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Landscape-scale wildlife species richness metrics to inform wind and solar energy facility siting: An Arizona case study

Kathryn A. Thomas[a,*], Christopher J. Jarchow[a], Terence R. Arundel[b], Pankaj Jamwal[a,1], Amanda Borens[a], Charles A. Drost[b]

[a] US Geological Survey Southwest Biological Science Center, N. Park St. Suite 221, Tucson, AZ 85719, USA
[b] US Geological Survey Southwest Biological Science Center, 2255N. Gemini Drive, Flagstaff, AZ 86001, USA

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ABSTRACT

The juxtaposition of wildlife and wind or solar energy facility infrastructure can present problems for developers, planners, policy makers, and management agencies. Guidance on siting of these renewable energy facilities may help identify potential wildlife-facility conflicts with species of regulatory or economic concern. However, existing spatial guidance usually does not consider all wildlife that might use a potential facility location or corridors for its servicing infrastructure. We illustrate an approach toward assessing potential wildlife-facility conflicts using readily available vertebrate habitat models. The U.S. Geological Survey's Gap Analysis Program (GAP) has developed spatial models of potential habitat for vertebrate species across the entire nation. To illustrate their applicability, we used GAP models to estimate richness of all native, terrestrial vertebrates within Arizona and for those vertebrates grouped by class or by sensitivity to the type of facility infrastructure. We examined the spatial overlap of high species richness of each group with agency-developed guidance used to inform facility-siting decisions and found that GAP-based richness mappings augmented existing guidance. As the GAP vertebrate habitat models are publicly available for the entire USA, use of these data can provide a coarse view of potential wildlife-facility conflicts and inform facility planning early in the process.

1. Introduction

In the western USA, the juxtaposition of wind and solar facility infrastructure with wildlife habitat has created concerns toward damage to wildlife species, degradation of their habitats (Lovich and Ennen, 2011; Mangun and Mangun, 2016; Moore-O'Leary et al., 2017) and for ease of facility siting, permitting, and operations (DeMarchis, 2010; Kahn, 2000; McIntyre and Duane, 2011). Renewable energy development is expected to continue expanding into the future with forecasts showing global demand for energy to increase up to 50% by 2030 (Naugle and Copeland, 2011) and with a predicted conversion of 100,000–200,000 km^2 of land toward renewable energy production in the USA by 2035 (McDonald et al., 2009; Northrup and Wittemyer, 2013). The western USA, where large expanses of public land occur, is particularly suitable for expansion of wind and solar energy operations. Estimates of wildlife habitat already affected just by wind energy development in western North America range from 14,000 to 56,000 km^2 (Lovich and Ennen, 2013). Encroachment into wildlife habitat and the accompanying potential for conflict between facility infrastructure and operations and wildlife is expected to increase. Federal, state, and local agencies managing habitat and wildlife look to avoid, minimize, or mitigate these conflicts and energy planners seek efficiency during siting studies through early identification of potential conflicts (Allison et al., 2014; Stoms et al., 2013).

Lovich and Ennen (2011, 2013) reviewed the types of impacts wind and solar energy infrastructure can pose to wildlife during the full life cycle of a facility. These impacts include habitat degradation or destruction, landscape fragmentation, and direct stress, injury or mortality of species. Wildlife must deal with increased noise, dust, and light pollution; electromagnetic effects; increased potential of fire; changes in microclimate; and, potentially increased risk of predation. Impact varies by species morphology, behavior, and phenology (Marques et al., 2014; Schuster, 2015) and by the species sensitivity to particular types of infrastructure. Collective impacts on wildlife may result in losses of local populations and declines in species abundance at a facility and surrounding areas (Lovich and Ennen, 2013).

Abbreviations: AZGFD, Arizona Game and Fish Department; BLM, Bureau of Land Management; CHAT, Crucial Habitat Assessment Tool; GAP, National Gap Analysis Program; GIS, Geographic Information System; SHCG, Species and Habitat Conservation Guide

* Corresponding author.
E-mail address: Kathryn_a_thomas@usgs.gov (K.A. Thomas).
[1] Pima County, Information Technology Department, 33 N. Stone Ave., Tucson, AZ 85701, USA.

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Perhaps the most robust data on wildlife interactions with renewable energy facilities are available for bats and birds. Wind turbines often causes direct mortality when birds collide with the turbine blades. Estimates of annual fatality are as high as 888,000 and 573,000 deaths per year for bats and birds, respectively, among 51,630 MW of wind facilities in the USA (Smallwood, 2013). Within this estimate were 83,000 deaths of raptors, including federally protected eagles. Higher mortality rates occur where turbines intersect avian and bat migratory pathways and this is of concern especially for birds with lower recruitment rates, such as raptors (Kuvlesky et al., 2007). For bats, tree-dwelling and migratory species are at greatest risk of mortality from wind turbines (Kuvlesky et al., 2007). Physical contact with turbines is not necessary for mortality as bats can also die from internal hemorrhaging as result of barotrauma, the sharp reduction of air-pressure near operating turbine blades (Baerwald et al., 2008).

Road networks servicing facility development also pose risks to a variety of species through collision with vehicles (e.g., Lovich et al., 2011) and, especially for birds, increased risk of electrocution from adjacent transmission lines (Kuvlesky et al., 2007; Marques et al., 2014). Roads can also reduce habitat quality by serving as a conduit for invasive plant encroachment and disrupting wildlife corridors, leading to reduced gene flow (Kuvlesky et al., 2007; Northrup and Wittemyer, 2013; Vandergast et al., 2013).

Siting of a wind or solar energy facility is contingent upon many factors, with wind and sunlight resource availability being a primary consideration; however, wildlife considerations strongly influence the permitting process (Kahn, 2000). Permitting for facility development on U.S. public lands is under federal and state agency purview. In the western U.S., the bulk of federal land is under the jurisdiction of the Bureau of Land Management (BLM) and to a lesser extent the U.S. Forest Service. Application for wind or solar energy facility permitting initiates review under the National Environmental Policy Act (NEPA; McIntyre and Duane, 2011). Review includes compliance with the Endangered Species Act (ESA) as determined by the U.S. Fish and Wildlife Service (USFWS) as well as compliance with a number of other land laws and resource and land use planning guidelines at the federal, state, and local levels (McIntyre and Duane, 2011). Species listed as threatened or endangered are a primary focus of the USFWS, but wildlife habitat is of consideration in the entire permitting process. For example, the Federal Land Policy and Management Act of 1976 (FLPMA) directs the BLM to ensure that wildlife habitat is protected and damage to habitat is minimized when approving a permit right-of-way (McIntyre and Duane, 2011).

Various studies have pointed out the utility of siting guidelines as an aid toward avoiding or minimizing damage to species and wildlife habitat during the early planning stage (Kuvlesky et al., 2007; Schuster et al., 2015). As a first step, the USFWS (2012) recommends an evaluation of potential facility locations at the landscape scale. Early consultation is advocated with developers and land managers and with regulatory agencies to proactively identify locations important to wildlife (Köppel et al., 2014; Naugle and Copeland, 2011), which includes the development and use of sensitivity maps for endangered species or species of concern (Marques et al., 2014); tools for mitigation recommendations based on expert estimates of species richness of sensitive plants and animals to (Kreitler et al., 2015; Moilanen, 2013); and identification of lands with low conservation value to minimize impacts to higher value lands for wildlife (Cameron et al., 2012; Hernandez et al., 2015; Stoms et al., 2013).

In the western USA, the Western Governors Association established the Western Governors' Wildlife Council and authorized the development of an online tool that displays priority wildlife habitat as a guide for project planning. The Crucial Habitat Assessment Tool (CHAT; State Wildlife Agencies of the Western United States, 2017) shows mapped priorities for wildlife habitat with the intent of providing siting guidance for energy projects (Mangun and Mangun, 2016). The wildlife habitat priorities were developed and contributed to CHAT by each of 16 contributing western states. The BLM in 2011 identified CHAT as one of the state and regional level data sources for use in their planning and management activities, pursuant to the signing of a memorandum of understanding between the Western Governors Association and the Department of Interior in 2009 to use the decision support tools established by the council (BLM, 2011; Western Governors Association, 2009).

As suggested by Lovich and Ennen (2011), publicly available geospatial data provide a readily available resource for identifying potential conflicts between wildlife and facility siting and operation. Species richness metrics, such as alpha (total species) richness, which provide an estimate of the magnitude of potential wildlife use of an area, have been used in conservation planning (Fleishman et al., 2006) and can provide estimates of the relative magnitude of wildlife usage of an area. The US Geological Survey National Gap Analysis Program's (GAP) production of vertebrate potential habitat models for wildlife across the nation (Gergely and McKerrow, 2013; USGS-GAP, 2014) is a source of data to develop metrics and mappings of species richness at a landscape scale. To illustrate development of landscape-scale richness metrics and mapping, we used GAP wildlife habitat models to calculate an estimate of alpha richness of wildlife across the state of Arizona. In Arizona, both wind and solar energy development are supported. In addition, under state law all native wildlife are given a level of protection (AZGFD, 2010, 2012a). We mapped the distribution of high species richness for a composite of all native terrestrial vertebrates for which GAP models were available and for groupings of these vertebrates by their particular sensitivities to wind or solar facility siting and operations. We compared the areas indicated as potentially supporting high wildlife species richness with spatial planning guidance developed by an Arizona state agency and by a federal agency (BLM) to illustrate how the wildlife richness metrics provide additional, augmentative information to aid early planning in renewable energy development.

2. Methods

We used existing spatial data, as described below. We projected all input data layers to NAD1983 UTM Zone 12 and spatially aligned each layer to contiguous 30 m resolution grid cells within the Arizona state boundary. Spatial data processing and analysis were conducted in ArcGIS 10.1 and 10.2 (Environmental Systems Research Institute, Redlands, California).

2.1. Vertebrate habitat data

The GAP vertebrate models represent habitats that are suitable for wildlife species across the United States, with each species represented by a unique spatial model. As the models predict suitable habitat, they represent the potential for species occupancy only. Each model is based on habitat-association descriptions derived from published literature for the species under consideration. GAP applied the habitat-association descriptions to spatial data (GIS rasters) for vegetation (ecological systems) and elevation, hydrology, land use, and edge or patch characteristics, as appropriate to the species, to create a spatial model of potential habitat for over 2000 species (USGS-GAP, 2013). Specific parameters for each species model are available online (National Gap Analysis Program Species Viewer, 2017) within the model report for each species. Iindividual species models (indicated as distribution models online) are available for download as rasters at 30-meter resolution.

Using a list provided by the Arizona Game and Fish Department (AZGFD) of terrestrial vertebrate species native to Arizona, we obtained GAP habitat models for the native terrestrial reptile, bird, and mammal species in the state. At the time of our analysis, GAP had developed only six models for amphibians occurring in Arizona; hence, we used amphibian habitat models developed by the Southwest Regional Gap Analysis Project (SWReGAP, 2017). The SWReGAP models also