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Potential Impacts of Energy Development on Shrublands in Western North America

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ABSTRACT

Impending rapid development of the abundant energy resources found in western North America may have dramatic consequences for its terrestrial ecosystems. We used lease and license data to provide an approximate estimate of direct and indirect potential impacts from renewable and non-renewable energy development on each of five major terrestrial ecosystems and completed more detailed analyses for shrubland ecosystems. We found that energy development could impact up to 21 percent (96 million ha) of the five major ecosystems in western North America. The highest overall predicted impacts as a percent of the ecosystem type are to boreal forest (23-32 percent), shrublands (6-24 percent), and grasslands (9-21 percent). In absolute terms, the largest potential impacts are to shrublands (9.9 to 41.1 million ha). Oil, gas, wind, solar, and geothermal development each have their greatest potential impacts on shrublands. The impacts to shrublands occur in all ecological regions across western North America, but potential impacts are greatest in the North American Deserts (up to 27 percent or 25.8 million ha), Great Plains (up to 24 percent or 8.9 million ha), and Northern Forests (up to 47 percent or 4.3 million ha). Conventional oil and gas development accounts for the largest proportion of the potential impact in all three of these regions. Some states or provinces may experience particularly large impacts to shrublands, including Alberta and Wyoming, where potential for oil and gas development is especially high, and New Mexico, where solar development could potentially affect large areas of shrubland. Understanding the scale of anticipated impacts to these ecosystems through this type of coarse-scale analysis may help to catalyze policy makers to engage in proactive planning.

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INTRODUCTION

World demand for energy is projected to increase by 50 percent between 2007 and 2030 (International Energy Agency 2007). This impending rapid development of energy resources may have dramatic consequences for terrestrial ecosystems and wildlife of western North America, because this region is rich in hydrocarbons and has high potential for renewable energy production. Hydrocarbons will remain the largest source of energy worldwide with oil, natural gas, and coal meeting 85 percent of this demand (International Energy Agency 2007). Increasing political uncertainty in many oil-producing nations has prompted accelerating exploitation of North American energy resources, and growing recognition of the potential social and biological ramifications of climate change is driving trends toward increasing development of reduced carbon or carbon-neutral energy sources such as solar, wind, nuclear, and geothermal power (Brooke 2008). The increasing demand for energy and the West's abundant supply nearly ensures these resources will be developed. If development continues at its current pace, the outcome will likely be "energy sprawl" (McDonald and others 2009), resulting in a western landscape increasingly fragmented by energy infrastructure such as roads, well pads, wind towers, and transmission lines.

Despite growing concerns regarding environmental impacts of energy sprawl, until recently the scope of the cumulative impacts on ecosystems was largely unknown. A recent study measured the potential impacts of major energy sources on terrestrial ecosystems in western North America (Copeland and others in press). Here we summarize the results of Copeland and others (in press) and describe the potential impacts on shrublands, the ecosystem projected to experience the greatest absolute impacts from potential energy development. We describe the energy resources impacting shrublands and the ecological divisions and states or provinces in which shrublands may experience the greatest impacts.

METHODS

We measured potential terrestrial impacts of major hydrocarbon and renewable energy sources across North America (figure 1), including oil and gas, oil shale, oil sands, coal, wind, solar, geothermal, and nuclear (measured as uranium). We did not consider hydropower or biofuels, as those impacts are largely aquatic or the terrestrial impacts have already occurred. More details about the geography and production efficiency for each of these major energy sources can be found in Copeland and others (2011).

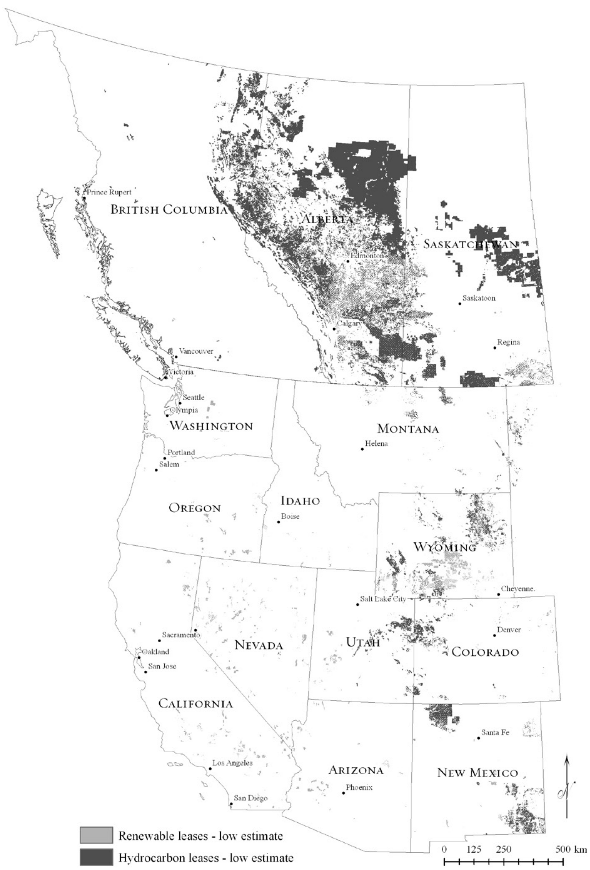

Figure 1. The distribution of leases for renewable and hydrocarbon energy resources across the western North America study area. Renewable leases are displayed over top of hydrocarbon leases, so not all hydrocarbon leases may be shown.

We measured current and potential energy impacts using July 2009 lease and license data from the U.S. National Integrated Lands System database (http: //www.geocommunicator.gov), Saskatchewan Mineral Disposition Maps and Databases, Alberta Energy, and British Columbia Ministry of Energy and Mines. For conventional oil and gas development, we determined a low estimate of impact using only leases with currently producing oil and gas wells (IHS incorporated, www.ihsenergy.com) and a high estimate that included all leases. Wind lease data for Canada were unavailable, so we used existing projects to estimate minimum or low impacts (Ventyx Energy 2009). Each wind project point was expanded to represent the land area impacted based on the power production of the project, assuming an impact of 20 ha per MW (US Department of Energy 2008a). We also calculated the footprint of proposed renewable energy zones for wind and solar energy development (Western Governors' Association 2009) to provide a high estimate of the amount of land that may be affected. Although development would not be restricted to these zones, nor would development likely impact the zones entirely, the zones do provide a coarse-scale estimate of the amount of land area that could be affected. Lease data provide an estimate of landscape-scale impacts, including direct and indirect potential future impacts. These datasets were limited to public lands or public subsurface minerals holdings, with the exception of the high estimate for wind and solar development, which incorporated private lands.

We estimated the footprint of energy development on each of five terrestrial ecosystem types: temperate forests, boreal forests, shrublands, grasslands, and wetlands (MEDIAS-France/Postel 2004; ESRI 2006). For shrublands (figure 2), we measured the potential impact of each type of energy development and the amount of shrubland impacted within each ecological division (figure 3, Commission for Environmental Cooperation 1997) and state or province.

RESULTS AND DISCUSSION

Existing and potential energy development could affect, either directly or indirectly, up to 21 percent (96 million hectares) of the five major ecosystems in western North America (Copeland and others 2011). The highest overall predicted impacts as a percent of the ecosystem type are to boreal forest, shrublands, and grasslands (figure 4). In absolute terms, the largest potential impacts are to shrublands; 9.9 to 41.1 million of 169.3 million total hectares may be affected. Oil, gas, wind, solar, and geothermal development each have their greatest potential impacts on shrublands (Copeland and others 2011).

Figure 2. The distribution of shrublands across the western North America study area.

For shrublands, conventional oil and gas development has the greatest current or potential impacts (figure 5). Wind and solar development have the next highest potential impacts on shrublands, but the magnitude of these impacts has greater uncertainty (figure 5). Development of wind and solar resources are expected to rapidly increase, yet face limitations related to electrical transmission and cost. United States and Canadian projections suggest that wind resources may be able to provide for 20 percent of annual electrical energy demand within the next 20 years. This would mean increasing from a current installed capacity of 9669 MW to 348,000 MW, a 36-fold increase (US Department of Energy 2008a; American Wind Energy Association 2009; Canadian Wind Energy Association 2009). Generation of power from solar-photovoltaic and solar-thermal technologies more than doubled in the US between 2000 and 2007, with current capacity at 983 MW. For solar technologies to become more cost effective, 86,000 to 125,000 additional MW need to be installed across the US by 2030 (US Department of Energy 2008b).

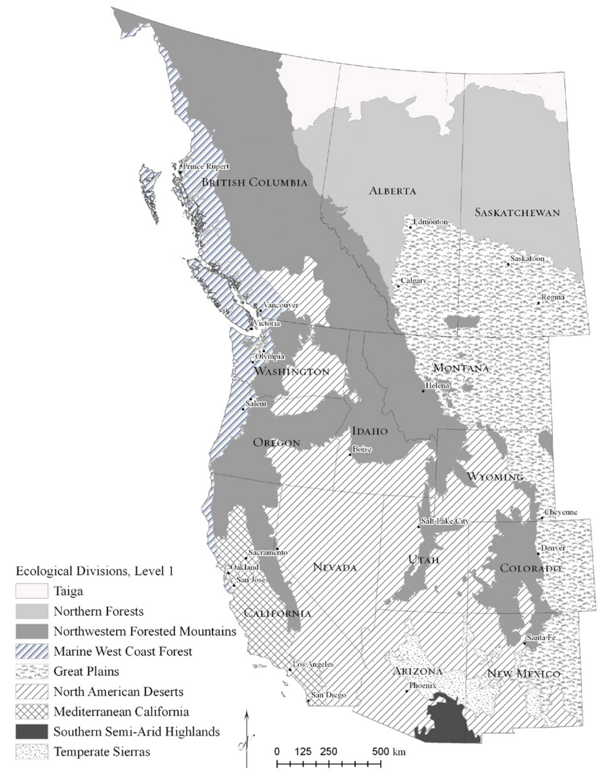

Figure 3. The distribution of level 1 ecological divisions across the western North America study area.

Shrublands are or will be impacted by energy development in all ecological divisions across western North America, but potential impacts are greatest in the North American Deserts, Great Plains, and Northern Forests (figure 6). In the North American Deserts, most energy-related impacts to shrublands would be from conventional oil and gas (2.1 to 7.9 million ha), wind (1.2 to 3.3 million ha) and solar development (60,000 ha to 15.4 million ha). Shrublands in the Great Plains could be most impacted by oil and gas development (2.4 to 5.6 million ha), followed by wind development (65,000 ha to 2.9 million ha) and coal mining (375,000 ha). In the Northern Forests, hydrocarbon extraction could have the greatest potential impacts on shrublands, with most impacts related to conventional oil and gas development (1.3 to 2.9 million ha), followed by oil sands development (859,230 ha) and coal mining (296,000 ha).

Some states or provinces may experience particularly large impacts to shrublands, including Alberta, Wyoming, New Mexico, and Saskatchewan (figure 7). Alberta's shrublands are at the greatest risk of loss or fragmentation from energy development; 36 percent to 56 percent of Alberta's shrublands could be impacted (figure 7). Most of this impact (65-78 percent) would be from oil and gas development (2.1 to 4 million ha), and oil sands development could also have considerable impacts (891,000 ha). In Wyoming, 15 percent to 42 percent of shrublands could be affected by energy development (figure 7). Oil and gas development also explains most of the potential impact (59-75 percent) in Wyoming (1.3 to 4.6 million ha), and wind development could also impact large areas of Wyoming shrublands (645,000 ha to1.9 million ha). Shrublands in Saskatchewan are most affected by oil and gas development and coal mining. In New Mexico, Nevada and Utah, most low-estimate energy impacts to shrublands are from oil and gas development, but additional high-estimate impacts are primarily related to solar development.

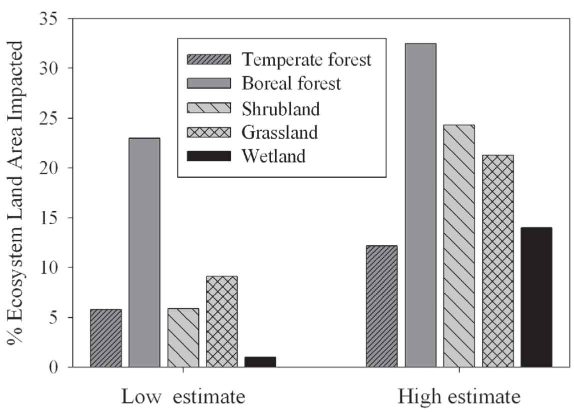

Figure 4. Low and high estimates of the percent of each major ecosystem in western North America that may be impacted by energy development.

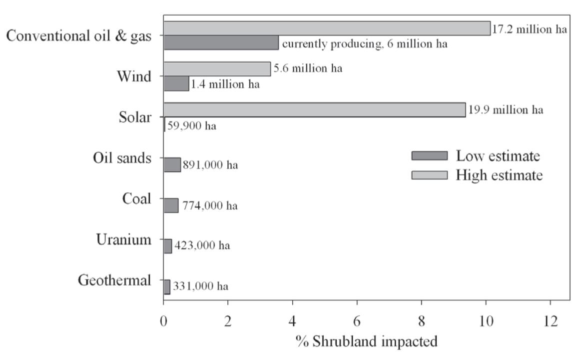

Figure 5. Low and high estimates of the proportion of shrubland ecosystems in western North America that may be impacted by each of seven types of energy development, followed by the numbers of hectares of shrublands that may be impacted.

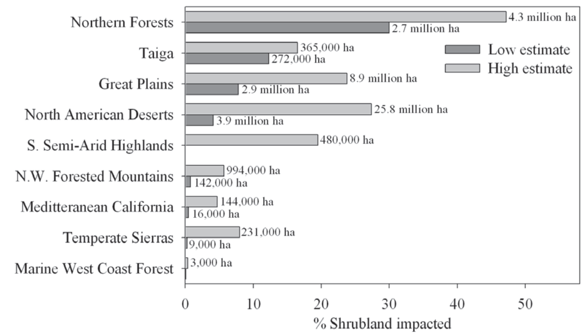

Figure 6. Low and high estimates of the proportion of shrubland ecosystems in each ecological division of western North America that may be impacted by energy development, followed by the numbers of hectares that may be impacted.

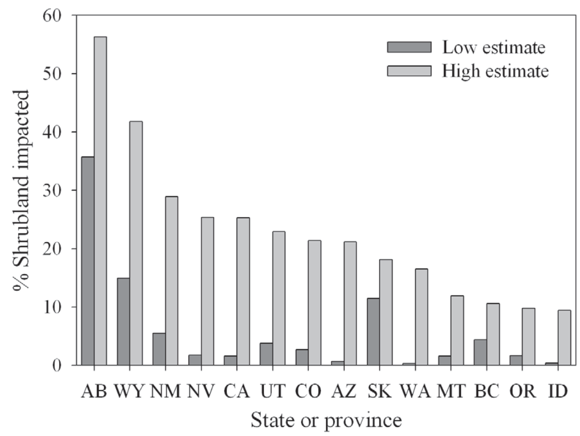

Figure 7. Low and high estimates of the proportion of shrubland ecosystems that may be impacted by energy development in each state or province of western North America: Alberta (AB), Wyoming (WY), New Mexico (NM), Nevada (NV), California (CA), Utah (UT), Colorado (CO), Arizona (AZ), Saskatchewan (SK), Washington (WA), Montana (MT), British Columbia (BC), Oregon (OR), and Idaho (ID).

These potential changes to shrubland ecosystems are alarming, especially because of the limited legal protection these systems currently receive, despite comprising ~30 percent of the land area of western North America and supporting wildlife species such as the greater sage-grouse (*Centrocercus urophasianus)*, pygmy rabbit (*Brachylagus idahoensis*), and Wyoming pocket gopher (*Thomomys clusius*) that have recently been considered for protection under the Endangered Species Act. In addition to impacts associated with energy development, shrubland ecosystems and their inhabitants are also suffering under additional stresses from residential development, invasive species, disease, and climate change. Understanding the scale of anticipated impacts to shrubland and other ecosystems through this type of coarse-scale analysis that highlights ecological and political regions of concern may help to catalyze policy makers to engage in proactive planning, ideally before projects begin, about how to avoid siting conflicts, maintain biodiversity, and determine suitable mitigation responses.

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