MANAGEMENT OF GREATER SAGE-GROUSE IN SOUTH DAKOTA

SOUTH DAKOTA DEPARTMENT OF GAME, FISH AND PARKS
PIERRE, SOUTH DAKOTA

WILDLIFE DIVISION REPORT 2021-16

NOVEMBER 2021

This supportive document provides information for the "*South Dakota Greater Sage-Grouse Action Plan, 2021–2026*" which provides management guidance for the South Dakota Department of Game, Fish and Parks (GFP) staff and Commission and can be found at https://gfp.sd.gov/management-plans/. Updates will occur when information is made available or as needed.

ACKNOWLEDGMENTS

Management Plan Team—Paul Coughlin, Tim Olson, Travis Runia, Alex Solem, Stan Michals, Anna Kopp, Eileen Dowd Stukel, Trenton Haffley, Shelly Deisch, Hilary Morey, Faren Wolter, and Chad Switzer of South Dakota Department of Game, Fish and Parks.

All text and data contained within this document are subject to revision for corrections, updates and data analyses.

Recommended citation:

South Dakota Department of Game, Fish and Parks, Division of Wildlife. 2021. Management of sage-grouse in South Dakota. Wildlife Division Report Number 2021-16. South Dakota Department of Game, Fish and Parks, Pierre, South Dakota, USA.

PUBLIC INVOLVEMENT

A virtual public meeting was held on August 13, 2020 to facilitate opportunity for public involvement at the beginning of the revision process. A draft of the "*South Dakota Greater Sage-Grouse Action Plan, 2021–2026*" was available for public comment from November 5–December 15, 2021.

TABLE OF CONTENTS

Page

Table of Contents 3

List of Figures 4

List of Tables 5

List of Acronyms 6

Introduction 7

General Greater Sage-grouse Ecology 8

Historical Information and Current Distribution 10

Monitoring and Current Status 11

Core Area Mapping 13

Hunting 17

Sage-grouse Research in South Dakota 21

Issues, Challenges, and Opportunities in South Dakota 23

Literature Cited 37

LIST OF FIGURES

Page

1. Pre-settlement distribution of potential sage-grouse habitat and current sage-grouse range (Schroeder et al. 2004). 8

2. From Doherty et al. (2010). Range-wide sage-grouse breeding density areas represent spatial locations of 25%, 50%, 75%, and 100% of the known breeding population, differentiated by color 11

3. Total males, attended leks, and males per attended lek for sage-grouse in South Dakota, 2005–2021 12

4. Male sage-grouse per attended lek in South Dakota 1990–2021. 13

5. South Dakota sage-grouse leks and sage-grouse locations (Swanson 2009, Parsons 2019) used in development of sage-grouse core areas. 15

6. South Dakota sage-grouse core areas and surface ownership. 16

7. Producing oil wells in South Dakota, 1954–2020 (SDANR 2020) 33

8. Producing gas wells in South Dakota, 1979–2020 (SDANR 2020). 34

9. Relation of producing oil and gas wells to sage-grouse core areas in South Dakota 35

10. Wind power classification in relation to South Dakota sage-grouse core areas 36

LIST OF TABLES

Page

1. South Dakota sage-grouse core area surface ownership acreage. 17

2. South Dakota sage-grouse hunting season records, 1955–2020. 20

3. Sage-grouse season recommendation guidelines for South Dakota, 2021–2026.... 21

LIST OF ACRONYMS

ABC	American Bird Conservancy
BCoR	Bird Conservancy of the Rockies
ESA	Endangered Species Act
GFP	South Dakota Department of Game, Fish and Parks
MOA	Memorandum of Agreement
MW	Megawatt
NRCS	Natural Resources Conservation Service
PF	Pheasants Forever
RMP	Resource Management Plan
SD	South Dakota
SDANR	South Dakota Department of Agriculture and Natural Resources
SPL	South Dakota Office of School and Public Lands
USDA	United States Department of Agriculture
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
WAFWA	Western Association of Fish and Wildlife Agencies
WNV	West Nile Virus

INTRODUCTION

The greater sage-grouse (*Centrocercus urophasianus*; hereafter sage-grouse) is the largest of all North American grouse, and often referred to as sage-hen, sage-chicken, or sage-cock. Adult males can weigh in excess of 5 lbs (2.3 kg) and measure 27–34 in (69–86 cm) in length, while adult females can weigh between 2–3 pounds (0.9–1.4 kg) and measure 18–24 in (46–61 cm). Both the male and female sage-grouse have a grayish-brown appearance, narrow pointed tail feathers, and feathering to the toes. Female grouse are more cryptic in coloration and adult males are distinguished by a dark throat surrounded by a V-shaped patch of white feathers on the neck. During courtship display activities, males extend two skin sacs of a yellow-green coloration found near the throat and possess pronounced yellow eyecombs.

Sage-grouse are a sagebrush obligate "landscape species" and thus require large contiguous tracts of sage steppe habitat for population subsistence (Aldridge et al. 2008, Wisdom et al. 2011). Sage-grouse populations have declined 80.7% from 1966–2019, although the rate of annual decline appears to slowing in recent years (Coates et al. 2021). Sage-grouse inhabit only 56% of their pre-settlement distribution (Figure 1; Schroeder et al. 2004). Loss and degradation of sagebrush (*Artemisia* spp.), improper livestock grazing, fire, invasive plant species, construction of anthropogenic infrastructure, oil and gas development, and increased mortality due to West Nile virus (WNV) have been identified as the major contributing factors (Knick and Connelly 2011, multiple chapters). More frequent drought associated with climate change could also be a threat (Blomberg et al. 2012). Overhunting was also a historic factor in the population decline. Declines in sage-grouse abundance and distribution in South Dakota (SD) are consistent with range-wide trends. Sage-grouse once inhabited the western third of the state outside of the Black Hills, but now primarily inhabit only portions of Butte and Harding counties (Smith et al. 2004). Sage-grouse is listed as a species of greatest conservation need in the South Dakota Wildlife Action Plan because the species is indicative of or depends upon a unique or declining habitat (GFP 2014).

In 2010, the U.S. Fish and Wildlife Service (USFWS) determined that the sage-grouse was warranted for protection under the Endangered Species Act (ESA) due to the loss and fragmentation of habitat and a lack of adequate regulatory mechanisms to stem habitat loss. The Service did not propose a listing rule at the time due to the need to address higher priority listing actions. When the Service made the warranted but precluded finding in 2010, the sage-grouse became a candidate species. Through a court-ordered work plan, the Service committed to resolve the sage-grouse's "candidate" designation by September 30, 2015 by either proposing to list the species as threatened or endangered or remove the species from the "Candidate List," an action already required by the ESA. After evaluating the best available scientific and commercial information regarding the sage-grouse, the Service has determined that protection for the sage-grouse under the ESA is no longer warranted and has removed the species from the candidate species list.

The future of sage-grouse is primarily dependent upon sagebrush steppe habitat, thus the bulk of this plan focuses on habitat management. Because habitat important to sage-grouse intersects many ownership boundaries, this plan addresses issues related to both public and private land. Only with cooperation among private and public entities can the goal for sage-grouse management be reached.

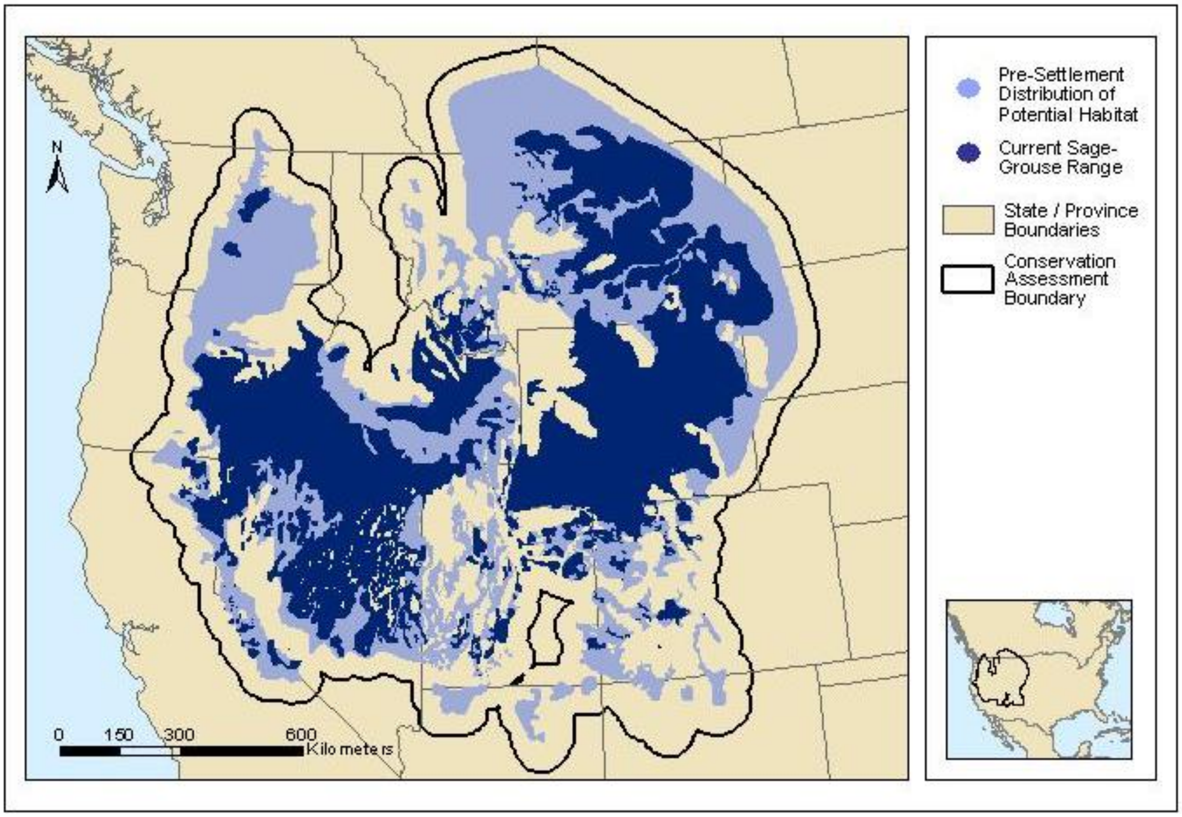

Figure 1. Pre-settlement distribution of potential sage-grouse habitat and current sage-grouse range (Schroeder et al. 2004).

GENERAL GREATER SAGE-GROUSE ECOLOGY

Sage-grouse are sagebrush obligates. At broad scales, contiguous sagebrush cover is the single most important variable influencing population subsistence (Aldridge et al. 2008, Wisdom et al. 2011). Wyoming big sagebrush (*Artemesia tridentata* ssp. *wyomingensis*) and silver sagebrush (*A. cana*) are the dominant sagebrush species within SD's occupied sage-grouse range. Sage-grouse depend entirely on sagebrush for both food and cover during winter and rely heavily on sagebrush during the rest of their annual life cycle (Connelly et al. 2000). Sagebrush height and density is lower in SD when compared to the center of the sage-grouse main range such as Wyoming (Lewis 2004).

Leks, or display areas are the center of breeding behavior where males gather to defend territories and perform courtship displays to attract and copulate with females. Sage-grouse are polygynous, meaning one male can breed with many females during a single breeding season. It is common for a few dominant males to perform a majority of the copulations on a lek (Schroeder et al. 1999). There is evidence that off-lek copulations by subordinate males increase the number of individual males that father chicks (Bush 2009). Both males and females can attend multiple leks during the breeding season or even during the same day (Walsh et al. 2004). Display activity on leks starts well before dawn and can last several hours. Display activity during evening hours is less intense and shorter in duration. In SD, lekking activity typically begins as early as late February, peaks in April or early May, and tapers off by early June. In SD leks are typically located on large clay flats with sparse vegetation.

Sage-grouse build ground nests that are usually located under sagebrush and lined with vegetation and feathers from the hen's brood patch. Sage-grouse typically select nest sites that possess canopy cover provided by sagebrush and visual obstruction provided by grass and forbs. On average, hens initiate nests within 1.8–5 mi (3–8 km) of the lek where they were observed (Schroeder et al. 1999). Research in SD found 97% and 68% of sage-grouse nests were within 4.3 and 1.9 mi (7 and 3 km) of the nearest attended lek, respectively (Kaczor 2008). Also in SD, Parsons (2019) found the average distance of nest to nearest active lek was 1.5 mi (2.5 km) with a range of 0.4−7.6 mi (0.6−12.2 km). Most nests (90%) were within 2.2 mi (3.5 km) of an attended lek and 93% of all nests found were within 2.5 mi (4 km) of an attended lek.

Most (~90%) sage-grouse hens will initiate at least one nest per breeding season (Schroeder et al. 1999, Kaczor 2008, Parsons 2019). If the initial nest fails, renesting rates average 29% (Connelly et al. 2004). Kaczor (2008) found 96% of hens initiated a nest and of those whose initial nests failed, 29% renested. Mean nest initiation date was April 24 and May 9 for renesting attempts. Clutch size for initial nests averaged 6.3–9.1 with an overall average of 7.3 for 11 studies throughout their range (Schroeder et al. 1999). Kaczor (2008) observed an average clutch size of 8.3 and 6.4 for initial and renest attempts, respectively. Reported nest success (percentage of nests that hatch ≥ 1 egg) rates ranged from 15–86% with an average of 48% for 16 studies (Connelly et al. 2004). Kaczor (2008) and Parsons (2019) estimated nest success of 45.6% and 29.0% respectively.

Successful sage-grouse nests hatch after 27 days of incubation and the precocial chicks leave the nest with the hen within a day. Ideal brood-rearing habitat is characterized by sagebrush canopy cover of 10–25% adjacent to areas rich in forbs and associated insects (Connelly et al. 2000). Sage-grouse hens lead broods to areas of higher herbaceous and forb cover likely because these areas have higher insect production (Holloran 1999, Kaczor 2008). Sage-grouse chicks rely on protein rich insects for a majority of their diet during the first 3 weeks of life and insect availability can influence chick survival (Johnson and Boyce 1990, Drut et al. 1994).

Chick survival during the first few weeks of age is low at 12–22% (Aldridge and Boyce 2007, Gregg et al. 2007) with only an estimated 10% of chicks surviving to breeding age (Crawford et al. 2004). Adult survival is much higher with annual estimates often exceeding 60% (Reviewed in Connelly et al. 2004). In SD Swanson (2009) found that adult and juvenile survival was relatively high November through June (monthly survival = 0.97, SE = 0.01) but much lower during July through October when WNV likely caused reduced survival (monthly survival = 0.97, SE < 0.01).

HISTORICAL INFORMATION AND CURRENT DISTRIBUTION

Sage-grouse were once found in 12 states and 3 provinces but have since been extirpated from Nebraska and British Columbia (Schroeder et al. 2004). Their current range-wide distribution (259,000 mi^2, 670,000 km^2) represents 56% of their estimated pre-settlement distribution (Schroeder et al. 2004; Figure 1). Sage-grouse once inhabited much of the western one-third of SD outside of the Black Hills but are now primarily restricted to portions of Butte and Harding counties. Fall River County had an attended lek as recently as 2006 (Hodorff 2013), but no leks have been observed since. Less than 1% of the range-wide sage-grouse breeding distribution occurs in SD (Doherty et al. 2010; Figure 2).

During pre-settlement times, this species was considered abundant in the western part of the state and present as far east as Corson County (Reviewed in Smith et al. 2004). Sage-grouse were still found as far east as Sage Creek in or around Badlands National Park as late as 1907, but were absent from this area by 1913 (Visher 1914). In 1910, sage-grouse were considered abundant in areas with sagebrush in Butte and Harding counties (Visher 1914). Hornaday (1916) identified Butte, Harding and Perkins counties as the only counties with sage-grouse by 1916. In the early 1920s, the South Dakota Geological and Natural History Survey indicated that sage grouse were found in Fall River, Butte, and Harding counties (Over and Thoms 1921). In the mid-1950s, sage-grouse were documented in Fall River, Butte, Harding, Meade, and Perkins counties; however the number of birds was considerably less in Meade and Perkins counties (Reviewed in Smith et al. 2004). In 1955, it was suggested that the population in Butte and Harding counties was roughly 15,000, but it is unknown how this was estimated (Nelson 1955).

After settlement, the sage-grouse range became more restricted likely in response to cropland expansion and other direct loss of sagebrush which impacted the natural vegetative communities and reduced available habitat (Smith et al. 2004). The current sage-grouse range is slightly reduced from than that of the 1950s. Most birds are found in the more extensive sagebrush range within Butte and Harding counties, with incidental sightings in Perkins, Meade and Fall River counties.

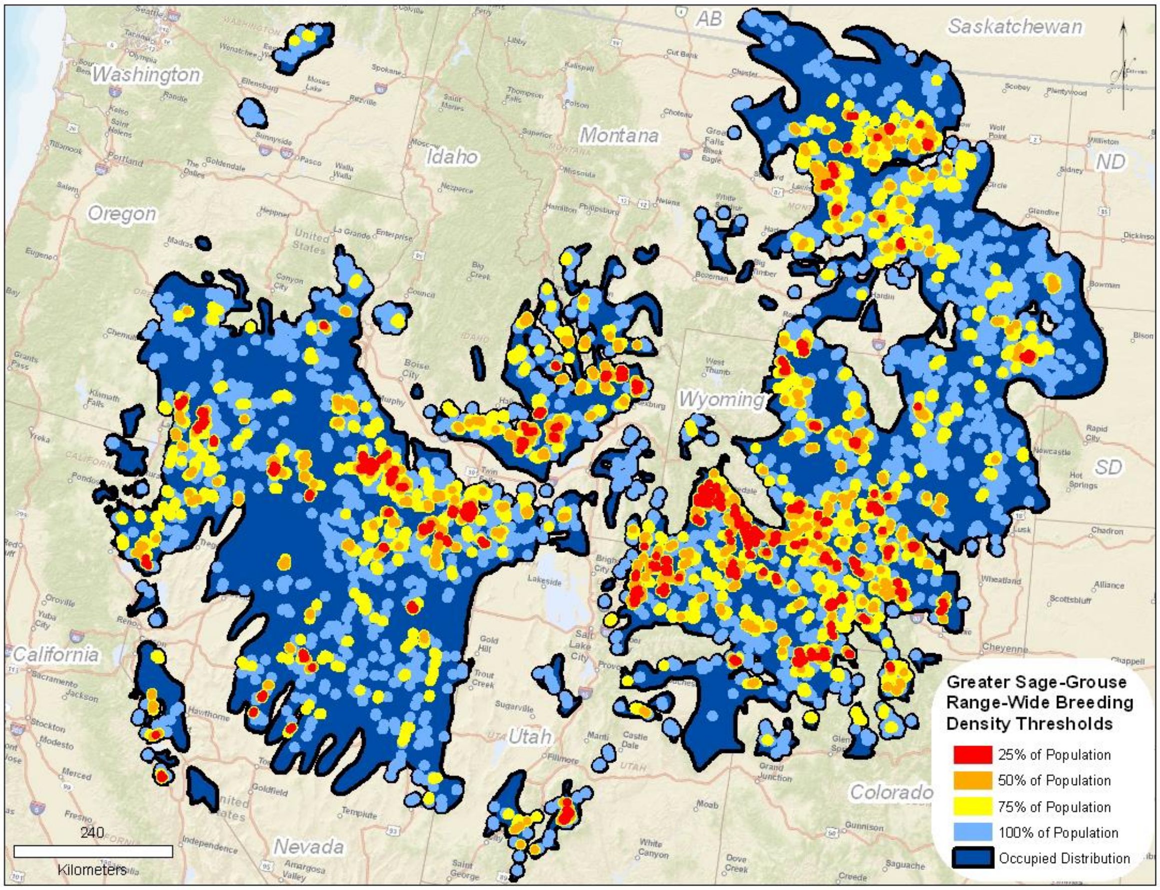

Figure 2. From Doherty et al. (2010). Range-wide sage-grouse breeding density areas represent spatial locations of 25%, 50%, 75%, and 100% of the known breeding population, differentiated by color. Red areas contain 25% of the nesting population in 3.9% of the bird's occupied range. Because colors are additive, red and orange areas combined capture 50% of the population in 10% of the range. Collectively, breeding density areas contain 25% of sage-grouse in 3.9% of the species range (2.9 million ha), 50% of birds in 10.0% of range (7.5 million ha), 75% of birds in 26.9% of range (20.4 million ha), and 100% of the known population in 54.6% (41.2 million ha) the species range.

MONITORING AND CURRENT STATUS

Throughout their range, sage-grouse populations are monitored by spring lek counts. Male grouse are counted on leks from the ground by trained observers within 1 hour of sunrise from mid-March through mid-May. The number of displaying males/lek and displaying males/geographic area are used to evaluate population trend.

GFP began collecting lek survey data in 1971; although a consistent lek count protocol was not followed until 1989. Even though a consistent lek count protocol is now used, some leks are not counted every year for various reasons (i.e. inclement weather, access) which creates challenges in data interpretation. Since 2005, it is believed most attended leks have been counted every year. All leks that have been attended in the previous 5 years are surveyed each year. Total males counted has declined since the near-term highs of 2006 (Figure 3). Since 1990, males/attended lek has been somewhat cyclical with a prominent apex in 2006 and valleys in 1996 and 2014 (Figure 4.). GFP also contributes all lek data to a coordinated national effort to periodically analyze trends in sage-grouse abundance at many temporal and spatial scales. The results of the comprehensive analysis can be found at: https://pubs.er.usgs.gov/publication/ofr20201154 .

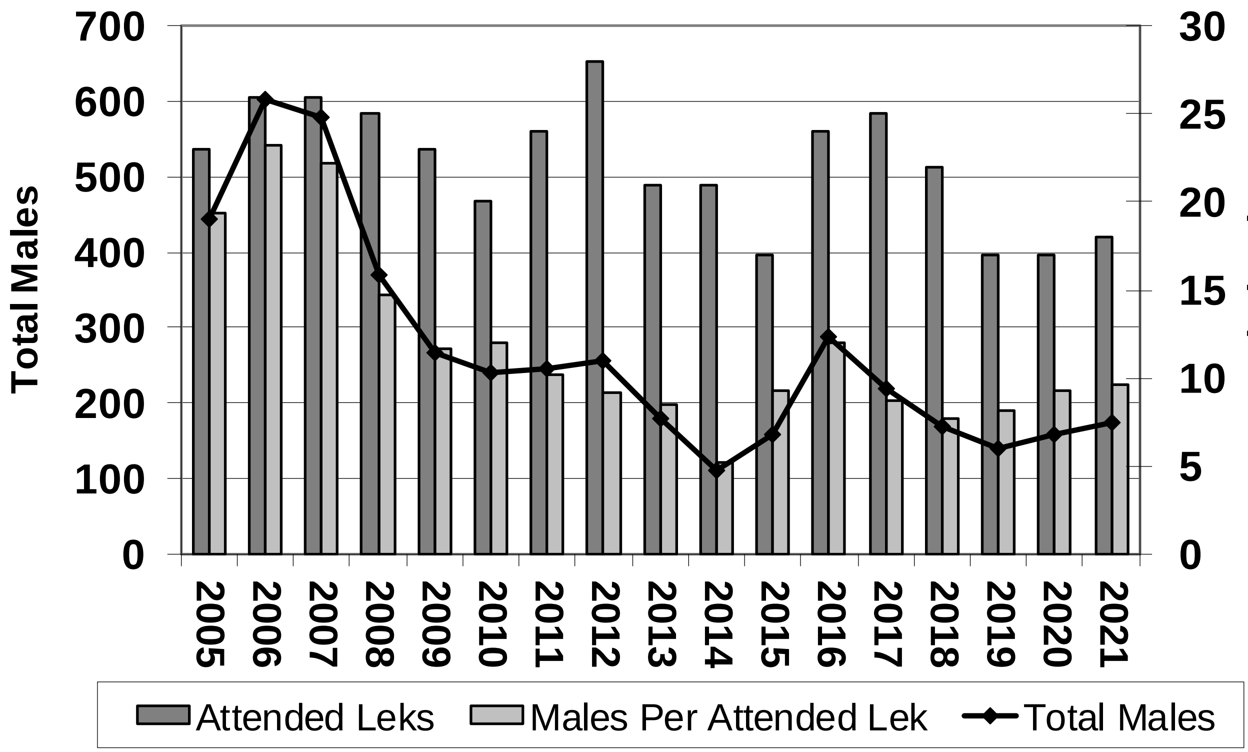

Figure 3. Total males, attended leks, and males per attended lek for sage-grouse in South Dakota, 2005–2021.

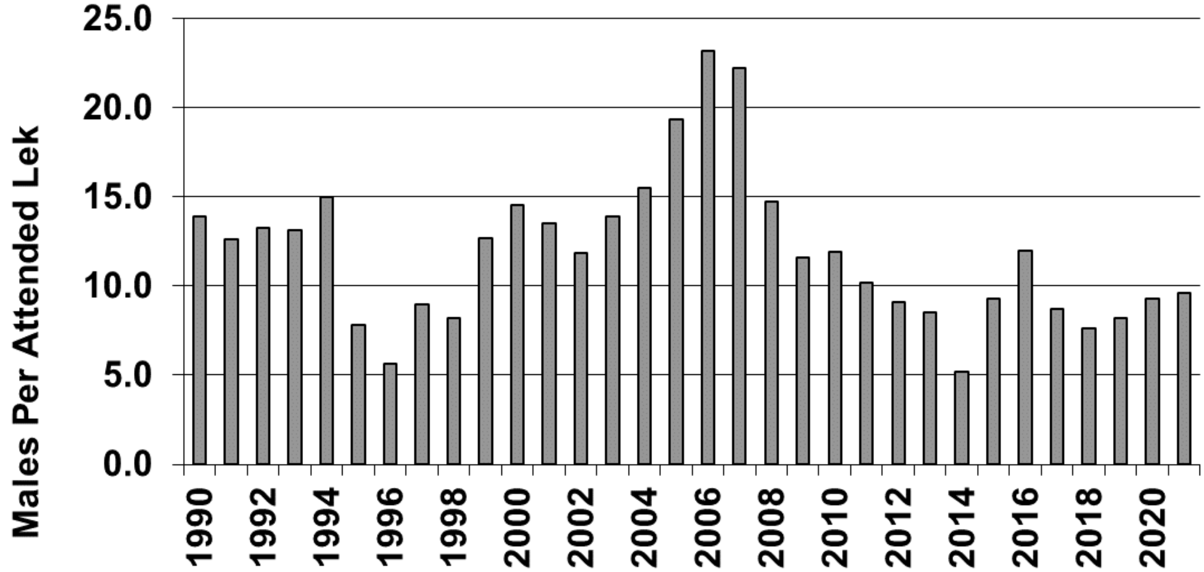

Figure 4. Male sage-grouse per attended lek in South Dakota, 1990–2021.

CORE AREA MAPPING

Across the sage-grouse range, important habitat areas have been delineated using data sources such as lek locations, breeding density maps, telemetry locations, resource selection functions, and landcover data. Commonly referred to as core areas or priority areas for conservation, the mapping products have served a key role in ongoing sage-grouse conservation efforts. The maps have served as the foundation of sage-grouse habitat management on federal lands, have been linked to policy in some states, and have guided prioritization of habitat delivery and protection on public and private lands. Core areas for SD were first delineated in 2014 as a component of the *sage-grouse management plan for SD 2014–2018*. Parsons (2019) used all available telemetry data collected in SD to evaluate the original core area. Results indicate 95% of known nests, 93% of breeding female locations, and 99% of winter locations occurred within the core area. Core areas were slightly modified in 2021 using additional data sources.

Considering SD's sage-grouse distribution is limited and on the edge of the species range, we identified a liberal area for inclusion in our core areas. We selected all leks (including leks within 4 miles (6.4 km) of SD border in other states) which have had at least 2 males for 2 of 5 consecutive years since 2000 and buffered them at a distance of 4 mi (6.4 km). We also included likely lek locations that did not have adequate survey history to classify the lek as active (e.g. >2 males observed in a year, but not surveyed for 5 consecutive years). We did not include areas of the lek buffer that overlapped large areas of non-habitat (e.g. lek buffers that overlapped forested areas). The 6.4 km buffer distance is estimated to encompass >90% of sage-grouse nests (Kaczor 2008, Parsons 2019). We used all bird locations from Swanson (2009) and bird locations, resource selection functions, and utilization distributions from Parsons (2019) to identify high use areas and important connectivity corridors. The final map was developed using a combination of the data listed previously and, wildlife biologists' opinion, including collaboration among bordering states and the Bureau of Land Management (BLM) (Figure 5).

SD's sage-grouse core area encompasses 1,026,307 surface acres (4,153 km^2), most (74%) of which is privately owned (Table 1). Nearly all of the publicly owned surface acres are owned by SD Office of School and Public Lands (SPL) or the BLM (Table 1). SD GFP and United States Forest Service (USFS) have minimal surface ownership of the core area. The juxtaposition of surface ownership is a patchwork of ownership entities (Figure 6).

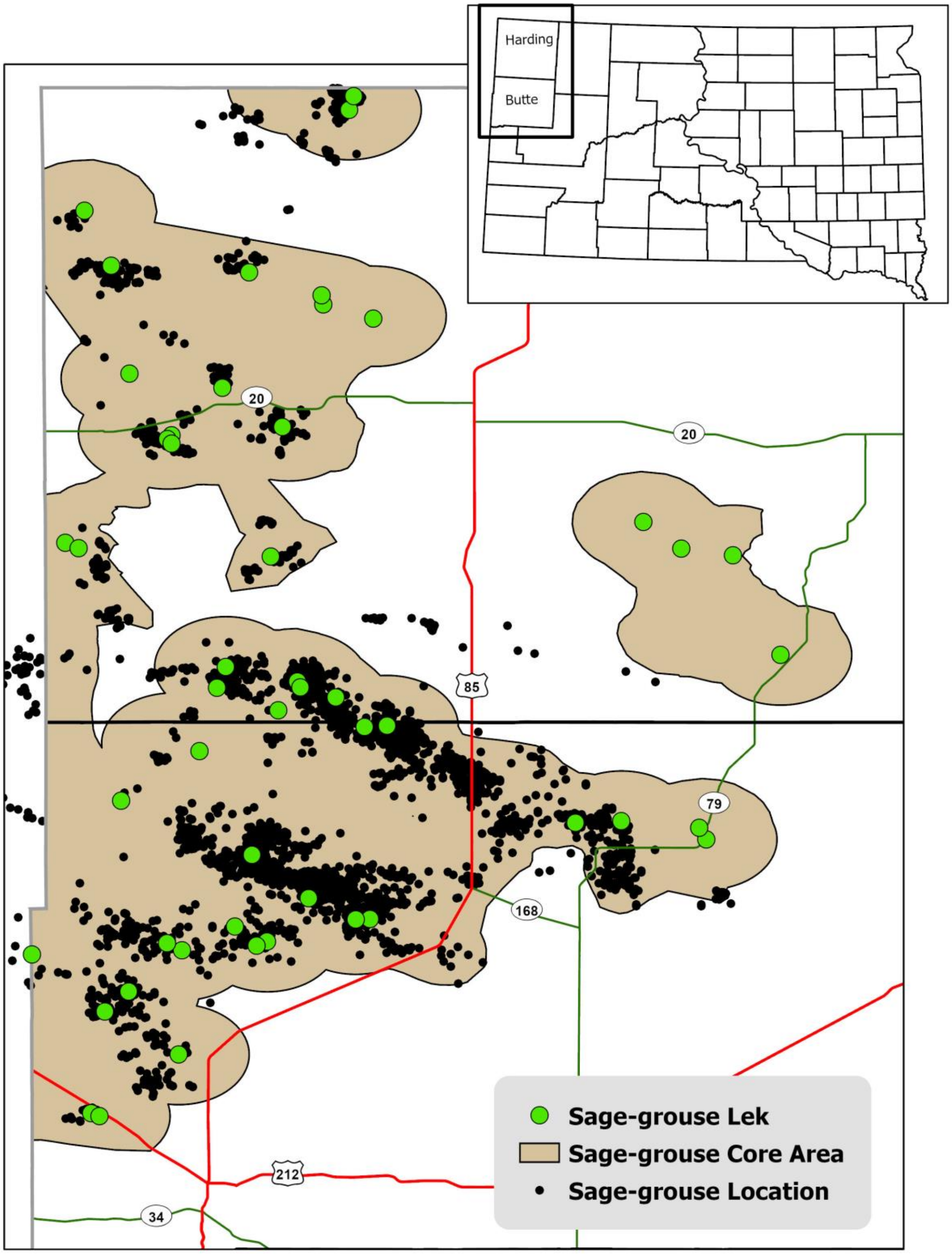

Figure 5. South Dakota sage-grouse leks and sage-grouse locations (Swanson 2009, Parsons 2019) used in development of sage-grouse core areas.

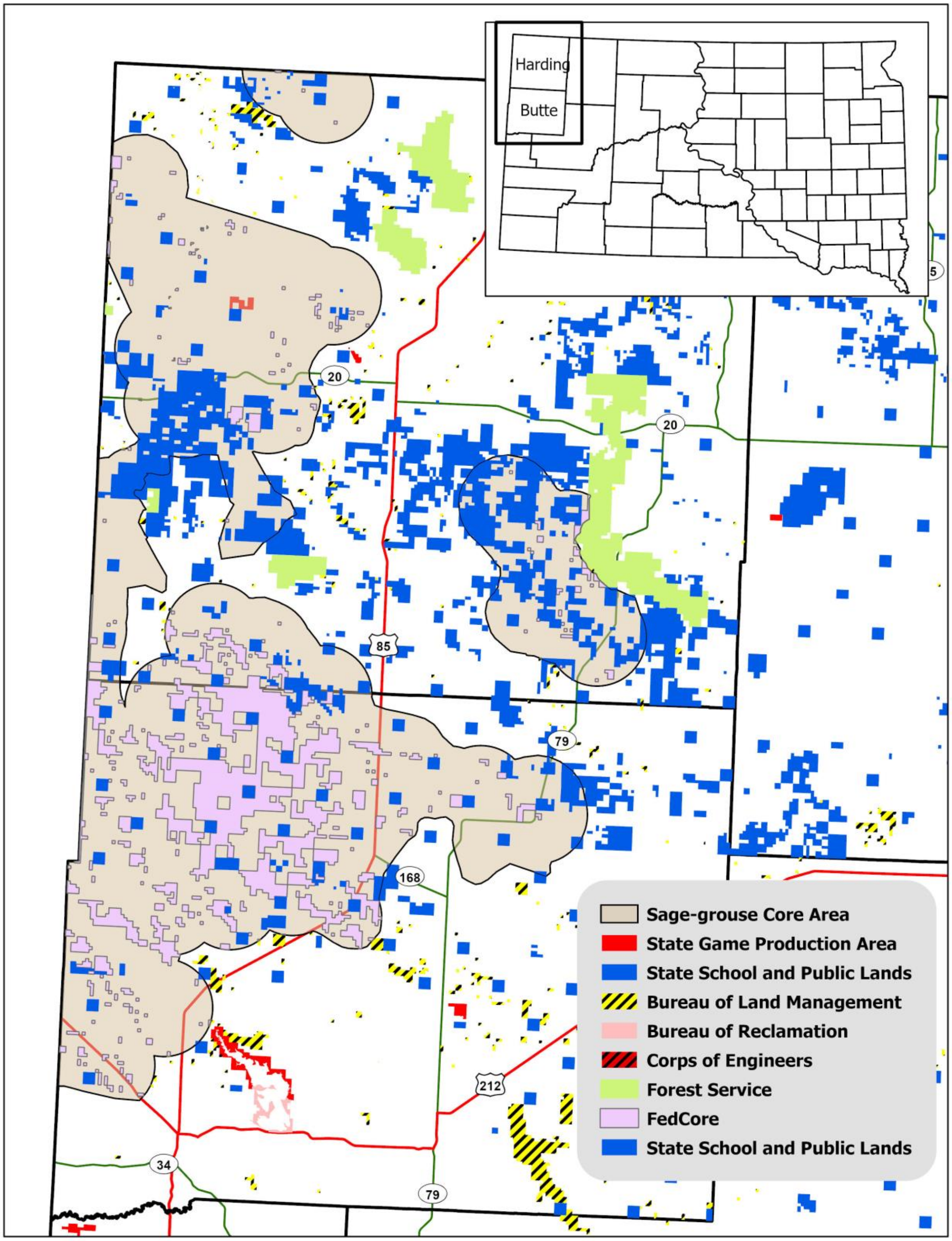

Figure 6. South Dakota sage-grouse core areas and surface ownership.

Table 1. South Dakota sage-grouse core area surface ownership acreage.

	Acres	% of Total
State		
School and Public Lands	133,069	12.97%
Game, Fish and Parks	408	0.04%
Total	133,477	13.01%
Federal		
Bureau of Land Management	129,308	12.60%
Forest Service	1,424	0.14%
Total	130,732	12.74%
Private		
Total	762,098	74.26%
Grand Total	1,026,307	

Hunting

Range-wide, sage-grouse have been hunted throughout recorded history, but harvest strategy and the understanding of the effect of harvest on populations has changed substantially during the past century. Excessive and under-regulated hunting in the late 1800s and early 1900s in combination with other factors obliterated sage-grouse populations (Patterson 1952). The crash in sage-grouse populations prompted many states to prohibit hunting until populations rebounded. Once populations rebounded, liberal hunting regulations were in place during much of the mid and late 20th century. Hunting seasons were crafted with the notion that hunting mortality was compensatory to natural mortality. This strategy assumes many young are produced, but over-winter survival is low, thus fall harvest has minimal influence on the next years breeding population (e.g. ring-necked pheasant, *Phasianus colchicus*).

Emerging research during the 1980s and 1990s suggested that the sage-grouse life history strategy of high annual survival (especially during winter) and relatively low reproductive output was different than many other upland game birds and thus required different harvest management. Throughout the 1990s many states shifted hunting seasons to encourage more restrictive harvest of sage-grouse. Although biologists now recognize that sage-grouse harvest must be highly regulated to be sustainable, an appropriate harvest rate has not been determined.

In SD, early hunting records are sparse; however it is thought that high harvest in the early 1900's was a factor that led to the rapid decline of sage-grouse (Reviewed in Smith et al. 2004). Department records indicate that the sage-grouse season reopened in 1955 for the first time since 1935 and approximately 600 birds were harvested. During the 1955 season, sage-grouse numbers were fairly abundant, as hunter interviews revealed that most hunters bagged their birds in less than one hour (Podoll 1957). Although abundant, the number of birds harvested was still quite low because of local opposition to the season.

From 1956–1999, the sage-grouse hunting season was intermittently closed (Table 2). From 2000–2012, an average of 33 hunters harvested an average of 16 sage-grouse annually. The 2000–2012 sage-grouse hunting season was very restrictive. Sage-grouse hunting was limited to two days in late September (Wednesday and Thursday), with a one bird season limit per hunter. Sage-grouse hunting was only open on public lands (BLM, USFS, SPL, and private land leased by GFP for public hunting as Walk-In Area) in Harding County and west of US Highway 85 in Butte County. Hunters were interviewed in the field to collect age and sex information from harvested birds. The season was closed in 2013 because the number of males counted on priority leks dipped below 100, the threshold identified to have a season in the 2008–2013 management plan. The season was open in 2016 because lek counts reached a threshold identified in the 2014–2018 plan. To assure the sage-grouse harvest was conservative, 40 access permits were made available through a lottery drawing for the 2016 season.

Given the difficulty to generate accurate sage-grouse population estimates (Anderson 2001, Baumgardt 2011), setting season structures to achieve specific harvest rates can be challenging. Reese and Connelly (2011) provide useful advice and state “A conservative, yet data-centered, approach to harvest may be warranted given the results of recent studies and the continuing concerns over population and habitat trends of greater sage-grouse.” Although concern over harvest is warranted, very few studies have identified harvest as a cause of population decline while many studies have linked habitat loss and degradation to population declines (Reese and Connelly 2011). Still, there is debate whether harvest mortality is additive or compensatory to natural mortality. Gibson et al. (2011) found that harvest mortality was additive to natural mortality in an isolated sage-grouse population subject to conservative hunting seasons in California. In Gibson et al.’s study, total sage-grouse harvest explained substantial variation in inter-annual population change suggesting additive hunting mortality resulted in a population decline. Results from Connelly et al. (2003) also suggest hunting mortality is additive in sage-grouse. Sedinger et al. (2010) found harvest rates near 10% were compensatory in a Colorado study. Sustainable harvest rates of 5–10% of fall populations have been suggested (Reviewed in Reese and Connelly 2011), but regulations should be tailored for specific populations and circumstances. A comprehensive white paper produced by WAFWA on hunting sage-grouse can be viewed here.

The plan will use a science-based adaptive harvest strategy for future hunting season recommendations. The total number of males counted on all leks in Butte and Harding counties will be the primary source of data to base hunting season recommendations. A short (2-4 day) resident only season will be considered when ≥ 300 males are counted on all leks in Butte and Harding counties for 2 consecutive years (Table 3). The threshold of 300 was selected because it represents a much above average level, and a level at which limited harvest would not harm the population. The plan recommends a drawing for up to 40 access permits to limit the potential harvest during the season. A similar approach was used in 2016 when 28 hunters harvested 10 sage-grouse. A sage-grouse season will not be recommended if the species is listed as threatened or endangered under the Federal Endangered Species Act or State Endangered Species Law. This ultra conservative approach would not lead to over harvest of sage-grouse. It is unlikely that the population would reach a high enough level to warrant a liberal hunting season because SD's fringe habitat is inherently marginal.

Table 2. South Dakota sage-grouse hunting season records 1955–2021.

Year	Season Dates	County	♂ Adult	♂ Juv	♀ Adult	♀ Juv	Male/ Female	Juvenile/Adult Males	Juvenile/Adult Females	Juv/Adult	# Hunters	Total Harvest
1955[ab]	Sept. 17-18	Harding & Butte	10	10	21	18	0.51	1.00	0.86	2.93	NA	600
1956-58[c]	Season Closed											
1959-61[c]	Unknown	Unknown	No Harvest Data									
1962-68[c]	Season Closed											
1969[c]	Aug. 30-Sept. 5	Harding & pt. Butte	No Harvest Data									
1970-72[c]	Listed as a Season in Hunting Handbook - No Harvest Data											
1973[c]	Aug. 25-31	Harding & Butte	NA	NA	NA	NA	0.59	NA	NA	1.01	80	271
1974	7-Day Season	Harding & Butte	16	7	28	11	0.59	0.44	0.39	0.41	29	37
1975	5-Day Season	Harding & Butte	5	1	10	4	0.43	0.20	0.40	0.33	28	20
1976-77[c]	Season Closed											
1978[c]	Sept. 1-7	Harding & pt. Butte	No Harvest Data									
1979[c]	Sept. 4-6	Harding & Butte	NA	NA	NA	NA	NA	NA	NA	1.75	27	13
1980[c]	Sept. 2-4	Harding & Butte	No Harvest Data									
1981-1999	Season Closed											
2000[d]	Sept. 20-21	Harding & Butte	6	10	1	7	2.00	1.67	7.00	2.43	28	24
2001[d]	Sept. 26-27	Harding & Butte	5	2	2	3	1.40	0.40	1.50	0.71	27	12
2002[d]	Sept. 25-26	Harding & Butte	5	5	3	3	1.67	1.00	1.00	1.00	32	16
2003[d]	Sept. 24-25	Harding & Butte	6	1	1	4	1.40	0.17	4.00	0.71	36	12
2004[d]	Sept. 22-23	Harding & Butte	8	5	0	12	1.08	0.63	0.00	2.13	53	25
2005[d]	Sept. 28-29	Harding & Butte	8	6	2	10	1.17	0.75	5.00	1.60	40	26
2006[d]	Sept. 27-28	Harding & Butte	2	7	2	4	1.50	3.50	2.00	2.75	46	15
2007[d]	Sept. 26-27	Harding & Butte	3	5	0	2	4.00	1.67	0.00	2.33	25	10
2008[de]	Sept. 24-25	Harding & Butte	6	3	3	5	1.13	0.50	1.67	0.89	24	17
2009[de]	Sept. 30-Oct. 1	Harding & Butte	0	2	2	3	0.40	-	1.50	2.50	20	7
2010[de]	Sept. 29-30	Harding & Butte	6	1	5	0	1.40	0.17	0.00	0.09	26	12
2011[de]	Sept. 28-29	Harding & Butte	3	3	3	2	1.20	1.00	0.67	0.83	27	11
2012[de]	Sept. 26-27	Harding & Butte	3	0	6	0	0.50	-	-	0.00	35	9
2013-2015	Season Closed											
2016[f g]	Sept. 17-18	Harding & Butte	1	3	2	4	0.40	3.00	2.00	2.33	28	10
2017-2021	Season Closed											

a. 1955 was first season since 1935
b. based on W-17-R-11 Job Completion Report. Harvest was estimated from questionaires. Sex and age data based on field checks
c. Information limited from 1956-1980; data sources (SD GFP P-R Project W-95-R-Jobs 1-8; Jerry Kobriger & George Vandel, pers. comm.)
d. Season open only on public lands and walk-in areas in Harding County and Butte County west of U.S. Hwy. 85.
e. In 2008, volunteer check stations at designated locations replaced field checks to determine hunter harvest and obtain biological information.
f. Mandatory check in of harvested sage-grouse
g. 40 access permits available through lottery drawing

Table 3. Sage-grouse hunting season recommendation guidelines for South Dakota 2021–2026.

Population Index	Hunting Season Recommendation
≥ 300 males counted on all leks in Butte and Harding counties for 2 consecutive years	Option for short (~2-4 day) hunting season in Harding County and Butte County west of US HWY 85, limit 1 sage-grouse per hunter per season. Random drawing for up to 40 access permits
< 300 males counted on all leks in Butte and Harding counties OR ≥ 300 males counted on all leks in Butte and Harding counties for only 1 year	No Hunting Season

SAGE-GROUSE RESEARCH IN SOUTH DAKOTA

Smith (2003, et al. 2005) evaluated landscape-level landuse surrounding sage-grouse leks using 2.5 mi (4 km) buffers in North and South Dakota. No difference in the percentage of cultivated lands was detected between active and inactive leks or between active leks and random sites in SD. However, no active leks were found in northeastern Harding County or southeastern Butte County, areas of which have higher cultivation than the rest of the counties. The lack of consistent historical records of lek locations may have prevented the ability to link cultivation to lek abandonment in this study.

Kaczor (2008, et al. 2011) studied the nesting and brood-rearing ecology of sage-grouse in Butte County during 2006 and 2007. Nest initiation was 96% with nest success estimated at 46%. Sixty-eight percent of nests were within 1.9 mi (3 km) of an active lek and 97% were within 4.3 mi (7 km). Hens selected nest sites with higher sagebrush cover and visual obstruction than what was available at random sites. Nest sites were composed of lower sagebrush canopy cover (10%) but higher grass height (10.6 in, 27 cm) and visual obstruction (4.2 in, 10.7 cm) than nest sites of sage-grouse within their core range of the Intermountain West (Kaczor 2008). Overall nest success was 45.6% with predation being the primary cause of nest failure. Documented nest predators included red fox (*Vulpes vulpes*), Badger (*Taxida taxus*), Coyotes (*Canis latrans*), and unknown avian. Red fox were the primary nest predator, destroying 34% of all nests compared to only 7% by coyotes. Survival of chicks to 3 weeks of age was 52%. Survival of chicks to 7 weeks of age varied by year and was 31–43%. Hens with broods selected areas of higher visual obstruction, bluegrass cover, sagebrush cover and sagebrush density than what was available at random. Documented causes of chick mortality included WNV infections and predation by red foxes, coyotes, bobcats (*Lynx rufus*), long-tailed weasels (*Mustella frenata*), and red-tailed hawks (*Buteo jamaicensis*). WNV was detected in 35% of samples submitted from dead chicks. Considering many samples were inconclusive due to environmental exposure, up to 60–70% of chick mortalities could have been attributed to WNV during 2006 and 2007. Results from this study suggest preservation of sagebrush cover and conservative utilization of rangeland will be important in providing high quality nesting and brood-rearing habitat for sage-grouse.

Swanson (2009, et al. 2013) investigated factors that influenced survival, brood breakup, seasonal movements, and winter habitat use of sage-grouse during 2006–2008. Swanson's research indicated that adult and juvenile survival was relatively high November through June (monthly survival = 0.97, SE = 0.01) but much lower during July through October when WNV likely caused reduced survival (monthly survival = 0.97, SE < 0.01). Low recruitment possibly caused by WNV was cited as a possible limitation to the sustainability of the low-density sage-grouse population. The median date of brood breakup was observed around the 4th of October when the chicks were near a median age of 134 days old. Sage-grouse displayed a moderate level of migration, with more pronounced movements occurring in spring and more subtle movements in summer and winter. Most sage-grouse were considered non-migratory. Winter habitat use in the region demonstrated that 15% sagebrush canopy cover and 7.9 in (20 cm) sagebrush height met their winter habitat requirements during winters with below normal snowfall. Swanson (2009) recommended that critical winter habitat areas be identified, and management of the sagebrush community structure be implemented.

Parsons (2019, et al. 2021) studied survival, breeding ecology, resource selection, and influence of WNV on sage-grouse in Harding County. WNV was only a suspected cause of death for one bird during the 2 year study. Estimated WNV minimum infection rate for *Culex tarsalis* during 2016 and 2017 was 3.3/1,000 and 1.6/1,000, respectively, resulting in a WNV prevalence rate of 0.2−7.8%. Larval *Culex tarsalis* were found in all water body types except stock tanks. Only 1.9% of sage-grouse had WNV antibodies which indicates the population is susceptible to future outbreaks. Hen survival during the reproductive season (1 April−15 September) was 0.68 (95% CI= 0.56–0.78). Mammalian predators were the leading suspected cause of mortality (40%), followed by unknown (25%), avian predation (15%), unknown predation (15%), and WNV (5%). Nest success was 29%, mammalian depredation was the primary cause of nest failure. Cameras were deployed on 25 of 46 failed nests. Cause-specific nest failures could be determined for 12 of the 25 failed nests with cameras. American badger depredation caused 50% of known cause nest failures (n=6), followed by coyote depredation (n=2), and abandonment (n=2). One nest was depredated by a striped skunk and one nest was found intact, but the female sage-grouse had been predated. Vegetation structure (e.g. grass height, shrub height) at and surrounding the nest site did not influence nest survival. However, hens selected nest sites with taller shrubs, taller grass, and more shrub cover than what was available. Bird location data from this study and previous studies in SD were combined, and resource selection functions and associated predictive maps were developed.

GFP is also engaged with USGS and BLM researchers on ongoing projects that support sage-grouse management in SD, including studies that 1) collect GPS tracking data to develop seasonal habitat maps and investigate sage-grouse ecology, 2) synthesize existing telemetry data to map seasonal habitat across the entire geographic range, 3) develop vegetation monitoring techniques for the sagebrush ecosystem with unmanned aerial systems, 4) map invasive sweetclover and evaluate effects on habitat quality for sage-grouse, 5) accurately map sagebrush in SD for fine-scale habitat modeling, and 6) characterize microclimate for assessing effects of fine-scale variation in temperature on sage-grouse habitat selection. Collectively, these studies seek to improve habitat prioritization and understanding of population dynamics for sage-grouse in SD.

ISSUES, CHALLENGES, AND OPPORTUNITIES IN SOUTH DAKOTA

Loss, fragmentation and alteration of sage-steppe habitat remains the greatest threat to sage-grouse populations across their range. Thus, management practices aimed at maintaining large tracts of intact habitat remain a priority across their range and in SD. This section outlines key management issues in SD including how GFP addresses each issue. Additionally, recommendations are provided to avoid or minimize negative impacts to sage-grouse habitat by specific threats.

Grazing and associated infrastructure (fence, water)

Livestock grazing is the most common use of sage-steppe lands in SD. Livestock grazing has the potential to have positive, neutral, or negative impacts on sage-grouse (Beck and Mitchell 2000). In the 2015 USFWS ESA listing decision, livestock grazing was determined to be a compatible use with sage-grouse and was not considered a range-wide threat to the species (USFWS 2015). Until recently, it was thought that there was a strong correlation between grass height and nesting success, and therefore, grass height targets of 7-10” were a common management objective (Connelly et al. 2000). Management guidelines with grass height targets were frustrating for managers and producers because grass height potential is influenced by grazing and uncontrollable factors such as weather and ecological site.

Recent research has cast doubt on the need for universal grass height targets in management guidelines. Many research studies on this topic were based on biased data in that grass height was measured at nest fate, so measurements at successful nests were taller than unsuccessful nests that were measured earlier in the growing season (Gibson et al. 2016). After correcting for this bias, evidence for a consistent relationship between grass height and nesting success was lacking (Smith et al. 2018a), although the relationship remained for at least one study (Doherty 2014). A recent meta-analysis of all available sage-grouse nesting datasets also showed no pattern in nest survival related to any fine scale habitat measurements (Smith et al. 2020). Parsons (2019) measured grass height after hatch or predicted hatch date, and did not find a relationship between grass height and nesting success in SD. Similar results were reported by a nearby study in Southeastern Montana (Foster et al. 2014). Both Parsons (2019) and Foster et al. (2014) reported grass height at nest sites to be well above range-wide averages reported in (Smith et al. 2020). In SD, Parsons (2019) observed an average grass height of 18.8” at nest sites in 2016–2017, and 70 of 71 nests had grass taller than 10”. Even though 2016 was a drought year, grass height at nest sites far exceeded published guidelines (Connelly et al. 2000) and heights observed in most sage-grouse studies across the range (Smith et al. 2020). The relatively tall observed grass height at nest sites likely contributes to valuable brood concealment cover as nests hatch.

Although difficult to quantify, rangeland within the sage-grouse range of SD is thought to be in good condition. On BLM lands, 94% of allotments are meeting rangeland health standards (BLM 2019) and observed grass height at nest sites appears adequate (Parsons 2019). However, working with landowners on voluntary actions to enhance already sound grazing practices will remain a priority moving forward. The department will continue to advocate for sound range management through its' Private Lands Habitat Program, and through partnerships with the South Dakota Grassland Coalition, South Dakota State University Extension, Natural Resources Conservation Service (NRCS), American Bird Conservancy (ABC), Bird Conservancy of the Rockies (BCoR), Pheasants Forever (PF) and others which will result in an enhanced level of education and outreach as well as technical and program-based assistance to ranchers. The desired strategy remains to work in tandem with landowners and other partners to improve range health and resiliency, sustain a local ranch-based economy thereby conserving and enhancing sage-grouse habitat. Overall, SD GFP's view on grazing aligns with Smith et al. (2018b):

> *"Grazing management that promotes robust, diverse native plant communities resistant to invasion by exotic annuals and resilient to disturbances such as drought and fire and prevents transitions to less desirable vegetation community states is critical to maintain the basic habitat components needed by sage-grouse over the long term."*

In portions of their range, fence collisions are considered a substantial mortality factor for sage-grouse (Stevens et al. 2012a). Probability of fence collisions by sage-grouse during the breeding season has been found to be most influenced by proximity of a fence to a lek and landscape ruggedness (Stevens et al. 2012a). Marking of fences reduces risk of collision (Stevens et al. 2012b). Of 135 and 20 sage-grouse deaths recorded in the Dakotas by Swanson (2009) and Parsons (2019) respectively, none were confirmed as fence collisions. We do not consider fence collisions as a major threat to sage-grouse in SD. However, we do not recommend building new fences within 1 mile of leks sites. If sage-grouse mortalities are observed at a fence, we recommend marking the fence.

Recommended avoidance measures

- Avoid overgrazing, especially in core areas. Overgrazing is the continued heavy grazing which exceeds the recovery capacity of the plant community and creates a deteriorated range (Society for Range Management 1998)

- Avoid building new fences within 1/2 mile of leks attended since 2000

- Implement grazing regimes which result in varying use through space and time

- Provide alternative water sources (e.g. tanks) to alleviate perennial/repetitive late season grazing in riparian/mesic areas which could enhance brood habitat. Note, water tanks are not known to be used by WNV-carrying mosquitos.

Recommended minimization measures

- Mark fences known to cause sage-grouse mortalities

- Avoid disruptive activities such as but not limited to well drilling, pipeline installation, or building new fence during the lekking season (March 1 – May 15) from 1 hour before sunrise to 2 hours after sunrise within 2 miles of leks attended in the current year.

Fire

Frequency of wildfires in the sage-brush ecosystem has increased since European settlement primarily due to human-caused ignitions and invasion of rangelands by the annual, early-senescing, highly flammable, and exotic cheatgrass (Baker 2011, Miller et al. 2011). Although historic fire regimes were compatible with sage-grouse habitat, the long recovery time of sagebrush after fire makes more frequent burns a serious threat to sage-grouse habitat. The issue of increased fire frequency and invasion by cheatgrass has been most prominent in the intermountain west, but increased fire frequency has been observed in all portions of the sage-grouse range (Miller et al. 2011). SD has been mostly spared from devastating fire in sage-grouse habitat, but the threat remains, although to a lesser extent than other portions of the sage-grouse range.

GFP is not directly responsible for fire suppression, but we do address the threat of fire in direct and indirect ways. Overgrazing is one mechanism that has led to increased coverage of cheatgrass. Overgrazing is the continued heavy grazing which exceeds the recovery capacity of the plant community and creates a deteriorated range (Society for Range Management 1998). The Department's advocacy for well-managed rangelands that was outlined in the previous section indirectly reduces rangeland susceptibility to cheatgrass invasion and the associated elevated fire risk. Prevention of and prompt response to wildfires is within the best interest of property owners and residents and is necessary to protect sage-steppe habitat. The GFP has addressed the threat of wildfire primarily during the firearm antelope season when fire conditions can be favorable and hunter activity can increase the threat of wildfire ignition. When wildfire conditions are favorable during the firearm antelope season, the GFP has conducted aerial reconnaissance in areas of high hunter density so wildfires could be quickly located and addressed. The GFP has also mobilized additional firefighting equipment including tanker aircraft to high risk areas. Press releases have also been used to make hunters and other members of the public aware of elevated wildfire risk situations and ways to prevent wildfires. The GFP will continue to take these actions in the future.

Recommended avoidance measures

- Avoid deliberate burning of sage-steppe habitat.

Recommended minimization measures

- Suppress wildfires in sage-steppe habitat as quickly as possible.

- Monitor post-fire vegetation response. If sagebrush does not recolonize consider supplemental seedings to enhance sagebrush re-establishment.

Energy Development and Minerals

Oil and Gas - Across the sage-grouse range, there is a high overlap among oil and gas development, potential for additional oil and gas development, and sage-grouse habitat (Naugle et al. 2011, Juliusson and Doherty 2017). Numerous studies have documented direct and indirect negative impacts on sage-grouse from oil and gas development and related infrastructure (Naugle et al. 2011, Holloran 2005, Aldridge and Boyce 2007, Walker et al. 2007, Doherty et al. 2008, Kirol et al. 2020). The impacts are generally more severe as disturbance (e.g. road or well density) of development increases (Naugle et al. 2011). Holloran (2005) found well densities greater than 1 pad/square mile impacted sage-grouse populations while densities of 8 wells per square mile exceeded the species threshold to exist (Holloran 2005, Walker et al. 2007). However, Kirol et al. (2020) examined data from over 1,000 nest locations and nearly 3,000 brood-rearing locations and found reduced survival of both at any level of energy-related surface disturbance. This suggests disturbance caps within nesting and brood-rearing habitat will not prevent negative impacts to nest and brood survival.

Within SD's sage-grouse range, oil and gas development has been limited (Figures 7, 8, and 9), and the potential for future development is predicted to be far less than areas farther west (Juliusson and Doherty 2017). Subsurface mineral rights within the core area are a mixture of public (state and federal) and private ownership. GFP reviewed and provided comment during the BLM Resource Management Plan (RMP) development (BLM 2015). The current BLM RMP includes no surface occupancy restrictions for oil and gas development in Priority Habitat Management Areas (PHMA) which is analogous to the core area from the 2014–2018 SD sage-grouse management plan. GFP will coordinate with the BLM and review any proposed actions related to the RMP or oil and gas development related to sage-grouse habitat. GFP will also provide the BLM updates to the core area map.

There are no formal procedures for GFP environmental review of state-owned subsurface mineral leases or drilling permit applications. Oil and gas drilling permits are issued by the South Dakota Department of Agriculture and Natural Resources (SDANR). Only 4 oil/gas drilling permits were issued in 2019, all in Fall River County (https://denr.sd.gov/des/og/newpermit.aspx). Drilling permits are valid for one year and not all permitted wells are drilled. There is opportunity to collaborate with SPL and SDANR to develop standardized methods for review of new applications for oil and gas leases and drilling permits within core areas which would assure sage-grouse habitat is considered when issuing permits and leases. An inter-department memorandum of agreement (MOA) among GFP, SDANR, and SPL to establish an environmental review process is identified as a strategy in action plan

Other Minerals - Among other minerals, bentonite mining has potential in the sage-grouse core area (Hosterman and Patterson 1922). Similar to other surface-disturbing development such as oil and gas, bentonite mining has been linked to avoidance behavior and reduced survival in sage-grouse (Pratt and Beck 2019). GFP is peripherally involved in the mineral exploration, extraction, and reclamation process by codified law 45-6-69 (notification of intent of operation at new mine site by operator), 45-6B-11 (may provide comment to SD DENR on reclamation plans), 45-6C-10 (may review and suggest restrictions to exploration operations that may impact riparian habitat or threatened or endangered species), and 45-6D-13 (may review and suggest restrictions to uranium exploration operations that may impact riparian habitat or threatened or endangered species (http://legis.sd.gov/Statutes/Codified_Laws/default.aspx).

Wind - Wind energy development is rapidly expanding across the United States (www.energy.gov/eere/wind/articles/top-trends-wind-technology) including some development in sage-grouse habitat. Within core areas, 76% of the landscape is categorized as having good to excellent wind power potential (Figure 11), although no development has occurred in the core areas. There is limited information related to potential impacts of wind energy on sage-grouse. Sage-grouse nest and brood survival declined with proximity to a wind turbine (LeBeau et al. 2014), but a larger sample covering more years revealed no effect on the same metrics (LeBeau et al. 2017a). LeBeau et al. (2017b) found no effect of a wind-energy facility on the trends in the number of males attending leks from pre- to post-development within a control and treatment area. LeBeau et al. (2019) found no effect of a wind energy facility on nest site selection, but LeBeau et al. (2017a) found females avoided wind energy infrastructure during brood-rearing and post-brood-rearing periods. LeBeau et al. (2014, 2017a) found no effect of wind energy development on adult survival.

For projects 100 MW or larger, wind energy developers must consult with the GFP for an environmental review as part of the PUC permitting process. The GFP may also be consulted for an environmental review if the project has a federal nexus which initiates the National Environmental Policy Act process.

Solar – Solar energy generation is rapidly increasing in the United States (https://www.eia.gov/renewable/data.php#solar), but only 2 utility scale solar generation facilities capable of generating 238 MW have been permitted in SD (puc.sd.gov). Only facilities ≥ 100 MW require a PUC permit. The direct impacts of solar generation infrastructure on sage-grouse is poorly understood, but the physical footprint of such facilities can be substantial with high likelihood of displacing sage-grouse if built in suitable habitat.

Recommended avoidance measures

- Avoid new development including associated infrastructure that would be additive to the current physical footprint within core areas and within 4 miles of leks that have been active since 2000.

Recommended minimization measures

- Minimize additional physical footprint from new development in core areas by utilizing existing roads and infrastructure (e.g. well pads).
    - If additional physical footprint is to occur in core areas, avoid development in sage-steppe habitat (e.g. target cropland, hayland, or non-habitat for development) if available.
- Avoid disruptive activities (e.g. drilling, pumping, construction, vehicle traffic and other noise producing activities) within core areas during the lekking, nesting and brood-rearing season (March 1-August 15), especially within 4 miles leks attended in the current year.
    - If disruptive activities cannot be avoided within 2 miles of attended leks during the lekking season of March 1–May 15, limit disruptive activities to 2 hours after sunrise to one hour before sunset within 2 miles of attended leks
- Include sound mitigation measures (e.g. mufflers, earthen berms) to reduce impacts from sound-producing infrastructure (pumping stations, etc.) in core areas
- Bury new transmission lines in core areas. If above ground transmission lines are built, install ant-perching devices to reduce use by raptors.
- Restore de-commissioned sites in core areas to expected native vegetation state including sagebrush where applicable.

Cultivation and other direct removal of sagebrush

Conversion of sage-steppe to cropland results in direct loss of sage-grouse habitat. An estimated 11% of the range-wide pre-settlement sagebrush acreage has been converted to cropland (Knick et al. 2011). Only 2.7% of the SD sage-grouse core area is classified as cropland by the 2019 National Landcover Dataset. A study evaluating sage-grouse in northwestern SD determined that the percentage of tilled ground within 2.5 mi (4 km) of active leks was no different in 1999–2000 compared to 1972–1976, nor was there a difference between the percentage of tilled ground near active and non-active leks for the same time periods (Smith 2003, 2005). Bauman et al. (2019) found 91.6% of the sage-grouse core area was undisturbed as of 2013. Sagebrush can also be eliminated by herbicide treatment or direct removal, although it is unknown to what extent this has historically or contemporarily occurred in SD.

Recommended avoidance measures

- Avoid conversion of sage-steppe to cropland in core areas
- Avoid elimination (herbicide treatment, direct removal) of sagebrush in core areas

Recommended minimization measures

- Avoid conversion of sage-steppe to cropland within 4 miles of leks attended since 2000
- Avoid sagebrush removal (herbicide treatment, direct removal) within 4 miles of leks attended since 2000
- Restore sage-steppe habitat in areas previously impacted by cropland conversion, herbicide treatment or direct removal of sagebrush

West Nile Virus

The arrival and rapid spread of the WNV since 1999 represents yet another threat to sage-grouse populations. WNV is a mosquito-borne flavivirus that predominately exists in a mosquito-bird-mosquito infection cycle. Once infected, sage-grouse exhibit very low survival rates and most die within 6-8 days of infection. Sage-grouse show very little resistance to WNV with limited potential to increase resistance over time (Walker and Naugle 2011). WNV outbreaks in 2006 and 2007 resulted in high sage-grouse mortality rates in SD (Kaczor 2008). Above normal July and August temperatures appear to contribute to WNV outbreaks, likely due to increased mosquito larval growth and adult activity, as well as increased virus replication rates within the host mosquito. Declines in sage-grouse abundance since 2007 as measured by spring lek counts may be partially explained by the WNV outbreaks of 2006 and 2007. Lek counts in adjacent Carter County Montana also declined sharply since a suspected WNV outbreak in 2007 (Foster et al. 2014). It is unknown if subsequent outbreaks of WNV have occurred since 2007, but a suspected outbreak did occur across the border in MT in 2010 (Foster et al. 2014).

In a 2016−2017 study in SD, only 1 sage-grouse mortality (5% of all mortalities) was attributed to WNV (Parsons 2019). The same study found only 3 of 158 sage-grouse (1.9%; 95% CI=0.4%−5.5%) contained WNV neutralizing antibodies during a 2016−2017 study. Although the study did not coincide with a WNV outbreak in sage-grouse, the population remains vulnerable to future outbreaks because very few individuals have immunity. During the same study, *Culex tarsalis* mosquito larvae were sampled from natural rivers, natural wetlands, stock ponds, stock dams, culverts/irrigation ditches and ephemeral water, but were not found in stock tanks. *Culex tarsalis* mosquito larvae occurred in ≤ 6% of samples from all water body types except culverts/irrigation ditches which was much higher at 33%. The results should be interpreted with caution because very few culverts/irrigation ditches were sampled. The presence of *Culex* *tarsalis* mosquito larvae in a variety of natural and artificial water sources represents a management challenge for WNV. Given the widespread availability of *Culex tarsalis* mosquito larvae habitat, it is unknown whether an increase or decrease in artificial water would influence the potential for a WNV outbreak in sage-grouse.

Recommended avoidance measures

- Avoid establishing new water bodies in core areas.

- Decommission artificial water bodies (stock dams, stock ponds) when alternative water sources (tanks) are available.

Recommended minimization measures

- Avoid establishing new water bodies within 4 miles of leks that have been active since 2000.

General habitat recommendations for core areas

- Remove encroaching trees, especially in sagebrush habitat. This applies to areas where the trees would not have historically occurred (e.g. in association with stock dams/ponds, planted trees), not trees in native ecological sites (e.g. riparian areas). Avoid tree establishment, except in association with existing trees or building sites, or ecological sites where they would have historically existed. Trees have a negative influence on sage-grouse habitat selection (Fedy et al. 2014). Removing trees can result in increased sage-grouse population (Olsen et al. 2021). Remove tall structures that could function similar to trees as raptor habitat (e.g. tall gate posts), or install anti-perching devices

- Avoid building new above ground power lines or similar tall structures, especially in sagebrush. Transmission lines have been found to have a negative influence on sage-grouse survival and habitat selection (LeBeau et al. 2019, Kohl et. al. 2019). Bury transmission lines/tall structures when possible. Remove decommissioned transmission lines/tall structures.

- Avoid building new roads, especially in sagebrush. Sage-grouse avoid roads (Fedy et al. 2014, Lazenby, et al. 2020). Restore unused roads to native conditions.

- Remove junk piles and abandoned buildings that could harbor generalist mammalian predators such as raccoons and striped skunks.

Partnerships and collaboration

Partnerships leverage GFP's capability to deliver habitat-related programs by pooling resources among entities. Since 2010, a key partnership among GFP, United States Department of Agriculture (USDA), and PF has funded a Range and Wildlife Conservationist position in the Belle Fourche NRCS office with the primary duty of implementing the USDA's Sage Grouse Initiative. The biologist utilizes federal conservation funds such as those provided through the Environment Qualities Incentives Program to encourage improved range management on privately managed lands which benefit sage-grouse. Since inception, the program has impacted over 350,000 acres through contracts with over 90 landowners. This partnership will likely remain a cornerstone of habitat management efforts in sage-steppe habitat. GFP is also engaged in a partnership with the ABC and USDA to fund a Conservation Specialist position stationed in the Buffalo NRCS office. Although not specific to sage-steppe habitat, the biologist works with producers on range management projects which have concurrent benefits to wildlife in Harding County. A similar partnership among GFP, BCoR and USDA support a biologist stationed in the Sturgis NRCS office which includes Butte County as a work area.

GFP works closely with federal land management agencies on sage-grouse management issues. GFP reviewed and provided feedback on the BLM RMP which was ultimately approved in September 2015. The BLM adopted the core areas as delineated in the *sage-grouse management plan South Dakota 2014−2018* as Priority Habitat Management Areas within the RMP. GFP and BLM shared data and expert opinion during the core area mapping process. GFP is committed to collaborating with BLM on sage-grouse management issues including future RMP revisions or other planning processes. The Forest Service (FS) is another key partner for sage-grouse management, although they manage far less sage-grouse habitat than BLM. GFP is collaborating with the FS on an ongoing Custer Gallatin National Forest (CGNF) planning process, which will apply to the Sioux Ranger District in SD. The final plan is scheduled to be released in 2021.

GFP is a member of the Western Association of Fish and Wildlife Agencies sagebrush executive oversight committee and inter-agency sagebrush conservation team. These groups have coordinated range-wide research and population monitoring; produced technical documents and white papers; and facilitated high level policy direction for the management of sage-grouse.

GFP, SPL, and SDANR have a common interest to conserve sage-grouse and their habitat. There are opportunities to improve collaboration among these 3 agencies to assure sage-grouse and their habitats are considered during state-involved procedures for energy development. A strategy identified in the action plan is to develop a streamlined environmental review process for state issued energy development permits or lease sales. If agreeable to all parties, the process will be described within a MOA which will be signed by department secretaries and made public. Although not regulatory in nature, this potential action is a good faith effort to integrate sage-grouse habitat considerations into state actions related to energy development.

Predation

Predation was not considered a primary threat to sage-grouse populations when the USFWS issued its not warranted ESA listing decision. Predation is a natural component of sage-grouse ecology and typically does not influence long term population trends when adequate habitat is available (Hagen 2011, Conover and Roberts 2016). We recommend habitat related mitigation measures to reduce predation as described in the previous section.

Mammalian predation is the primary cause of nest failure in SD. Parsons (2019) found 50% of nest failures were caused by American badger followed by coyotes (8%). A single nest was depredated by a striped skunk and red fox were not the cause of any known nest failures. In an earlier study, red fox were the primary nest predator, destroying 34% of all nests compared to only 7% by coyotes (Kaczor 2008). Parsons (2019) found during the spring and summer, mammals caused most mortalities (40%) followed by avian (15%). In a year-round study, Swanson (2009) found evidence of predation associated with 71% of sage-grouse deaths, with 58 and 42% of those deaths caused by mammals and raptors respectively.

Predator removal is occasionally suggested by the public to improve sage-grouse survival or nesting success. In western states, there is indication that raven removal can boost sage-grouse nest survival in areas where raven densities are very high and supported by human activities (reviewed in Conover and Roberts 2017). Although American badgers are a common sage-grouse nest predator, there is no research to determine whether removal increases nesting success of sage-grouse. Sage-grouse nesting success declined as more coyotes were removed in a Wyoming study (Dinkins et al. 2016). One possible explanation could be an increase in lower level predators in response to less competition with coyotes (Mezquida et al. 2006, Levi and Wilmers 2012). There are too few studies to conclude that predator removal increases survival rates of sage-grouse (reviewed in Conover and Roberts 2017). Raptors are protected under the 1918 Migratory Bird Treaty Act and eagles are further protected under the 1940 Bald and Golden Eagle Protection Act. Therefore, potential predator control is limited to mammalian predators.

Aggressive coyote removal efforts are already ongoing in Butte and Harding counties by GFP, multi-county predator control district, and USDA's Animal and Plant Health Inspection Service to protect livestock. Some red fox are also removed by operations targeting coyotes. It is unknown whether existing removal efforts are having a positive, negative, or neutral influence on sage-grouse survival or nesting success, or if there are unintended consequences from the release of lower level predators (e.g. red fox, American badger). American badger is the only common sage-grouse nest predator that is not already targeted by removal efforts. It is unknown if American badger control could improve nesting success or increase the population. Since mammalian predator control has not shown consistent benefits to sage-grouse (Conover and Roberts 2017) or other upland nesting game birds in SD (Docken 2011), there are no immediate plans in initiate predator control beyond current efforts.

Translocations

Release of translocated sage-grouse has been used with some success to increase sage-grouse population size, particularly for small and isolated populations. Releases conducted in the spring near lek sites in areas where physical barriers (e.g. mountain range) prevent large outward movements have been most successful (e.g. Duvuvuei 2017). It is unknown whether augmentations could be used successfully in SD. SD's sage-grouse range lacks a physical barrier with populations to the west which could allow released sage-grouse to disperse over long distances, thus not benefiting the target area. Furthermore, without a long-term solution to uncontrollable threats such as WNV, translocations would not be an effective recovery tool.

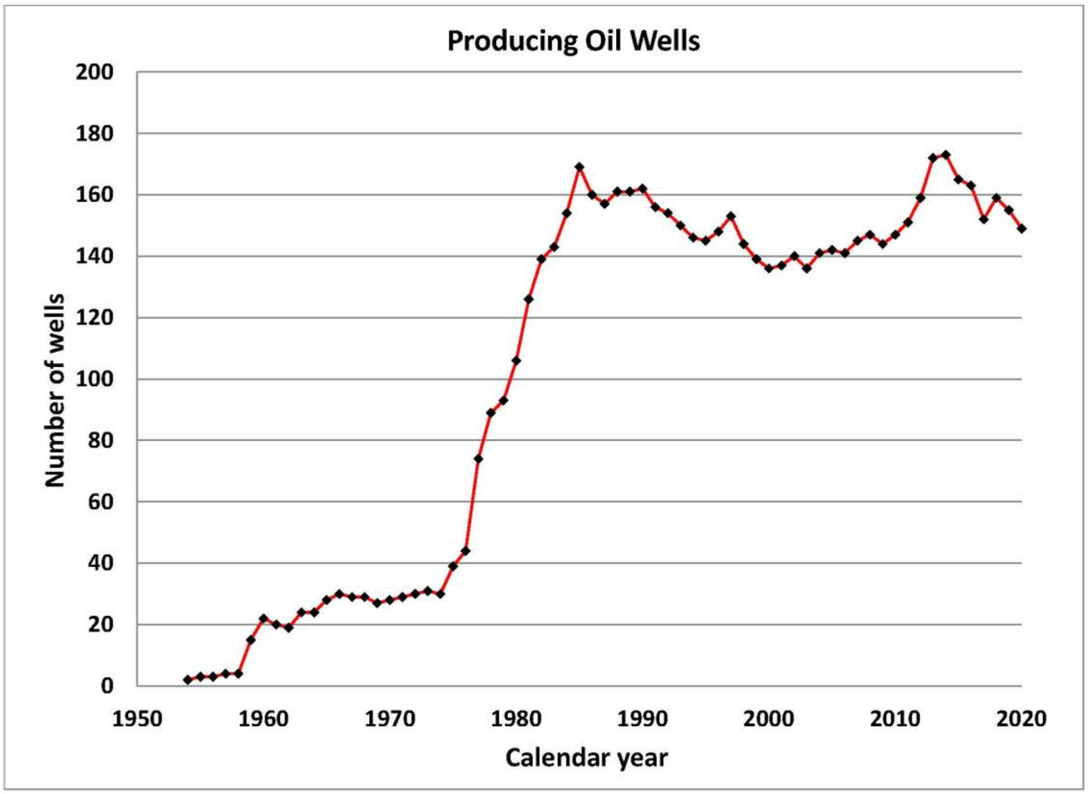

Figure 7. Producing oil wells in South Dakota, 1954–2020 (https://denr.sd.gov/des/og/producti.aspx).

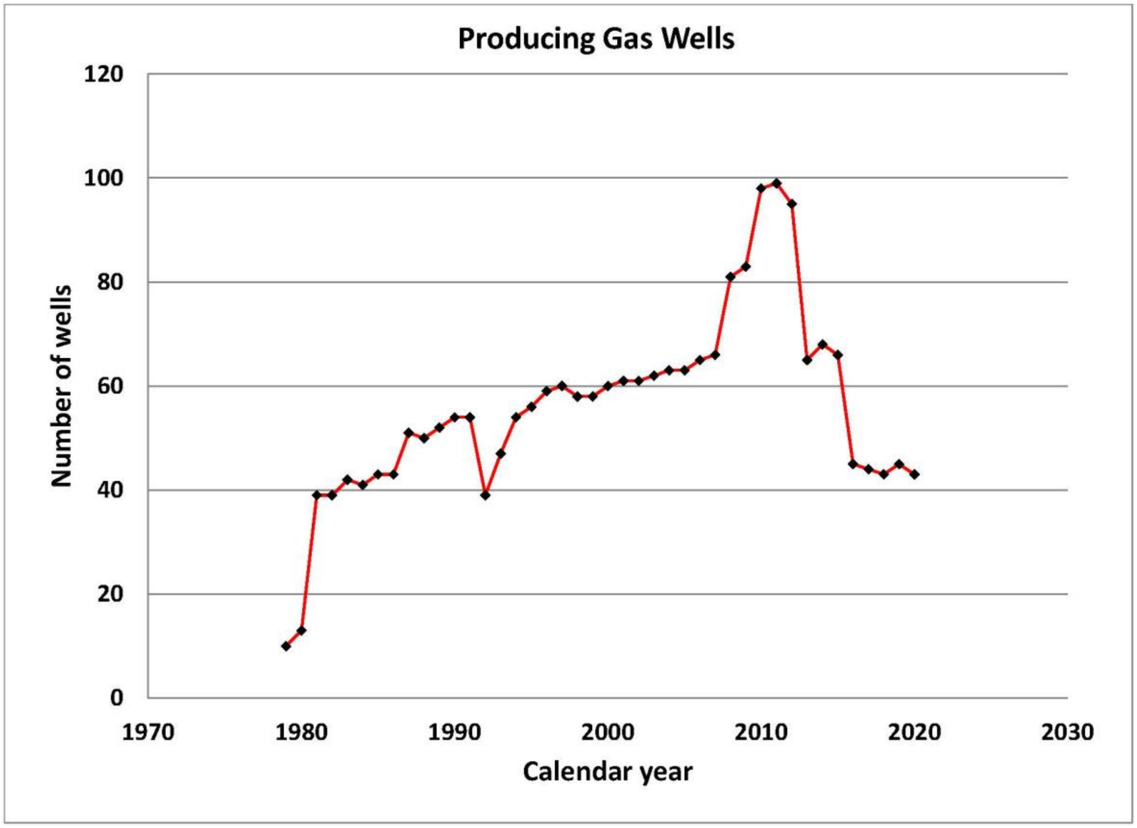

Figure 8. Producing gas wells in South Dakota, 1979–2020 (https://denr.sd.gov/des/og/producti.aspx).

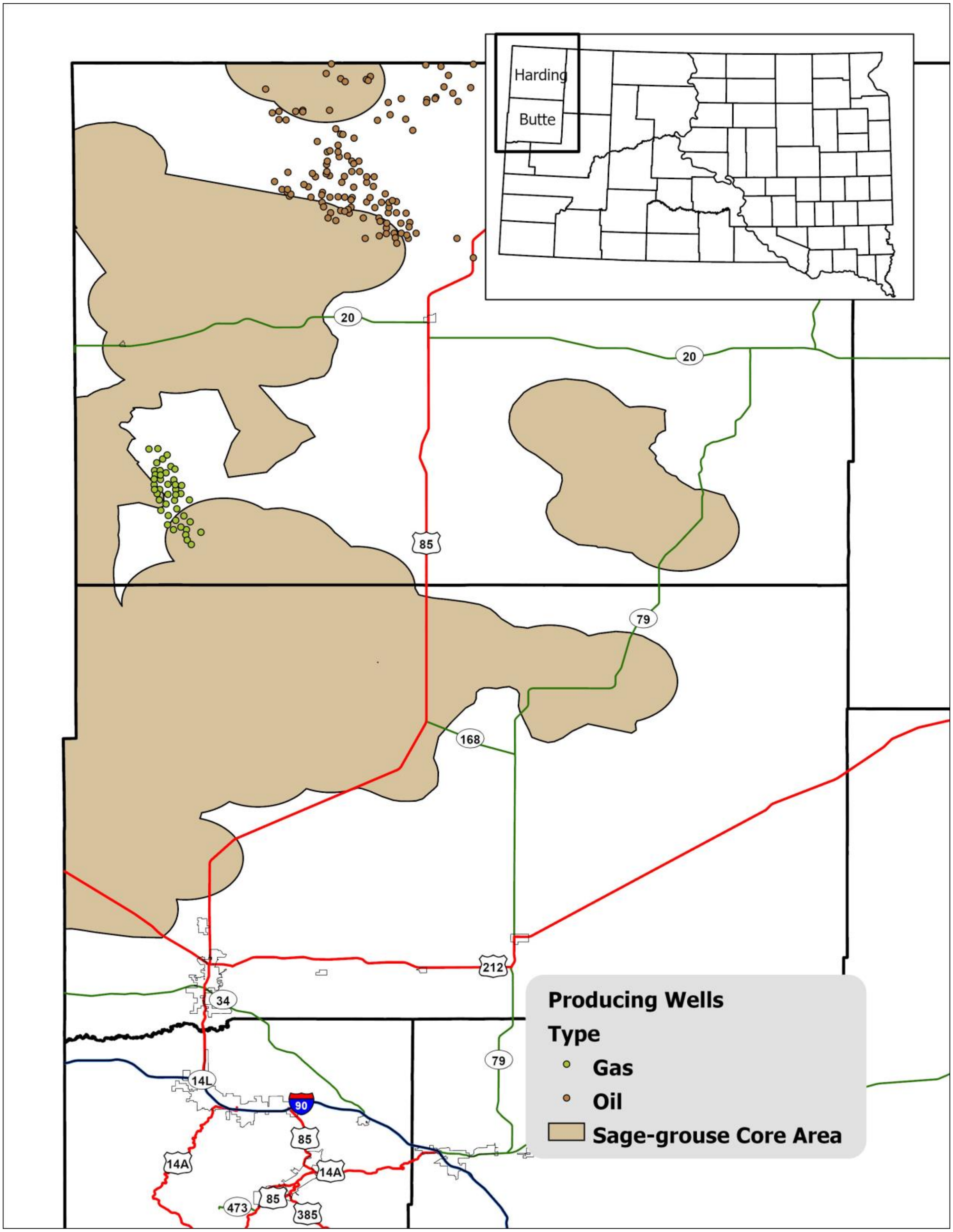

Figure 9. Relation of producing oil and gas wells to sage-grouse core areas in South Dakota.

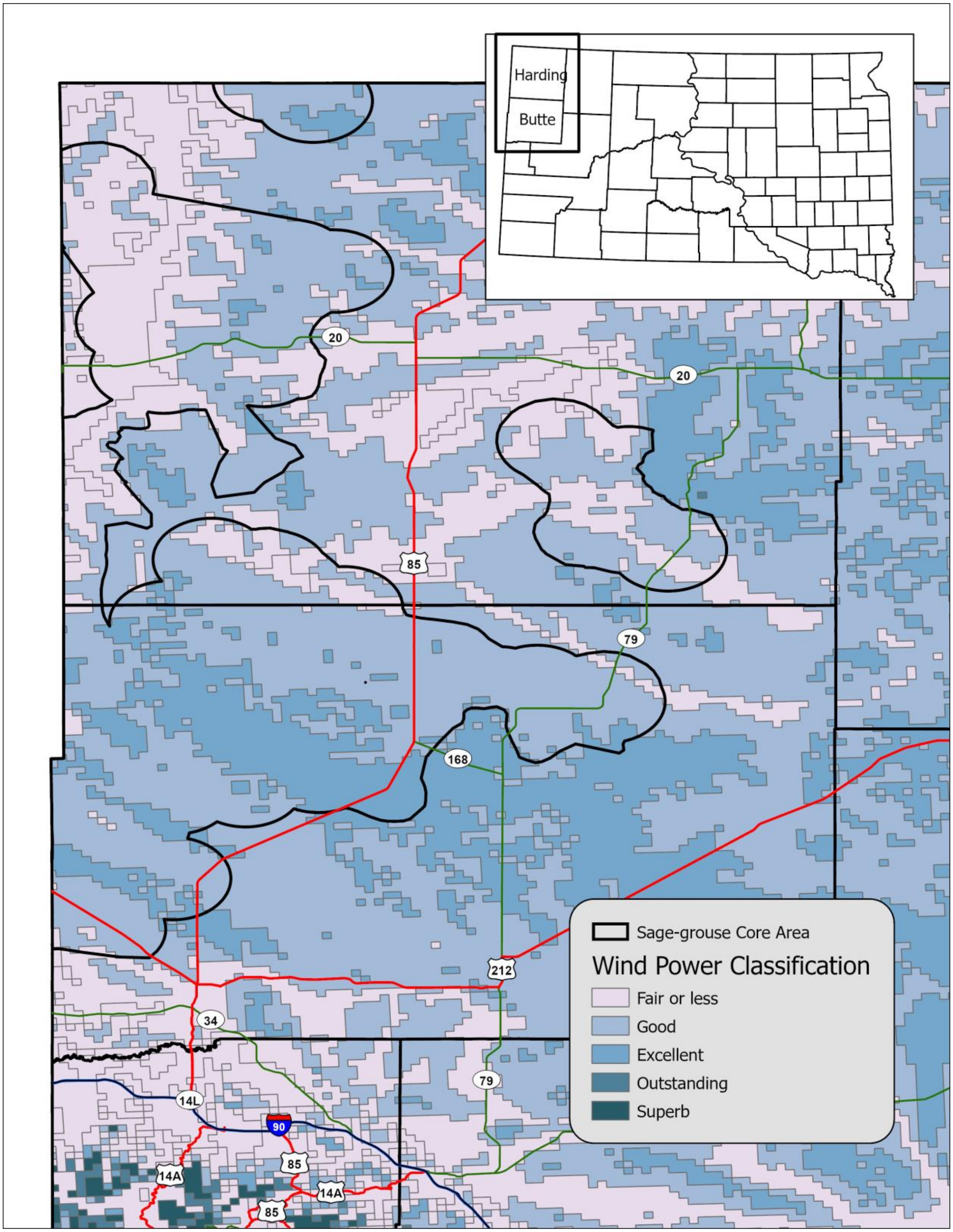

Figure 10. Wind power classification in relation to South Dakota sage-grouse core areas (National Renewable Energy Laboratory 2012).

LITERATURE CITED

Aldridge, C. L., S. E. Nielsen, H. L. Beyer, M. S. Boyce, J. W. Connelly, S. T. Knick, and M. A. Schroeder. 2008. Range-wide patterns of greater sage-grouse persistence. Diversity and Distributions 14:983–994.

Aldridge, C. L. and M. S. Boyce. 2007. Linking occurrence and fitness to persistence: habitat based approach for endangered greater sage-grouse. Ecological Applications 17:508–526.

Anderson, D. R. 2001. The need to get the basics right in wildlife field studies. Wildlife Society Bulletin 29:1294–1297.

Baker, W. L. 2011. Pre-Euro-American and recent fire in sagebrush ecosystems. Pp 185–201 *in* S. T. Knick and J. W. Connelly (editors). Greater Sage-Grouse: ecology and conservation of a landscape species and its habitat. Studies in Avian Biology 38. University of California Press, Berkeley.

Bauman, P., T. Butler and B. Richardson. 2019. Quantifying undisturbed (native) lands in western SD: September 2019 preliminary data. South Dakota State Extension Service.

Baumgardt, J. A. 2011. Probability of attendance and sightability of greater sage-grouse on leks: relating lek-based indices to population abundance. Ph.D. Dissertation. University of Idaho.

Beck, J. L., and D. L. Mitchell. 2000. Influences of livestock grazing on sage grouse habitat. Wildlife Society Bulletin 28:993–1002.

Blomberg, E. J., J. S. Sedinger, M. T. Atamian, and D. V. Nonne. 2012. Characteristics of climate and landscape disturbance influence the dynamics of greater sage-grouse populations. Ecosphere 3:1–20.

Bureau of Land Management. 2015. South Dakota approved resource management plan. United States department of the interior, bureau of land management South Dakota field office, Belle Fourche, South Dakota, USA.

Bureau of Land Management. 2019. Annual rangeland inventory and monitoring report. United States department of the interior, bureau of land management South Dakota field office, Belle Fourche, South Dakota, USA.

Bush, K. L. Genetic diversity and paternity of endangered Canadian greater sage-grouse (*Centrocercus urophasianus*). 2009. Ph.D. Dissertation, University of Alberta, Edmonton, Alberta. 202 pp.

Coates, P. S., Prochazka, B. G., O'Donnell, M. S., Aldridge, C. L., Edmunds, D. R., Monroe, A. P., Ricca, M. A., Wann, G. T., Hanser, S. E., Wiechman, L. A., and Chenaille, M. P. 2021. Range-wide greater sage-grouse hierarchical monitoring framework—Implications for defining population boundaries, trend estimation, and a targeted annual warning system: U.S. Geological Survey Open-File Report 2020–1154.

Connelly, J. W., S. T. Knick, M. A. Schroeder, and S. J. Stiver. 2004. Conservation Assessment of Greater Sage-grouse and Sagebrush Habitats. Western Association of Fish and Wildlife Agencies. Cheyenne, Wyoming.

Connelly, J. W., K. P. Reese, and M. A. Schroeder. 2003. Monitoring of greater sage-grouse habitats and populations. Experiment Station Bulletin 80, University of Idaho, Moscow.

Connelly, J. W., M. A. Schroeder, A. R. Sands, and C. E. Braun. 2000. Guidelines to manage Sage-grouse populations and their habitats. Wildlife Society Bulletin 28:967–985.

Connelly, J. W., and C. E. Braun. 1997. Long-term changes in sage-grouse *Centrocercus urophasianus* populations in western North America. Wildlife Biology 3:229–234.

Conover, M. R., and A. J. Roberts. 2017. Predators, predator removal, and sage-grouse: A review. The Journal of Wildlife Management 81:7–15.

Crawford, J. A., R. A. Olson, N. E. West, J. C. Mosley, M. A. Schroeder, T. D. Whitson, R. F. Miller, M. A. Gregg, and C. S. Boyd. 2004. Ecology and management of sage-grouse and sage-grouse habitat. Journal of Range Management 57:2–19.

Dinkins, J. B., M. R.Conover, C. P. Kirol, J. L. Beck, and S. N. Frey. 2016. Effects of common raven and coyote removal and temporal variation in climate on greater sage-grouse nesting success. Biological Conservation 202:50–58.

Docken, N. R. 2011. Effects of block predator management on duck and pheasant nest success in eastern South Dakota. M.S. thesis. South Dakota State University, Brookings, USA.

Doherty, K. E., D. E. Naugle, B. L. Walker, and J. M. Graham, J. M. 2008. Greater sage-grouse winter habitat selection and energy development. The Journal of Wildlife Management 72:187–195.

Doherty, K. E., J. D. Tack, J. S. Evans, and D. E. Naugle. 2010. Mapping breeding densities of greater sage-grouse: A tool for range-wide conservation planning. BLM completion report. 29 pp.

Doherty, K. E., D. E. Naugle, J. D. Tack, B. L. Walker, J. M. Graham, and J. L. Beck. 2014. Linking conservation actions to demography: grass height explains variation in greater sage-grouse nest survival. Wildlife Biology 20:320–325.

Duvuvuei, O. V., N. W. Gruber-Hadden, T. A. Messmer, M. R. Guttery, and B. D. Maxfield. 2017. Contribution of translocated greater sage-grouse to population vital rates. The Journal of Wildlife Management 81:1033–1041.

Drut, M. S., W. H. Pyle, and J. A. Crawford. 1994. Diets and food selection of sage-grouse chicks in Oregon. Journal of Range Management Archives 47:90–93.

Fedy, B. C., Doherty, K. E., Aldridge, C. L., O'Donnell, M., Beck, J. L., Bedrosian, B., Gummer, D., Holloran, M. J., Johnson, G. D., Kaczor, N. W., Kirol, C. P., Mandich, C. A., Marshall, D., McKee, G., Olson, C., Pratt, A. C., Swanson, C. C., and Walker, B. L. 2014. Habitat prioritization across large landscapes, multiple seasons, and novel areas: An example using greater sage-grouse in Wyoming. Wildlife Monographs 190:1–39.

Foster, M. A., J. T. Ensign, W. N. Davis, and D. C. Tribby. 2014. Greater sage-grouse in the southeast Montana sage-grouse core area. Final Report. Montana Fish, Wildlife and Parks and United States Department of the Interior Bureau of Land Management.

Gibson, R. M., V. C. Bleich, C. W. McCarthy, and T. L. Russi. 2011. Hunting lowers population size in greater sage-grouse. Pp. 307–315 *in* B. K. Sandercock, K. Martin, and G. Segelbacher (editors). Ecology, Conservation, and Management of Grouse. Studies in Avian Biology 39. University of California Press, Berkley.

Gibson, D., E. J. Blomberg, and J. S. Sedinger. 2016. Evaluating vegetation effects on animal demographics: the role of plant phenology and sampling bias. Ecology and Evolution 6:3621–3631.

Gregg, M. A., M. R. Dunbar, and J. A. Crawford. 2007. Use of implanted radiotransmitters to estimate survival of greater sage-grouse chicks. Journal of Wildlife Management 71:646–651.

Hagen, C. A. 2011. Predation on greater sage-grouse: facts, process, and effects. Pp. 95–100 *in* S. T. Knick and J. W. Connelly (editors). Greater sage-srouse: ecology and conservation of a landscape species and its habitat. Studies in Avian Biology 38. University of California Press, Berkeley.

Hodorff, B. 2013. Biological assessment and evaluation for the range allotment management plan in the Fall River West and Oglala geographic areas. United States Department of Agriculture, Forest Service.

Holloran, M. J. 1999. Sage-grouse (*Centrocercus urophasianus*) seasonal habitat use near Casper, Wyoming. M.S. Thesis, University of Wyoming, Laramie.

Holloran, M. J. 2005. Greater sage-grouse (*Centrocercus urophasianus*) population response to natural gas field development in western Wyoming. Dissertation, University of Wyoming, Laramie.

Hosterman, J.W., and S. H. Patterson. 1922. Bentonite and fuller's earth resources of the United States: U.S. Geological Survey Professional Paper 1522.

Hornaday, W. T. 1916. Save the sage-grouse from extinction: a demand from civilization to the western states. New York Zoological Park Bulletin 5:179–219.

Johnson, G. D. and M. S. Boyce. 1990. Feeding trials with insects in the diet of sage-grouse chicks. Journal of Wildlife Management 54:89–91.

Juliusson, L. M., and K. E. Doherty. 2017. Oil and gas development exposure and conservation scenarios for greater sage-grouse: combining spatially explicit modeling with GIS visualization provides critical information for management decisions. Applied geography 80:98–111.

Kaczor, N. W. 2008. Nesting and brood-rearing success and resource selection of greater sage-grouse in northwestern South Dakota. M.S. Thesis, South Dakota State University, Brookings.

Kaczor, N. W., K. C. Jensen, R. W. Klaver, M. A. Rumble, K. M. Herman-Brunson, and C. C. Swanson. 2011. Nesting success and resource selection of greater sage-grouse. Pp. 107–118 *in* B. K. Sandercock, K. Martin and G. Segelbacher (editors). Ecology, conservation, and management of grouse. Studies in Avian Biology 39. University of California Press, Berkeley.

Knick S. T. and J. W. Connelly (editors). 2011. Greater sage-grouse: ecology and conservation of a landscape species and its habitat. Studies in Avian Biology 38. University of California Press, Berkeley.

Knick, S. T., S.E. Hanser, R. F. Miller, D. A. Pyke, M. J. Wisdom, S. P. Finn, E. T. Rinkes, and C. J. Henny. 2011. Ecological influence and pathways of land use in sagebrush. Pp. 203–251 *in* S. T. Knick and J. W. Connelly (editors). Greater sage-grouse: ecology and conservation of a landscape species and its habitat. Studies in Avian Biology 38. University of California Press, Berkeley.

Kohl, M. T., T. A. Messmer, B. A. Crabb, M. R. Guttery, D. K. Dahlgren, R. T. Larsen, S. N. Frey, S. Liguori, and R. J. Baxter. 2019. The effects of electric power lines on the breeding ecology of greater sage-grouse. PloS one 14:e0209968.

Lazenby, K. D., P. S. Coates, S. T. O'Neil, M. T. Kohl, and D. K. Dahlgren. 2020. Nesting, brood rearing, and summer habitat selection by translocated greater sage-grouse in North Dakota, USA. Ecology and Evolution 11:2741–2760.

LeBeau C. W., J. L. Beck, G. D. Johnson, and M. J. Holloran. 2014. Short-term impacts of wind energy development on greater sage-grouse fitness. Journal of Wildlife Management 78:22–530.

LeBeau C. W., G. D. Johnson, M. J. Holloran, J. L. Beck, R. M. Nielson, M. E. Kauffman, E. J. Rodemaker, and T. L. McDonald. 2017a. Greater sage-grouse habitat selection, survival, and wind energy infrastructure. Journal of Wildlife Management 81:690–711.

Lebeau C. W., J. L. Beck, G. D. Johnson, R. M. Nielson, M. J. Holloran, K. G. Gerow, and T. L. McDonald. 2017b. Greater sage-grouse male lek counts relative to a wind energy development. Wildlife Society Bulletin 41:17–26.

Lebeau C. W., K. T. Smith, M. J. Holloran, J. L. Beck, M. E. Kauffman, G. D. Johnson. 2019. Greater sage grouse habitat function relative to 230-kV transmission lines. Journal of Wildlife Management 83:1773–1786.

Levi, T and C. C. Wilmers. 2012. Wolves-coyotes-foxes: a cascade among carnivores. Ecology 93:921–929.

Lewis A. R. 2004. Sagebrush steppe habitats and their associated bird species in South Dakota, North Dakota, and Wyoming: life on the edge of the sagebrush ecosystem. Ph.D. Dissertation, South Dakota State University, Brookings.

Mezquida, E. T., S. J. Slater, and C. W. Benkman. 2006. Sage-grouse and indirect interactions: potential implications of coyote control on sage-grouse populations. Condor 108:747–759.

Miller, R. F., S. T. Knick, D. A. Pyke, C. W. Meinke, S. E. Hanser, J. M. Wisdom, and A. L. Hild. 2011. Characteristics of sagebrush habitats and limitations to long-term conservation. Greater sage-grouse: ecology and conservation of a landscape species and its habitats. Pp 145–184 in S. T. Knick and J. W. Connelly. Greater sage-grouse: ecology and conservation of a landscape species and its habitat. Studies in Avian Biology 38. University of California Press, Berkeley.

National Agricultural Statistics Service. United States Department of Agriculture. 2013 Cropland Data Layer. Accessed 10/24/14.

National Renewable Energy Laboratory. 2012. Wind Data. http://www.nrel.gov/gis/data_wind.html. Accessed 11/8/12.

Naugle, D. E., K. E. Doherty, B. L. Walker, M. J. Holloran, and H. E. Copeland. 2011. Energy development and greater sage-grouse. Pp. 489–503 *in* S. T. Knick and J. W. Connelly. Greater sage-grouse: ecology and conservation of a landscape species and its habitat. Studies in Avian Biology 38. University of California Press, Berkeley.

Nelson, B. A. 1955. Some interesting facts about our pheasants and sage-grouse seasons. South Dakota Conservation Digest 22:2–4.

Olsen, A. C., J. P. Severson, J. D. Maestas, D. E. Naugle, J. T. Smith, J. D. Tack, K. H. Yates, and C. A. Hagen. 2021. Reversing tree expansion in sagebrush steppe yields population-level benefit for imperiled grouse. Ecosphere 12:e03551.

Over, W. H., and C. S. Thoms. 1921. Birds of South Dakota. Bulletin 9. University of South Dakota, Vermilion.

Parsons, L. 2019. Greater sage-grouse survival, breeding ecology, resource selection, and west nile virus prevalence on the eastern fringe of their range. Ph.D. Dissertation. South Dakota State University, Brookings. 245 pp.

Parsons, L. A., T. J. Runia, G. P. Vincent, A. J. Gregory, and J. A. Jenks. 2021. Greater sage-grouse survival varies with breeding season events in West Nile virus non-outbreak years. The Condor 123:1–14.

Patterson, R. L. 1952. The sage-grouse in Wyoming. Wyoming Game and Fish Commission and Sage Books, Inc., Denver, Colorado.

Podoll, E. 1957. Sage-Grouse Hunting Season, 1955. Completion Report. Project W-17-R-11. Department of Game, Fish, and Parks.

Pratt, A. C., and J. L. Beck, J. L. 2019. Greater sage-grouse response to bentonite mining. The Journal of Wildlife Management 83:866–878.

Reese, K. P. and J. W. Connelly. 2011. Harvest management of greater sage-grouse. Pp. 101–111 *in* S. T. Knick and J. W. Connelly. Greater sage-grouse: ecology and conservation of a landscape species and its habitat. Studies in Avian Biology 38. University of California Press, Berkeley.

Reese, K. P. and R. T. Bowyer (editors). 2007. Monitoring populations of sage-grouse. College of Natural Resources Experiment Station Bulletin 88. University of Idaho, Moscow.

Schroeder, M. A., C. L. Aldridge, A. D. Apa, J. R. Bohne, C. E. Braun, S. D. Bunnell, J. W. Connelly, P. A. Deibert, S. C. Gardner, M. A. Hilliard, G. D. Kobriger, S. M. McAdam, C. W. McCarthy, J. J. McCarthy, D. L. Mitchell, E. V. Rickerson, and S. J. Stiver. 2004. Distribution of sage-grouse in North America. Condor 106:363–376.

Schroeder, M. A., J. R. Young, and C. E. Braun. 1999. Sage-grouse (*Centrocercus urophasianus*). No. 425 in: The birds of North America, A. Poole, and F. Gill, editors. The Academy of Natural Sciences, Philadelphia, Pennsylvania; The American Ornithologists' Union, Washington, D.C.

Sedinger J. S., G. C. White, S. Espinosa, E. T. Partee and C. E Braun. 2010. Assessing compensatory versus additive harvest mortality: an example using greater sage-grouse. Journal of Wildlife Management 74:326–332.

Smith, J. T., L. D. Flake, K. F. Higgins, G. D. Kobriger, and C. G. Homer. 2005. Evaluating lek occupancy of greater sage-grouse in relation to landscape cultivation in the Dakotas. Western North American Naturalist 65:310–320.

Smith, J. T., L. D. Flake, K. F. Higgins, and G. D. Kobriger. 2004. History of greater sage-grouse in the Dakotas: Distribution and population trends. Prairie Naturalist 36:213–230.

Smith, J. 2003. Greater sage-grouse on the edge of their range: leks and surrounding landscapes in the Dakotas. M. S. Thesis, South Dakota State University, Brookings.

Smith, J. T., J. D. Tack, K. E. Doherty, B. W. Allred, J. D. Maestas, L. I. Berkeley, S. J. Dettenmaier, T. A. Messmer, and D. E. Naugle. 2018a. Phenology largely explains taller grass at successful nests in greater sage-grouse. Ecology and Evolution 8:356–364.

Smith, J. T., J. D. Tack, L. I. Berkeley, M. Szczypinski, and D. E. Naugle. 2018b. Effects of rotational grazing management on nesting greater sage-grouse. The Journal of Wildlife Management 82:103–112.

Smith, J. T., B. W. Allred, C. S. Boyd, J. C. Carlson, K. W. Davies, C. A. Hagen, and J. D. Tack. 2020. Are sage-grouse fine-scale specialists or shrub-steppe generalists? The Journal of Wildlife Management 84:759–774.

Society for Range Management. 1998. A glossary of terms used in range management, fourth edition. 20 pp.

South Dakota Department of Game, Fish and Parks. 2014. South Dakota Wildlife Action Plan. Wildlife Division Report 2014-03. South Dakota Department of Game, Fish and Parks, Pierre.

South Dakota Department of Agriculture and Natural Resources, Minerals and Mining Program. 2021. Oil and Gas Drilling Permits. http://denr.sd.gov/des/og/newpermit.aspx. Accessed 06/10/2021.

Stevens, B. S., J. W. Connelly, and K. P. Reese. 2012a. Multi-scale assessment of greater sage-grouse fence collision as a function of site and broad scale factors. The Journal of Wildlife Management 76:1370–1380.

Stevens, B. S., K. P. Reese, J. W. Connelly, and D. D. Musil. 2012b. Greater sage-grouse and fences: does marking reduce collisions? Wildlife Society Bulletin 36:297–303.

Swanson, C. C. 2009. Ecology of greater sage-grouse in the Dakotas. Ph.D. Dissertation, South Dakota State University, Brookings.

Swanson, C. C., M. A. Rumble, T. W. Grovenburg, N. W. Kaczor, R. W. Klaver, K. M. Herman-Brunson, and K. C. Jensen. 2013. Greater sage-grouse winter habitat use on the eastern edge of their range. The Journal of wildlife management. 77:486–494.

U. S. Fish and Wildlife Service. 2015. 50 CFR Part 17 Endangered and threatened wildlife and plants; 12-month findings for petitions to list the greater sage-grouse (*Centrocercus urophasianus*) as threatened or endangered. Proposed Rule. 86 pp.

Visher, S. S. 1914. A preliminary report on the Biology of Harding County, northwestern South Dakota. United States Geological Survey, South Dakota Geological Survey Bulletin 6.

Walker, B. L., D. E. Naugle, and K. E. Doherty. 2007. Greater sage-grouse population response to energy development and habitat loss. The Journal of Wildlife Management 71:2644–2654.

Walker B. L. and D. E. Naugle. 2011. West Nile virus in sagebrush habitat and impacts on greater sage-grouse populations. Pp. 127–142 *in* S. T. Knick and J. W. Connelly. Greater sage-grouse: ecology and conservation of a landscape species and its habitat. Studies in Avian Biology 38. University of California Press, Berkeley.

Walsh, D. P., G. C. White, T. E. Remington, and D. C. Bowden. 2004. Evaluation of the lek-count index for greater sage-grouse. Wildlife Society Bulletin 32:56–68.

Wisdom, M. J., C. W. Meinke, S. T. Knick, and M. A. Schroeder. 2011. Factors associated with extirpation of sage-grouse. Studies in Avian Biology 38:451–474.