CURRENT ECOLOGICAL STRESSORS

Solar development would not represent the only stress on California desert ecosystems; the region has seen significant stresses from human activity, both historic and current. The California desert has histroically served as major trade and migration routes, and was exploited by early settlers, miners, and cattlemen.[1] Today the desert is surrounded by some of the most populous counties in California whose residents place increasing demands on its natural resources. The following provides an overview of the major current stressors, including urban and suburban development, grazing and agriculture, water demand, linear corridors, OHV recreation, invasive species, military operations, and mining.

Urban and Suburban Development

Dramatic population growth in the California desert since the 1980s is correlated with suburban expansion.[2] This growth has continued; San Bernardino County alone showed a population increase of 17.9 percent between 2000 and 2008 according to the U.S. Census Bureau.[3] Population increase typically results in expansion of developed land; as an example, the town of Victorville (in San Bernardino County) experienced a population increase from 8,100 in 1962 to 60,650 in 1995, which was accompanied by an increase of developed area from 25 km^2 to 175 km^2 over the same time period.[4] This sustained growth paired with limited resources in the California desert means people rely on importing necessities such as food, water, and energy. Resource importation results in higher demand on fossil fuel-based transportation as well.[5] Urban and suburban development and population growth lead to additional linear corridors as well as increased groundwater withdrawal and surface water diversion. These developments also contribute to habitat fragmentation, which can have negative impacts on wildlife and plants.

Grazing and Agriculture

The 1980 CDCA Plan states that: "Currently and historically, livestock grazing has been and continues to be a significant use of renewable resources on public land in the California desert."[6] Under the CDCA Plan, the BLM leases 4.5 million acres (36 percent of public lands in the CDCA) to graze cattle and sheep. While livestock production provides benefits in the form of food and fiber, negative ecological impacts are incurred. Negative impacts of livestock grazing in desert ecosystems include decreased plant cover and biomass, shifts in the vegetation community, soil disturbance, soil compaction, and increased spatial

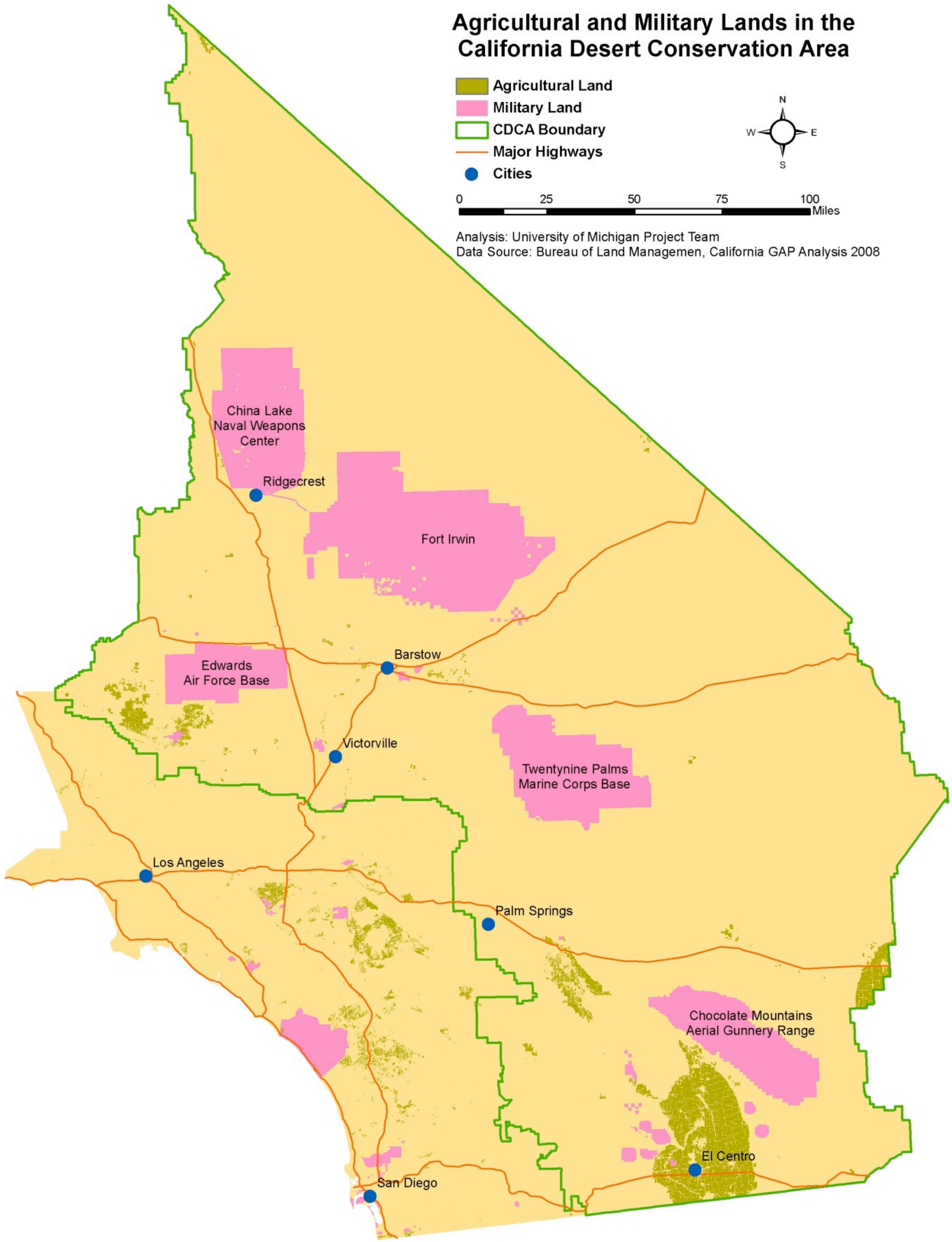
Figure 2.4 Grazing Allotment, Mojave National Preserve. Image Credit: Nerissa Rujanavech.

and temporal heterogeneity of water and soil nutrients.[7] Overgrazing may trigger the decline of arid rangeland through a positive feedback cycle of damage to vegetation and soil structure, and reduced capacity of the soil to capture and retain water, which leads to slowed recovery of vegetation (Figure 2.4).[8] Livestock can also damage soil crusts, which has serious implications for desert ecosystems. The impact that livestock has on soil structure and plants may negatively affect wildlife that depend on desert vegetation for shelter or food.

Agriculture occupies several hundred thousand acres of land in the California desert (Map 2.5). While agricultural production occurs on private land, ecological impacts can be felt beyond land ownership boundaries. For example, Imperial Valley has been heralded as one of the most productive agricultural areas in the world. In 2008, combined field crop and livestock production in Imperial County grossed almost $1.7 million on approximately 600,000 acres of land.[9] In order to sustain such high productivity in an extremely arid region, the Imperial Valley diverts roughly 2.8 to 3.0 million acre-feet of surface water from the Colorado River per year, water that historically replenished aquifers and sustained natural plant and animal communities.[10] Irrigation practices combined with heavy use of pesticides are responsible for the degradation of river water quality and aquatic ecosystems in the New and Alamo Rivers.[11] In addition, poor water management on agricultural land can increase soil salinity and alkalinity while livestock feed and farming practices can facilitate the spread of invasive plant species.[12,13]

Water Demand

The California desert is relatively lacking in surface water. Reliance on groundwater, therefore, is resulting in overdraft conditions in many groundwater basins that are tapped to support agriculture and municipal uses. In fact, communities in the California desert rely on sources outside of the ecosystem (such as Northern California and the Colorado River) for much of their water use, as many regional sources are depleted or nearly depleted.[14] Surface water diversions up-river may lead to heavier dependence on groundwater basins, and overdraft occurs when water extraction exceeds groundwater recharge. When groundwater levels are low, particularly in valleys characterized by fine-grained sediment, there is a greater risk for land subsidence.[15] Subsidence, or a drop in land-surface elevations, can disrupt surface drainage, reduce aquifer-system storage capacity, form earth fissures, and damage wells, buildings, roads, and utility infrastructure.[16] For example, historical ground water pumping in Antelope Valley, which mainly supported agriculture, contributed to more than six feet of land subsidence by the late 20th century.[17] Agriculture has been replaced by population growth as the major stress on the water source, but efforts have been made to import surface water to the area.[18] While subsidence may have been halted in Antelope Valley, the current surface water resource is also limited; periods of drought could lead to increased ground water withdrawal and potentially renewed subsidence.[19]



Map 2.5 Agricultural and Military Lands in the CDCA.

Linear Corridors

Figure 2.5 Linear Corridor, Mojave National Preserve. Image Credit: Sarah Tomsky.

Linear corridors such as roads and vehicular routes, railways, pipelines, and powerlines create long, narrow corridors of disturbance that can impact land far beyond the actual area of the infrastructure (Figure 2.5). For example, 8,000 km of overhead power transmission lines present in the California desert in 1980 were found to impact more than 69,000 acres of land.[20] In a 2006 study by Boarman and Sazaki, the authors found that desert tortoise (*Gopherus agassizii*) populations were reduced in a zone at least 400 meters from roadways.[21] Direct impacts include destruction of soil and plant cover during construction, and prevention of recovery and revegetation of an area due to infrastructure operation and maintenance.[22]

The California desert contains a wide variety and abundance of vehicular routes, including OHV trails, unimproved and improved local roads, arterial roads, and limited-access highways.[23] In a 2009 study, Brooks and Lair refer to vehicular routes as "one of the most intense and pervasive forms of anthropogenic disturbance in the Mojave Desert."[24] Vehicular routes can impact soils by disturbing soil crusts, changing water runoff patterns, and accelerating soil erosion rates, which impacts plant productivity and composition through an alteration of water and nutrient flow across the landscape.[25,26] These routes can also facilitate human access to natural areas, which can amplify other human-related disturbances such as illegal collection and vandalism of plants and animals.[27,28] In addition, routes can increase air pollution, increase accumulation of pollutants (e.g. heavy metals) in soils and plants, facilitate non-native species invasion, and lead to wildlife mortality.[29]

Potential Major Corridor: The DesertXpress

The DesertXpress, a high-speed passenger train proposed to run between Victorville, California and Las Vegas, Nevada, represents a potentially major new linear corridor running through the California desert. Meant to offer an alternative transportation option for Californians to access Las Vegas, project proponents highlight the need for reduced automobile congestion along Interstate 15. To that end, the rail would generally run alongside I-15, mainly utilizing public Right-of-Way over BLM managed lands.[30] In the Draft EIS Report, prepared by the U.S. Department of Transportation's Federal Railroad Administration in March of 2009, several potential impacts to biological resources were identified if the project proceeds. The impacts of this proposed linear corridor could include (but are not limited to) permanent removal of some special-status plants, loss of suitable desert tortoise (*Gopherus agassizii*) and Mohave ground squirrel (*Spermophilus mohavensis*) habitat, increased habitat fragmentation as a result of added barriers to wildlife movement, and mortality of wildlife during construction phase.[31]

OHV Recreation

OHV use is a popular recreational activity in the California desert. OHVs, also known as ORVs (off-road vehicles), include four-wheel drive trucks and sport-utility vehicles, all-terrain vehicles (ATVs), and dirt bikes. The creation of new, illegal OHV routes is a serious problem on BLM land. A single pass by a vehicle will leave a track, and repeated use of the track can create a visible trail.[32] The inadvertent or intentional creation of new trail networks in desert areas is particularly problematic because the lack of dense vegetation makes it easy for OHVs to drive off-route. Equally challenging for the BLM are closing illegal routes, restoring past damage, and preventing the creation of illegal routes in the first place. OHV use in fragile desert ecosystems destroys soil crusts and soil stabilizers, increases wind and water erosion, contributes to soil compaction, decreases water infiltration into the soil, crushes plant stems, foliage, and roots, and increases noise and air pollution that negatively impacts wildlife.[33] Compacted soils reduce plant and seedling survival by impeding root growth. OHV use in legal recreation areas can also have negative ecological impacts. For example, the Imperial Sand Dunes Recreation Area is an intensively used OHV area that receives over 1.4 million OHV visitors per year.[34] OHV use has been found to negatively impact the survival of an Algodones Dunes endemic plant, the Peirson's milk-vetch (*A. m.* var. *peirsonii*), a threatened species under the Endangered Species Act, causing both short- and long-term damage.[35] OHV use in the Mojave Desert has also been shown to produce noise levels loud enough to cause hearing loss in kangaroo rats (*Dipodomys* spp.), desert iguanas (*Dipsosaurusdorsalis* spp.), and fringe-toed lizards (*Uma* spp.), which may affect species survival.[36] Engine emissions from OHVs are not regulated in the same way as on-road vehicles, and are significant contributors to air pollution, affecting humans and wildlife.[37]

Invasive Species

Invasive plants have a significant impact on native species throughout California. The colonization of natural areas by non-native plants has been facilitated by transportation corridors and habitat disturbances such as OHV recreation, livestock grazing and agriculture.[38] In the California desert, invasive plants compete for resources, such as water and soil nutrients, and can use allelopathic chemicals to inhibit native plant growth.[39] Invasive plants also disrupt natural fire regimes. In riparian areas invasive plants, such as saltcedar (*Tamarix* spp.), pose serious threats to native vegetation and wildlife species.

Military Operations

The military has a large historic and current presence in the California desert. During World War II, the U.S. Army established several temporary camps and training grounds in the Mojave Desert and over a million soldiers have passed through these training facilities.[40] Today active military bases include the National Training Center at Fort Irwin, the Marine Corps Air Ground Combat Center at Twentynine Palms, China Lake Naval Air Weapons Station, and the Chocolate Mountain Aerial Gunnery Range (Map 2.4).[41] Military bases can provide protection from disturbances by limiting public access to large areas, but military training exercises and infrastructure can also be detrimental to the desert ecosystem. Tent sites, roads, tanks, and vehicles can compact soil, alter soil texture, remove topsoil, alter drainage, and decrease plant density and cover (Figure 2.6).[42]

Figure 2.6 Marine Corps Air Ground Combat Center, Twentynine Palms, CA. Image Credit: Sarah Tomsky.

Mining

In 2008, the State of California supported 717 active non-fuel mines.[43] Mining has occurred in the California desert since the late 1880s and continues to the present day. The CDCA produces a variety of mineral commodities and has "excellent potential" for future production, according to the CDCA Plan.[44,45] Impacts of mining include the construction of pits, ore dumps, and mine tailings, the evaporation of compounds from dry lake mine operations, and exposure of wildlife to radioactive materials.[46] Rare-earth metals, for example, are currently being mined near the town of Mountain Pass in San Bernardino County (Figure 2.7). These rare-earth minerals have many uses; of particular interest is the importance of some of these minerals in the manufacturing of "green" technologies such as hybrid cars, wind turbines and compact fluorescent lightbulbs.[47] In the case of Mountain Pass Mine, impacts have included radioactive wastewater leaks.[48] The mining operation was shut down for several years due to environmental impacts, though it was recently permitted to reopen, following statements from the mining company that these impacts have been resolved.[49] While the mined rare-earth materials are needed for environmentally friendlier energy and transportation alternatives, the resulting environmental impact to produce these technologies is difficult to ignore.

Figure 2.7 Mountain Pass Mine, San Bernardino County. Image Credit: California State Mining and Geology Board.

Climate Change

All of the above impacts must also be considered in the context of climate change and its biological and ecological implications. Climate models show a slow warming of the Mojave and Sonoran Desert regions, especially at night.[50] This warming is likely to alter precipitation regimes and weather patterns, which could alter plant cover and productivity, and affect ecosystem functions, species distribution, and community composition.[51,52] Desert ecosystems are particularly sensitive to changes in atmospheric carbon dioxide. Future rises in atmospheric carbon dioxide will affect rates of plant photosynthesis and water loss, and are predicted to increase efficiency and productivity in desert plants.[53,54] Increased plant productivity, especially the productivity of invasive grasses, could increase the incidence of wildfire in the desert.[55,56] Increased variability, more episodic climate events, and more severe and persistent droughts are predicted for desert ecosystems worldwide.[57] Therefore, climate change has implications for plants and their pollinators, wildlife species, and ecosystem processes, and may exacerbate impacts from current stressors.

Addressing climate change may include a transition from fossil fuel-based energy generation to renewable energy sources. Given this, utility-scale solar facilities may be one way for California to meet its growing energy needs while also reducing greenhouse gas emissions. However, the sensitivity of desert ecology must be considered in the decision-making process, especially given the existing stressors on the ecosystems. In order to understand how solar development may affect desert ecology, it is necessary to know how these ecological processes function and why they are important. Having provided this information above, our ecological impact analyses in Chapters 5 and 6 can be understood in the context of this broader ecosystem functioning.

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Chapter 2

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