Western San Joaquin Valley Least Conflict Solar Energy Assessment

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In the Western San Joaquin Valley (WSJV) of California, approximately 64,000 acres of utility-scale solar energy projects are proposed or under construction. Many of these projects are sited within remnant San Joaquin Valley (SJV) ecosystems. These ecosystems, of which less than 5% of their historical range is left, have largely been converted to irrigated agriculture and urban land uses (U.S. Fish and Wildlife Service 1998). These ecosystems are essential to the recovery and ultimate survival of a suite of endangered, threatened, and sensitive species identified in the Recovery Plan for Upland Species of the San Joaquin Valley, California (U.S. Fish and Wildlife Service 1998), including the endangered San Joaquin kit fox (kit fox), giant kangaroo rat, and blunt-nosed leopard lizard.

The objective of this assessment is to characterize the land use and conservation constraints and opportunities associated with siting solar energy facilities in the WSJV. This approach identifies areas with high conservation value that are important to avoid when planning energy infrastructure, as well as areas of lower environmental conflict potentially suitable for development. While the approach we take focuses on refining the conservation values in the study area, we also classify the region's agricultural resources using simple, broadly applicable classes to begin to assess trade-offs or synergies between agricultural production, habitat conservation and energy development. In our assessment of biodiversity conservation values, we focus on core and high quality habitat for multiple listed species, including kit fox, and emphasize the preservation of connectivity for kit fox and other wide-ranging species.

One primary goal of the assessment is to identify areas within the region that may be suitable, after more comprehensive site-level investigation, for the development of utility-scale solar plants without jeopardizing conservation values. Yet, given the historical habitat loss in the region, much of the remnant, lower elevation WSJV habitats are extremely important for multiple listed species. This presents a significant constraint on future energy development in the region, both renewable and non-renewable. While we focused this assessment on solar energy development because of the number of proposed projects and potential ecosystem impacts, the approach we have taken can be applied to other land uses with significant terrestrial impacts, such as hydraulic fracturing (fracking) for oil exploration. Most of the currently mapped Monterey shale formation occurs within the WSJV.

This report summarizes the overall purpose and need for this assessment, presents a detailed description of the methods and provides a summary of the results.

1. Introduction

The WSJV is an area of high conservation value, which historically has been impacted by land conversion and degradation (U.S. Fish and Wildlife Service 1998, Germano et al. 2011), and which is currently threatened by incompatible utility-scale solar energy (Figure 1), oil development using hydraulic fracturing and continued agricultural and urban expansion. The WSJV represents the last remaining habitat for a suite of threatened, endangered, and sensitive species, including kit fox (Federally endangered (FE), State threatened (ST)), giant kangaroo rat (FE, State endangered (SE)), and blunt-nosed leopard lizard (FE, SE and California Fully Protected Species under Fish and Game Code 5050), whose recovery depends on the protection and restoration of these remaining habitats (U.S. Fish and Wildlife

Service 1998). For that reason, the United States Fish and Wildlife Service (FWS) have designated large portions of the WSJV as core, satellite, and linkage recovery areas (U.S. Fish and Wildlife Service 1998). For recovery to occur, these areas must be protected from further land conversion and degradation. While threats from utility-scale solar energy and fracking development are widely dispersed within the WSJV, some of the largest utility-scale solar projects have been sited within core recovery areas, including at the Carrizo Plain in southeastern San Luis Obispo County, Panoche Valley in San Benito County, and portions of the natural areas of Kern County, as well as within other priority recovery areas (Figure 1).

There is currently no comprehensive assessment or plan that would allow utility-scale solar projects to be sited within the WSJV in a way that is compatible with species recovery. Given the current pace and scale of solar energy development within the WSJV, an assessment is needed to identify areas with high conservation value important to avoid as well as areas of potential least conflict where utility-scale solar energy development may be compatible. In this assessment, we chose to achieve this objective by focusing on core and high quality habitat for multiple listed species, including kit fox while also emphasizing connectivity for kit fox and other wide-ranging species in the WSJV. We focused on kit fox because it is federally endangered and state threatened (U.S. Fish and Wildlife Service 1998, 2010), can be used as an umbrella (or representative) species for a suite of threatened, endangered, and sensitive SJV species (U.S. Fish and Wildlife Service 1998), and there is a large amount of high quality habitat suitability, habitat permeability, and recovery data currently available (e.g. Cypher et al. 2007, Constable et al. 2009, Cypher et al. in prep). The decision to use kit fox so prominently in this assessment was made in consultation with SJV species experts, including Brian Cypher and Scott Phillips of the Endangered Species Recovery Program (ESRP), as well as environmental non-governmental organization (NGO) and agency staff working within the WSJV on solar development and species recovery issues.

We focused this assessment on the WSJV because it has high solar resource potential, high conservation value, and has multiple solar energy facilities proposed or under construction. Most of the assessment area is privately owned and governed by local land use authority. As was true in The Nature Conservancy's (the Conservancy) Mojave-wide and Western Mojave Desert solar energy assessment (Cameron et al. 2012a, 2012b), we expect that this study will provide counties, landowners, permitting agencies, solar energy developers, agricultural interests, and other entities information that will help in planning for energy development in a way that does not adversely affect the broader conservation values of the WSJV. As new information becomes available the inputs into the conservation value or land use characterization should be updated to reveal a new pattern of constraints and opportunities for energy development in the coming decades.

Because parcelization is often cited as an impediment to utility-scale solar energy development on private lands, this assessment includes an analysis of private land ownership patterns within areas of potential least environmental conflict. However, we do not investigate the planning and zoning designations for private lands in the region. This aspect of development feasibility should be investigated by stakeholders including the cities and counties within the study area. While we take a landscape view on conservation values within a study area that spans several counties, we do not intend to supersede local land use authority, but rather seek to provide a common set of information that county land use planners, as well as state and federal agency planners can consider as they engage stakeholders on development plans.

1.1 Study Area

The study area for this assessment was chosen to encompass 1) all of the existing and proposed large utility-scale solar projects in the WSJV, 2) all of the moderate to high suitable and high permeability kit fox habitat, including core, satellite, and recovery areas, 3) the Westlands Water District, an area that is commonly proposed as environmentally compatible for utility-scale solar development within the region, and 4) the Tulare Basin (west of Delano, CA), which is a priority conservation area for bird species and is not captured by kit fox suitability and/or permeability models (Figure 1).

The study area is 5.7 million acres. There are approximately 64,000 acres of utility-scale solar photovoltaic (PV) projects sited within the study area (Figure 1). We chose to focus on this study area and not the broader SJV because the vast majority of large projects are on the west side, and efficiently completing the study will allow stakeholders to use the information when it is more timely for projects currently sited and under review. A larger footprint would have necessitated additional conservation value and land use considerations, which would have complicated the assessment and lengthened the time for completion. There is also a larger SJV solar feasibility study (*Identification and quantification of potential conservation conflicts between solar energy development and special-status upland species of the San Joaquin Valley*) currently underway being led by the California Department of Fish and Wildlife (DFW) (Krista Tomlinson and Brian Salazar) and ESRP (Brian Cypher, Scott Phillips, and Patrick Kelly). By working closely together with DFW and ESRP, we hope that our assessment will provide important data and recommendations for their larger, more comprehensive study.

The eastern and western portions of the WSJV have very different dominant land uses. Both sides are influenced heavily by agriculture, but the eastern side of the study area is dominated by intensive agriculture (cropland), while the western side is dominated by more natural, open rangeland used for livestock grazing (Figure 2). Just as the conservation value of the western portion of the study area is varied and therefore explicitly considered in the assessment, the agricultural conservation values of the study area are varied and so need to be mapped and ranked separately. In the study area, there are approximately 979,373 acres of prime farmland, 112,022 acres of unique farmland and 791,673 acres of farmland of statewide significance (Figure 3), and also 2,896,698 acres of Williamson Act land (Figure 4). These numbers highlight the importance of agriculture from a gross acreage and economic standpoint, but also the amount of high quality agricultural habitat that exists within the study area. For the purposes of this assessment, we have mapped and ranked the agricultural considerations of the study area using prime farmland, other irrigated agriculture, and salt-affected land designations (Figure 2), recognizing that there are many different ways that these land uses could have been alternatively mapped. We do not distinguish between actively grazed and ungrazed rangeland as it is too difficult to do accurately over large areas.

2. Methods

2.1 Overview and assumptions

We conducted this least conflict assessment using a similar approach as to what the Conservancy did in the Western Mojave Desert (Cameron et al. 2012b), designating the biodiversity conservation values and dominant land uses across the entire study area and then combining and ranking these designations based on potential environmental conflict. The final conflict classes are based on input we received from environmental (Defenders of Wildlife, Center for Biological Diversity, Audubon-California, Sierra Club, Natural Resources Defense Council), agency (FWS, DFW, Bureau of Land Management (BLM)), and other (California Farm Bureau, California Association of Resource Conservation Districts, Pacific Gas & Electric, American Farmland Trust) partners. While this input was critical to improving the document, this is not a consensus document meant to represent the views of these organizations.

We first mapped and excluded areas that have a legal designation that prevents development, including from utility-scale solar. This included permanently protected public and private lands and areas with conservation easements (Table 1). We assume that these designations will prevent development for the foreseeable future.

A primary component of this analysis is to compile a variety of relevant data to assess the biodiversity conservation values of the study area. In the next section we discuss the data sources and processing steps to define the classification of moderate and high biodiversity conservation value. Any areas not mapped as either high or moderate biodiversity conservation value were considered to have low biodiversity conservation value.

To assess constraints and opportunities related to current land use we assembled data and mapped the primary land uses in the study area. To do this we divided the study area into prime farmland, other irrigated agriculture (non-prime), salt-affected lands, natural or semi-natural open habitat, and urbanized land, including industrial land uses such as oil extraction (Table 1). There were many potential ways to map land uses within this study area, but these designations best met the objectives of this assessment. Salt-affected land was considered to have the lowest and prime farmland the highest agricultural value.

Finally, to complete the potential least environmental conflict assessment, we combined the biodiversity conservation and land use value designations and assigned relative levels of conflict. Areas with low biodiversity conservation value and salt-affected soils were designated as the areas of least conflict. Areas with high biodiversity conservation value, regardless of the land use, were designated as areas of most conflict. All other areas were considered to have moderate potential conflict either because of the biodiversity or agricultural values present.

2.2 Inputs and criteria factors for conflict determination

Legally excluded areas

We separately mapped areas that had a legal or administrative designation that prevents development. We created this layer using data from GreenInfo Network (2012) and The Nature Conservancy (2013) (Table 1). There were 534,499 acres of excluded areas within the study area. These areas of exclusion were used as an overlay on the least conflict assessment and solar development compatibility maps.

Excluded areas included land with the following designations: National Park Service; Wilderness Areas; Wilderness Study Areas; BLM National Conservation Areas; National Recreation Areas; National Monuments; private preserves and reserves; Inventoried roadless areas on United States Forest Service (USFS) lands; National Historic and Scenic Trails; National Wild, Scenic, and Recreational Rivers; conservation mitigation banks under conservation easements approved by DFW, FWS, Army Corps of Engineers, and California State Parks; DFW Wildlife Areas and Ecological Reserves; State Wildlife Management Areas; and Department of Defense (DOD). Not all of these designations are found within the study area.

Biodiversity Conservation Values

We ranked the biodiversity conservation values of the study area into high, moderate, and low classes. Class designation was based on the objectives of the assessment, data availability for the study area, and data quality. We used kit fox as an umbrella or representative species for a suite of SJV threatened, endangered, and sensitive species including giant kangaroo rat and blunt-nosed leopard lizard. Expert review confirmed that by using kit fox habitat suitability, permeability, and recovery data we would capture most of the species of interest in the study area (B. Cypher and S. Phillips, personal communication, March 2012). Possible exceptions may include Swainson's hawk, which often prefers riparian and agricultural lands (Woodbridge 1998) that have may have lower suitability and/or permeability for kit fox.

High Biodiversity Conservation Value

We designated high biodiversity conservation value areas based on the presence of 1) wetlands, 2) moderate to high suitable kit fox habitat, 3) high permeability kit fox areas, 4) FWS kit fox core recovery areas, 5) mitigation lands set aside as part of the development of the Carrizo Plain solar projects, and 6) lands within the Grasslands Ecological Area or within 1 km of the San Joaquin River to represent waterbird conservation and restoration priorities (Table 1). We dissolved each of the following datasets together to create a single high biodiversity conservation value layer using ArcGIS 10.1 (ESRI, Redlands, CA). These areas are significant enough from a conservation and species recovery standpoint that they should be excluded from all future utility-scale solar energy development.

We used wetlands data from the 2011 National Wetlands Inventory (NWI) dataset. Wetlands are a rare land cover type within the WSJV and support a disproportionately large number of listed and sensitive species. Therefore, solar energy development should be excluded from these areas. In addition to mapped wetlands, we included the land within the Grasslands Ecological Area and within 1 km of the

San Joaquin River to represent areas that have restoration potential for future suitable habitat for shorebirds and waterfowl, as well as other birds.

For kit fox, we used the 2012 kit fox habitat suitability and 2008 kit fox permeability datasets developed by Scott Phillips and Brian Cypher at ESRP (Table 1). Both the suitability and permeability datasets use GIS-based modeling procedures, a simple additive weighting model for habitat suitability and cost distance model for habitat permeability (Cypher et al. 2007, Constable et al. 2009, Cypher et al. in prep). In the ESRP habitat suitability dataset, suitability is classified as low or no suitability, low to moderate suitability, or moderate to high suitability based on land use/land cover, topographic/terrain ruggedness, and vegetation density preferences of kit fox (Cypher et al. 2007, Constable et al. 2009, Cypher et al. in prep). For our purposes, we combined the moderate and high suitability classes together to create a single kit fox moderate-high habitat suitability data layer. These areas represent the best remaining kit fox (and the species we used kit fox to represent) habitat, and are therefore essential for species recovery.

In the ESRP kit fox permeability dataset, potential connectivity is based on principles of least cost distance, or the difficulty of movement through the landscape (Cypher et al. 2007, Constable et al. 2009). Permeability across the landscape is scaled from 100 (high cost of movement) to 1 (low cost of movement). We considered high permeability to be any portion of the study area that had cost values <10. These areas are the most important for maintaining connectivity between core and satellite recovery sites and supporting species recovery. This value was chosen based on expert input, knowledge of the landscape, and the kit fox habitat suitability model outputs. We clipped this dataset to our study area boundary and dissolved values <10. By selecting this threshold we captured the most important areas for general habitat connectivity as well, which will support movement for a large variety of wide-ranging species.

While most of the land covered by the habitat suitability and permeability data is within core recovery areas, we also included the designated areas themselves as high biodiversity conservation value. We used the 2007 FWS kit fox recovery data (developed as part of the FWS 5 year review of kit fox recovery) to designate core areas as high biodiversity conservation value (Table 1). These areas are the most important for kit fox (and the species we used kit fox to represent) recovery.

Land set aside for mitigation of projects under development was also considered high biodiversity conservation value. We used data for the mitigation lands set aside in 2012 as part of development of the utility-scale solar projects in the Carrizo Plain, California (Table 1). These areas were designated as high biodiversity conservation value because they are important for kit fox recovery, especially movement within and between the projects, and should not be developed further.

Moderate Biodiversity Conservation Value

We designated moderate biodiversity conservation value areas based on the presence of 1) FWS kit fox satellite and linkage recovery areas, 2) Audubon Important Bird Areas (IBAs), 3) the Conservancy's portfolio conservation areas, 4) serpentine soils, 5) California Rangeland Conservation Coalition (CRCC) "essential" areas for rangeland conservation, and 6) compatible agricultural crops for shorebirds and waterfowl within three kilometers of designated valley floor protected areas or easements (Table 1). We dissolved each of the following datasets together to create a single moderate biodiversity conservation value layer using ArcGIS 10.1 (ESRI, Redlands, CA). These areas contribute significantly to conservation and recovery goals so should be avoided, when possible, when planning future utility-scale solar energy development.

A number of layers were included in the moderate conservation value group because they complement the kit fox habitat layers. For important bird conservation values, we used the 2004 Audubon IBAs dataset and bird-compatible crop types adjacent to valley floor protected areas and easements (Table 1). We included these crop types to recognize the benefits provided by flooded agricultural to bird populations, especially when they are adjacent to large complexes of natural or managed wetlands in protected areas. To capture areas with high intactness and a diversity of conservation targets, we used the Conservancy's portfolio conservation areas from various ecoregional assessments (Table 1). To represent additional areas important for rare plants, we used serpentine soil designations from both the 1977 California Geology and 2012 SSURGO datasets (Table 1). Rare plant data is not readily available for many parts of the study area, but we wanted to try to capture this suite of important conservation values.

Livestock grazing is a dominant land use in the western portion of the study area and can be an effective tool for maintaining large intact landscapes as well as promoting herbaceous diversity and habitat values at finer scales. Building on an analysis of important areas for biodiversity conservation in rangelands, we included the CRCC's "essential" areas for rangeland conservation dataset from 2007 (Table 1). We included this data layer in the moderate biodiversity conservation value layer because it captures the matrix of natural and semi-natural open habitat within the study area that is important for a variety of conservation values including wide-ranging species (i.e. connectivity), oak woodlands, and grasslands.

When combining the data layers for the moderate and high conservation value classes, we gave precedence to the "high" category to be conservative in how we characterize land as suitable for potential utility-scale solar energy development.

Low Biodiversity Conservation Value

Anything not designated as high or moderate biodiversity conservation value was designated as low biodiversity conservation value. Yet, lands that have a low biodiversity conservation value but occur within natural habitat types, are grouped with the moderate conservation value lands with natural habitat on the final maps, to simplify display and recognize the limitations of this approach in characterizing site-specific conservation values. Because the inputs are primarily broad-scale, it is important to emphasize that natural areas without mapped features from the moderate and high conservation value classes could still contain conservation values when investigated at finer scales.

Given this, we have used a conservative approach to represent the solar energy development feasibility in these areas.

Land Uses

To meet the objectives of this assessment, we mapped the following land uses across the study area: natural or semi-natural open habitat, prime farmland, other irrigated agriculture, salt-affected lands and urban/industrial areas (Figure 2, Table 1). For the urban/industrial, irrigated agriculture, and natural or semi-natural open habitat classes, we used a dataset compiled by ESRP (ESRP 2012) primarily from various Department of Water Resources (DWR) county land use surveys, but including Farmland Mapping & Monitoring Program (FMMP), NWI and California Gap Analysis program data. The categories used to map the "Urban / Industrial" class are shown in Table 1 and are not affected by inputs described below. For irrigated agriculture, we included primarily row crops (see Table 1), but also included feedlots, though the extent of these areas is minimal in the whole study area (approximately 8,400 acres). We excluded rice from the irrigated agriculture group because ricelands function like wetlands for many bird species given the frequency and duration of flooding. Natural or semi-natural open habitat (including rice) was mapped as the inverse of the developed classes (urban/industrial or irrigated agriculture).

Prime farmland is a key resource in California and by virtue of its productivity and historical loss and degradation is itself a high conservation priority. We combined the prime farmland data with the irrigated agriculture layer and assigned the overlapping land to a prime farmland category, making the remaining irrigated land fall into the "other irrigated agriculture" class. We overlaid this new agriculture layer with data representing the extent of lands that have drainage problems and are considered "salt-affected". For this, we used data from the United States Department of Agriculture Natural Resources Conservation Service (USDA-NRCS) Soil Survey Geographic (SSURGO) database made available to us by the USDA-NRCS office in Hanford, CA. The classification used to define these areas is shown in Table 1. We gave precedence to the salt-affected lands, and assigned any areas from any other classes to the "salt-affected" class where there was overlap.

2.3 Combining criteria factors to assign levels of potential environmental conflict

We combined the biodiversity conservation value and land use value categories for each location within the study area in order to produce relative conflict classes, which we then assigned to least, moderate, and most potential environmental conflict categories. We categorized all High Conservation Value / Land Use combinations as most conflict. We categorized Low Conservation Value / Salt-affected lands as least conflict. The remaining classes were categorized as moderate potential conflict because of their biodiversity conservation (i.e. Moderate Conservation Value) and/or agricultural (i.e. other irrigated agriculture or prime farmland) values. In all biodiversity conservation classes, the salt-affected lands class was considered to have the least and the natural habitat land use class the most potential environmental conflict. Other irrigated agriculture and prime farmland were considered to have moderate potential environmental conflicts.

2.4 Parcel data layer creation

We created a parcel data layer for the study area using spatial data from two sources, CoreLogic Parcel Point Technology and County Assessor's offices. From CoreLogic we obtained the following data (the date signifies the year CoreLogic acquired the parcel dataset, although it is close to the parcel vintage in all cases): Fresno (2011), Kings (2009), Madera (2009), Merced (2010), Monterey (2011), San Luis Obispo (2012), Santa Barbara (2012), and Ventura (2010). From County Assessor's Offices we obtained the following data (the date signifies the vintage of the parcel dataset): Kern (2012), San Benito (2011), and Tulare (2013).

Using ArcGIS 10.1 (ESRI, Redlands, CA), we selected the parcel data for each county if it intersected the study area, merged it into one data layer, and dissolved polygons by ownership name. This created a layer of private land ownership where adjacent parcels owned by the same land owner became one "property". Only parcels adjacent to each other were dissolved by ownership name and if there was no ownership name the record was assigned a unique identifier before being dissolved.

We mapped properties greater than 500 acres that intersected with least conflict areas, with the assumption that parcels greater than 500 acres would be easier to develop for utility-scale solar projects.

2.5 Solar compatibility data

We obtained solar project footprints, when possible, for the study area from agency, environmental NGO, and/or solar project developer staff. When footprints were not available, we used data from the Renewable Energy Action Team (REAT; downloaded December 2012). REAT data was clipped to the boundary of the study area. For all REAT data, we created a scaled project footprint based on proposed acreage values, which are represented by circles on maps throughout this assessment. In places where we had both the proposed project footprint and the REAT data, we used the project footprint data.

We assessed the compatibility of solar development based on solar insolation (i.e. the amount of solar radiation energy received on a given surface area and recorded during a given time), the slope of the land, and the presence and/or proximity of a transmission line and/or substation. This was similar to what the Conservancy did in the Western Mojave Desert solar assessment (Cameron et al. 2012b). Even though we recognized that actual transmission capacity (and not just presence) is a major driver of potential utility-scale solar energy development, we did not base our solar compatibility assessment on capacity because those data were not available.

Using solar insolation data from the National Renewable Energy Laboratory (NREL), we classified the data into the following solar insolation classes ($kWh/m^2/day$): <5.5, >5.5. These classes were consistent with those used in the Conservancy's Western Mojave Desert solar assessment (Cameron et al. 2012b), and are relevant to the likelihood of solar energy development and the potential size of the project.

We created slope data using a 30 meter digital elevation map obtained from the U.S. Geological Survey (USGS) National Elevation Dataset (NED). For the purposes of this assessment, we masked out anything greater than 10% slope because these areas are not currently considered suitable for solar technologies, and mapped the study area in to 0-5% and 5-10% slope classes. We obtained transmission line and substation data in December 2012 through a Conservancy contract with Ventyx, and clipped it to the boundary of the study area in ArcGIS 10.1 (ESRI, Redlands, CA). We symbolized transmission lines by carrying capacity (kV) and grouped in them in to categories that are considered to be the industry standard (i.e. 500 kV, 230-287 kV, 100-161 kV, under 100 kV, Step-Up).

3. Results

3.1 Biodiversity Conservation Value / Land Use combinations

Each location within the study area had a mapped biodiversity conservation value and land use class. By combining land use and the biodiversity conservation value classification, this assessment provides more context for the constraints and opportunities on siting. In a way, the combination of the two composite layers makes the other layer more useful as a screen on potential siting locations. For example, knowing where kit fox permeable habitat overlaps with irrigated agriculture provides a first level filter on the type of outreach an energy developer might prioritize and substantively, what constraints they may experience in trying to permit and build a facility.

Within the High Biodiversity Conservation Value class there were four mapped land use class combinations, natural habitat, prime farmland, other irrigated agriculture, and salt-affected lands (Figure 5), which covered 2,199,089 acres (Table 2). All of this land was placed into the highest potential environmental conflict class (Figure 6), and therefore should not be considered for utility-scale solar development. There are 48,478 acres of solar projects that occur within the High Biodiversity Conservation Value classes, including the Carrizo Plain California Valley Solar Ranch and Topaz Solar Farm, which are currently under construction, and the Panoche Valley Solar Farm and Kern Solar Ranch, which are under review (Figure 5). There were 90,063 acres of High Biodiversity Conservation Value land mapped in the Westlands Water District (Table 3). The majority of these areas are part of the FWS Ciervo-Panoche core recovery area (Figures 1 and 5).

Within the Moderate Biodiversity Conservation Value class there were four mapped land use class combinations, natural habitat, prime farmland, other irrigated agriculture, and salt-affected lands (Figure 7), which covered 1,887,319 acres (Table 2). There are 8,191 acres of solar projects that occur within the Moderate Biodiversity Conservation Value classes.

Within the Low Biodiversity Conservation Value class there were three mapped land use class combinations, prime farmland, other irrigated agriculture, and salt-affected lands (Figures 6 and 7), which covered a total of 1,452,865 acres (Table 2). There are 6,036 acres of solar projects that occur within the Low Biodiversity Conservation Value classes, including the Westlands Solar Park, which is under review.

There were 677,752 acres of Low Biodiversity Conservation Value / Prime Farmland or Other Irrigated Agriculture land mapped within the study area (Table 2), of which 166,643 and 28,109 acres, respectively, is in the Westlands Water District (Table 3). All of this land was placed in to the moderate conflict class along with all Moderate Biodiversity Conservation Value areas (Figures 6 and 7), and therefore should be avoided, when developing utility-scale solar development. Potential biodiversity conservation value conflict varies across the approximately 3 million acres of land (Table 2), in Low Biodiversity Conservation Value to Moderate Biodiversity Conservation Value (Figure 7). These conflict determinations should be incorporated in to any future utility-scale solar energy development plans.

3.2 Potential priority siting areas

There were 435,601 acres of Low Biodiversity Conservation Value / Salt-affected lands mapped within the study area (Table 2), 197,578 acres of which is in the Westlands Water District (Table 3). All of this land was placed in to the lowest conflict class (Figure 6), and therefore should be the first land considered for future utility-scale solar development. All of the least conflict areas, within and outside of the Westlands Water District, meet some of the basic solar development compatibility tests, including slopes <10% (in this study area, all least conflict areas occur on land with slopes 0-5%) and solar insolation >5.5 kWh/m2/day (in this study area, most locations have solar insolation values between 5.5 and 6.5 kWh/m2/day) (Figure 8). Many of the least conflict areas are comprised of parcels with single ownerships greater than 500 acres (Figure 9).

Some of the least conflict areas are close to larger (e.g. 230-287 kV) capacity transmission lines, but actual capacity available for new generation on those lines is unknown (Figure 8). Recognizing that availability of transmission is one of the key drivers for developers in siting solar facilities, the Conservancy requested input from PG&E regarding the transmission and interconnection in the area covered by the scope of this assessment. PG&E provided an overview of transmission planning and interconnection processes based on three publicly available documents that contain transmission information, including the Annual California Independent System Operator (CAISO) Transmission Plan, California Independent Operator Generation Interconnection Queue (http://www.caiso.com/planning/Pages/GeneratorInterconnection/Default.aspx), and PG&E WDT Cluster (http://www.pge.com/b2b/newgenerator/cluster/). PG&E explained how the publically available information demonstrated that the existing transmission system within the WSJV study area is congested. Various types of upgrades would be necessary to reliably and safely interconnect new generation in this area. While these transmission constraints provide a shorter-term challenge in interconnecting near-term projects, the situation also affords decision-makers an opportunity. The CAISO has recently approved the Gates-Gregg 230 kV line in the Central Valley. This is a reliability-driven project with additional policy or economic benefits. The line will be constructed as a double circuit 230 kV line with one side strung. The line will facilitate future development requirements to supply load or integrate renewable generation in the area. CAISO analysis recommends an in-service date of no later than May 2022. Further transmission upgrades will be required to bring renewable energy generated in the WSJV into the electrical grid. Prioritizing upgrades to those areas that have low environmental impact and low levels of conflict will provide a meaningful incentive for developers to site in these areas and will also encourage renewable energy development in a manner to protect species, habitats and ecosystem function.

4. Recommendations on Policy and Process

1. **Coordinated Energy and Conservation Planning**: There is no coordinated energy and conservation planning process underway in this part of the state, but there are many proposed projects. Where there are renewable energy planning processes (e.g., general plan amendments, Habitat Conservation Plans, etc.) within this region, best available scientific information should be incorporated into evaluation, planning and decision-making.
2. **Interconnection**: Access to available transmission and distribution capacity is an important development factor in siting renewable energy projects. Within the WSJV transmission and distribution investments should be prioritized to areas that present lower risk to biodiversity and agricultural resource values.
3. **Cumulative Impacts:** Ensure that the cumulative impacts of all development in the region are taken into account; plan for and implement regional mitigation efforts that combine resources that address offsets from multiple projects and direct those resources to priority conservation areas, as developed under Regional Advance Mitigation Planning (RAMP).

5. Conclusions

5.1 Uses of this Assessment

This assessment can act as a "first filter" screening of locations within the WSJV to assess the likelihood that those areas will present conservation conflicts. It is designed to help developers and other stakeholders apply the precautionary principle and proactively avoid areas likely to have a higher risk of conflicts, in favor of other areas likely to have lower risk. This approach could help reduce the up-front costs and risks of development projects. Siting projects in already degraded areas will lessen overall impacts of development, while also providing stakeholders additional time to study the more ecologically intact areas of the San Joaquin Valley and evaluate the conservation-compatibility of development in those areas. Utilities can use this assessment to evaluate the potential risk associated with timely completion of projects, as one component of their project evaluation process. Developers and regulatory agencies can use this assessment to identify priority conservation areas as sources of mitigation land for projects that need compensatory mitigation.

This assessment can complement proposed or future local, state and federal planning processes that seek to develop renewable energy resources while maintaining resource conservation values. It is not offered to replace these stakeholder-driven processes, or to supersede local land use planning and authority; public input on siting decisions is important. Rather, we present these results as a transparent analysis of available data, and offer a tool that can inform land use decision making.

5.2 Limitations of this Assessment

This assessment is a GIS-based analysis, and cannot substitute for site-based field assessment of resource values because many resources and locations within the study area are poorly surveyed. Although we believe the analysis can be used to presumptively rule out some areas for siting, the reverse is not true—data gaps limit the ability to use this assessment to support positive site-level decisions for development. As a filter, it should be used to sort areas into different categories of constraint from an environmental point of view, and to prioritize further investigation for conservation or development. This study is meant to aid local land use authorities such as counties in assessing the potential environmental conflict associated with different scenarios of solar energy development. We underscore that the results of the study are not meant to be interpreted as suggested zoning or designations.

Literature cited

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Table 1. Excluded Area, Biodiversity Conservation Value, and Land Use Value data sources.

Name	**Source**
Excluded Areas	
Excluded protected areas and easements	GreenInfo Network 2012, TNC 2013
Biodiversity Conservation Value	
High	
San Joaquin kit fox habitat suitability	ESRP 2012
San Joaquin kit fox habitat permeability	ESRP 2008
San Joaquin kit fox recovery areas	FWS 2007
Wetlands	NWI, USGS 2011
Carrizo Plain solar mitigation sites	Topaz First Solar 2012, California Valley Solar Ranch 2012
Grasslands Ecological Area	TNC San Joaquin River Conservation Action Plan 2009
San Joaquin River buffer (1 km/3280 ft)	National Hydrography Data
Moderate	
Audubon Important Bird Areas	Audubon 2004
The Nature Conservancy's portfolio of conservation areas	TNC 2006-2012
Serpentine soils (rare plant proxy)	DMG 1977, SSURGO 2012
California Rangeland Conservation Coalition essential areas for rangeland conservation	CRCC 2007
Waterbird crop types near refuges in valley floor (3km/1.86 miles)	DWR/ESRP 2012
Land Use Value	
Natural or semi-natural open habitat	DWR/ESRP 2012
Prime farmland	FMMP 2008
Irrigated agriculture (orchards, vineyards, field crops, idle, grain/pasture, feedlot)	DWR/ESRP 2012
Salt-affected lands (one of these groups): 1) Soils with threshold values of electrical conductivity (EC) ≥ to 4 mmhos cm^{-1}; 2) Soils with combined threshold values of EC ≥ to 4 mmhos cm^{-1} and Sodium Adsorption Ratio (SAR) ≥ 13.	NRCS 2012
Other	
Urban/Industrial (classes included: bridge, canal bank, farmstead, freeway, oil field/extractive, undercrossing, urban, urban commercial, urban industrial, urban landscaped, urban residential, and urban vacant)	DWR/ESRP 2012

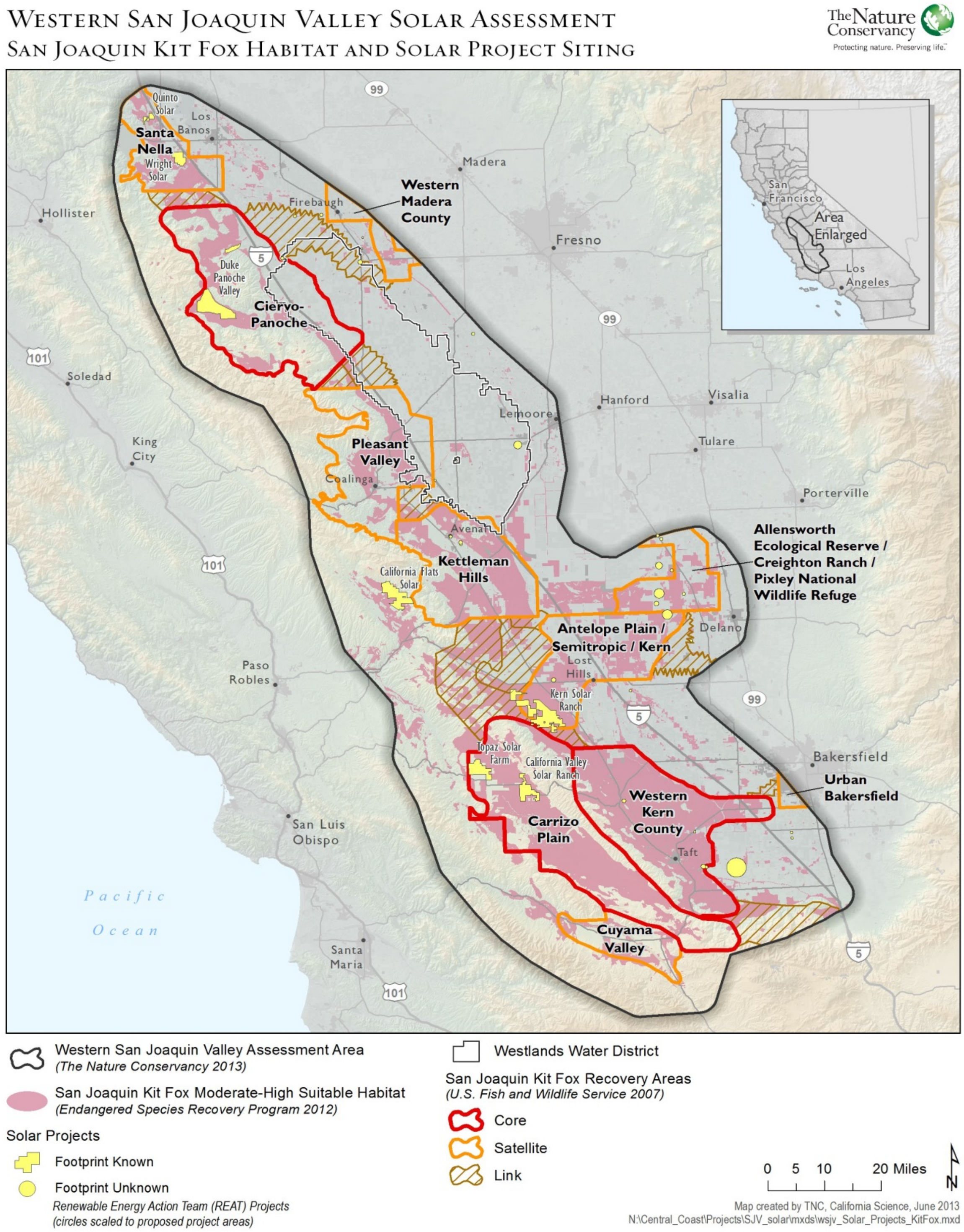
Table 2. Acreage by class for areas of potential environmental conflict.

Conflict Class	Acres
Low Biodiversity Conservation Value / Salt-affected lands	435,601
Low Biodiversity Conservation Value / Other irrigated agriculture	187,118
Low Biodiversity Conservation Value / Prime farmland	490,634
Low Biodiversity Conservation Value / Natural habitat	339,512
Moderate Biodiversity Conservation Value / Salt-affected lands	305,962
Moderate Biodiversity Conservation Value / Other irrigated agriculture	170,321
Moderate Biodiversity Conservation Value / Prime farmland	331,695
Moderate Biodiversity Conservation Value / Natural habitat	1,079,340
High Biodiversity Conservation Value / Salt-affected lands	395,809
High Biodiversity Conservation Value / Other irrigated agriculture	45,583
High Biodiversity Conservation Value / Prime farmland	124,567
High Biodiversity Conservation Value / Natural habitat	1,633,130
Total	5,539,272
Other	
Urban / Industrial	113,131

Table 3. Acreage by class for areas of potential environmental conflict within the Westlands Water District.

Conflict Class	**Acres**
Low Biodiversity Conservation Value / Salt-affected lands	197,578
Low Biodiversity Conservation Value / Other irrigated agriculture	28,109
Low Biodiversity Conservation Value / Prime farmland	166,643
Low Biodiversity Conservation Value / Natural habitat	1,118
Moderate Biodiversity Conservation Value / Salt-affected lands	22,005
Moderate Biodiversity Conservation Value / Other irrigated agriculture	12,922
Moderate Biodiversity Conservation Value / Prime farmland	73,136
Moderate Biodiversity Conservation Value / Natural habitat	928
High Biodiversity Conservation Value / Salt-affected lands	10,021
High Biodiversity Conservation Value / Other irrigated agriculture	4,279
High Biodiversity Conservation Value / Prime farmland	59,423
High Biodiversity Conservation Value / Natural habitat	16,340
Total	592,500
Other	
Urban / Industrial	12,635

Figure 1.



WESTERN SAN JOAQUIN VALLEY SOLAR ASSESSMENT
SAN JOAQUIN KIT FOX HABITAT AND SOLAR PROJECT SITING
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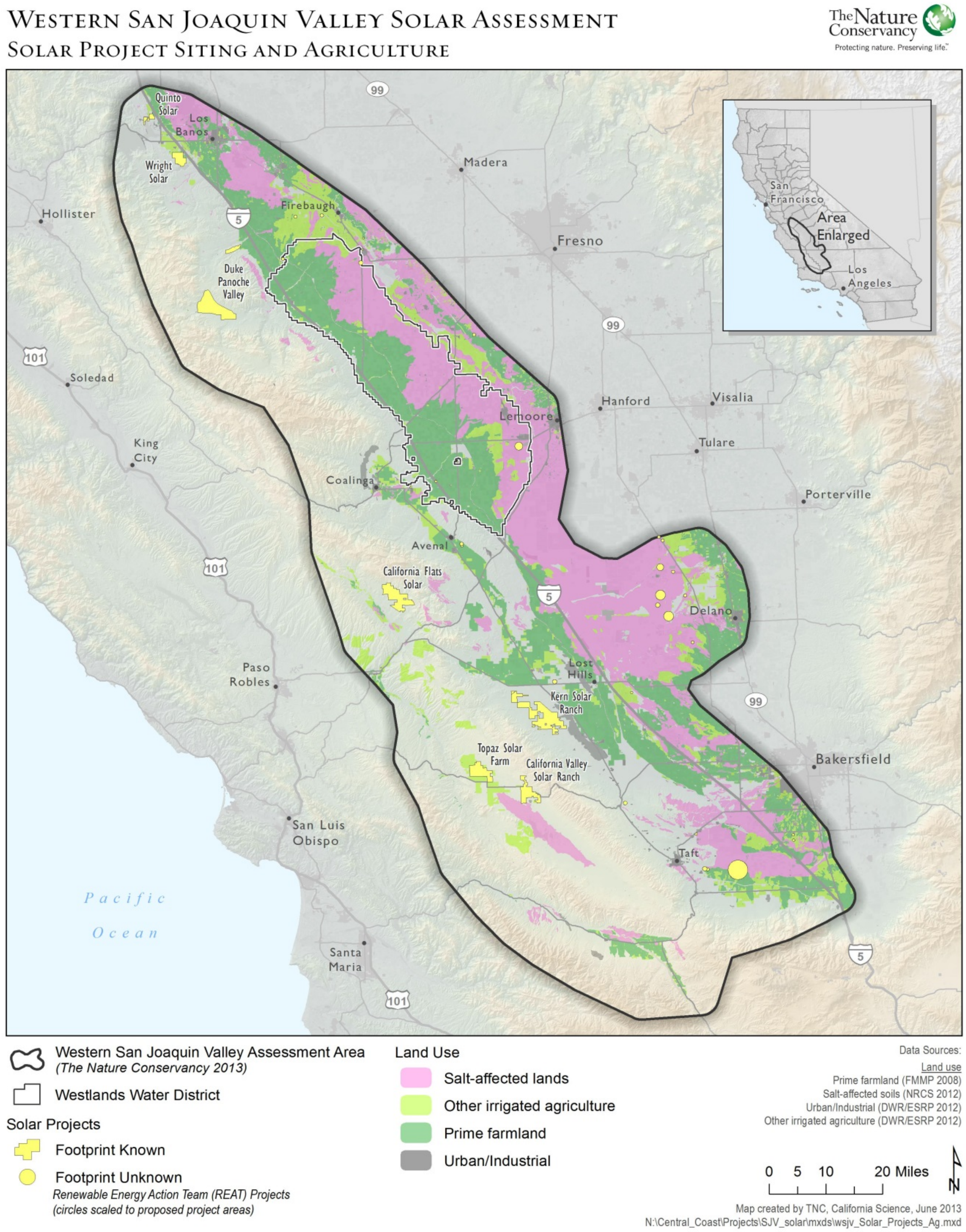
Quinto Solar
Los Banos
Santa Nella
Wright Solar
Hollister
Firebaugh
Madera
Western Madera County
Fresno
Duke Panoche Valley
Ciervo-Panoche
Soledad
Hanford
Visalia
Lemoore
Tulare
King City
Pleasant Valley
Coalinga
Porterville
Avenal
Allensworth Ecological Reserve / Creighton Ranch / Pixley National Wildlife Refuge
California Flats Solar
Kettleman Hills
Delano
Antelope Plain / Semitropic / Kern
Paso Robles
Lost Hills
Kern Solar Ranch
Topaz Solar Farm
California Valley Solar Ranch
Bakersfield
Urban Bakersfield
Western Kern County
Carrizo Plain
San Luis Obispo
Taft
Pacific Ocean
Cuyama Valley
Santa Maria
San Francisco
Area Enlarged
Los Angeles
Western San Joaquin Valley Assessment Area (The Nature Conservancy 2013)
San Joaquin Kit Fox Moderate-High Suitable Habitat (Endangered Species Recovery Program 2012)
Solar Projects
Footprint Known
Footprint Unknown
Renewable Energy Action Team (REAT) Projects (circles scaled to proposed project areas)
Westlands Water District
San Joaquin Kit Fox Recovery Areas (U.S. Fish and Wildlife Service 2007)
Core
Satellite
Link
0 5 10 20 Miles
N
Map created by TNC, California Science, June 2013
N:\Central_Coast\Projects\SJV_solar\mxds\wsjv_Solar_Projects_KitFox.mxd

Figure 2.



WESTERN SAN JOAQUIN VALLEY SOLAR ASSESSMENT
SOLAR PROJECT SITING AND AGRICULTURE
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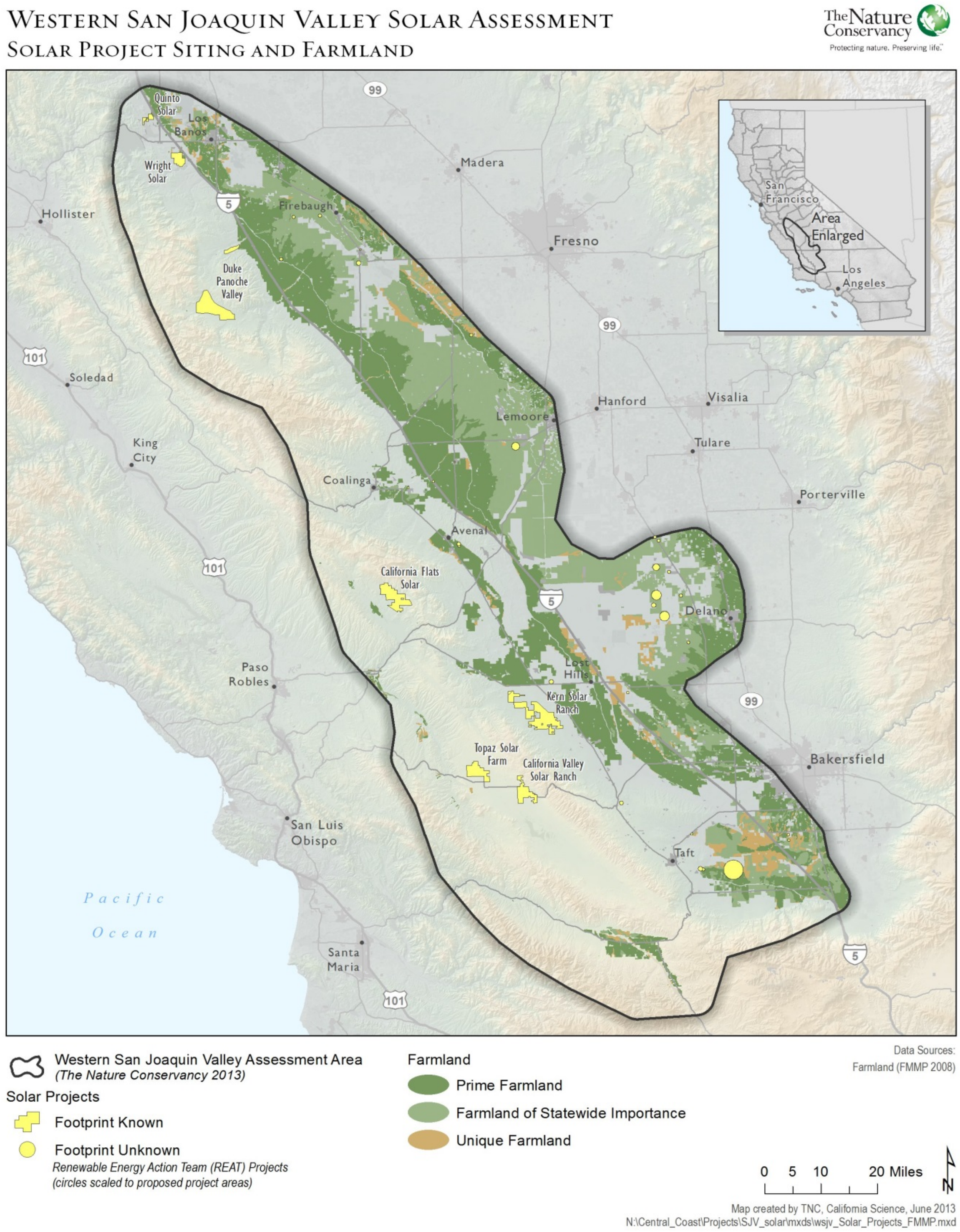
Quinto Solar
Los Banos
Wright Solar
Madera
Hollister
Firebaugh
Fresno
Duke Panoche Valley
Soledad
Hanford
Visalia
Lemoore
Tulare
King City
Coalinga
Porterville
Avenal
California Flats Solar
Delano
Paso Robles
Lost Hills
Kern Solar Ranch
Topaz Solar Farm
California Valley Solar Ranch
Bakersfield
San Luis Obispo
Taft
Pacific Ocean
Santa Maria
San Francisco
Area Enlarged
Los Angeles
Western San Joaquin Valley Assessment Area
(The Nature Conservancy 2013)
Westlands Water District
Solar Projects
Footprint Known
Footprint Unknown
Renewable Energy Action Team (REAT) Projects
(circles scaled to proposed project areas)
Land Use
Salt-affected lands
Other irrigated agriculture
Prime farmland
Urban/Industrial
Data Sources:
Land use
Prime farmland (FMMP 2008)
Salt-affected soils (NRCS 2012)
Urban/Industrial (DWR/ESRP 2012)
Other irrigated agriculture (DWR/ESRP 2012)
0 5 10 20 Miles
N
Map created by TNC, California Science, June 2013
N:\Central_Coast\Projects\SJV_solar\mxds\wsjv_Solar_Projects_Ag.mxd

Figure 3.



WESTERN SAN JOAQUIN VALLEY SOLAR ASSESSMENT
SOLAR PROJECT SITING AND FARMLAND
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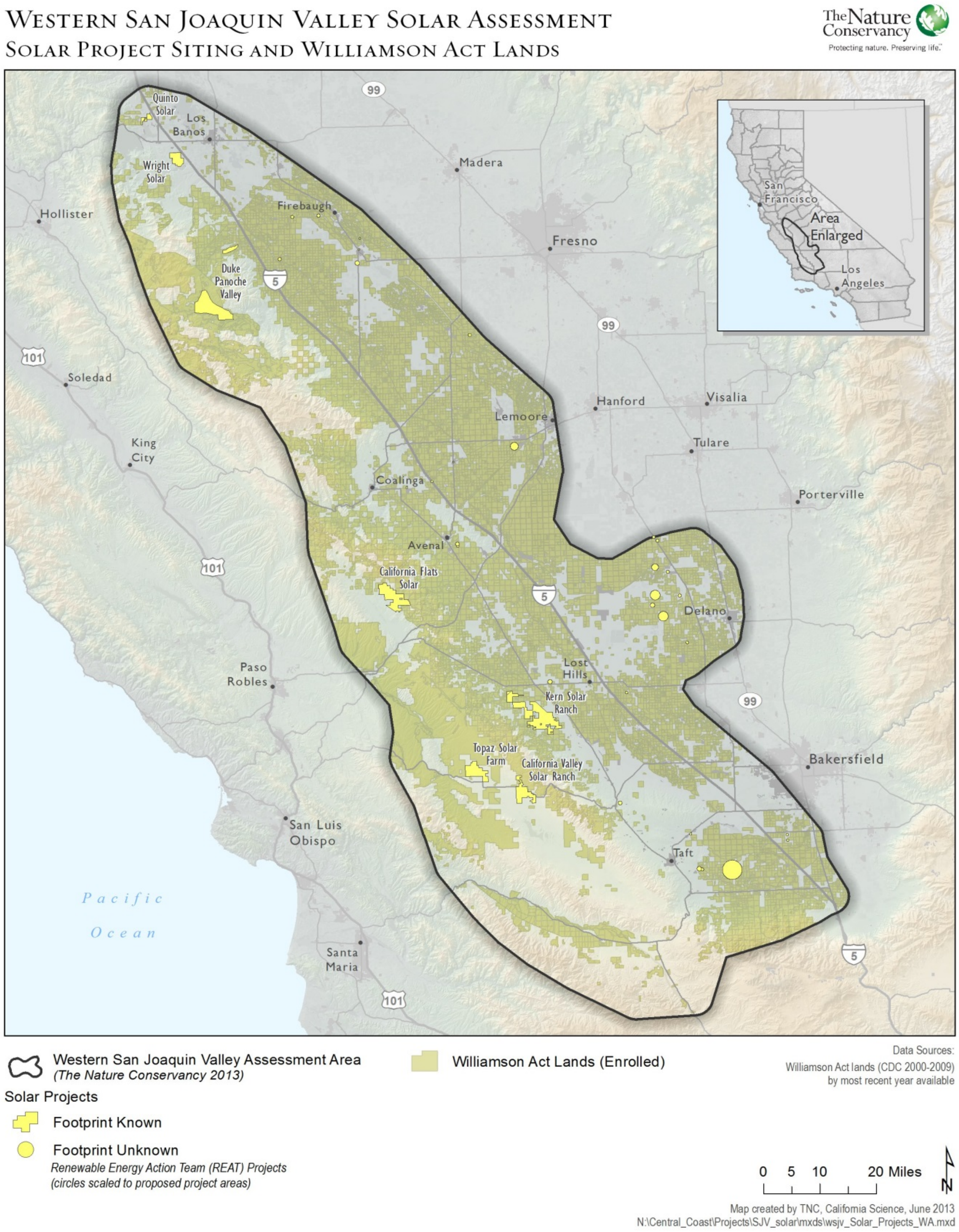
Quinto Solar
Los Banos
Wright Solar
Madera
Firebaugh
Hollister
Fresno
Duke Panoche Valley
Soledad
Hanford
Visalia
Lemoore
Tulare
King City
Coalinga
Porterville
Avenal
California Flats Solar
Delano
Lost Hills
Paso Robles
Kern Solar Ranch
Topaz Solar Farm
California Valley Solar Ranch
Bakersfield
San Luis Obispo
Taft
Pacific Ocean
Santa Maria
San Francisco
Area Enlarged
Los Angeles
99
5
101
Western San Joaquin Valley Assessment Area
(The Nature Conservancy 2013)
Solar Projects
Footprint Known
Footprint Unknown
Renewable Energy Action Team (REAT) Projects
(circles scaled to proposed project areas)
Farmland
Prime Farmland
Farmland of Statewide Importance
Unique Farmland
Data Sources:
Farmland (FMMP 2008)
0 5 10 20 Miles
N
Map created by TNC, California Science, June 2013
N:\Central_Coast\Projects\SJV_solar\mxds\wsjv_Solar_Projects_FMMP.mxd

Figure 4.


WESTERN SAN JOAQUIN VALLEY SOLAR ASSESSMENT
SOLAR PROJECT SITING AND WILLIAMSON ACT LANDS
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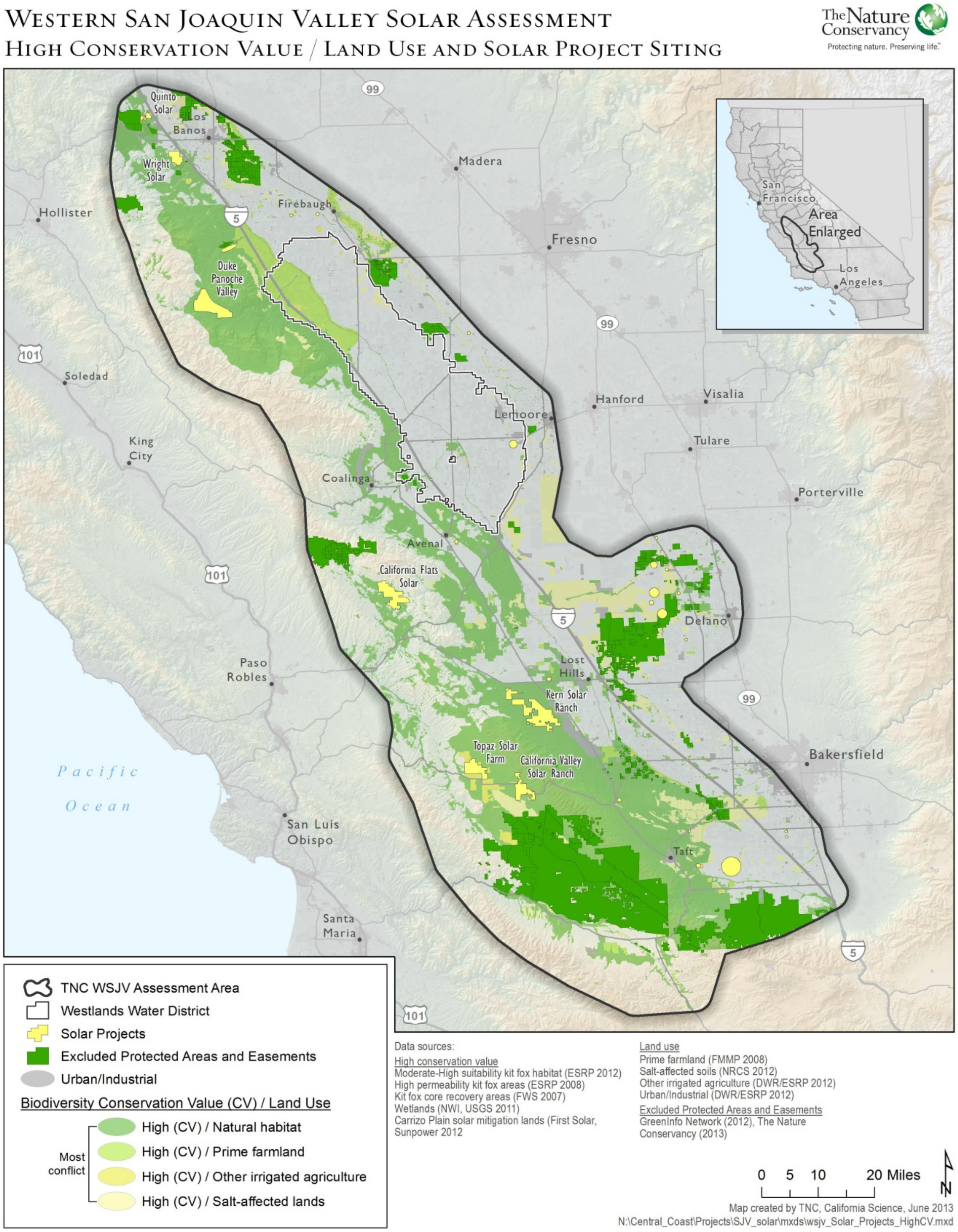
Quinto Solar
Los Banos
Wright Solar
Madera
Hollister
Firebaugh
Fresno
Duke Panoche Valley
Soledad
Hanford
Visalia
Lemoore
King City
Tulare
Coalinga
Porterville
Avenal
California Flats Solar
Delano
Paso Robles
Lost Hills
Kern Solar Ranch
Topaz Solar Farm
California Valley Solar Ranch
Bakersfield
San Luis Obispo
Taft
Pacific Ocean
Santa Maria
San Francisco
Area Enlarged
Los Angeles
Western San Joaquin Valley Assessment Area
(The Nature Conservancy 2013)
Williamson Act Lands (Enrolled)
Data Sources:
Williamson Act lands (CDC 2000-2009)
by most recent year available
Solar Projects
Footprint Known
Footprint Unknown
Renewable Energy Action Team (REAT) Projects
(circles scaled to proposed project areas)
0 5 10 20 Miles
N
Map created by TNC, California Science, June 2013
N:\Central_Coast\Projects\SJV_solar\mxds\wsjv_Solar_Projects_WA.mxd

Figure 5.


WESTERN SAN JOAQUIN VALLEY SOLAR ASSESSMENT
HIGH CONSERVATION VALUE / LAND USE AND SOLAR PROJECT SITING
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Quinto Solar
Los Banos
Wright Solar
Madera
Hollister
Firebaugh
Fresno
Duke Panoche Valley
Soledad
Hanford
Visalia
Lemoore
Tulare
King City
Coalinga
Porterville
Avenal
California Flats Solar
Delano
Paso Robles
Lost Hills
Kern Solar Ranch
Topaz Solar Farm
California Valley Solar Ranch
Bakersfield
Pacific Ocean
San Luis Obispo
Taft
Santa Maria
San Francisco
Area Enlarged
Los Angeles
TNC WSJV Assessment Area
Westlands Water District
Solar Projects
Excluded Protected Areas and Easements
Urban/Industrial
Biodiversity Conservation Value (CV) / Land Use
Most conflict
High (CV) / Natural habitat
High (CV) / Prime farmland
High (CV) / Other irrigated agriculture
High (CV) / Salt-affected lands
Data sources:
High conservation value
Moderate-High suitability kit fox habitat (ESRP 2012)
High permeability kit fox areas (ESRP 2008)
Kit fox core recovery areas (FWS 2007)
Wetlands (NWI, USGS 2011)
Carrizo Plain solar mitigation lands (First Solar, Sunpower 2012
Land use
Prime farmland (FMMP 2008)
Salt-affected soils (NRCS 2012)
Other irrigated agriculture (DWR/ESRP 2012)
Urban/Industrial (DWR/ESRP 2012)
Excluded Protected Areas and Easements
GreenInfo Network (2012), The Nature Conservancy (2013)
0 5 10 20 Miles
N
Map created by TNC, California Science, June 2013
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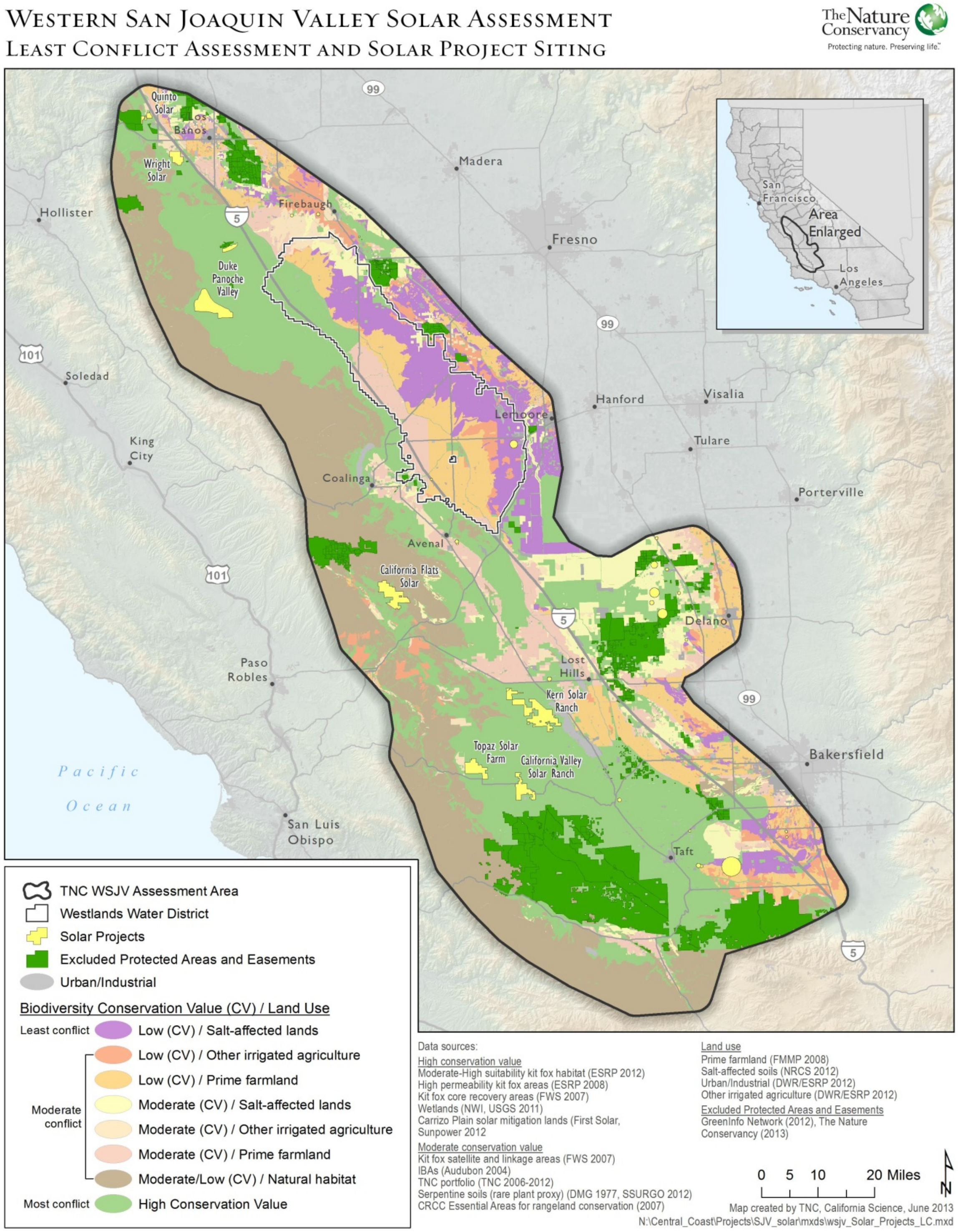
Figure 6.



WESTERN SAN JOAQUIN VALLEY SOLAR ASSESSMENT
LEAST CONFLICT ASSESSMENT AND SOLAR PROJECT SITING
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Quinto Solar
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Hollister
Fresno
Duke Panoche Valley
San Francisco
Area Enlarged
Los Angeles
Soledad
Hanford
Visalia
Lemoore
Tulare
King City
Coalinga
Porterville
Avenal
California Flats Solar
Delano
Paso Robles
Lost Hills
Kern Solar Ranch
Topaz Solar Farm
California Valley Solar Ranch
Bakersfield
Pacific Ocean
San Luis Obispo
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TNC WSJV Assessment Area
Westlands Water District
Solar Projects
Excluded Protected Areas and Easements
Urban/Industrial
Biodiversity Conservation Value (CV) / Land Use
Least conflict
Low (CV) / Salt-affected lands
Low (CV) / Other irrigated agriculture
Low (CV) / Prime farmland
Moderate conflict
Moderate (CV) / Salt-affected lands
Moderate (CV) / Other irrigated agriculture
Moderate (CV) / Prime farmland
Moderate/Low (CV) / Natural habitat
Most conflict
High Conservation Value
Data sources:
High conservation value
Moderate-High suitability kit fox habitat (ESRP 2012)
High permeability kit fox areas (ESRP 2008)
Kit fox core recovery areas (FWS 2007)
Wetlands (NWI, USGS 2011)
Carrizo Plain solar mitigation lands (First Solar, Sunpower 2012
Moderate conservation value
Kit fox satellite and linkage areas (FWS 2007)
IBAs (Audubon 2004)
TNC portfolio (TNC 2006-2012)
Serpentine soils (rare plant proxy) (DMG 1977, SSURGO 2012)
CRCC Essential Areas for rangeland conservation (2007)
Land use
Prime farmland (FMMP 2008)
Salt-affected soils (NRCS 2012)
Urban/Industrial (DWR/ESRP 2012)
Other irrigated agriculture (DWR/ESRP 2012)
Excluded Protected Areas and Easements
GreenInfo Network (2012), The Nature Conservancy (2013)
0 5 10 20 Miles
N
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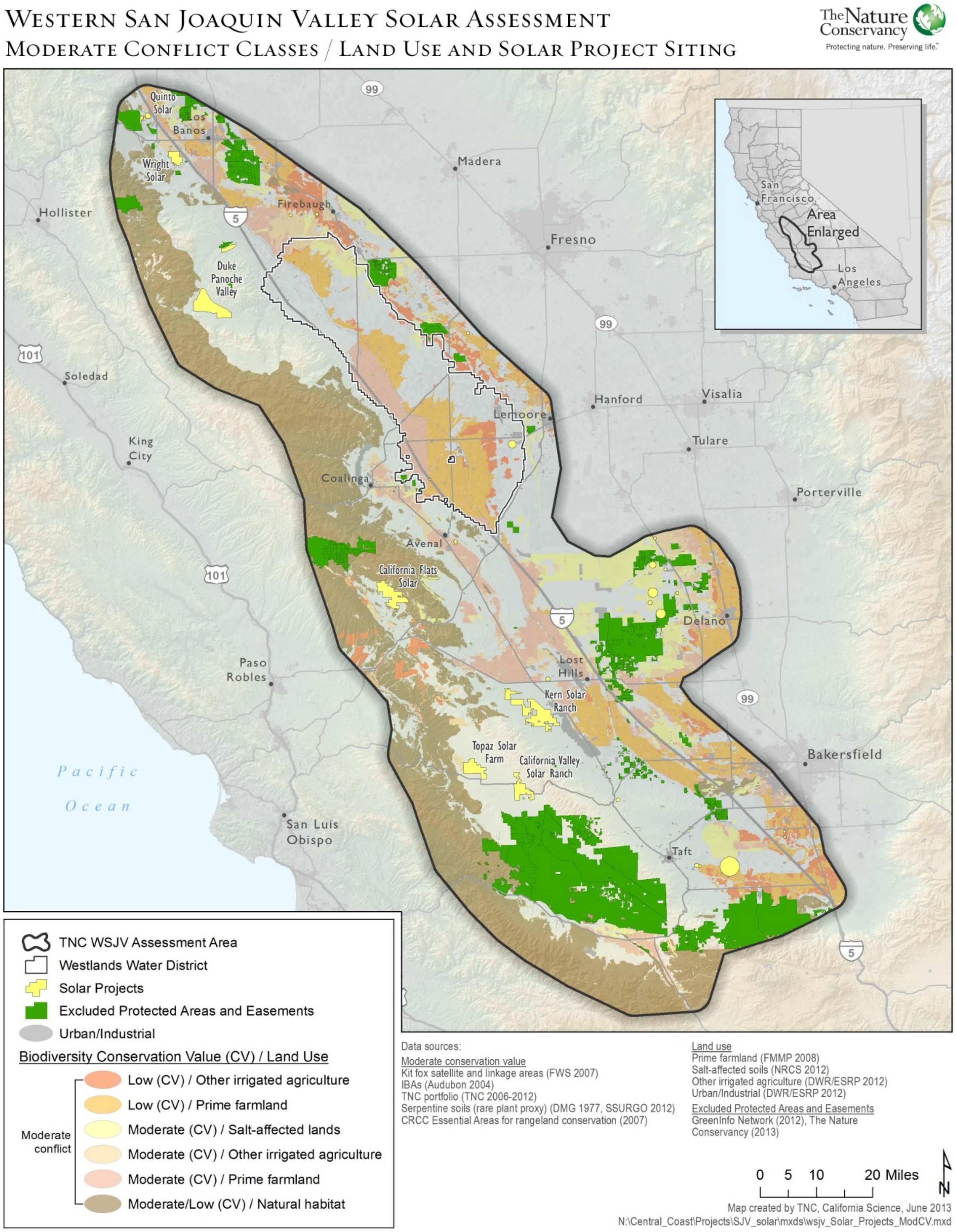
Figure 7.



WESTERN SAN JOAQUIN VALLEY SOLAR ASSESSMENT
MODERATE CONFLICT CLASSES / LAND USE AND SOLAR PROJECT SITING
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Quinto Solar
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Hollister
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Fresno
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San Francisco
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Los Angeles
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Lost Hills
Kern Solar Ranch
Topaz Solar Farm
California Valley Solar Ranch
Bakersfield
Pacific Ocean
San Luis Obispo
Taft
TNC WSJV Assessment Area
Westlands Water District
Solar Projects
Excluded Protected Areas and Easements
Urban/Industrial
Biodiversity Conservation Value (CV) / Land Use
Moderate conflict
Low (CV) / Other irrigated agriculture
Low (CV) / Prime farmland
Moderate (CV) / Salt-affected lands
Moderate (CV) / Other irrigated agriculture
Moderate (CV) / Prime farmland
Moderate/Low (CV) / Natural habitat
Data sources:
Moderate conservation value
Kit fox satellite and linkage areas (FWS 2007)
IBAs (Audubon 2004)
TNC portfolio (TNC 2006-2012)
Serpentine soils (rare plant proxy) (DMG 1977, SSURGO 2012)
CRCC Essential Areas for rangeland conservation (2007)
Land use
Prime farmland (FMMP 2008)
Salt-affected soils (NRCS 2012)
Other irrigated agriculture (DWR/ESRP 2012)
Urban/Industrial (DWR/ESRP 2012)
Excluded Protected Areas and Easements
GreenInfo Network (2012), The Nature Conservancy (2013)
0 5 10 20 Miles
N
Map created by TNC, California Science, June 2013
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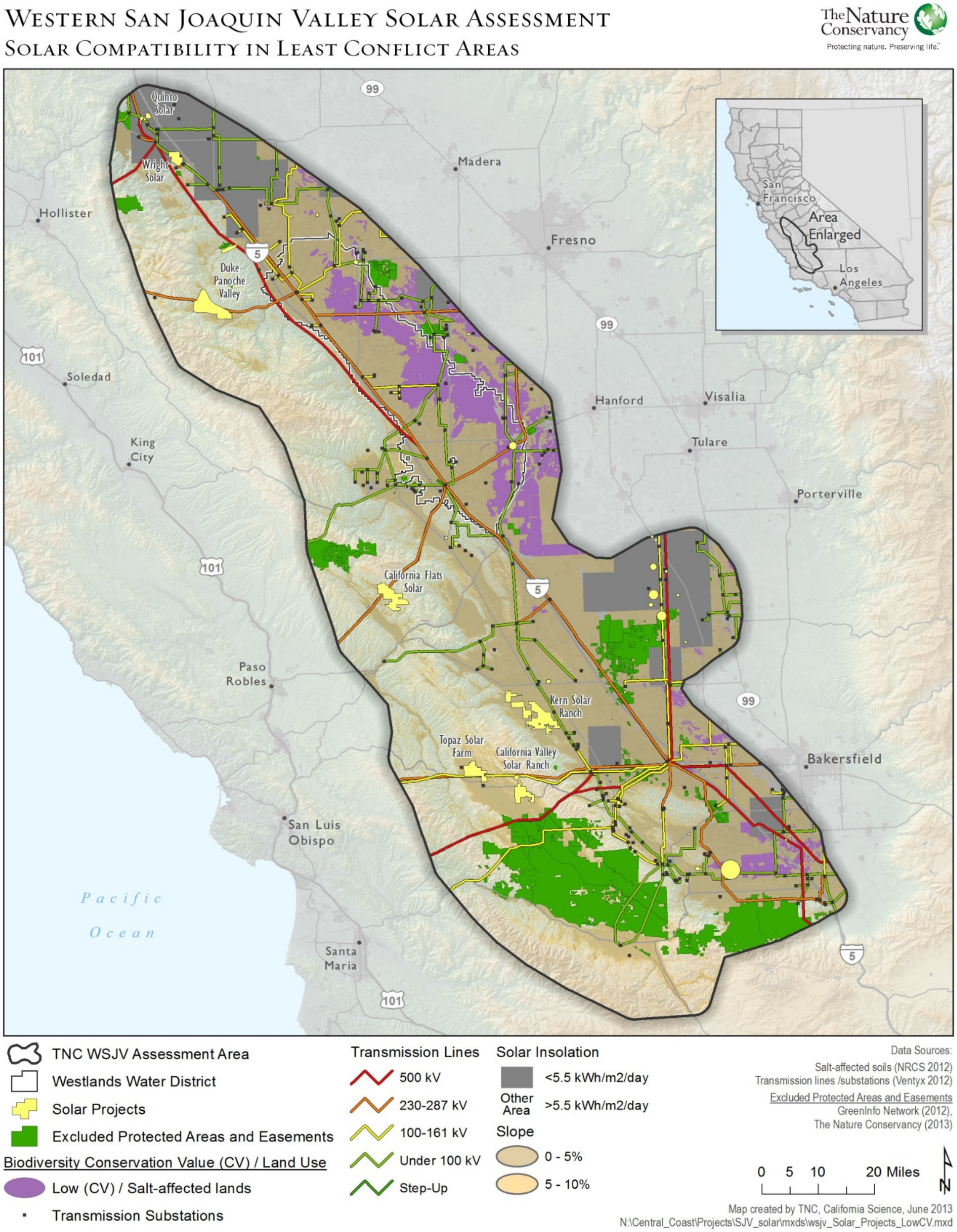
Figure 8.



Western San Joaquin Valley Solar Assessment
Solar Compatibility in Least Conflict Areas
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Quinto Solar
Wright Solar
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King City
Hanford
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Tulare
Porterville
California Flats Solar
Paso Robles
Kern Solar Ranch
Topaz Solar Farm
California Valley Solar Ranch
Bakersfield
San Luis Obispo
Pacific Ocean
Santa Maria
San Francisco
Area Enlarged
Los Angeles
TNC WSJV Assessment Area
Westlands Water District
Solar Projects
Excluded Protected Areas and Easements
Biodiversity Conservation Value (CV) / Land Use
Low (CV) / Salt-affected lands
Transmission Substations
Transmission Lines
500 kV
230-287 kV
100-161 kV
Under 100 kV
Step-Up
Solar Insolation
<5.5 kWh/m2/day
Other Area
>5.5 kWh/m2/day
Slope
0 - 5%
5 - 10%
Data Sources:
Salt-affected soils (NRCS 2012)
Transmission lines /substations (Ventyx 2012)
Excluded Protected Areas and Easements
GreenInfo Network (2012),
The Nature Conservancy (2013)
0 5 10 20 Miles
N
Map created by TNC, California Science, June 2013
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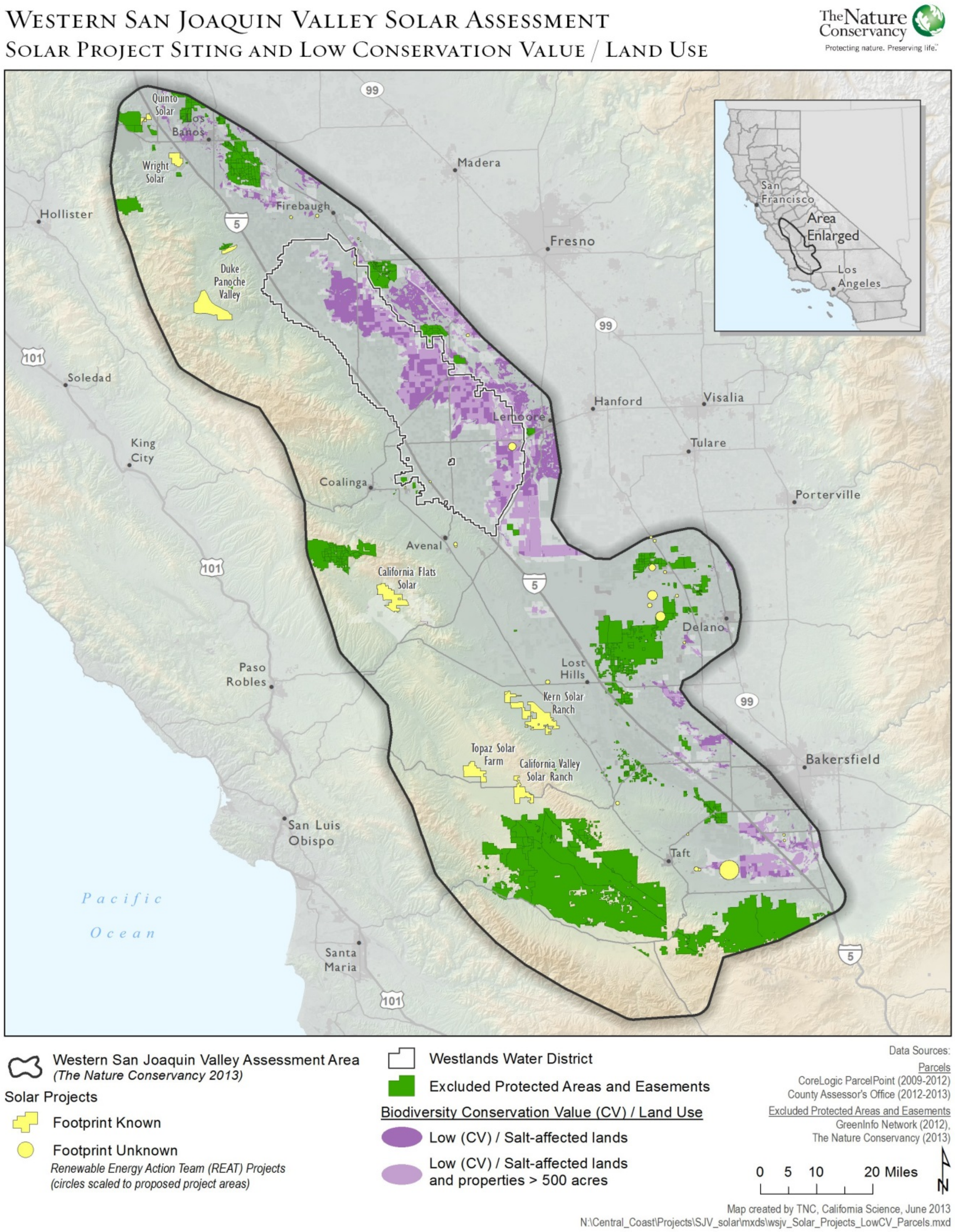
Figure 9.


Western San Joaquin Valley Solar Assessment
Solar Project Siting and Low Conservation Value / Land Use
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Hollister
Firebaugh
Fresno
Duke Panoche Valley
San Francisco
Area Enlarged
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Lemoore
King City
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Coalinga
Porterville
Avenal
California Flats Solar
Delano
Paso Robles
Lost Hills
Kern Solar Ranch
Topaz Solar Farm
California Valley Solar Ranch
Bakersfield
San Luis Obispo
Taft
Pacific Ocean
Santa Maria
Western San Joaquin Valley Assessment Area
(The Nature Conservancy 2013)
Solar Projects
Footprint Known
Footprint Unknown
Renewable Energy Action Team (REAT) Projects
(circles scaled to proposed project areas)
Westlands Water District
Excluded Protected Areas and Easements
Biodiversity Conservation Value (CV) / Land Use
Low (CV) / Salt-affected lands
Low (CV) / Salt-affected lands and properties > 500 acres
Data Sources:
Parcels
CoreLogic ParcelPoint (2009-2012)
County Assessor's Office (2012-2013)
Excluded Protected Areas and Easements
GreenInfo Network (2012),
The Nature Conservancy (2013)
0 5 10 20 Miles
N
Map created by TNC, California Science, June 2013
N:\Central_Coast\Projects\SJV_solar\mxds\wsjv_Solar_Projects_LowCV_Parcels.mxd