WildLight Final Report

San Joaquin Valley Landscape-Scale Planning for Solar Energy and Conservation

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SAN JOAQUIN VALLEY LANDSCAPE-SCALE PLANNING FOR SOLAR ENERGY AND CONSERVATION

Final Report

A Group Project submitted in partial satisfaction of the requirements for the Bren School of Environmental Science & Managements' Master of Environmental Science and Management degree.

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1. EXECUTIVE SUMMARY

California has dramatically advanced its deployment of renewable energy technologies in an effort to reduce greenhouse gas emissions. Through the implementation of the 33% Renewable Portfolio Standard (RPS), the state government has spurred installation of utility scale (>20MW) renewables, and the largest growth is projected to come in the form of photovoltaic solar energy (CPUC Calculator). Numerous projects have been slated for and constructed in the Mojave Desert, but issues with the Endangered Species Act (ESA) and protracted stakeholder conflicts have significantly slowed construction in many instances, or led to unmitigated harm to wildlife in others. These conflicts and push backs have led developers to seek opportunities in the San Joaquin Valley of California, an area where ESA issues are perceived to be less likely, and large tracts of previously developed land are available. The Smart from the Start Report, released by Defenders of Wildlife in 2012, states that there is a need for more decision support tools for smart growth initiatives, and this analysis is a critical first step.

The goal of the San Joaquin Valley (SJV) Landscape-Scale Planning for Solar Energy and Conservation analysis, or WildLight, is to identify areas of maximum data consensus for photovoltaic solar development within the SJV. A secondary goal of the analysis is to identify high value conservation lands within the valley that can be conserved and can also serve as mitigation areas for the construction of solar developments. Through the generation of a spatial model that incorporates data from the major stakeholder groups in the region, areas that satisfy the following criteria are highlighted as areas most desirable for utility scale solar development:

- Low Agricultural Value
- Low Conservation Value
- High Solar Suitability

To model these three distinct valuations, a set of spatial model outputs was combined. Data was generated or collected by the WildLight Team, stakeholder groups, government agencies, and university researchers. All of this data was input into the Environmental Evaluation Modeling System, an innovative and powerful decision support framework developed by the Conservation Biology Institute. This model allows for the integration and comparison of widely varied data types, and the outputs are simple and easily interpreted. This model utilizes the best available data, but was designed to be highly adaptable and capable of incorporating new data as it becomes available.

The final results of the WildLight analysis are presented in Figure 1. Dark green areas (A) are maximum consensus areas where utility scale solar development will be least likely to spur conflict between developers and other stakeholder groups. Conversely, purple areas represent areas of low consensus. Likewise, dark green zones (B) are high value conservation lands that could potentially be conserved or used by solar developers as mitigation areas for their projects whereas purple represents areas with low conservation value.

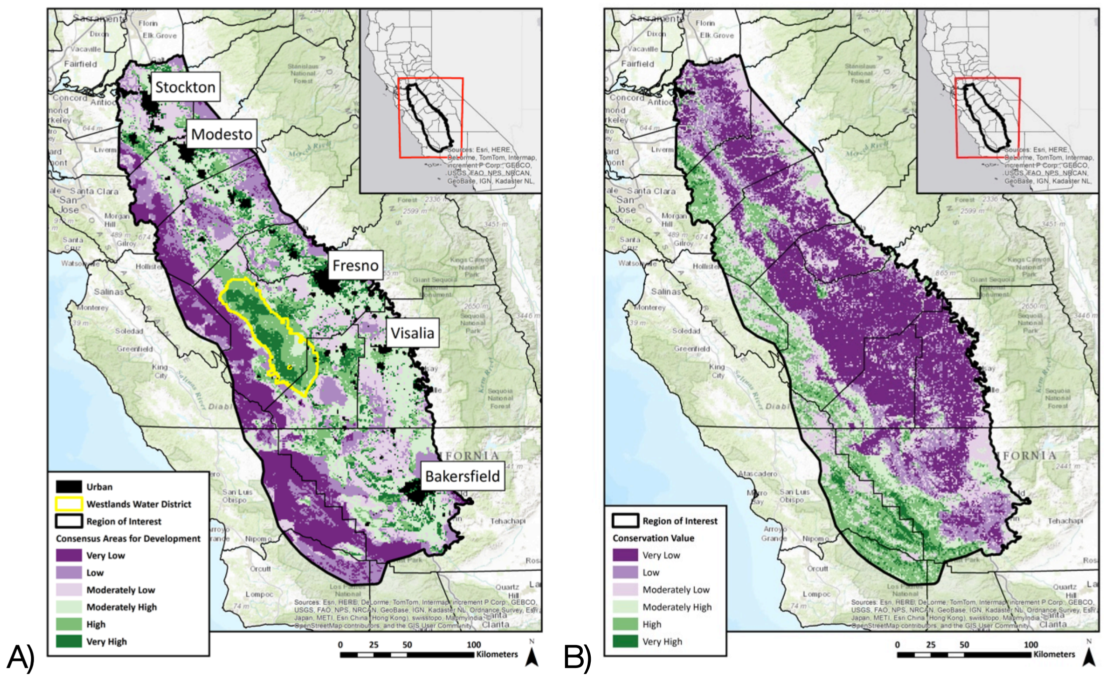

Figure E1. A) Environmental Evaluation Modeling System output of Consensus Areas for Solar Development B) Environmental Evaluation Modeling System output for areas of High Conservation Value.

This analysis and model output identified Westlands Water District and urban areas as high consensus areas within the SJV for utility-scale solar development. Areas of high conservation value were notably rimming the valley floor and were concentrated along the western foothills. Around 1 million acres were identified as very high consensus for utility-scale solar energy development, with ~200,000 acres identified as very high in conservation value.

Incorporating stakeholder preferences is an important next step necessary to enhance and apply the results of this model. Thus far, interviews have been conducted with a small group of solar developers, consultants, and county planners in an effort to improve our model and inform its application. In the future, additional input from agricultural and county government stakeholder groups will provide further suggestions for ways to increase the power of our model.

2. INTRODUCTION

As California's population continues to expand and the effects of climate change increase, there is an increasing need for clean and reliable energy (Norman et al., 2008, Shafiee & Topal 2009; Hernandez et al. 2014). California began a concerted transition towards renewable energy with the passage of SB1078 in 2002. This piece of legislation put forth the Renewable Portfolio Standards (RPS) program, which required that 20% of California's procurement of retail energy needed come from renewable energy sources by 2020. In 2011, the RPS was amended to require 33% by 2020 and has been bolstered by financial incentives from the American Recovery and Reinvestment Act (ARRA) of 2009 (Defenders of Wildlife, 2013).

Solar energy has emerged as one of the most economically viable forms of renewable energy. Technological improvements in the efficiency of photovoltaic (PV) panels and a decline in the price of these panels beginning in late 2008 (Bazilian et al., 2013) have continued to drive solar energy rates down. Additionally, the high on-peak energy production and predictability of performance make solar energy an attractive option. Projections by the Office of the Governor estimate that nearly 100,000 acres of land within the state will be needed to reach the 33% RPS standard by 2020, and 1 million acres of land will be required to reach the greenhouse gas reduction targets by 2050 (Elkind, 2011). California currently has 212,261 acres of solar planned, under construction, or in use (Hernandez et al. 2014). Additionally, the California Public Utilities Commission estimates that photovoltaic solar is likely to see a higher rate of growth compared to other renewables, within the state's renewable energy portfolio (Figure 1).

To keep pace with this demand, agencies are under extreme pressure to approve development permits, in some cases before the full environmental impacts are known (Cameron et al., 2012). Meeting the 33% RPS calls for 20,000 MW of new renewable capacity by 2020, with an estimated 12,000 MW coming from smaller scale distributed generation facilities, and the remaining 8,000 MW coming from large scale wind, solar and thermal generators, that connect directly to the transmission grid (19). Countering this argument for large increases in distributed generation, the amount of power estimated to come from distributed versus utility scale projects is in constant flux, with some projections predicting a much higher proportion of energy coming from utility scale developments than from a distributed network (CPUC). As of late 2014, there is enough renewable energy facilities built, and in the planning and permitting stage, to fulfill the 33% RPS target (CEC, 2014).

An overview of the planning and permitting process for meeting the RPS can be found in **Appendix A.**

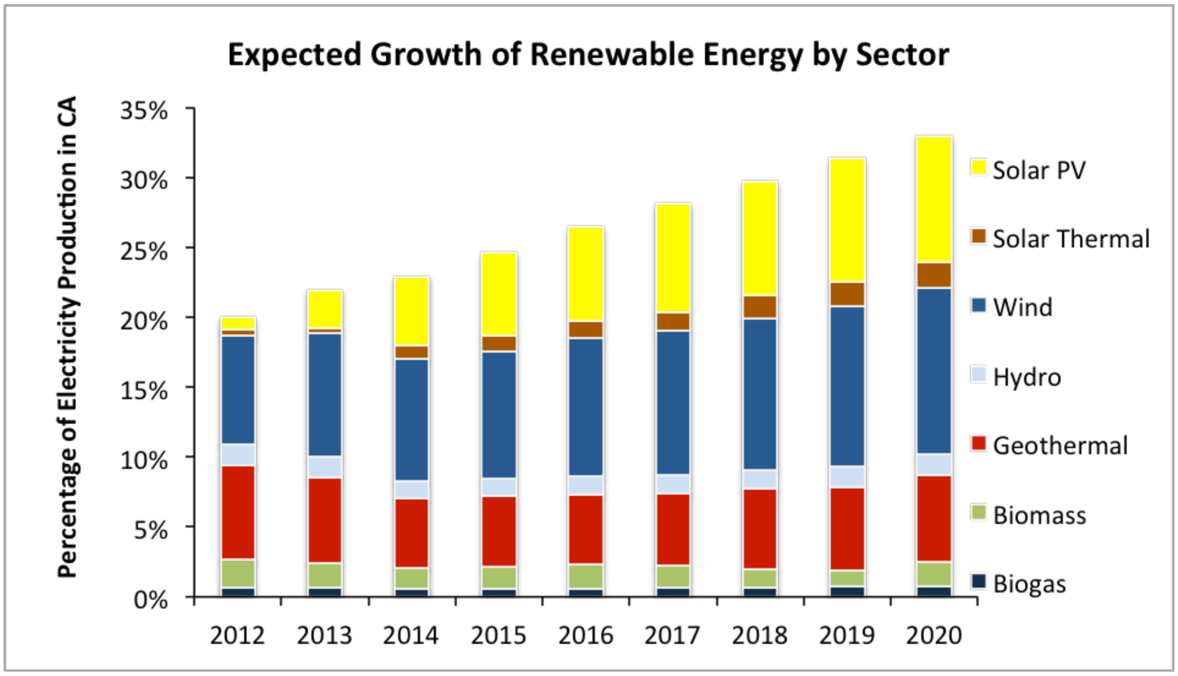

Figure 1. Projected growth of different renewable energy technologies as a percentage of the renewable portfolio (2012-2020). Source: California Public Utilities Commission

The state of California has undertaken a renewable energy planning process for the Mojave and Sonoran Deserts, called the Desert Renewable Energy Conservation Plan, to inform the process of developing renewable energy in these areas. However, due to the abundance of rare and endangered species present in the California desert, there is increased interest in siting renewable energy in less contested areas throughout the state. Since 2008 there has been a large push by environmental groups, the state, and developers alike to site solar energy development in the San Joaquin Valley. The assumed benefits of developing within this region include cheap private land, access to existing transmission lines, less issues with protected species (Germano et al., 2011) and less opposition to development on already degraded agricultural land.

To help inform large land use changes such as utility-scale solar development, this analysis will develop a model that will identify areas for development that are agreeable to the major stakeholder groups within the region: agriculture, solar development, and conservation. The output of this model can serve as a decision support tool by planners, developers, and other groups, by identifying maximum consensus areas for solar development. Projects that utilize this model will be able to move forward expeditiously and in a manner that does not sacrifice the well being of wildlife in order to meet our renewable energy goals. Additionally, the project will highlight possible mitigation areas through the identification of high priority conservation lands that are not currently protected.

3. REGIONAL SETTING

The San Joaquin Valley is the southern most of two river valleys that lie end to end and comprise the Central Valley of California. The San Joaquin River runs north and drains the majority of the valley. The study area for this analysis includes all eight counties (San Joaquin, Stanislaus, Merced, Madera, Fresno, Kings, Tulare, and Kern) on the valley floor, limited by the Sierra foothills to the east. Areas in the west were chosen to include lands of management concern as outlined by previous analyses (Figure 2).

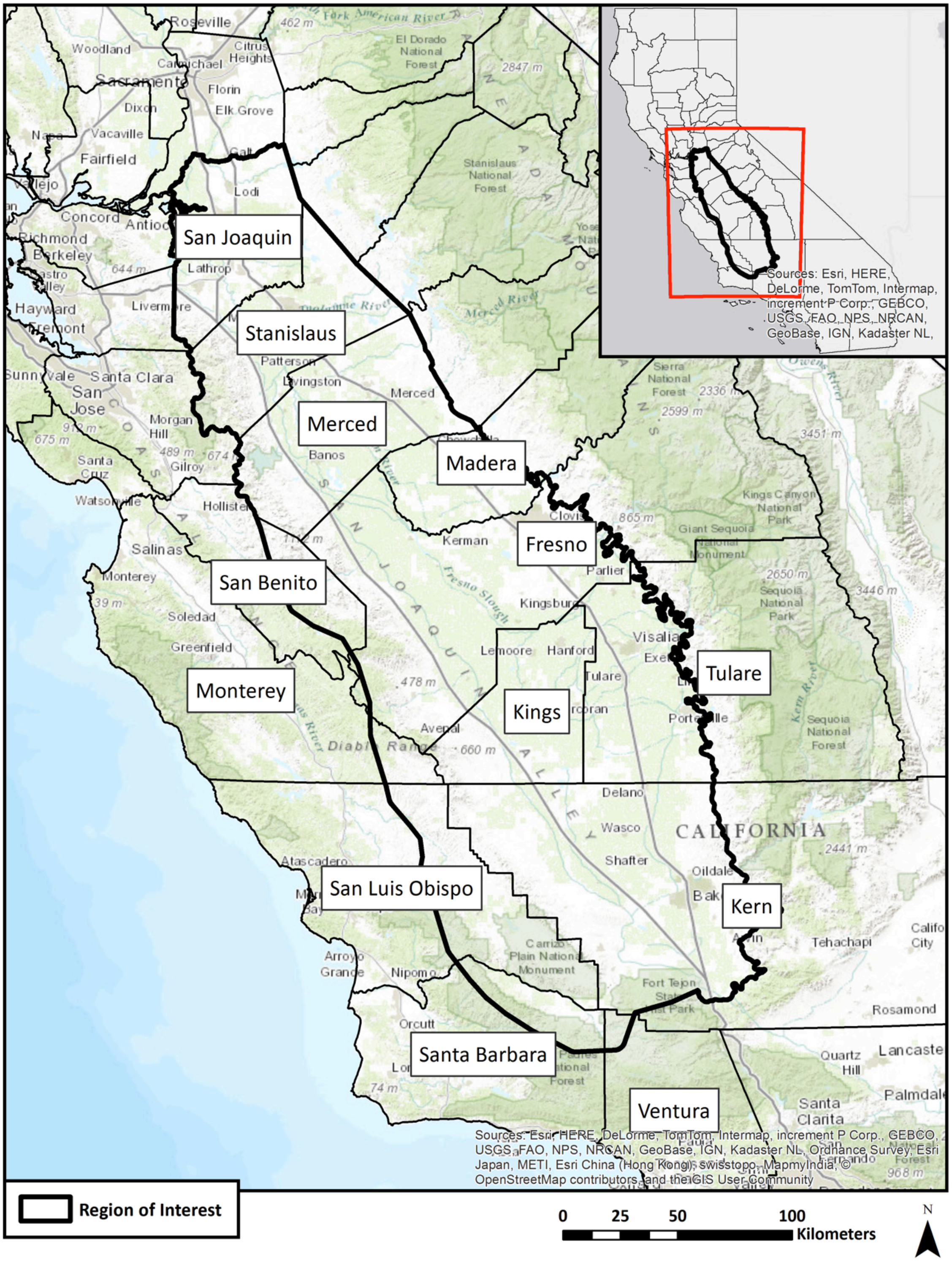

Figure 2. Map of the study area for the San Joaquin Valley Landscape Scale Solar Assessment

Agricultural Setting

The San Joaquin Valley is California's most important agricultural region and one of the most productive in the world. Home to six of the top ten agricultural counties in the state, these counties generated an average of $2.2 to $6.8 billion during the 2013-2014 fiscal year (CDFA, 2014). In the eastern portion of the valley, high value crops such as almonds, grapes, stone fruits, citrus, and livestock dominate the landscape (CDFA, 2014). Alternatively, the western portion of the valley has more low value seasonal crops such as greens and cotton. The western valley is also characterized by poor drainage, with drainage issues in this region dating back to the early 20th Century. Highly saline soils are increasing the risk to crop yields, particularly in the Westlands Water District. The Westlands Water District includes large portions of Fresno and Kings counties where natural selenium levels are high, further compounding the problem.

The primary mechanism for the conservation of agricultural land in California is the California Land Conservation Act of 1965, also called the Williamson Act. This is a state policy requiring contracting landowners to restrict land uses to agriculture on their parcels in return for reduced property taxes. New regulations approved in December 2013 have created a pathway for solar-use easements, which allows landowners to cancel these contracts. The new solar-use easement provisions require that soil and water quality testing be done. Additionally, landowners must be able to prove that their yield is declining over a period of six years (Williamson Act, Section 3103). These testing requirements are designed to ease restrictions on marginal lands while simultaneously protecting prime agricultural areas, incentivizing counties and landowners to convert water stressed and salt affected lands to solar-use easements.

Urban Expansion

While the SJV is known mostly for its agricultural bounty, it is also home to several growing urban and suburban areas. While these are not the largest cities in California, the urban centers in the SJV have been growing rapidly, and contain 8 of the top 15 fastest growing counties in California over the last several years. In response to this rapid growth, several county governments came together for the San Joaquin Valley Blueprint Planning Process in 2009 with the goal of achieving a density level of 6.8 dwelling units per acre by 2050. Some of the stated goals of this project were to reduce the total acres of natural habitat developed, as well as reduce the acres of farmland consumed through development (San Joaquin Valley Blueprint, 2009).

Ecological Setting

In addition to urban expansion, much of the land on the Valley floor has been converted to agriculture and grazing lands, leaving the remaining natural ecosystems fragile and fragmented. Historically, large expanses of the SJV were a network of rivers, marshes, and freshwater lakes. The three largest lakes were Kern, Buena Vista, and Tulare Lake. Tulare Lake was once the largest lake west of the Mississippi and was over 700 square miles (Schoenherr 1992). Four great rivers, the Kern, Kings, San Joaquin, and the Merced River, fed this inland system of marshes and riverine habitats. Much of the aforementioned riverine and wetland habitat was converted for agricultural use in the early 19th century because of the thick nutrient rich soil left by millennia of intermittent flooding. In most cases, the change in land use forced wildlife into marginal habitat and into greater conflict with human land uses. As the valley rises into the foothills of the coastal and Sierra Nevada ranges on the west and east respectively, open space and usable habitat increase. These areas contain several varieties of plant and shrub communities as well as native grasslands that provide habitat for many endangered and threatened species. However, much of the best habitat for these species once lied on the valley floor, which has been displaced by agriculture, thus leaving much the remaining habitat as sub-optimal.

Existing Conservation

In an effort to address deteriorating habitats, existing conservation areas have been created. These are land holdings, which are unlikely to be developed due to deed restrictions and/or mandates by the managing agency or organization. These include lands under the jurisdiction of the United States Forest Service, Bureau of Land Management, Fish and Wildlife Service, National Parks Service, California State Lands Commission, California Department of Fish and Wildlife, county and municipal parks and open space, and non-government land trusts. These areas are primarily concentrated in the Coast Ranges and upland valley regions of the study area, particularly in the southwest where the Los Padres National Forest represents the largest contiguous area of such land holdings.

4. METHODS

The WildLight analysis combines three land valuation modules: Conservation Value, Agricultural Value, and Solar Suitability. To model these three distinct land valuations, a set of spatial submodules is used. Data was generated or collected by the WildLight Team, stakeholder groups, government agencies, and university researchers.

All of this data was input into the Environmental Evaluation Modeling System (EEMS), an innovative and powerful decision support framework developed by the Conservation Biology Institute. This model allows for the integration and comparison of widely varied data types, and the outputs are simple and easily interpreted maps. By dividing the landscape into 1km^2 cells, the model takes a birds eye view of the SJV that is large enough to visualize spatial trends, yet fine enough to understand how a single solar development will affect the surrounding area. The area required for a 20 MW utility scale solar development is approximately 140 acres or 0.56 km^2. The 1km^2 cell chosen for this analysis would therefore be able to accommodate a solar development as seen within the valley currently. While our model utilizes the best available data, it was also designed to be highly adaptable and capable of incorporating new data as it becomes available.

The final operation of this model is a weighted sum of the Conservation Value, Agricultural Value, and Solar Suitability. In its current form, the model most accurately represents the preferences of the conservation stakeholders, making this a limitation to the applicability of our current results. The next step for this project is to distribute the results to various stakeholders, which will allow for a more accurate determination of weights from all parties. The feedback provided through this process and thus future versions are expected to be based on the preferences of all of the stakeholder groups, time and data allowing. This would bring the results of this model closer to representing a true consensus among all parties concerned with solar development in the SJV.

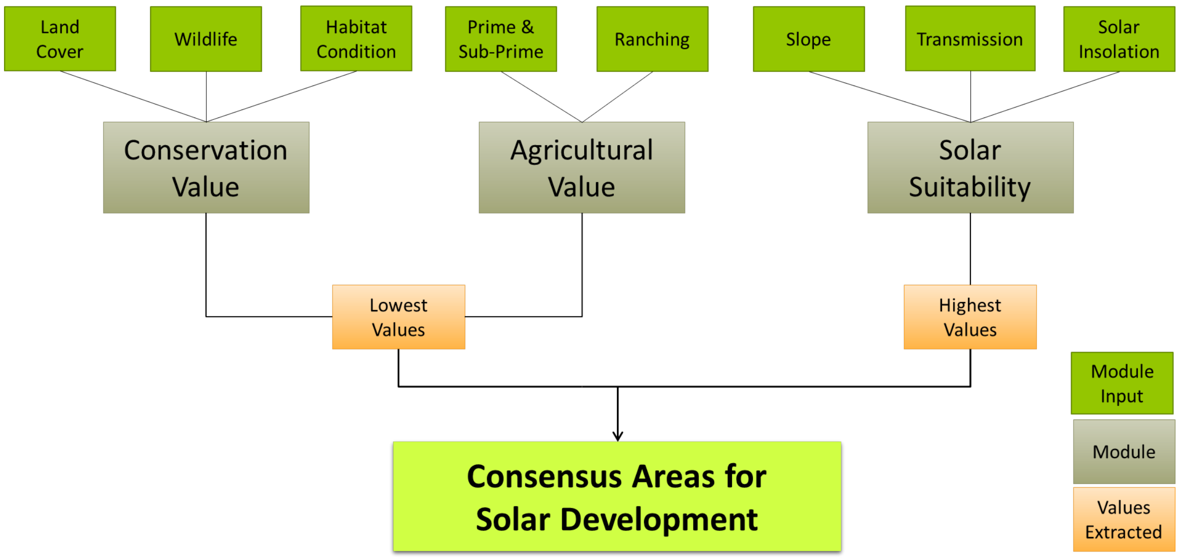

Figure 3. Conceptual map of the WildLight modeling approach with module inputs in dark green, modules in gray and extracted values in orange.

This model is highly parameterized and so in order to refine value weights, the WildLight team interviewed a group of solar industry professionals. These interviews were designed to illuminate which factors were critical in determining siting decisions and the results of these interviews are incorporated into the solar suitability module.

A total of 16 people were interviewed in order for the WildLight team to assess the preferences of professionals in the field of solar energy development. These practitioners have experience in implementing solar projects on a large scale are most familiar with the associated issues.

Table 1. Description of the interviewees and the time that they were interviewed for the WildLight project

Interviewee Description	Time of Interview
Mid sized solar developer	1/16/15, 3:00 PM
Mid sized solar developer	1/20/15, 4:30 PM
Consulting firm	1/22/15, 3:00 PM
Large scale solar developer	
Retired solar developer	
County planner	1/22/15, 1:00 PM
Consultant	1/23/15, 11:00 AM
Large scale solar developer	1/23/15, 4:00 PM
Small scale solar developer	1/27/15, 4:40 PM
Consultant firm	
Small scale solar developer	1/28/15, 4:45 PM
Small scale solar developer	1/28/15, 5:16 PM
Large scale solar developer	1/30/15, 9:00 AM
Large scale solar developer	1/30/15, 9:30 AM
Large scale solar developer	1/30/15, 4:18 PM
County planner	2/2/15, 2:00 PM

Agricultural Land Value

Agricultural land value was established through the combination of two sets of data including the Strategic Farmland Valuation and the California Rangeland Conservation Coalition Priorities. The values from these two datasets are combined in the EEMS model, and low values are extracted. The data used in this module is seen below in Table 1.

Table 2. Model inputs and data sources for the Agricultural Land Value module

Model Inputs	Data Source
Farmland Classifications	UC Davis Information Center for the Environment - Strategic Farmland Model
	American Farmland Trust
Rangeland Classifications	California Rangeland Conservation Coalition (CRCC) Priority Areas

The Strategic Farmland model was developed by researchers at the Information Center for the Environment at UC Davis and has already been applied to areas within the SJV (Schmidt et al., 2010; Thompson, 2008). The model identifies "land most likely to remain economically viable for high-value commercial agriculture in the long term, given its inherent characteristics and surrounding conditions " (Thompson, 2008). This is a highly complex model that improves upon common agricultural land valuation systems including the California Department of Conservation's Farmland Mapping and Monitoring program (FMMP) and Land Evaluation and Site Assessment Model. The improvements come through incorporation of several important factors such as soil productivity, water cost and reliability, microclimate, environmental sensitivity, and urban growth pressure.

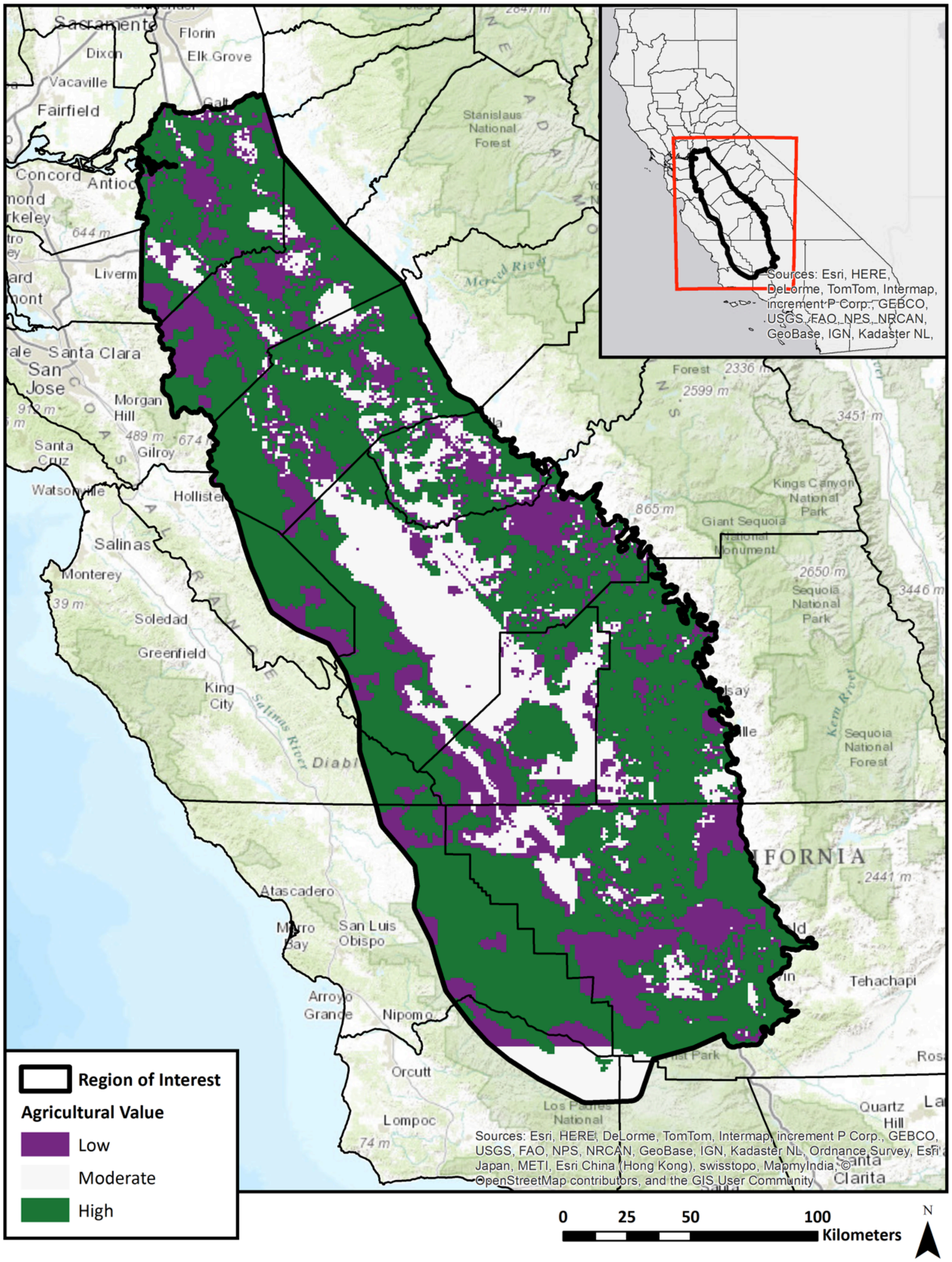

Figure 4. Agricultural Land Value Map with high value lands shown in green and low value lands shown in purple.

Rangeland designations were taken from the California Rangeland Conservation Coalition's Biological Prioritization of Rangelands to determine the location of high value rangeland. Researchers at The Nature Conservancy, led by Dick Cameron, performed this assessment of California's privately owned rangeland (Cameron, 2007). The goal of their assessment was to preserve rangeland, one of California's most threatened habitats (Maestas et al. 2003; Theobald 2005). For the WildLight analysis, well-managed rangelands are viewed as having inherent value for conservation and grazing, and are not ranked highly for solar suitability (Pyke and Marty 2005).

Conservation Value

The conservation value of the landscape was determined by combining Land Cover, Wildlife, and Habitat Condition attributes. Each of these were calculated independently and then combined within the EEMS model framework. To determine the priority level of a given cell, the map layer containing the location and spatial extent of current conservation areas was overlaid upon the results, with high priority areas being those areas with high conservation value not currently under existing conservation or preservation measures.

Table 3. Model inputs and data sources for the Conservation Land Value module and three submodules: Land Cover, Wildlife, and Habitat Condition

Model Inputs	Data Source
Land Cover	
Wetlands	FWS National Wetlands Inventory
Important Bird Areas	National Audubon Society
Vegetative Communities (Diversity)	USGS Gap Analysis Project
Under Represented Communities	USGS Gap Analysis Project
Wildlife	
Species Richness	California Natural Diversity Database (2014)
Current Habitat	Species Distribution Models (MaxEnt)
Habitat Resilience	Climate Projection SDMs (MaxEnt)
Habitat Condition	
Permeability	Theobald et al.
Landscape Condition	NatureServe Landscape Condition Model

Land Cover

Land cover represents the diversity of vegetative communities within the San Joaquin Region and the presence of under-represented, rare, or otherwise important habitats for conserving wildlife. Land cover was ranked based on a weighted sum score which incorporated diversity of land cover types, relative abundance of land cover types, presence of wetlands, and presence of Important Bird Areas (IBAs). The

United States Geological Survey Gap Analysis Project (GAP) has produced one the most detailed and consistent spatial data sets for vegetative associations and land cover types available. This data is intended to support tools such as this assessment (Gergely and McKerrow, 2013). Wetlands, particularly those designated by the National Audubon Society as IBAs are important stopovers for migratory birds in the Pacific Flyway. Protection of these areas is critical as they represent the last remaining habitats of this kind in California. As such, wetlands data from the U.S. Fish and Wildlife Service National Wetland Inventory and IBA spatial locations from the National Audubon Society have been included in this assessment.

Wildlife

Wildlife represents the value of each 1km^2 reporting unit for biodiversity and species of management concern. Wildlife value was based on native species richness, rare species richness, presence of rare species habitat, and presence of rare species habitats projected to be resilient to climate change.

Native species richness is from the California Department of Fish and Wildlife (CDFW) Areas of Conservation Emphasis (ACE II) assessment. A richness index based on the number of species predicted to occur in an area through the California Wildlife Habitat Relationship System (CWHR) was extracted for each reporting unit (CDFG, 2010).

Rare species richness was calculated as the number of California Natural Diversity Database (CNDDB) occurrences within a given 1km^2 cell. CNDDB point records were filtered to only include those which were still presumed to be extant and had an accuracy of 1km or finer. Records, which met accuracy requirements but had been obscured beyond 1km accuracy were also excluded. All points were given a 1km buffer to standardize accuracy before count per reporting unit was calculated.

Rare species habitat presence was assessed through species distribution modeling. A suite of 17 species were selected from a list of CNDDB occurrences within the study area based on jurisdictional status (threatened or endangered on either the Federal Endangered Species Act (FESA), the California Endangered Species Act (CESA),) and having more than 50 extant occurrences. The initial list had a total of 12 species (Table 1.) and included plants, amphibians, mammals, reptiles and birds. Additionally 5 Species of Special Concern were added to even out taxonomic representation and provide species with large available occurrence data within the assessment area.

Table 4. Target Species for the WildLight Analysis (E= Endangered, T=Threatened, SSC= Species of Special Concern, FP = Fully Protected, 1B.1 = Rare, Threatened, or Endangered in California and Elsewhere – Seriously Endangered in California, 1B.2 = Rare, Threatened, or Endangered in California and Elsewhere – Fairly Endangered in California)

Taxa	Common Name	Scientific Name	Species Code	State Listing	Federal Listing
Plants	Succulent Owl's Clover	*Castilleja campestris ssp. succulent*	CACA	Endangered	Threatened
	Kern Mallow	*Eremalche parryi ssp. kernensis*	ERPA	-	Endangered
	San Joaquin Woolly-Threads	*Monolopia congdonii*	MOCO	-	Endangered
Amphibians	California Tiger Salamander	*Ambystoma californiense*	AMCA	Threatened	Threatened
	California Red-Legged Frog	*Rana draytonii*	RADR	-	Threatened
	Western Spadefoot Toad	*Spea hammondi*	SPHA	SSC	SSC
Reptiles	Blunt-Nosed Leopard Lizard	*Gambelia sila*	GASI	Endangered	Endangered
	Horned Lizard	*Phronosoma blainvillii*	PHBL	SSC	SSC
	Giant Garter Snake	*Thamnophis gigas*	THGI	Threatened	Threatened
Birds	Tricolored Blackbird	*Agelaius tricolor*	AGTI	SSC	SSC
	Burrowing Owl	*Athene cunicularia*	ATCU	SSC	SSC
	Swainson's Hawk	*Buteo swainsoni*	BUSW	Threatened	-
Mammals	Nelson's Antelope Squirrel	*Ammospermophilus nelson*	AMNE	-	Threatened
	Giant Kangaroo	*Dipodomys ingens*	DIIN	Endangered	Endangered

	Rat				
	Tipton's Kangaroo Rat	*Dipodomys nitratoides nitrotoides*	DINI	Endangered	Endangered
	San Joaquin Kit Fox	*Vulpes macrotis mutica*	VUMA	Threatened	Endangered
	American Badger	*Taxidea taxus*	TATA	SSC	SSC

The current habitat of these target species was modeled using the Maximum Entropy Modeling Software, MaxEnt. The MaxEnt model (Philips et al. 2006) uses species occurrence data and environmental predictor variables to determine the likely distribution of species on the landscape. The predictor variables used in this analysis were a combination of bioclimatic, soil, land cover, and topographic variables. A full description of the MaxEnt software and the data used can be found in **Appendix B,** and individual species distribution models can be found in **Appendix C**.

Table 5. Input variables and data sources for MaxEnt species distribution modeling

Variable Type	Variable	Source
TopoClimate	Spring Solar Radiation	Digital Elevation Model
Topographic	Slope	Digital Elevation Model
Topographic	Elevation	Digital Elevation Model
Soil	Available Water Holding Capacity (0-100cm)	SSURGO
Soil	Particle Size (Loamy, Sandy, Clayey etc.)	SSURGO
Geomorphology	Topographic Relief (i.e. Hillshade)	Digital Elevation Model
Land Classification	Land cover	National Land Cover Database 2011
Land Classification	Wetland Type	USFWS CONUS
Bioclimate	Maximum Temperature of Warmest Period [June/July/August]	California Climate Commons
Bioclimate	Minimum Temperature of Coldest Period [Dec/Jan/Feb]	California Climate Commons
Bioclimate	(Aridity Index (Annual Precipitation/Potential Evapotranspiration)	California Climate Commons
Bioclimate	Annual Precipitation (mm)	California Climate Commons

This analysis also modeled resilient habitat by combining the scores from the target species for each climate to generate a single data layer. Excluded from this score were those habitats created or lost by changing climatic conditions. Determining areas of stable habitat is critical: as ecosystems are projected to shift (Preston et al., 2008), stable habitat will serve as the best investment option for conservation organizations or developers mandated to find land for mitigation (Iwamura et al., 2012).

This method of modeling resilient habitat is very similar to the approach taken in modeling resilient habitat for target species for the DRECP (Davis et al., 2013). This was determined by modeling the target species using the same variables but using future projections from the following three climate models: Flexible Global Ocean-Atmosphere-Land System (FGOALS) model G2 – RCP 8.5, Institut Pierre Simon Laplace (IPSL) CM5 model – Representative Concentration Pathway (RCP) 8.5, Community Climate System Model (CCSM) 4 – RCP 8.5. By utilizing this method and weighting these results lower than other wildlife scores, the WildLight model incorporates climate change impacts without placing too much confidence in these predicted outcomes.

These three scores were combined in the EEMS modeling system using a weighted sum. The current habitat was weighted highest because of the regulatory significance of the target species. It was indicated in interviews with developers that the softs costs associated with a project, which are the non-install costs like permitting, were critical in determining project viability and certain species present on a potential parcel of land could significantly increase these costs through CEQA mandated mitigation plans and litigation from various conservation groups and wildlife agencies.

Habitat Condition Score

The San Joaquin Valley contains extensive areas where habitat condition has been degraded by urban and suburban development, construction of transportation and other infrastructure, as well as agriculture and ranching activities (Saunders et al., 1991; Fahrig 2003). These land uses have resulted in removal and alteration of native vegetative communities, introduction of common exotic and invasive species, and highly altered hydrologic conditions. NatureServe's Landscape Condition Model (LCM) reveals the spatial extent and magnitude of ecological degradation across the landscape and has been applied to the WildLight study area.

Habitat fragmentation, or the loss of permeability and the resultant impacts to biodiversity (Fahrig, 2003), is another key concern with utility scale solar energy (USSE) siting. Much of the SJV is in agricultural production, leaving few key areas to provide connectivity between patches of suitable habitat. Many species in the valley rely on the ability to travel long distances in search of food, water, and suitable mates. Large fenced solar facilities as well as transmission lines can disrupt habitat connectivity and limit gene flow across the landscape (Lovich et al., 2011 and Fahrig, 2003). Theobald et al. (2012) modeled fragmentation by scoring the landscape for permeability. Effectively, the value represents the ease with which animals and ecological processes can move across a landscape. Permeability is calculated through repetitive iterations measuring least cost path (LCP) and cost distances between two randomly selected locations. Scoring is based on the level of disturbance from several types of human modifications and includes energy transmission corridors, different traffic levels, and development risk (Theobald et al., 2012).

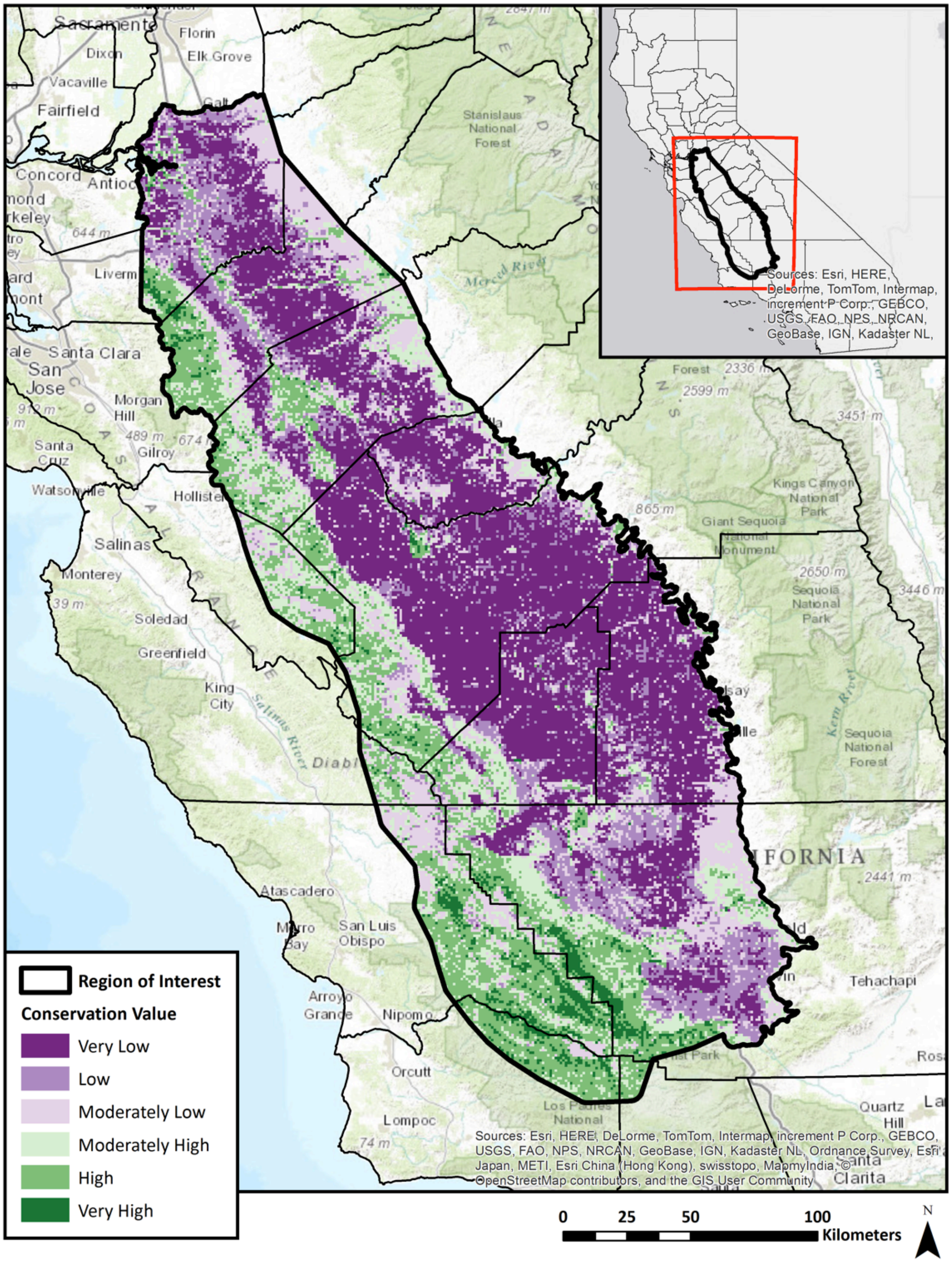

Figure 5. Conservation Values with high conservation value shown in green and low conservation value in purple.

Solar Suitability

The solar suitability of a cell was determined by combining three variables prioritized according to their stated importance during developer interviews. The most important factor determining the suitability of land for a proposed project was proximity to and available capacity of existing transmission lines. To address these concerns within our analysis, we included a map of transmission density from ESRI. Though this map does not contain data for remaining capacity on a given line, this additional attribute would greatly strengthen the results of our map in the future. Regardless, increasing capacity of existing lines will always be less costly than planning new lines and so this layer still provides an important input to the model.

Table 6. Model inputs and data sources for the Solar Suitability module

Model Inputs	**Data Source**
Solar Insolation	National Renewable Energy Laboratory
Slope	California 10m DEM
Transmission Density	ESRI

Solar developers also responded that there was a slope threshold of ~6° that was used in determining the adequacy of an area. This threshold is set because it becomes logistically more difficult to install and maintain photovoltaic solar developments on sloped terrain. While much of the valley floor is flat and falls below this threshold, there are areas on either side of the valley floor that rise into the Coast and Sierra Nevada Ranges, respectively, that are outside of this range and have therefore been excluded from our analysis.

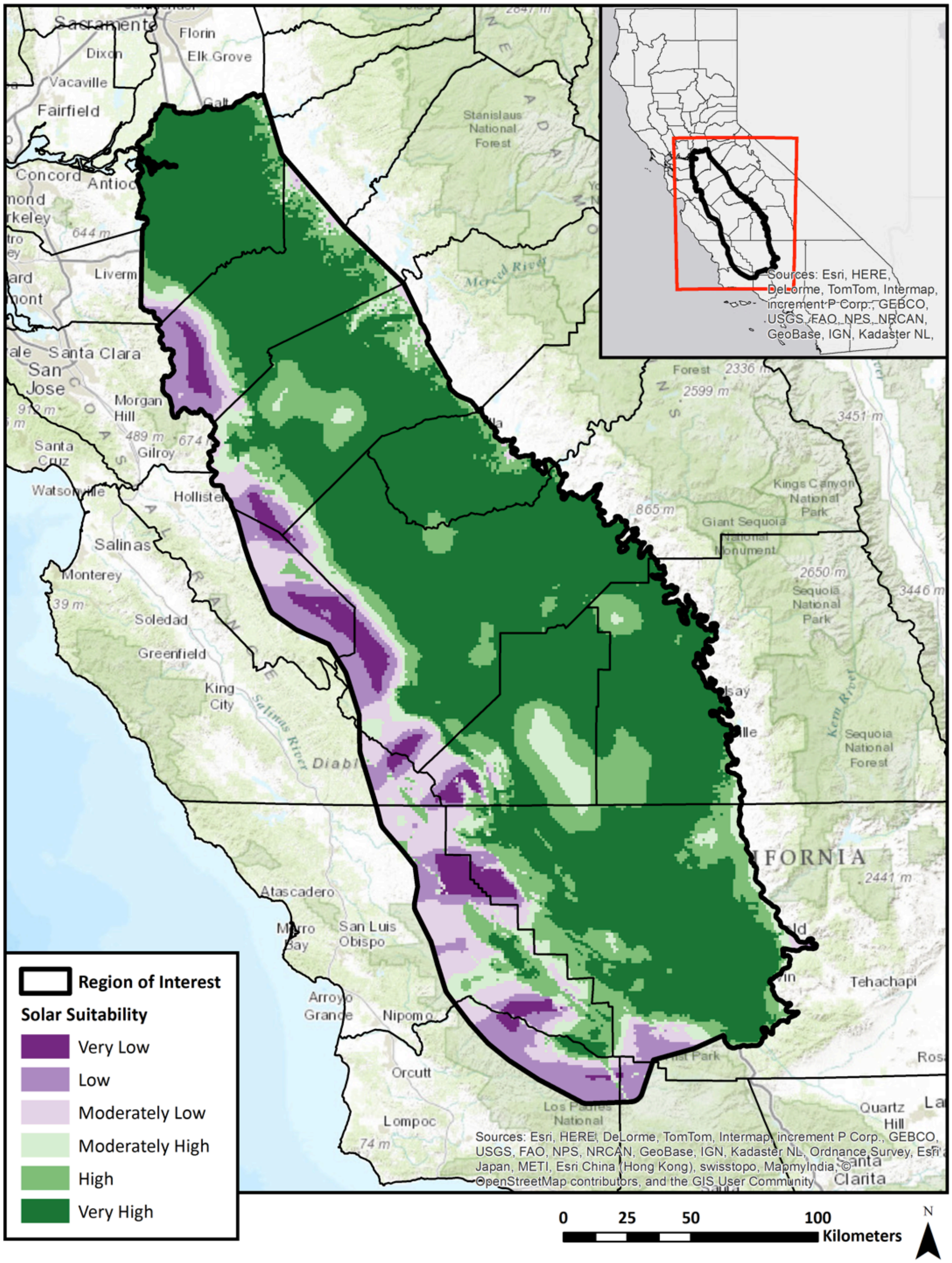

Figure 6. Map of solar suitability in the San Joaquin Valley with areas of low suitability in purple and areas of high suitability in green.

Data for solar insolation was obtained from the National Renewable Energy Laboratory (NREL). Insolation is the amount of solar radiation energy received on a given area for a given duration, commonly in watt-hour per square meter (Wh/m^2). This model uses information on cloud cover, atmospheric water vapor and trace gases, and the amount of aerosols in the atmosphere, to calculate the monthly average daily total insolation falling on a horizontal surface. Solar insolation is mostly consistent throughout the valley floor with increased values in the foothills to the southwest. Solar developers indicated that while this is not an important concern for photovoltaic solar developments, it is important when considering concentrated solar energy facilities For this reason, solar insolation was weighted the lowest within the Solar Suitability Module.

5. RESULTS

High Priority Conservation Areas

The high conservation value module results have been over laid with areas currently under conservation below (Figure 6). A description of the model weights and thresholds for this model can be found in **Appendix D**. The green areas show lands with high wildlife, land cover, and habitat condition values, but are not currently being protected.

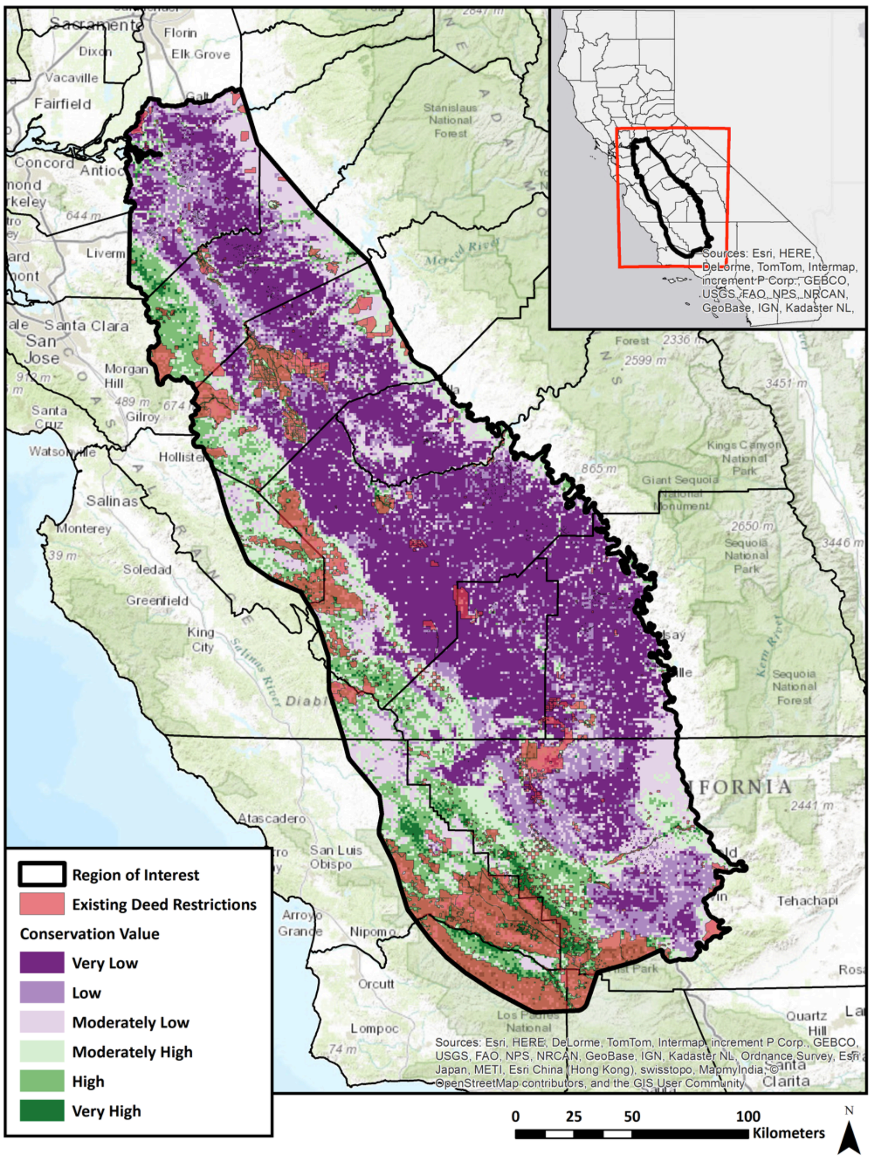

Figure 7. High Priority Conservation areas with existing conservation areas shown in red

These unprotected priority conservation lands are distributed throughout the study area, and a breakdown of their area in square kilometers is shown in Figure 9. The majority of the very high, high, and moderately high conservation value area is in Kern County. Kern County contains 26%, followed by Fresno (12%), San Luis Obispo (12%), and Merced counties (11%) (Figure 8). These counties accounted for the majority of these unprotected areas. The unprotected areas in the southwest, which include those found in San Luis Obispo and Kern counties, include the western foothills of the Valley and the Carrizo plain, Antelope Plain, Elk Hills, and Southern Valley Terraces.

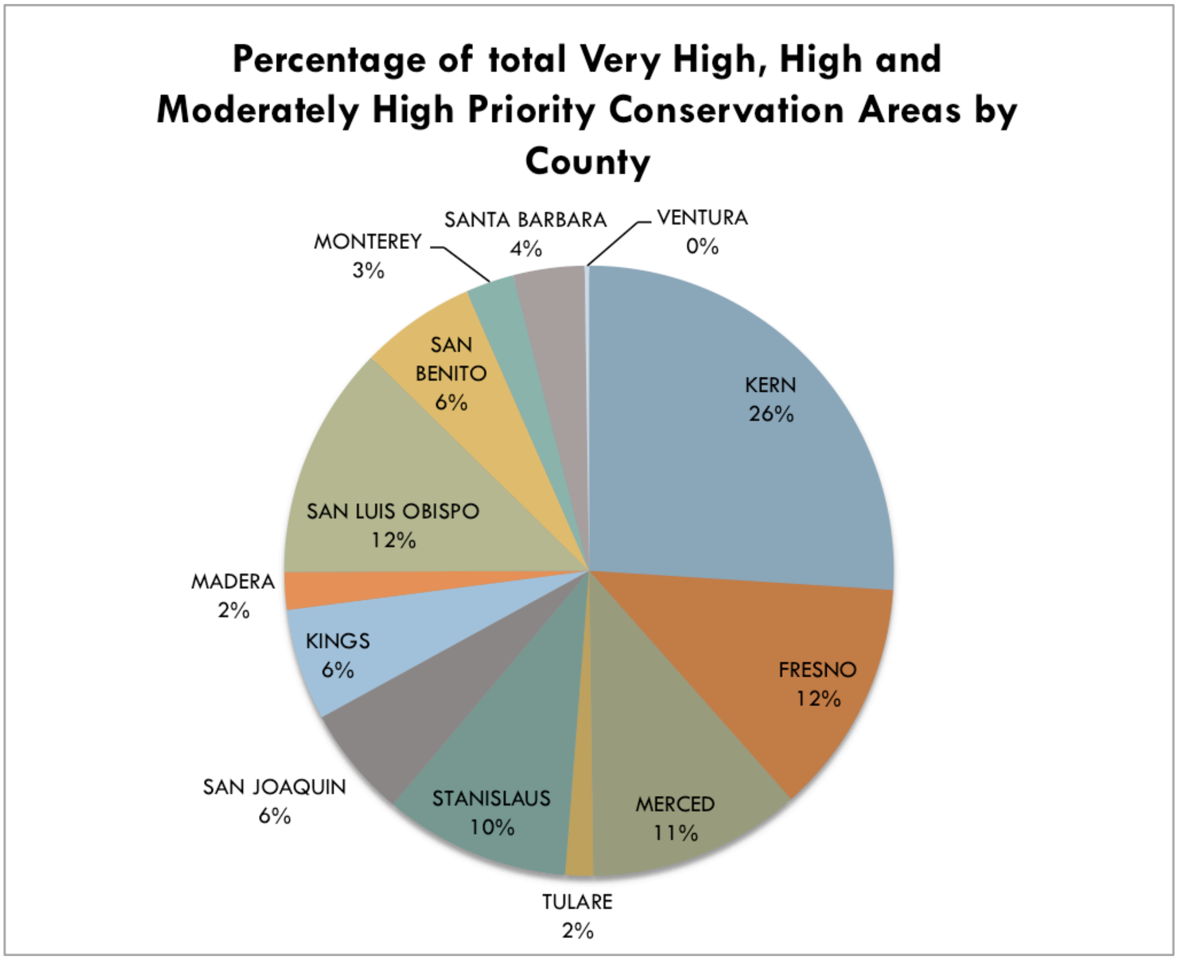

Figure 8. Percentage of total very high, high, and moderately high priority conservation areas by county with currently protected lands counted.

Within the southwest portion of the study areas, the San Luis and Los Banos reservoirs provide suitable wetland and upland grassland habitats for numerous species of management concern. In particular, the combination of aquatic and upland habitat is well suited for California Tiger Salamander, Foothill Yellow Legged Frog, Western Spadefoot Toad, and California Red-legged Frog, which has designated critical habitat south of the San Luis Reservoir (Bureau of Reclamation, 2013). This region is also identified as a satellite population for San Joaquin Kit Fox with a linkage to the Ciervo-Panoche core population at the Little Panoche Valley, which also represents core habitat areas for Blunt Nosed Leopard Lizard and Giant Kangaroo Rat (USFWS, 1998).

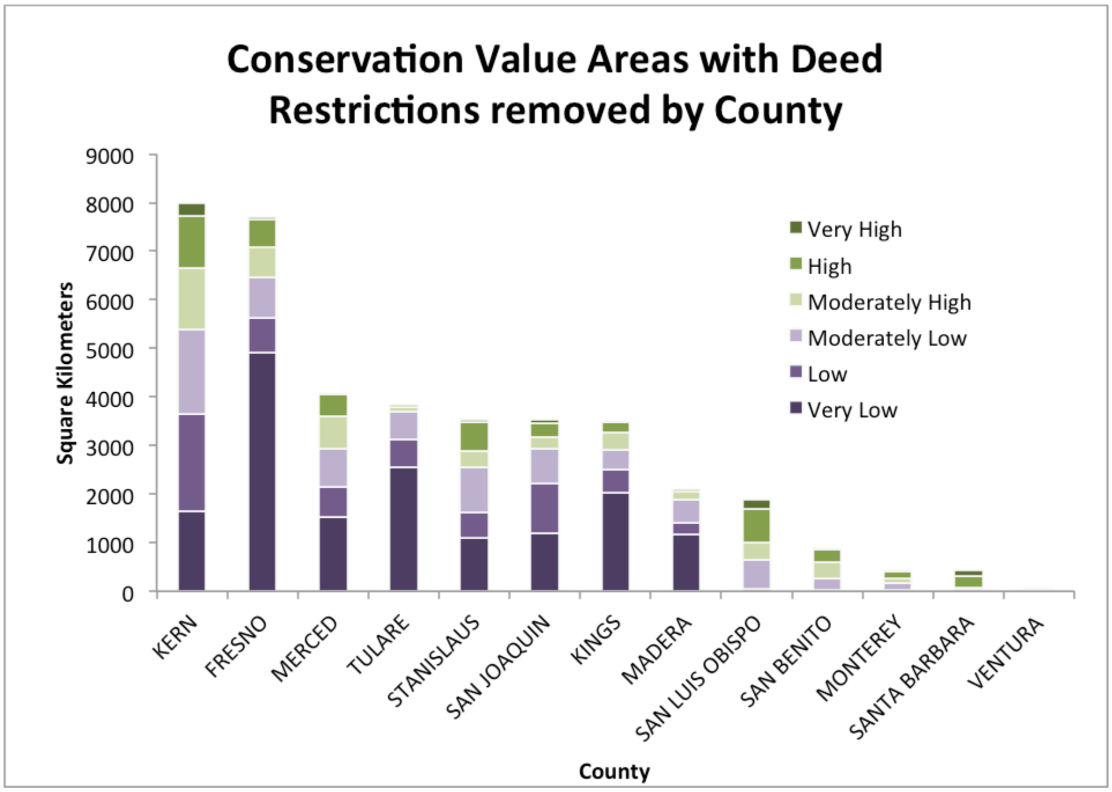

Figure 9. Area (km^2) of unprotected high priority conservation lands by county with high priority areas listed in green and low priority areas listed in purple.

It should also be noted that much of the conserved land is in the southwestern portion of the valley. Large areas of the Los Padres National Forest, the Lokern Ecological Preserve, Elk Hills Ecological Preserve, and the Tule Elk State Reserve and the Soda Lake National Monument, are found in this region, however large areas remain vulnerable to development.

While the largest areas of high priority lands are in this southwestern portion of the valley, there are other critical areas that represent a wide range of habitat types. The

Sierra Foothills vernal pool complex, Corral Hollow, the Northern San Joaquin Basin, the south San Joaquin Valley floor, San Juan Valley, and Eastern Kern County, are all home to threatened and endangered species and contain areas of valuable, intact habitat.

Consensus Areas for Solar Development

The consensus areas for solar development, based on the best available data and inputs from conservation, agriculture, and solar developer stakeholders, are shown in Figure 10 below.

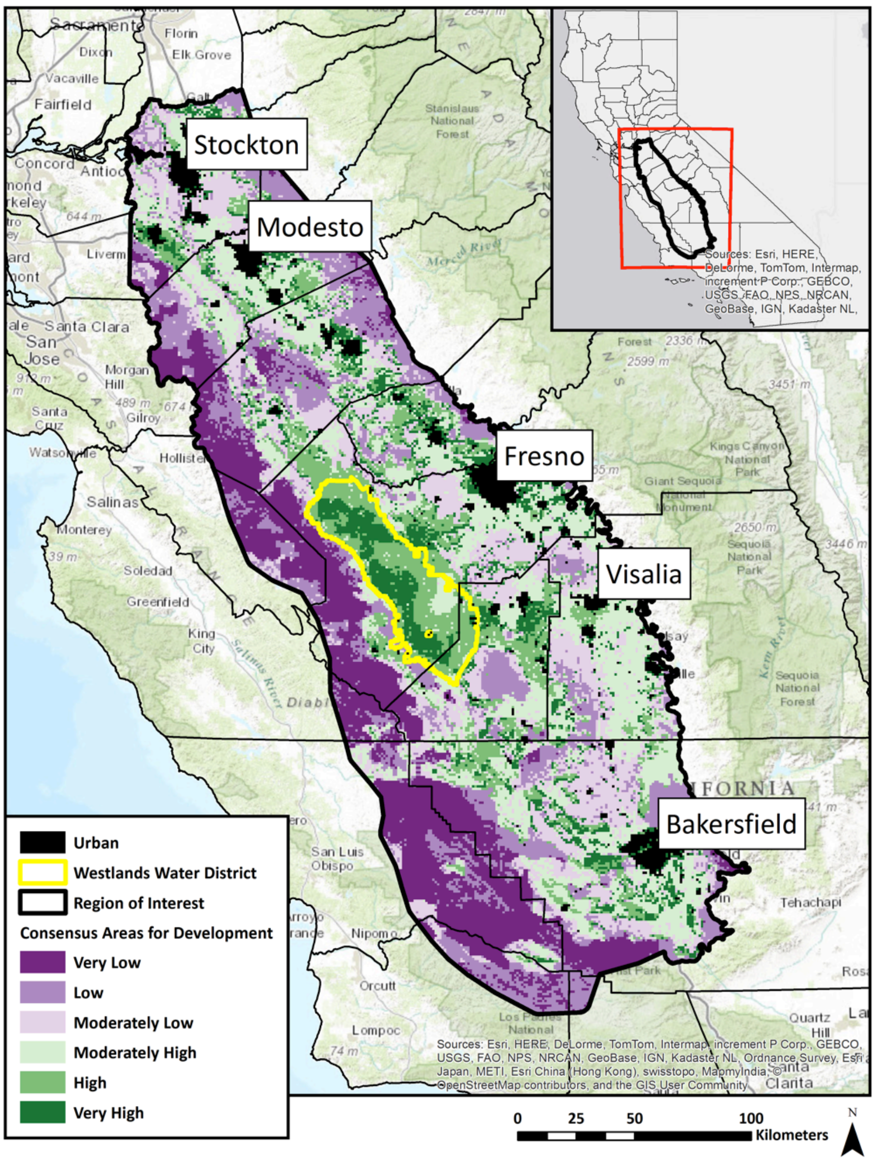

Figure 10. Map of consensus areas for solar development with high consensus areas in green and low consensus areas in purple.

The largest area of suitable lands for solar development is in Fresno County, which contains 26% of the total very high, high, and moderately high consensus areas for solar development. A large proportion of this area is contained within the Westlands Water District. Fresno County (26%), Kern (20%), Tulare (11%) and Kings (11%) counties contain the majority of consensus areas for solar development. Additionally, the small portions of San Benito, Ventura, Santa Barbara, and Monterey contained no consensus areas, but also contained the smallest proportion of the study area (**Figures 11, 12**).

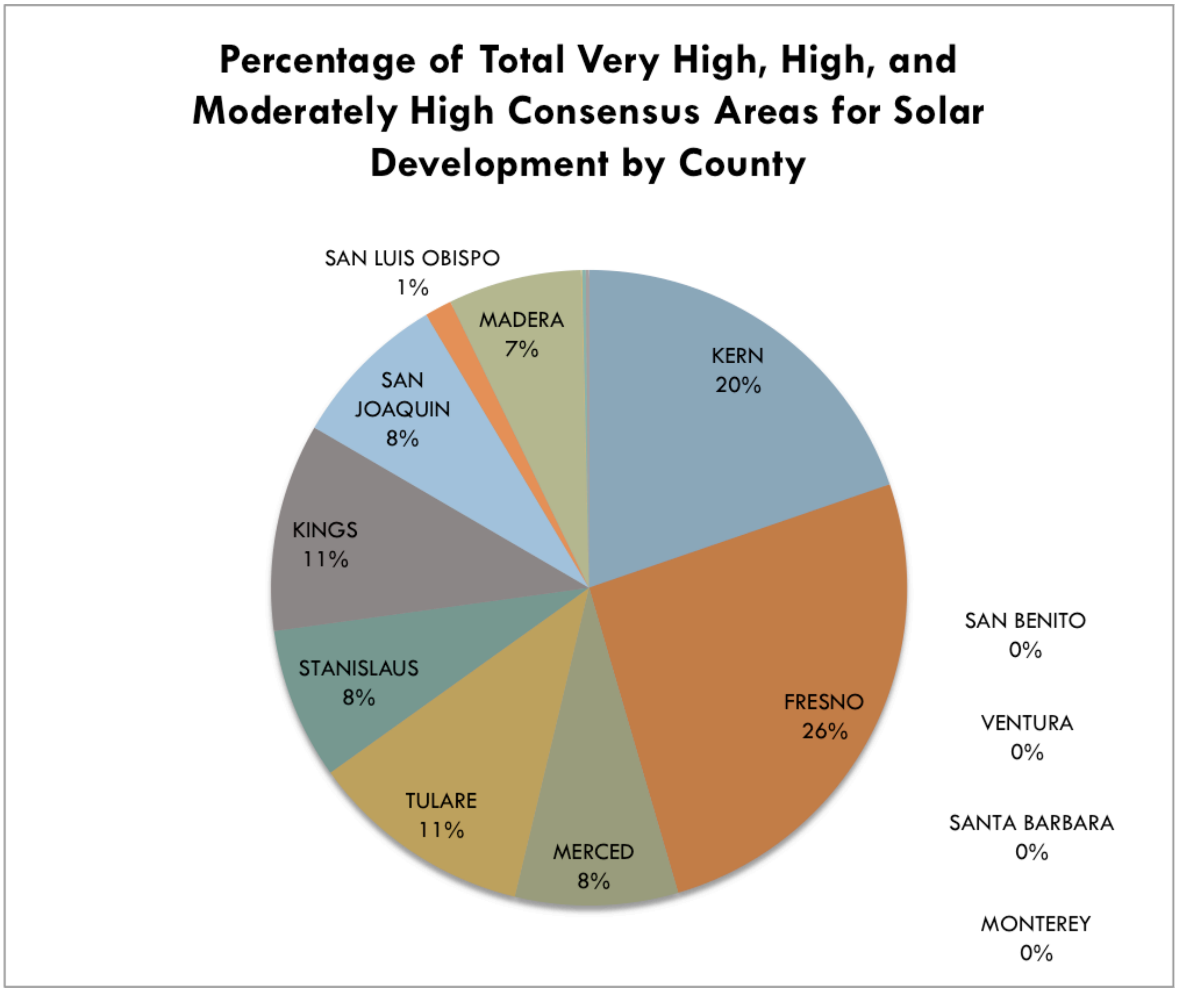

Figure 11. Percentage of total very high, high, and moderately high consensus areas for solar development by county.

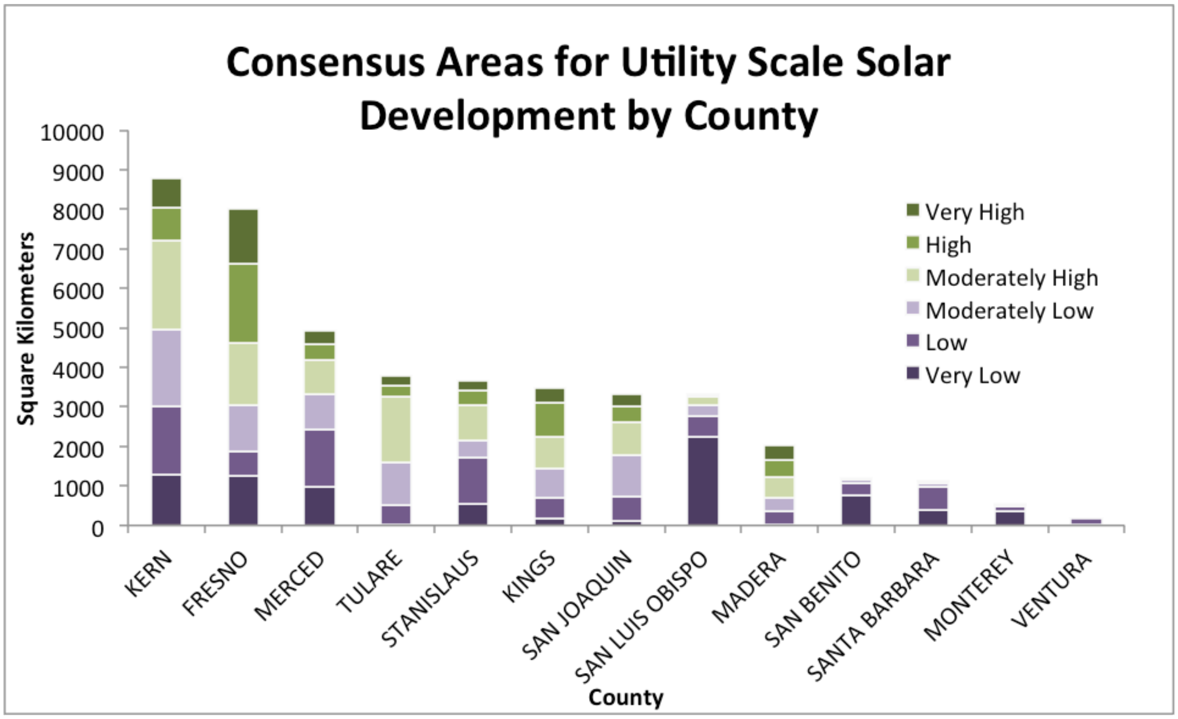

Figure 12. Consensus areas for utility scale solar development shown by county with high consensus areas in green and low consensus areas shown in purple.

Urban Areas

This analysis did not actively exclude urban zones when modeling areas of high consensus areas for solar development. However, these areas emerged from the model based on their low agricultural and conservation values. Similar to the utility scale figures presented in Figures 11 and 12, Fresno contains the highest proportion of urban areas followed by Stanislaus and King counties.

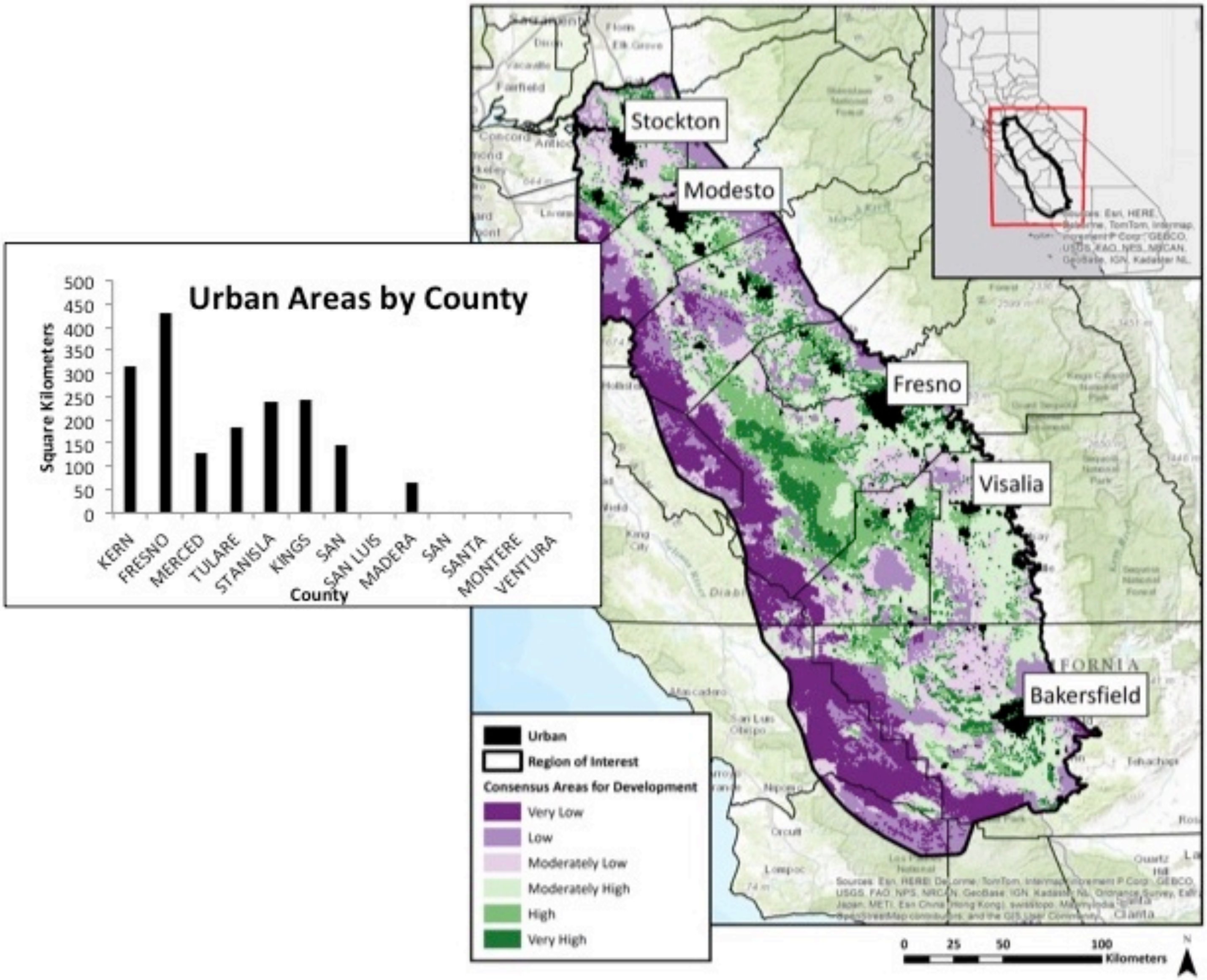

Figure 13. Consensus areas for solar development, with green being high, and purple being low consensus. Urban areas are shown in black, with the amount of land (km^2) of urban areas by county shown to the left.

6. DISCUSSION

The WildLight model results clearly illustrate the opportunities for low conflict, high consensus solar development as well as high priority conservation lands to be used for mitigation. Our results can provide decision support for developers, counties, and growers interested in solar development within the San Joaquin Valley.

Applications for Solar Development

The concept of ag-to-solar has accelerated since the passage of AB32 and presents a new option to growers whose lands are becoming increasingly untenable as a result of high salinity, water scarcity, and the rising price of inputs. A paper by Ethan Elkind (2011) outlined the key steps to streamlining the ag-to-solar pathway in California. The first barrier listed in this paper is "Lack of Definition of Suitable Farmland for Renewable Energy Development". The WildLight analysis is a first step towards moving past this barrier. Our model has the necessary attributes of transparency and adaptability needed to incorporate the feedback of various stakeholder groups into the structure of the model.

If stakeholder consensus can be formed around this definition of suitable agricultural land for solar development, then the state should incorporate this into permitting guidelines. This could happen at the county level by informing general plan or zoning ordinance amendments or guiding the creation of renewable energy overlay zones (CCPDA, 2012). This would allow for streamlined multiagency permitting on lands that were preselected for development. Similar programs have been implemented in land conservation, notably Sustainable Conservation's Permit Coordination Program. This program provides multi-agency permitting to land owners willing to partner for conservation projects.

Another barrier for the ag-to-solar transition is the lack of coordinated land use planning and development protocols (Elkind, 2011). Several counties, including Kern and King, have large amounts of both highly suitable land for solar development as well as high priority conservation areas, however their ag-to-solar pathways are very different. This has been indicated to be a hurdle in the literature, as well as by solar developers who are primarily interested in predictability within the project approval process.

Westlands Water District

The Westlands Water District (WWD) straddles the county line of King and Kern counties and has a very high potential for smart solar siting. This area is subject to a decreasing water supply as well as large swathes of salt affected lands (Westlands Water District, 2001; Chang et al., 2014). As a result, WWD annually fallows ~100,000 acres of land due to areas that have hyper saline soils that cannot be effectively managed (Westlands Water District, 2001).

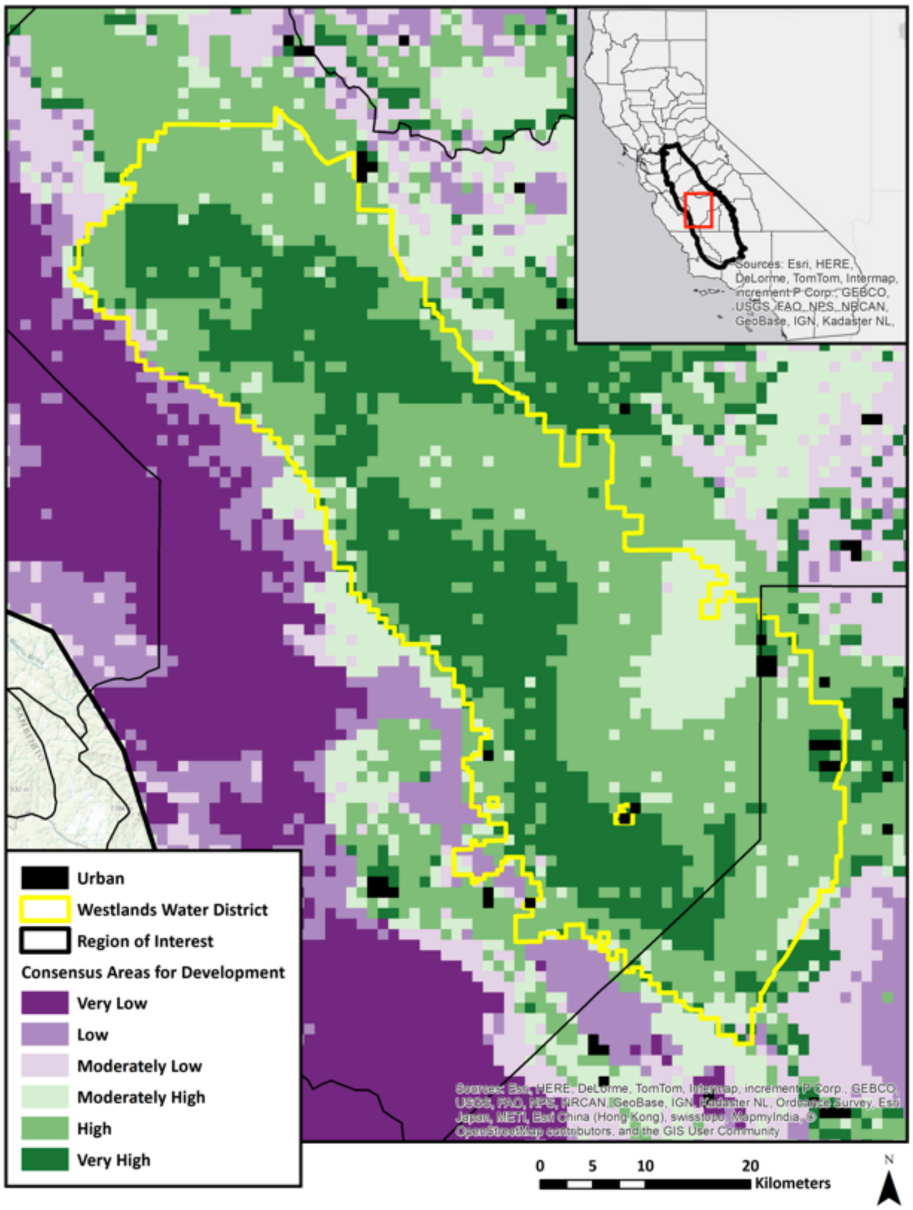

Figure 14. Consensus Areas for Solar Development within the Westlands Water District map.

The WWD has been open to transitioning land from agriculture to solar, and released a white paper that laid out terms for a land retirement within the district. Since the release of this document, the Westlands Solar Park was founded with the goal of generating up to 5GWs of renewable energy in the southeast portion of the District. Developers interested in siting solar in the WWD are faced with the challenge of working between two county governments while selecting suitable sites for development. The results of this model could aide in cross-county coordination, if sites of high data consensus for solar development were amended into a county general plan or zoning ordinance for both counties. This would not only provide developers with predictability, but would provide consistency in land valuation across county lines.

The WWD is a large contiguous area of high consensus land, and so would be suitable for a programmatic Environmental Impact Report (EIR). Such an EIR would reduce the burden to developers in creating a full scale EIR, and would allow them to tier off the programmatic EIR. This would make it more efficient for them to comply with CEQA requirements, while also addressing cumulative impacts from solar in the WWD (CCPDA, 2012). Programmatic EIRs have been created for geographically defined areas in the California desert (Defenders of Wildlife, 2012) and provide an additional incentive for developers to site solar in the WWD.

Urban Areas

In addition to pointing out the WWD, the highlighting of urban areas as highly suitable for utility scale solar development within our consensus areas map serves as a further justification that our model is prioritizing areas with low value conservation and agricultural lands, as well as areas with high transmission densities. While the model is designed to analyze the landscape for utility scale solar suitability, this result supports Defenders of Wildlife's stance to increase use of distributed solar power as well. Distributed generation is an important part of the California Energy Commission's plan to meet the RPS by 2020. Our model indicates that pushing for increased distributed and rooftop solar energy would lessen the impact of large solar projects on agricultural and conservation stakeholder groups, while utilizing existing energy infrastructure.

Applications for High Priority Conservation Lands

Our results show that the San Joaquin Valley contains a large amount of suitable habitat for threatened, rare, and species of special concern – particularly in the foothill regions rimming the valley floor. As urban growth, agricultural expansion, and solar development continue, finding ways of conserving the remaining high value land will be increasingly important.

Identifying high conservation value areas provides an important data set, which can be used to:

1) Locate the most effective areas for mitigation of project impacts
2) Locate the most effective areas for establishing habitat conservation plans (HCPs) or Multispecies Habitat Conservation Plans (MHCPs)
3) Identify suitable areas for conservation banking
4) Prioritize acquisition of development rights for conservation through land purchase, conservation easements, and transferrable development rights programs.

Mitigation

Mitigation of project impacts varies depending on the character, setting, and magnitude of the anticipated impact. Following an initial environmental review, many projects are redesigned such that they qualify for a Mitigated Negative Declaration (MND), which reduces monetary costs and time associated with a full Environmental Impact Report (EIR). Larger projects with significant and unavoidable impacts may require preparation of Mitigation, Monitoring, and Reporting Program (MMRP) as part of the project's permitting requirements. This often requires purchasing offsets through establishing an HCP (FESA sect. 10A1(b) incidental take permit (ITP) requirements), habitat restoration and/or enhancement, establishing protected habitat elsewhere through purchase of the land or conservation easement, or purchase of credits from a conservation bank deemed to have a nexus to the anticipated project impacts.

7. CONCLUSION

The model presented here combines a wide array of data sets and stakeholder preferences to identify areas in the valley that are compatible for utility scale solar energy development, and high priority conservation areas. While different ag-to-solar pathways exist based on the regulations of particular counties, this map can illustrate to county administrators that conservation, agriculture, and solar energy can coexist on the landscape.

The results of this map could most easily be applied by developers to site solar on high consensus areas and using high priority conservation areas for mitigation. This provides the desired triple bottom line needed to alleviate the controversy that can surround solar development. First, the people in the Valley are considered and the agricultural lively hood is maintained on lands that will be viable and profitable into the future. Second, the planet benefits from protection of strategically selected high value lands. And lastly, solar developers and landowners have the opportunity to make a profit through the generation of clean and renewable energy on well-suited lands.

The approach taken by the WildLight team can aid environmentalists, developers, and other stakeholders in the application of the precautionary principle to proactively avoid areas likely to have higher risks of conflict. This can reduce up-front costs and risks within the development process and minimize overall environmental and cultural impacts of large land use changes such as utility scale solar development. Decision support tools such as our model will become increasingly important for development in the future, as the California Governor’s Office continues to push for an increased Renewable Portfolio Standard.

APPENDIX A. SOLAR PROCESS REVIEW

Recent developments in state level energy policy have spur the increase of utility scale solar in California. This trend began with the passage of Assembly Bill 32, which Governed Schwarzenegger signed into law in 2006. The law called for the mandatory annual reporting of GHG emissions and set fourth a preliminary plan to reduce greenhouse gas emissions to 1990 levels by 2020, representing a 25% reduction statewide (Assembly Bill 32).

Assembly Bill 32 set forth guidelines for emission reduction levels called for the California Air Resources Control Board (CARB) generate a scoping plan to meet these targets. This plan included a set of renewable energy portfolio standards (RPS). These standards require that 33% of total procurement within the state, by 2020 comes from eligible renewable energy resources to (CPUC Renewables Overview). Meeting the RPS calls for 20,000 MW of new renewable capacity by 2020, with an estimated 12,000 MW coming from smaller scale distributed generation facilities, and the remaining 8,000 MW coming from large scale wind, solar, and thermal generators, that connect directly to the transmission grid (CEC, 2012). Large (tier 4) utility scale solar (>20 MW), is the focus of this report.

The California Public Utilities Commission (CPUC) executes and administers the RPS compliance rules for retail sellers in California, which include the three investor-owned utilities: Pacific Gas and Electric (PG&E), San Diego Gas and Electric (SDG&E), and Southern California Edison (SCE). The California Energy Commission (CEC) is responsible for certifying generation facilities as renewable (CPUC Renewables Overview). Annual compliance check from the CPUC insure that the utilities have enough Renewable Energy Credits to meet the mandated 33% level.

These policy shifts prompted the creation of several financial incentives for utility scale solar development including tax credits, cost recovery schemes and treasury grants (NREL, 2012). The American Recovery and Reinvestment Act, passed in February of 2009, further expanded the availability of these financial incentives (NREL, 2012). Several initiatives, including the American Recovery and Reinvestment Act in 2009 and more recently with the Department of Energy's Sunshot program have been used to keep fund utility scale projects. While this has driven the expansion of solar energy within the state it is unclear if these incentives will persist. Therefore, is it important for planning efforts to be directed towards the reduction of cost associated with permitting

Utility scale solar energy developments require a suite of county, state and federal agency permits, and typically an environmental impact statements is required (CEC, 2010). After the completion of this report several public hearings and reviews take place, at which time public comments are submitted. If the project is deemed to no environmental impacts or the impacts are minimal, a negative declaration or mitigated declaration is issued and the project can continue. It is most common for utility scale solar developments to distribute energy though grid by utilizing existing transmission infrastructure (CEC, 2010; Cal ISO, 2014). This reduces the burden of permitting new transmission lines, which would be very costly as the span long strips of the landscape.

APPENDIX B. INPUTS INTO MAXENT MODEL

Below is a description of the species occurrence and environmental data that was collected and processed into ASCII files for use with the MaxEnt model (**Table B1**).

Table B1. Descriptions and sources of predictor variables used for MaxEnt species distribution modeling

Variable Type	Variable	Source
TopoClimate	Spring Solar Radiation	Digital Elevation Model
Topographic	Slope	Digital Elevation Model
Topographic	Elevation	Digital Elevation Model
Soil	Available Water Holding Capacity (0-100cm)	SSURGO
Soil	Particle Size (Loamy, Sandy, Clayey etc.)	SSURGO
Geomorphology	Topographic Relief (i.e. Hillshade)	Digital Elevation Model
Land Classification	Land cover	National Land Cover Database 2011
Land Classification	Wetland Type	USFWS CONUS
Bioclimate	Maximum Temperature of Warmest Period [June/July/August]	California Climate Commons
Bioclimate	Minimum Temperature of Coldest Period [Dec/Jan/Feb]	California Climate Commons
Bioclimate	(Aridity Index (Annual Precipitation/Potential Evapotranspiration)	California Climate Commons
Bioclimate	Annual Precipitation (mm)	California Climate Commons

Species occurrence data

Species occurrence data was collected from the updated 2014 California Native Diversity Data Base (CNDDB) data layer. This data was filtered to show listed and pending California Endangered Species Act (CESA) and Federal Endangered Species Act (FESA) records and this set of filters included 12 species and 5 additional species of special concern were added to the list.

Soil Variables

Soils data were collected from United States Department of Agriculture (USDA), Natural Resource Conservation Service (NRCS) SSURGO Data Downloader.

The following two soil variables were selected as inputs for the MaxEnt model:

- Soil Particle Size (categorical)
- Water Holding Capacity at 100cm

Digital Elevation Model (DEM)

Several topographic variables were derived from a 10m digital elevation model (DEM). The DEM was resampled up to 1 kilometer and then processed in ArcGIS.

The following four DEM derived variables were selected as inputs for the MaxEnt model:

- Elevation
- Slope
- Relief
- Spring Solar Radiation

Bioclimatic Variables

All climate data were accessed through the California Landscape Conservation Cooperative's Climate Commons website (California Landscape Conservation Cooperation, 2012). The bioclimatic datasets used in this analysis are generated by the California Basin Characterization Model (CA-BCM 2014). This model calculates complex temperature and precipitation variables, and uses a monthly regional water balance (Flint and Flint 2013) to predict the hydrologic response of basin across the California hydrologic region.

The following four bioclimatic variables were selected as inputs for the MaxEnt model:

- Maximum temperature in the Warm Period
- Minimum Temperature in the Cold Period
- Annual Precipitation
- Aridity

Incorporating Climate Data into the MaxEnt Model

The projected climate data used in this analysis are all CMIP5 (5th Phase of the Coupled Model Intercomparison Project) General Circulation Models (GCMs:

- Community Climate System Model (CCSM) 4 – Representative Concentration Pathway (RCP) 8.5
  The Community Climate System Model (CCSM) out of the National Center for Atmospheric Research (NCAR) is composed of a coupler component and separate simulations for the atmosphere, land, land-ice, sea-ice (Gent et al. 2011).
- Flexible Global Ocean-Atmosphere-Land System (FGOALS) model G2 – RCP 8.5 Developed by the State Key Laboratory of Numerical Modeling for Atmospheric Sciences and Geophysical Fluid Dynamics, the Flexible Global Ocean-Atmosphere-Land System (FGOALS) model is made up of four component models (atmosphere, ocean, sea ice, and land surface) coordinated through a coupler that allows the exchange of water, energy, and momentum between them (Zhou et al. 2014).
- Institut Pierre Simon Laplace (IPSL) CM5 model –RCP 8.5
  IPSL, developed by the Institut Pierre Simon Laplace, is a classical model coupling an atmosphere-land surface model to an ocean-sea ice model. Representing the dominant physical, biogeochemical, and dynamical processes driving climate systems, the latest version also contains a representation of aerosols, tropospheric and stratospheric chemistry, as well as an interactive carbon cycle (Dufresne et al. 2013).

Climate Projection Model Characteristics

Within our region of interest, IPSL predicted the highest mean maximum temperature (35.61±1.52°C) in the warmest period (June, July, and August) followed closely by FGOALS (35.42±1.50°C) and CCSM4 (35.31±1.55°C). Historic mean maximum temperatures in the warmest period (34.08±1.46°C) fall, on average, 1.37°C below those estimated by our three chosen climate models. Mean annual precipitation followed a similar pattern with IPSL predicting the greatest amount (313.74±110.08mm). CCSM4 projected only 34.64mm more precipitation (291.91±105.07mm) than historic means (279.10±102.43mm), while FGOALS was the only model that predicted less mean annual precipitation (265.14±97.49mm) than historic records (Figure 1).

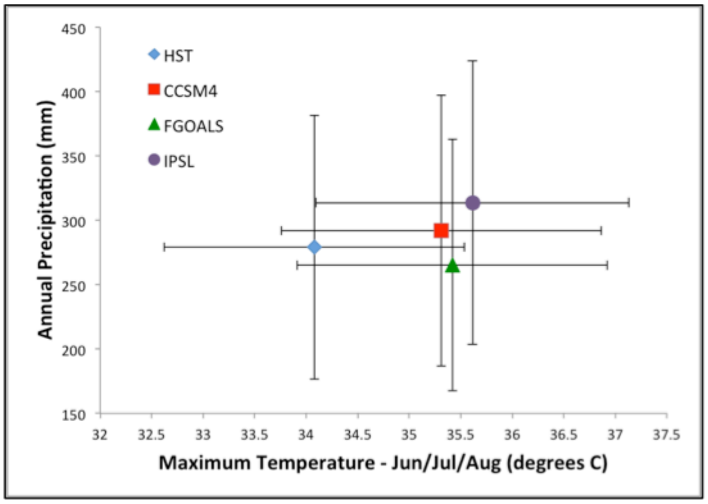

Figure 1. Historic and projected annual precipitation and maximum temperature in the warmest quarter within our region of interest. Historical means (HST) are for the time period 1981-2010 while projected means (CCSM4, FGOALS, IPSL) represent climate model projections for 2011 to 2039. The length of the whiskers from each data point represents one standard deviation from the mean.

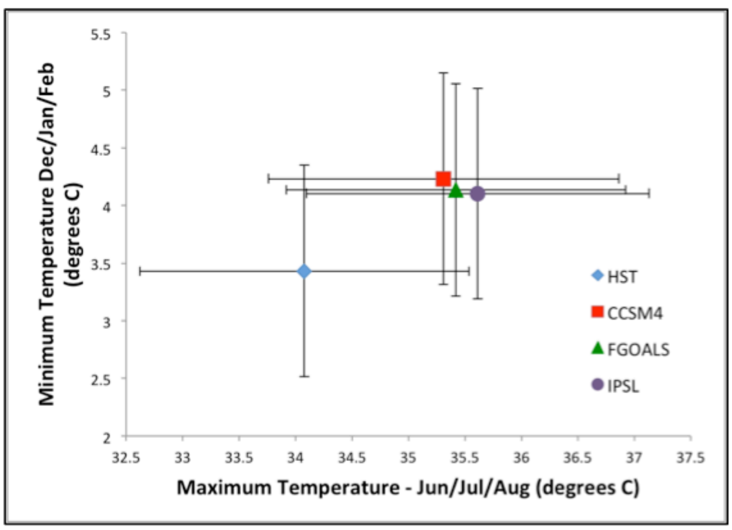

Figure 2. Modeled minimum winter temperatures and maximum summer temperatures for 1981 – 2010 (HST) and 2011 – 2039 (CCSM4, FGOALS, IPSL). Whisker lengths denote one standard deviation from the mean.

In general, all three models predict increases in temperatures not only in the summer, but also throughout the year. Minimum temperatures in the coolest quarter (December, January, and February) are projected to rise in all climate models with the largest increase predicted by CCSM4 (4.23±0.92°C). FGOALS and IPSL predict similar increases (4.13±0.92°C and 4.11±0.91°C, respectively), with an average difference of 0.73°C from historic recordings (3.43±0.92°C).

APPENDIX C. MAXENT SPECIES DISTRIBUTION MODELS

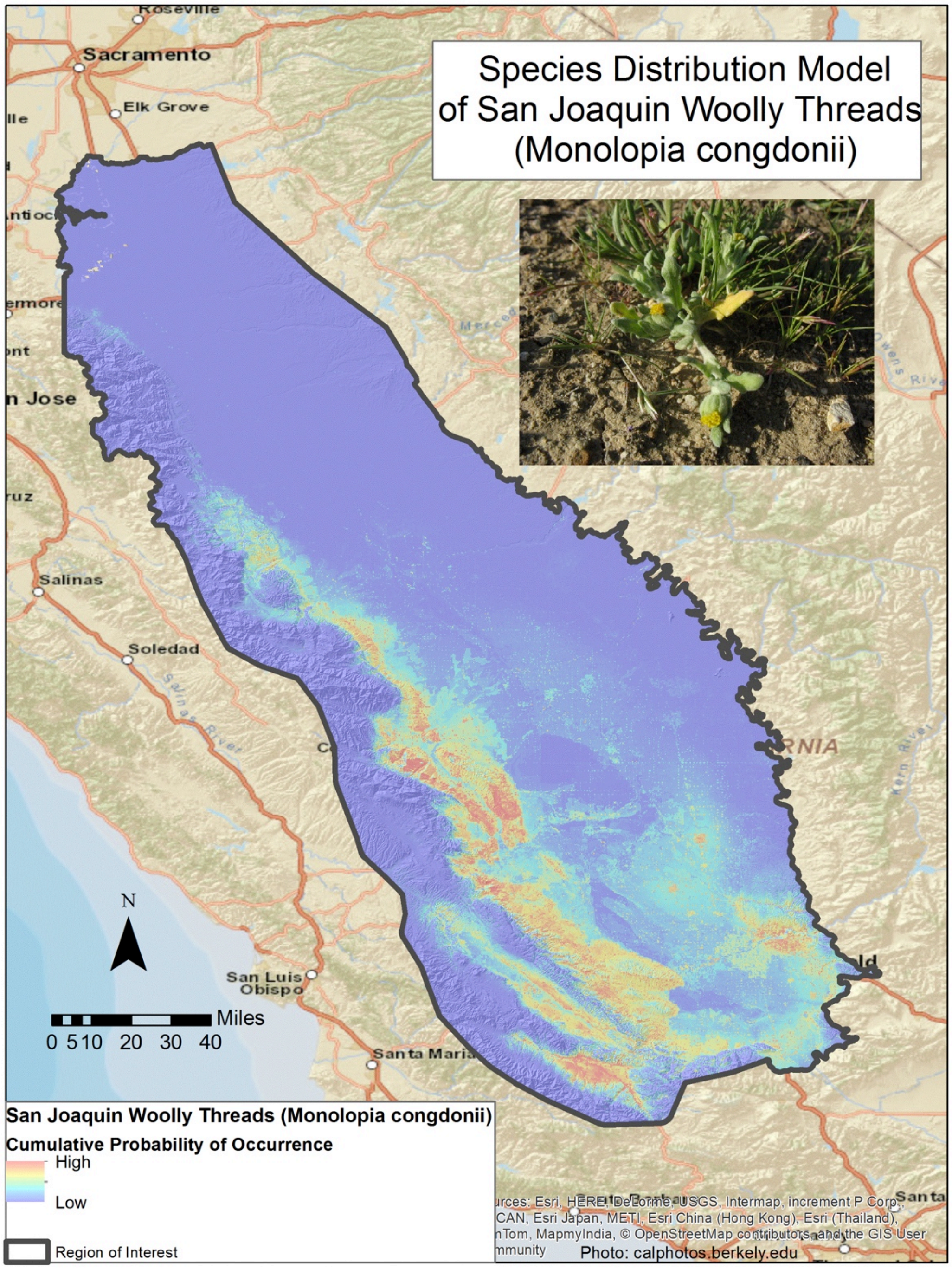

Figure C1. MaxEnt species distribution model for the San Joaquin Woolly Threads (*Monolopia congdonii*) with high probabilities of occurrence shown in red and low probabilities shown in blue.

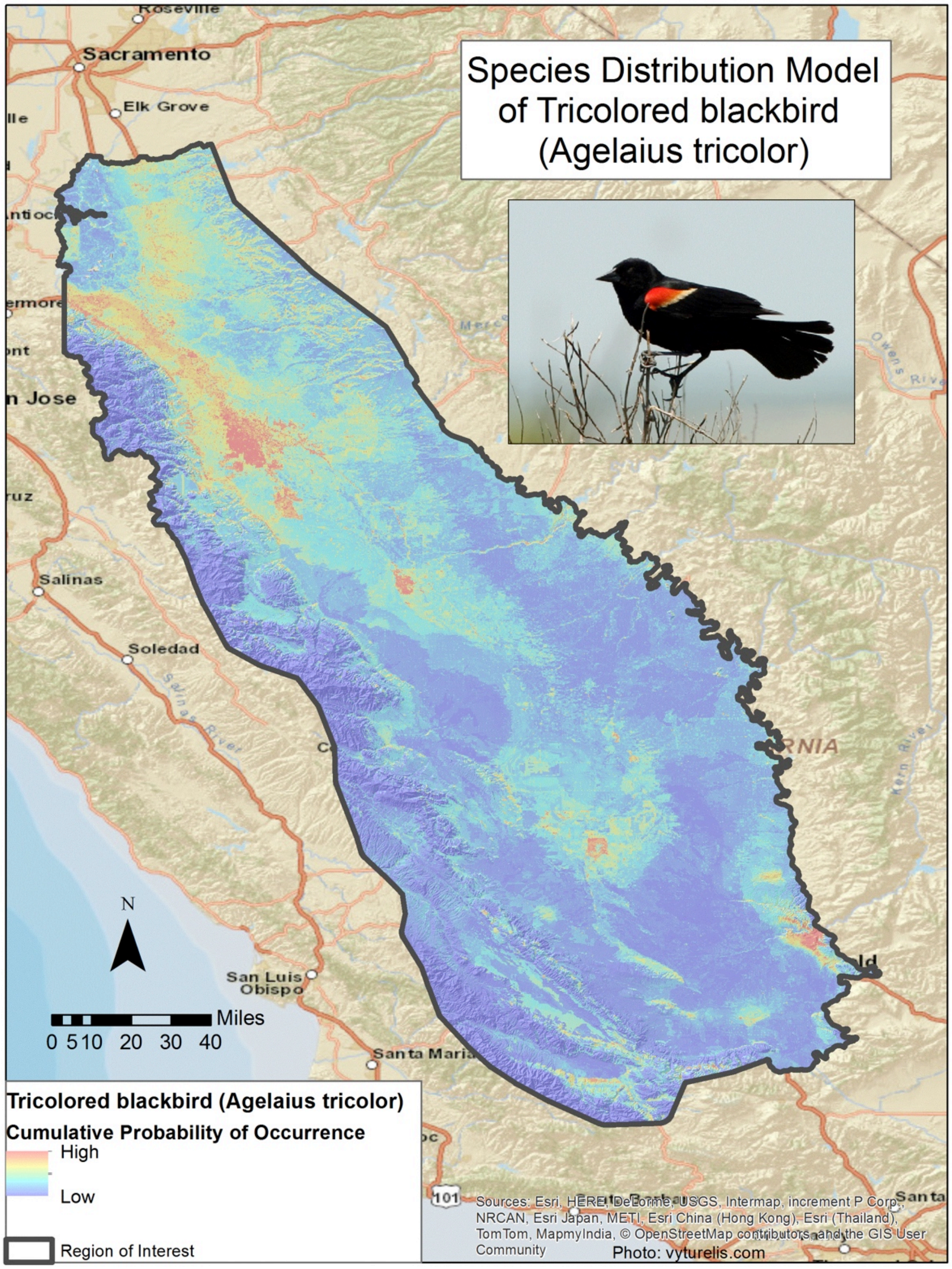

Figure C2. MaxEnt species distribution model for the Tricolored Blackbird (*Agelaius tricolor*) with high probabilities of occurrence shown in red and low probabilities shown in blue.

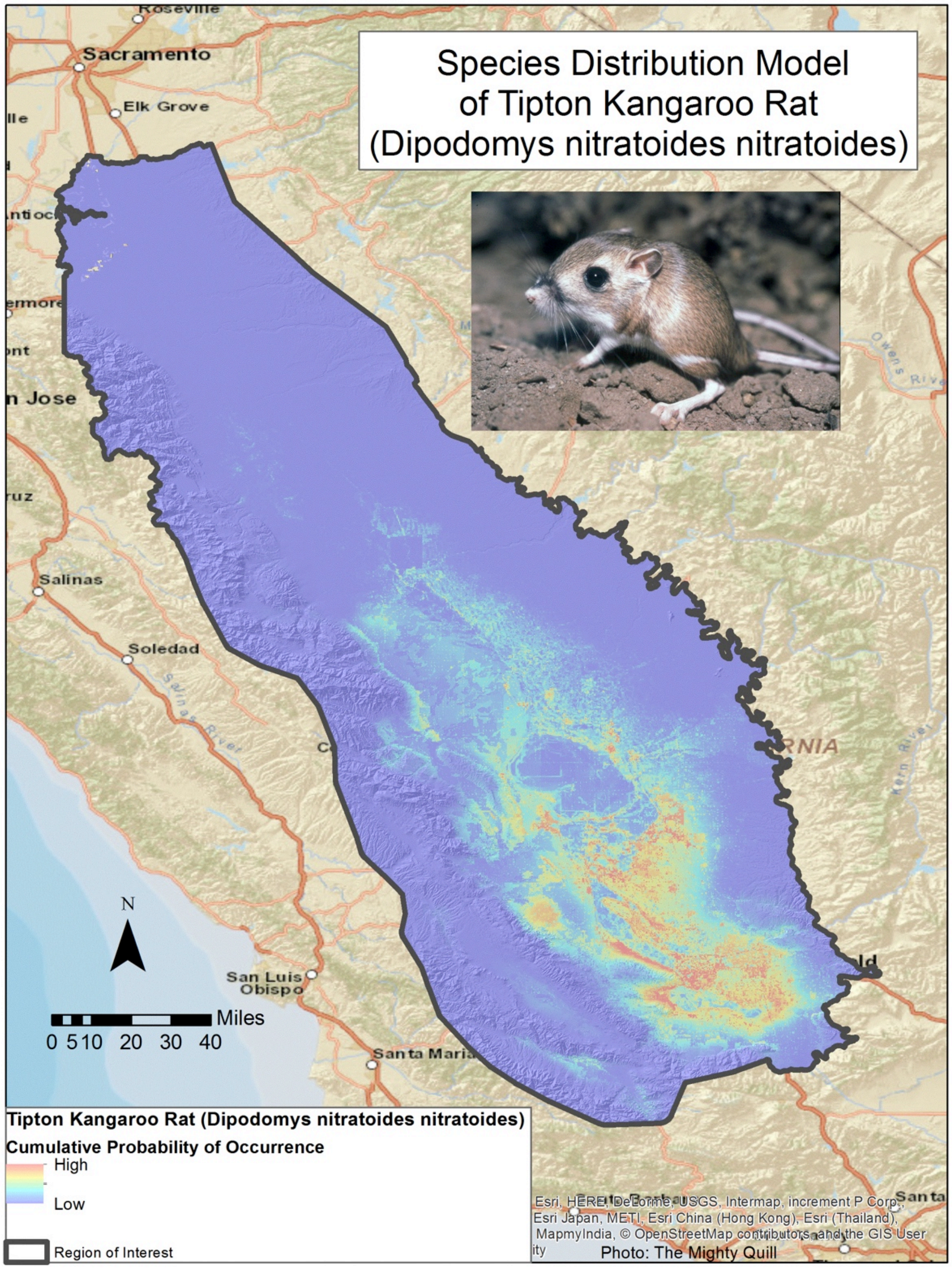

Figure C3. MaxEnt species distribution model for the Tipton Kangaroo Rat (*Dipodomys nitratoides nitratoides*) with high probabilities of occurrence shown in red and low probabilities shown in blue.

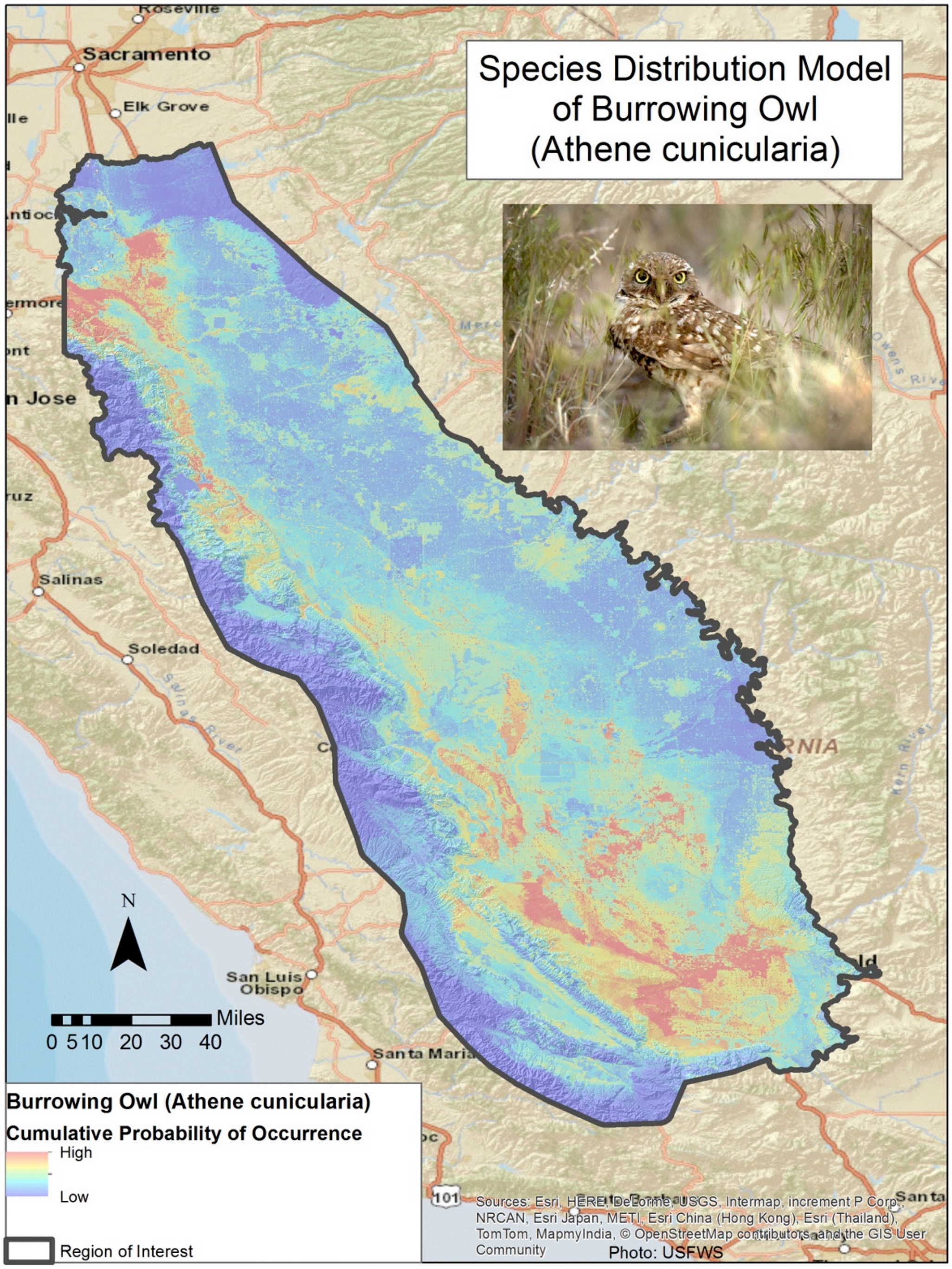

Figure C4. MaxEnt species distribution model for the Burrowing Owl (*Athene cunicularia*) with high probabilities of occurrence shown in red and low probabilities shown in blue.

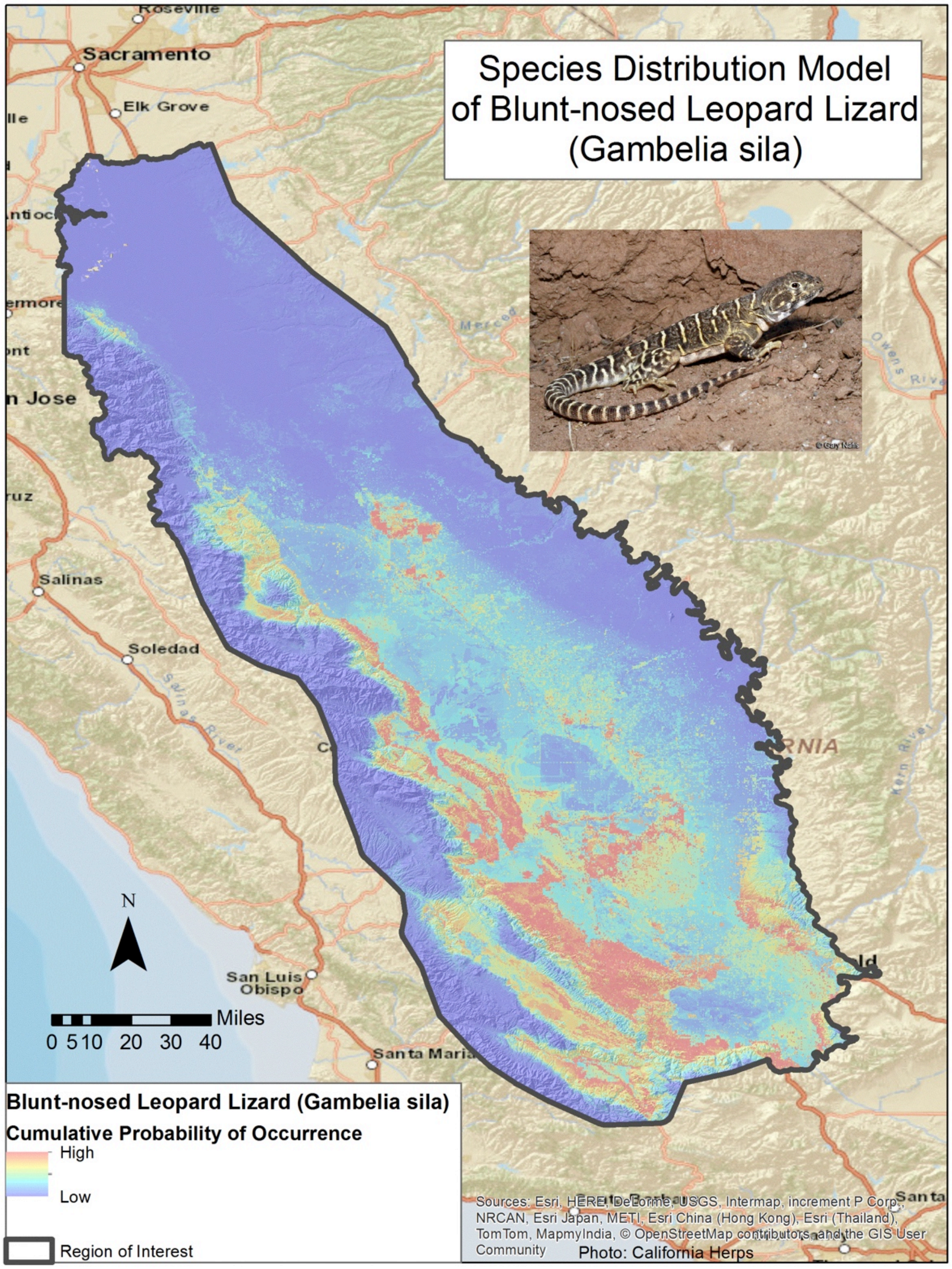

Figure C5. MaxEnt species distribution model for the Blunt-nosed leopard Lizard (*Gambilia sila*) with high probabilities of occurrence shown in red and low probabilities shown in blue.

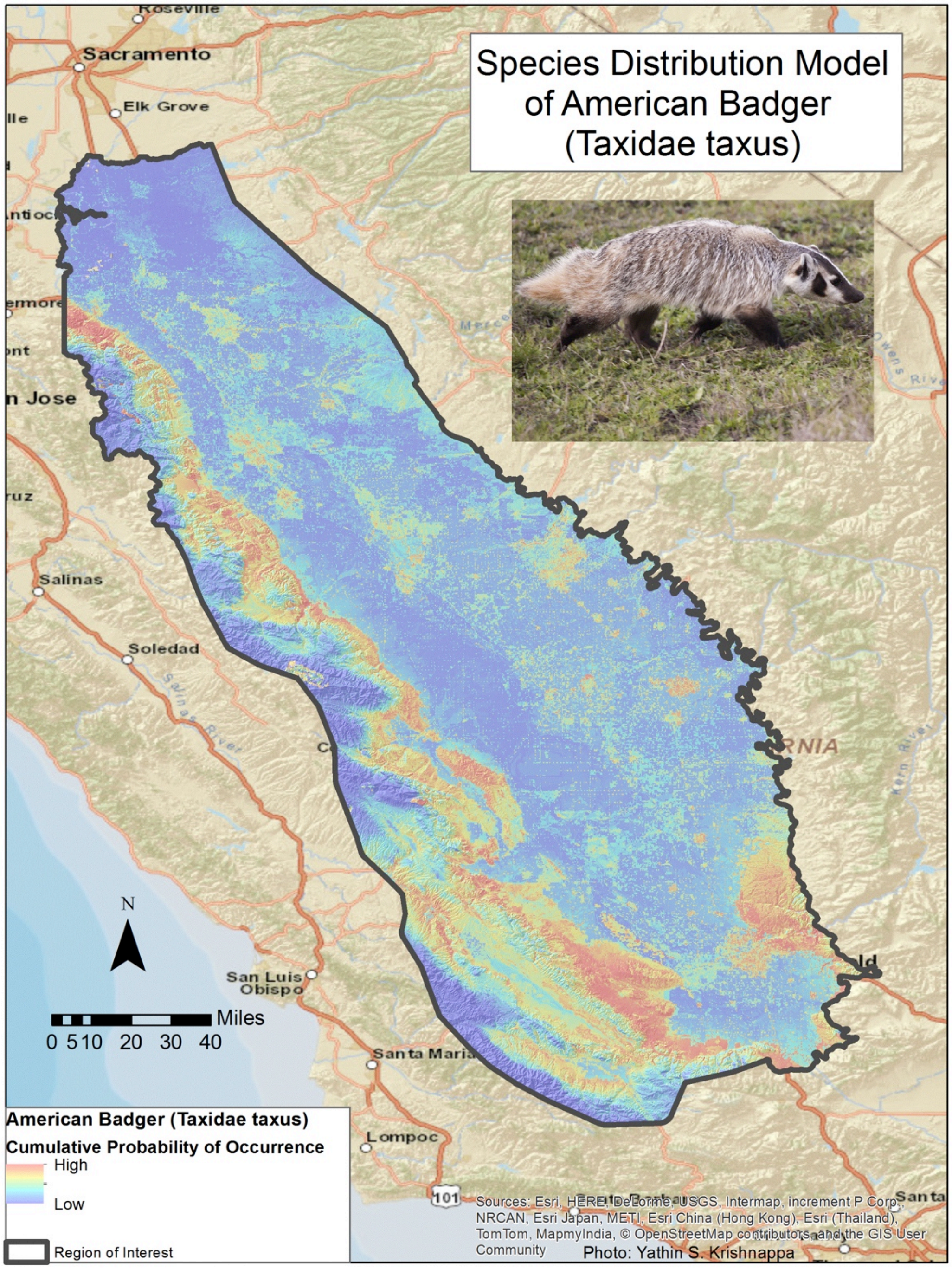

Figure C6. MaxEnt species distribution model for the American Badger (*Taxidae taxus*) with high probabilities of occurrence shown in red and low probabilities shown in blue.

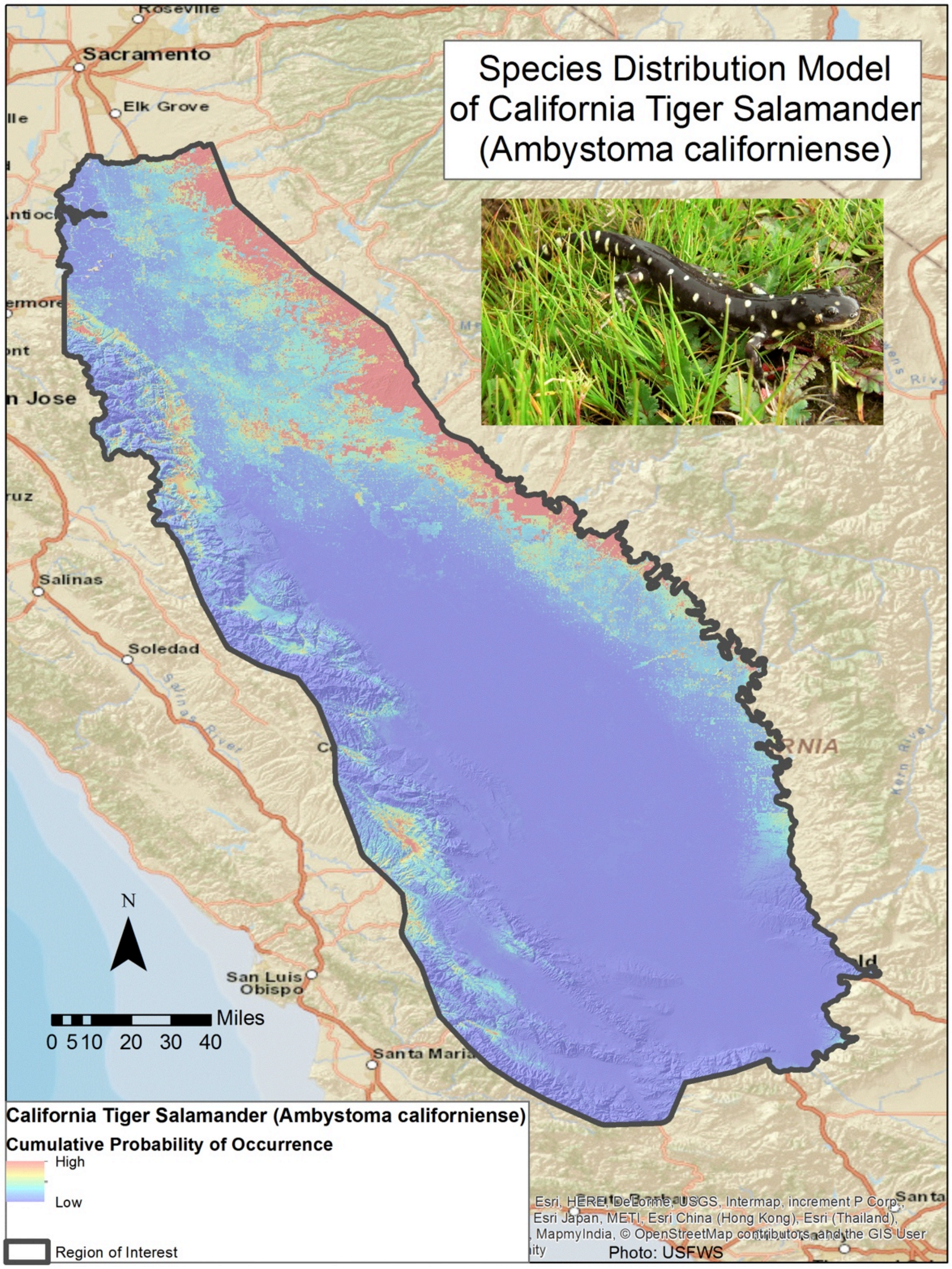

Figure C7. MaxEnt species distribution model for the California Tiger Salamander (*Ambystoma californiense*) with high probabilities of occurrence shown in red and low probabilities shown in blue.

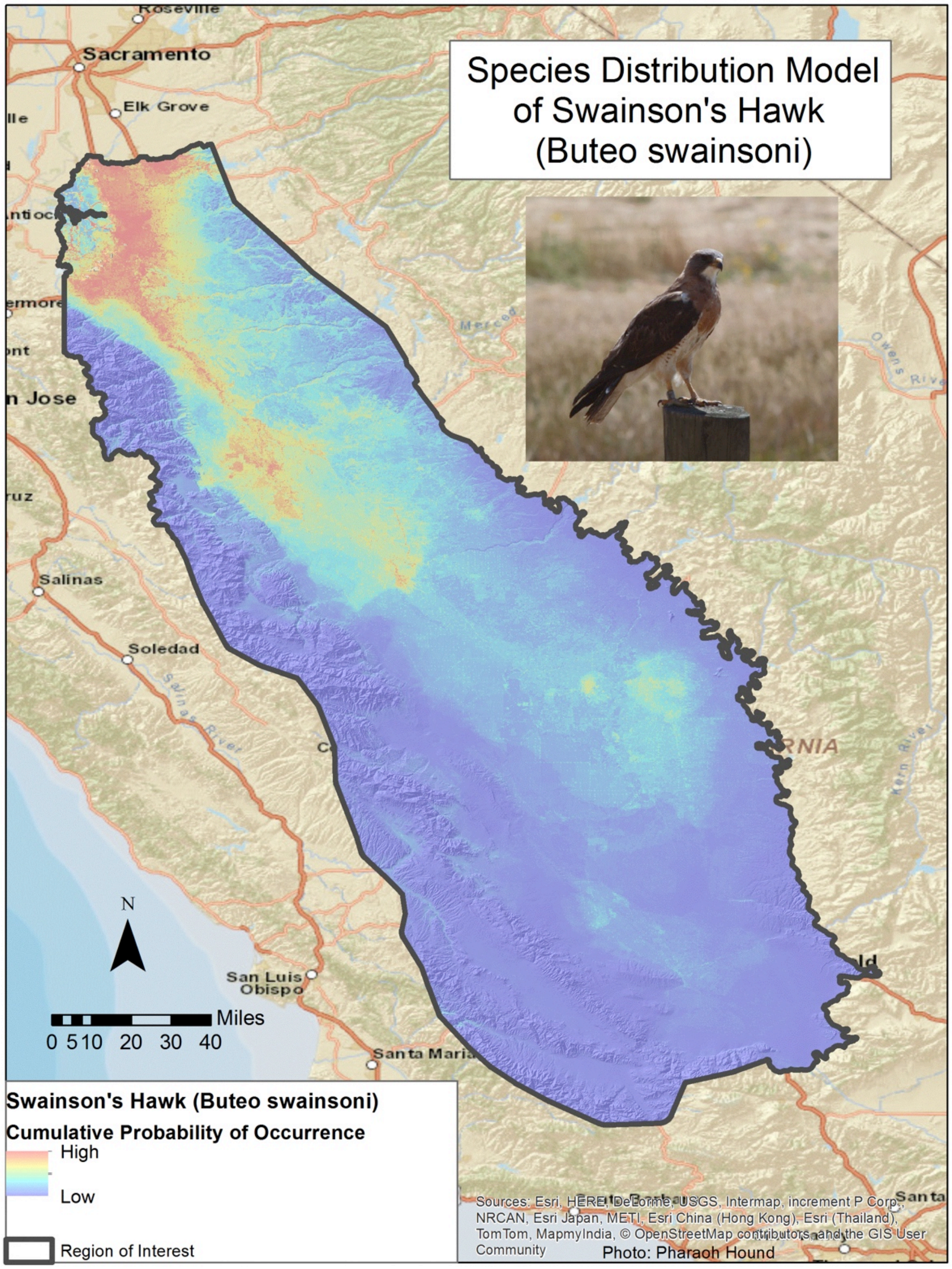

Figure C8. MaxEnt species distribution model for the Swainson's Hawk (*Buteo swainsoni*) with high probabilities of occurrence shown in red and low probabilities shown in blue.

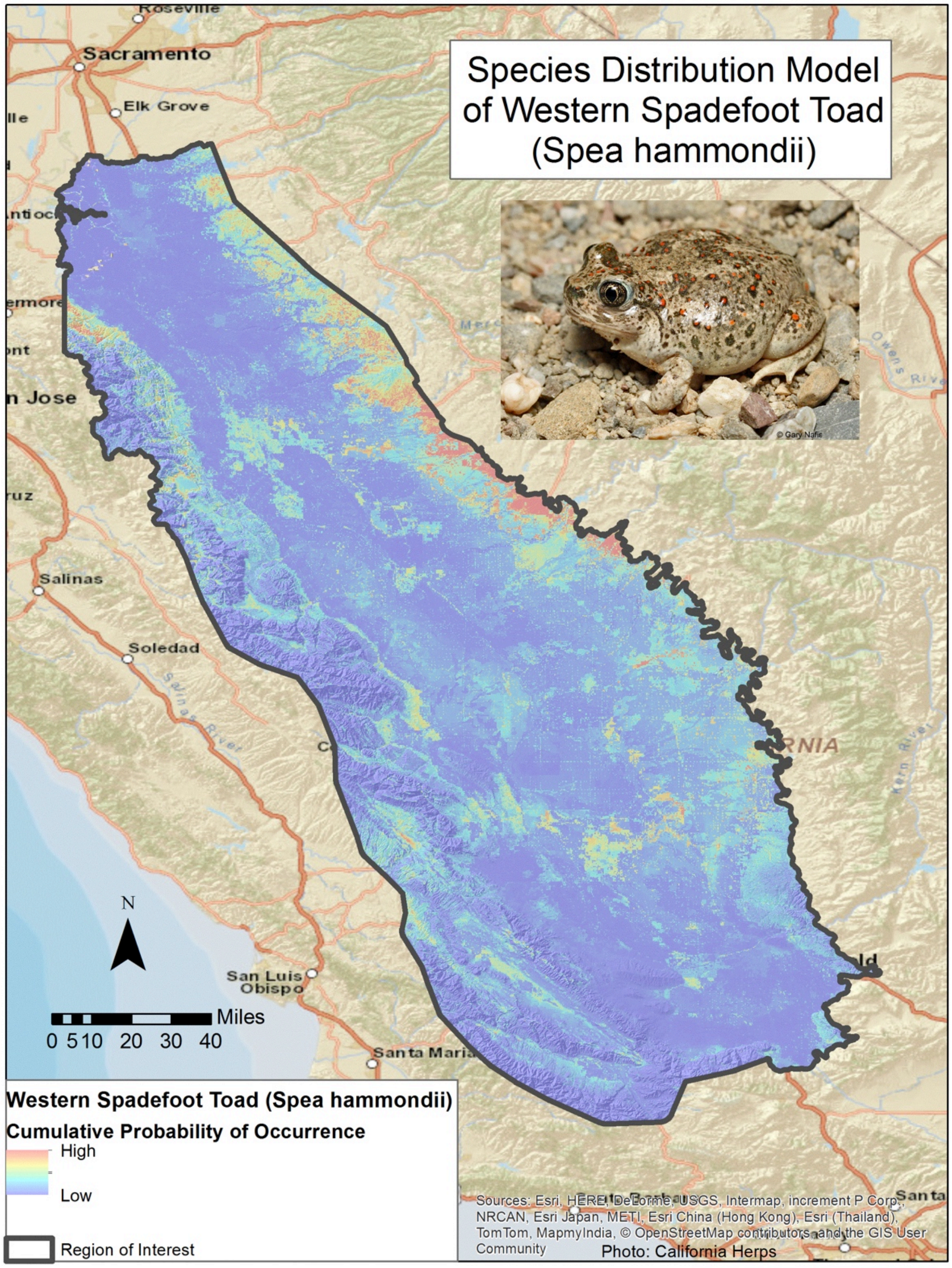

Figure C9. MaxEnt species distribution model for the Western Spadefoot Toad (*Spea hammondii*) with high probabilities of occurrence shown in red and low probabilities shown in blue.

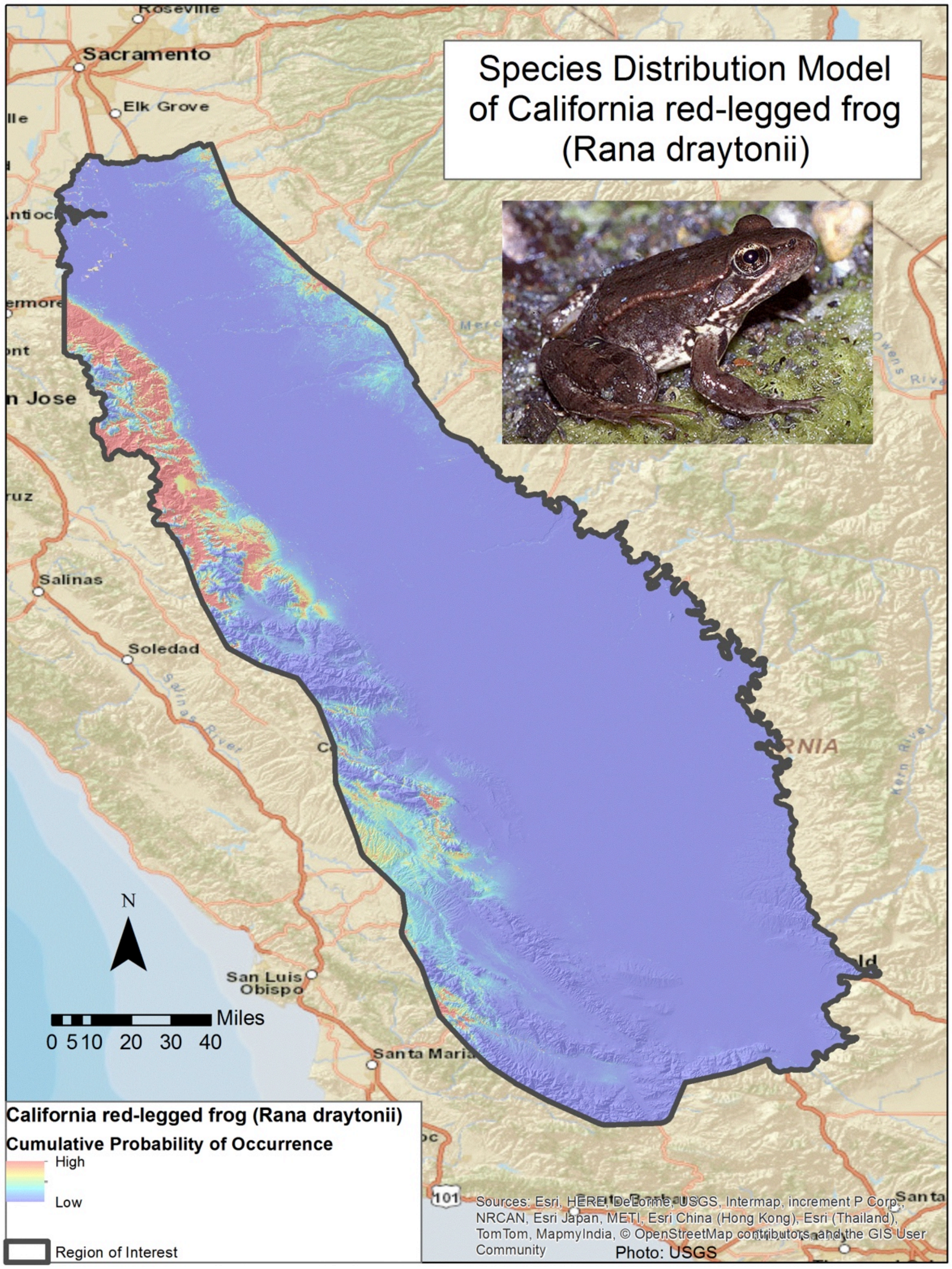

Figure C10. MaxEnt species distribution model for the California Red-legged Frog (*Rana draytonii*) with high probabilities of occurrence shown in red and low probabilities shown in blue.

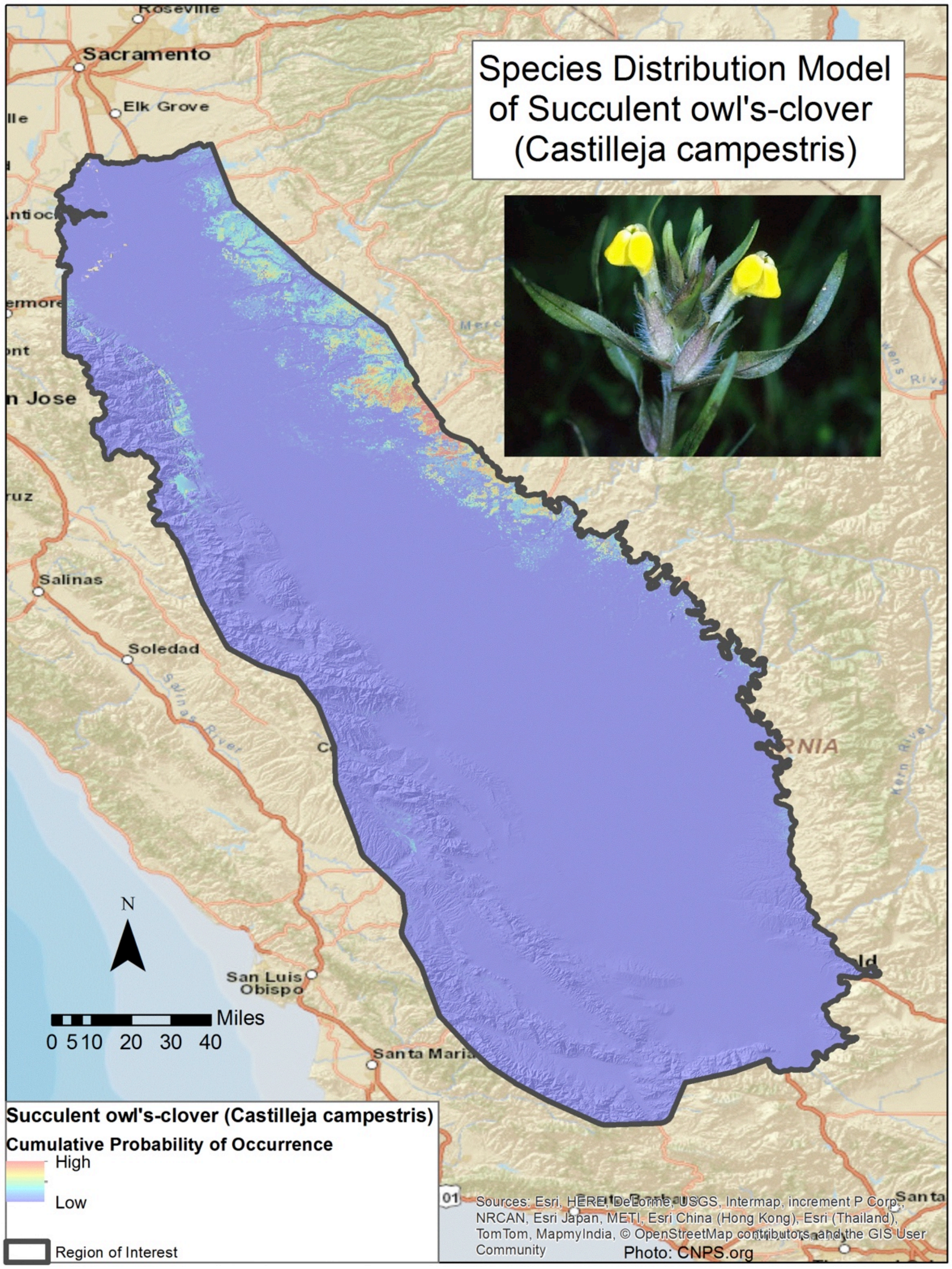

Figure C11. MaxEnt species distribution model for the Succulent Owl's-clover (*Castilleja campestris*) with high probabilities of occurrence shown in red and low probabilities shown in blue.

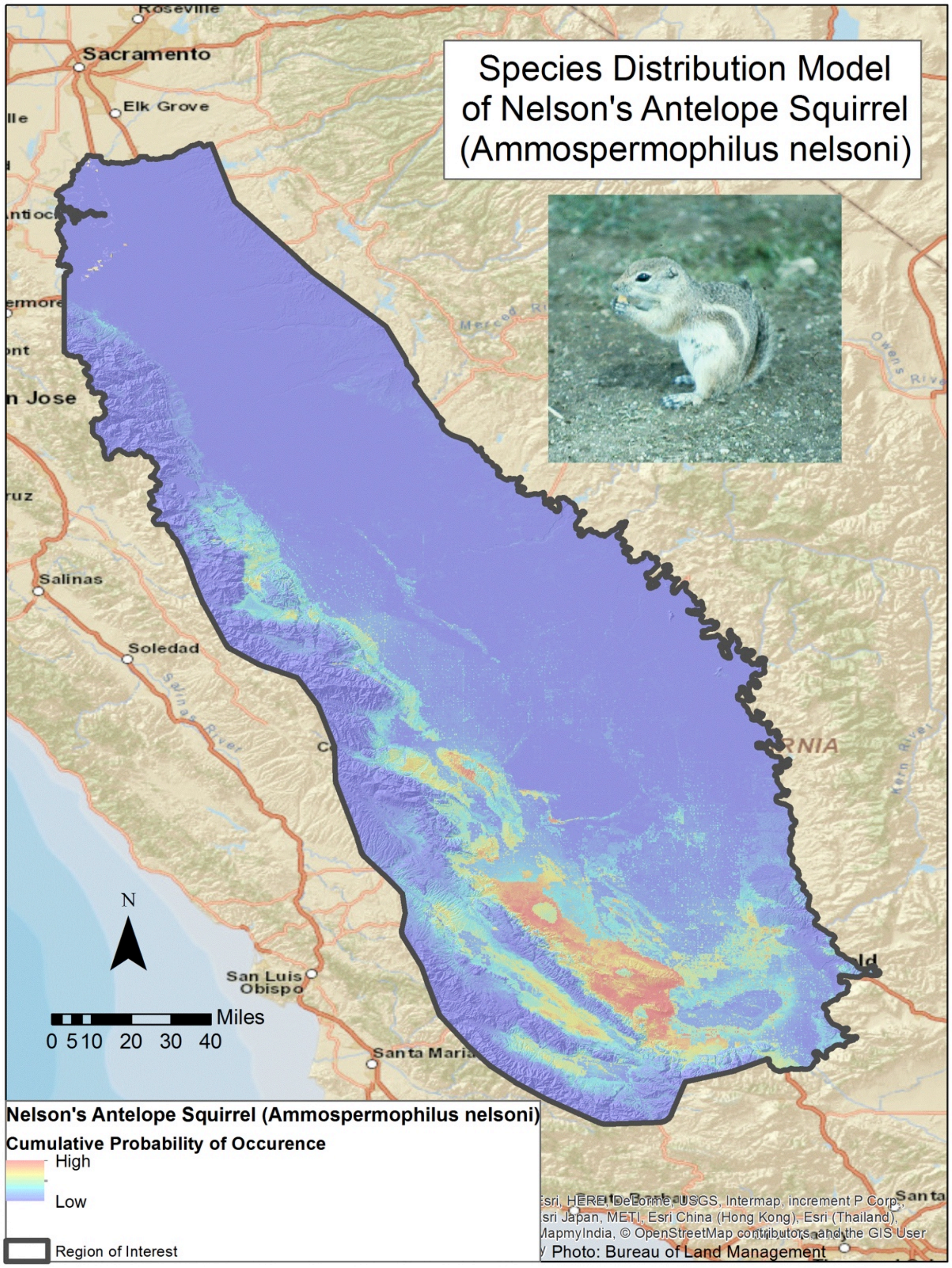

Figure C12. MaxEnt species distribution model for the Nelson's Antelope Squirrel (*Ammospermophilus nelsoni*) with high probabilities of occurrence shown in red and low probabilities shown in blue.

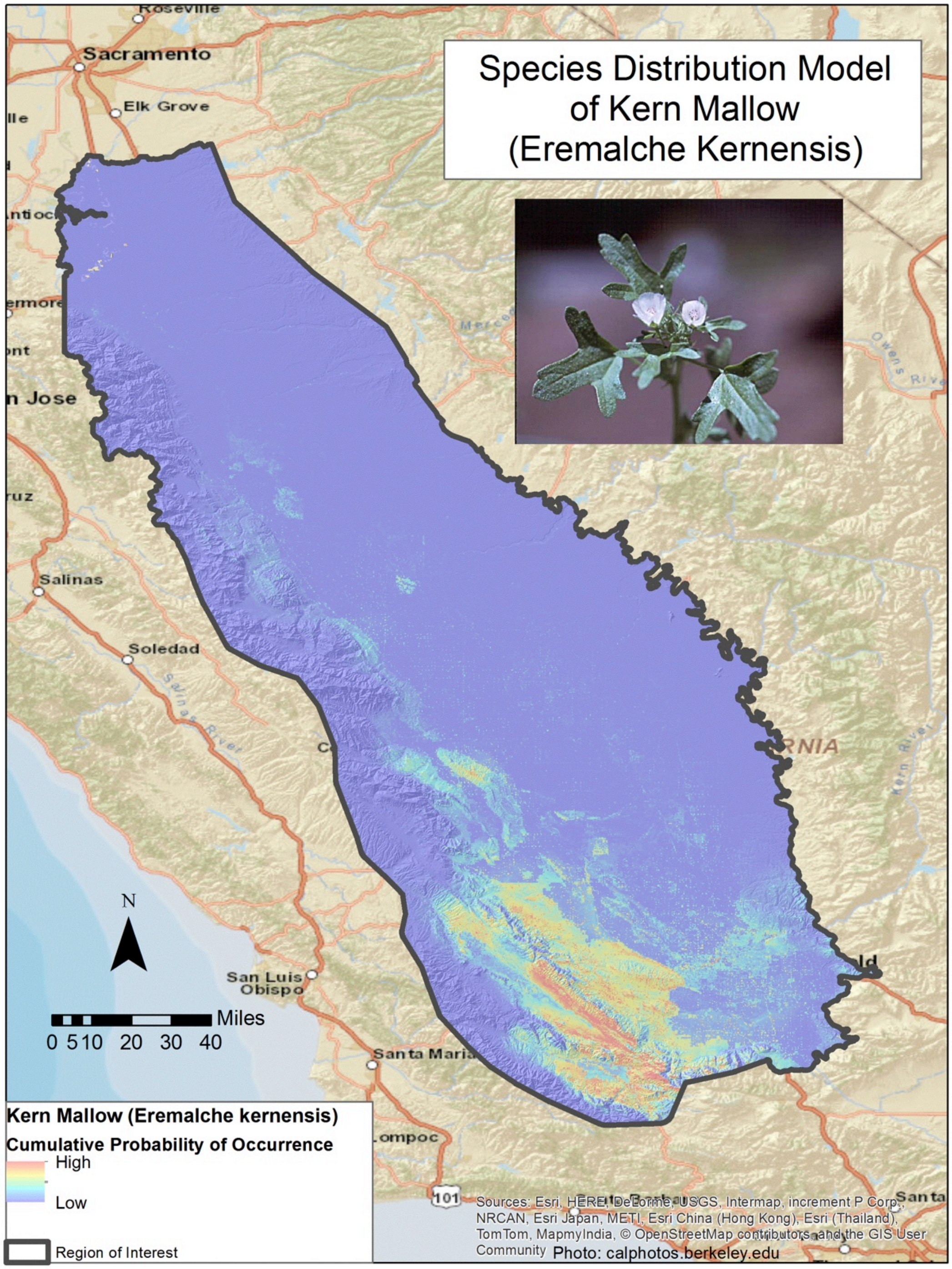

Figure C13. MaxEnt species distribution model for the Kern Mallow (*Eremalche kernensis*) with high probabilities of occurrence shown in red and low probabilities shown in blue.

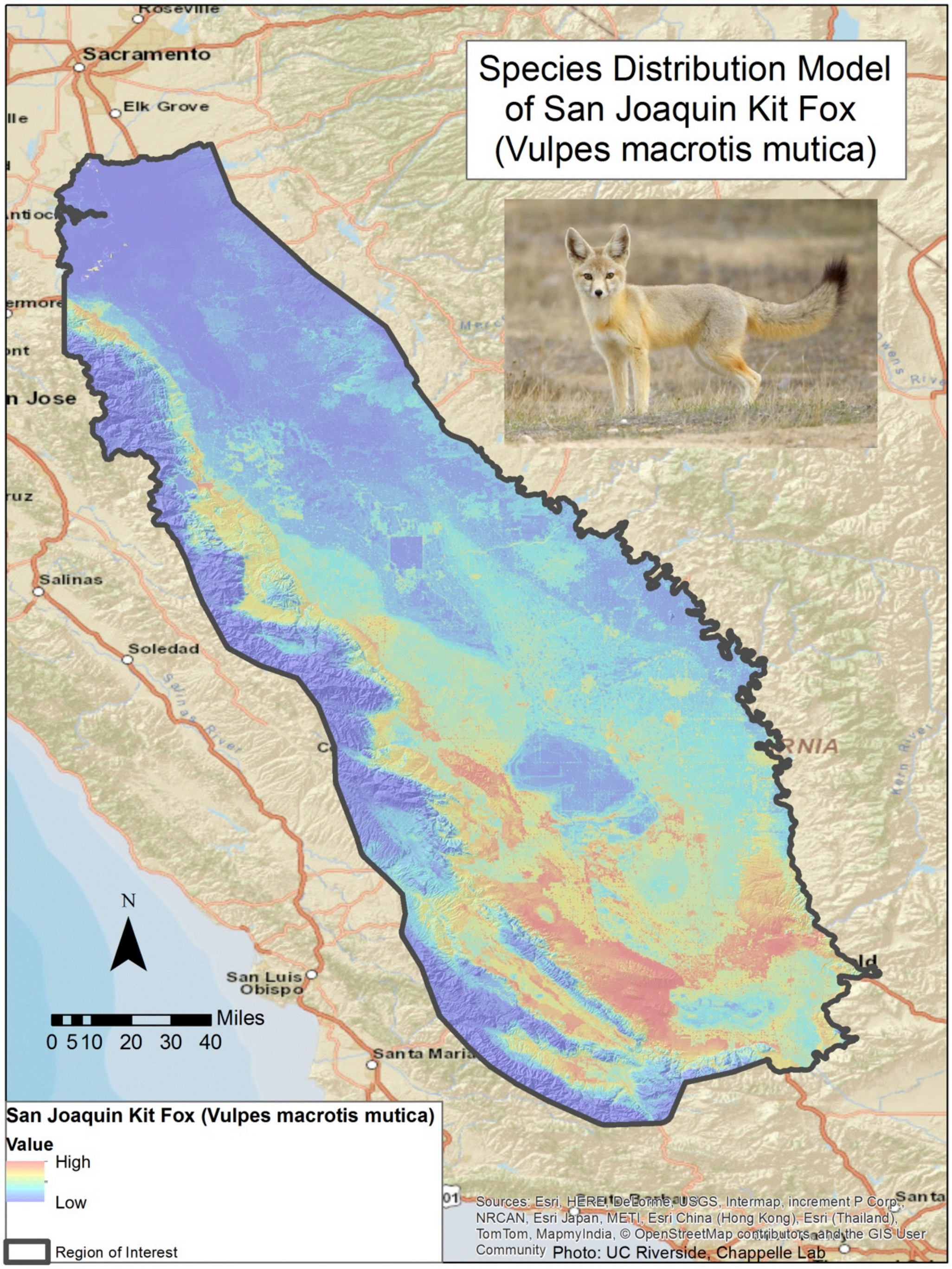

Figure C14. MaxEnt species distribution model for the San Joaquin Kit Fox (*Vulpes macrotis mutica*) with high probabilities of occurrence shown in red and low probabilities shown in blue.

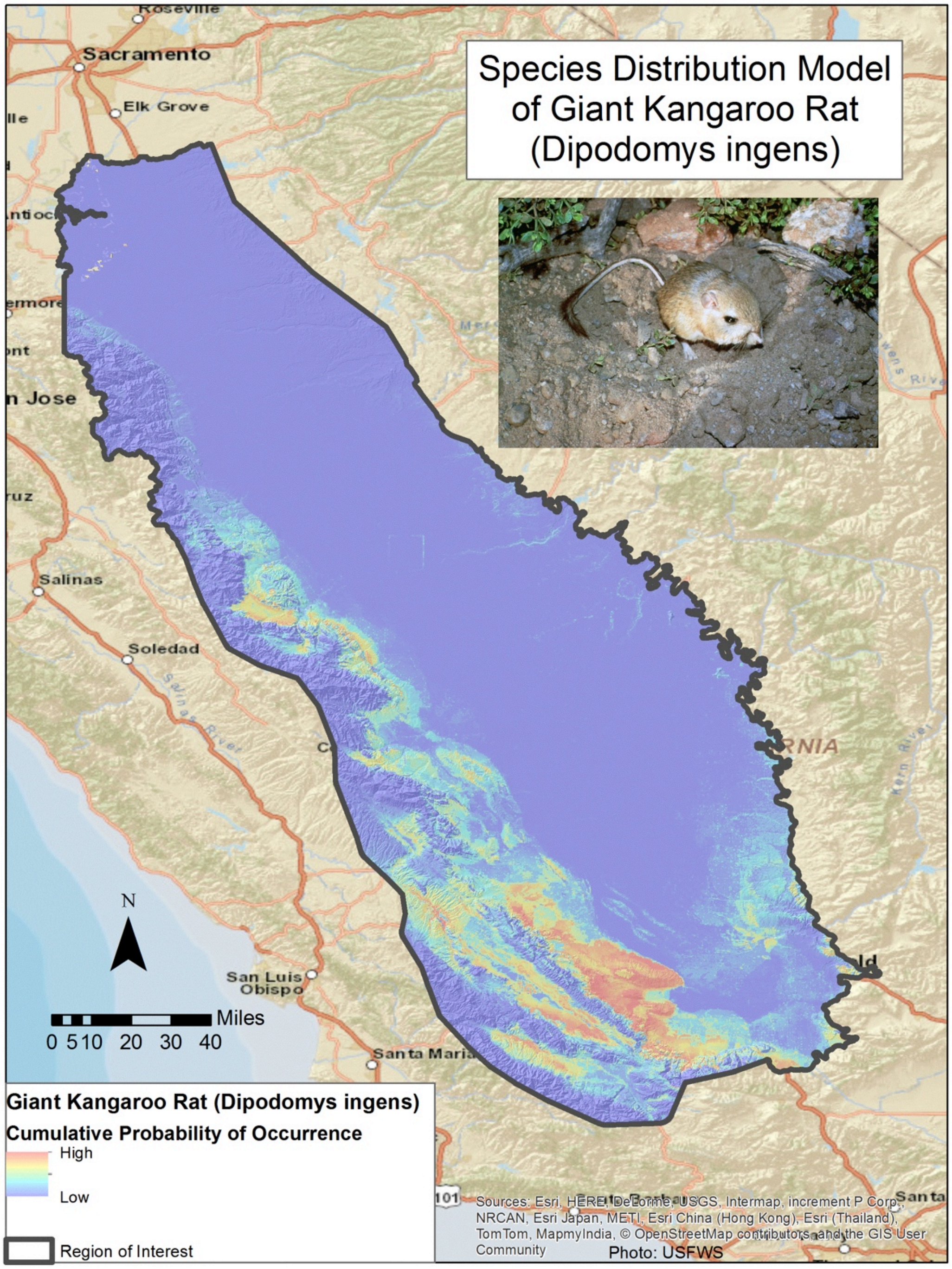

Figure C1. MaxEnt species distribution model for the Giant Kangaroo Rat (*Dypidomys ingens*) with high probabilities of occurrence shown in red and low probabilities shown in blue.

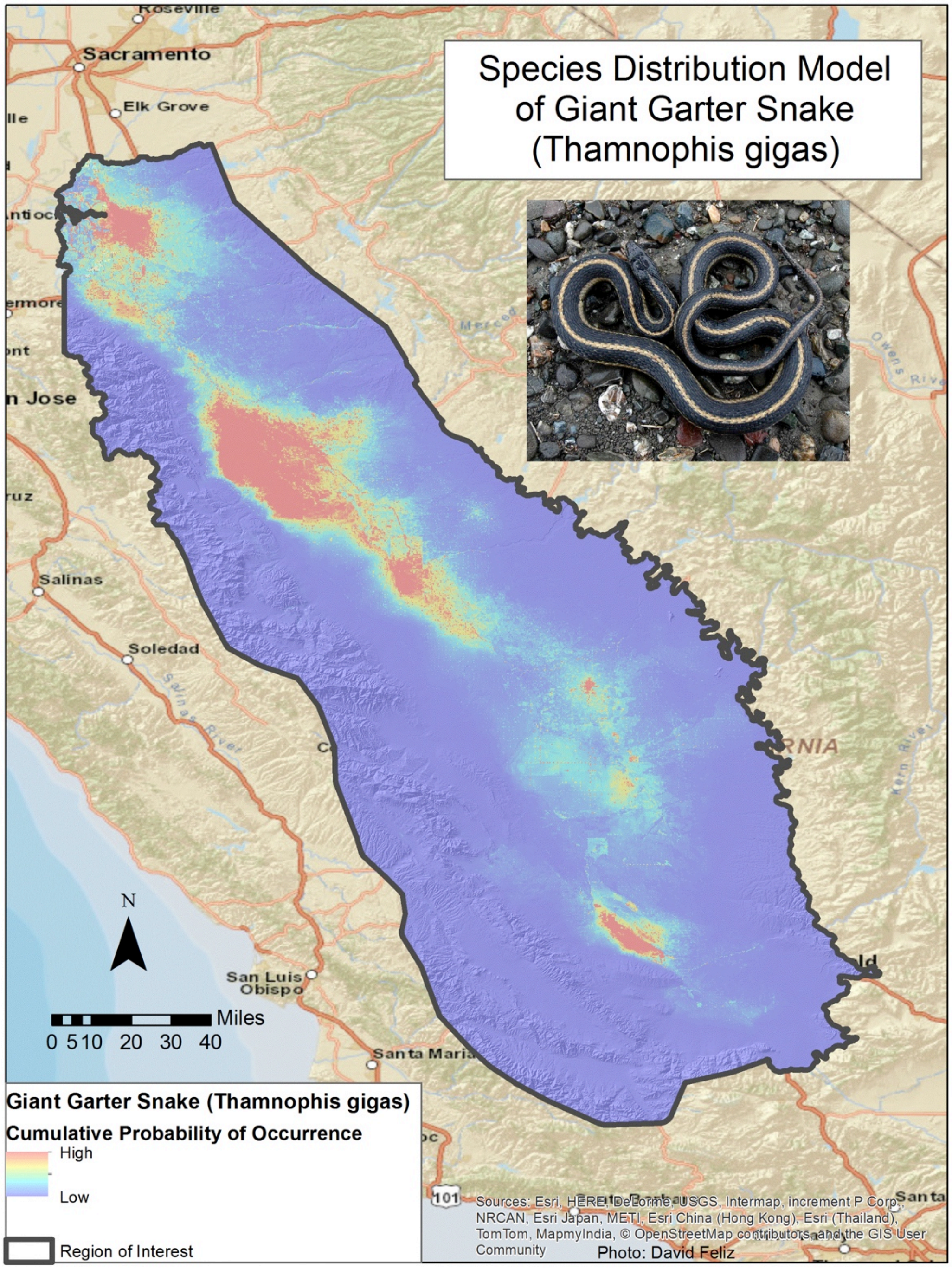

Figure C16. MaxEnt species distribution model for the Giant Garter Snake (*Thamnophis gigas*) with high probabilities of occurrence shown in red and low probabilities shown in blue.

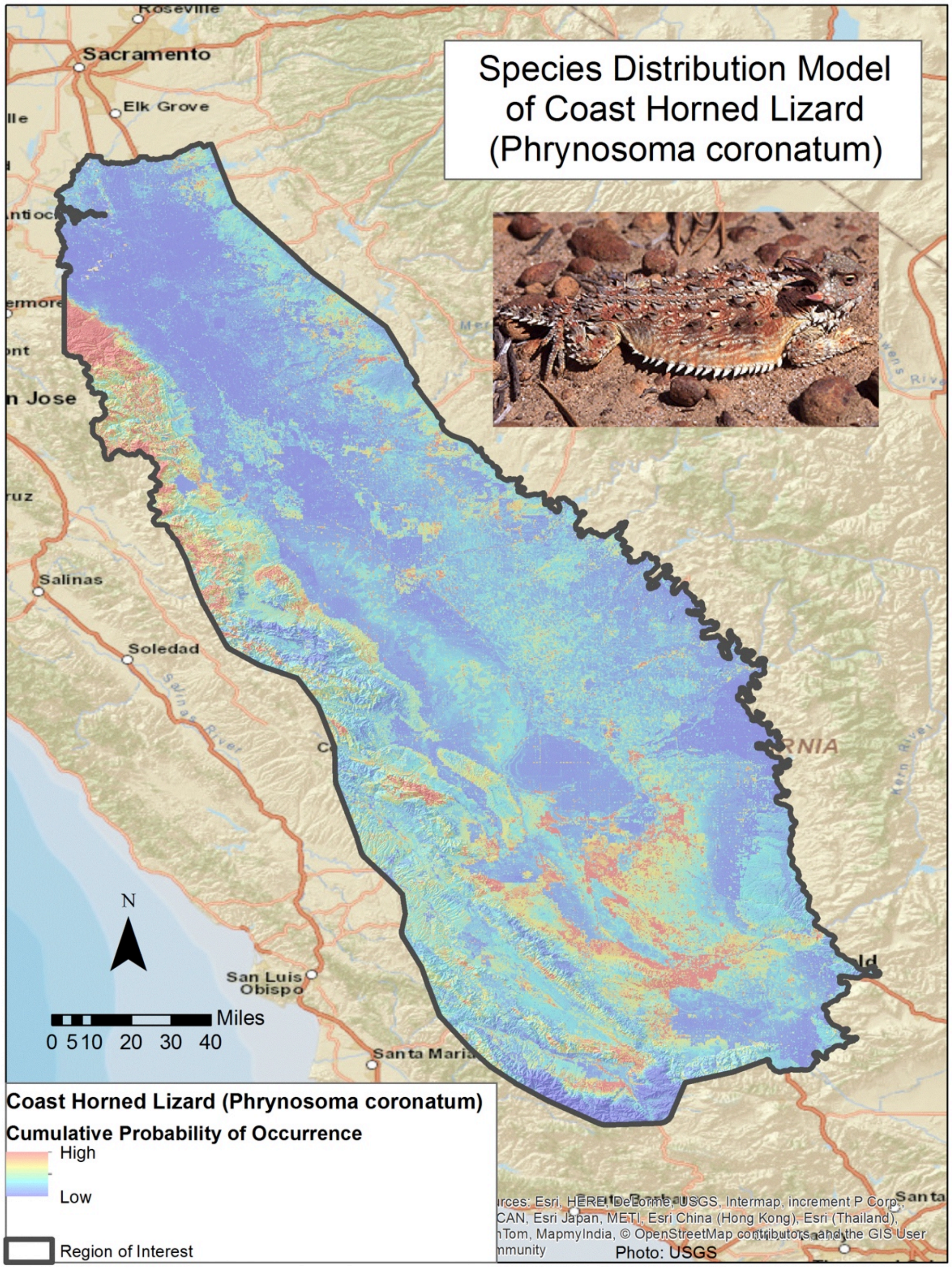

Figure C17. MaxEnt species distribution model for Coast Horned Lizard (*Phyrnosoma coronatum*) with high probabilities of occurrence shown in red and low probabilities shown in blue.

APPENDIX D. ENVIRONMENTAL EVALUATION MODELING SYSTEM (EEMS)

Developed by a team of scientists at the Conservation Biology Institute, the EEMS is a tree-based fuzzy logic modeling system that can be used to determine ecological outcomes for potential future habitat, landscape vulnerability to climate change and ecological and/or development conflicts. Within the EEMS model, fuzzy logic is used to take disparate data and normalize them into a common range of values ("fuzzy space"). Fuzzy logic allows values that represent different environmental attributes to be compared. Spatial data layers are fed into the model, at which point the range of values is stretched on a -1 to 1 scale.

The model combines layers that have been converted to a fuzzy scale using a set of operators. The WildLight analysis makes use of the several of these operators, including the weighted sum which allows the user to set weights for layers before summing their values. The weights used in the model were chosen based on several criteria. A literature search was done to determine the relative importance of the factors within the model. Additionally, the results of interviews with solar developers and other stakeholders informed the weights used within the model.

Lastly, thresholding for fuzzy values was done using the thresholding tool that is part of the EEMS model package. This thresholding tool reads the values in the data table and optimizes how the values will be stretched on the fuzzy scale. These values can be altered manually, but for this analysis the default thresholds were used. Tables containing the thresholds and weights for each of the modules can be found below.

Table C.1. EEMS model weights and thresholds for the final run (Trial 19) of the Conservation Value module

Conservation Value	Trial 19		
	True Threshold (1)	**False Threshold (-1)**	**Weight**
Vegetation			
Wetlands	43209492	0	0.5
Important Bird Areas	1	0	0.5
Vegetative Communities (Diversity)	20	1	2
Rare Land Cover	0.0005	0	2
ACEII Rare Communities	NA	NA	NA
Wildlife			
Rare Species Richness	8	0	0.5
Habitat Resilience	6	0	0.3
Current Habitat	4.52	0.00610436	1
Native Species Richness	0.8	0.16	0.5
Landscape			
Impermeability (Theobald)	1	961	NA
Condition (Natureserve)	77	5	NA

Table C.2. EEMS model weights and thresholds for the final run (Trial 19) of the Agricultural Land Value module

Agriculture			
	True Threshold (1)	**False Threshold (-1)**	**Weight**
Agriculture	2	0	NA
CCRC	1	0	NA

Table C.3. EEMS model weights and thresholds for the final run (Trial 19) of the Solar Suitability module

Solar			
	True Threshold (1)	**False Threshold (-1)**	**Weight**
Insolation	6.48	4.75	0.2
Slope	0	6	0.5
Transmission Density	0.00056412	0	1

Table C.3. EEMS model weights and thresholds for the final run (Trial 19) of the Solar Suitability module

Consensus Areas			
	True Threshold (1)	**False Threshold (-1)**	**Weight**
Least Conflict	1.794096	-3.327289	1
Solarfzy	1.402589	-1.416636	0.5

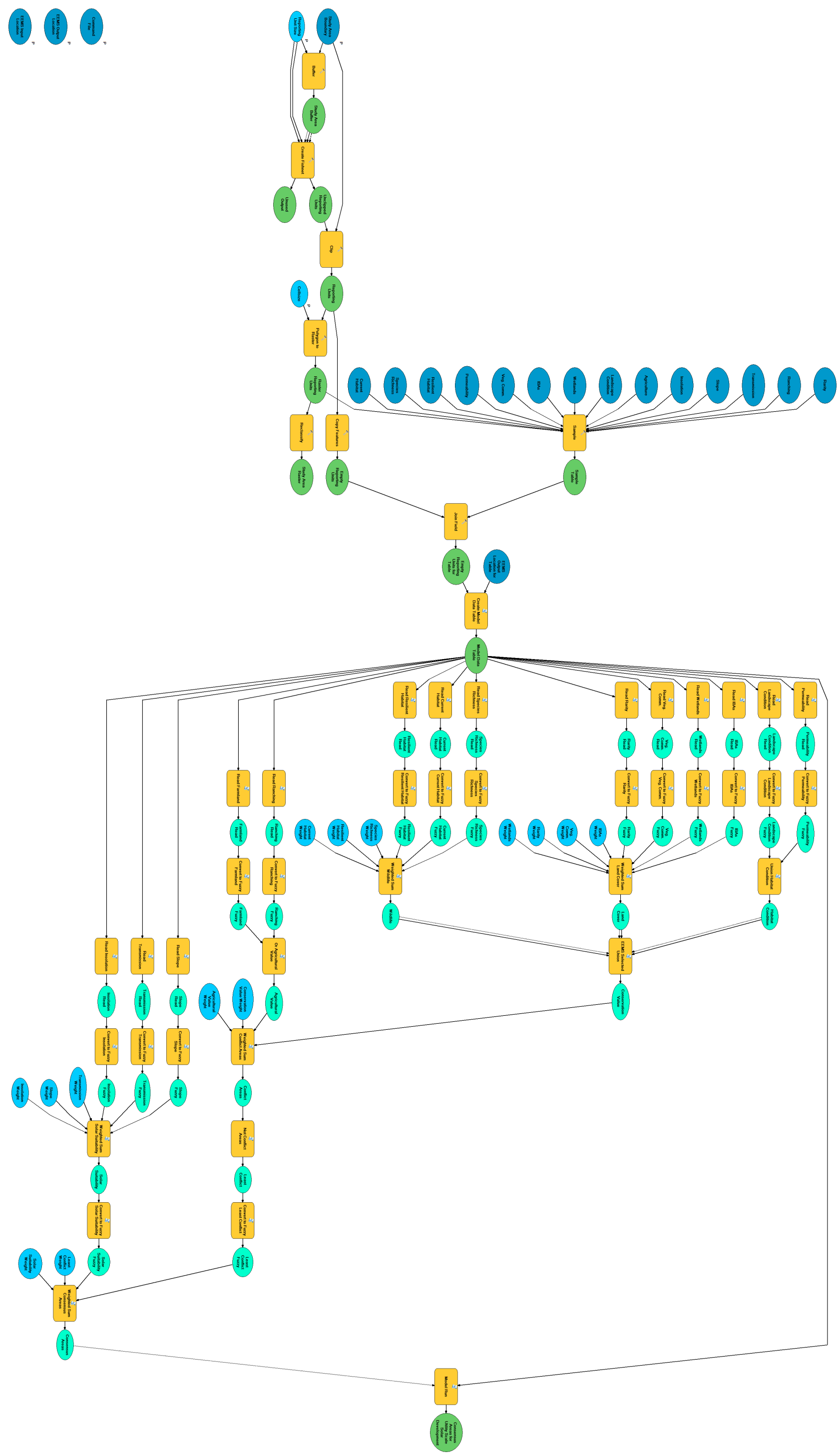

Figure 1C. Schematic of the WildLight EEMS model in the ArcGIS model builder evironment.

APPENDIX F. SOLAR PROFESSIONALS INTERVIEWS

A total of 16 people were interviewed in order for the WildLight team to assess the preferences of professionals in the field of solar energy development. These practitioners have experience in implementing solar projects on a large scale are most familiars with the associated issues.

Table D1. Description of the interviewees and the time that they were interviewed for the WildLight project

Interviewee Description	Time of Interview
Mid sized solar developer	1/16/15, 3:00 PM
Mid sized solar developer	1/20/15, 4:30 PM
Consulting firm	1/22/15, 3:00 PM
Large scale solar developer	
Retired solar developer	
County planner	1/22/15, 1:00 PM
Consultant	1/23/15, 11:00 AM
Large scale solar developer	1/23/15, 4:00 PM
Small scale solar developer	1/27/15, 4:40 PM
Consultant firm	
Small scale solar developer	1/28/15, 4:45 PM
Small scale solar developer	1/28/15, 5:16 PM
Large scale solar developer	1/30/15, 9:00 AM
Large scale solar developer	1/30/15, 9:30 AM
Large scale solar developer	1/30/15, 4:18 PM
County planner	2/2/15, 2:00 PM

Interview Question 1 Results

- In your organization's opinion, what are the main drivers and incentives (i.e. Federal, state, and local policies/processes) to produce utility scale PV projects in the SJV?

Solar developers Consultants and planners generally agreed that the RPS was the driving factor for solar development in both the SJV. It was indicated that this investment tax credit had also been helpful in attracting investment, in turn make solar energy more affordable. Developers stated that the investment tax credit phase down at the end of 2016 would likely slow down solar development.

Interview Question 2 Results

- In your organizations opinion, what elements are most important in influencing your decision to develop in given location?

For developers, existing transmission infrastructure is the single most important attribute for siting a utility scale solar development. By siting a facility in close proximity (<1 mile) from transmission, developers reduce the barriers to a power purchase agreement with electrical utilities. Many developers stated that they avoid proposing development on high quality agricultural due to resistance from landowners and Farm Bureaus. The larger developers noted that biological issues with species such as Swainson Hawk, Tiger Salamander because there is no take permitted for these species. Most developers tended to prefer degraded agricultural land for development because of less of a chance of costly mitigation plans and opposition from various interest groups. Other important factors included solar isolation and flat topography.

Interview Question 3 Results

- How useful would a least conflict/consensus map be to your organization if it included agricultural land values, and solar suitability and conservation value?

A majority (> 50%) of developers said a map containing a consistent land prioritization system would be useful for them. The other half said a map would be somewhat useful, and a few said not at all useful. This result appears to be correlated with the size of the proposed development, with larger developers stating that a map would be useful if the it highlighted areas with lower predicted soft costs. Every county has different requirements for utility scale solar, and so linking areas with county specific requirements would be useful. This map would need to utilize the most nuanced transmission layer available ideally including information on available line capacity.

Consultants indicated that a map with particular mitigation requirements would be useful, and that incorporating such a map in to state level policies, or county general plans would increase the effectiveness of such a product. Codifying such a map into regulation would make development more predictable for investors.

Interview Question 4 Results

- In your organizations opinion, what lengthens the permitting time for solar projects and how could the process be streamlined?

The consensus among developers, consultants, and planners was that navigating the CEQA process protracted the development timeline most severely. One developer mentioned that a programmatic EIR like those used to develop public lands in desert, could also be useful in this context. Consultants and planners were generally more accepting of CEQA requirements and they viewed the slowness of CEQA as inherent to the statute, but that an exemption to CEQA for solar projects on lands that with low agricultural or conservation value was seen a possible solution.

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