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Siting solar energy development to minimize biological impacts

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ABSTRACT

After solar and other renewable energy developers select generally suitable sites for exploration, they frequently encounter conflict over biodiversity conservation values that were not factored into the initial suitability rating methods. This paper presents a spatial multicriteria analysis method for modeling risk of conflict with biological resources and applies the model in the California deserts where such conflicts are rapidly rising. The premise of the model is that the least conflict will occur on sites that are the most ecologically degraded with low conservation value and that would engender low off-site impacts when connecting to existing transmission infrastructure. Model results suggest sufficient compatible land exists in flat, non-urban areas to meet state solar energy targets of 8.7 GW of installed capacity in the California deserts for 2040. The model is a promising tool to fill the gap between site suitability analysis for renewable energy and regional biodiversity conservation planning to identify areas where rapid impact assessment and permitting will generate the least regrets.

1. Introduction

Areas of high solar energy potential are often in fragile ecosystems that are easily disturbed and hard to restore. The best way to minimize environmental impacts in accordance with the mitigation hierarchy of the US National Environmental Policy Act is to avoid sites where impacts are likely to be unacceptably high. Great interest in utility-scale solar energy development in the deserts of the southwestern U.S. has created an urgent need for regional conservation planning to map and protect areas of high conservation value [1–3]. However, this planning approach requires time-consuming collection, compilation and analysis of biological data. In the interim, it makes sense to quickly map sites that stakeholders can agree have low potential conservation value and thereby avoid unnecessary conflicts and delays in the review and permitting process.

Such mapping builds on the long tradition of land suitability analysis based on spatial multicriteria analysis. Its application for renewable energy is more recent, however [4–6]. Geographic information systems (GIS) have been used to model spatial patterns of suitability and constraints for development of solar [6–8], wind [6,9,10], and wave or tidal [11,12] resources. Two basic approaches have been used. Some studies used Boolean logic to exclude lands based on "hard constraints" where development is legally prohibited (e.g., parks) or operationally infeasible (e.g., greater than a threshold distance from roads and transmission lines) [4]. Other studies combined values of energy potential with those of technical and environmental factors to derive an overall suitability score [5,6,8,9]. Known biological constraints such as designated critical habitat for endangered species can be incorporated in this approach. Outside of these constrained areas, however, the potential for conflict with biological resources is highly uncertain, ranging from most compatible to most potential conflict. Energy developers, permitting agencies, and conservation interests would all benefit from information to reduce this uncertainty, particularly for identifying the most compatible or "no regrets" sites [3].

To help fill this need, this paper presents an alternative approach based on modeling the relative likelihood that a site will not incur substantial impacts on biological resources from renewable energy development. We refer to this metric as a *Compatibility Index*. Developing projects on low compatibility lands increases the risk of loss of conservation values and the risk that solar developers would face stiff opposition from conservation interests or high mitigation costs. Although the two forms of risk are perceived from opposite perspectives, both share a similar measurement of the potential for conflict [13]. We have chosen the term "compatibility" or the absence of conflict, to highlight the potential for meeting renewable energy objectives without unacceptable loss of biological resources.

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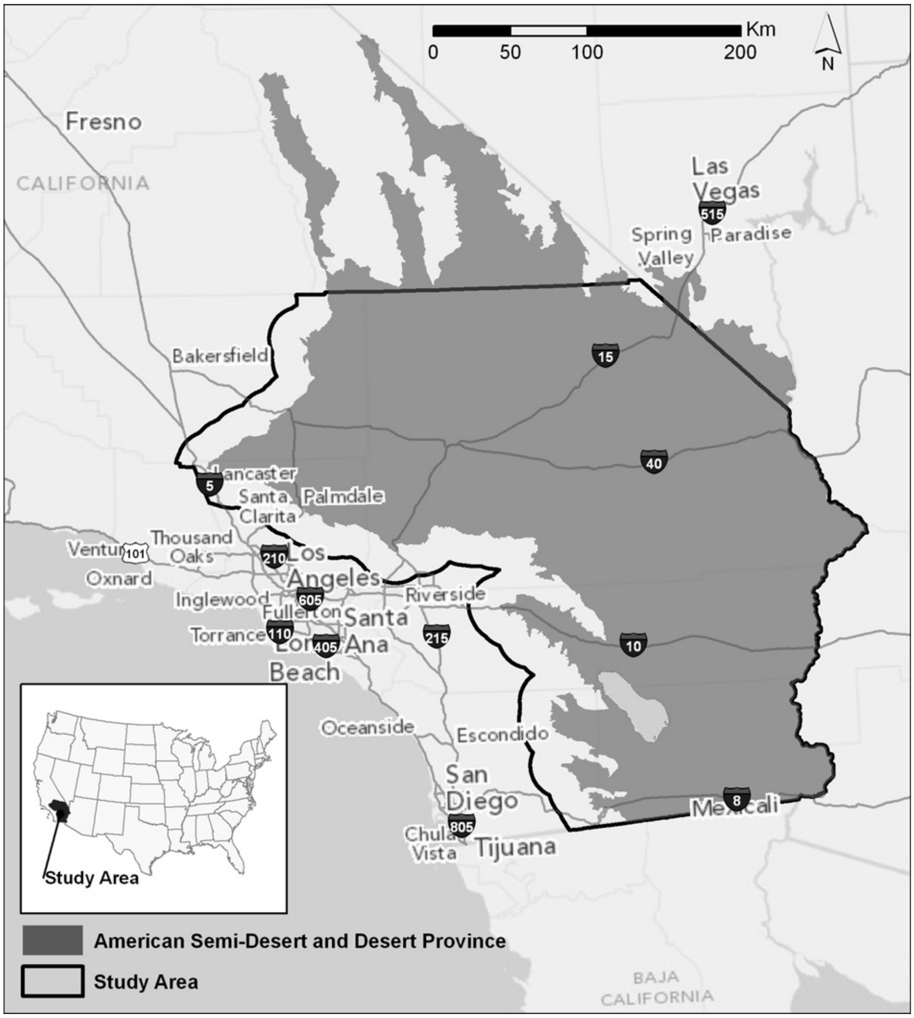

Fig. 1. Location map of American Semi-Desert and Desert Province and the study area in southeastern California.

The paper lays out the logic and assumptions of the model, and implements it for the California deserts. The model is not a complete assessment of suitability for solar energy development. However, this model can be used by developers in conjunction with models of other constraints and opportunities in order to make comprehensive siting decisions. The model is also not a comprehensive assessment of biological conservation value but provides a landscape level overview of areas that are unlikely to have high value. To illustrate the utility of the model, we answer two research questions: What areas in the region could be considered most compatible with conservation of biological resources? What is the total area of the most compatible sites relative to projected need?

2. Methods

2.1. Study area description

The American Semi-Desert and Desert province (#322; [14]) in the southwestern United States is endowed with excellent solar insolation, averaging 6.5 kWh m^{-2} day^{-1} (National Renewable Energy Laboratory, http://www.nrel.gov/gis/). The average for the conterminous 48 states is only 5.1 kWh m^{-2} day^{-1}. The topography includes extensive plains between rocky mountain ranges. The vegetation is very sparse, dominated by shrubs such as creosote bush (*Larrea tridentata*) and burrobush (*Ambrosia dumosa*). The region is relatively unencumbered by land uses that would preclude solar energy development.

State and federal laws and policies to increase low-carbon energy production have spurred a flurry of permit applications from solar energy developers in this region. The agencies charged with issuing permits have been hard-pressed to keep up with the workload [2]. At the federal level, the Bureau of Land Management (BLM) and the Department of Energy (DOE) are conducting a study to designate desirable “solar energy zones” (SEZ) for fast-tracking solar energy permitting on lands managed by BLM [2]. Agencies are also planning for transmission corridors to support the anticipated development [15].

The presence of many sensitive species, ecological processes and natural communities in this region, has made the siting of large-scale renewable energy development challenging. Within California, a group of stakeholders—agencies, energy companies, and conservation groups—are developing the Desert Renewable Energy Conservation Plan (DRECP) to protect areas of highest conservation value and to mitigate impacts from renewable energy development projects on species and habitats in areas designated for energy development [16]. The California Energy Commission estimates that 25,000 ha of utility-scale solar projects will be required in the DRECP area with 8.7 GW of installed capacity to achieve 2040 greenhouse gas reduction goals [17]. The Energy Commission assumed that 42% of this capacity would be for solar thermal