Cumulative Impacts of Large-scale Renewable Energy Development in the West Mojave

Effects on habitat quality, physical movement of species, and gene flow.

A Group Project submitted in partial satisfaction of the requirements for the degree of Master of Environmental Science and Management at the Donald Bren School of Environmental Science and Management

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Executive Summary

Climate change is considered as one of the greatest environmental challenges of our time. To help combat climate change and its associated risks, the United States is looking toward renewable energy as a viable alternative to fossil fuel energy sources. To help slow our contribution to climate change, California’s Governor has issued an executive order requiring one-third of statewide electricity production to come from renewable sources by 2020. In order to fulfill these unprecedented goals, developers are looking beyond distributed generation and small scale energy plants to large-scale wind and solar developments.

With its large, windy, open expanses, perpetually sunny days, and general lack of development, the West Mojave has quickly become the focus of in-state renewable energy planning. However, large-scale renewable energy development has ecological consequences of its own.

1.1. Project Significance

The purpose of this project is to examine the cumulative effects on habitat fragmentation, species movement and gene flow in the West Mojave, given specific scenarios of large-scale renewable energy development in the region. As we turn to large-scale solar and wind farms to satisfy our growing need for renewable energy, we must consider the impacts these projects can have to the immediate landscape as well as to ecological processes. The West Mojave contains some of the most pristine areas in California, and is home to more than 20 endangered or threatened species (CDFG 2009a) and several flagship species, including the desert tortoise (Gopherus agassizii) and the bighorn sheep (Ovis Canadensis nelsoni). Although individual project permitting and regional conservation planning efforts evaluate certain aspects of the environmental impacts of such projects, rarely do these avenues evaluate the cumulative impacts of a network of multiple projects.

1.2. Establishing Development Scenarios

This project calculated that California is expected to demand an additional 50,000 to 286,000 GWh of renewable energy in 2050. To meet these demands, providers have submitted numerous applications to the California Energy Commission and Bureau of Land Management (BLM) California Desert District to build solar and wind projects in the West Mojave region (BLM 2008). The applications range from 50 to 2,500 Megawatts each, and together would cover more than one million acres in the region (BLM 2009).

Because it is hard to predict exactly how many large-scale renewable energy developments will actually be built in the West Mojave, we began by creating two renewable energy development scenarios to bracket the minimum and maximum expected renewable energy demand in 2050. The California Energy Commission
created the Renewable Energy Transmission Initiative (RETI) to determine where transmission lines to reach large-scale renewable energy developments must be built. RETI identified over 2,150 potential, proposed, or planned energy projects throughout the state of California and grouped them into Competitive Renewable Energy Zones (CREZs). Each CREZ can contain wind, solar, and geothermal projects, and there are 29 CREZs throughout the state of California. Eighteen zones exist either partially or wholly within the West Mojave study region. To satisfy the low predicted demand, the analysis assumed that six of the CREZs within the West Mojave – those which RETI identified as the most economically and environmentally viable – would be built. To satisfy the high predicted demand, the analysis assumed all eighteen zones within the study region would be developed.

In order to isolate the effects of renewable energy versus other development and change that will occur by 2050, all of the modeling done in this analysis was conducted on four scenarios.

- The **Present Scenario** reflects current vegetation types, present urban development, roads, and other infrastructure such as dams, aqueducts and canals.
- The **Future Baseline Scenario** reflects the features of the Present Scenario, but also incorporates additional urban development projected to 2050, and a simple climate change model of a 2°C temperature rise.
- The **Low Renewable Energy Development Scenario** ("Low Scenario") reflects the Future Baseline Scenario with the addition of six CREZs in the western reaches of the study area.
- The **High Renewable Energy Development Scenario** ("High Scenario") reflects the Future Baseline Scenario with the addition of all eighteen CREZs throughout the study area.

### 1.3. Connectivity Analysis

A connectivity analysis is useful to quantify how large-scale renewable energy development and associated infrastructure may cause barriers to species movement and gene flow. Generally, connectivity refers to the degree to which a landscape allows for the flow of organisms among habitat patches and populations, and it is imperative for both species survival and biodiversity. Individuals must be able to move between habitat patches to meet their resource needs, while populations must be connected to allow for dispersal, gene flow, and re-colonization (Bennet 2003); when populations are isolated, they become susceptible to inbreeding depression and are less able to adapt to varying environmental conditions like climate change (Frankham 2005).

This analysis employed a software program called Circuitscape to conduct a connectivity analysis for two flagship species of the Mojave Region: the desert tortoise and the desert bighorn sheep. Circuitscape uses circuit theory to predict connectivity by connecting populations to each other through the landscape, which acts as a circuit of varying conductance. The results highlight potential pathways that organisms might take
to travel between populations and critical habitat areas given the conductance of the surrounding habitat.

1.3.1. Habitat Fragmentation Analysis

This analysis employed a software program called Fragstats to analyze landscape fragmentation and quantify changes to total desert tortoise critical habitat, bighorn sheep core habitat, and to specific habitats important for species movement across all scenarios. The Fragstats analysis shows that the total core habitat area decreases for all scenarios and for both species. The Fragstats analysis reinforces the fact that renewable energy development can decrease essential habitat.

1.3.2. Desert Tortoise Connectivity

The desert tortoise is found in the Mojave and is widely distributed in a variety of desert habitats, especially creosote scrub (USFWS 2008). Habitat fragmentation and barriers to movement can severely limit desert tortoise populations (Edwards et al. 2004). Although their historic habitat was relatively continuous in the West Mojave (Hagerty 2008), it is becoming more fragmented in the face of increased development and urbanization. Highways are specifically problematic due to the increased likelihood of fatal incidents with motor vehicles (Boarman et al. 1997). In fact, highways can depress desert tortoise population density as far as 400m away (Boarman and Sazaki 2006).

This analysis modeled connectivity pathways between eight desert tortoise critical habitats as designated by the 1994 Desert Tortoise Recovery Plan. The analysis indicates that there is a slight shift in desert tortoise movement patterns from the Present to Future Baseline Scenarios, likely due mostly to the modeled climate change. In the Low Scenario, the large-scale renewable energy development has relatively little impact on the connectivity of the desert tortoise; because the developments occur mainly to the west of the desert tortoise critical habitats, they do not significantly block tortoise movement. Interestingly, however, a number of project developments overlap with the western critical habitats. Although these developments may not affect tortoise connectivity to a large degree, they may compound habitat loss issues. Many of the CREZs in the High Renewable Energy Development Scenario are planned for areas important for tortoise connectivity and within desert tortoise critical habitats. Scattered CREZs surrounding critical habitats impeded tortoise movement to and from those habitats.
1.3.3. Desert Bighorn Sheep Connectivity

In the West Mojave, desert bighorn sheep exist in 69 small, distinct populations, each of which depends on migrants from other populations to maintain genetic diversity. Thus, bighorn sheep exist as a meta-population, and the individual populations and the habitat connecting them are highly important. Should one population become isolated or decline, every population is at a greater risk of extinction.

This analysis modeled connectivity between all 69 sheep populations, and conducted a more detailed analysis on a subset of eight populations. Bighorn sheep movement patterns between the Present and Future Baseline scenario for the eight populations are similar, although many pathways are constrained to higher elevations due to climate change. The connectivity analysis indicates that proposed future large-scale renewable energy development, especially in the High Scenario, obstructs major pathways for movement, such as the pathways between the southwest and northeast Mojave Desert.

Quantitative outputs from the Circuitscape connectivity model were combined with population genetic data to predict migration rates between bighorn sheep populations. Migration rates between all populations decrease from the Present to all three future scenarios. Specifically, migration rates between the San Gabriel Mountains population, the largest in the region, and populations in the northeast are significantly impacted. In the High Scenario, the migration rates between these populations decrease to near or below one migrant per generation, the minimum migration rate necessary to maintain adequate gene flow to prevent genetic isolation (Mills and Allendorf 1996). Cumulatively, large-scale renewable energy development could significantly impact gene flow between many other sheep populations as well, decreasing the viability of the entire metapopulation of desert bighorn sheep in the West Mojave.

1.4. Recommendations for Renewable Energy Development Planners

The team identified a number of federal and regional planning processes that can benefit from this type of analysis. Federal processes include the Western Regional Energy Zone initiative Phase 1 renewable energy zone identification process and Phase 2 transmission planning, as well as the BLM application streamlining process, which are all in early stages and can benefit from studies such as these, which can provide useful data and methods to evaluate connectivity concerns. The team also recommends that the BLM work with other land holding natural resource agencies to maintain connectivity between publicly owned areas of ecological significance.

State processes include the Renewable Energy Action Team planning process, which should work to address connectivity specifically and include connectivity concerns in their Best Management Practices. The nearly complete Renewable Energy Transmission Initiative (RETI) Phase 2 transmission planning should address some of the connectivity concerns identified by these studies (where applicable, given the expedited timeframe). Given these analyses, RETI could also consider re-analyzing the environmental impacts of specific problematic CREZs.
1.5. **Recommendations for Conservation Organizations**

Conservation organizations can help preserve connectivity in the West Mojave by actively participating in the planning processes above in order to provide expertise for analyses similar to this one, and perhaps recreate and expand upon our research. Possibilities include evaluating additional species and incorporating different development scenarios. Using some of the data provided by this report, conservation organizations can collaborate with agencies to identify and ensure the conservation and proper management of public holdings encompassing important connectivity areas, as well as identify private holdings that might be targeted for easements or acquisition to better ensure the conservation of connectivity in the West Mojave.