river's edge. Protected lands in this landscape unit include Federally designated Indian Pass, Picacho Peak, and Little Picacho wilderness areas, as well as one small ACEC (Indian Pass ACEC). Two national wildlife refuges, Cibola and Imperial National Wildlife Refuges (NWRs), provide additional protection for habitats and wildlife along the River. Both NWRs extend into Arizona, thereby protecting river-side and water-related wildlife habitats on both side of the Colorado River. Protection of habitats along the river is guided by the Lower Colorado River Multi-Species Conservation Program (Lower Colorado River Multi-Species Conservation Plan 2004).

Conservation strategies for this landscape should focus on increasing protection of BLM lands from conversion and fragmentation. Gentle terrain, such as near Vinagre Wash and upper Picacho Wash, are at risk of solar energy development while the southwest corner of this landscape, in the Cargo Muchacho Mountains, is at risk of wind energy; these development projects should be sited in adjacent Category C and D lands. Increased protection of these lands will protect desert dry wash woodlands, saguaros, pupfish ponds, flat-tailed horned lizards, and bighorn sheep, as well as protecting watershed and ground water basins near Yuma. Increased enforcement of OHV regulations should accompany restoration of closed dirt roads (as feasible), primarily in the southwestern portion of the unit, to protect natural resources (e.g., flat-tailed horned lizards) and maintain intactness of this landscape. Invasive plant removal programs, such as tamarisk removal, and riparian habitat restoration along the Colorado River, should be expanded to protect unique riverside habitats. Finally, the impacts of burro grazing (such as potential impact on riparian habitats and saguaros) should be reduced by increasing patrols aimed at reducing trespass out of management areas, removing burros from inappropriate areas, and enforcing BLM burro population target goals.

As traffic on State Highway 78 increases, this landscape will be at increased risk of isolation from other intact landscapes. Connectivity planning should therefore be undertaken to develop the most effective means of maintaining landscape connectivity to areas to the west (in Landscape Unit 5) so that species such as desert tortoise, bighorn sheep, and flat-tailed horned lizards can move between the two landscape units (also see recommendations for Category C lands). Inholdings in the northern portion of this landscape unit, in and near Vinagre Wash, should be targeted for increased protection. In addition, Tribal lands in the southern portion of the unit should be managed to meet conservation objectives for Category A and B lands, including protection of landscape integrity, conservation targets, and natural landscape processes.

Category C Lands

Category C lands include approximately 14 percent of our study area, and represent open space that is fragmented by roads, sparse rural residential communities, or other human uses. They nonetheless contain important conservation targets, provide potential habitat linkages, or provide a buffer between Category D lands and the Landscape Units discussed above. For example, to the west of the Imperial Valley, Category C lands support playas and extensive sand dune habitats. Here and to the east of the Imperial Valley, they support flat-tailed horned lizard habitat, including FTHL management areas. Although Category C lands do not represent a large percentage of our study area, their management for conservation is important for numerous resources. To achieve conservation objectives for this land category we recommend the following:

- Promote protection of sensitive species and isolated sensitive native ecosystems (e.g., pupfish habitat).
- Eliminate or control non-native invasive plants to prevent encroachment into priority landscape units (see also Section 6.3.1).
- Implement water conservation programs to contribute to the State's goal of reducing use of Colorado River water, and to reduce overdraft of local groundwater basins (see also Section 6.3.1).

- Plan future renewable energy production and transport facilities such that they:
  - do not threaten sensitive plants or animals.
  - do not threaten sensitive habitats (e.g., playas, sand dunes, pupfish ponds). Ideally, they should be sited on previously disturbed lands.
  - do not disrupt wildlife habitat permeability.
  - do not create an additional strain on the desert's limited water supply. This will rely on choice of technologies and site location (e.g., a net water saving may be realized if solar facilities are placed in retired agricultural lands versus pristine desert areas).
  - are sited near energy use areas, thereby reducing the need for transport facilities. For this reason, renewable energy sources should ideally be located in or near urban centers in Category D lands.
- Promote connectivity among Landscape Units (Category A and B lands) by managing Category C lands to promote wildlife permeability and, as feasible, natural processes such as water flows and sand transport:
  - Conduct a habitat connectivity assessment to determine where important linkages may exist (e.g., for desert tortoises, flat-tailed horned lizards, bighorn sheep), and where future road improvements may protect and/or re-establish habitat connectivity.
- Increase enforcement of existing land use regulations, especially those beneficial to desert conservation efforts in adjacent landscape units (e.g., enforcement of OHV use regulations).
- Improve facilities and rider experience at designated OHV use areas, to help reduce trespass into closed areas.

Category D Lands

Category D lands include approximately 14 percent of our study area, and represent areas dominated by urban communities and agriculture. They may, nonetheless, contain specific conservation targets or provide habitat for some wildlife species, and their management for conservation can significantly benefit natural lands and biodiversity of the Sonoran Desert in California, and the quality of life of its residents and visitors. A key example is the Salton Sea and adjacent agricultural lands, which provide a critical and unparalleled natural resource for migratory birds, particularly in light of the loss of wetland habitats in other parts of California and northern Mexico (Section 4.1.3. and Appendix B). To achieve conservation objectives for this land category we recommend the following:

- Manage and/or restore agricultural lands to benefit native species.
  - In collaboration with Salton Sea restoration efforts (Section 4.1.3), promote a collaborative effort to protect, enhance, and restore habitat for migratory and resident birds of the Salton Sea (see also Section 6.3.2). This will require close

collaboration with, and support of, private land owners, farmers, and ranchers, and must be coordinated with mitigation projects for water conservation and transfer activities being conducted by the Imperial Irrigation District.

- Implement water conservation programs to contribute to the State's goal of reducing use of Colorado River water, and to reduce overdraft of local groundwater basins (see also Section 6.3.1).
- Protect open spaces such as parks, greenbelts, and riparian areas that support wildlife.
- Eliminate or control non-native invasive plants (see also Section 6.3.1).
- Promote strong enforcement of air and water quality regulations, as well as regulations to reduce nitrogen deposition (see also Section 6.3.1).
- Encourage energy conservation and use of local generation of renewable power (e.g., rooftop solar). Promote local generation of renewable energy in land planning and development requirements.
- For commercial renewable energy production, emphasize Category D lands as the recommended location. Plan future facilities such that they:
  - do not threaten sensitive plants or animals
  - do not threaten sensitive habitats (e.g., pupfish ponds).
  - do not create an additional strain on the desert's limited water supply. This will rely on choice of technologies and site location (e.g., a net water saving may be realized if solar facilities are placed in retired agricultural lands).
- Promote programs that reduce indirect impacts on adjacent wildlands (e.g., programs that address night lighting, use of pesticides, roaming pets, planting of invasive plant species).

Maintaining Landscape Connectivity

As discussed in section 3.3.1 and 5.2, maintenance of landscape integrity is key to effectively conserving the Sonoran Desert landscape by maintaining connectivity among communities and habitats, preserving the functionality of ecosystem processes and the long-term viability of wildlife populations, maintaining resilience to global climate change, reducing the potential for exotic species invasions, and protecting air and water quality. Maintaining and restoring landscape integrity at multiple scales is an overarching conservation objective for the Sonoran Desert of California. In this report we have stressed the maintenance of integrity within and among the priority landscape units in the California Sonoran Desert. Equally important is maintenance of connectivity between the California Sonoran Desert and adjacent regions. This includes connectivity to the South Coast ecoregion, the Mojave ecoregion, and to Mexico.

Maintaining connectivity to Mexico is key to providing habitat for wide-ranging species, for supporting high diversity and integrity of ecological communities in the face of climate change, and for protecting binational watersheds. The Las Californias Binational Conservation Intiative has established a vision for binational connectivity across the Peninsular Ranges, referred to as the Parque-to-Park Binational Corridor, that seeks to link protected lands in the U.S. (e.g., Anza Borrego Desert State Park and BLM protected areas) to those in northern Baja California, Mexico (e.g., Parque Constitucion de 1857). Given the presence of extensive protected areas in the U.S. and Mexico adjacent to the Las Californias Binational Conservation Initiatve study area (Appendix A, Figure A-1), tremendous opportunities exist to expand the Parque-to-Park Binational Corridor eastward to create a globally significant binational conservation landscape with the potential to link three major ecological regions (Sonoran Desert, Mojave Desert, and South Coast ecoregion). This concept is discussed further in Appendix A.

Protection of habitats in the Sonoran Desert of California also contributes to landscape connectivity at far larger scales. Protection of the Salton Sea and neighboring agricultural lands and the Colorado River corridor provides crucial foraging and resting areas for migratory birds along the Pacific Flyway (Appendix B). Many migratory species of bats also rely on flowering plants in the Sonoran Desert on their migrations. Without conservation of these Sonoran Desert resources, a significant global migration pattern could be significantly impacted. Similarly, the Colorado River is a crucial source of freshwater, sediment and nutrients to the northern Gulf of California and its delta, and protecting the conservation functions of this river system is key to conserving the biodiversity of the entire Gulf of California ecosystem.

6.3. Implementing the Vision

Implementing this vision for the Sonoran Desert of California and realizing the above conservation opportunities will require overcoming a variety of obstacles, such as those discussed in Section 4.2. However, as we have stressed throughout this report, a crucial objective for the California Sonoran Desert is to protect the expanses of high integrity lands that support resources unique to this region. Highly significant investments have been, and are continuing to be, made in the California Sonoran. These investments, and ultimately the long-term sustainability of the entire California Sonoran ecosystem, must be protected via a number of general strategies. First and foremost, more attention and resources should be dedicated to protecting this incredibly special place. However, resources will always be limiting, so we need to increase the efficiency of our conservation actions through coordination and collaborations that can most effectively conserve the large intact landscapes that the Sonoran currently supports. Finally, we must seek to reduce the existing threats to this landscape today, as they will only become worse and more costly to address in the future, by acquiring strategic inholdings, improving enforcement of existing regulations and land uses, and minimizing fragmentation of intact areas by future development projects. Securing and protecting the existing integrity of the California Sonoran Desert is the most effective conservation strategy available to land managers.

6.3.1. Protecting and Building on Existing Investments

Every year, multiple agencies with land use authority in California's Sonoran Desert invest extensive resources in the protection, management, and restoration of the extensive system of public lands, based on their long-standing recognition of the region's incredible natural resources; a commitment reinforced by the designation of the CDCA. Continued and enhanced protection of existing public lands in the California Sonoran Desert is crucial, especially as we continue to learn more about their importance to biodiversity protection and the potential adverse consequence of global climate change and numerous other threats present in the region. Our assessment has identified many areas critical to the long-term maintenance of regional conservation values. Many of these areas, already in public ownership, need enhanced protection to maintain their conservation value, which can only be achieved by strategically investing more resources, increasing the efficiency of conservation resource expenditures, and eliminating key threat factors..

It will also be necessary to build on these existing investments, to maintain the landscape processes that tie the desert's species and communities together. For example, maintaining landscape integrity is necessary for the long-term viability of desert ecosystems. Existing conservation investments in the desert have often focused on mountainous terrain and much of its low elevation gentle terrain remains unprotected, leaving many protected areas isolated as "islands" (Davis et al. 1998). It is well accepted that smaller isolated reserves are not as effective at maintaining biodiversity as a larger network of connected reserves, and landscape connectivity has become increasingly important as we look to a future altered by global climate change. Linking together existing isolated or small protected areas with increased land protection and/or improved management will ensure that these existing investments remain viable in the future. Designation of the California Desert Conservation Area by Congress in 1976 provides a legislative context for such a vision.

6.3.2. Promoting Collaborative Conservation

Given the increased pressures threatening the Sonoran Desert of California in the face of limited resources, there is a need to increase the efficiency of existing efforts. Collaborative conservation efforts are one means of accomplishing this. Conservation collaborations may also be a powerful way to bring new resources to the California Sonoran Desert.

Although the many agencies and organization working in California's Sonoran Desert have diverse mandates and management goals (Section 4.2.1, Appendix E), natural resources protection and management is a common denominator in many of their missions and mandates. The protection of natural communities, native species, and biodiversity is an element of nearly all of the missions and management plans of public agencies in the Sonoran Desert of California, and can provide a common thread for bringing together future conservation collaborations. The rational for protecting natural resources may be diverse (e.g., the DOD wishing to buffer military lands and the BLM wishing to maintain or reestablish habitat connectivity for native species), but collaboration will increase the likelihood of all agencies successfully achieving their missions. The most effective conservation efforts in the Sonoran Desert in California may be collaborative because of the vastness of the landscape, the multitude of land managers, and the scale of many of the management issues and conservation challenges. We encourage agencies, organizations, and individuals to initiate or continue dialog about their specific needs, shared goals, and mutually beneficial opportunities. We offer the following recommendations:

- Continue and expand activities of the Desert Managers Group as a means of increasing cooperative management among agencies. Reactivate inactive working groups (currently over half of the 13 working groups are inactive) or consider creation of new working groups (e.g., working groups to address climate change, watershed and ground water basin conservation, or habitat connectivity).

- Promote a regional approach for conservation of California's desert by pursuing a collaborative effort to retain the CDCA in the National Landscape Conservation System[2] (NLCS; Section 1.1).
- Encourage partnerships between public land managers and conservation organizations working in the region to acquire fee title or conservation easements on key inholdings and buffers zones. If needed, consider formation of a land trust such as the Anza-Borrego Foundation (which focuses its efforts on inholdings within Anza-Borrego Desert State Park), to acquire and protect the multiple small inholdings, many owned by the State Lands Commission, that are scattered throughout Category A and B lands.
- Develop and promote collaborative relationships with private land owners to maximize the conservation value of private lands. This may include restoration of lands that will benefit adjacent public lands (e.g., exotic plant removal) or land management actions to maintain wildlife permeability across private lands.
- Develop and promote collaborations between the DOD, other Federal and State agencies, and conservation groups, to encourage military land buffering as a means of protecting both military training missions and natural resources. Programs such as REPI (Appendix E) are designed to ensure the military's ability to continue military training on its land in the face of potential encroachment of non-compatible land uses that may adversely impact DOD training missions. Such initiatives can represent valuable tools for conservation of natural resources.
- Develop collaborative programs for long-term sustainability of groundwater basins. This will require joint efforts of agencies, Tribes, private land owners, and all water-users (e.g., residential, industrial, resort, and all agriculture). Communities and their respective water districts should work closely with the State Water Resources Control Board to develop long-term sustainable water use plans that protect local groundwater basins, while helping to reduce California's use of Colorado River water (Section 5.3.3). Because the entire desert faces the challenge of limited water availability and California must, as a whole, reduce its use of Colorado River water, stringent conservation of local sources (watershed and groundwater sources) should form the basis of these plans. For example, in the Borrego Valley, where groundwater overdraft is a serious concern for the community of Borrego Springs, as well as nearby natural communities (e.g., mesquite bosques), an overall reduction in groundwater use, via water conservation, must be realized.
- Establish collaborative programs to maintain and restore watershed health.

[2] Although the CDCA has been included in the NLCS since its inception in 2000, it is unclear whether the NLCS Act, currently under review, will include the CDCA. The act, which would authorize the system under Federal law, was introduced in 2007, approved by the House of Representatives in 2008, and is currently under Senate review.

Management and restoration to reduce water diversion and pollution will depend greatly on collaboration between Federal and State (e.g., Watershed Protection division of the CRWQCB - Colorado River Basin Region) agencies, Native American Tribes, and private land owners. Promote status and protection of selected rivers by proposing Wild and Scenic River status, under the National Wild and Scenic Rivers Act (16 U.S. C. 1271-1287, Public Law 90-542, as amended).

- Look for opportunities to utilize and build on existing regional conservation programs such as the Lower Colorado River Multi-Species Conservation Program, mitigation programs for the Imperial Irrigation District's water transfers to the San Diego County Water Authority, and ultimately the San Diego East County Multiple Species Conservation Plan, the Coachella Valley Multiple Species HCP, and the Agua Caliente Tribal HCP, to strategically conserve key resource areas.
- Establish and continue collaborative programs to control non-native invasive plants. Collaborations such as the establishment of the Low Desert Weed Management Area, initiated by the Desert Managers Group, should be promoted and expanded. Coordination with others such as the California Invasive Plant Council will benefit this effort. Plan for localized or widespread surges in non-native invasive plants in response to increasing atmospheric carbon dioxide (as a result of climate change) or nitrogen deposition (currently the greatest concern is in areas near the Coachella Valley). Coordinate with efforts of the Lower Colorado River Multi-Species Conservation Program to remove invasive plants and restore riparian habitats along the Colorado River.
- Consider establishing a collaborative program to restore and enhance habitat for migratory birds in the agricultural areas of the Imperial Valley near the Salton Sea. The Central Valley Joint Venture plan to conserve bird habitat (Central Valley Joint Venture 2006), a highly collaborative effort which includes private landowners and farmers, may serve as a model. Ideally, planning should begin as soon as possible, in the event this effort could benefit from (or provide benefits to) Salton Sea restoration efforts.
- Establish and continue collaborative efforts to maintain landscape connectivity. Work with partners in the U.S. and Mexico to promote connectivity to other ecoregions and other portions of the Sonoran Desert (Section 6.2.2, Appendix A). Conduct a landscape connectivity analysis to identify key linkage areas between landscape units within California's Sonoran Desert. Identification of these areas will provide guidance on where construction of crossing structures and land management activities are most likely to increase wildlife permeability and landscape integrity.
- Promote transportation and land management measures that reduce nitrogen deposition. These measures, which will be most effective if pursued in collaboration with jurisdictions outside of this region, such as in the Los Angeles basin, may include:
    - Automobile regulations to reduce vehicle emissions.
    - Public mass transportation options to reduce vehicle use.

- Agricultural and landscape protocols that reduce or limit the use of nitrogen-based fertilizers.

The above efforts will require increased coordination and specific allocation of funds. Reaffirming a commitment to the working groups of the Desert Managers Group may facilitate some of these efforts, and should be pursued as a means of increasing communication and sharing information. Joint management planning will be needed, ideally within an established framework to ensure long-term follow-through. Ideally all agencies would contribute funding, or joint fund-raising efforts could be undertaken.

In addition, a shared commitment to protection of the Sonoran Desert in California can result in a shared position regarding policy, such as policies related to water conservation, land use practices, or land designations.

6.3.3. Conclusion

With this framework, our intent is to promote an ecoregional vision for conservation management of the Sonoran Desert in California, and we suggest that this vision includes an important role for everyone who cares for this desert. We recognize that management challenges exist, but hope that a shared vision for the long-term sustainability of this important desert ecosystem will motivate us to find our way past these obstacles. Our hope is that our recommendations can be used by multiple partners as a framework to build on their individual efforts and achievements for improved protection and management of California’s Sonoran Desert. Our recommendations stress improving the efficiency of our conservation actions by conserving the high integrity of this vast landscape, an approach that will be key in today’s world of limited budgets and resources. We identified six large landscapes units whose protection is critical to maintaining the conservation values of the Sonoran Desert in California. Long-term protection of these landscape units will rely on enhanced conservation of existing public lands, and enhanced protection and management of lands outside of the existing protected areas network.

Although much of our conservation vision was focused on the six large landscape units, we stress that effective protection of California’s Sonoran Desert must involve improved management of all lands within this region. All lands, including those classified as Category C and D, can and should be managed in a way that benefits the long-term viability of the desert. In fact, much of the long-term viability of the desert, its ecosystems, and its species, depends on decisions made in relation to management of Category C and D lands.

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8. APPENDICES

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Appendix A
The Role of the California Sonoran Desert in Conserving Transboundary Connectivity

The importance of maintaining landscape connectivity within the Sonoran Desert of California has been emphasized by this report, but much of the conservation value of this region also lies in maintaining its connectivity to other ecological regions and portions of the Sonoran Desert outside of California. The California Sonoran is a biogeographic cornerstone of a massive landscape critical to conservation of a diverse and highly unique portion of the planet. The Sonoran Desert is the link between two of the World's eight major ecozones – the Nearctic and Neotropic. The California Sonoran sits at the juncture of the South Coast ecoregion of the cismontane California Floristic Province and the trans-montane North American desert, and is contiguous with the Mojave Desert (Figure A-1). As a result, the Sonoran Desert of California supports a number of endemic taxa, including a large number of relict plant species reflecting its evolutionary legacies, but it also shares biotic elements of the bioregions surrounding it. It is a subtropical transition zone to tropical regions to the south, supports a variety of imperiled species such as Peninsular bighorn sheep, and is part of a major corridor for migratory birds and bats.

The Sonoran is also a bridge between two geopolitical landscapes in the United States and Republic of Mexico, and is a focus of conservation efforts in both countries. The international boundary between the two countries not only divides an ecologically rich region, it divides the region into distinct political, legal, and socioeconomic characteristics that complicate transboundary conservation efforts. Recently, the U.S.-Mexico border has been a focus of U.S. Homeland Security efforts to reduce illegal border crossings, including Congressionally-mandated enhancements of the border fence to reduce illegal border crossings. The proposed fence enhancements threaten to physically sever habitats that straddle the border and block species movement between habitats on both sides of the border. However, binational collaboration on resource protection and management continues, and is critical to the long-term sustainability of many border ecosystems. For example, the binational International Boundary and Water Commission (IBWC) oversees implementation of U.S.-Mexico treaties concerning allocation of Lower Colorado River water, with direct implications on the health of resources along the Colorado River and in the Delta and northern Gulf of California. Moreover, numerous non-governmental conservation organizations from both countries are working on natural resource conservation issues. Wide-ranging species such as Sonoran pronghorn, jaguar, California condor, and bighorn sheep historically used habitats that spanned the international boundary and freely moved across the border region. Conservation of these and other species depends on binational cooperation to conserve habitats on both sides of the border and maintain viable transboundary connectivity between them.

The transboundary region around California's Sonoran Desert presents a rare opportunity to create a binational conservation landscape of a globally significant scale. Extensive protected areas are well distributed through the northwestern Sonoran ecoregion (Figure A-1). For example, in Sonora, Mexico, the Alto Golfo y Delta del Rio Colorado Biosphere Reserve and El Pinacate y Gran Desierto de Altar Biosphere Reserve are contiguous with Cabeza Prieta National Wildlife Refuge and Organ Pipe National Monument in southern Arizona, which are in turn connected to a number of other protected areas by extensive U.S. federal lands in Arizona and

California. In California, Anza-Borrego Desert State Park, the Santa Rosa and San Jacinto Mountains National Monument, and Joshua Tree National Park, part of a designated UNESCO Biosphere Reserve, protect significant lands along the western and northern margins of the Sonoran Desert, and these parks are connected to a number of other protected areas within the Congressionally-designated California Desert Conservation Area. These conserved areas are contiguous with public lands in the adjacent South Coast and Mojave Desert ecoregions. Thus, these existing conservation investments provide significant connectivity between California's Sonoran Desert and adjacent protected areas in Arizona's Sonoran Desert, the South Coast and Mojave ecoregions, and the Sonoran Desert, Colorado River Delta, and Northern Gulf of California in Mexico. However, the conserved lands in the California Sonoran and adjacent areas are a foundation for a much more extensive transboundary protected areas network within the northwestern Sonoran ecoregion that complements these existing conservation investments.

Las Californias Binational Conservation Initiative, developed and implemented by Conservation Biology Institute (CBI), The Nature Conservancy (TNC), Pronatura, and Terra Peninsular, is a vision for binational conservation in the California—Baja California border region. Las Californias Initiative has proposed a conservation corridor connecting Parque Nacional Constitución de 1857 in the Sierra Juárez of Baja California to state and federal protected areas in San Diego and Imperial counties, such as Anza-Borrego Desert State Park. This transboundary conservation corridor, referred to as the Parque-to-Park Binational Corridor, lies along the western border of the Sonoran ecoregion, and is intended to conserve a landscape that provides habitat for wide-ranging species such as bighorn sheep, mountain lions, and California condors, supports high diversity and integrity of ecological communities that will allow species to adjust their ranges in response to climate change, protects forests and headwater watershed basins that support critical ecological services such as water supply and carbon sequestration, and protects rural lifestyles of families that have lived in the region for generations. Terra Peninsular has recently obtained a conservation lease for a large ranch north of Parque Nacional Constitucion de 1857, and TNC purchased a property at the southern end of Anza-Borrego Desert State Park, near the U.S.-Mexico border, that will be transferred to the California Department of Parks and Recreation. These actions are the first steps in securing the Parque-to-Park Binational Corridor. TNC, CBI, and Terra Peninsular are actively investigating land tenure in the region and working on designing and securing the remainder of the Corridor.

Securing conservation areas and connectivity between California's Sonoran Desert and northeastern Baja California is important for a variety of wide-ranging species. For example, bighorn sheep in the U.S. Peninsular Ranges are not currently known to cross the U.S.-Mexico border, yet moved through this area historically. Reestablishing connectivity of bighorn sheep populations in California and Baja California is a long-term goal of the U.S. Fish and Wildlife Service's recovery plan for bighorn sheep in the Peninsular Ranges. Although the current status of bighorn sheep in northeastern Baja California is uncertain, they were detected in the Sierra Cucapá and the Sierra Juárez as recently as the 1990s, and these ranges may continue to provide viable habitat for bighorn if connectivity to the Sierra Juárez can be maintained.

California's Sonoran Desert can play an important role in anchoring the conservation areas in this western Sonoran landscape. The ongoing Parque-to-Park Binational Corridor effort will ultimately create a conservation connection between protected areas in the western portion of the

California Sonoran and Parque Nacional Constitucion de 1857 in the high country of the Sierra Juárez. As Parque Nacional Constitucion de 1857 lies west of the Alto Golfo y Delta del Rio Colorado Biosphere Reserve (Figure A-1), a more significant conservation area connecting the Sonoran portion of the UNESCO Mojave and Colorado Deserts Biosphere Reserve, through BLM Wilderness Areas, to the Alto Golfo y Delta del Rio Colorado Biosphere Reserve and Parque Nacional Constitucion de 1857 can be created by expanding this proposed conservation corridor to the east, to encompass the eastern escarpment and bajadas of the Sierra Juárez, the Laguna Salada basin, and the Sierra Cucapá and Sierra el Mayor ranges.

Furthermore, south of Parque Nacional Constitución de 1857 is a vast, contiguous, high integrity montane landscape extending to Parque Nacional San Pedro Martir. The eastern escarpment of these mountain ranges, which are the extension of the California Peninsular Ranges into Baja California, is the southwestern extension of the Sonoran Desert along the western side of the Sea of Cortez ultimately reaching the northern boundary of the enormous Valle de los Cirios National Protected Area in Mexico (Figure A-1). Thus, the existing conservation investments in Mexico and the U.S., and the ongoing binational conservation efforts in the region, have established a solid framework to forge a transboundary protected areas network that could encompass millions of acres of a dramatic and functional landscape along the entire northwestern Sonoran Desert region and adjacent portions of the South Coast and Mojave Desert ecoregions. Establishing conserved connectivity between California's Sonoran Desert and the existing protected areas in northeastern Baja California would be a natural first step in realizing the vision of a protected areas network extending south to the Parque Nacional San Pedro Martir and, ultimately, to the Valle de los Cirios Natural Protected Area.

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Appendix B
Methods for Developing a Framework for Conservation Management

Approach Overview

The goal of this project was to identify and describe conservation opportunities in the Sonoran Desert of California. To accomplish this, we first described conservation values of the study area (Section 3), summarized existing conservation and management activities (Section 4), and described conservation threats and challenges (Section 5).

To guide our identification of conservation opportunities, we selected multiple conservation targets and used these, in concert with an evaluation of landscape intactness and the use of reserve design software Marxan (Ball and Possingham 2000, Possingham et al. 2000) to divide the study area into four broad categories based on landscape integrity and conservation value. Within these land categories, opportunities were identified by examining existing conservation efforts in relation to threats and challenges, and possible options for alleviating these threats and challenges.

Our assessments were also informed by review of pertinent literature, reports, and maps regarding the conservation, management, and ecology of the Sonoran Desert, in particular its California extent. We also met with numerous individuals, organizations, and agencies involved in management and conservation of the region (Table B-1) to obtain their input on conservation priorities and threats, management challenges, selection of targets, data availability, as well as existing and planned management protocols.

Table B-1. Organizations and agencies contacted for input

Anza-Borrego Foundation and Institute
Bureau of Land Management (El Centro, Palm Springs/South Coast, and Needles)
California Department of Fish and Game (South Coast and Inland Desert regions)
California Department of Parks and Recreation (Colorado Desert District)
Coachella Valley Mountains Conservancy
Department of Defense (MCI West Governmental and External Affairs, USMC Western Regional Environmental Office)
Desert Managers Group
Desert Protective Council
Joshua Tree National Park
Mojave Desert Land Trust
Native American Lands Conservancy
Regional Water Quality Control Board
Resources Law Group
San Diego County Water Authority
U.S. Fish and Wildlife Service (Carlsbad Field Office)
U.S. Forest Service (San Bernardino and Cleveland National Forests)
U.S. National Wildlife Refuge (Cibola and Imperial)
University of California (Boyd Deep Canyon Desert Research Center)

Delineating and Describing the Study Area

For the purpose of this framework, we adopted the Sonoran Desert ecoregion boundary described by W. L. Jepson (Baldwin et al. 2002). In California, the Sonoran Desert is bounded to the north by the Mojave Desert and to the west by the higher elevations of the Peninsular Ranges. Although we based our study on Jepson's ecoregion boundaries, we also considered the area including watersheds that run into the Sonoran Desert, recognizing that influences from outside the ecoregion, such as waterflow, can impact the health of this ecoregion (Figure 2-1). For selected assessments of connectivity to areas outside of our study area, we further extended our assessment to include protected areas north and west of our study area (e.g., Joshua Tree National Park and Forest Service lands to the west) and into the northeastern portions of Baja California (Appendix A). We assembled existing digital maps to examine the biological resources, existing management and conservation status, and potential threats (Table B-2).

Table B-2. Digital data sources[1]

Data Type	Source	Type	Scale	Date
Ecoregion	1. Viers et al. 2006	vector	unknown	2006
Digital Elevation Model – California	1. ESRI® Data & Maps, http://www.esri.com	raster	1000 m	1996
Digital Elevation Model – California	1. USGS, http://seamless.usgs.gov/	raster	30 m	1999
Digital Elevation Model – Mexico	1. SRTM http://www2.jpl.nasa.gov/srtm/	raster	90 m	2006
Satellite imagery	1. ESRI, ArcGIS Online I3_Imagery_Prime_World_2D, http://www.esri.com/software/arcgis/arcgisonline/index.html	raster	1 m	various
Ownership	Public Conservation and Trust Lands, PCTL_05, http://gis.ca.gov/catalog/BrowseRecord.epl?id=31122	vector	1:100,000	2007
Hydrology - California	1. NHD, http://nhd.usgs.gov/ 2. ESRI® Data & Maps, http://www.esri.com	vector vector	1:100,000 1:200,000	2005 2002
Hydrology - Mexico	1. ESRI® Data & Maps, http://www.esri.com	vector	1:200,000	2002
Federal Protected Areas and Management Categories	1. BLM's WEMO, NECO, and NEMO plans, http://www.blm.gov/ca/gis/ 2. USFS, http://www.fs.fed.us/r5/rsl/clearinghouse/gis-download.shtml	vector vector	various various	various various
State Protected Areas and Management Categories	1. California Department of Fish and Game, http://www/dfg/ca/gov/biogeodata/gis/clearinghouse.asp	vector	1:24,000	2008

[1] See Appendix D for scientific names of species, and Appendix F for acronyms used in this report.

GAP ratings – California	1. The California Gap Analysis Project (GAP), http://www.biogeog.ucsb.edu/projects/gap/gap_home.html	vector	1:100,000	1999
Land use	1. Existing vegetation data (eVeg), http://fs.fed.us/r5/rsl/projects/mapping/accuracy.shtml 2. Farmland Mapping and Monitoring Program (FMMP), http://redirect conservation.ca.gov/DLRP/fmmp/product_page.asp 3. Multi-Resolution Land Characteristics Consortium (MRLC), http://www.mrlc.gov/ 4. GAP, http://www.biogeog.ucsb.edu/projects/gap/gap_home.html	vector vector raster vector	various 1:24,000 90 m 1:100,000	1997 2004 2001 1999
Roads – California	1. TIGER, http://www.esri.com/data/download/census2000_tigerline/index.html 2. ESRI® Data & Maps, http://www.esri.com	vector vector	1:100,000 1:200,000	2000 2002
Roads – Mexico	1. ESRI® Data & Maps, http://www.esri.com	vector	1:200,000	2002
Vegetation: Anza-Borrego Desert State Park	1. Anza-Borrego Desert State Park (ABDSP)	vector	1:24,000	1998
Vegetation: California	1. GAP, http://www.biogeog.ucsb.edu/projects/gap/gap_home.html	vector	1:100,000	1999
Ciénagas	1. CNDDB, http://www.dfg.ca.gov/biogeodata/cnddb/	vector	various	2008
Pupfish habitat	1. CNDDB, http://www.dfg.ca.gov/biogeodata/cnddb/	vector	various	2008
Dunes	1. CNDDB, http://www.dfg.ca.gov/biogeodata/cnddb/ 2. GAP, http://www.biogeog.ucsb.edu/projects/gap/gap_home.html	vector vector	various 1:100,000	2008 1999
Palm Oases	1. CNDDB, http://www.dfg.ca.gov/biogeodata/cnddb/ 2. ABDSP 3. eVeg, http://fs.fed.us/r5/rsl/projects/mapping/accuracy.shtml	vector vector vector	various 1:24,000 various	2008 1998 1997

Mesquite bosques	1. CNDDB, http://www.dfg.ca.gov/biogeodata/cnddb/ 2. ABDSP 3. eVeg, http://fs.fed.us/r5/rsl/projects/mapping/accuracy.shtml 4. GAP, http://www.biogeog.ucsb.edu/projects/gap/gap_home.html	vector vector vector vector	various 1:24,000 various 1:100,000	2008 1998 1997 1999
Playas	1. GAP, http://www.biogeog.ucsb.edu/projects/gap/gap_home.html 2. NHD http://nhd.usgs.gov/ 3. ABDSP	vector vector vector	1:100,000 1:100,000 1:24,000	1999 2005 1998
Saguaros	1. CNDDB, http://www.dfg.ca.gov/biogeodata/cnddb/	vector	various	2008
Water-related habitat	1. NHD, http://nhd.usgs.gov/ 2. CNDDB, http://www.dfg.ca.gov/biogeodata/cnddb/ 3. eVeg, http://fs.fed.us/r5/rsl/projects/mapping/accuracy.shtml 4. ABDSP 5. Multi-source Land Cover Data (fVeg), fttp://frap.fire.ca.gov/data/frap.gisdata/download.asp?rec=fveg02_2 6. GAP, http://www.biogeog.ucsb.edu/projects/gap/gap_home.html	vector vector vector vector raster vector	1:100,000 various various 1:24,000 100 m 1:100,000	2005 2008 1997 1998 2002 1999
Solar Radiation	1. National Renewable Energy Laboratory, http://www.nrel.gov/gis	raster	10 km	2005
Wind Potential	1. U.S. Department of Energy, http://www.eere.energy.gov/windandhydro/windpoweringamerica/maps_template.asp?stateab=ca	vector	200 m	2003
Geothermal potential	1. California Dept. of Conservation, Division of Oil, Gas, and Geothermal Resources, http://www.conservation.ca.gov/dog/geothermal/maps/Pages/index.aspx 2. Idaho National Laboratory, State Geothermal Resource Maps; http://geothermal.inel.gov/maps/index.shtml 3. Sass and Priest 2002	vector vector raster	various various unknown	2002 2003 2002

Livestock Grazing Allotments	1. BLM, http://www.blm.gov/ca/gis/ 2. USFS, http://www.fs.fed.us/r5/rsl/clearinghouse/gis-download.shtml	vector vector	1:100,000 various	2003 2005
Wild Horse and Burro Management Areas	1. BLM, http://www.blm.gov/ca/gis/	vector	1:24,000	2006
Watersheds	1. CALWATER 2.2, http://gis.ca.gov/meta.epl?oid=22175	vector	1:24,000	1999
Groundwater basins	1. California Department of Water Resources, via CaSIL http://gis.ca.gov/meta.epl?oid=278	vector	1:250,000	1994
Flat-tailed horned lizard	1. BLM	vector	unknown	unknown
Desert tortoise	1. USFWS, http://criticalhabitat.fws.gov/	vector	unknown	1994
Bighorn Sheep	1. USFWS, http://criticalhabitat.fws.gov/ 2. California Department of Fish and Game	vector vector	unknown unknown	2006 unknown
Least Bell's Vireo	1. USFWS, http://criticalhabitat.fws.gov/	vector	1:100,000	1994
Triple-ribbed milk-vetch	1. CNDDB, http://www.dfg.ca.gov/biogeodata/cnddb/	vector	various	2008
Peirson's milk-vetch	1. USFWS, http://criticalhabitat.fws.gov/	vector	unknown	2004

Selection of Conservation Targets

We initially selected vegetation communities as our primary conservation targets, assuming that vegetation communities would represent and encompass habitats of numerous individual species, including endemic, threatened, and endangered species. Despite a large human population, the presence of several nearby academic institutions (i.e., University of California, San Diego State University), a large percentage of land under public ownership (i.e., BLM, California State Parks, Department of Defense), and a globally unique and threatened concentration of biodiversity, databases of biological resources in the Sonoran Desert in California were generally incomplete and of low resolution. We used the California Gap Analysis vegetation layer which, although available for the entire study area, did not include a high level of detail and did not delineate a number of localized communities. For this reason, we augmented our list of vegetation community targets with selected special desert elements. These were chosen because they either supported unique habitats and micro-ecosystems (e.g., playas, sand dunes) or were otherwise believed to represent biodiversity not captured in more generalized vegetation communities (e.g., saguaros, pupfish habitat).

We did not select individual species as our targets due to incomplete species mapping across the entire study area, and because the choice of species (e.g., endemic versus threatened or endangered versus indicator species) was not straightforward. Although an ideal approach may have involved an analysis of all species, this would have been impossible because high numbers of species inhabit the study area, and data and our knowledge about most of these species are limited. We assumed that conservation of native vegetation communities and landscape processes such as habitat connectivity will serve as a basis for protecting multiple individual species, recognizing that additional species-specific conservation actions may be warranted.

Vegetation Communities

Using Gap vegetation data, we identified 35 vegetation communities in the study area (Tables B-2 and B-3). These were collapsed to nine categories as candidate conservation targets, with six ultimately selected as vegetation community targets. We chose not to include Non-native Grassland Sonoran Desert Mixed Scrub as a separate conservation target because the one area where this community was found, at the north end of the San Jacinto Mountains, had apparently been type-converted from the original Sonoran Desert Mixed Scrub as a result of altered fire regimes (increased fire frequency) in recent years, facilitating the invasion of non-native grasses. For this reason, and because restoration may be an option for this area, we recoded this area as Sonoran Desert Mixed Scrub for our subsequent analyses. We also combined several of the original 35 vegetation communities with locational data from other sources to delineate special desert elements (Table B-3). The following six vegetation communities were chosen as conservation targets:

- Desert dry wash woodland
- Mojave creosote bush scrub
- Mojavean pinyon and juniper woodland
- Peninsular pinyon and juniper woodland
- Sonoran creosote bush scrub
- Sonoran desert mixed scrub

Special Desert Elements

We chose the following special elements as additional targets, because they represent localized or unique habitats or represent an additional measure of biodiversity not captured in the above vegetation communities (see Section 3 for descriptions):

- Pupfish habitat
- Palm oases
- Mesquite bosques
- Saguaros
- Ephemeral playas (dry lakes)
- Ciénagas (marshes)
- Sand dunes
- Water-related habitats

Although other special elements were deemed important to include in the above list, inadequate spatial data existed for some (e.g., desert pavement, cliffs, caves/mines) while others were considered to be captured in selected targets (e.g., microphyll woodlands were considered to be captured by desert dry wash woodland communities). The target "water-related habitats" was created by merging GIS layers for rivers, ephemeral and perennial streams, with riparian habitats (e.g., Sonoran cottonwood riparian forest, arroyo willow, Fremont cottonwood).

Landscape-scale Ecological Processes

At a landscape scale, we also evaluated the following ecological processes, which represent important functional attributes of this region:

- Watershed integrity and health
- Connectivity
    - Connectivity among protected areas
    - Connectivity across elevational gradients
    - Connectivity to protected areas outside study area
- Eolian Processes and Sand Deposition
- Fire Regimes

Table B-3. Gap vegetation communities in the study area, and combined categories selected as vegetation community conservation targets.

Vegetation Communities present in Study Area	Combined Vegetation Categories
Alkali Playa[1]	
Desert Dry Wash Woodland	Desert Dry Wash Woodland
Desert Dry Wash Woodland Chenopod Scrub	Desert Dry Wash Woodland
Desert Dry Wash Woodland Desert Dunes[2]	Desert Dry Wash Woodland
Desert Dry Wash Woodland Mojave Creosote Bush Scrub	Desert Dry Wash Woodland
Desert Dry Wash Woodland Sonoran Creosote Bush Scrub	Desert Dry Wash Woodland
Desert Dry Wash Woodland Sonoran Desert Mixed Scrub	Desert Dry Wash Woodland
Desert Dunes[2]	
Mojave Creosote Bush Scrub	Mojave Creosote Bush Scrub
Mojave Creosote Bush Scrub degraded	Mojave Creosote Bush Scrub
Mojave Creosote Bush Scrub Mojave Mixed Woody and Succulent Scrub	Mojave Creosote Bush Scrub
Mojave Creosote Bush Scrub Sonoran Desert Mixed Scrub	Mojave Creosote Bush Scrub
Mojavean Pinyon and Juniper Woodland Semi-Desert Chaparral	Mojavean Pinyon and Juniper Woodland
Mojavean Pinyon and Juniper Woodland Sonoran Desert Mixed Scrub	Mojavean Pinyon and Juniper Woodland
Non-Native Grassland Sonoran Desert Mixed Scrub[3]	
Peninsular Pinyon and Juniper Woodland	Peninsular Pinyon and Juniper Woodland
Peninsular Pinyon and Juniper Woodland Semi-Desert Chaparral	Peninsular Pinyon and Juniper Woodland
Peninsular Pinyon and Juniper Woodland Sonoran Cottonwood-willow Riparian Forest[4]	
Peninsular Pinyon and Juniper Woodland Sonoran Desert Mixed	Peninsular Pinyon and Juniper

Scrub	Woodland
Sonoran Creosote Bush Scrub	Sonoran Creosote Bush Scrub
Sonoran Creosote Bush Scrub degraded	Sonoran Creosote Bush Scrub
Sonoran Creosote Bush Scrub Desert Dry Wash Woodland	Sonoran Creosote Bush Scrub
Sonoran Creosote Bush Scrub Desert Dunes[2]	
Sonoran Creosote Bush Scrub Desert Saltbush Scrub	Sonoran Creosote Bush Scrub
Sonoran Creosote Bush Scrub Mojavean Desert Scrub	Sonoran Creosote Bush Scrub
Sonoran Creosote Bush Scrub Non-Native Grassland	Sonoran Creosote Bush Scrub
Sonoran Creosote Bush Scrub Sonoran Desert Mixed Scrub	Sonoran Creosote Bush Scrub
Sonoran Desert Mixed Scrub	Sonoran Desert Mixed Scrub
Sonoran Desert Mixed Scrub degraded	Sonoran Desert Mixed Scrub
Sonoran Desert Mixed Scrub Mesquite Bosque[5]	
Sonoran Desert Mixed Scrub Mojavean Desert Scrub	Sonoran Desert Mixed Scrub
Sonoran Desert Mixed Scrub Mojavean Pinyon and Juniper Woodlands	Sonoran Desert Mixed Scrub
Sonoran Desert Mixed Scrub Non-Native Grassland	Sonoran Desert Mixed Scrub
Sonoran Desert Mixed Scrub Peninsular Pinyon and Juniper Woodland	Sonoran Desert Mixed Scrub
Sonoran Desert Mixed Scrub Sonoran Creosote Bush Scrub	Sonoran Desert Mixed Scrub

[1] Combined with special element target “Playas”
[2] Combined with special element target “Sand Dunes”
[3] Recoded as vegetation community target “Sonoran Desert Mixed Scrub”
[4] Combined with special element target “Water-related habitats”
[5] Combined with special element target “Mesquite Bosque”

Selection of Focal Species

We identified the following set of focal species, and used them as case studies to examine the effectiveness of current conservation efforts and/or to identify risks and potential solutions. Species (or groups of species) were selected to represent a variety of taxa and habitat types, or because they were dependent on a unique ecological process or were a sensitive or listed species.

Flat-tailed Horned Lizard

Flat-tailed horned lizards rely on undisturbed, low-elevation, desert lands and availability of a specialized food source. Typical habitat of this species is found at low elevations (typically < 800 feet), and includes sandy desert hardpan and gravel flats with sparse vegetation (most typically creosote bush and burrobush), overlain with fine windblown sand. This species is not common on larger dunes, however. Flat-tailed horned lizards feed almost exclusively on ants (95% of all food items), and are most common in areas with high density of harvester ants (Turner and Medica 1982). Although they may run to flee predators, their primary methods of defense are to remain motionless and rely on their cryptic coloration, to bury themselves in find sand, or to hide under small rocks or in shallow burrows. Flat-tailed horned lizards are therefore highly vulnerable to mortality from vehicles, especially off-road vehicles. Historically, this species’ range included much of our study area from the Coachella Valley south through Imperial Valley, west into Anza-Borrego Desert State Park, and south into Mexico, but much of its range has been impacted by human activities such as off-road vehicle use, roads, urban development, border activities, and utilities construction (Turner and Medica 1982, Grant and

Doherty 2005). It was estimated that 43-49% of the species' historic habitat in the United States had been lost by 2003 (Flat-tailed Horned Lizard Interagency Coordination Committee [FTHL ICC] 2003). The species has been proposed for Federal listing but the formation of an interagency Rangewide Management Strategy has precluded listing to date (FTHL ICC 2003). Flat-tailed horned lizards are a California State Species of Concern.

Desert Tortoise

Desert tortoises rely on desert washes, canyon bottoms, oases, alluvial fans, flat creosote scrub habitats, and occasionally rocky, boulder-strewn hillsides between sea level and 1220 meter (4000 ft) elevations (Stebbins 1985, MacMahon 1992, Ivanyi et al. 2000). Tortoises are slow to mature (reaching maturity at 13-15 years) and may live up to 40-50 years in the wild (Germano 1992). For cover and reproduction (egg deposition), desert tortoises dig shallow burrows, often in banks of washes, or make us of existing crevices and depressions. Availability of shelter sites may limit population size (Ivanyi et al. 2000). Desert tortoises, which are most active in spring and summer, can survive extended dry periods by seeking cover and going into hibernation or estivation, during which their metabolic rate, digestion, and water loss are greatly reduced (Ivanyi et al. 2000). They are herbivores who rely on a wide diversity of native plants such as spring annuals (e.g., grasses, globemallow, desert vine) and cacti. Mating occurs in spring and summer, and one or two clutches of eggs are laid per year. Hatchling survival is low, however, except during exceptionally wet years. Desert tortoises are federally listed as threatened and are at risk from habitat destruction (for urban development, energy developments, agriculture), upper respiratory disease, predation of young by ravens, roads, off-highway vehicle use, and grazing (USFWS 1990). Additional serious threats come in the form of invasive exotic plants (e.g., grasses, Saharan mustard) and resulting altered fire regimes that threaten the native desert vegetation communities that this species relies on.

Bighorn Sheep

Bighorn sheep are a large wide-ranging species that requires connectivity across a large landscape. Although the distribution of this species is typically associated with mountainous terrain with relatively open vegetation, bighorn sheep commonly use a variety of desert terrain types, including canyon bottoms, washes, alluvial fans, plateaus, and valley floors. These areas may be used both for movement between mountainous areas and as important foraging areas (e.g., Schwartz et al. 1986, Bleich et al. 1997). Bighorn sheep are generalist herbivores and feed on a wide variety of desert plants, including cacti. In most desert ranges, summer use tends to focus near water sources (e.g., Cunningham and Ohmart 1986), but some populations have been reported to exist in areas with no known standing water (Krausman et al. 1985, Krausman and Leopold 1986). Bighorn sheep females form matrilineal groups that exhibit limited exploratory behavior and are typically associated with a particular mountain range or set of ranges. These groups are linked by more distantly ranging males (Geist 1971). In California's deserts, bighorn sheep have been described as forming a metapopulation (a system of multiple populations linked via occasional movement of individuals; Bleich et al. 1996) and maintenance of connectivity among these populations has become an important component of conservation strategies for this species (Schwartz et al. 1986, Bleich et al. 1996, USFWS 2000). Desert bighorn sheep are threatened by habitat loss and fragmentation, disease, predation by mountain lions, human activities, drought, and climate change (Schwartz et al. 1986, Bleich et al. 1996, USFWS 2000, Epps et al. 2004, 2005). Bighorn sheep in the Peninsular Ranges, at the western edge of the Sonoran Desert, are Federally listed as an endangered population (USFWS 2000).

Birds of the Salton Sea

The Salton Sea and surrounding lands provide important habitat for an incredible number of birds, not only in sheer numbers but also in the number of species. At least 400 bird species have been documented at the Salton Sea, including approximately 100 locally breeding species (Shuford et al. 2002). Millions of birds are present in some winters, with eared grebe numbers alone as high as 3.5 million (Shuford et al. 2002). Sensitive or at-risk species supported by the Salton Sea include brown pelicans, American white pelicans, American bittern, white-faced ibis, Yuma clapper rail, fulvous whistling-duck, wood stork, long-billed curlew, mountain plover, western snowy plover, burrowing owl, and greater sandhill cranes (Shuford et al. 2002, Patton et al. 2003, Bunn et al. 2007). The value of the Salton Sea is increased by its location along the Pacific Flyway and by its diverse associated habitats, including nearby agricultural lands (Shuford et al. 2002, Bunn et al. 2007). Open deep waters, shorelines dotted with riparian vegetation and open beaches, and small islands create a variety of options for feeding and nesting birds. Nearby irrigated crop lands, interspersed with canals, small lakes, and marshes provide important foraging, roosting, and nesting sites (Shuford et al. 2002).

The sea and its associated habitat are considered one of the most important wetlands for birds in all of North America. In the intermountain and desert region of the west, the Salton Sea is considered the most important shorebird area during the spring, and second only to the Great Salt Lake in the fall (Shuford et al. 2002). As such, the sea is crucial to survival of bird species that are of continental and regional importance. For example, in some years, 90% or more of the North American's eared grebe population may pass through the area, while approximately 40% of the endangered Yuma clapper rail's United State's population is found at the sea (Shuford et al. 2002). In the face of extensive losses of wetlands throughout California, the ecological value of the Salton Sea is further magnified.

The health of this ecosystem is tenuous, however, placing these many bird populations at incredible risk. In recent years, a number of bird and fish die-offs have occurred. Although small-scale die-offs of birds have occurred at the Salton Sea since at least 1917, recent die-offs of fish and birds have been both larger and more frequent (Patton et al. 2003). Fish die-offs are believed to be caused by high sulfide and ammonia concentrations at the bottom of the sea mixing with surface waters during summer months (Setmire et al. 1993, cited in Patton et al. 2003). Bird die-offs are not well understood, but may be caused by botulism, cholera, and/or avian Newcastle disease (Friend 2002), with botulism outbreaks, favored by low oxygen concentrations combined with high water temperature and salinity, considered a main suspect (Rocke and Samuel 1999, Patton et al. 2002). Ecological health of the Salton Sea and the viability of its fish and bird populations are intimately tied to larger conservation issues related to water management in the Sonoran Desert of California (Section 5).

Least Bell's Vireo

Least Bell's vireo is an obligate riparian species during its breeding season, using structurally diverse woodlands along watercourses, including cottonwood-willow forests, oak woodlands, and mule fat scrub, and preferring early successional willow-dominated riparian woodlands

(USFWS 1998b). This subspecies breeds in California and northwestern Baja California, Mexico, and winters in southern Baja California (USFWS 1998b). During winter, they may be found in mesquite scrub communities in arroyos, palm groves, and hedgerows near agricultural fields and rural residential areas (USFWS 1998b). Habitat requirements during the breeding season appear to be linked to vegetation structure rather than species composition. The two most serious threats to this species are extensive loss and degradation of breeding habitat and brood parasitism by the brown-headed cowbird. Human activities such as stream channelization, water impoundment or extraction, water diversion, intensive recreation, and development put the species' habitat at risk (USFWS 1998b). Livestock grazing also has negative impacts on habitat quality (USFWS 1998b). Populations were once widespread in California wherever appropriate habitat was found, but by 1986 the entire statewide population was estimated at 300 pairs, with most in San Diego County (USFWS 1998b). In May 3, 1986, the USFWS listed the species as endangered. Since the initiation of aggressive cowbird removal programs, least Bell's vireo populations have increased and have begun to expand back into historical habitat. Habitat protection is crucial to their continued recovery.

Triple-ribbed milk-vetch:
Triple-ribbed milk-vetch is a perennial herb endemic to California, and is found in limited locations along sandy and gravelly soils in dry washes, at the base of canyon slopes, and on steep scree slopes of decomposed granite (USFWS 1998a). Within our study area, the range of this Federally endangered species, with only 100 known individuals in 1998, is believed to extend from Morongo and Whitewater Pass at the north end of the Coachella Valley, south to the Orocopia Mountains (Munz and Keck 1959, USFWS 1998a). Specimens have been found in Big Morongo Canyon and its tributaries, in Whitewater Canyon, and in Mission Creek (USFWS 1998a). An additional specimen was discovered in Agua Alta Canyon, a branch of Martinez Canyon in the Santa Rosa Mountains, suggesting that its range includes additional slopes and canyons of the Santa Rosa and San Jacinto mountains (USFWS 1998a). Triple-ribbed milk-vetch is a short-lived perennial that may vary greatly in numbers from year to year and location to location. It may not be present in the form of standing adults during some drought years, and may instead occur as a seed bank or as plants persisting as perennial root crowns (USFWS 1998a). Although the occurrence of triple-ribbed milk-vetch may be associated with disturbance (natural or man-made), it is threatened primarily by land conversion and off-highway vehicle use (Coachella Valley Association of Governments 2007). For example, a crude oil pipeline runs through its habitat at Big Morongo Canyon and maintenance of this line has, on several occasions, resulted in loss of a number of individuals (USFWS 1998a). Persistence of this species may also depend on active and intact natural hydrologic regimes (Coachella Valley Association of Governments 2007), making it vulnerable to changes in waterflow patterns, climate change, and human activities.

Peirson's milk-vetch:
Peirson's milk-vetch is a dune-endemic plant threatened by human activities in California's Sonoran Desert. Within our study area, this native member of the pea family was historically found in dune areas in the Borrego Valley and in portions of the Algodones Dunes (USFWS 2008a). It is now only known to occur in the Algodones Dunes, as one population scattered among multiple colonies, and is Federally listed as endangered (USFWS 2008a). Peirson's milk-vetch is found in the slopes and valleys of the dunes, primarily along the western edge of the

dunes (USFWS 1998a). This short-lived perennial is uniquely adapted to survival in a dune environment, with a long taproot for reaching moisture and anchoring the plant during high winds. Because growth and reproduction of this species are closely tied to local rainfall patterns, the species may, at any given time, be present as standing plants, as a "soil seed bank" in the dune sand, or as plants persisting as perennial root crowns (USFWS 2008a). The primary threat to this species is off-highway vehicle (OHV) use (USFWS 1998a). Individuals may be crushed by vehicles, but the effect of vehicular activity may extend beyond direct damage to individual plants, as OHV use may have negative impacts on reproduction via loss of soil moisture or changes to dune morphology (USFWS 1998a, Groom et al. 2007).

Description and Rating of Conservation Threats and Challenges

In Section 5 of this report, we describe the threats and challenges facing biodiversity in the Sonoran Desert of California. For our evaluation of potential conservation opportunities, we also characterized, when possible, the geographic distribution of each threat, and categorized the degree of threat in each area (Table B-4). The geographic distribution and relative severity of some threats were difficult to describe but, although we did not map them, their impacts are discussed in Sections 5 and 6 of the report. Impacts of climate change are, for example, difficult to predict and map. Although nitrogen deposition rates have been measured and/or modeled for much of the western states (Fenn et al. 2003, Tonnesen et al. 2007), detailed information was not available for our entire study area. Mining was not mapped as a separate threat because of difficulties in predicting where the many and varied mining resources may be found. We therefore assume that the relative risk due to mining would be captured in the risk of land conversion (Figure 5-1). Finally, impacts such as those from modified fire regimes and indirect influences of urbanization are discussed in relation to fragmentation in Sections 5 and 6.

Table B-4. Approach for spatially classifying threats.

Threat (Figure)	Approach for Spatially Classifying Relative Threat
Land Conversion (Figure 5-1)	Risk of land conversion was classified according to the corresponding Gap Status of each land area. We adopted classifications and assigned ratings used in the California Gap Analysis Project (Davis et al. 1998). For lands not assigned a status by Davis et al. (1998), we assigned a status according to their classification definitions. Gap Status 1 (low threat) Gap Status 2 (med) Gap Status 3 (high) Gap Status 4 (very high threat)
Fragmentation (Figure 5-1)	Fragmentation was depicted by the cost surface generated for the Marxan analysis (see *Biological Integrity of the Landscape*, below) to depict current impacts. The degree of fragmentation is shown as the cost surface.

Relative Probability of Renewable Energy Development

(Figure 5.2)

Lands were rated by the relative probability that they would be developed for solar, wind, or geothermal power generation, based on potential of generation in each area.

A. Solar: We used solar radiation ratings obtained from National Renewable Energy Laboratory (NREL) maps to identify areas most likely to be developed for solar production. We assigned a low risk rating to areas with low radiation areas (< 6.0 kWh/m^2/day), sloped areas (> 3% slope), contiguous areas of less than 1 km^2, and any areas in the Salton Sea. Remaining areas were classified according to radiation values to create the three following ratings (probability of development):

- <u>Low</u> = areas excluded in above steps
- <u>Med</u> = 6.0 – 7.0 kWh/m^2/day
- <u>High</u> = > 7.0 kWh/m^2/day

B. Wind: We used the 50m Wind Resource map from the U.S. Dept. of Energy to identify areas most likely to be developed for wind power. According to the U.S. Dept. of Energy, Class 4 or higher can be useful for generating wind power with large turbines; we therefore created the three following ratings (probability of development):

- <u>Low</u> = Class 1, 2, 3
- <u>Med</u> = Class 4 and 5
- <u>High</u> = Class 6 and 7

C. Geothermal: We used three sources for assigning ratings related to probability of development for geothermal projects: (1) the California State Dept. of Conservation's "Geothermal Map of California" (http://www.conservation.ca.gov/dog/geothermal/maps/Pages/index.aspx), (2) Idaho National Laboratory's State Geothermal Resource maps (http://geothermal.inel.gov/maps/index.shtml), and (3) Sass and Priest (2002). We used maps from these sources to categorize lands according to the following ratings:

- <u>Low</u> = all areas not in "med" or "high"
- <u>Med</u> = all areas in "zone of elevated heat flow" (Sass and Priest 2002) but not in category "high"
- <u>High</u> = all known geothermal resource areas, State geothermal fields, power plants, and active wells (California Dept. of Conservation), plus all wells and springs > 50° C (Idaho National Laboratory), with an area of impact of 1.63 km^2 (400 acres) centered on the spring or well. This area of impact was based on the reported footprint of the Truckhaven Geothermal Power Plant (http://www.enex.is/?pageID=567).

The above ratings for solar, wind, and geothermal were then modified by considering the four Gap Status ratings, because they would influence the probability of land being developed:

	Gap1	Gap2	Gap3	Gap4
Low potential*	Low	Low	low	Low
Med potential*	Low	Low	med	med
High potential*	Low	Low	high	high

* original rating for solar, wind, geothermal development.

	Rating 1 = low probability of development Rating 2 = medium probability of development Rating 3 = high probability of development
Watershed Impairment (Figure 5-3)	We assumed that the relative risk of watershed impairment is related to: 1) Percent of urban development 2) Percent of agriculture 3) Total length of roads and canals 4) Percent of unprotected lands (Gap Status 4) We used the sum of the above values to assign watersheds to the following categories: Rating 1 = low impairment risk (0-20) Rating 2 = medium impairment risk (20.01-45) Rating 3 = high impairment risk (>45)
Groundwater Basin Impairment (Figure 5-3)	We assumed that the relative risk of groundwater basin impairment is related to: 1) Percent of urban development 2) Percent of agriculture 3) Percent of unprotected lands (Gap Status 4) We used the sum of the above values to assign groundwater basins to the following categories: Rating 1 = low impairment risk (0-33) Rating 2 = medium impairment risk (34-66) Rating 3 = high impairment risk (>66)
Relative Probability of OHV Activity (Figure 5-4)	We used two approaches for mapping the relative probability of OHV activity: 1) Relative probability assigned according to management protocols: We categorized probability according to the following criteria: OHV A1 (low probability): Areas closed to vehicles, such as wilderness or ecological reserves. OHV A2 (medium probability): Areas that allow vehicles on designated roads, with tight restrictions/patrol to limit off-road travel. OHV A3 (high probability): Areas that allow vehicles on designated roads, with limited restrictions/patrol to limit off-road travel. OHV A4 (highest probability): Areas such as private lands and BLM or State Parks OHV recreational areas, where vehicle use is heavy and widespread. 2) Relative probability assigned according to proximity to roads, open routes, open OHV recreational areas, private land: We categorized probability by assuming that potential use is higher near roads, open routes, open OHV recreational areas, and on private lands, and that potential use is lower in areas closed to vehicles (e.g., wilderness, ecological preserves): OHV B1 (low probability): Areas closed to vehicles, such as wilderness and ecological reserves, *except* areas in the below OHV 2 and OHV 3 ratings, *plus*

	all areas not captured in the below OHV 2 and 3 ratings. OHV B2 (med probability): All areas within 200-1600 meters from open routes, roads, private land, or open OHV recreational areas. OHV B3 (high probability): All open OHV recreational areas and private lands, plus all lands within 200 meters of these areas, roads, or open routes.
Risk of Tamarisk Invasion (Figure 5-5)	We assumed that the following habitats are "at risk": ▪ water-related habitats ▪ washes ▪ playas ▪ ciénagas ▪ pupfish habitat We further assumed that terrain with slopes > 20% is at lower risk, and rated lands according to the following criteria: Rating 1 (low risk) = areas not in "at risk" habitat types Rating 2 (medium risk) = "at risk" habitats in steep terrain (≥ 20% slope) Rating 3 (high risk) = "at risk" habitats in gentle terrain (< 20% slope)
Risk of Saharan Mustard Invasion (Figure 5-5)	We assumed that risk is highest near converted lands (urban and agriculture), paved roads/railroads, unpaved roads, and open OHV routes, and that risk is also elevated in washes and dune habitats (Brooks 1995, Sánchez-Flores 2007). We further assumed that risk is higher at gentle slopes than on steep slopes, and therefore classified lands according to the following criteria: Rating 1 (low risk) = all areas not within Rating 2 or 3 (medium and high risk), plus all areas with slopes ≥ 20%. Rating 2 (medium risk) = all washes and dunes not included in Rating 3 Rating 3 (high risk) = areas within 10 km of paved roads, railroads, and converted lands, and within 500 meters of unpaved roads/open routes, minus areas with slopes ≥ 20%.
Risk of Livestock Grazing (Figure 5-5)	We assumed that grazing impacts are elevated in all grazing allotments, and in lands within 7 km (4.4 miles) of these areas. In the absence of cattle dispersal distances, we based this distance on (approximately one half of) known dispersal distances of wild horses (Berger 1987), and categorized lands according to the following criteria: Rating 1 (low risk) = all areas not in "high" risk Rating 2 (high risk) = all areas within 7 km of a grazing allotment.
Risk of Burro Impacts (Figure 5-5)	We assumed that burro impacts are elevated in BLM Wild Horse and Burro Management Areas (WHBMA), in lands within 7 km (4.4 miles) of WHBMAs, and within 14 km (8.8 miles) of WHBMAs if this connects them to the Colorado River. Distances are based on dispersal distances of wild horses (Berger 1987). Lands were categorized according to the following criteria: Rating 1 (low risk) = all areas not in "high" risk

		Rating 2 (high risk) = all areas within 7 km of a WHBMA or within 14 km of a WHBMA in a direct line towards Colorado River, if the latter connects them to Colorado River.

Describing the Current Conservation Landscape

The Sonoran Desert in California is a diverse landscape, both in terms of natural biodiversity and function, and in degree of human impact. As a result, a range of conservation opportunities and appropriate strategies exist across this landscape. These are best identified by describing the existing conservation landscape, the protection that currently exists, and threats and challenges that face the landscape.

To describe the conservation landscape, we sought to categorize lands by habitat intactness and conservation target value. To accomplish this, we first described the biological integrity of the landscape, and then used the site selection program Marxan (Ball and Possingham 2000, Possingham et al. 2000) to guide our identification of areas meeting conservation goals related to vegetation community and special desert element targets. Marxan provided an objective process for identifying conservation portfolios within our study area that best met a set of predetermined conservation goals in the most efficient manner (within the smallest area possible) given the integrity of the landscape. We used this information to guide our assignment of lands to four categories and this, in turn, facilitated identification of unique conservation objectives for each of the four categories. The remainder of this section describes the inputs to Marxan (cost surface values, goals), and our methods for using Marxan output to inform our delineation of four categories across the current conservation landscape.

Geographic Units of Analysis

For evaluation using Marxan, the study area was divided into a set of cells or analysis units, each with a set of attributes based on presence of conservation targets (i.e., vegetation communities and elements) and costs (cost surface, see below). Based on a previous evaluation of planning unit sizes for a similar analysis (Conservation Biology Institute 2004), we chose to use 250 acre (100 hectares) hexagons as our analysis units.

Biological Integrity of the Landscape

We used the extent and distribution of urbanization, agriculture, and roads as an index of fragmentation. This measure formed the cost surface for Marxan analyses (with increased fragmentation assumed to increase the relative cost of conserving a cell), and allowed us to identify areas of intact landscapes. We used GIS layers of roads, urbanization, and agriculture to construct the cost layer as follows:

- Major roads were buffered by 25 m (82 ft) on each side, for a total footprint width of 50 m (164 ft).
- Minor roads (including dirt roads) were buffered by 10 m (33 ft) on each side for a total footprint width of 20 m (66 ft).

- Agricultural categories from the vegetation database were extracted and defined as the Agricultural layer.
- We assigned costs to these layers as follows:
    - Urban and major roads = 5 points/ha
    - Minor roads = 5 points/ha
    - Agriculture = 1 point/ha
    - The grid of 250 acre (100 hectare) hexagonal analysis units was overlaid on these layers, and the corresponding cost values assigned to each unit (Figure 6-1).

Conservation Goals for Identifying Areas of High Target Value

We used program Marxan to guide our understanding of the landscape's conservation patterns in relation to conservation targets based on vegetation communities and special desert elements (Section 3.5). We defined conservation goals as percentages of each vegetation community and special desert element that should be included in each of the Marxan portfolios. Similar approaches have previously been used to guide conservation planning in southern California (e.g., Natural Community Conservation Planning [NCCP] programs, and the Las Californias Binational Conservation Initiative; CBI 2004). We defined two goal sets: Goal Set 1 prioritized irreplaceability (highlighting targets that are rare or have limited distribution) while Goal Set 2 prioritized ecosystem representation by selected uniform levels of all targets (Table B-5).

Table B-5. Conservation goal sets used for Marxan analysis

	Acres in California's Sonoran Desert	**% of California's Sonoran Desert**	**Goal Set 1** (% of target to include in portfolio)	**Goal Set 2** (% of target to include in portfolio)
Vegetation Communities				
Sonoran creosote bush scrub	3,250,668	45.07	25%	50%
Sonoran desert mixed scrub	1,522,868	21.11	25%	50%
Desert dry wash woodland	785,530	10.89	25%	50%
Mojave creosote bush scrub	196,952	2.73	75%	50%
Peninsular pinyon & juniper woodland	74,698	1.04	75%	50%
Mojavean pinyon & juniper woodland	42,301	0.59	75%	50%
Elements				
Water-related habitats	460,275	6.36	25%	50%
Sand dunes	648,918	9.00	25%	50%
Palm oases	63,341	0.88	75%	50%
Playas	62,605	0.87	75%	50%
Mesquite bosques	36,467	0.51	75%	50%
Saguaros	10,042	0.14	75%	50%
Ciénagas	7,718	0.11	75%	50%
Pupfish habitat	2,527	0.04	75%	50%

Selecting Preliminary Conservation Portfolios

To account for Marxan's stochastic optimization algorithms, which can result in numerous portfolio selections, we ran Marxan 10 times for each goal set, with each run including 1,000,000 iterations, and then determined the frequency with which each geographic cell was selected in the 10 runs. For each of the two goal sets, cells selected in at least 6 of the 10 runs were considered to meet the target conservation goals (Figure 6-1).

Although some previous site selection applications (e.g., CBI 2004) locked in existing protected areas, thereby "anchoring" portfolios to existing protected areas, we chose to evaluate potential portfolios without anchoring them to existing protected areas. That is, Marxan was able to select portfolio sites regardless of land ownership or protected status, relying simply on our goals sets and the cost surface (which placed a high cost on urban areas). This was deemed more useful for our purposes, because it (1) allowed us to overlay protected areas as a secondary step to assess where potential portfolios fell outside of these areas, and (2) allowed us to examine the extent to which potential portfolios fell within existing protected areas.

Identifying Categories of the Current Conservation Landscape

We used landscape integrity (based on cost surface) and Marxan results to guide our assignment of lands to four categories (Figures 6-1 and 6-2). The following four categories provided a classification of the entire study area in terms of conservation status, which subsequently allowed us to define unique conservation objectives for each category:

> Category A: Lands that have a high level of landscape integrity (low or no fragmentation) and satisfy at least one of our two conservation goals of irreplaceability and ecosystem representation.
>
> Category B: Lands that have a high level of landscape integrity or satisfy at least one of our two conservation goals of irreplaceability or ecosystem representation. As such, lands in this category may have high target value but have compromised integrity, or they may have high integrity and lower target value.
>
> Category C: Natural areas or open space that are fragmented by roads, sparse rural residential communities, or other human uses, but which may nonetheless contain conservation targets, provide potential habitat linkages, or provide a buffer around Category A and B lands.
>
> Category D: Lands that are dominated by urban communities and agriculture, but which may contain isolated conservation targets or provide habitat for some wildlife species.

Developing A Vision for Enhanced and Effective Conservation Efforts

The above four categories acknowledge the differences that exist across the conservation landscape of California's Sonoran Desert, and allowed us to define the following unique conservation objectives for each category:

> Category A: Protect large, intact habitat blocks to conserve irreplaceable biological resources, support natural ecological processes (e.g., fire and water-flow regimes), and

maintain habitat connectivity. Prevent agents of fragmentation (e.g., development, roads), invasion of exotic species, and other direct and indirect human impacts from occurring in these areas.

Category B: Promote land uses and management practices that maintain or improve landscape integrity and protect conservation targets. Promote restoration of habitat connectivity, natural vegetation communities, and ecological processes (e.g., water-flow regimes, eolian processes).

Category C: Encourage sustainable land uses that minimize impacts to natural resources, allow protection of sensitive species and isolated high value native ecosystems, and maintain landscape permeability to wildlife movement.

Category D: Focus conservation and management efforts on natural areas (e.g., open spaces, riparian habitats, canyons) that support local wildlife, improve air and water quality, recharge groundwater aquifers, and otherwise improve human quality of life. Promote management of agricultural landscapes to support key wildlife resources (e.g., birds at the Salton Sea).

We identified and discussed conservation opportunities by examining each of the four land categories in terms of objectives, existing conservation activities (in particular protective land status), and threats and challenges (Section 6). We then identified those areas where additional efforts could reduce risks and advance conservation towards attainment of the stated conservation objectives.

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Appendix C
The Cultural Resources of the Sonoran Desert in California

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ASM PARC, July 2008

I. Introduction

The purpose of this study is to provide a cultural resources overview for The Nature Conservancy's conservation assessment of the Sonoran Desert in California. The overview is framed by selected conservation targets, consisting of vegetation communities and special elements, including water-related elements.

A cultural resource can be any of these things:

- An archaeological site or place
- A historic site or place
- A traditional location important to Native Americans

A. Archaeological Sites and Places

Habitation areas, such as villages and seasonal camps, were located in proximity to water sources. Other localities including gathering areas, trails, shrines, quarries, and rock alignments, paintings, and etchings were not specifically located near water but are distributed throughout the desert.

Archaeological sites contain evidence of past human activities, such as flaked stone used for tools, pottery, midden (soils that have been altered over time by human occupation), stone hearths and other features, and rock alignments. Several different types of Native American pottery are found at sites in California's Sonoran Desert, reflecting stylistic traditions, availability of material, and cultural change over time. The pottery is generally undecorated, although zigzags, dots, and incised lines were used on occasion. Many different forms were made, ranging from large water storage ollas to tobacco pipes.

Individual clans in the desert had established territories, which were protected from others. Mesquite groves and other food gathering locations were owned.

According to tradition, Native Americans have lived in the desert since the beginning of time (a creation site is located within the project area). Archaeological research has recovered cultural materials that are nearly 10,000 years old.

Archaeological sites in the desert are very fragile since many are only present on the surface of the ground. The extensive prehistoric trail systems that cross the desert, with associated rock features and pottery, are particularly subject to damage.

B. Historic Sites and Places

The desert also contains historic landscapes and sites. Although the first European contact with Native Americans in the area was in 1540, the Anza and Garces expeditions of 1774 and 1775-76 were the earliest documented presence through the Sonoran Desert. The earliest European settlement was the establishment of the Mission in San Diego in 1769; therefore, the year 1769 is used as a marker for the beginning of the historic period. Historic locations include roads (the Plank Road, for example), mining towns and processing centers, homesteads, and military sites.

C. Traditional Locations

The Sonoran Desert is a traditional cultural landscape for California Indian people. The desert is included in the tribal territories of the desert Kumeyaay (Kamia), Kwaaymii, Cahuilla, Serrano, Chemehuevi, Mojave, Halchidhoma, and Quechan. The desert contains many locations that are sacred to Native Americans. Geoglyphs, which are rock alignments and patterns on the ground visible from above and are abundant in the desert, are particularly fragile examples of sacred sites. Other traditional locations may not have been modified by humans, but are natural areas where important cultural events occurred. These areas could be mountain tops, rock formations, or rivers. Springs are often regarded as sacred locations.

II. Conservation Targets

A. *Vegetation Community Targets*

Sonoran Creosote Bush Scrub. Despite the paucity of rainfall in this community, Native American archaeological sites are frequently found near drainages and washes. These sites often feature roasting hearths, midden deposits, milling features used to process food and textile plants, and evidence of stone tool manufacturing. When present, sites may extend over many acres, and feature artifact concentrations as evidence of special activity areas. Prominent trails and rock rings are preserved in the desert pavement. Trails are associated with cairns, shrines, pot drops, and rock alignments.

- Lake Cahuilla Shoreline. As the lake filled and receded over past centuries, until circa AD 1700, Native Americans camped along its shoreline to fish and gather resources. Fish traps and habitation sites are located along the shoreline around its entire length. The fish traps consist of V or U shaped rock alignments along the various shoreline stands. At its maximum stand during late prehistory, the lake would have measured 106 miles north to south, and 34 miles east to west; the maximum depth would have been 320 feet. This maximum lake stand is on the 40 foot contour level, which has been inventoried by various archaeologists since the 1920s. The lake contained five species of freshwater fish, a mollusk, and was a magnet for many species of birds. Obsidian Butte, located at the southern end of the lake, was southern California's major source for volcanic glass, used for tools. The west side of the lake was a source for "wonderstone", a type of colorful rock that was highly regarded by prehistoric flintknappers. Native Americans adapted to the rise and fall of Lake Cahuilla for at least 11,000 years, during the late Pleistocene-Holocene epochs. The remaining evidence for shoreline archaeological sites is being impacted by agriculture, mineral exploitation, recreation, and development.

- West Mesa (Superstition Hills and Mountains). An archaeological site complex on West Mesa represents temporary camps of people who came into the desert from the mountains during the fall and early spring and lived around the temporary pans and ephemeral ponds located in this area. The sites consist of hearths, pottery, flaked stone, fish bone, shell, and milling stones used to process seeds.
- Algodones Dunes. There are many ethnographic villages (occupied at the time of historic contact) located in the vicinity of the dunes. Indian wild grass seeds were gathered from the dunes. There are also areas sacred to the Quechan in this area.
- Plank Road. A road made of wooden planks was used in the early 1920s. It was the only route through the dunes. Portions still exist but are threatened by recreational activities in the dunes. Many planks have been burned as firewood.
- Geoglyphs. The area along the Colorado River contains numerous rock alignments and patterns known as geoglyphs. Many of these are associated with a Native American trail that runs parallel to the Colorado River and crosses the Big Maria and Whipple Mountains, where there are complex systems of geoglyphs, some of which are figures only visible from above. These alignments are very fragile since they occur only on the ground surface.
- Pilot Knob. This is a sacred area to the Quechan Indian people and is known as *Avi Kwalal*. Geoglyphs, trails, and habitation sites are located in the area.
- Coyote Canyon. Archaeological sites and areas important to the Cahuilla are located in the canyon.

Sonoran Desert Mixed Scrub. Large, complex archaeological sites are found within this community, particularly in drainages and along the western edge of the desert where sites can exceed 40 acres in size. These sites feature roasting hearths, rock shelters, midden deposits, large dispersed areas of stone tool production, associated series of milling features for processing food and textile fibers, and dense scatters of broken pottery representing types from throughout the region. Continuous archaeological resources are often found along the bases of hills, scattered among the rocks.

- Anza-Borrego Desert State Park. The western part of the park is within this vegetation community. Drainages in this area are the focus of extensive prehistoric and ethnographic habitation consisting of midden deposits, milling features, flaked and ground stone, shell beads, and hearth features. Examples include Grapevine Canyon, Vallecito Valley, Mine Wash, Sentenac Canyon, Blair Valley and Ghost Mountain, Piedras Grandes, Indian Hill and Dos Cabezas, Mountain Palm Springs, Split Mountain, Harper Flat, and Hapaha Flat. The park also contains the historic remains of World War II training activities. Open camping and a recent increase in public recreation in the park has resulted in incremental damage to sites.
- Corn Springs in Chuckwalla Mountains. This area is an important archaeological complex containing habitation sites, trails, petroglyphs (figures etched into the patinated

surface of boulders), historic mining sites, rock rings, and geoglyphs. Major villages are located at springs in the Chuckwalla Mountains.

- North Chuckwalla Mountains. The mountains contain petroglyphs and quarries established by Native Americans.

Desert Dry Wash Woodland. These areas were largely used for special purposes by Native Americans. Few large permanent occupation areas are located in this community. For example, the sites in the Chocolate Mountains are small camps consisting of rock rings and features or cleared circles. The camps, located primarily on terraces, contain pottery fragments and limited evidence for stone tool manufacturing and use. In the upper elevations and on alluvial fans, trails are present indicating the use of travel corridors.

- Tumco Historic Site. Gold was discovered in the Cargo Muchacho Mountains by the Spanish. Eventually, a mining district consisting of processing operations and a town site was established. American Girl Mine was another important historic district. This area is also significant to Native Americans.
- Geoglyphs, including the Snyder geoglyphs, are located in this community. Mineral development threatens these sensitive resources.

Mojave Creosote Bush Scrub. Much of this community is along the ancient shorelines of Lake Cahuilla.

- Lake Cahuilla Shoreline. The northern end of the ancient lake is within this community. There are sites associated with the shoreline in the northeastern corner of Anza-Borrego Desert State Park, but many are located outside the park and are unprotected. The most intensive prehistoric settlement along the lake shore appears to have been in the northwest, in the Coachella Valley.
- Mecca Hills. This area is a traditional location for the Cahuilla Indians, and is part of their origin stories.

Mojavean Pinyon and Juniper Woodland. Villages were located near mountain springs and in valleys or at the base of canyons. Pine nuts and acorns were a major source of food for the Cahuilla. The mountains also were used to gather yucca, agave, and mesquite. Higher elevations above 5000 feet were used for specific hunting and gathering purposes.

- Santa Rosa and San Jacinto Mountains. This area is culturally important to the Cahuilla Indians, and Santa Rosa Mountain and Tahquitz Peak are regarded as sacred. Archaeological resources present include habitation sites with midden and rock house structures, food processing areas such as agave roasting pits, stone tool manufacturing sites, and sacred areas. Summer villages were located at the higher elevations, and winter villages at the lower elevations. Trails connect the various cultural locations in the area.

Peninsular Pinyon and Juniper Woodland. This community contains rich resources for seasonal gathering. The upper elevations were exploited for pine nuts, the foothills for agave, and desert areas like San Sebastian Marsh for mesquite beans and seeds. A wide variety of seeds were used for food and medicine, including chia and panic grass. Juniper berries were also eaten fresh or dried. Canyons, such as Cottonwood and Storm Canyons in the Laguna Mountains, were travel corridors, and the ridges are locations for small camps and roasting pits and hearths.

- Table Mountain National Register District. The area contains numerous archaeological resources representing seasonal exploitation of agave and other plant foods. The sites are impacted by recreational use of trails.
- Drainages from Laguna Mountain. The canyons extending from Laguna Mountain to the desert contain trails and shrines. These corridors were used by Native Americans as they traveled seasonally from the upper to the lower elevations. Large village sites are located at the base of the canyons, where as the drainages empty into the desert. Notable concentrations of archaeological sites are found in Mason Valley, Vallecito Valley, and The Potrero. A recent increase in recreational activity threatens archaeological sites in these locations.

B. Special Elements

<u>Fan Palm Oases</u>. Clusters of fan palms, such as those along the Jacumba Mountains and Santa Rosa Mountains, were magnets for Native Americans who were attracted to the pooled water often found in the groves. The oases also attracted bighorn sheep and other game animals. Archaeological sites located in palm oases often have deep midden deposits, indicating their use over many years. Public use of palm oases and seasonal flash floods have damaged archaeological sites.

<u>Mesquite Groves</u>. Mesquite groves, such as those along San Felipe Creek, produced important food for Native Americans. The Cahuilla and Kwaaymii, for example, processed and consumed the beans as a dietary staple. Mesquite groves were owned by specific Indian groups. The groves often indicated the presence of water, and game animals visited the areas. Archaeological sites are located adjacent to the groves.

- Vallecito Valley and Mason Valley. An extensive series of archaeological sites have been investigated by the San Diego Museum of Man. The sites focused on mesquite bean processing. The Mason Valley area was occupied by Native Americans into the late 1800s.
- Colorado River. The mesquite groves along the Colorado River were a major food source for Native Americans.

<u>Sand Dunes</u>. The dunes on the west and east sides of the Salton Sea are culturally important as part of the ancient Lake Cahuilla shoreline site complex. Recreational activity from off highway vehicles damages sites in the dunes. Artifacts from older sites often erode from beneath active dunes.

- Imperial Dunes cultural landscape. In addition to the habitation sites located in the dunes, there are also burial grounds, sacred sites, trails, and resource procurement locations. The Imperial Sand Dunes Pot Drop Complex contains extensive scatters of Native American pottery shards that may be associated with trails connecting the Colorado River with Lake Cahuilla. The dunes are also referred to in traditional Native American narratives as places where cultural events occurred in the past.

- Yuha Basin. A portion of the basin has been listed on the National Register of Historic Places for its important habitation sites, trails, geoglyphs, and stone tool manufacturing sites. Emigrant trails from the historic period also cross the basin.

Water Related (including drainages). Seasonal camps and village sites were located along springs and drainages. Even if water was present for only a brief period, specific resources needed by the Indians would have been available and exploited at that time. Archaeological evidence ranges from larger villages along major drainages, to small camps, to individual bedrock milling features indicating brief, seasonal use.

- Colorado River. The Indians living along the Colorado River practiced floodwater farming, relying on the annual flush of the river to deposit sediment nutrients on their crop lands. The horticulture of the Colorado River people mirrored that of southwestern Indian groups (maize, squash, pumpkin). Gourds grown in field plots along the river were traded west to the coastal Indians for use as rattles, an essential element of origin or Bird songs.

Playas, ciénagas, marshes. These fresh water sources were critical to the Native American settlements of the desert. Some water sources, such as Sentenac Marsh, were also occupied by historic settlers and ranchers.

- San Sebastian Marsh. Native Americans lived around the marsh into the mid-1850s. Anza described the people when he visited in 1774, noting that agave obtained from the mountains was a major food. Mesquite beans were available from plants growing in groves and dunes within the site boundaries. Extensive archaeological resources are located around the marsh. Over fifty archaeological sites, representing a complex of activities, have been recorded at the marsh. Site types include habitation areas, burial areas, midden deposits, flaked stone tool manufacturing areas, a petrified wood cache, and pottery scatters.
- Palen Dry Lake/Sidewinder Well and Ford Dry Lake. Playas represent dry lakes where stands of fresh water intermittently exist. Ancient archaeological sites are located around the edges of these dry lakes, and artifacts erode from dunes and sediments. Some of the archaeological sites on the shores of Palen Dry Lake may date to the Late Pleistocene.

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Appendix D
Scientific Names of Plants and Animals

Common Name	Scientific Name
Reptiles and Amphibians	
Bullfrog	*Rana catesbeiana*
California king snake	*Lampropeltis getulus californiae*
Coachella fringe-toed lizard	*Uma inornata*
Colorado Desert fringe-toed lizard	*Uma notata*
Desert slender salamander	*Batrachoseps aridus*
Desert tortoise	*Gopherus agassizii*
Flat-tailed horned lizard	*Phrynosoma mcalli*
Gopher snake	*Pituophis melanoleucus*
Sandstone night lizard	*Xantusia henshawi gracilis*
Mammals	
Bighorn sheep	*Ovis canadensis*
Burro	*Equus asinus*
Coachella Valley round-tailed ground squirrel	*Spermophilus tereticaudus chlorus*
Coyote	*Canis latrans*
Mountain lion	*Puma concolor*
Palm Springs pocket mouse	*Perognathus longimembris bangsi*
Southern mule deer	*Odocoileus hemionus fuliginatus*
Western yellow bat	*Lasiurus xanthinus*
Birds	
American bittern	*Botaurus lentiginosus*
American white pelican	*Pelecanus erythrorhynchos*
Ash-throated flycatcher	*Myiarchus cinerascens*
Brown pelican	*Pelecanus occidentalis*
Brown-headed cowbird	*Molothrus ater*
Burrowing owl	*Athene cunicularia*
Common raven	*Corvus corax*
Eared grebe	*Podiceps nigricollis*
Elf Owl	*Micrathene whitneyi*
European starling	*Sturnus vulgaris*
Fulvous whistling-duck	*Dendrocygna bicolor*
Gila woodpecker	*Melanerpes uropygialis*
Gilded flicker	*Colaptes chrysoides*
Greater sandhill crane	*Grus canadensis tabida*
Hooded Orioles	*Icterus cucullatus*
Least Bell's Vireo	*Vireo bellii pusillus*
Long-billed curlew	*Numenius americanus*
Mountain plover	*Charadrius montanus*
Purple martin	*Progne subis*
Red-tailed hawk	*Buto jamaicensis*

Southwestern willow flycatcher	*Empidonax traillii extimus*
Western screech owl	*Megascops kennicottii*
Western snowy plover	*Charadrius alexandrinus nivosus*
White-faced ibis	*Plegadis chihi*
Wild turkey	*Meleagris gallopavo*
Wood stork	*Mycteria americana*
Yuma clapper rail	*Rallus longirostris yumanensis*
Plants	
Algodones Dunes sunflower	*Helianthus tephrodes*
Arundo	*Arunda donax*
Barrel Cactus	*Ferocactus cylindraceus*
Blue palo verde	*Cercidium floridum*
Borrego bedstraw	*Galium borregoense*
Borrego Valley peppergrass	*Lepidium felipense*
Brittle bush	*Encelia farinosa*
Bufflegrass	*Cenchrus ciliaris or Pennisetum ciliaris*
Burrobush	*Ambrosia dumosa*
California fan palm	*Washingtonia filifera*
Cape rye grass	*Stipa capensis*
Catclaw acacia	*Acacia greggii*
Cattail	*Typha domingensis*
Cheatgrass	*Bromus tectorum*
Cheesebush	*Hymenoclea salsola*
Cholla cactus	*Opuntia* spp.
Coachella Valley milk-vetch	*Astragalus lentiginosus var. coachellae*
Cottonwood	*Populus* spp.
Creosote bush	*Larrea tridentata*
Crucifixion thorn	*Castela emoryi*
Desert lavender	*Hyptis emoryi*
Desert sunflower	*Helianthus* spp.
Desert vine	*Janusia gracilis*
Desert Willow	*Chilopsis linearis*
Dune (or Wiggins') croton	*Croton wigginsii*
Dunn's mariposa lily	*Calochortus dunnii*
Elephant tree	*Bursera microphylla*
Ephedra	*Ephedra* spp.
Fountain grass	*Pennisetum setaceum*
Gander’s cryptantha	*Cryptantha ganderi*
Giant salvinia	*Salvinia molesta*
Globemallow	*Sphaeralcea* spp.
Honey mesquite	*Prosopis glandulosa*
Hydrilla	*Hydrilla verticillata*
Iceplant	*Carpobrotus chilensis, C. edulis*
Ironwood	*Olneya tesota*
Joshua tree	*Yucca brevifolia*

Juniper	*Juniperus californica*
Mojave yucca	*Yucca schidigera*
Munz's cholla	*Opuntia munzii*
Ocotillo	*Fouquieria splendens*
Old han schismus	*Schismus barbatus*
Orocopia sage	*Salvia greatae*
Parish's meadowfoam	*Limnanthus gracilis parishii*
Parry's spineflower	*Chorizanthe parryi*
Peirson's milk-vetch	*Astragalus magdalenae var. peirsonii*
Pinyon pine	*Pinus monophylla*
Red brome	*Bromus rubens or B. madritensis rubens*
Ripgut brome	*Bromus diandrus*
Rush	*Juncus* spp.
Sagebrush	*Artemesia californica*
Saguaro	*Carnegiea gigantea*
Saharan mustard	*Brassica tournefortii*
Sand food	*Pholisma sonorae*
Scarlet wisteria	*Sesbania punicea*
Screwbean mesquite	*Prosopis pubescens*
Smoketree	*Psorothamnus spinosus*
Sycamore	*Platanaceae racemosa*
Tamarisk	*Tamarix ramosissima*
Teddy-bear cholla	*Opuntia bigelovii*
Triple-ribbed milk-vetch	*Astragalus tricarinatus*
Tule	*Scirpus acutus*
Velvet mesquite	*Prosopis velutina*
Invertebrates	
Andrew's dune scarab beetle	*Pseudocotalpa andrewsi*
Argentine ant	*Linepithema humile*
California McCoy snail	*Eremarionta rowelli mccoiana*
Carlson's dune beetle	*Anomala hardyorum*
Crayfish	*Procambarus clarkii*
European honeybee	*Apis mellifera*
Fairy shrimp	*Streptocephalus and Branchinecta spp.*
Fire ant	*Solenopsis invicta*
Giant palm-boring beetle	*Dinapate wrightii*
Hardy's dune beetle	*Anomala carlsonii*
Harvester ant	*Pogonomyrmex desertorum*
White desert snail	*Eremarionta immaculata*
Fish	
Desert pupfish	*Cyprinodon macularius*
Gulf croaker	*Micropogonias megalops*
Orangemouth corvina	*Cynoscion xanthulus*
Sailfin molly	*Poecilia latipinna*

Sargo	*Anisotremus davidsoni*
Tilapia	*Tilapia* spp.
Western mosquitofish	*Gambusia affinis*

Appendix E
Existing Management And Conservation Efforts

Federal Lands

The vast majority of federal lands in the study area are owned by the BLM, while other Federal landowners include the U.S. Department of Defense, National Parks, the Forest Service, and the U.S. Fish and Wildlife Service (Table 2-1, Section 2.5).

Bureau of Land Management

In California, the Sonoran Desert falls within the California Desert Conservation Area (CDCA), an area of 25 million acres designated in 1976 through the Federal Land Policy and Management Act. Congress created the CDCA in recognition of the area's special values, its proximity to urban areas, and the need for a comprehensive management plan. The BLM manages approximately half of this area, according to guidelines established in the CDCA Plan, originally established in 1980, and revised in 1999, which directs BLM to "…provide for the immediate and future protection and administration of the public lands in the California Desert within the framework of a program of multiple use and sustained yield, and the maintenance of environmental quality" (BLM 1999). The plan establishes goals for protection and use of the desert by designating the following four multiple use classes, and establishing a framework for managing resources within each classes:

- Class C (controlled): Approximately 3,667,000 acres, including 69 wilderness areas, that are to be preserved in a natural state, and where access is generally limed to non-motorized, non-mechanical means.
- Class L (limited use): Approximately 4 millions acres managed to protect sensitive, natural, scenic, ecological, and cultural resource values, and where multiple uses of low-intensity are allowed.
- Class M (moderate use): Approximately 1.5 million acres managed to provide for higher intensity use and protection of resources. Multiple uses such as mining, livestock grazing, recreation, energy, and utility development are allowed but damage must be mitigated.
- Class I (intensive use): Approximately 500,000 acres managed to allow for concentrated human use. Some protection of resources occurs, and mitigation and rehabilitation occurs when possible.

Within each class, the plan provides a framework for targeting goals associated with 12 plan elements which include cultural resources, Native American values, wildlife, vegetation, wilderness, wild horses and burros, livestock grazing, recreation, motorized vehicle access, geology-energy minerals, energy production and utility corridors, and land tenure adjustment (BLM 1999). In addition, sensitive species and resources may receive addition protection by specific land designations, such as "Areas of Critical Environmental Concern" (ACEC), Special Areas, Natural Areas, and Wilderness Study Areas.

In addition to the CDCA plan, area-specific management in our study area is further guided by the following amendments to the plan: (1) West Mojave Desert/CDCS Plan Amendment, (2) Northern and Eastern Colorado Desert/CDCA Plan Amendment, (3) Imperial San dunes Recreation Area Management Plan/CDCA Plan Amendment, (4) Western Colorado Desert/ CDCA Plan Amendment, (5) Coachella Valley/CDCA Plan Amendment, (6) Santa Rosa and San Jacinto Mountains National Monument Management Plan, (7) Eastern San Diego County Resource Management Plan. The BLM, together with the U. S. Forest Service, also administers the Santa Rosa and San Jacinto Mountains National Monument.

National Parks

The California Desert Protection Act of 1994 (16 U.S.C. §§ 410aaa through 410aaa-83, October 31, 1994) abolished Joshua Tree National Monument, originally established in 1936, and incorporated its lands into a newly created Joshua Tree National Park.

The mission of Joshua Tree National Park is: "The National Park Service at Joshua Tree National Park preserves and protects a representative area of the Colorado and Mojave Deserts and the natural and cultural resources for the benefit and enjoyment of present and future generations. The park strives to maintain its rich biological and geological diversity, cultural history, recreational resources, and outstanding opportunities for scientific study" (National Park Service 2001).

Environmental management of Joshua Tree National Park is primarily guided by the 1995 General Management Plan, as amended by the Backcountry and Wilderness Management Plan (completed in 2000), and the Joshua Tree National Park Fire Management Plan (2005). A long-term future strategy is outlined in the First Annual Centennial Strategy: Joshua Tree National Park (August 2007). The Backcountry and Wilderness Management Plan provides management for lands originally in the monument and those added when the national park was created, in terms of trail use, road status, climbing management, auto camping, area closures, group size, artificial water sources, and desert tortoise recovery, in support of the park's mission.

U. S. Forest Service

The U. S. Forest Service owns and manages the Cleveland National Forest and the San Bernardino National Forests, located at the western and northwestern edges of the Sonoran Desert ecoregion, respectively. Although both forests primarily comprise high elevation lands outside of the Sonoran ecoregion, they also include desert habitats at their lower elevations and important desert transition habitat at mid-elevations, thus providing connectivity between the Sonoran ecoregion and high elevation areas to the west and northwest of the ecoregion.

The Forest Service's 2005 Land Management Plan provides management direction for these two forests, as well as for the Angeles and Los Padres national forests, by presenting a vision for the southern California forests and providing a strategy and design criteria for each individual forest. (U. S. Forest Service 2005a). The Forest Service's mission, "… to sustain the health, diversity, and productivity of the nation's forests and grasslands to meet the needs of present and future generations", is carried through with a renewed emphasis on *condition of the land* rather than *outputs of the land* (U. S. Forest Service 2005b).

The Forest Services' strategic goals are:

1) reduce the risk from catastrophic wildland fire,
2) reduce the impacts from invasive species,
3) provide outdoor recreation opportunities,
4) help meet energy resource needs,
5) improve watershed conditions, and
6) mission-related work in addition to that which supports the agency's goals,

accompanied by the following subgoals: (1) prevent severe wildland fires, (2) stop the introduction, establishment, and spread of invasive species, (3) reduce the conversion of forests and grasslands that lead to fragmentation of rural landscapes through subdivision, and (4) manage impacts of motorized recreation vehicles by restricting use to designated roads and trails.

The Forest Service, together with the BLM, also administers the Santa Rosa and San Jacinto Mountains National Monument.

U. S. Department of Defense

The mission of the U. S. Department of Defense (DOD) is to provide the military forces needed to deter war and to protect the security of our country. The DOD owns and manages the Chocolate Mountains Naval Aerial Gunnery Range and Naval Air Facility El Centro in the Sonoran Desert of California. The Chocolate Mountains Naval Aerial Gunnery Range provides a large land and airspace area for air tactics, Close Air Support missions, laser system operations, and air-to-ground bombing, rocket, and strafing exercises, while Naval Air Facility El Centro provides training to active and reserve aviation units and activities of the Navy's operating and training forces. Training on the latter includes practice gunnery, bombing, carrier landings and air combat (GlobalSecurity.org 2008).

While the DOD's primary goal is military readiness, the department's long-term management goals also include safeguarding native environments and species that rely on them. The DOD has responsibilities through the Sikes Act (16 U.S.C. 670a-670f, as amended) to conserve and protect biological resources on its lands. In 1997, the Sikes Act was amended to call for Integrated Natural Resource Management Plans (INRMPs) via voluntary cooperative agreements between DOD installations, the USFWS, and state fish and wildlife agencies (USFWS 2008b). INRMPs are developed to guide landscape-level management and conservation on DOD lands, ideally in coordination with state agencies and various stakeholders, to facilitate integration of conservation measures and military operations. An INRMP has been developed for Naval Air Facility El Centro, but such a plan still needs to be developed for the Chocolate Mountains Naval Aerial Gunnery Range.

An additional tool promoting dual protection of natural resources and the military's ability to continue training is the Readiness and Environmental Protection Initiative (REPI), which was designed to ensure the military's ability to continue military training on its land in the face of potential encroachment of non-compatible land uses that may adversely impact DOD training missions (10 U.S.C. §2684a Cooperative Agreement Authority). By promoting partnerships with state governments or conservation groups, the REPI can be used to preserve important habitat and provide a buffer around military lands so that training can continue.

U.S. Fish and Wildlife Service

The mission of the U. S. Fish and Wildlife Service (USFWS) is to conserve, protect, and enhance the nation's fish and wildlife and their habitats for the continuing benefit of people. In support of this mission, the service owns and manages the Coachella Valley National Wildlife Refuge (NWR) and the Sonny Bono Salton Sea NWR in California's Sonoran Desert. Located in Arizona, two additional refuges, the Cibola and Imperial refuges also provide haven for wildlife along the Colorado River.

The USFWS oversees recovery of Federally threatened and endangered species through its implementation of the Endangered Species Act of 1973. As part of this responsibility the agency provides oversight and approval of habitat conservation plans such as the Coachella Valley Multiple Species Habitat Conservation Plan and the San Diego East County Multiple Species Conservation Program plan, both currently being developed, as well as the Lower Colorado River Multiple Species Conservation Program, completed in 2004.

Other federal agencies responsible for management and conservation of lands in this region include the Bureau of Reclamation and the Bureau of Indian Affairs (see Section 4.1.3). The U.S. Geological Survey collects and provides environmental data to guide management of public lands.

State Lands

The California Department of Parks and Recreation is the largest state land owner in the Sonoran Desert in California, followed by the State Lands Commission, the CDFG, and the Coachella Valley Mountains Conservancy (Table 2-1, Figure 2-3). Other state lands are administered by the University of California and the Department of Transportation.

California Department of Parks and Recreation

The mission of the California Department of Parks and Recreation is to provide for the health, inspiration, and education of the people of California by helping to preserve the state's extraordinary biological diversity, protecting its most valued natural and cultural resources, and creating opportunities for high-quality outdoor recreation. In California's Sonoran Desert, CDPR owns and manages Anza-Borrego Desert State Park, two state vehicular recreation areas (Heber Dunes and Ocotillo Wells state vehicular recreation areas), two recreation areas (Picacho and Salton Sea state recreation areas), and additional park property at Indio Hills Palms. At the western edge of the Sonoran Desert ecoregion, at the headwaters of important watersheds feeding the desert lands below, CDPR owns Cuyamaca Rancho State Park and Mount San Jacinto State Park.

CDPR lands are managed for a range of purposes, with management zones delineated to address and manage various uses. For example, Ocotillo Wells State Vehicular Recreation Area is managed for recreational vehicular use, while Anza-Borrego Desert Park, managed according to the ABDSP General Plan adopted in 2005, includes the following six management zones:

- State wilderness: areas to be preserved in a natural state, where access is generally limed to non-motorized, non-mechanical means.
- Cultural Preserve: areas delineated for preservation of culturally significant sites, building, or zones that represent significant places or events during the human history of California.
- Backcountry: a predominantly natural environment unmodified except for primitive roads, trails, and primitive campgrounds, and appropriate for exploration by foot, vehicle, horse, and bike.
- Focused-use Zone I: small, highly regulated areas for high impact uses such as campgrounds, picnic areas, restrooms, and visitor centers.
- Focused-use Zone II: small, highly regulated areas for moderate impact uses such as primitive campgrounds, equestrian staging facilities, toilets, and interpretive elements.
- Information/Entrance Zone: small areas dedicated to visitor information and park orientation.

ABDSP is the largest state park in California, and protects a wealth of significant natural and cultural resources. In parks such as this, the CDPR states the following as its first priority: "…to manage for the health of the resources, then determine the maximum degree to which the public can access and enjoy the very resources to which they are drawn, without compromising their experience by compromising the condition of the resources" (California State Parks 2005).

<u>California Department of Fish and Game</u>
The mission of the CDFG is to manage California's diverse fish, wildlife, and plant resources, and the habitats upon which they depend, for their ecological values and for their use and enjoyment by the public. CDFG directly oversees and conducts the majority of wildlife monitoring in the state, and is responsible for sound management of wildlife populations. Regulatory direction comes from the California State Fish and Game Commission, which makes decisions on proposed regulations, permits, licenses, and management policies.

In the Sonoran Desert of California, CDFG owns and manages 9 ecological reserves as part of an ecological reserve system authorized by the California Legislature in 1968, and designed to protect rare plants, animals and habitats, and to provide areas for education and scientific research (Lewis 2001). In addition, CDFG owns three State Wildlife Areas, which typically allow a wider range of activities, such as hunting. Land acquisition is guided by the California Wildlife Conservation Board through their selection, authorization, and fund allocation for purchase of lands for protection and restoration of wildlife habitat.

CDFG presented a long-term management vision for wildlife management in the California Wildlife Action Plan (Bunn et al. 2007), which addressed the following questions:

- What are the species and habitats of greatest conservation need?
- What are the major stressors affecting California's native wildlife and habitats?
- What are the actions needed to restore and conserve California's wildlife, thereby reducing the likelihood that more species will approach the condition of threatened or endangered?

The plan provided recommendations for addressing major wildlife stressors in the Sonoran Desert ecoregion, which were determined to include water diversion, inappropriate off-road vehicle use, loss and degradation of dune habitats, growth and development, and invasive species (Bunn et al. 2007).

State Lands Commission

The California State Lands Commission's mission is to manage approximately 4.5 million acres of land held in trust for the people of California. The State holds these lands "for all the peoples of the State for the public trust purposes of water related commerce, navigation, fisheries, recreation, and open space". The Public Trust Doctrine originally required that land and water be maintained for "commerce, navigation, and fisheries". Subsequent revisions added hunting, fishing, swimming, and recreational boating to the list of requirement, and more recent revisions expanded the requirements to include "preservation of those lands in their natural state" in order to protect scenic and wildlife habitat values (California State Lands Commission 2008).

Included in lands managed by the commission are what are commonly referred to as "school lands". These lands, half of which are located in the California desert, are what remain of approximately 5.5 million acres that Congress granted to California in 1853 to benefit education. The State retains surface and mineral ownership of approximately 469,000 acres of these lands, and only mineral rights on an addition 790,000 acres. Revenue from these lands supports the State Teacher's Retirement System (California State Lands Commission 2008).

The Coachella Valley Mountains Conservancy

The Coachella Valley Mountains Conservancy was created as a state agency within the Resources Agency to acquire and hold, in perpetual open space, mountainous lands surrounding the Coachella Valley and natural community conservation lands within the Coachella Valley. This decision by the California legislature was based on the determination that lands in the Coachella Valley contained unique and important open space, wildlife, scenic, environmental, anthropological, cultural, scientific, educational, and recreational resources that should be held in trust for the enjoyment of, and appreciation by, present and future generations.

The Salton Sea

As described in Sections 3.2 and 5.3.3, the health of the Salton Sea and the many species that rely on it are at risk from declining environmental conditions and future water management changes. As a result of the Quantification Settlement Agreement (QSA) of 2003, which was intended to reduce California's use of Colorado River water to the state's allocated amount, less water will flow into the Salton Sea as a result of agreements that would (1) transfer water from Imperial Irrigation District to other water districts and (2) line the All American Canal. These changes will create additional challenges for management of the sea. As part of the QSA, the State of California agreed to assume most of the financial responsibility of mitigating for these impacts and, more generally, for restoration of the Salton Sea (Legislative Analyst's Office 2008). As a result of the QSA, the state is required to implement a restoration project with the following objectives:

- Restoration of long-term stable aquatic and shoreline habitat for the historic levels and diversity of fish and wildlife.
- Elimination of air quality impacts from restoration projects.
- Protection of water quality.

Many agencies including federal and local governments are involved in the restoration effort, and the process is advised by the Salton Sea Advisory Committee, with the California Department of Water Resources (CDWR) and CDFG playing lead roles in preparing a restoration plan. In May 2007, the Secretary for Resources provided to the Legislature the Salton Sea Ecosystem Restoration Preferred Alternative Report and Funding Plan, and Ecosystem Restoration Study, which was followed by a Final Programmatic Environmental Impact Report. In January 2008, the Legislative Analyst's Office released a report ,"Restoring the Salton Sea", which makes recommendations on how the legislature should proceed with the restoration (The California Resources Agency 2008). At the time of this writing, the legislature has not made a decision on how to proceed.

Formal involvement in the restoration effort by the federal government is optional and has not been decided; the Bureau of Reclamation was required to present a restoration plan to Congress by the end of 2006, and Congress will use that plan to make a decision on federal involvement (Legislative Analyst's Office 2008). Locally, input and involvement of counties, water districts, and tribes occurs via the Salton Sea Authority, a joint powers agency chartered by the State of California in 1993 "…to ensure the continued beneficial uses of the Salton Sea" (The Salton Sea Authority 1997).

Although some important decisions must still be made by the legislature and federal agencies, it is likely that the actual restoration of the sea will be extremely complex and that future management will be intensive. The preferred alternative in the Legislative Analyst's Office's recent report calls for a reduction in useable water by 60 percent, with 52 miles (84 km) of barrier and perimeter dikes and earthen berms to collar the water into a horseshoe shape along the northern shoreline. The central portion would be allowed to dry and serve as a brine sink while saline habitat complexes would be developed at both the north and south ends to provide wildlife habitat (Legislative Analyst's Office 2008).

Native American Lands

The Sonoran Desert in California includes the ancestral and present-day homes of a number of Native American tribes, including the Cahuilla, Chemehuevi, and Yuma tribes (Appendix C). The Federal government maintains a special trust relationship with Indian tribes, as a result of various treaties, statutes, Executive Orders, judicial decisions, and other legal instruments (USFWS 2008c). This relationship creates an enforceable fiduciary responsibility to Indian tribes to protect their lands and resources. Indian lands are, however, not federal public lands or part of the public domain, and are therefore not directly subject to federal public land laws (USFWS 2008c).

The Bureau of Indian Affairs (BIA), within the U.S. Department of the Interior, is responsible for the administration and management of land held in trust by the U.S. government for native American Indians (Bureau of Indian Affairs 2008). Land protection related to development on forests and rangelands, leasing assets on these lands, protection of water and land rights, and direction of agricultural programs are components of the bureau's responsibilities (Bureau of Indian Affairs 2008). Although Indian lands are exempt from a number of laws, involvement by the BIA in such land management situations triggers selected federal laws such as the National Environmental Policy Act (NEPA). Application of specific laws to Indian lands and activities has not always been clear. For example, complexity of the relationship between the Endangered Species Act and tribal rights required a Secretarial Order (#3206, "American Indian Tribal Rights, Federal-Tribal Trust Responsibilities, and the Endangered Species Act") to clarify the responsibilities of agencies and the exercise of tribal rights.

Within the framework of applicable laws, Tribal lands are managed by individual tribes according to tribal goals and objectives (USFWS 2008c), and management may differ from tribe to tribe. For example, the Agua Caliente Band of Cahuilla Indians recently released for public review its draft Tribal Habitat Conservation Plan (THCP), which would apply only to the tribe's lands in and around Palm Springs.

Regional and Local Government Lands

In addition to federal and state lands, the Sonoran Desert in California includes a large number of jurisdictions at the city and county level, resulting in a diverse set of management goals and plans. In some cases these goals and management strategies are being coordinated among jurisdictions to address long-term habitat and species recovery goals and land management strategies.

In the Coachella Valley, the Coachella Valley Association of Governments (CVAG) is lead agency on development of the Coachella Valley Multiple Species Habitat Conservation Plan, which aims to conserve over 24,000 acres of open space and protect 27 plant and animal species. Participants include Riverside County, at least 8 cities, the Coachella Water District, and the

Imperial Water District. To the south, the County of San Diego is lead on the San Diego County's East County Multiple Species Conservation Program (ECMSCP) Plan, also an HCP, which is being prepared to protect sensitive plants, animals, and their habitats in an area of approximately 1.6 million acres, in the unincorporated portions of San Diego County (County of San Diego, 2008). To the east, along the border of Arizona and Nevada, the U. S. Bureau of Reclamation is the lead agency responsible for implementing the Lower Colorado River Multi-Species Conservation Program (LCR MSCP) plan. This HCP was developed to conserve at least 26 federal and state-listed candidate and sensitive species along the lower Colorado River, from Lake Mead to the international border with Mexico (Lower Colorado River Multi-Species Conservation Program 2004).

In addition to the above planning efforts, each county has a general plan which addresses land management and conservation issues, and numerous cities have their own environmental goals and plans, with some but not all incorporated into one of the abovementioned HCPs.

Non-governmental Organization Lands

A number of non-governmental organizations are dedicated to the protection of open space, natural habitats, and biodiversity in the Sonoran Desert in California. Although not all of the following are long-term land stewards, all work to acquire natural area lands for eventual transfer to public ownership, for the purpose of protecting sensitive and rare habitats and species, and for maintaining linkages between ecological preserves, parks and other wildlife refuges:

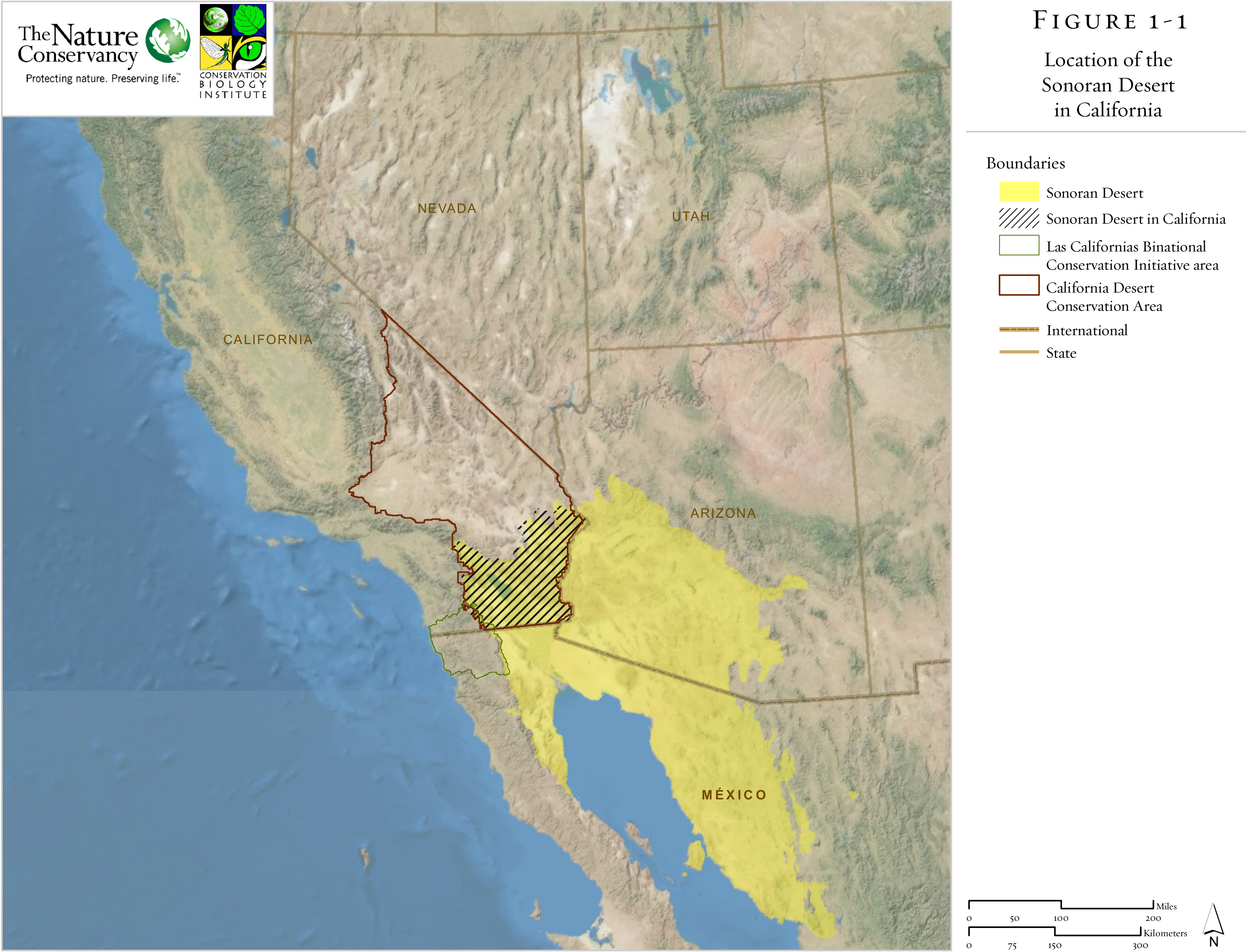
- Anza-Borrego Foundation
- The Nature Conservancy
- The Riverside Land Conservancy
- The Wilderness Land Trust
- The Wildlands Conservancy

Private Lands

A large proportion of the Sonoran Desert in California is in private ownership (Table 2-1, Section 2.5). Management of privately owned land is diverse and unpredictable. The type of use may range from highly protected status to high-density industrial and urban development. As described in Section 2.4, land use patterns have evolved during past years towards increased intensity of use, primarily as a result of water importation and transportation improvements. As southern California's human population grows, it is likely that greater demands will be placed on the desert in terms of development, agriculture, recreation, and energy production and transport.

Appendix F
Acronyms Used in this Report

Acronym	Full Name
ABDSP	Anza-Borrego Desert State Park
ACEC	Area of Critical Environmental Concern
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
CBI	Conservation Biology Institute
CDCA	California Desert Conservation Area
CDFG	California Department of Fish and Game
CDPR	California Department of Parks and Recreation
CDWR	California Department of Water Resources
CNDDB	California Natural Diversity Database
CRWQCB	California Regional Water Quality Control Board
CVAG	Coachella Valley Association of Governments
DMG	Desert Managers Group
DOD	Department of Defense
DOE	Department of Energy
ESRI	Environmental Systems Research Institute
eVeg	Existing vegetation data (U.S. Forest Service)
FLPMA	Federal Land Policy and Management Act
FMMP	Farmland Mapping and Monitoring Program
fVeg	Forestry-Vegetation Management Concentration
GAP	Gap Analysis Program
HCP	Habitat Conservation Plan
INRMP	Integrated Natural Resource Management Plan
MRLC	Multi-Resolution Land Characteristics Consortium
NCCP	Natural Community Conservation Planning
NECO	BLM Northern and Eastern Colorado Desert/CDCA Plan Amendment
NEMO	BLM Northern and Eastern Mojave Desert/CDCA Plan Amendment
NEPA	National Environmental Policy Act
NHD	National Hydrography Dataset
NWR	National Wildlife Refuge
NOAA	National Oceanic and Atmospheric Administration
OHV	Off-highway Vehicle
PCTL	Public Conservation and Trust Lands
PEIS	Programmatic Environmental Impact Statement
QSA	Quantification Settlement Agreement
SRTM	Shuttle Radar Topography Mission
TNC	The Nature Conservancy
UNESCO	United Nations Educational, Scientific, and Cultural Organization
USFWS	United States Fish and Wildlife Service
USGS	U.S. Geological Survey
WEMO	BLM West Mojave Desert/CDCA Plan Amendment
WHBMA	Wild Horse and Burro Management Area


The Nature Conservancy
Protecting nature. Preserving life.™
CONSERVATION BIOLOGY INSTITUTE
NEVADA
UTAH
CALIFORNIA
ARIZONA
MÉXICO
Figure 1-1
Location of the Sonoran Desert in California
Boundaries
Sonoran Desert
Sonoran Desert in California
Las Californias Binational Conservation Initiative area
California Desert Conservation Area
International
State
Miles
0 50 100 200
Kilometers
0 75 150 300
N

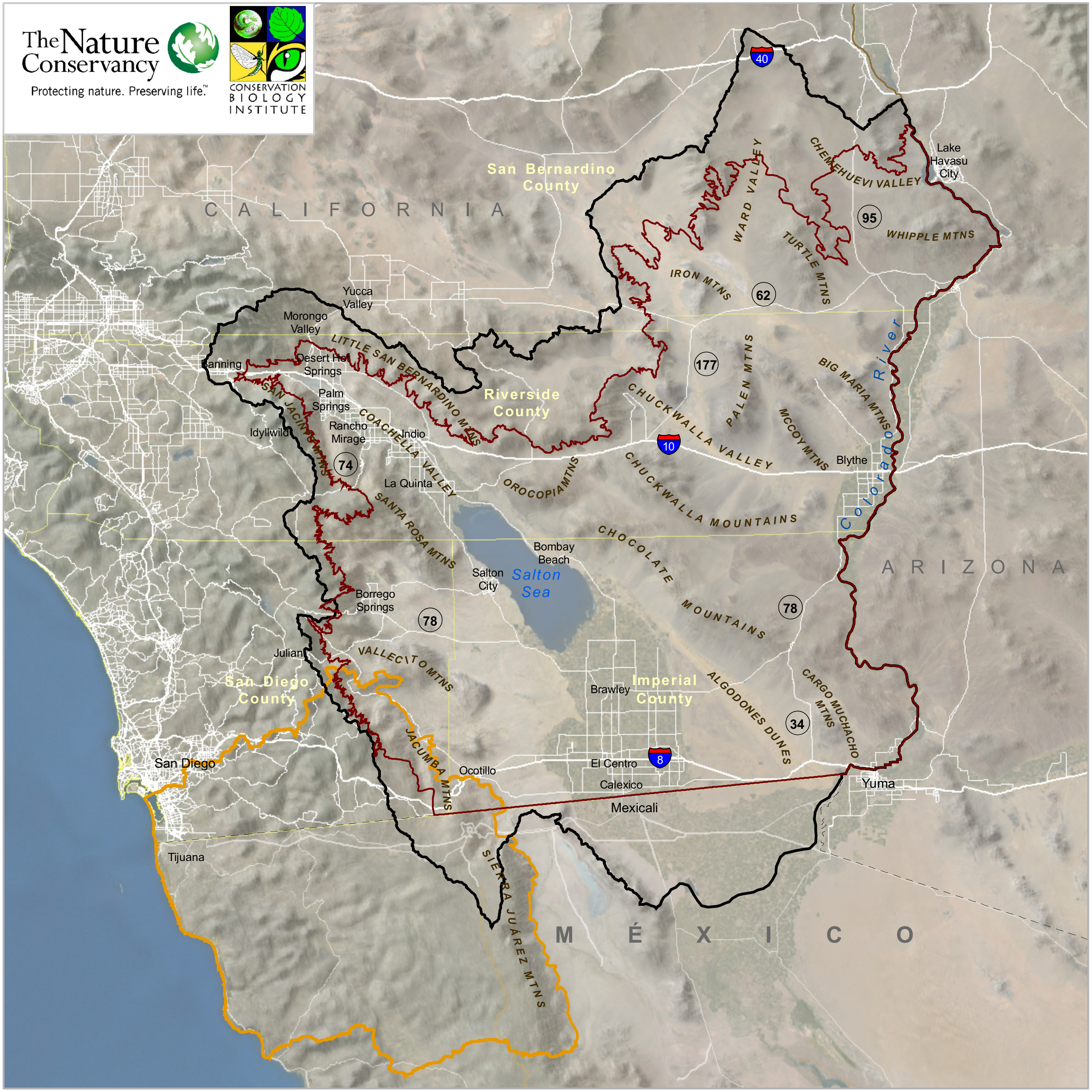


FIGURE 2-1

The Sonoran Desert, California, conservation assessment study area

Project Area

- Transboundary Study Area
- Sonoran Ecoregion, California
- Las Californias Binational Conservation Initiative area

Administrative

- International Border
- State Boundary
- County Boundary

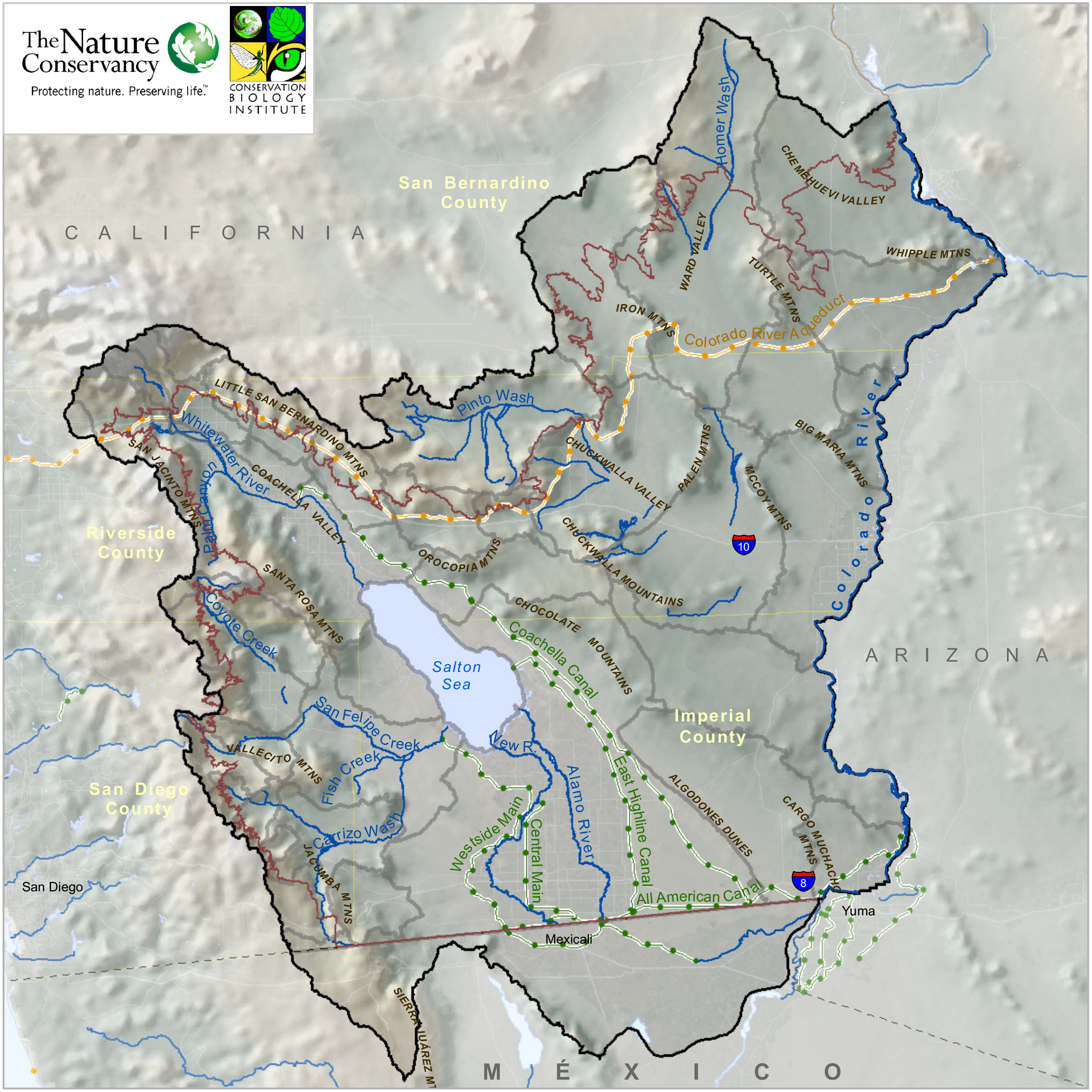
Miles: 0 10 20 40

Kilometers: 0 15 30 60

N

Figure 2-2

Hydrology



Project Area

- Transboundary Study Area
- Sonoran Ecoregion, California

Hydrology

- Perennial River or Creek
- Canal
- Aqueduct
- Watershed Boundary

Administrative

- International Border
- State Boundary
- County Boundary

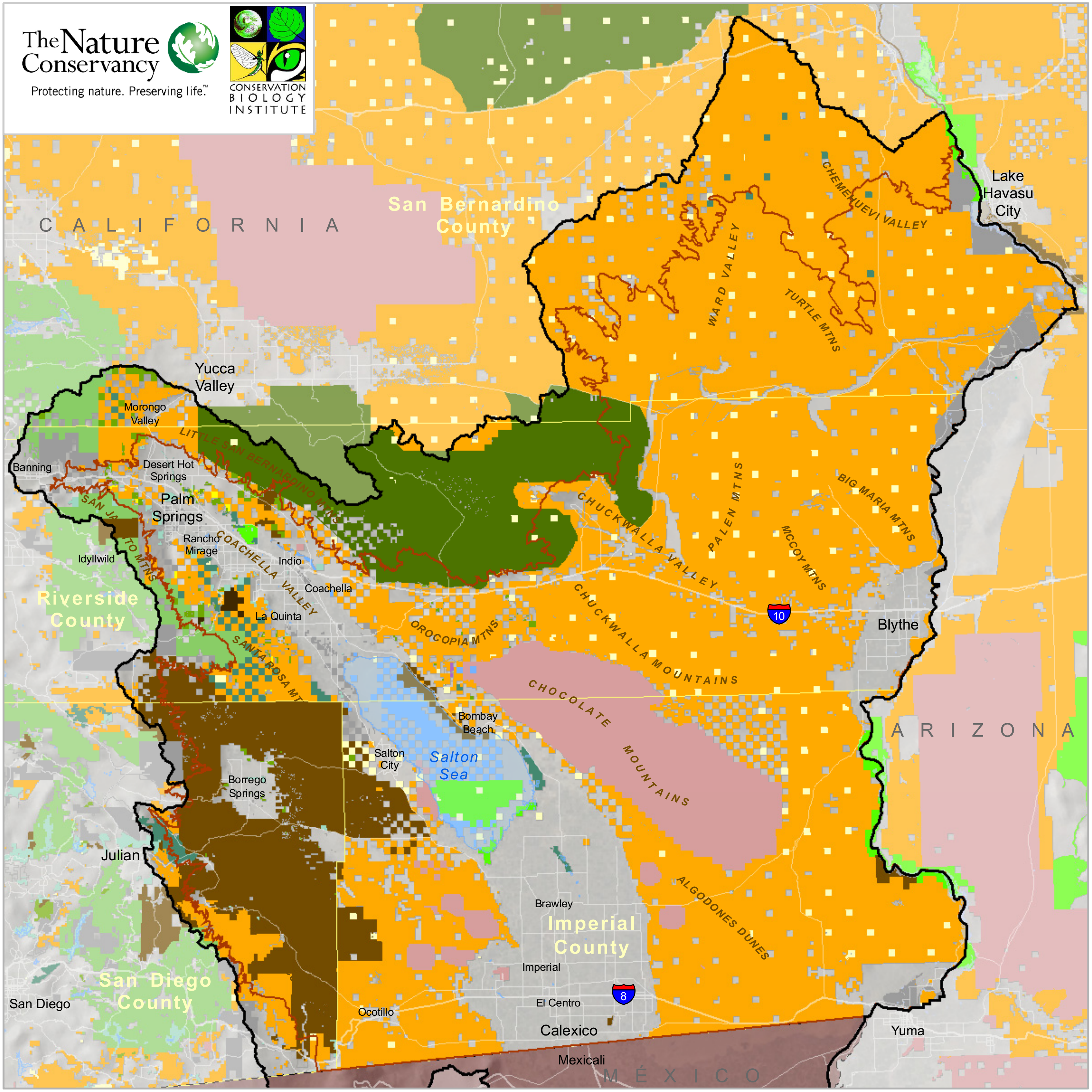
0 10 20 40 Miles

0 15 30 60 Kilometers

N

Figure 2-3

Ownership



Project Area

- Transboundary Study Area
- Sonoran Ecoregion, California

Federal

- National Park Service
- US Fish and Wildlife
- US Forest Service
- Bureau of Land Management
- Department of Defense
- Bureau of Reclamation

State

- University of California
- CA Dept. of Parks & Recreation
- CA Dept. of Fish & Game
- Coachella Valley Mtn Conservancy
- State Land Commission
- CalTrans

Local

- City or County

Other

- Conservation NGO
- Tribal land
- Private land, United States
- México

Administrative

- International Border
- State Boundary
- County Boundary

Miles: 0 5 10 20

Kilometers: 0 12.5 25 50

N

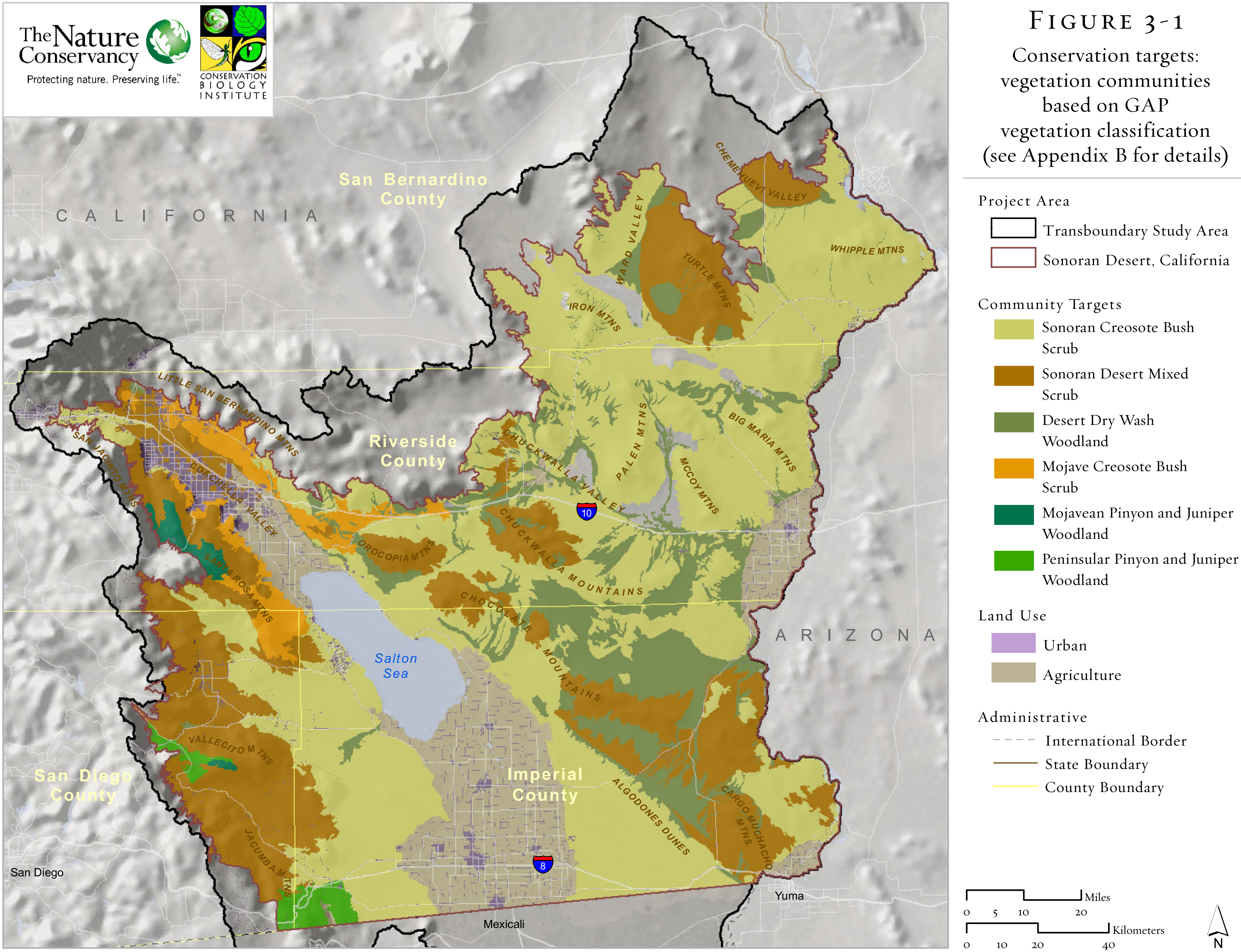


Figure 3-1

Conservation targets: vegetation communities based on GAP vegetation classification (see Appendix B for details)

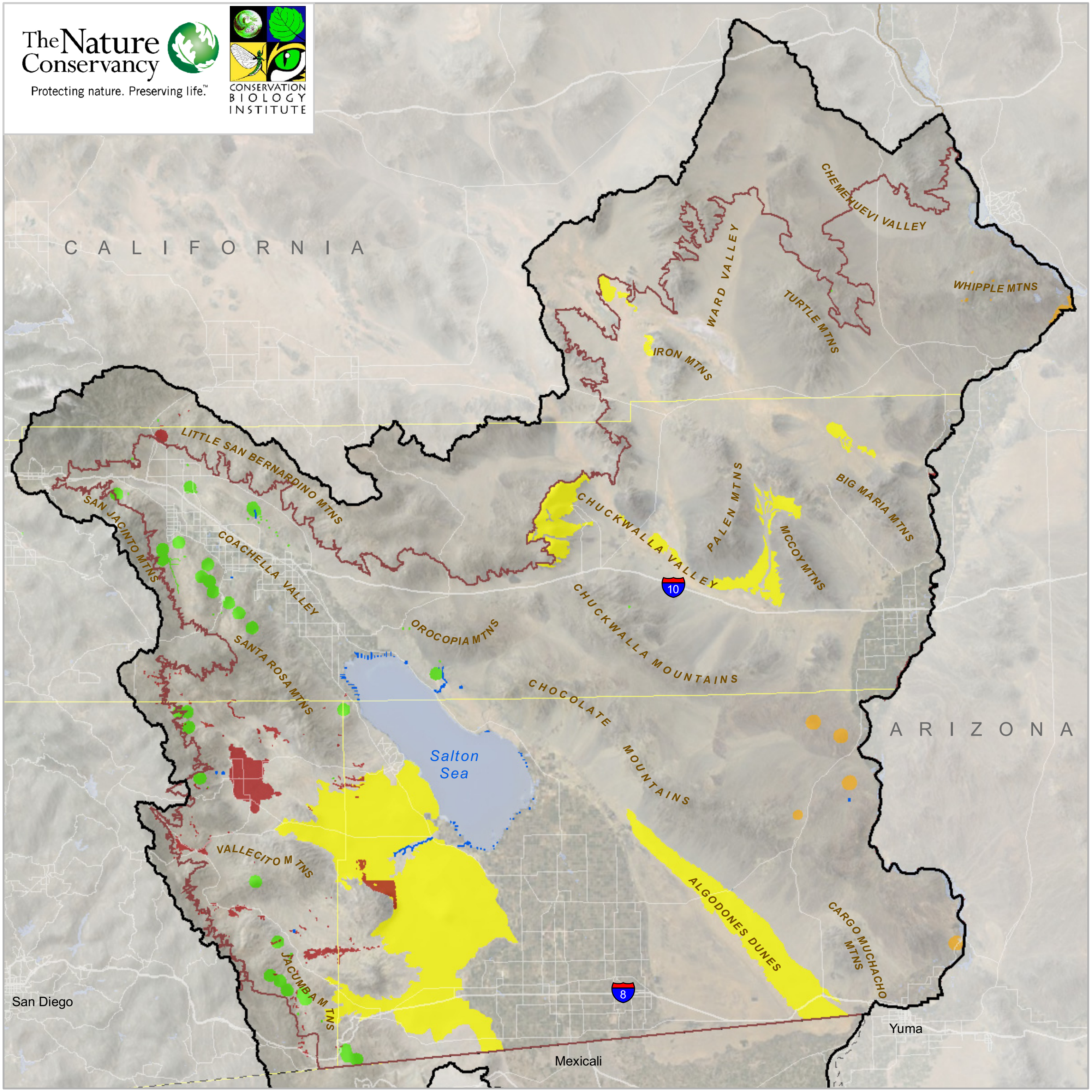


Figure 3-2

Conservation targets: known distribution of palm oases, pupfish ponds, saguaros, sand dunes, and mesquite bosques (see Appendix B for details)

Project Area

- Transboundary Study Area
- Sonoran Ecoregion, California

Conservation Targets

- Palm oasis
- Mesquite bosque
- Pupfish pond
- Saguaro
- Sand dune

Administrative

- International Border
- State Boundary
- County Boundary

Miles: 0 5 10 20

Kilometers: 0 12.5 25 50

N

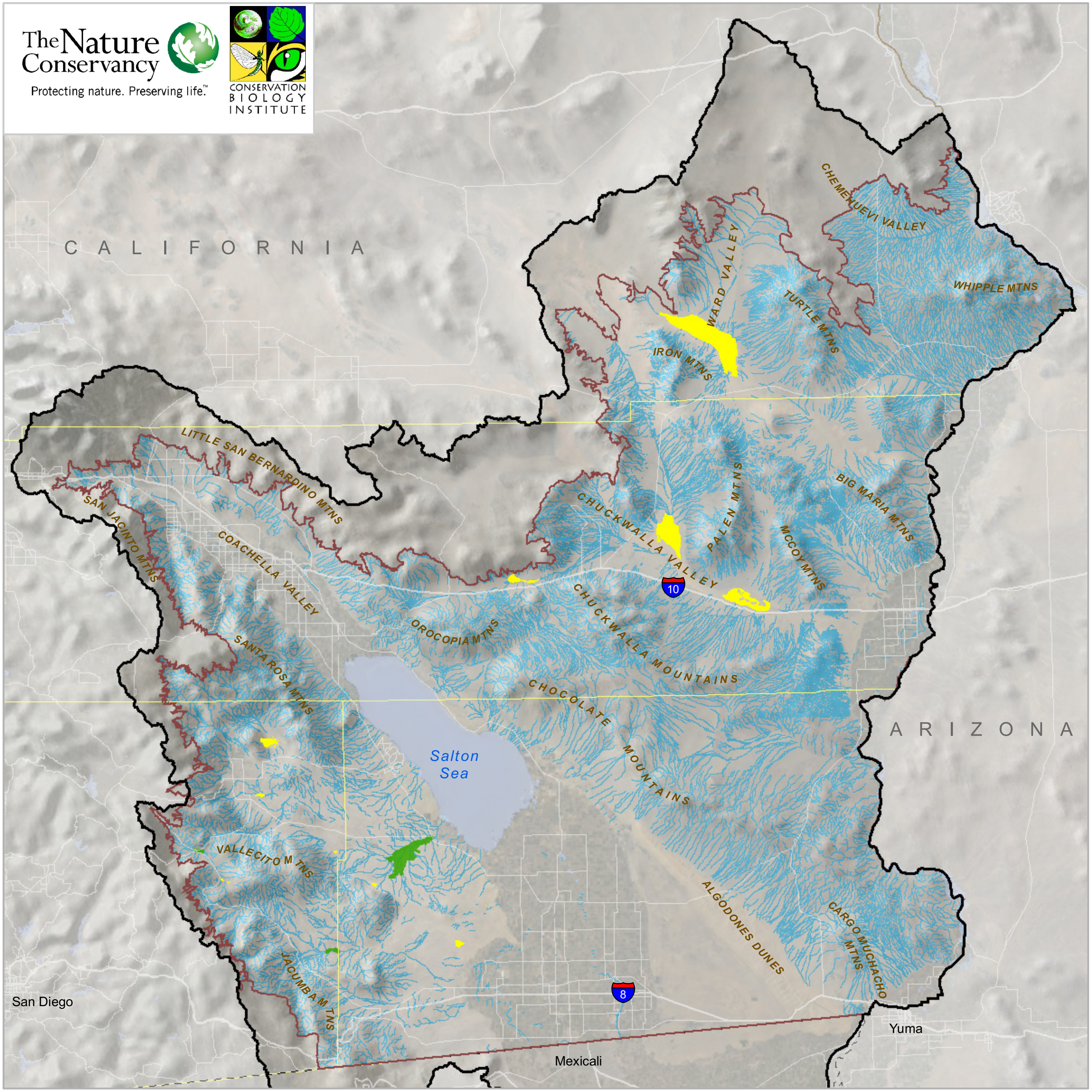


FIGURE 3-3

Conservation targets: known distribution of ciénagas, playas, and combined water-related habitats (see Appendix B for details)

Project Area

- Transboundary Study Area
- Sonoran Ecoregion, California

Conservation Targets

- Playa
- Ciénaga
- Combined water-related habitats

Administrative

- International Border
- State Boundary
- County Boundary

Miles: 0, 5, 10, 20

Kilometers: 0, 12.5, 25, 50

N

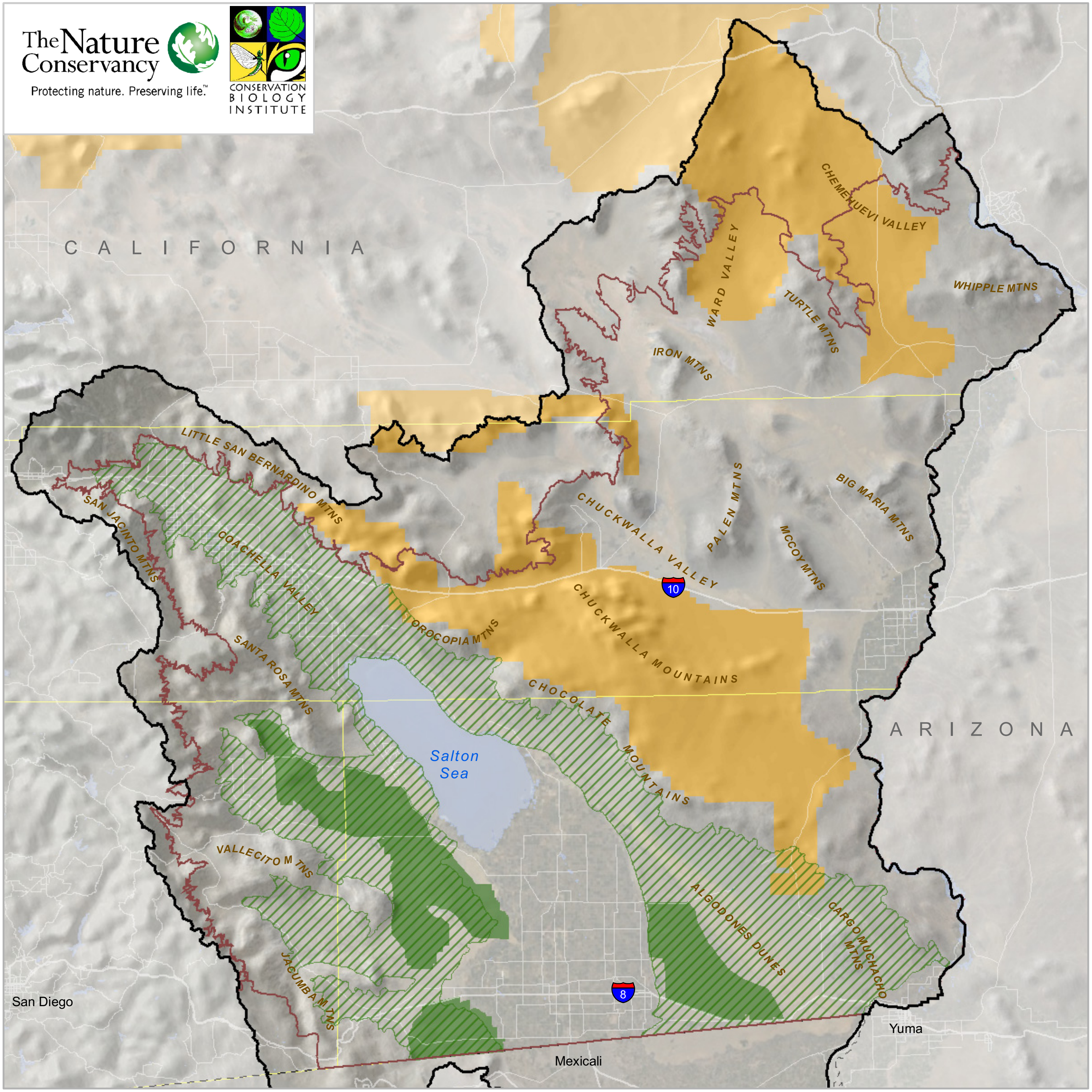


Figure 3-4

Focal species:
flat-tailed horned lizard
and desert tortoise

Project Area
- Transboundary Study Area
- Sonoran Ecoregion, California

Flat-tailed horned lizard
- Range
- Management Areas

Desert tortoise
- Critical Habitat

Administrative
- International Border
- State Boundary
- County Boundary

Miles: 0, 5, 10, 20
Kilometers: 0, 12.5, 25, 50
N

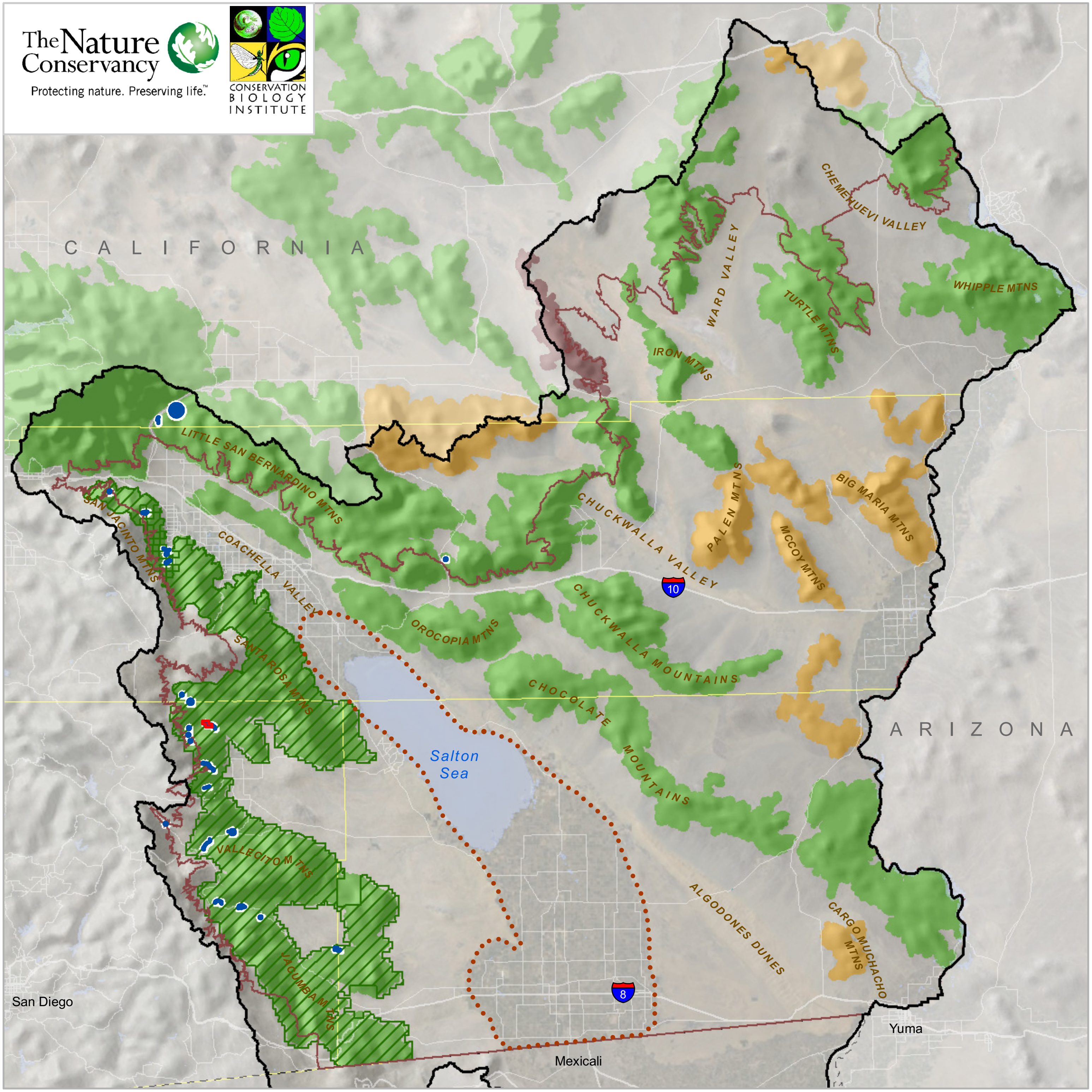


Figure 3-5

Focal species:
bighorn sheep, Least Bell's vireo,
and birds of the Salton Sea

Project Area
- Transboundary Study Area
- Sonoran Ecoregion, California

Least Bell's vireo
- Occurrence record
- Critical Habitat

Bighorn sheep
- Extant
- Status Unknown
- Extirpated
- Critical Habitat - Peninsular Ranges

Birds of the Salton Sea
- Migration stopover area, generalized

Administrative
- International Border
- State Boundary
- County Boundary

Miles: 0 5 10 20
Kilometers: 0 10 20 40
N

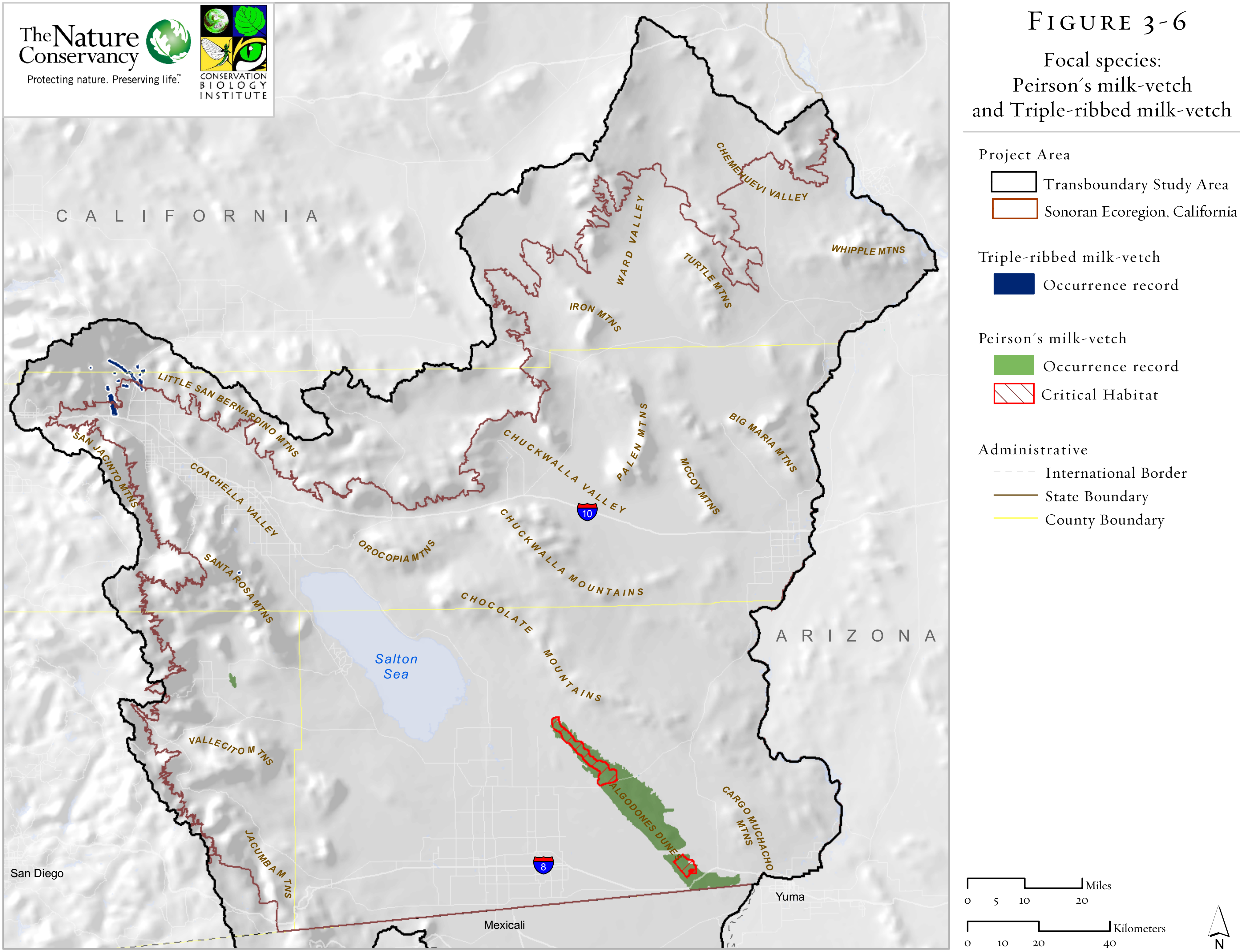


Figure 3-6

Focal species:
Peirson's milk-vetch
and Triple-ribbed milk-vetch

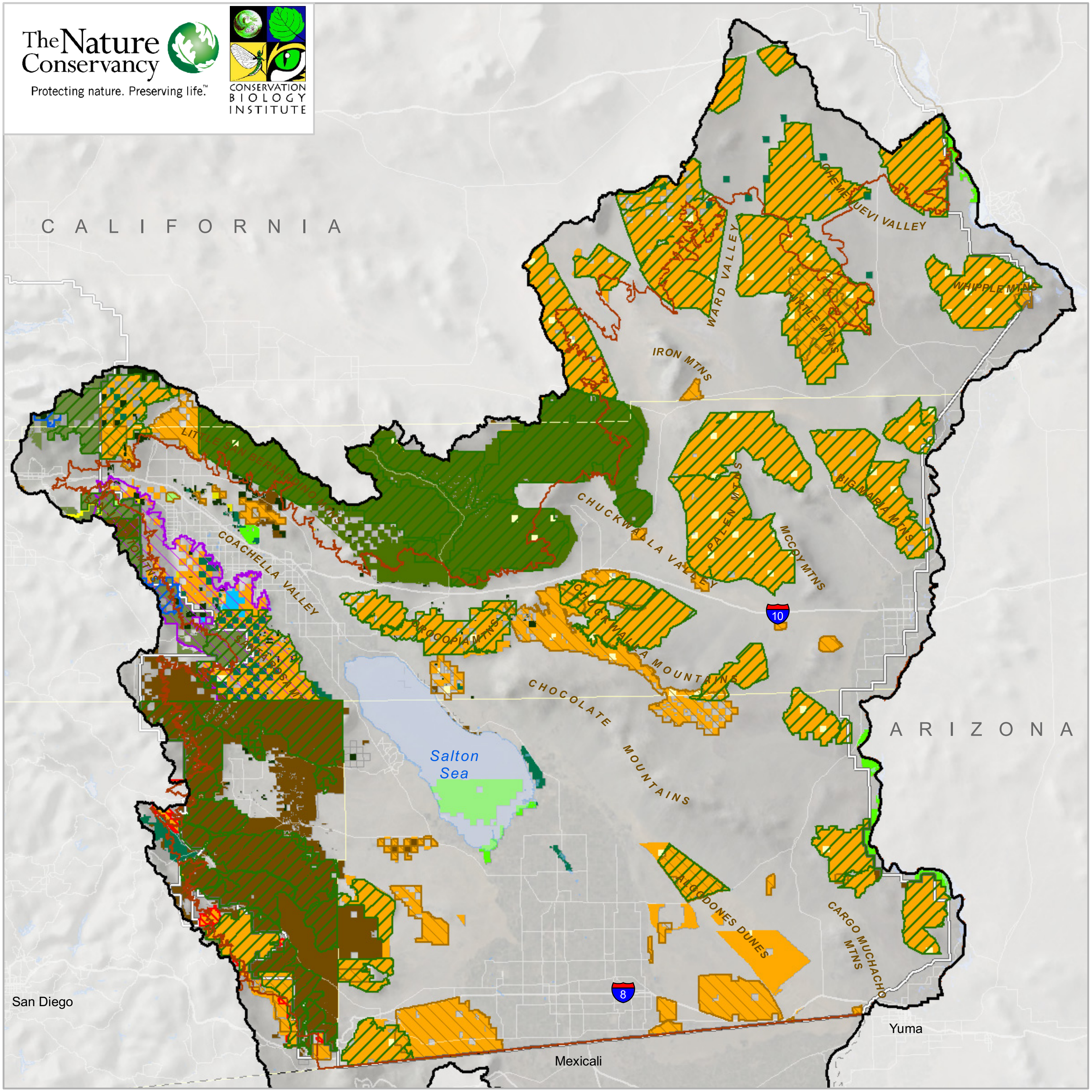


Figure 4-1

Lands with elevated protection (classified as GAP 1 or 2; see Section 5.1 for details).

Note: Freeman poperties owned by the Ca. Dept. of Parks and Recreation are not included because of undetermined management status of properties

Project Area

- Transboundary Study Area
- Sonoran Ecoregion, California

Management Status

- Wilderness
- Area of Critical Environmental Concern
- Recommended Wilderness
- BLM Wilderness Study Area
- National Monument
- USFS Special Interest Area

Owner / Manager

- National Park Service
- US Fish and Wildlife
- US Forest Service
- Bureau of Land Management
- University of California
- CA Dept. of Parks & Recreation
- CA Dept. of Fish & Game
- State CV Mtn Conservancy
- State Land Commission
- City or County
- Conservation NGO

Administrative

- California Desert Conservation Area
- International Border
- State Boundary
- County Boundary

Miles: 0 5 10 20

Kilometers: 0 12.5 25 50

N

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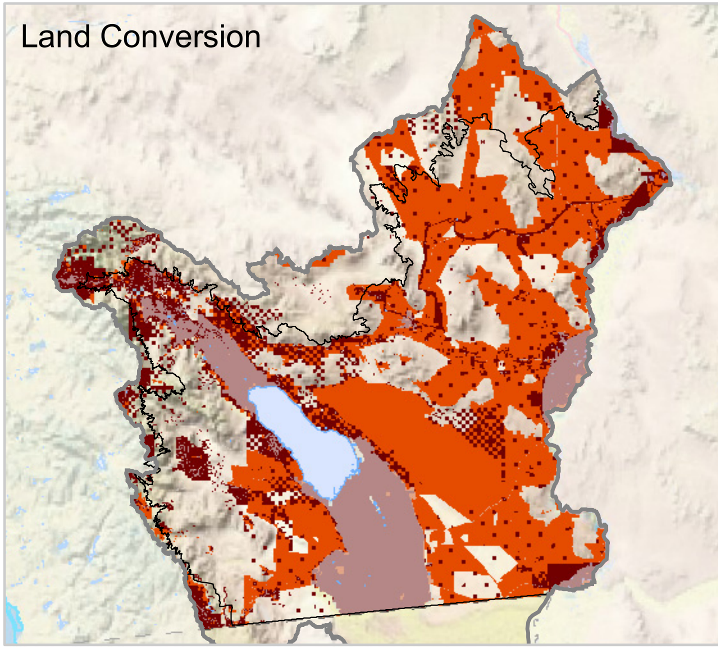
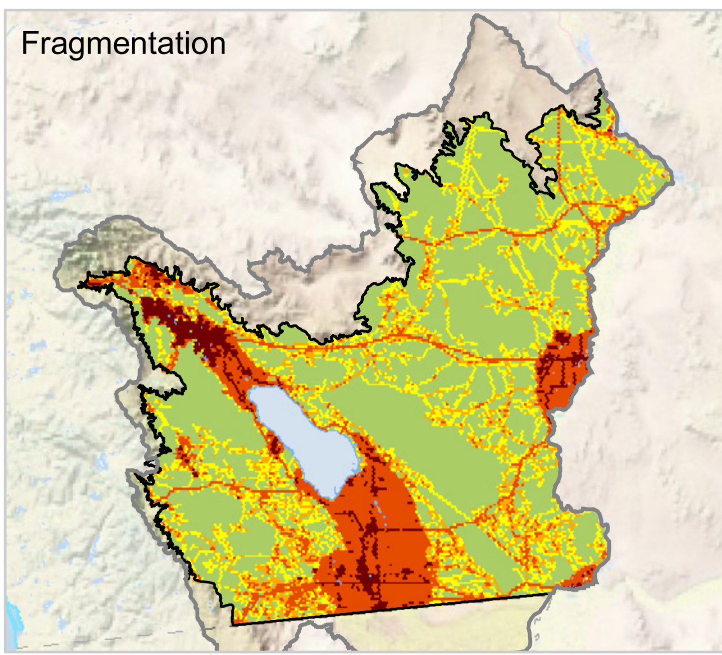
Figure 5-1

Risk of Land Conversion and Existing Fragmentation
(see Appendix B for details)



Threat of Land Conversion

- High
- Medium
- Existing Urban/Ag



Fragmentation

- Severe
- High
- Medium
- Low
- Very Low

Project Area

- Transboundary Study Area
- Sonoran Ecoregion, California

Miles: 0 25 50 100

Kilometers: 0 25 50 100

N

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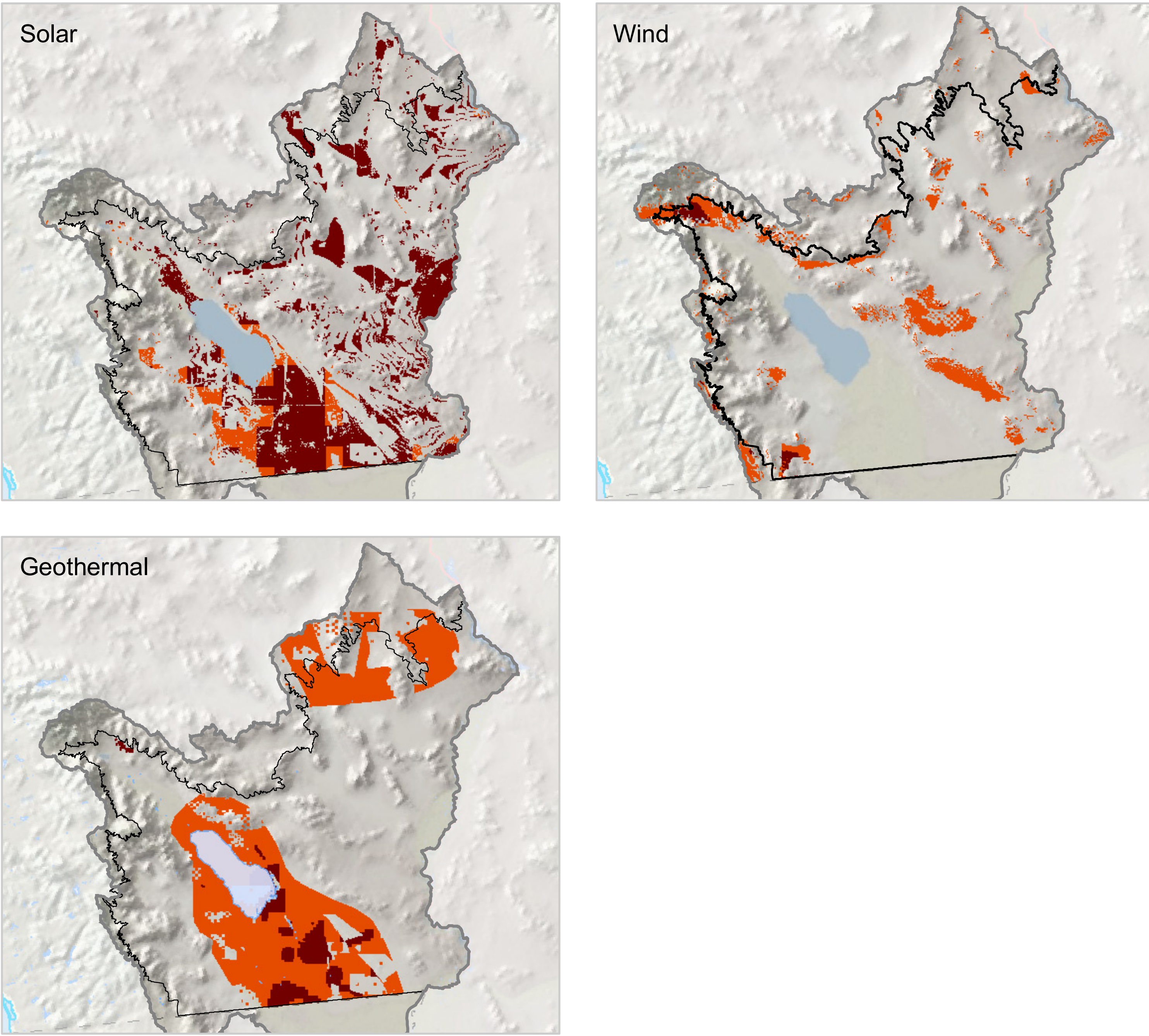
Figure 5-2

Relative probability of renewable energy development (see Appendix B for details)



Project Area

- Transboundary Study Area
- Sonoran Ecoregion, California

Threat level

- High
- Medium

Miles: 0, 25, 50, 100

Kilometers: 0, 25, 50, 100

N

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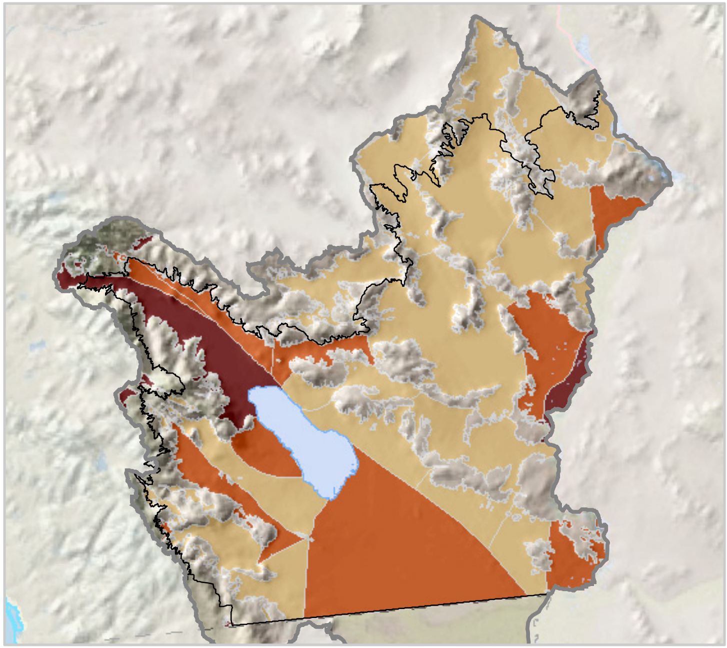
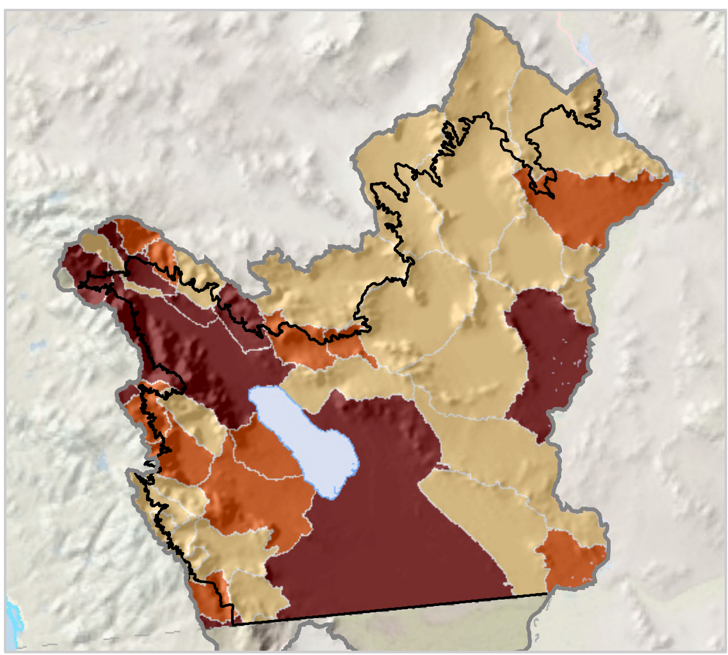
Figure 5-3

Risk of groundwater and watershed impairment
(see Appendix B for details)



Risk of Groundwater Basin Impairment

- High
- Medium
- Low



Risk of Watershed Impairment

- High
- Medium
- Low

Project Area

- Transboundary Study Area
- Sonoran Ecoregion, California

Miles: 0, 25, 50, 100

Kilometers: 0, 25, 50, 100

N

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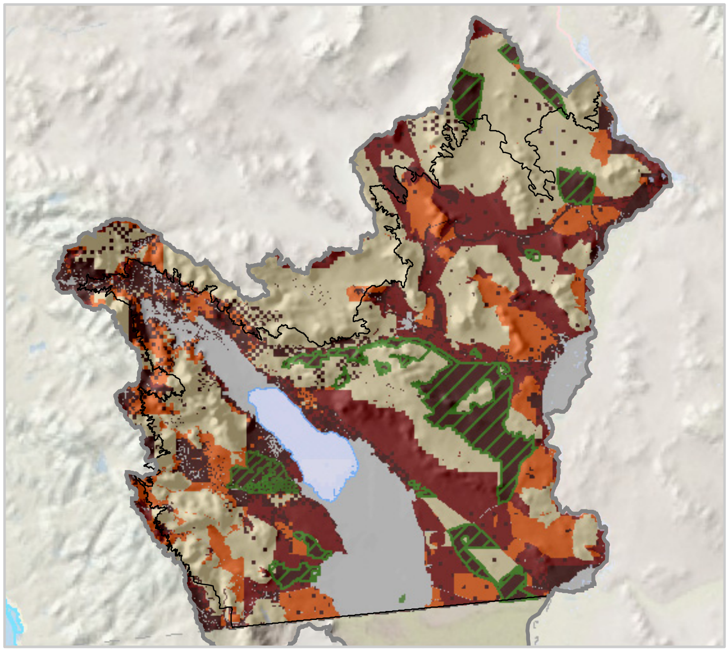
Figure 5-4

Relative probability of OHV activity (see Appendix B for details)



Potential OHV activity based on land management protocols

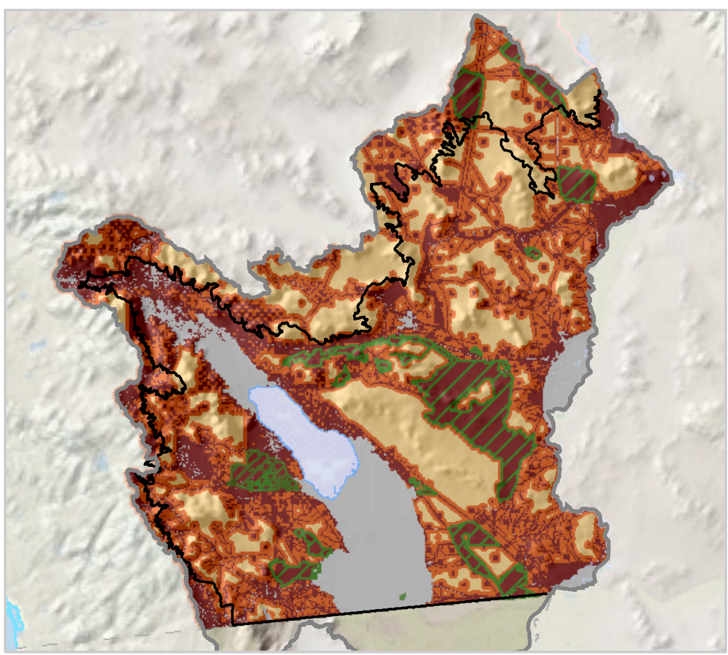
- Very High
- High
- Medium
- Low

Land status

- Designated State or Federal Vehicular Recreation Areas or Open OHV Areas

Land use

- Urban and agricultural lands



Potential OHV activity based on proximity to roads, open routes, open OHV areas, and private lands

- High
- Medium
- Low

Land status

- Designated State or Federal Vehicular Recreation Areas or Open OHV Areas

Land use

- Urban and agricultural lands

Project Area

- Transboundary Study Area
- Sonoran Ecoregion, California

Miles: 0, 25, 50, 100
Kilometers: 0, 25, 50, 100

N

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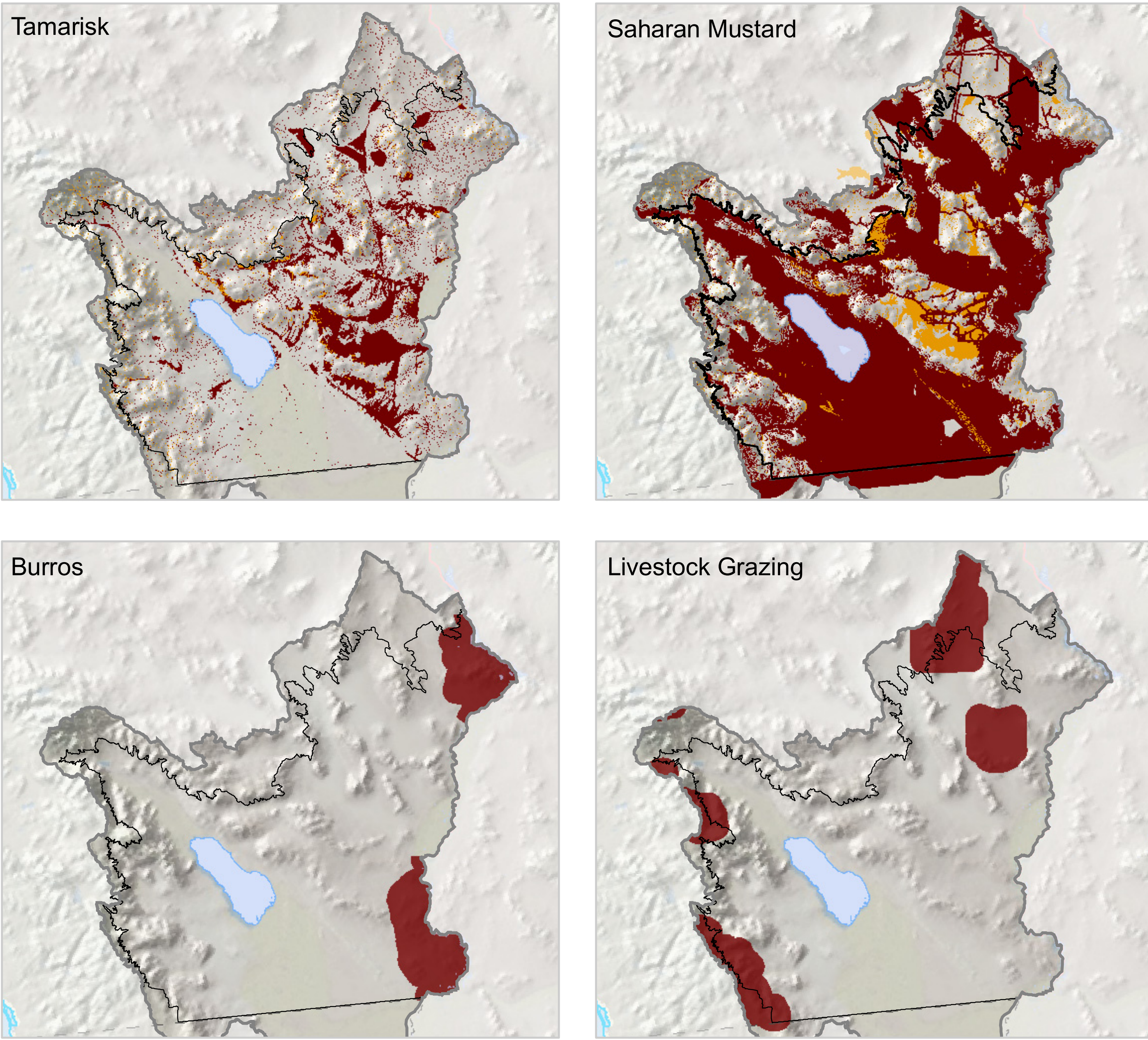
Figure 5-5

Risk of tamarisk, Saharan mustard, burros, and livestock grazing (see Appendix B for details)



Project Area

- Transboundary Study Area
- Sonoran Ecoregion, California

Potential Risk

- High
- Medium

Miles: 0, 25, 50, 100

Kilometers: 0, 25, 50, 100

N

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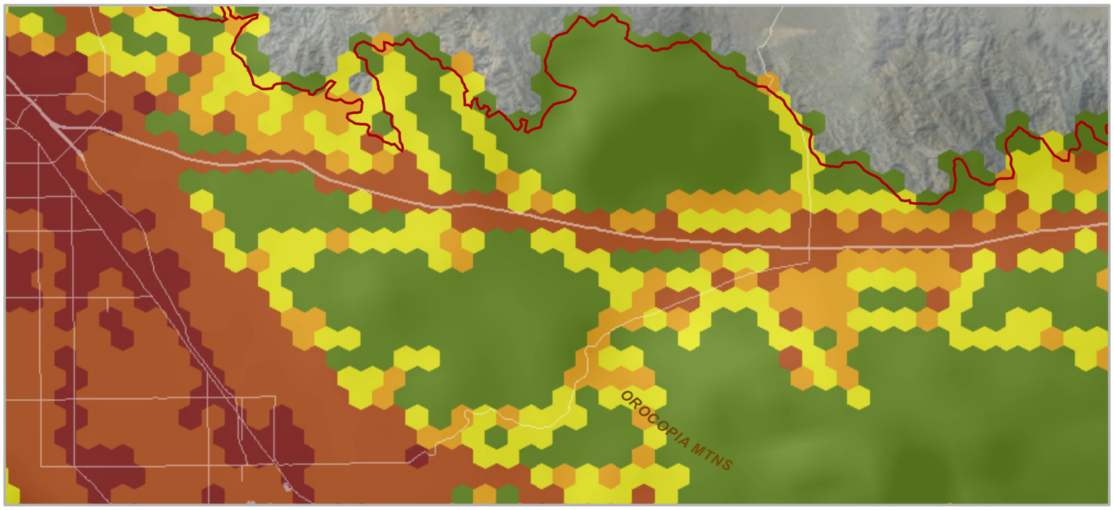
Figure 6-1

Determination of conservation categories:
(see Appendix B and Section 6.1.3 for details)

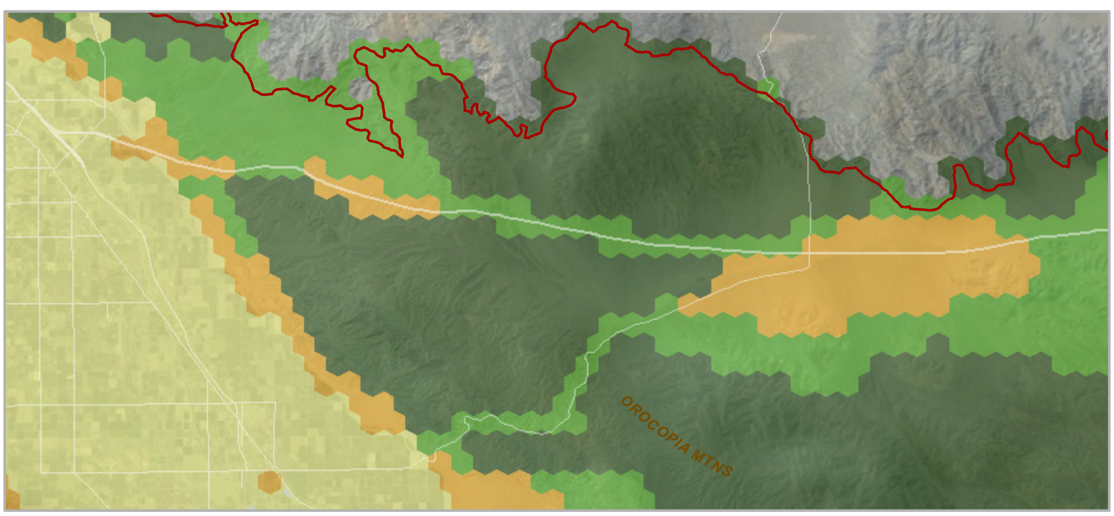


I

A cost surface, defined as the inverse of landscape integrity, establishes the relative cost of conserving a cell.

II

The program Marxan was used to identify areas of high conservation value given the distribution of conservation targets, costs, and established conservation goals.



III

The distribution of landscape integrity and conservation values determined by Marxan were used to assign lands to four conservation categories.

Project Area
- Sonoran Ecoregion, California

I - Cost Surface
- High
- Medium
- Low

II - Marxan Results
- Selected for at least one goal set in at least 6 of 10 runs

III - Conservation Categories
- A
- B
- C
- D

Miles: 0, 1.25, 2.5, 5

Kilometers: 0, 2.5, 5, 10

N

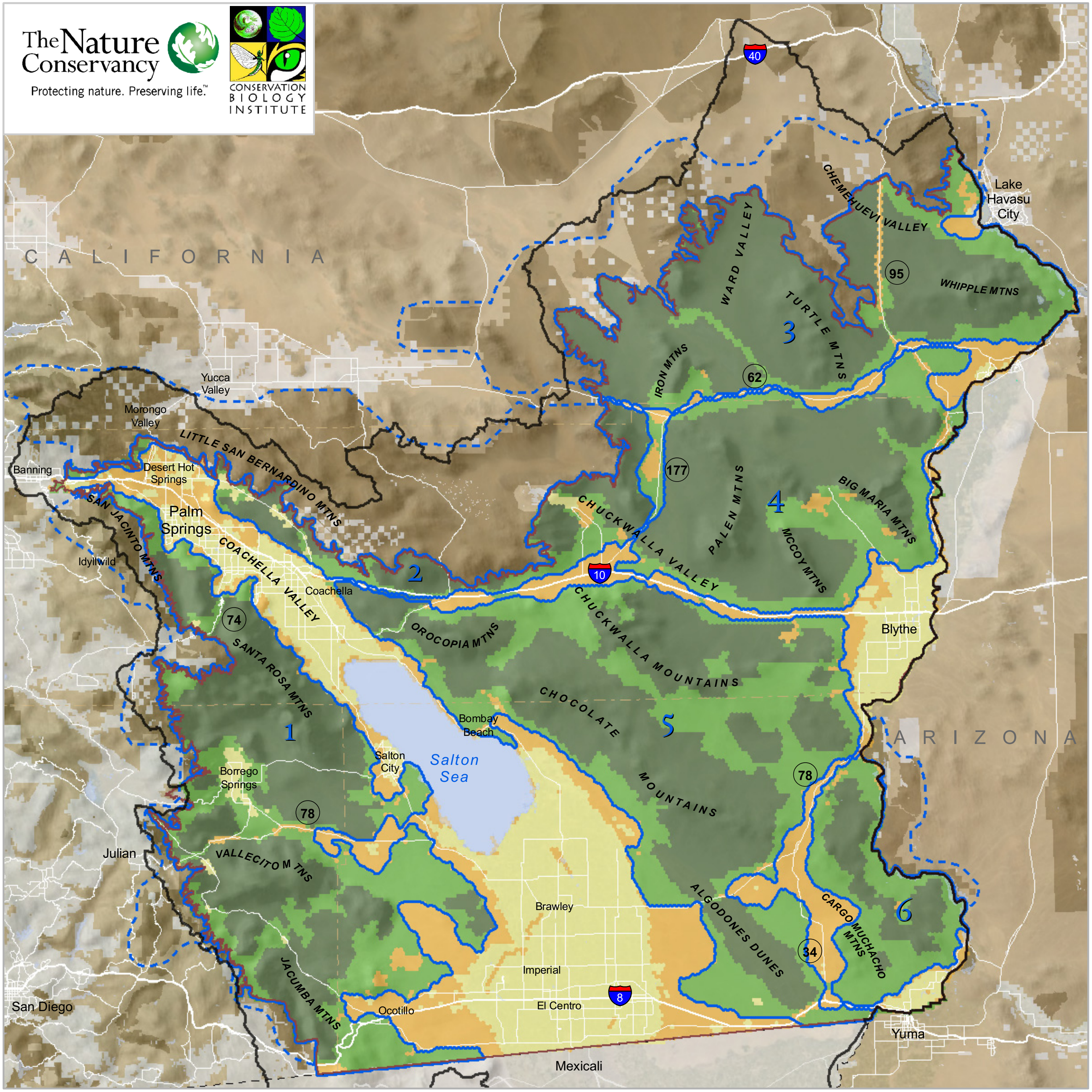


Figure 6-2

Conservation categories and resulting six landscape units (see Appendix B and Section 6 for details)

Project Area

- Transboundary Study Area
- Sonoran Ecoregion, California

Landscape Unit

- Primary unit, Sonoran Desert
- GAP 1 and 2 lands adjacent to unit outside of Sonoran study area (generalized)

Conservation Categories

- A
- B
- C
- D

GAP Status for lands outside of the study area

- 1 or 2
- 3

Administrative

- International Border
- State Boundary
- County Boundary

Miles: 0 5 10 20

Kilometers: 0 12.5 25 50

N

Figure A-1

California-Baja California transboundary region of the Sonoran ecoregion (see Appendix A for details)