EXECUTIVE SUMMARY

Integrating Land Conservation and Renewable Energy Goals in California

A Study of Costs and Impacts Using the Optimal Renewable Energy Build-Out (ORB) Model

Solar panels at the Fuller Star plant in Lancaster, CA. © Dave Lauridsen for The Nature Conservancy

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This Executive Summary was prepared by The Nature Conservancy as a summary of a more detailed technical report prepared by Grace C. Wu (Energy and Resources Group, University of California at Berkeley) and Energy + Environmental Economics, sponsored by, and with significant contributions from The Nature Conservancy. The views expressed in the summary are those of The Nature Conservancy. We acknowledge and extend a special thanks to Jim Downing for preparation of the Executive Summary.

Wind turbines in the Mojave desert outside the main area of the Tehachapi corridor in California. © Ian Shive

Introduction

California has ambitious renewable energy targets and abundant wind, geothermal, concentrating solar power (CSP) and solar photovoltaic (PV) resources. However, many of California's undeveloped landscapes have high conservation values, creating the potential for conflict between renewable energy development and conservation goals.

Such conflicts can unnecessarily degrade the habitat, biodiversity and other values of natural landscapes. They can also seriously impede renewable energy development. Projects have been subject to multi-year delays, major cost increases and in some cases abandonment.

To minimize these conflicts, land conservation values must be integrated into the state's long-term planning for transmission and renewable energy procurement.[1] Guiding the transmission planning process is especially important because decisions on transmission upgrades and new lines constrain the siting of future renewable energy projects.

Currently, transmission and long-term procurement planning decisions are informed by output from the California Renewable Portfolio Standard Calculator v6.0 (RPS Calculator). This calculator receives input data on transmission availability, renewable energy resource potential and other factors. From this information, it produces a portfolio of future renewable energy projects (for multiple technologies), organized by Super Competitive Renewable Energy Zone (Super CREZ),[2] that meets a projected future load at the lowest cost.

The RPS Calculator accounts for prohibitions on renewable energy development in some areas, such as national parks.[3] But it does not account for the many areas where renewable energy development may generate conflict due to impacts on conservation values. As a result, the RPS Calculator may overstate the potential capacity for renewable energy development in areas where projects are likely to be infeasible

1 These planning processes include the California Public Utilities Commission (CPUC) Long-Term Procurement Plan (LTPP), the California Independent System Operator (CAISO) Transmission Planning Process (TPP), and others.

2 Super Competitive Renewable Energy Zones are roughly county-scale energy planning units for which renewable resource potential, transmission capacity and renewable energy project costs have been estimated. The maps in this report show the Super CREZ boundaries.

3 The full list of areas excluded from renewable energy development in the RPS Calculator has not been released for public review.

due to, for instance, poor alignment with land-use planning designations for biodiversity conservation. While the RPS Calculator helps to analyze one policy goal—increased renewable energy development—it does not incorporate information on important natural habitats, and thus does not produce scenarios that planners can use to steer development away from such areas.

The model and analyses presented in this report fill that gap.

The Optimal Renewable energy Build-out (ORB) model generates input data for the RPS Calculator that reflects the renewable energy potential in each Super CREZ when certain lands are excluded due to their conservation value. With this input, the RPS Calculator generates portfolios of future renewable energy production that minimize cost given the resource availability and other constraints in each Super CREZ.

The ORB model then takes these portfolios from the RPS Calculator and models the specific locations of the utility-scale wind, PV, CSP and geothermal projects that would make up each portfolio, while avoiding the most important conservation lands.[4] This project location information is used to assess the overall environmental impacts of each portfolio.

This report presents the portfolios generated at four different levels of environmental exclusion, from least restrictive to most restrictive. Each level of exclusion is evaluated under three 2030 renewable energy build-out scenarios: 33% of generation in-state; 50% in-state; and 50% generation from a combination of in-state and out-of-state sources (anywhere within the Western Electricity Coordinating Council, or WECC, region). The combinations of environmental protection categories and build-out scenarios are presented as a plausible range of future scenarios for renewable energy development in California. The scenarios are meant to illustrate the magnitude of trade-offs between the development of renewable energy capacity, environmental impacts and costs given a range of inputs and assumptions.

The study described in this report is intended to be a proof of concept for integrating environmental exclusions into renewable energy planning models and decision-making

Sheep used for weed and grass management grazing at the Fuller Star solar project in Lancaster, CA. © Dave Lauridsen for The Nature Conservancy California.

in California. In order to demonstrate how this integration could be accomplished and why it may be valuable, the study employs a tool—the RPS Calculator—that the state currently uses to inform planning and long-term procurement decision-making. As of this writing, the RPS Calculator is under public review and active revision; this report is not meant to endorse the assumptions in the version of the RPS Calculator used in this study or to imply that the build-outs generated by the ORB model represent the full suite of options for achieving California's renewable energy goals.[5]

This summary explains the methodology used in the study and shows how including environmental criteria would influence the spatial distribution, technology mix and overall environmental impact of future renewable energy projects in California.

4 By contrast, the RPS Calculator models only the total renewable generation and technology type within the boundaries of each Super CREZ; it does not specify project locations for generic future projects within each Super CREZ, nor does it provide information on specific locations for existing or commercial projects.

5 The RPS Calculator Version 6.0 does not include load outside of the CAISO balancing authority area.

Methods

The original ORB model was developed by Grace Wu of UC Berkeley, with guidance from Energy and Environmental Economics (E3), and Lawrence Berkeley National Laboratory (LBNL), and was published in a peer-reviewed scientific journal.[6] With The Nature Conservancy's support, ORB was modified and extended to examine scenarios associated with the RPS Calculator. A detailed description of the model is provided in the full report; a summary of its key features follows.

The ORB model works in conjunction with the RPS Calculator (Figure 1). The ORB model provides environmentally constrained resource availability inputs to the RPS Calculator, but it does not alter the calculator's inner workings, which generate the least-cost, best-fit renewable energy portfolio to meet a given generation target.

Environmental Exclusions

The ORB model uses four levels of increasingly restrictive environmental exclusion (Table 1). The land categorizations and datasets draw primarily on previous renewable energy planning studies, including the WECC Transmission Expansion Plan, the Western Renewable Energy Zones (WREZ) project and the Renewable Energy Transmission Initiative (RETI), along with important additional data inputs from The Nature Conservancy (Table 1). The full list of data sources appears in Table A-2 in the full report.

6 Wu GC, Torn MS, Williams JS. 2015. Incorporating Land-Use Requirements and Environmental Constraints in Low-Carbon Electricity Planning for California. Environmental Science and Technology 49: 2013–2021.

Figure 1: How the ORB model interacts with the RPS Calculator

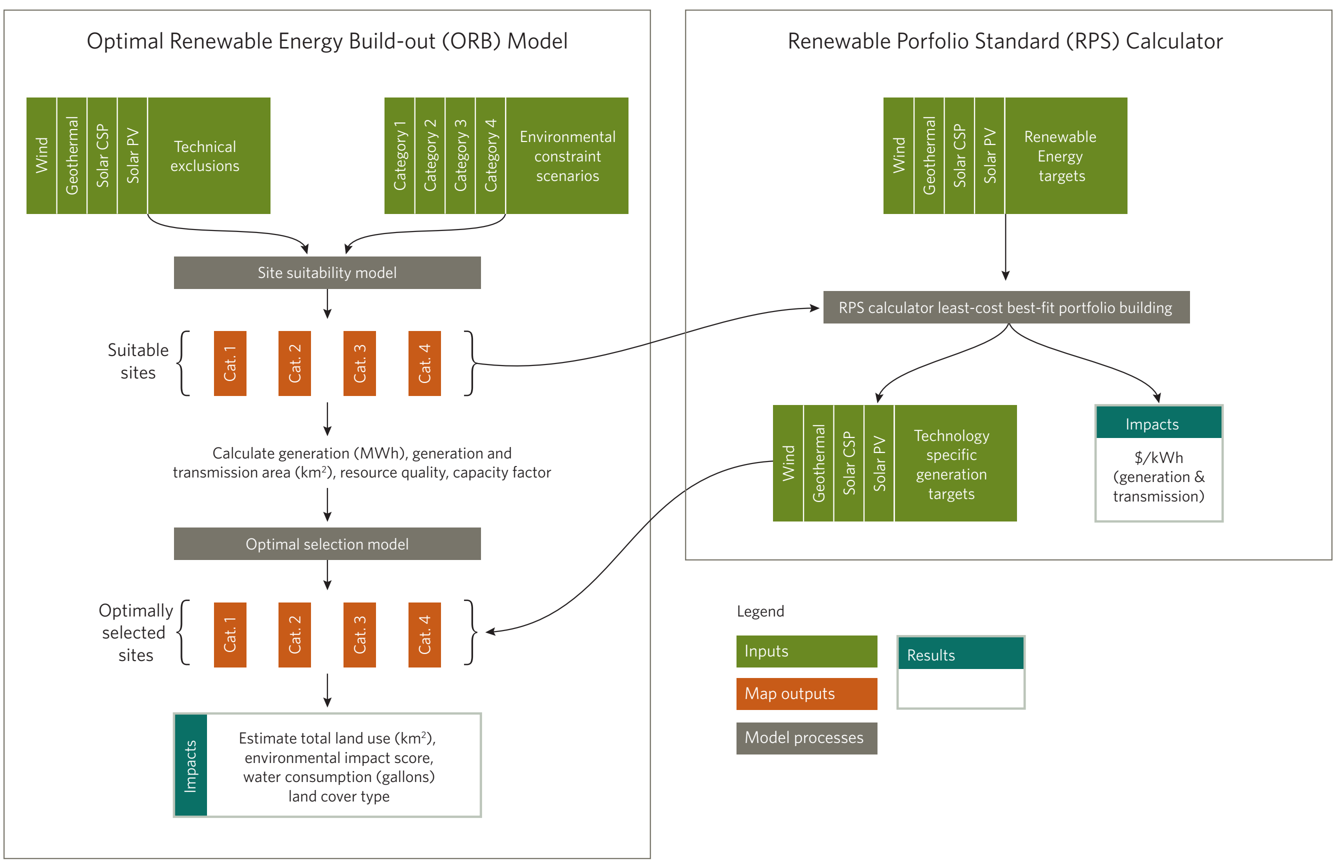


Table 1: Land categories and environmental exclusion levels used in the scenario analyses

Category	Definition	Examples
1	Lands with legal restrictions prohibiting energy development as identified in previous renewable energy planning efforts, including WREZ[6] and RETI[7].	National parks, national monuments, state wilderness areas, state forests, conservation and mitigation banks, wetlands and protected historical and cultural areas.
2	Lands with administrative and legal designations by public agencies in order to protect ecological and social values. Areas include "avoid" and "Category 2" areas identified in WREZ and RETI studies, respectively.	Multiple categories of designations for Bureau of Land Management (BLM) lands, including National Conservation Areas, Special Recreation Areas, Research Natural Areas and Wildlife Management Areas; state reserves; US Forest Service Research Natural Areas and Special Interest Areas; lands precluded from development under Habitat Conservation Plans (HCPs); habitat areas for threatened or endangered species.
3	Lands with ecological, economic or social value.	Several conservation organizations' priority conservation areas; Prime Farmland; lands proposed for designation as Wilderness, Los Angeles County Significant Ecological Areas; habitat for candidate or special-status species
4	Lands with broad-scale ecological value based on regional models and studies, including contiguous high quality suitable habitat and ecologically intact lands.	State-identified wildlife corridors; high quality contiguous habitat; Desert tortoise habitat identified by the US Fish and Wildlife Service; Audubon Society Important Bird Areas.

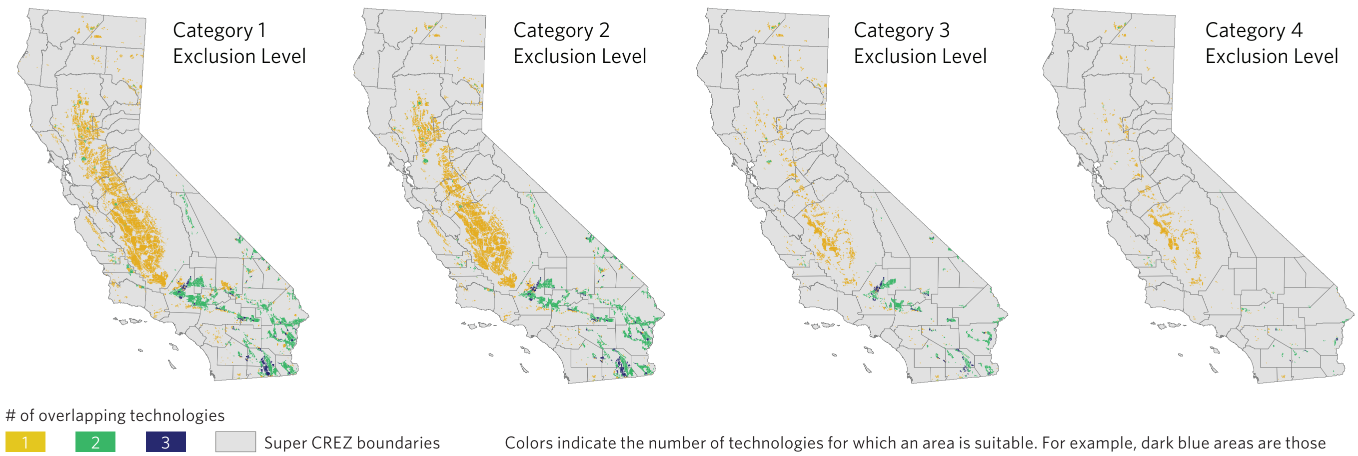
ORB Environmental Exclusion Level	Lands Excluded
Category 1 Exclusion Level	Category 1
Category 2 Exclusion Level	Categories 1 and 2
Category 3 Exclusion Level	Categories 1, 2 and 3
Category 4 Exclusion Level	Categories 1, 2, 3 and 4

In addition to these four categories, the ORB model excludes lands that are not suitable for utility-scale renewable energy development for physical, technical or socio-economic reasons, such as urban areas and lands with low resource potential, steep slope or high elevation. See the full report for a list of all criteria.

Lands that do not fall within areas covered by exclusion category 1, 2, 3 or 4 or the above suitability exclusions are considered to be suitable candidates for renewable energy development (Figure 2).

7 Black & Veatch Corp.; NREL. *Western Renewable Energy Zones, Phase 1: QRA Identification Technical Report*; NREL/SR-6A2-46877; Western Governor's Association, 2009.
8 California Public Utilities Commission [CPUC]. *Renewable Energy Transmission Initiative (RETI) Phase 1B*; 2009.

Figure 2: Each additional level of environmental exclusion further reduces the land area that may be developed for renewable energy.



Colors indicate the number of technologies for which an area is suitable. For example, dark blue areas are those that are suitable for any possible combination of three out of the four technologies (e.g., wind, solar PV, solar CSP). The maps show suitable sites for Category 1 exclusion level through Category 4 exclusion level.

Modeling Optimal Project Siting

The RPS Calculator generates aggregate renewable energy portfolios at the Super CREZ scale. It does not give higher-resolution spatial information about project siting.

The ORB model takes the output of the RPS Calculator and determines optimal siting, in contiguous development zones of 2 to 20 km^2, for all generation capacity in a portfolio. The optimization is based on maximizing resource quality and minimizing proximity to transmission, substations and roads.

Comprehensive location information for existing and commercial[9] renewable projects statewide is not available publicly, so the ORB model generates proxy locations for them. At Category 3 Exclusion Level (excluding land in Categories 1, 2 and 3) and Category 4 Exclusion Level (excluding Category 1-4 lands), there are not enough suitable sites in several Super CREZs to locate the existing and commercial generation capacity. In these cases, the model relaxes the environmental exclusion level in a given Super CREZ until it finds enough sites to place the existing and commercial projects. For instance, the 50% in-state portfolio generated at Category 4 Exclusion Level includes existing and commercial projects sited on Category 4 lands in eight Super CREZs and on both Category 3 and Category 4 lands in three Super CREZs.

9 "Commercial" projects are those that have a CPUC-approved power purchase agreement (PPA).

Impact Analysis

The ORB model uses the scenarios it generates on the potential size and location of the projects in a renewable energy portfolio to evaluate environmental impact in several ways:

- **Conservation impact:** For each portfolio, the model sums the total area of projects located in Category 2, 3 or 4 lands, indicating the extent of likely conservation conflict.
- **Water consumption:** The model estimates the water demand of each portfolio using published data on the water demand of each renewable generation technology.[10] The model reports aggregate water use as well as the water use by groundwater basin.
- **Pre-existing fragmentation of project lands:** The model calculates the weighted average housing density (households per km^2) of all project areas in each portfolio. Housing density is a proxy for landscape fragmentation; a portfolio with a high average housing density is likely to be less disruptive, on average, to intact landscapes than a portfolio with a low average housing density.
- **Potential land cover change due to project development:** The model maps the project areas in each portfolio against U.S. Geological Survey GAP land cover data to determine the total affected area for each land cover type.

10 Macknick J, Newmark R, Heath G, Hallet K. 2011. A Review of Operational Water Consumption and Withdrawal Factors for Electricity Generating Technologies. NREL/TP-6A20-50900. National Renewable Energy Laboratory, Golden CO.

Key Results

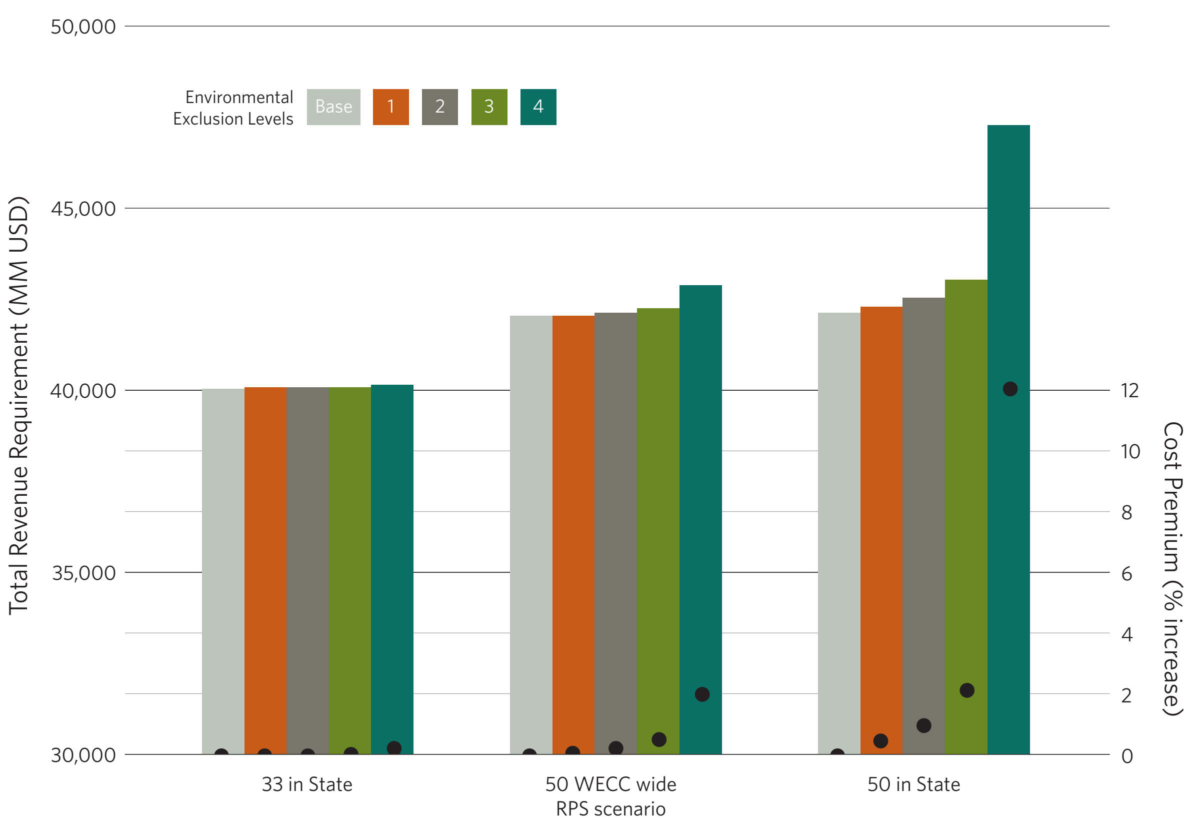
A 50% renewables portfolio with a low impact to important natural areas can be achieved at a cost premium of 2% or less.

In all but one scenario evaluated, avoiding sensitive environmental areas in the siting of future renewable energy projects increased electricity costs very modestly over the RPS Calculator base case. The study found a cost premium of 2% for the 50% in-state renewable portfolio at Category 3 Exclusion Level as well as for the 50% WECC-wide portfolio at Category 4 Exclusion Level (Figure 3).[11]

The cost premium was higher—12%—for the 50% in-state, Category 4 Exclusion Level scenario. In this case, the environmental constraints sharply limit new in-state wind projects, necessitating disproportionate build-out of solar technologies, which leads to solar energy curtailment; in particular, the Category 4 Exclusion Level scenario includes a large increase in CSP development.

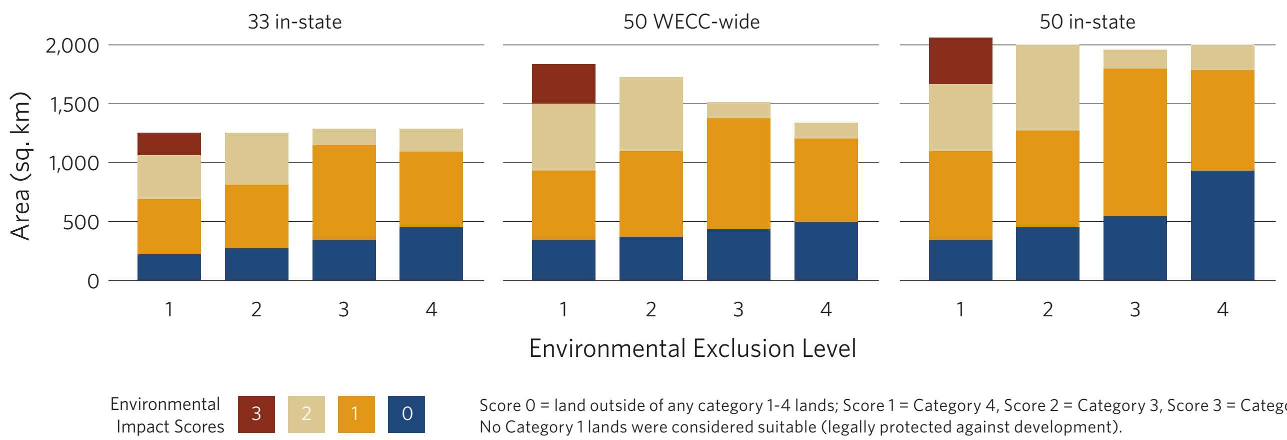
11 The estimate for the 50% WECC-wide portfolio includes the costs of both out-of-state and in-state generation and transmission.

Figure 3: The analysis suggests that avoiding natural areas would have a very modest impact on electricity prices under most build-out scenarios.



The bar plot corresponds to the primary (left) y-axis indicating the total revenue requirement (total electricity costs) of each RPS Calculator portfolio (note that the left y-axis begins at $30,000 MM USD). The x-axis shows each environmental exclusion level for each RPS target scenario—33% in-state, 50% WECC-wide, 50% in-state by 2030—in increasing order of in-state renewable energy generation. The secondary (right) y-axis and the scatterplot show the electricity cost premium (in percent increase) of imposing an environmental exclusion level above the base case. The RPS Calculator's environmental base case is the unmodified Calculator v6.0, which does not incorporate environmental exclusions developed in this present study.

Figure 4: At higher environmental exclusion levels, much less land with high conservation value is developed for wind, solar PV, solar CSP, and geothermal energy.



Score 0 = land outside of any category 1-4 lands; Score 1 = Category 4, Score 2 = Category 3, Score 3 = Category 2. No Category 1 lands were considered suitable (legally protected against development).

Overall environmental impact decreases sharply at higher exclusion levels

While environmental exclusions result in only a small increase in electricity costs, they yield a large reduction in environmental impact.

At the 50% in-state target, for instance, the Category 1 Exclusion Level portfolio contains 398 km^2 of projects on Category 2 land and 591 km^2 on Category 3 land, out of a total developed area of roughly 2,000 km^2 (Figure 4). By contrast, the Category 3 Exclusion Level portfolio includes no projects on Category 2 land and only 156 km^2 on Category 3 land[12], indicating a much-reduced risk of environmental conflict.

These figures illustrate what is at stake in planning for California's renewable energy future. Renewable energy planning tools that optimize for energy resource quality and distance to transmission and roads—and do not account explicitly for environmental values—will tend to place a great deal of new infrastructure on environmentally sensitive lands.

Environmental exclusions shift the location of renewable energy development and the land-cover types impacted.

In the 50% in-state and WECC-wide scenarios, environmental exclusions drive several notable shifts in modeled future renewable energy development patterns. In both instances, at Category 4 Exclusion Level, Sacramento Valley wind generation decreases, replaced by either PV and CSP (for the in-state case) or out-of-state wind (for the WECC-wide case). For the in-state case, the larger modeled PV generation capacity consists largely of new projects in the Central Valley. A high level of environmental exclusion tends to push solar development north, away from the southern deserts.

Environmental exclusions drive development onto already-fragmented landscapes.

For the 50% in-state case, increasing the environmental exclusion level from 1 to 4 increases the average housing density of lands in the vicinity of renewable energy projects from 2.2 to 4.3 homes per km^2, suggesting that development is shifted away from relatively pristine areas onto landscapes with more fragmentation. This result underscores the importance of collaboration with local communities for determining level of conflict for development.

12 Representing existing and commercial projects on Category 3 lands.

Recommendations

Conservation of California's landscapes provides wildlife habitat, improves air and water quality, stores carbon, supports jobs and provides other economic and societal benefits. As this study shows, the goals of expanding renewable energy development and protecting natural landscapes are not mutually exclusive, given the appropriate planning and policy framework.

The following recommendations for policymakers identify actions to achieve these dual goals:

- *Expand collaboration between the state's energy and natural resource agencies as California plans for increased penetration of renewables.* Cooperation will be essential if the state is to achieve the goals of reducing carbon pollution, expanding renewable energy and protecting natural resources.
- *Make the protection of natural resources a central objective of the long term planning necessary to achieve a low carbon resource portfolio to meet California's energy needs.* Land conservation values must be integrated into the state's long-term planning for renewable energy generation, including procurement and transmission, to guide development to less environmentally sensitive areas and avoid costs to developers and taxpayers associated with environmental risk. These process improvements should be informed by landscape-scale planning for renewable energy and biodiversity conservation.
- *Expand landscape-scale planning for renewable energy and biodiversity conservation.* To reduce the potential for conflict between renewable energy development and natural resource protection goals, extend stakeholder-based planning processes to all areas of the state where renewable energy development is likely.

Kelso Dunes in Mojave National Preserve, California. © Dave Lauridsen for The Nature Conservancy