

Habitat Conservation in the Panoche Valley Region: Contributions to the Conservation and Recovery of Listed Species

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The Panoche Valley, located in central California, has long been recognized as an important area for a number of rare and sensitive species, including several that have been afforded protection under the Federal and California Endangered Species Acts. Many of these species are endemic to the San Joaquin Valley bioregion, which includes the Panoche Valley. The importance of this area has increased as habitats in the San Joaquin Valley have become critically limited due to ongoing conversion to agricultural, urban, and industrial uses. However, relatively little of the habitat in the Panoche Valley region is protected in perpetuity. Thus, permanent protection of additional natural lands in this region would contribute significantly to biodiversity conservation and the recovery of listed species.

A large solar plant project has been proposed for construction in the Panoche Valley, which would be constructed on 2,506 acres on the floor of the Panoche Valley. As part of the mitigation for project impacts, the solar plant project has also proposed permanently conserving 24,176 acres of habitat. This paper assesses the habitat value of the Panoche Valley to listed species, as well as whether the proposed conservation lands provide an opportunity to contribute to the conservation of rare species in the region.

The Panoche Valley proper is located in eastern San Benito County (Fig. 1). The bioregion that includes the valley also extends into southwestern Merced County and northwestern Fresno County. This region is situated on the western edge of the San Joaquin Valley at the base of the Coast Ranges. Arid grasslands and shrublands are the dominant habitat types within the region. These types are preferred habitats for many sensitive species. Specific types include annual grasslands dominated by introduced species such as bromes (*Bromus spp.*) and wild oats (*Avena spp.*), and shrublands dominated by saltbushes (*Atriplex spp.*) and ephedra (*Ephedra spp.*). Other habitats are limited in occurrence but contribute to regional biodiversity and include oak and juniper woodlands, ponds and wetlands, and vernal pools (Energy Renewal Partners 2014). Topographically, the terrain ranges from flat or very gently sloping on valley floors to very steep and rugged hills that are highly dissected by drainages, and this terrain variation creates numerous microhabitats that also contribute to regional biodiversity.

Human presence and impacts in the Panoche Valley and surrounding region have been relatively light. The region is very sparsely populated with most residences occurring in the valley itself. Possibly due to limited water availability, irrigated agriculture has only ever been conducted on just a few hundred acres, although dry land farming may have been occurred at some point over much of the valley floor. The primary land use has been livestock grazing. Limited mining has occurred in the region as well. Consequently, habitat quality tends to be high and with little fragmentation. This is in sharp contrast to nearby San Joaquin Valley lands where most habitat

has been converted and what little habitat remains is highly degraded and fragmented (U.S. Fish and Wildlife Service 1998, Kelly et al. 2005).

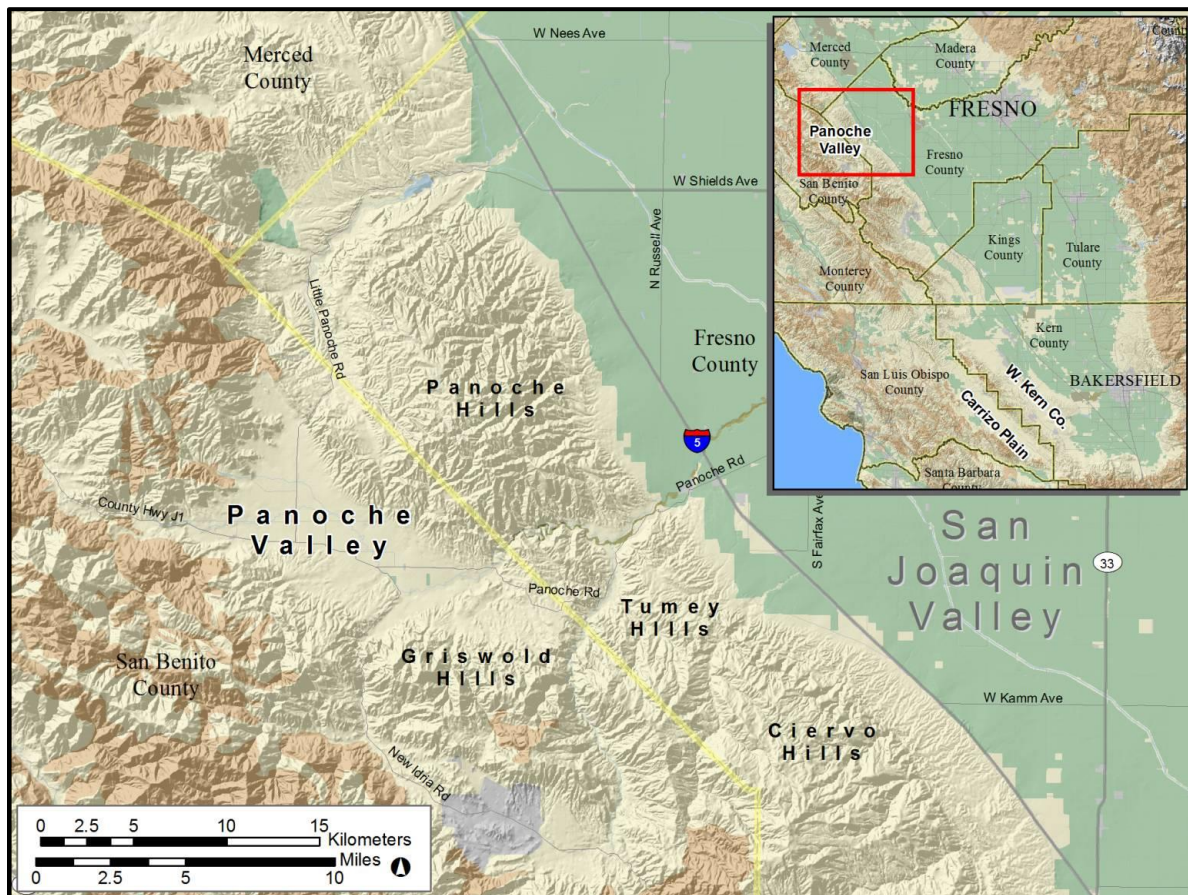


Figure 1. Panoche Valley region in central California and location relative to other areas important for listed species (e.g., Western Kern County and Carrizo Plain). Green shading is irrigated agriculture.

A number of sensitive species are known to occur in the Panoche Valley region. Protected species include the San Joaquin kit fox (*Vulpes macrotis mutica*; Fed Endangered, CA Threatened), giant kangaroo rat (*Dipodomys ingens*; Fed Endangered, CA Endangered), San Joaquin antelope squirrel (*Ammospermophilus nelsoni*; CA Threatened), blunt-nosed leopard lizard (*Gambelia silus*; Fed Endangered, CA Endangered and “Fully Protected”), California tiger salamander (*Ambystoma californiense*; Fed Threatened, CA Threatened), vernal pool fairy shrimp (*Brachinecta lynchi*; Fed Threatened), and San Joaquin woolly-threads (*Monolopia [=Lembertia] congdonii*; Fed Endangered). Also, California condors (*Gymnogyps californianus*; Fed Endangered, CA Endangered) are known to fly over the region and may possibly land to feed on occasion. Other sensitive species recorded in the region include American badger (*Taxidea taxus*), mastiff bat (*Eumops perotis*), golden eagle (*Aquila chrysaetos*), mountain plover (*Charadrius montanus*), loggerhead shrike (*Lanius ludovicianus*), tricolored blackbird (*Agelaius tricolor*), burrowing owl (*Athene cunicularia*), coast horned lizard (*Phrynosoma coronatum*), San Joaquin coachwhip (*Masticophis flagellum ruddocki*), western pond turtle (*Actinemys*

marmorata), Lost Hills crownscale (*Atriplex coronata* var. *vallicola*), round-leaved filaree (*California macrophylla*), Hall's tarplant (*Deinandra halliana*), Hospital Canyon larkspur (*Delphinium californicum* ssp. *interius*), recurved larkspur (*Delphinium recurvatum*), Temblor buckwheat (*Eriogonum temblorense*), pale-yellow layia (*Layia heterotricha*), Munz's tidy-tips (*Layia munzii*), Panoche pepper-grass (*Lepidium jaredii* ssp. *album*), showy golden madia (*Madia radiata*), Indian Valley bush-mallow (*Malacothamnus aboriginum*), and chaparral ragwort (*Senecio aphanactis*). Thus, the Panoche Valley region provides important habitat for a wide diversity of rare species as well as many common ones.

Importance of the Panoche Valley Region for Listed Species

For some listed species, the Panoche Valley and surrounding region encompass a significant proportion of the remaining habitat. These include the San Joaquin kit fox, giant kangaroo rat, blunt-nosed leopard lizard, San Joaquin antelope squirrel, and San Joaquin woolly-threads. For these species, the region is critically important. For other species, such as the California tiger salamander, vernal pool fairy shrimp, and California condor, the region only encompasses a small proportion of the remaining habitat. For these species, the region is important (because any remaining habitat is vital for a listed species), but less critically so. For each listed species, the relative importance of the Panoche Valley region for the conservation and recovery of that species is summarized below.

San Joaquin kit fox

The San Joaquin kit fox once probably occurred throughout the San Joaquin Valley with its range also including the Carrizo Plain, Cuyama Valley, portions of northeastern San Luis Obispo County, and possibly the Salinas Valley (U.S. Fish and Wildlife Service 1998). Kit foxes now primarily occur in the southern portion of the San Joaquin Valley, Carrizo Plain, Cuyama Valley, and a narrow band of habitat (mostly west of Interstate 5) from Kern County north to about Santa Nella, which is just north of the Panoche Valley region (Cypher et al. 2013). Functionally, kit foxes currently persist in a metapopulation that consists of 3 “core” populations and a small number of “satellite” populations. The Panoche Valley region is considered one of the 3 core areas and supports one of the 4 largest remaining kit fox populations (U.S. Fish and Wildlife Service 1998, Cypher et al. 2013).

Kit fox presence in the Panoche Valley region is well documented (Energy Renewal Partners 2014). Recent surveys (Constable et al. 2009, Energy Renewal Partners 2014) indicated that foxes appear to occur throughout the region except perhaps in the most rugged terrain. The region appears to support a population that is independently viable and not dependent on immigration to avoid extirpation. A factor contributing to this demographic robustness likely is the abundance of kangaroo rats found in the region. Kit fox populations appear to more stable and persistent in areas with an abundance of kangaroo rats (Grinnell et al. 1937, Cypher et al. 2013). Furthermore, this kit fox population possesses distinctive genetic attributes not present in kit foxes elsewhere (Wilbert 2013). Thus, it is important for maintaining a diverse genetic pool that increases resistance to environmental and ecological change, such as climate change. The Panoche Valley region also is vital for maintaining connectivity for kit foxes between populations to the south and north (Constable et al. 2009). Populations north of this region are

small and less secure, and likely depend on periodic immigration from the south in order to avoid extirpation. Currently, very little of the suitable habitat for kit foxes in this region is permanently protected. Thus, conservation of additional habitat will benefit the conservation and recovery of this species, and indeed, habitat conservation in the Panoche Valley region is identified as part of the recovery strategy for this species (U.S. Fish and Wildlife Service 1998).

Giant kangaroo rat

The giant kangaroo rat was once widely distributed across the western side of the San Joaquin Valley, Temblor Mountains, Carrizo Plain, Cuyama Valley, San Juan Creek Valley in northeastern San Luis Obispo County (U.S. Fish and Wildlife Service 1998). The species still occurs throughout much of this range, although significant habitat loss has occurred in some areas. The Panoche Valley region supports one of the 3 largest remaining populations of giant kangaroo rats (U.S. Fish and Wildlife Service 1998).

As with kit foxes, the presence of giant kangaroo rats in the Panoche Valley region is well documented (Williams et al. 1995, U.S. Fish and Wildlife Service 1998). Recent surveys indicated that this species still is widely distributed in this region (Bean 2012, Energy Renewal Partners 2014). The giant kangaroo rat population in the Panoche Valley region appears to be independently viable and not dependent on immigration to avoid extirpation. Dispersers from this population may be critical for the persistence of smaller populations, particularly to the south. Furthermore, this population may possess distinctive genetic attributes not present in giant kangaroo rat populations elsewhere (Good et al. 1997, Loew et al. 2005). Thus, this population is important for maintaining a diverse genetic pool that increases resistance to environmental and ecological change, such as climate change. Currently, very little of the suitable habitat for giant kangaroo rats in this region is permanently protected. Thus, conservation of additional habitat will benefit the conservation and recovery of this species, and indeed, habitat conservation in the Panoche Valley region is identified as part of the recovery strategy for this species (U.S. Fish and Wildlife Service 1998). In particular, the Silver Creek Ranch has been identified as an area of significant conservation importance for giant kangaroo rats (Williams et al. 1995, U.S. Fish and Wildlife Service 1998).

Blunt-nosed leopard lizard

The historic range of the blunt-nosed leopard lizard probably was similar to that of the San Joaquin kit fox, with the exception that lizards did not ever occur in the Salinas Valley (U.S. Fish and Wildlife Service 1998).

The presence of blunt-nosed leopard lizards in the Panoche Valley region is well known (U.S. Fish and Wildlife Service 1998) although there have been few formal survey efforts in the past. Recent surveys indicated that this species still is abundant and widely distributed in this region, again in areas that also constitute suitable habitat for kit foxes (Energy Renewal Partners 2014). The blunt-nosed leopard lizard population in the Panoche Valley region appears to be persistent, independently viable and not dependent on immigration to avoid extirpation. Also, based on preliminary results from an on-going genetic study, this population also possesses distinctive genetic attributes not present in blunt-nosed leopard lizard populations elsewhere (M. Westphal,

U.S. Bureau of Land Management, personal communication). Thus, this population is important for maintaining a diverse genetic pool that increases resistance to environmental and ecological change, such as climate change. Currently, very little of the suitable habitat for blunt-nosed leopard lizards in this region is permanently protected. Thus, conservation of additional habitat will benefit the conservation and recovery of this species, and indeed, habitat conservation in the Panoche Valley region is identified as part of the recovery strategy for this species (U.S. Fish and Wildlife Service 1998). In particular, the Silver Creek Ranch has been identified as an area of particular conservation importance for blunt-nosed leopard lizards (U.S. Fish and Wildlife Service 1998).

San Joaquin antelope squirrel

The historic range of the San Joaquin antelope squirrel likely was very similar to that of the blunt-nosed leopard lizard (U.S. Fish and Wildlife Service 1998). As with the other species, the area occupied by this species has been significantly reduced due to habitat loss, degradation, and fragmentation. The Panoche Valley region comprises the northeastern limit of the species' range.

The presence of San Joaquin antelope squirrels in the Panoche Valley region is well known (U.S. Fish and Wildlife Service 1998) although there have been few formal survey efforts in the past. Recent surveys indicated that this species still is abundant and widely distributed in this region, primarily in areas that also constitute suitable habitat for kit foxes and blunt-nosed leopard lizards (Energy Renewal Partners 2014). Relatively little is known about the San Joaquin antelope squirrel population in the Panoche Valley region, but it appears to be persistent based on its continued presence there. Because this population is at the edge of the species' range and is somewhat isolated, it may possess unique genetic attributes, although no genetic studies have been conducted to date. Currently, very little of the suitable habitat for San Joaquin antelope squirrels in this region is permanently protected. Thus, conservation of additional habitat will benefit the conservation and recovery of this species, and indeed, habitat conservation in the Panoche Valley region is identified as part of the recovery strategy for this species (U.S. Fish and Wildlife Service 1998).

California tiger salamander

California tiger salamanders historically ranged throughout grassland habitats in central California where vernal pools and other temporary water bodies necessary for breeding were abundant. The species still occurs within this range, although the total area occupied has been reduced by habitat loss and degradation (U.S. Fish and Wildlife Service 2009). The Panoche Valley region is on the eastern edge of the range for the Central California Distinct Population Segment of California tiger salamanders.

The presence of California tiger salamanders in the Panoche Valley region has been documented previously, and was documented recently during surveys conducted in 2009-2010 (Energy Renewal Partners 2014). Salamanders were found in 2 locations in the recent surveys, but a number of ephemeral pools are present in the region and it is possible that the species occurs in additional locations. The Panoche Valley region comprises a relatively small proportion of the

range for California tiger salamanders, and habitat suitability may not be optimal because years in which precipitation is insufficient to fill ephemeral pools are not uncommon. However, because this region is located on the fringe of the species' range and is somewhat isolated, there is a reasonable probability that this population may possess unique genetic attributes that increase the total genetic diversity for California tiger salamanders. Genetic analyses of this population have not been conducted. Few if any of the occupied habitat is permanently protected. A recovery plan has not been completed for this species, but habitat conservation throughout the range likely will be a significant part of any recovery strategy.

Vernal pool fairy shrimp

Vernal pool fairy shrimp probably historically occurred in vernal pools throughout California. Although habitat within this large range has been significantly reduced, the species still occurs from southern California all the way up into southern Oregon. The Panoche Valley region is located approximately in the middle of the southern half of this range. The region lies within the Central Coast vernal pool region (U.S. Fish and Wildlife Service 2005).

The presence of vernal pool fairy shrimp in the Panoche Valley had not been documented until recently. To date, just one location has been found (Energy Renewal Partners 2014). Other potential habitat is present in the region and the species may occur in other locations as well. The known location and much of the potential habitat are not permanently conserved. However, habitat conservation is the primary strategy identified in the recovery plan that includes vernal pool fairy shrimp.

San Joaquin woolly-threads

San Joaquin woolly-threads historically occurred throughout alkali scrub habitats in the southern and central San Joaquin Valley, Carrizo Plain, and Cuyama Valley. This species has been extirpated from most locations on the San Joaquin Valley floor and now persists primarily along the valley margins, particularly in low foothill areas of the Coast Ranges (U.S. Fish and Wildlife Service 1998). The Panoche Valley region is located at the very northern extreme of the range.

The presence of San Joaquin woolly-threads in the Panoche Valley region is well documented (U.S. Fish and Wildlife Service 1998). The population in this region is relatively small. However, due to its location on the margin of the species' range and relative isolation, it potentially could possess unique genetic attributes. Currently, very little of the suitable habitat for San Joaquin woolly-threads in this region is permanently protected. Thus, conservation of additional habitat will benefit the conservation and recovery of this species. Indeed, habitat conservation is identified as the primary recovery task for this species (U.S. Fish and Wildlife Service 1998).

California condor

California condors once ranged extensively in California. Due to perilous declines in numbers, all individuals were captured and placed in captivity. With captive breeding and reintroduction programs, several populations have been reestablished, including one less than 20 miles from the

Panoche Valley region (U.S. Fish and Wildlife Service 1996). Birds from this population occasionally fly over the region. California condors also potentially could forage in the region, although this has not been documented to date. Habitat conservation could benefit the recovery of this species by providing safe areas for foraging and resting, and where disturbance by humans is minimal.

Regional Importance for Conservation

The Panoche Valley region is of highly significant importance for both for the conservation of listed and sensitive species, as described above, and for the conservation of regional biodiversity. This importance is based on a number of factors including habitat quantity and quality, unique environmental conditions, connectivity to other regions, and unique genetic diversity.

As frequently alluded to in the species accounts above, the destruction and degradation of natural habitats is a pervasive and significant cause of the endangerment of specific species and of loss of biodiversity. This loss has been particularly acute in the San Joaquin Valley (U.S. Fish and Wildlife Service 1998, Kelly et al. 2005). The Panoche Valley region constitutes a marginal extension of the San Joaquin Valley and also constitutes one of the few remaining areas with intact habitat for San Joaquin Valley species. The relatively large quantity and relatively high quality of the remaining habitat in this region is sufficient to support viable and persistent populations of several listed species, as described previously. Factors such as terrain, water availability, distance from development infrastructure, and historical patterns of property ownership all may have contributed to the relatively light anthropogenic disturbance incurred by the region. Thus, the region still supports robust populations of several endangered and sensitive species, and is critically important to the conservation and continued persistence of these species. However, existing land use designations over much of region, particularly private lands, do not preclude future activities (e.g., dryland farming) that could erode habitat value.

In addition to being situated on the edge of the San Joaquin Valley, the Panoche Valley region also is located far to the north of most of the arid habitats in the San Joaquin Valley. This has 2 important consequences: environmental conditions and population influences. The primary remaining habitat areas for the listed species endemic to the San Joaquin Valley bioregion (e.g., San Joaquin kit fox, giant kangaroo rat, blunt-nosed leopard lizard, San Joaquin antelope squirrel, San Joaquin woolly-threads) are the western Kern County region and the Carrizo Plain region. These regions are located almost 200 km south of the Panoche Valley region (Fig. 1). Each region is subject to somewhat different environmental and anthropogenic influences (e.g., precipitation, resource availability, hydrocarbon extraction activity, etc.). Having multiple populations subject to different influences decreases the probability that a catastrophic or episodic event (e.g., drought, decline in food availability, disease, wild fire, oil spill, etc.) will cause a species to go extinct. Furthermore, due to variation in environmental and anthropogenic stressors, population dynamics for a given species are more likely to vary dissimilarly among regions thereby reducing the probability of extinction for an entire species from demographic stochasticity. Indeed, the recovery plan for San Joaquin Valley species (U.S. Fish and Wildlife Service 1998) identifies these differing conditions as a primary reason for conserving habitat in the Panoche Valley region.

The fact that the Panoche Valley region is a marginal extension of the San Joaquin Valley, located at the northwestern extent of many species' ranges, and subject to different conditions compare to regions further south has resulted in unique genetic attributes among a number of species. As mentioned previously, novel haplotypes have been identified among San Joaquin kit foxes, blunt-nosed leopard lizards, and giant kangaroo rats in the region. Among non-listed species, novel genetic attributes also have been found in night lizards (*Xantusia vigilis*; M. Westphal, U.S. Bureau of Land Management, personal communication). Genetic studies have not been conducted on most other species and it is possible that other genetically unique populations occur in this region. Unique genetic attributes are valuable as they increase the overall genetic diversity within a species and provide the genetic variability necessary to respond to environmental changes.

The Panoche Valley region also is critical for maintaining connectivity between habitat areas to the north and south. This is particularly true for San Joaquin kit foxes. Lands to the west of the region generally are too rugged with unsuitable vegetation communities, and therefore cannot serve as effective movement corridors. Lands to the east have almost all been converted to agriculture and also are not conducive to movement of dispersal by foxes and other species. Thus, the only viable linkage between lands to the north and south is the Panoche Valley region.

Summary

For the many reasons detailed above, permanent protection of habitat in the Panoche Valley region would contribute significantly to the conservation of biodiversity and particularly to the conservation of a number of rare species. Much of the high-quality habitat is on private property which is not managed for rare species and where maintenance of current conditions is not guaranteed in the absence of conservation mechanisms. Substantial acreage in the region is owned and managed by the U.S. Bureau of Land Management, primarily in the Panoche Hills, Tumey Hills, and Griswold Hills. However, these lands are generally quite rugged and encompass relatively little of the suitable habit necessary for most of the listed species. Protection of additional habitat in this region is warranted, and indeed, necessary to maintain the long-term viability of populations. Protection of habitat in the Panoche Valley region was identified in three official Recovery Tasks (2.1.14, 5.3.4, 5.3.5) as necessary for the conservation and recovery of a number of listed and at-risk species (U.S. Fish and Wildlife Service 1998). Such protection can be achieved through fee-title purchase of lands or through permanent conservation easements. Furthermore, these lands should be managed appropriately to maximize habitat suitability, which will help further enhance the long-term viability of populations. Such management should include protection of lands from human disturbances (e.g., off-highway vehicle use, dumping, hunting, etc.), habitat management (e.g., grazing to reduce non-native grass cover), habitat restoration (e.g., shrub restoration in previously disturbed areas), monitoring habitat conditions, and monitoring population trends of listed species. Long-term conservation and management of protected lands will require dedicated funding through endowments or other funding mechanisms to ensure that resources are consistently available to conduct such activities. Thus, actions that permanently protect additional habitat and that provide secure funding mechanisms for long-term management of this habitat are a high priority for the Panoche Valley region.

A large solar plant project has been proposed for construction in the Panoche Valley. Although there would be some impacts associated with the project, it also would provide an opportunity to permanently protect a significant quantity of high quality habitat for rare species in this region. The project itself would be constructed on 2,506 acres on the floor of the Panoche Valley. The project would result in the temporary or permanent disturbance of these lands, but continued use of the project site by species after construction is probable based on observations from 2 large solar projects on the northern Carrizo Plain where San Joaquin kit foxes and giant kangaroo rats are exhibiting use of the sites. Proposed project design (e.g., fence modifications to allow animal passage, 500-m wide internal corridor, additional corridors around periphery) and operations and maintenance practices (e.g., vegetation management, speed limits, avoidance of burrows, etc.) after construction would facilitate use of the Panoche Valley project site by species. Furthermore, 24,176 acres of habitat will be permanently conserved and appropriately managed for rare species. This includes conservation lands (2,514 ac) in and around the project site, and 2 large properties (Silver Creek Ranch – 10,890 ac; Valadeao Ranch – 10,772 ac) that will be purchased as mitigation for the project. The majority of the habitat on these lands is of high quality and many of the rare species mentioned previously including most of the listed species are present on these lands. These proposed conservation lands are contiguous with BLM lands and would result in large blocks of protected habitat as well as provide movement corridors through the region. All of these lands would be conserved in perpetuity and managed appropriately for rare species by a qualified conservation organization with endowment funds from the solar plant owner. The permanent protection and management of these lands would contribute significantly to the conservation of rare species in this region.

Literature Cited

- Bean, W. T. M. 2013. Spatial ecology of the giant kangaroo rat (*Dipodomys ingens*): a test of species distribution models as ecological revealers. PhD dissertation, University of California, Berkeley, CA.
- Constable, J. L., B. L. Cypher, S. E. Phillips, and P. A. Kelly. 2009. Conservation of San Joaquin kit foxes in western Merced County, California. California State University-Stanislaus, Endangered Species Recovery Program, Fresno, CA.
- Cypher, B. L., S. E. Phillips, and P. A. Kelly. 2013. Quantity and distribution of suitable habitat for endangered San Joaquin kit foxes: conservation implications. *Canid Biology and Conservation* 16:25-31.
- Energy Renewal Partners. 2014. Biological assessment for the Panoche Valley solar facility. Energy Renewal Partners, West Lake Hills, TX.
- Good, S. V., D. F. Williams, K. Ralls, and R. C. Fleischer. 1997. Population structure of *Dipodomys ingens* (Heteromyidae): the role of spatial heterogeneity in maintaining genetic diversity. *Evolution* 51:1296-1310.

- Grinnell, J., D. S. Dixon, and J. M. Linsdale. 1937. Fur-bearing mammals of California, Volume 2. University of California Press, Berkeley, CA.
- Kelly, P. A., S. E. Phillips, and D. F. Williams. 2005. Documenting ecological change in time and space: the San Joaquin Valley of California. Pages 57-78 in E.A. Lacey and P. Myers, editors. Mammalian diversification: from chromosomes to phylogeography. Publications in Zoology Series, University of California Press, Berkeley, CA.
- Loew, S. S., D. F. Williams, K. Ralls, K. Pilgrim, and R. C. Fleischer. 2005. Population structure and genetic variation in the endangered giant kangaroo rat (*Dipodomys ingens*). Conservation Genetics 6:495-510.
- U.S. Fish and Wildlife Service. 1996. Recovery plan for the California condor. U.S. Fish and Wildlife Service, Portland, OR.
- U.S. Fish and Wildlife Service. 1998. Recovery plan for upland species in the San Joaquin Valley, California. U.S. Fish and Wildlife Service, Portland, OR.
- U.S. Fish and Wildlife Service. 2005. Recovery plan for vernal pool ecosystems of California and southern Oregon. U.S. Fish and Wildlife Service, Portland, OR.
- U.S. Fish and Wildlife Service. 2009. Species account: California tiger salamander. http://www.fws.gov/sacramento/es_species/Accounts/Amphibians-Reptiles/Documents/california_tiger_salamander.pdf
- Wilbert, T. R. 2013. Patterns and processes of genetic diversity in the endangered San Joaquin kit fox. PhD dissertation, George Mason University, Fairfax, VA.
- Williams, D.F., M.K. Davis, and L.P. Hamilton. 1995. Distribution, population size, and habitat features of giant kangaroo rats in the northern segment of their geographic range. Final report, California Department of Fish and Game, Wildlife Management Division, Bird and Mammal Conservation Program, Sacramento, CA.