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Observations of Greater Sage-Grouse at a solar energy facility in Wyoming

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Abstract.—Photovoltaic, utility-scale solar energy (PV USSE) development is expected to expand in the United States over the next decade and has the potential to impact wildlife through direct mortality and habitat loss. However, the current understanding of wildlife responses, including responses of Greater Sage-Grouse (*Centrocercus urophasianus*; hereafter, sage-grouse), to solar energy development is limited, resulting in uncertainty about potential impacts associated with development and operation. During bird and bat carcass searches at a PV USSE facility in Sweetwater County, Wyoming, we opportunistically observed sage-grouse foraging and loafing inside the facility. We recorded 19 groups of live sage-grouse, representing a total of 47 observations of sage-grouse during 2 years of environmental monitoring. An additional 8 groups were recorded by trail cameras, representing 11 observations of sage-grouse. Observations occurred between early June and mid-January, with 74% of observations occurring between mid-August and mid-November. It is possible that sage-grouse may have used the facility for increased foraging opportunities or thermal refuge. However, our observational study does not provide evidence that sage-grouse necessarily selected for areas within the facility. Additional research on resource selection and demographic responses by sage-grouse would provide more inference on how sage-grouse respond to PV USSE development.

Resumen.—Se espera que el desarrollo de la energía solar fotovoltaica (FV) a escala de servicios públicos (USSE) se expanda en los Estados Unidos durante la próxima década, lo cual podría afectar a la vida silvestre a través de la mortalidad directa y la pérdida de hábitat. Sin embargo, el conocimiento actual sobre las respuestas de la fauna silvestre al desarrollo de la energía solar es limitado, incluyendo el caso del urogallo de las artemisas (*Centrocercus urophasianus*; en adelante, el gallo de salvia), generando incertidumbre sobre los posibles impactos asociados con el desarrollo y funcionamiento del servicio de energía solar. Durante la búsqueda de aves y murciélagos en una instalación fotovoltaica de USSE en el condado de Sweetwater, Wyoming, observamos de forma oportunista a los gallos de salvia forrajeando y descansando en el interior de la instalación. Registramos 19 grupos de gallos de salvia vivos, lo que representa un total de 47 observaciones de gallos de salvia durante dos años de monitoreo ambiental. Otros ocho grupos fueron grabados por las cámaras de rastreo, lo que representa 11 observaciones de gallos de salvia. Las observaciones ocurrieron entre principios de junio y mediados de enero, y el 74% de las observaciones ocurrió entre mediados de agosto y mediados de noviembre. Es posible que el gallo de salvia haya utilizado la instalación para aumentar sus oportunidades de forrajeo o como refugio térmico. Sin embargo, nuestro estudio observacional no aporta evidencias de que los urogallos necesariamente eligen áreas dentro de la instalación. Investigación adicional acerca de la selección de recursos y las respuestas demográficas del urogallo proporcionaran más certidumbre sobre cómo el urogallo responde al desarrollo de la USSE PV.

Photovoltaic, utility-scale solar energy development (PV USSE) is forecasted to expand over the next 10 years in the United States (USEIA 2018), potentially resulting in the conversion of natural landscapes to PV USSE facilities. The development of PV USSE can affect wildlife through direct mortality, habitat modification, and disruption of movement patterns (Grodsky et al. 2017, Agha et al. 2020, Chock et al. 2021). Kosciuch et al. (2020) summarized direct bird mortality at PV USSE facilities in the southwestern United States, but behavioral responses of birds to PV USSE development are not widely studied. In one instance, DeVault et al. (2014) found that bird diversity and abundance were lower in the PV USSE facilities compared to reference areas. However, the authors noted that there were habitat differences between the solar facilities and reference areas, which limited their ability to distinguish an effect of the solar facility from effects of habitat. Thus, limited

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information about bird behavioral responses to PV USSE introduces uncertainty about potential impacts associated with PV USSE development and operation.

Greater Sage-Grouse (*Centrocercus urophasianus*; hereafter, sage-grouse) inhabit sagebrush (*Artemisia* spp.) ecosystems, which contain solar resources attractive to PV USSE developers (Agha et al. 2020). Sage-grouse population declines have prompted conservation actions, including the development of management plans that aim to avoid and minimize impacts to sage-grouse habitat (e.g., BLM 2019). Conservation buffers to limit disturbance in important sage-grouse habitat have been developed for most types of anthropogenic development (Manier et al. 2014). Yet, conservation buffers have not been implemented for PV USSE development because there is little available information on the response of sage-grouse to this type of development. During operational monitoring at a PV USSE facility in southwestern Wyoming, we opportunistically observed sage-grouse foraging and loafing inside the facility and summarize the observations here.

Our study site consisted of an 80-megawatt PV USSE facility, which included a perimeter fence and dirt roads, developed on roughly 283 ha of BLM-administered land located 18 km northwest of Green River in Sweetwater County, Wyoming (collectively referred to as the "facility"). The facility is located in a region dominated by Wyoming big sagebrush (*A. tridentata wyomingensis*). Anthropogenic activity on site was typical of that at most other PV USSE facilities, with infrequent vehicle and pedestrian activity associated with biologists or solar maintenance technicians. Other activity at the facility included mowing to reduce vegetation growth, which was conducted once each year in early fall, outside of the bird breeding season.

After construction was completed, vegetation was re-established through reseeding of graded areas, where vegetation was removed, with a native seed mix including thickspike wheatgrass (*Elymus lanceolatus*), Indian ricegrass (*Achnatherum hymenoides*), Sandberg bluegrass (*Poa secunda*), bluebunch wheatgrass (*Pseudoroegneria spicata*), Gardner's saltbush (*Atriplex gardneri*), shadscale (*Atriplex confertifolia*), Rocky Mountain penstemon (*Penstemon strictus*), blue flax (*Linum lewisii*), and bottlebrush squirrelltail (*Elymus elymoides*). Thus, the vegetation assemblage changed from Wyoming big sagebrush–dominated habitat to predominantly grassland habitat. The predominant plant species observed within the facility included thickspike wheatgrass and Indian ricegrass.

During a 2-year postconstruction fatality monitoring study, we opportunistically recorded incidental observations of live sage-grouse within the facility while conducting bird and bat carcass searches within the solar arrays and along portions of the fence line, or while conducting bias trials. Carcass searches involved walking along facility roads and scanning down panel rows for bird or bat carcasses; 47% of the facility was sampled during each site visit. Bias trials involved placement of bird carcasses to measure how long a carcass persisted on the landscape or the likelihood that a biologist found a carcass.

We conducted on-site carcass searches for all bird and bat species once every 2 weeks from early March 2019 to early March 2021, for 52 total site visits over the 2-year period. During each of the 52 visits, we were on site for 1 to 2 days. Carcass searches were conducted during daylight hours year-round. Sage-grouse observations were recorded during carcass searches or on Bushnell trail cameras (Bushnell Outdoor Products, Cody Overland Park, Kansas) used for capturing scavenging events associated with carcass persistence trials. Two hundred sixty-eight trial carcasses were placed at the facility over the 2-year study, each monitored by a trail camera for 14 to 42 days. For each sage-grouse observation, we recorded the date, time, location (coordinates or array unit number), and number of individuals; age and sex were recorded when possible.

We recorded 19 groups of sage-grouse, representing a total of 47 observations. An additional 8 groups were recorded by trail cameras, representing 11 observations. In total, 27 groups of sage-grouse totaling 58 observations were recorded. No sage-grouse fatalities were found during the 2-year fatality monitoring study.

Eight of the 58 sage-grouse observations were of males and 13 were of females; sex was unknown or not recorded for the remaining 37 observations. Eighteen of the 58 sage-grouse observations were of adults and 7 were of

Fig. 1. Greater Sage-Grouse (*Centrocercus urophasianus*) inside a photovoltaic utility-scale solar energy facility in Wyoming in 2019.

juveniles; age was unknown or not recorded for the remaining 33 observations. We recorded various behaviors, including foraging and loafing in the shade of the solar panels (Fig. 1).

Sage-grouse were observed between early June and mid-January, with 74% (43 of 58) of sage-grouse observations occurring between mid-August and mid-November. The highest number of observations occurred in November (17), followed by August (12) and October (9). We did not observe any sage-grouse between February and May of either study year. Observations that were spatially referenced occurred from 5 to 571 m ($n = 18, \bar{x} = 216$ m) inside the perimeter fence.

Our study provides evidence that sage-grouse used the landscape inside the facility during the postbreeding portion of their life cycle, a generally unexpected result based on how sage-grouse respond to other forms of anthropogenic development (e.g., Naugle et al. 2011). Many forms of energy development result in complete removal of vegetation (e.g., Kirol et al. 2020) and increased human activity (e.g., Sawyer et al. 2009). The vegetation within the facility generally lacks a sagebrush overstory, but complete removal of vegetation did not occur and the site was reseeded following construction. Solar facilities also generally have lower human activity following construction compared to other forms of energy development. A wind turbine could be visited monthly as part of a spill prevention plan, or quarterly for inspection, whereas a producing natural gas well could be visited more than 1500 times per year (Sawyer et al. 2009). In contrast, a PV USSE facility can be monitored remotely, and the visits by personnel are limited to as-needed visits to effect repairs (BLM 2018). Thus, the combination of vegetation conditions and low human activity may have contributed to sage-grouse use of the area during the postbreeding period.

Forbs and invertebrates are important food resources for sage-grouse during late spring and summer (Wallestad and Eng 1975, Barnett and Crawford 1994). Sagebrush reduction resulting from facility development could lead to increased invertebrate abundance. For example, Hess and Beck (2014) found a 2.3-fold increase in grasshopper (order Orthoptera) abundance in burned Wyoming big sagebrush compared to untreated sites. Although mowed Wyoming big sagebrush does not necessarily increase invertebrate abundance (Hess and Beck 2014), seeding of thickspike wheatgrass likely created conditions favorable for grasshoppers (Branson and Sword 2009). If invertebrate abundance at the facility was increased compared to the surrounding habitat, it could have created favorable foraging conditions for sage-grouse.

Thermal refuge is another component of sage-grouse habitat that has received attention in the last 10 years. Sage-grouse have been documented to use snow burrows for thermal conservation in winter (Back et al. 1987), and females select nest sites that modulate temperature change (Anthony et al. 2021). While sage-grouse thermal ecology during the postbreeding period has not been evaluated, shading by solar panel infrastructure could potentially create a favorable thermal environment for sage-grouse (see Fig. 1).

In the absence of additional information, we can only speculate about the reason sage-grouse were regularly observed inside the facility. We cannot reach conclusions regarding overall effects of the facility development on locally breeding sage-grouse given our observational study; however, we observed use of the facility by sage-grouse during the postbreeding period. We caution that other facilities located in the sage-grouse range will likely have differing restoration methods and other environmental and anthropogenic features that could result in different use patterns than those we observed. Our observational study does not provide evidence that sage-grouse selected for areas in the facility; rather, sage-grouse occurred within the facility, and additional research evaluating sage-grouse behavioral responses would provide more inference on how sage-grouse respond to PV USSE development.

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