Wyoming Sage-Grouse Job Completion Report

June 2022-May 2023

Nyssa Whitford
Sage-Grouse/Sagebrush Biologist
Wyoming Game and Fish Department

Table of Contents

Statewide

Job Completion Report

Prepared By: Nyssa Whitford, Sage-Grouse/Sagebrush Biologist

Period Covered: 6-1-2022 to 5-31-2023

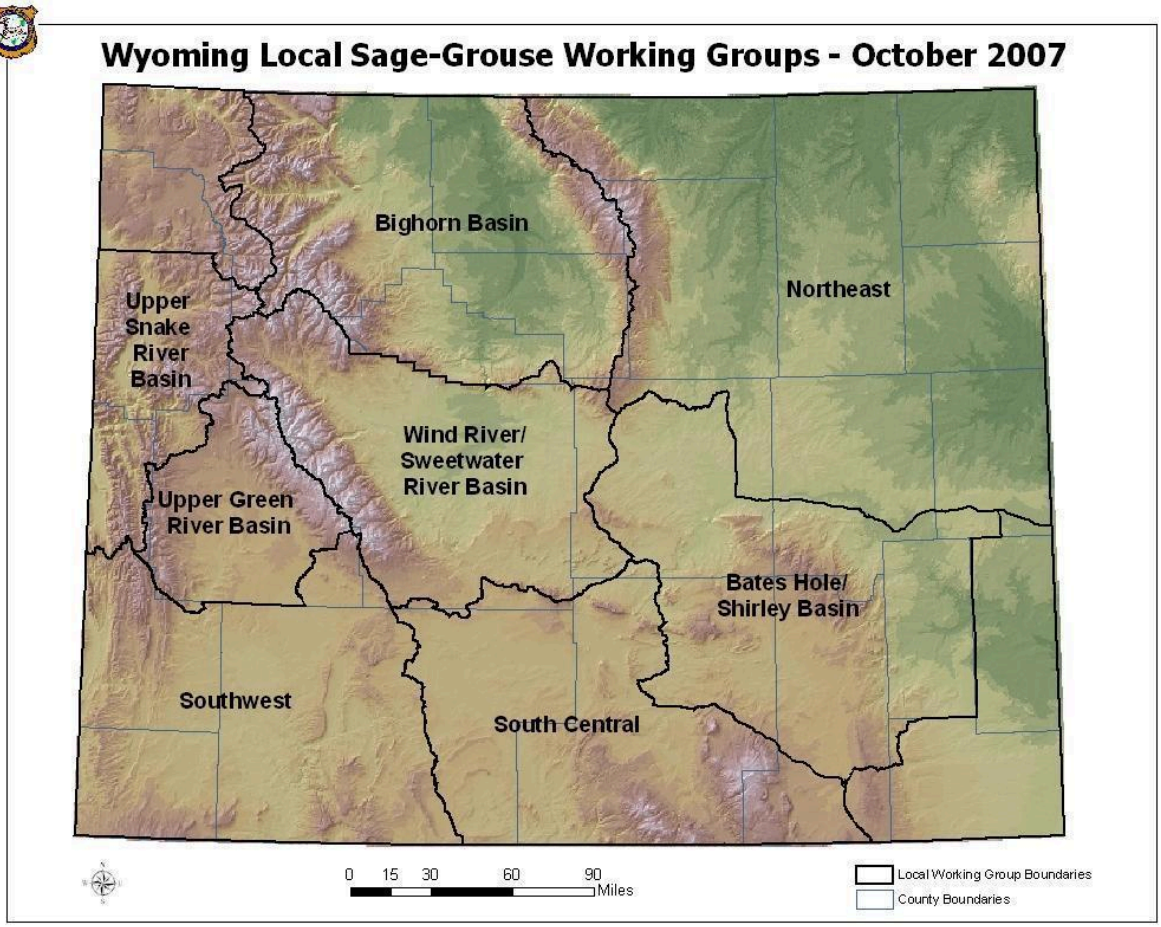


Table 1: Leks Counted

Year	Occupied	Counted	Percent Counted	Peak Males	Average Peak Males
2014	1,798	772	42.9%	11,466	20.6
2015	1,826	742	40.6%	19,505	34.2
2016	1,842	732	39.7%	23,387	40.4
2017	1,831	689	37.6%	18,701	35.4
2018	1,820	800	44%	17,124	28.2
2019	1,797	700	39%	11,888	21.8
2020	1,769	780	44.1%	12,402	21.5
2021	1,754	762	43.4%	10,257	19.0
2022	1,739	707	40.7%	9,917	20.1
2023	1,718	458	26.7%	6,695	20.9

Occupied - Must have been active once during previous 10 years, calculated based on the official definitions

Average Peak Males - Includes only those leks where one or more strutting males were observed. Does not include "Active" leks where only sign was documented

Table 2: Leks Surveyed

Year	Occupied	Surveyed	Percent Surveyed	Peak Males	Average Peak Males
2014	1,798	839	46.7%	8,604	16.5
2015	1,826	880	48.2%	17,029	27.7
2016	1,842	949	51.5%	19,888	31.3
2017	1,831	960	52.4%	17,893	28.1
2018	1,820	808	44.4%	12,397	22.8
2019	1,797	869	48.4%	9,554	18.2
2020	1,769	676	38.2%	6,741	16.5
2021	1,754	754	43%	6,017	14.1
2022	1,739	821	47.2%	7,033	15.5
2023	1,718	940	54.7%	11,379	21.3

Occupied - Must have been active once during previous 10 years, calculated based on the official definitions

Average Peak Males - Includes only those leks where one or more strutting males were observed. Does not include "Active" leks where only sign was documented

Table 3: Leks Checked

Year	Occupied	Checked	Percent Checked	Peak Males	Average Peak Males
2014	1,798	1,611	89.6%	20,070	18.6
2015	1,826	1,622	88.8%	36,534	30.9
2016	1,842	1,681	91.3%	43,275	35.6
2017	1,831	1,649	90.1%	36,594	31.4
2018	1,820	1,608	88.4%	29,521	25.6
2019	1,797	1,569	87.3%	21,442	20.1
2020	1,769	1,456	82.3%	19,143	19.5
2021	1,754	1,516	86.4%	16,274	16.8
2022	1,739	1,528	87.9%	16,950	17.9
2023	1,718	1,398	81.4%	18,074	21.1

Occupied - Must have been active once during previous 10 years, calculated based on the official definitions

Average Peak Males - Includes only those leks where one or more strutting males were observed. Does not include "Active" leks where only sign was documented

Table 4: Lek Status of Leks Checked

Year	Active	Inactive	Unknown	Known Status	% Active	% Inactive
2014	1,105	353	153	1,458	75.8%	24.2%
2015	1,215	275	132	1,490	81.5%	18.5%
2016	1,259	275	147	1,534	82.1%	17.9%
2017	1,204	304	141	1,508	79.8%	20.2%
2018	1,179	300	129	1,479	79.7%	20.3%
2019	1,134	298	137	1,432	79.2%	20.8%
2020	1,028	338	90	1,366	75.3%	24.7%
2021	1,022	320	174	1,342	76.2%	23.8%
2022	1,009	328	191	1,337	75.5%	24.5%
2023	925	258	215	1,183	78.2%	21.8%

Occupied - Must have been active once during previous 10 years, calculated based on the official definitions

Inactive - Confirmed no birds/sign present (see official definitions)

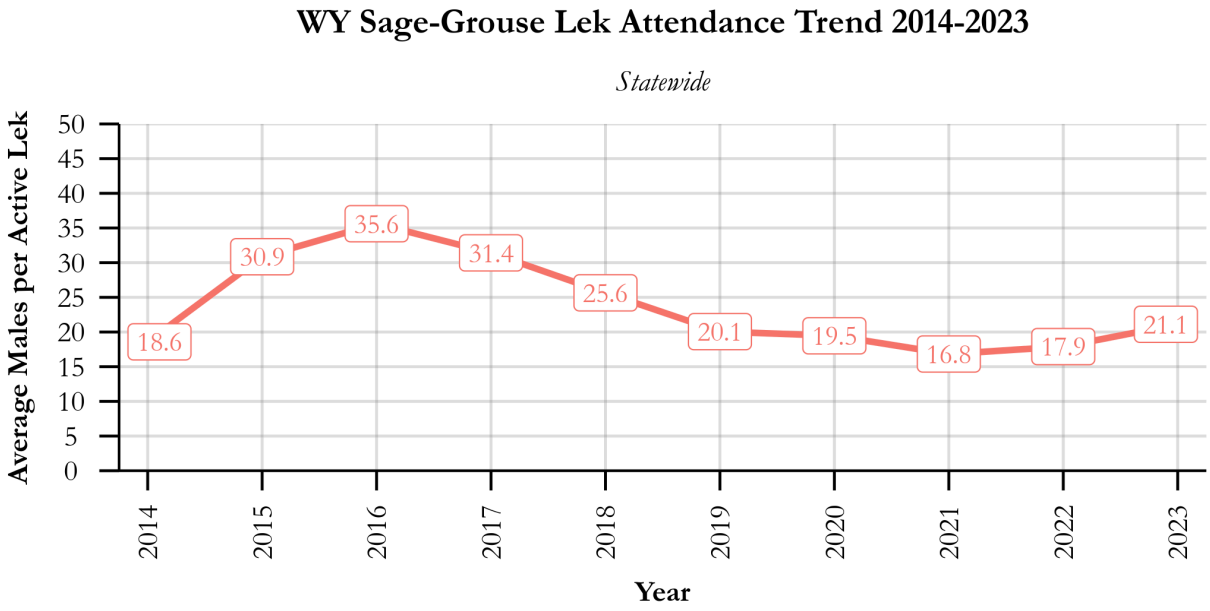


Figure 1: Average Peak Males

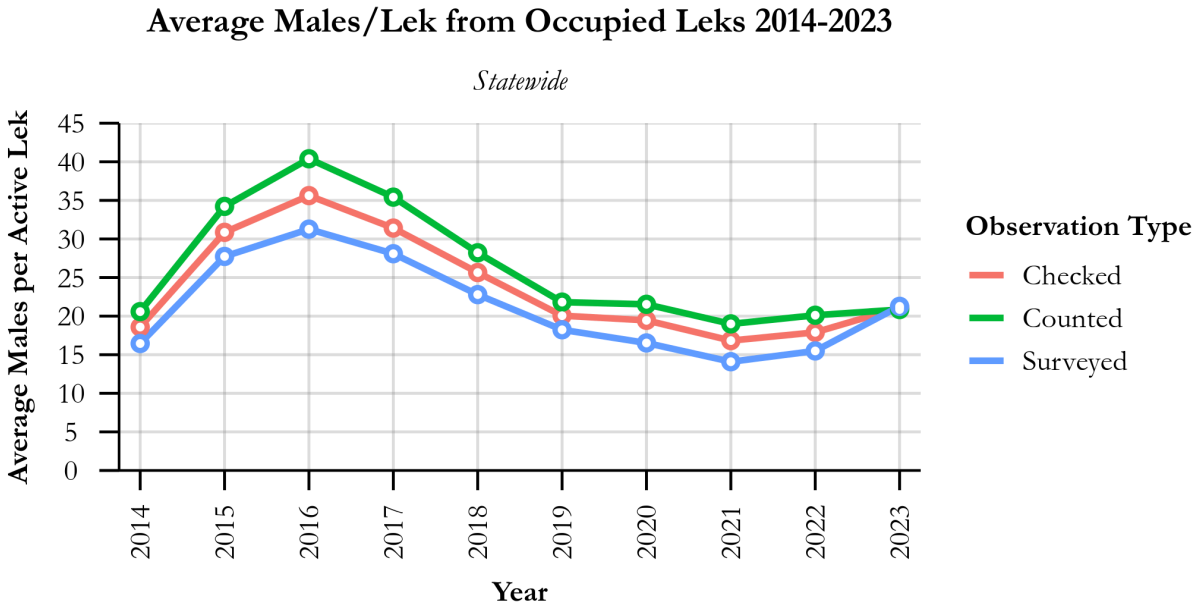


Figure 2: Average Peak Males

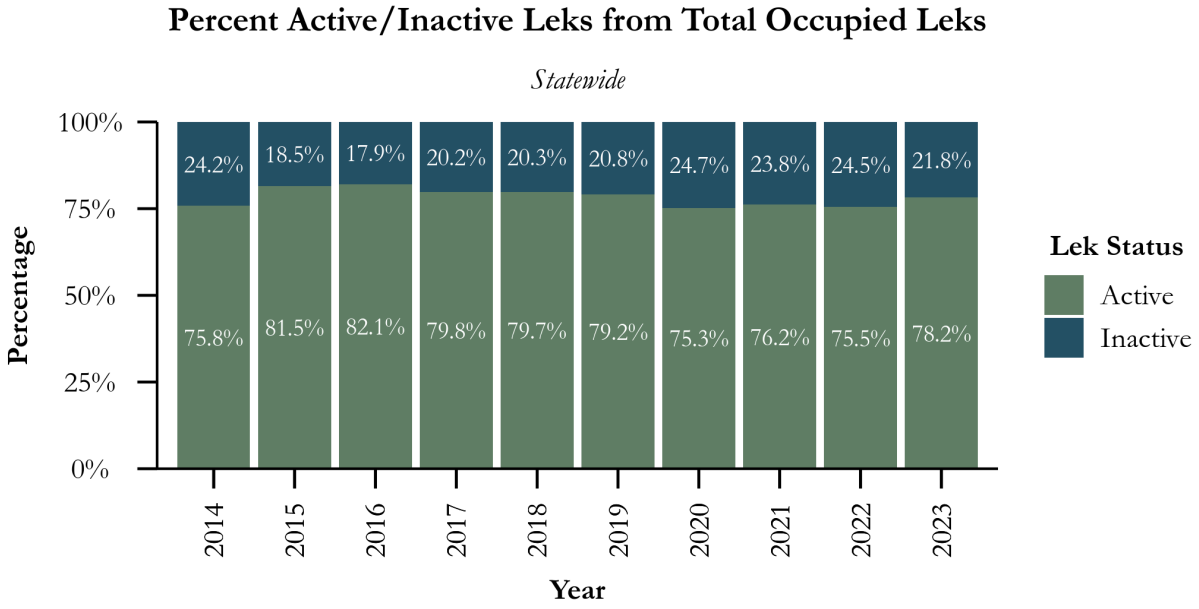


Figure 3: Lek Status

Table 5: Hunting Seasons

Year	Season Start	Season End	Length	Bag/Possession Limit
2013-1	Sep-21	Sep-30	10	2/4
2013-4	Sep-21	Sep-23	3	2/4
2014-1	Sep-20	Sep-30	11	2/4
2014-4	Sep-20	Sep-22	3	2/4
2015-1	Sep-19	Sep-30	12	2/4
2015-4	Sep-19	Sep-21	3	2/4
2016-1	Sep-17	Sep-30	14	2/4
2016-4	Sep-17	Sep-19	3	2/4
2017-1	Sep-16	Sep-30	15	2/4
2017-4	Sep-16	Sep-18	3	2/4
2018-1	Sep-15	Sep-30	16	2/4
2018-4	Sep-15	Sep-17	3	2/4
2019-1	Sep-21	Sep-30	10	2/4
2019-4	Sep-21	Sep-23	3	2/4
2020-1	Sep-19	Sep-30	12	2/4
2020-4	Sep-19	Sep-21	3	2/4
2021-1	Sep-18	Sep-30	13	2/4
2021-4	Sep-18	Sep-20	3	2/4
2022-1	Sep-17	Sep-30	14	2/4
2022-4	Sep-17	Sep-19	3	2/4

Table 6: Harvest Totals

Year	Harvest	Hunters	Days	Birds/Day	Birds/Hunter	Days/Hunter
2013	5,726	3,383	7,672	0.7	1.7	2.3
2014	7,094	3,526	8,642	0.8	2.0	2.5
2015	10,498	4,299	10,231	1.0	2.4	2.4
2016	10,526	4,674	11,476	0.9	2.3	2.5
2017	7,817	3,576	8,646	0.9	2.2	2.4
2018	10,422	5,035	13,092	0.8	2.1	2.6
2019	7,615	4,229	9,473	0.8	1.8	2.2
2020	6,544	3,227	9,705	0.7	2.0	3.0
2021	8,457	5,107	14,465	0.6	1.7	2.8
2022	11,640	6,361	16,467	0.7	1.8	2.6
Average	**8,634**	**4,342**	**10,987**	**0.8**	**2.0**	**2.5**

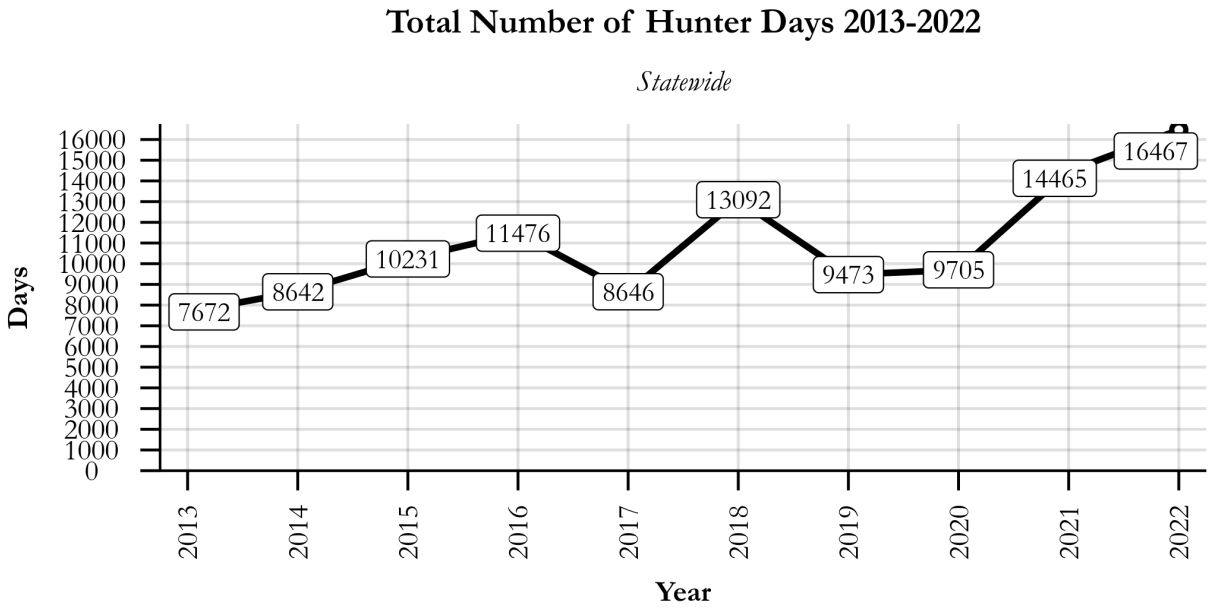


Figure 4: Harvest Days

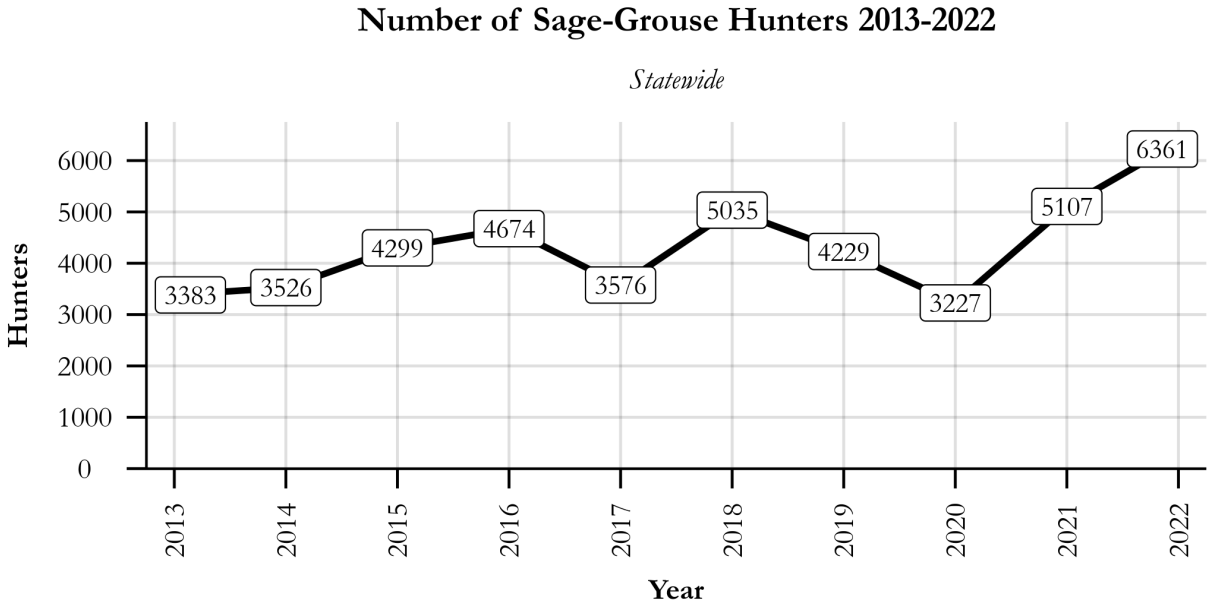


Figure 5: Hunters

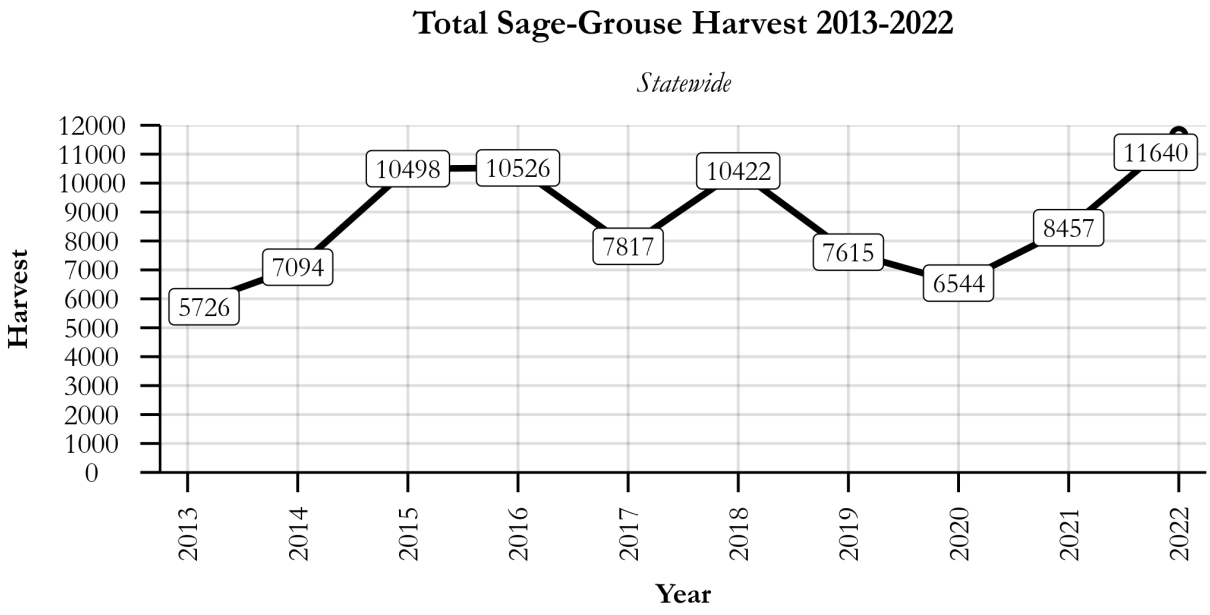


Figure 6: Total Harvest

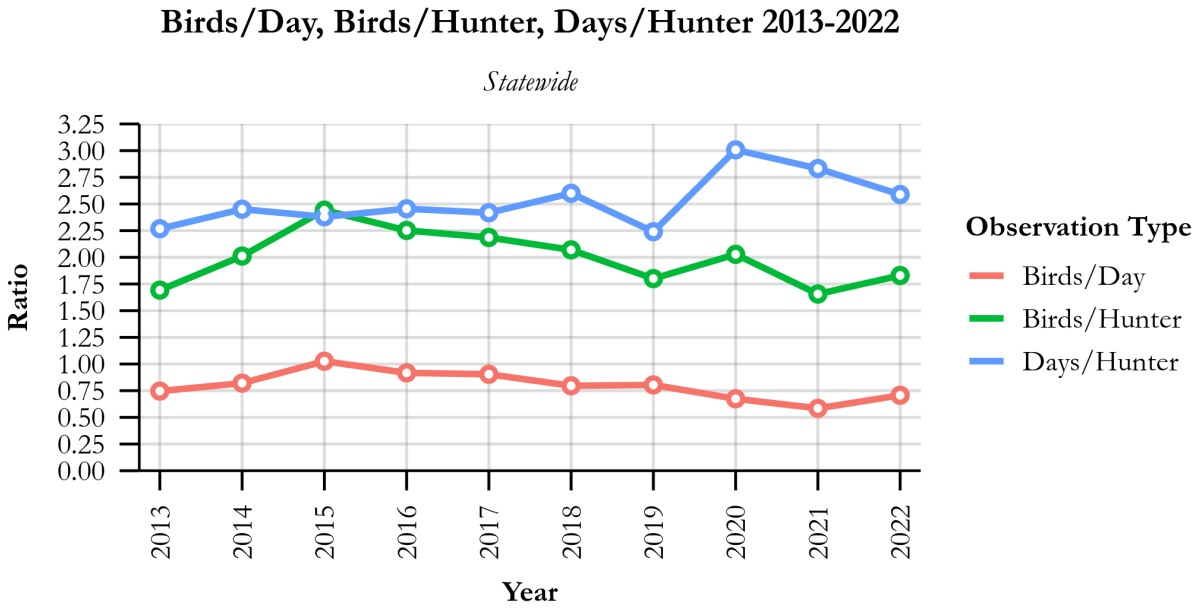


Figure 7: Harvest Ratios

Table 7: Harvest Composition

		Percent Adult		Percent Yearling		Percent Chick		
Year	Sample Size	Male	Female	Male	Female	Male	Female	Chicks/Hens
2013	1,258	12%	35.8%	2.3%	6.5%	18.8%	24.4%	1.0
2014	1,533	9.5%	23.9%	2.5%	7.8%	28.8%	27.5%	1.8
2015	2,300	12.7%	25.8%	3.6%	5.4%	24.8%	27.7%	1.7
2016	2,097	16.9%	33%	4.5%	7.6%	16.7%	21.2%	0.9
2017	2,047	13.8%	31.7%	3.3%	6%	20.7%	24.6%	1.2
2018	2,112	14.2%	32.4%	6.2%	11.3%	13.9%	22%	0.8
2019	1,631	10.4%	31.5%	3.2%	9.7%	14.9%	30.3%	1.1
2020	2,171	9.8%	31.5%	4.1%	9.1%	17.4%	28.1%	1.1
2021	1,542	10.2%	39.8%	2.8%	8%	16%	23%	0.8
2022	1,829	8.3%	29.5%	2.6%	7.9%	22.2%	29.5%	1.4

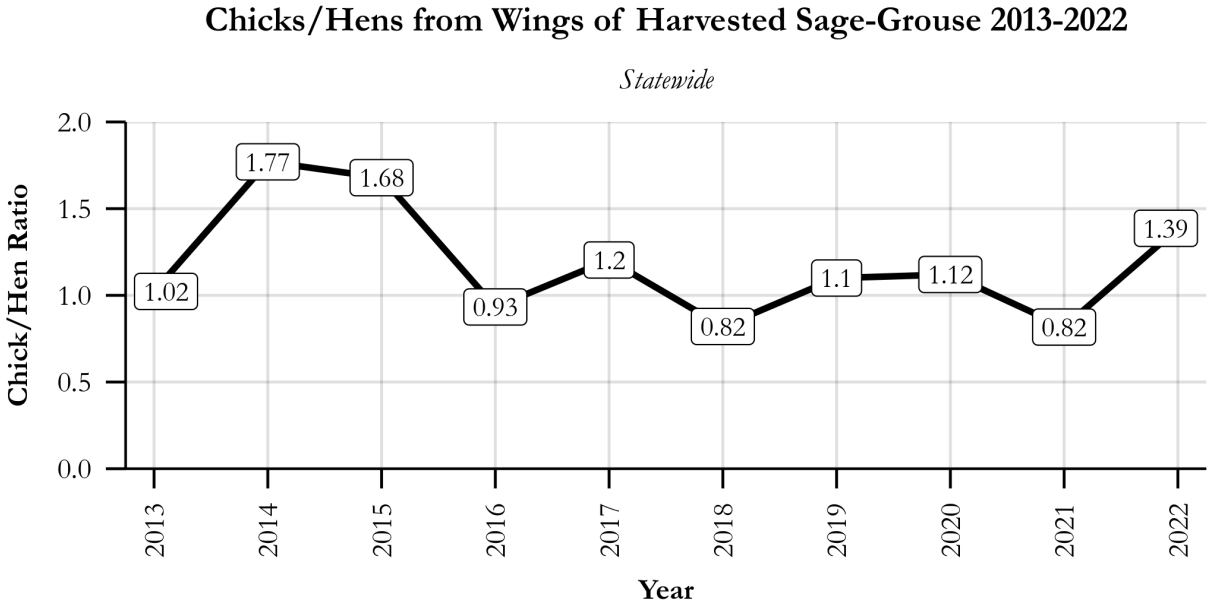


Figure 8: Chick/Hen Ratio

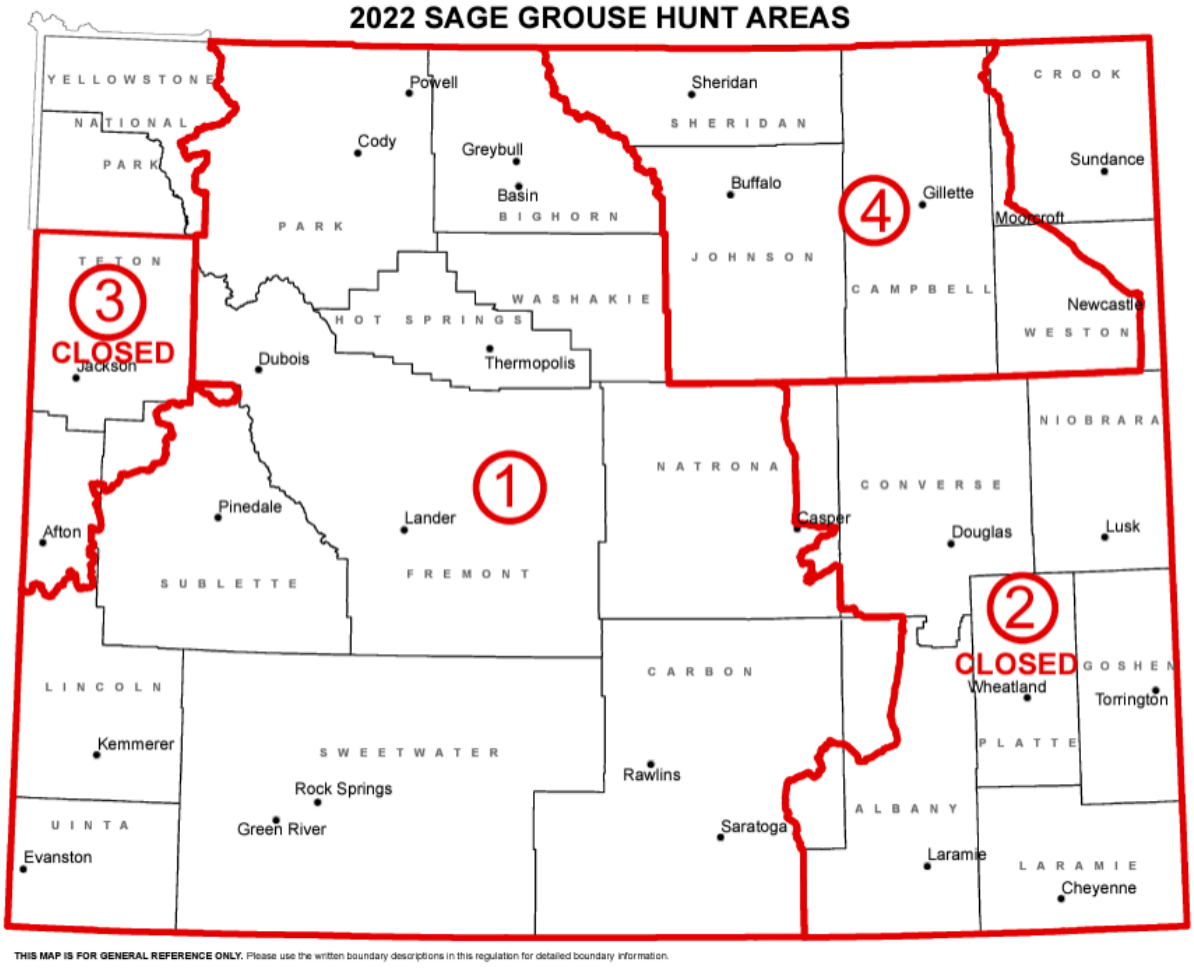
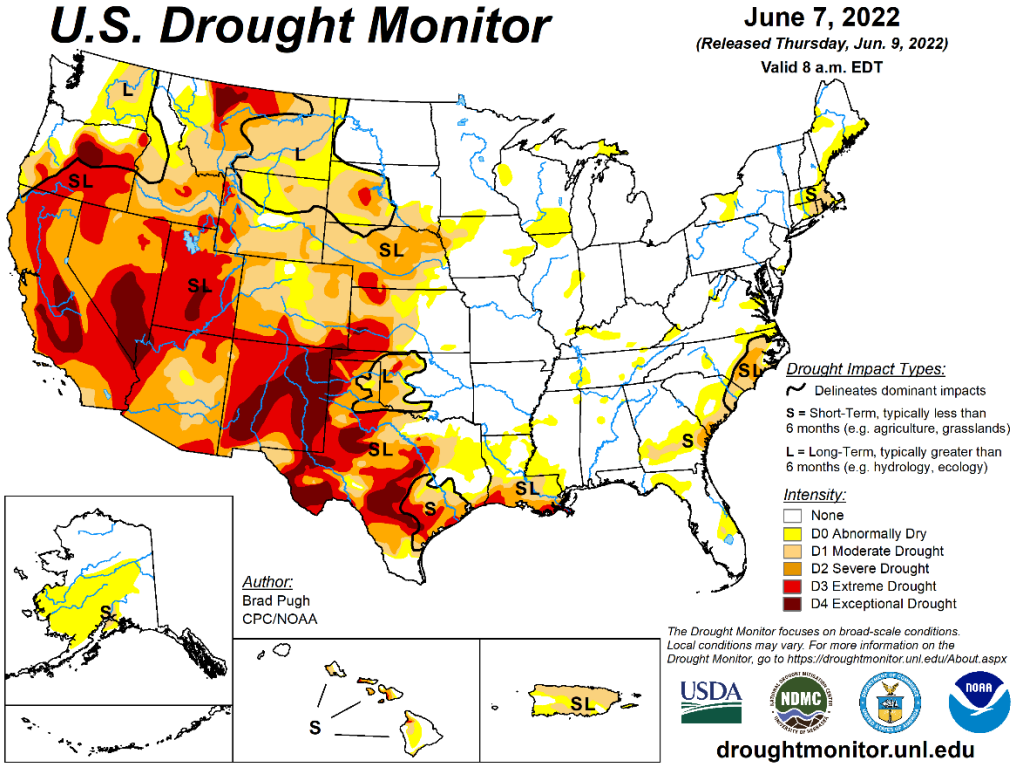


Figure 9: 2022 Sage-Grouse Hunt Areas


U.S. Drought Monitor
June 7, 2022
(Released Thursday, Jun. 9, 2022)
Valid 8 a.m. EDT
Drought Impact Types:
Delineates dominant impacts
S = Short-Term, typically less than 6 months (e.g. agriculture, grasslands)
L = Long-Term, typically greater than 6 months (e.g. hydrology, ecology)
Intensity:
None
D0 Abnormally Dry
D1 Moderate Drought
D2 Severe Drought
D3 Extreme Drought
D4 Exceptional Drought
Author:
Brad Pugh
CPC/NOAA
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. For more information on the Drought Monitor, go to https://droughtmonitor.unl.edu/About.aspx
USDA
NDMC
NOAA
droughtmonitor.unl.edu

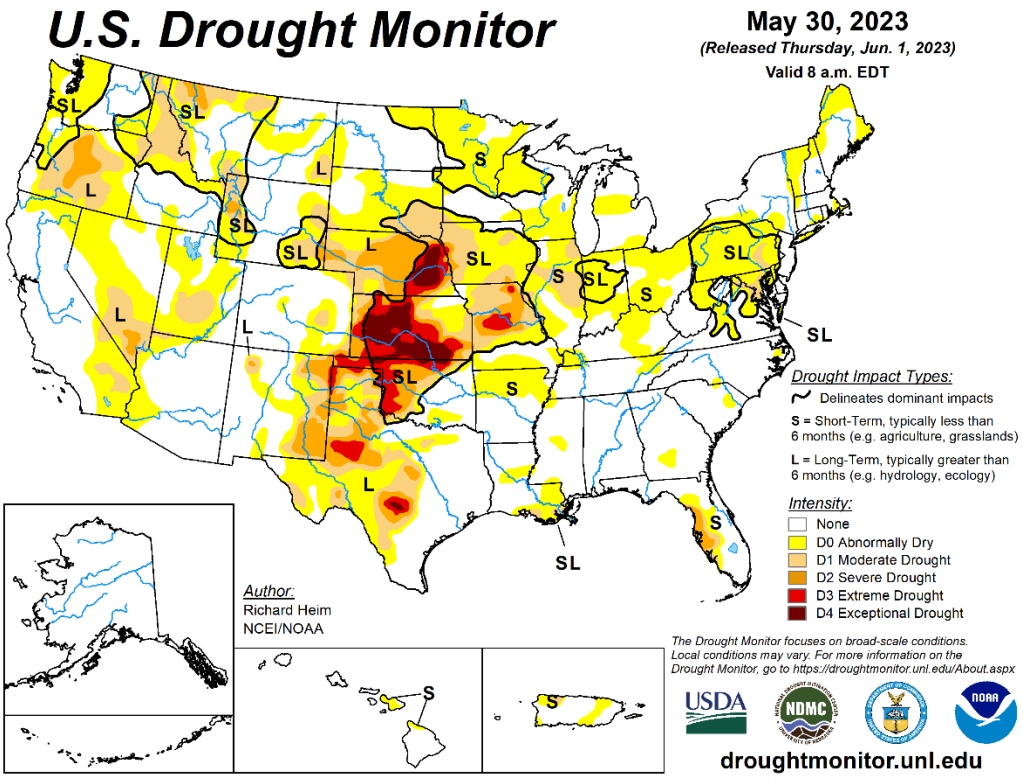

U.S. Drought Monitor
May 30, 2023
(Released Thursday, Jun. 1, 2023)
Valid 8 a.m. EDT
Drought Impact Types:
Delineates dominant impacts
S = Short-Term, typically less than 6 months (e.g. agriculture, grasslands)
L = Long-Term, typically greater than 6 months (e.g. hydrology, ecology)
Intensity:
None
D0 Abnormally Dry
D1 Moderate Drought
D2 Severe Drought
D3 Extreme Drought
D4 Exceptional Drought
Author:
Richard Heim
NCEI/NOAA
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. For more information on the Drought Monitor, go to https://droughtmonitor.unl.edu/About.aspx
USDA
NDMC
NOAA
droughtmonitor.unl.edu

Figure 10: June 7, 2022 vs May 30, 2023 Drought Monitor Maps (National Drought Mitigation Center)

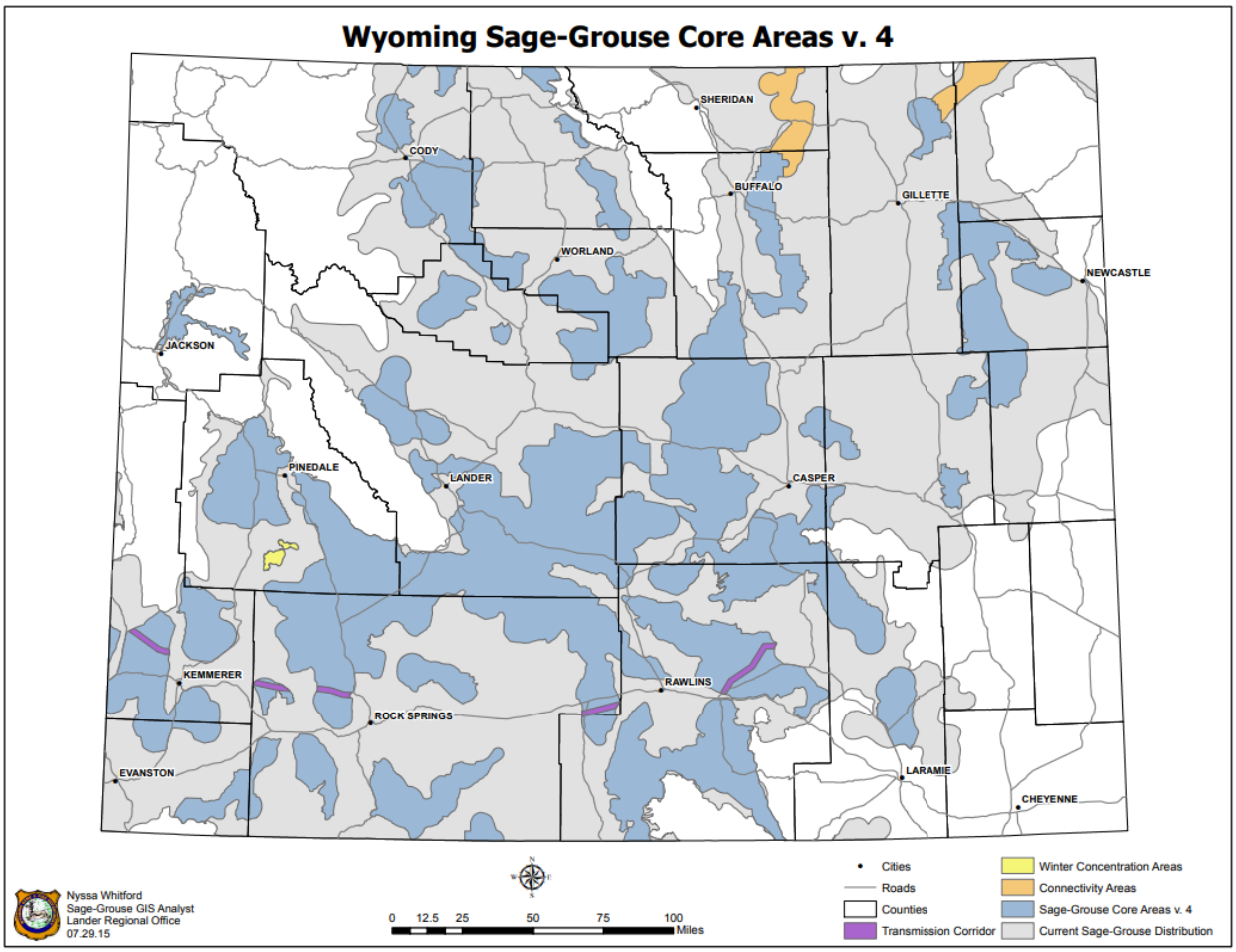


Figure 11: Wyoming Sage-Grouse Core Areas, version 4

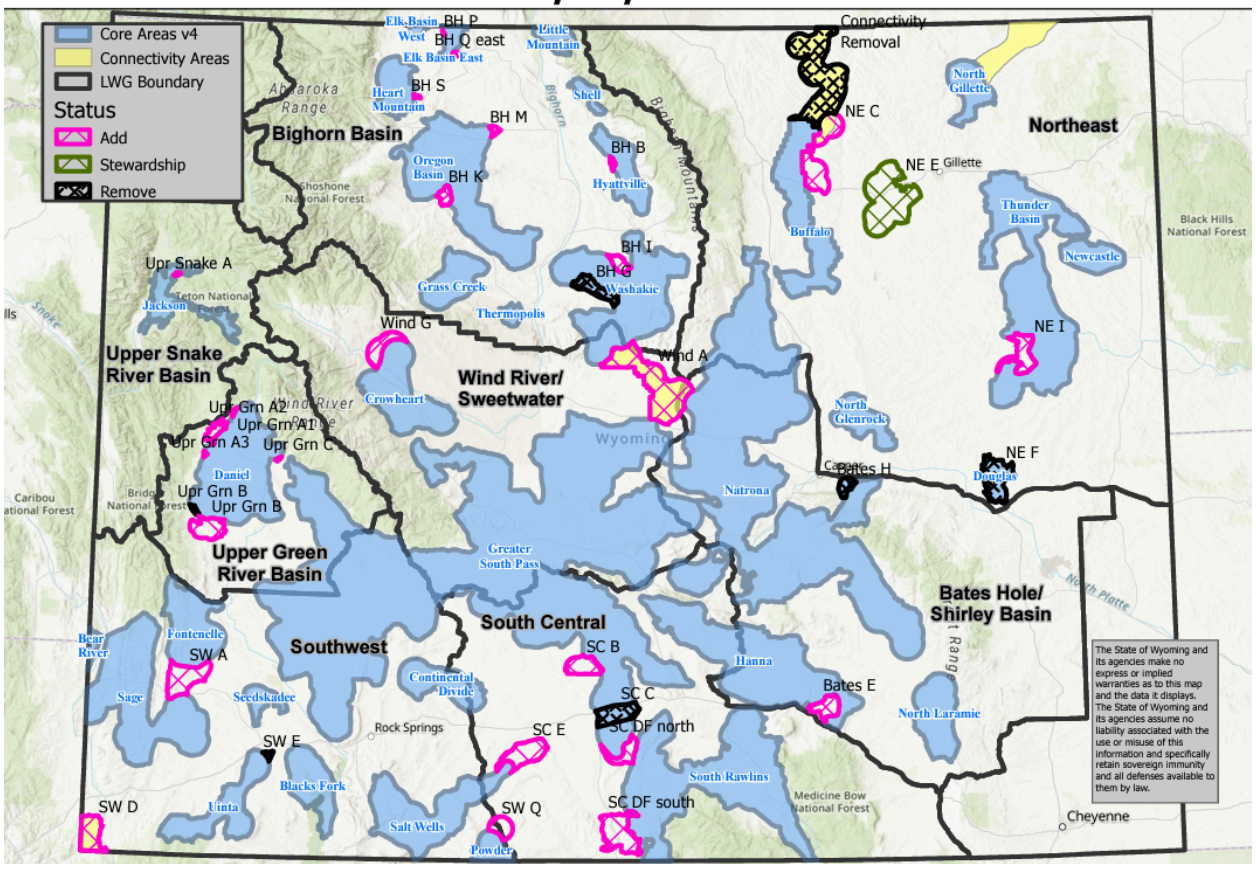


Figure 12: Proposed Sage-Grouse Core Area Revisions, 12.22.23

Lek Monitoring:

Approximately 37% of the range wide greater sage-grouse (Centrocercus urophasianus; hereafter, sage-grouse) population lives in Wyoming and 90% of estimated historic habitat in Wyoming is still occupied. There are just over 1,700 known, occupied sage-grouse leks in Wyoming. Wyoming Game and Fish Department (WGFD) personnel and sage-grouse stakeholders monitored 81% of these leks in the spring of 2023 (**Table 3**). Persistent winter conditions across much of Wyoming hampered lek monitoring efforts and resulted in a 6% decrease in leks monitored in 2023. While the long winter took its toll on ungulates, sage-grouse seemed to have fared well as they were able to fly to the few wind swept ridges available and burrow into the snow for food and cover. Results indicate 925 leks were confirmed active, 258 confirmed inactive, and 215 were unknown or unchecked. The average number of males observed was 21.1 per active lek, a 15% increase from the 17.9 males per active lek observed in the spring of 2021, suggesting an overall population increase and a stabilization of recent trends (**Table 3**). In 2023, 18,074 male sage-grouse were observed on leks compared to 16,950 males observed on leks in 2022 (**Table 3**). Methods for collecting sage-grouse data are described in the sage-grouse chapter of the WGFD Handbook of Biological Techniques (Whitford and Bish 2022), which is largely based on Connelly et al. 2003.

Lek monitoring data for the 2023 breeding season are summarized in Tables 1-4 and Figures 1-3. For the 10-year period (2014-2023), average male lek attendance ranged from 16.8 males/lek in 2021, the lowest average males per lek since 2013, to a high of 35.6 males/lek in 2016 (**Table 3**). The proportion of active, occupied leks increased slightly from 75.5% in 2022 to 78.2% in 2023 (**Table 4**). In 2023, average lek size was 21.1 males/active lek which is 9% lower than the previous 10-year (2014-2023) average of 23.3 males/active lek (**Table 3**). This indicates a population decline over a 10 year period. Short-term trends in statewide populations are believed to be largely weather related. In the late 1990s, 2004-05, and again in 2014-15, timely precipitation resulted in improved habitat conditions allowing greater numbers of sage-grouse to successfully reproduce. Drought conditions throughout this decade are believed to have caused lower grouse survival leading to population declines. The current lessening of drought conditions could be influencing a stabilization, to slight increase, in population trends over the last couple years. While these trends are valid at the statewide scale, trends can be more varied at the local level. Sub-populations more heavily influenced by anthropogenic impacts (residential development, intensive energy development, large-scale conversion of habitat from sagebrush to grassland or agriculture, interstate highways, etc.) have experienced declining populations or localized extirpation.

It is important to note that not all leks were checked from year to year over the last 10 years. However, leks that were checked consistently over the same period demonstrated the same trends except in some local areas as described in the Regional JCRs. Small changes in the statistics reported between annual JCRs are due to revisions and/or the submission of data not previously available for entry into the database (late submission of data, discovery of historical data from outside sources, etc.). These changes have not been significant on a statewide scale and interpretation of these data has not changed.

While a statistically valid method for estimating population size for sage-grouse has not yet been applied in Wyoming, monitoring male attendance on leks provides a reasonable index of relative change in abundance in response to prevailing environmental conditions over time. However, lek data must be interpreted with caution for several reasons: 1) the observation effort and the number of leks visited has varied over time, 2) not all leks have been located, 3) sage-grouse populations cycle, 4) the effects of yet to be located or unmonitored leks that have become inactive cannot be

quantified or qualified, and 5) lek locations may change over time. Both the number of leks and the number of males attending these leks must be quantified in order to estimate population size.

Harvest:

The 2022 hunting season (**Figures 4**-8 and **Tables 5**-7) for most of the state (Area 1) was 1 day longer than 2021 due to the calendar effect of opening the season on the third Saturday of September. In 2021, the third Saturday was September 18, but in 2022, it was September 17.

Hunting seasons and harvest in Wyoming are shown in **Tables 5**-7. Due to concerns over low populations, the statewide hunting season was shortened and the daily bag limit decreased to two sage-grouse in 2002 and has remained very conservative since that time. Two areas, eastern Wyoming (Area 2) and the Snake River Drainage in northwest Wyoming (Area 3), are closed to sage-grouse hunting (**Figure 9**). The data presented in **Tables 6** and **7** and **Figures 4**-8 are estimated from a voluntary hunter survey. Over the last several years, surveys indicate the number of hunters statewide has steadily increased. Generally, during the past 10 years, overall harvest appeared to be correlated to both hunter numbers and sage-grouse abundance.

There are two notable changes that have, or will, take place outside the timeframe of this report. In 2023, north eastern Wyoming (Area 4) was closed to all sage-grouse hunting. When making this recommendation, the Department considered long-term population trends, habitat conditions, genetic connectivity between states, and possible effects of west nile virus. Starting in 2024, hunting sage-grouse will require a free permit. That permit will allow the department to survey sage-grouse hunters soon after the season closes and better track hunter harvest.

Production:

Hunters voluntarily submit sage-grouse wings at wing barrels across half of the state. Wings are gathered and then aged/sexed by molt patterns, and numbers of chicks per hen are calculated and used as an index of productivity. While there are biases associated with the hunter selectivity of different age/sex groups of sage-grouse, trends still provide yearly comparisons of relative chick production. The 2022 wing data indicate a chick:hen ratio of 1.4 chicks per hen (**Table 7** and **Figure 8**). This level of productivity is typically associated with a stable population. The 2023 lek data (all leks checked) indicated a 15% increase in the average numbers of males on leks (**Table 3**). Considering the opportunistic sampling of hunter harvested wings and that wings are not collected statewide, due to shorter seasons or closed hunting areas, this inconsistency is not unexpected. When 1998-2022 data are pooled, average male lek attendance declined an average of 11% when chick:hen ratios the previous fall were less than 1.4:1, were closer to 0% change (-3%) when chick:hen ratios the previous fall were 1.4 to 1.6:1 and increased an average of 32% when chick:hens ratios were 1.7:1 or higher. Additional data are required to strengthen the statistical basis of these analyses.

Habitat:

As of June 2022, 60% of Wyoming was experiencing moderate, severe, or extreme drought (**Figure 10**). As of late May 2023, conditions had improved with no areas in Wyoming experiencing severe or extreme drought (**Figure 10**). For the biological year considered, conditions improved across the state with the greatest improvement in central and western Wyoming. The severe and prolonged winter much of Wyoming experienced in early 2023 was largely responsible for the improvement in drought conditions. In general, spring precipitation is positively linked to summer chick survival,

autumn chick:hen ratios, which are in turn, linked to the next year's lek counts of males. However, periods of prolonged cold, wet weather may have adverse effects on hatching success, chick survival, and plant and insect phenology and production. Even though the winter was persistent, and spring lek attendance appeared to be delayed in central and western Wyoming, it does not appear to have hindered recruitment for this biological year. Efforts to quantify/qualify these effects in a predictable fashion over meaningful scales have largely failed.

While we believe that most of the currently occupied leks in Wyoming have been documented, other seasonal habitats such as nesting/early brood-rearing and winter concentration areas have not been identified. Efforts to map seasonal ranges for sage-grouse will continue by utilizing winter observation flights and the on-going land cover mapping efforts of the USGS (Fedy et al. 2014), BLM, WGFD, the Wyoming Geographic Information Science Center (WYGISC) of the University of Wyoming, and others.

Disease:

A highly pathogenic form of avian influenza (HPAI) was again documented in large portions of the sage-grouse range in Wyoming. Although no sage-grouse in Wyoming were documented having contracted this disease, several other avian species were lab verified across the state. During this biological year, Nevada did report a collared sage-grouse hen had succumbed to HPAI. It is unknown how this disease may affect sage-grouse, but it is of concern and should continue to be closely monitored as this strain of HPAI continues to surface.

While West Nile virus (WNv) was documented in Wyoming during this biological year, no sage-grouse mortality events were documented. The last major mortality event was in 2003 when West Nile virus was first documented in sage-grouse in northeast Wyoming. Due to the difficulty in monitoring WNv in sage-grouse, human and livestock cases can provide an indication of WNv prevalence in a given year. (Wyoming State Vet Lab, https://www.uwyo.edu/wyovet/index.html).

Conservation Planning:

The Wyoming Game and Fish Commission typically allocates $548,000 annually to fund Sage-Grouse local working group projects. During Fiscal Year 2023, nineteen (19) projects (Attachment A) were funded. Most of the projects are supported by multiple cost-sharing partners. Cumulatively, three-hundred and thirty-three (333) projects have been approved since the Local Working Groups inception in 2005. Projects include habitat treatments/restoration, improved range management infrastructure and grazing management plans, applied research, inventories, monitoring, and public outreach.

Management of greater sage-grouse habitat in Wyoming is based on a "core area" strategy of limiting human disturbance in the most important sage-grouse habitats (**Figure 11**). This strategy is codified by a Governor's executive order. The Executive Order and related materials are available at: **https://wgfd.wyo.gov/Habitat/Sage-Grouse-Management**

The Core Area Strategy is being implemented across the state under the guidance of a state/federal interagency team of specialists (Sage-grouse Implementation Team; SGIT) who meet on a regular basis to discuss issues related to implementation of the strategy. A key component of the strategy's implementation is the Density and Disturbance Calculation Tool (DDCT). This tool was developed by agency GIS specialists as an interactive, on-line application. Until early 2022, this tool was

provided by the University of Wyoming's Geographic Information and Science Center. Currently, the Wyoming Game and Fish maintains and manages the application.

In accordance with Appendix I of the State of Wyoming 2019-3 Executive Order, the State Adaptive Management Working Group (SAMWG) requested information and recommendations from each Local Working Group (LWG) as well as WGFD biologists in early 2022 regarding 2021 trends and current conditions of sage-grouse populations and sagebrush habitat. The LWGs reviewed data and, in conjunction with input from WGFD, provided recommendations on areas of concern to the SAMWG. This resulted in the SAMWG's determination, either in part or in whole, that the following 16 core areas were deemed areas of concern: Blacks Fork, Buffalo, Douglas, Greater South Pass, Hanna, Heart Mountain, Hyattville, Jackson, Natrona, Newcastle, North Glenrock, North Laramie, Oregon Basin, Sage, South Rawlins, and Washakie. In many instances a request was made by the LWGs to establish a technical team to evaluate these issues further. On August 8, 2022, a Strike Team was officially convened by the SAMWG to begin the process of a more rigorous evaluation of potential causal factors related to areas of concern within a subsample of the aforementioned core areas. The six core areas selected for this exercise were Blacks Fork, Hanna, Natrona, Sage, South Rawlins, and Washakie. These six core areas occurred within five different LWG areas: Bates Hole/Shirley Basin, Southwest, South Central, Wind River/Sweetwater, and the Bighorn Basin. The Strike Team was tasked with taking a deeper look at information and recommendations from the LWGs following their initial assessments of causal factors as well as considering other sources of information and data with the end goal of producing a revised report to the SAMWG. A report was delivered to the SAMWG by the end of 2022. After the SAMWG reviewed the report, a letter was sent for Governor Mark Gordon on January 24, 2023 outlining actionable items related to invasive annual grasses, fire management, disturbance calculations, core area boundary adjustments, conifer removal, wet meadows, feral horses, and the adaptive management process. This letter, and the Strike Team report, was shared with the Sage-Grouse Local Working Groups. This process has yet to begin for lek monitoring data collected during the spring of 2022 or 2023. The delay can be attributed to the state's active participation in the BLM Resource Management Planning (RMP) Amendment process for sage-grouse which will include an adaptive management component.

As part of this RMP process, the BLM is updating their priority habitat, or core, areas. In March 2023, the SGIT assigned a subcommittee to review the Wyoming Sage-Grouse Core Area Map and recommend changes. The subcommittee reached out to WGFD for biological information and also met at least once with each Sage-Grouse Local Working Group. The goal was to have extensive stakeholder engagement and provide BLM an updated version of the core areas as an alternative for their RMP amendment. As of January 2024, this process is still ongoing but the BLM has incorporated core area recommendations from the state of Wyoming into their draft RMP amendment. Please see **figure 12** for the December 22, 2023 version of the draft core areas.

Management Recommendations:

1. Implement Wyoming Governor's Sage-Grouse Executive Order and Core Area Strategy.
2. Continue to implement local conservation plans in all 8 planning areas.
3. Continue to refine and enhance the sage-grouse database and Job Completion Report intranet program.

4. Continue to map lek perimeters and integrate these data into the WGF lek database. Priority for this effort should be based on the lek size of lek and impending development actions that may impact leks.

5. Personnel monitoring leks should review and consistently follow established lek monitoring protocol each year.

6. Map seasonal habitats (nesting/early brood rearing, winter concentration areas) for sage-grouse using data from the on-going land cover mapping project and sage-grouse observations.

Literature Cited:

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

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

National Drought Mitigation Center. 2024. U.S. Drought Monitor Map Archive. https://droughtmonitor.unl.edu/Maps/MapArchive.aspx

Whitford, N. W. Bish. 2022. Chapter 12: Sage Grouse (*Centrocercus urophasianus*). Pages 12-1 to 12-43 in Handbook of Biological Techniques: third edition. Wyoming Game and Fish Department. Cheyenne, WY.

Bates Hole

Job Completion Report

Prepared By: Willow Bish, Terrestrial Habitat Biologist

Period Covered: 6-1-2022 to 5-31-2023

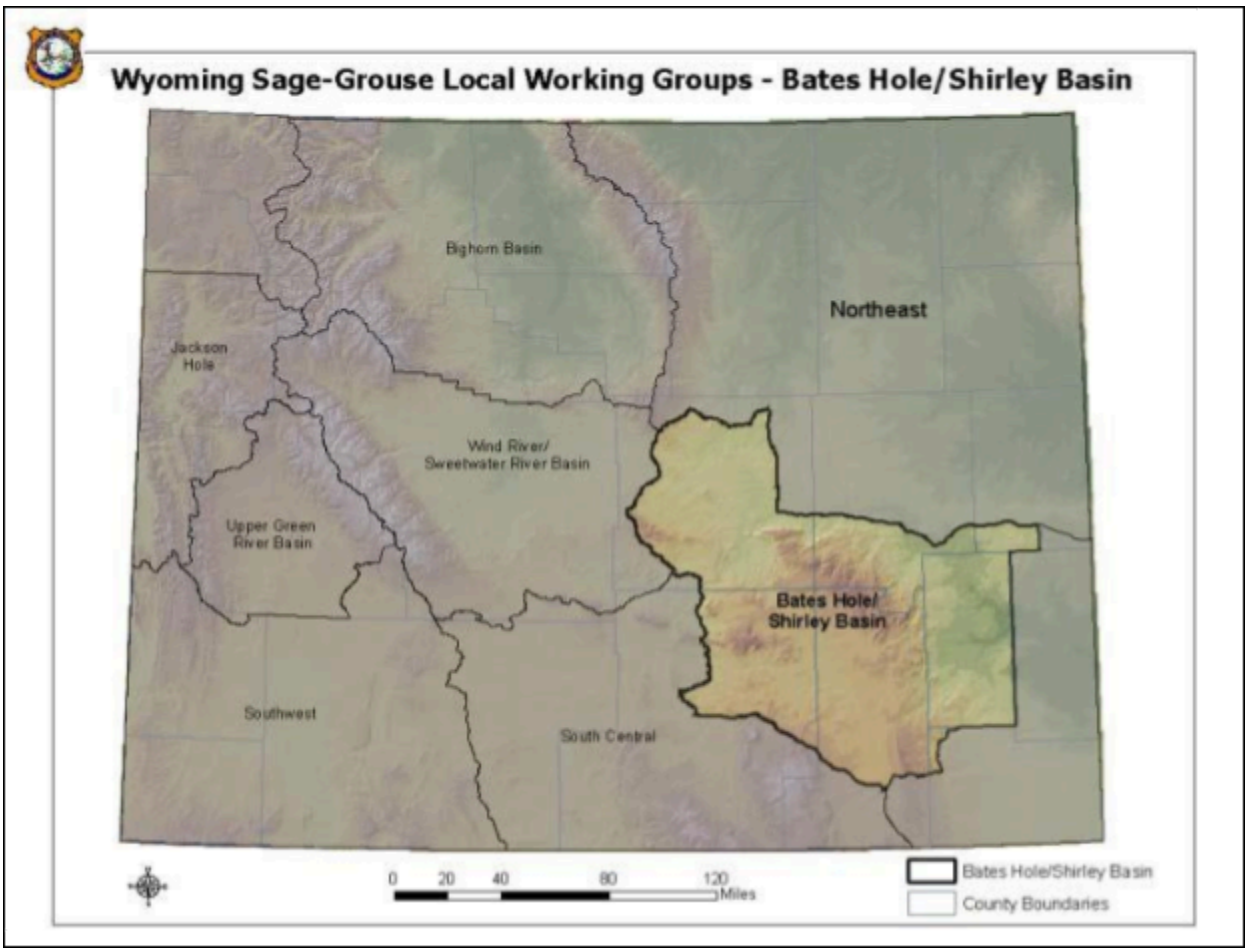


Table 1: Sage-Grouse Lek Characteristics

	Group	N	Percent
BLM Office			
	Casper	130	40.4%
	Lander	2	0.6%
	Newcastle	1	0.3%
	Rawlins	189	58.7%
Biologist			
	Casper	118	36.6%
	Douglas	11	3.4%
	Laramie	112	34.8%
	Saratoga	72	22.4%
	Sinclair	2	0.6%
	Wheatland	7	2.2%
Classification			
	Occupied	202	62.7%
	Undetermined	24	7.5%
	Unoccupied	96	29.8%
County			
	Albany	80	24.8%
	Carbon	107	33.2%
	Converse	12	3.7%
	Laramie	2	0.6%
	Natrona	114	35.4%
	Niobrara	1	0.3%
	Platte	6	1.9%

	Group	N	Percent
Land Status			
	BLM	109	33.9%
	BOR	1	0.3%
	Private	184	57.1%
	State	28	8.7%
Lek Status			
	Active	129	40.1%
	Inactive	66	20.5%
	Unknown	127	39.4%
Management Area			
	F	322	100%
Region			
	Casper	129	40.1%
	Lander	2	0.6%
	Laramie	191	59.3%
Warden			
	Douglas	3	0.9%
	East Casper	37	11.5%
	East Rawlins	2	0.6%
	Elk Mountain	69	21.4%
	Glenrock	9	2.8%
	Lusk	1	0.3%
	Medicine Bow	74	23%
	North Laramie	40	12.4%
	West Casper	79	24.5%
	West Cheyenne	2	0.6%
	Wheatland	6	1.9%

Table 2: Leks Counted

Year	Occupied	Counted	Percent Counted	Peak Males	Average Peak Males
2014	221	86	38.9%	1,261	19.4
2015	222	102	45.9%	2,869	33.0
2016	223	86	38.6%	2,893	40.2
2017	224	79	35.3%	2,213	35.7
2018	219	109	49.8%	1,944	24.0
2019	217	89	41%	1,474	21.1
2020	213	116	54.5%	1,513	18.2
2021	212	106	50%	1,259	16.4
2022	209	108	51.7%	1,524	19.8
2023	205	60	29.3%	997	23.2

Occupied - Must have been active once during previous 10 years, calculated based on the official definitions

Average Peak Males - Includes only those leks where one or more strutting males were observed. Does not include "Active" leks where only sign was documented

Table 3: Leks Surveyed

Year	Occupied	Surveyed	Percent Surveyed	Peak Males	Average Peak Males
2014	221	120	54.3%	928	13.4
2015	222	94	42.3%	1,677	26.6
2016	223	103	46.2%	2,298	31.9
2017	224	124	55.4%	2,143	29.0
2018	219	80	36.5%	1,105	20.5
2019	217	99	45.6%	1,060	20.4
2020	213	58	27.2%	648	18.5
2021	212	74	34.9%	659	16.5
2022	209	82	39.2%	737	18.9
2023	205	129	62.9%	1,847	24.3

Occupied - Must have been active once during previous 10 years, calculated based on the official definitions

Average Peak Males - Includes only those leks where one or more strutting males were observed. Does not include "Active" leks where only sign was documented

Table 4: Leks Checked

Year	Occupied	Checked	Percent Checked	Peak Males	Average Peak Males
2014	221	206	93.2%	2,189	16.3
2015	222	196	88.3%	4,546	30.3
2016	223	189	84.8%	5,191	36.0
2017	224	203	90.6%	4,356	32.0
2018	219	189	86.3%	3,049	22.6
2019	217	188	86.6%	2,534	20.8
2020	213	174	81.7%	2,161	18.3
2021	212	180	84.9%	1,918	16.4
2022	209	190	90.9%	2,261	19.5
2023	205	189	92.2%	2,844	23.9

Occupied - Must have been active once during previous 10 years, calculated based on the official definitions

Average Peak Males - Includes only those leks where one or more strutting males were observed. Does not include "Active" leks where only sign was documented

Table 5: Lek Status

Year	Occupied	Active	Inactive	Unknown	Known Status	% Active	% Inactive
2014	221	138	48	20	186	74.2%	25.8%
2015	222	154	33	9	187	82.4%	17.6%
2016	223	146	22	21	168	86.9%	13.1%
2017	224	148	45	10	193	76.7%	23.3%
2018	219	138	43	8	181	76.2%	23.8%
2019	217	133	37	18	170	78.2%	21.8%
2020	213	125	38	11	163	76.7%	23.3%
2021	212	122	36	22	158	77.2%	22.8%
2022	209	128	38	24	166	77.1%	22.9%
2023	205	123	22	44	145	84.8%	15.2%

Occupied - Must have been active once during previous 10 years, calculated based on the official definitions

Inactive - Confirmed no birds/sign present (see official definitions)

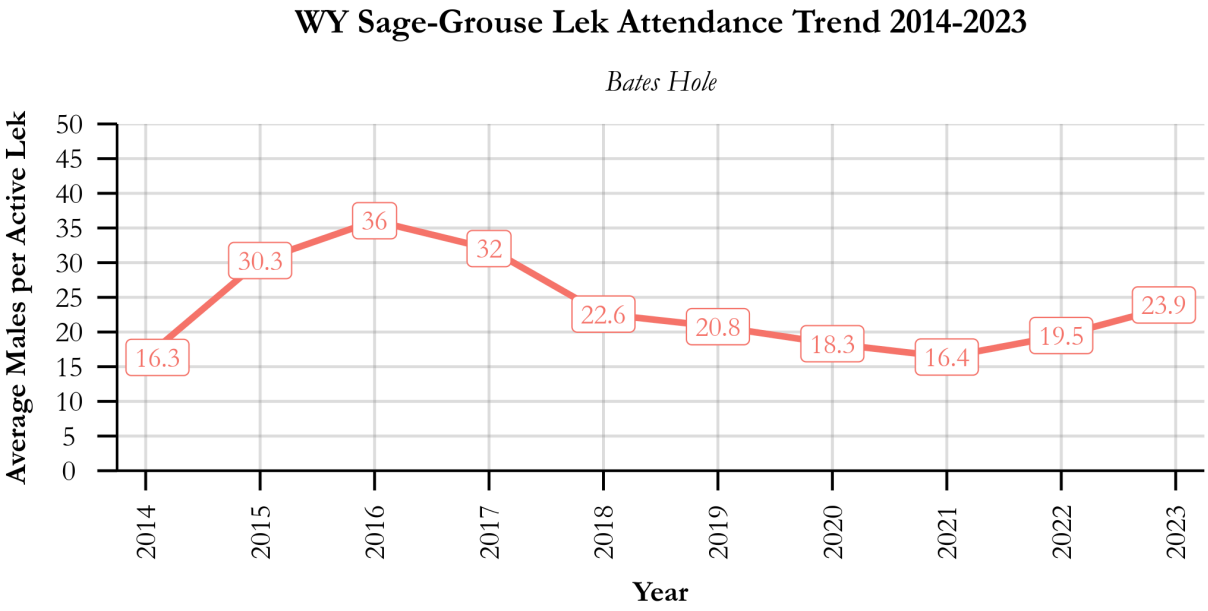


Figure 1: Average Peak Males

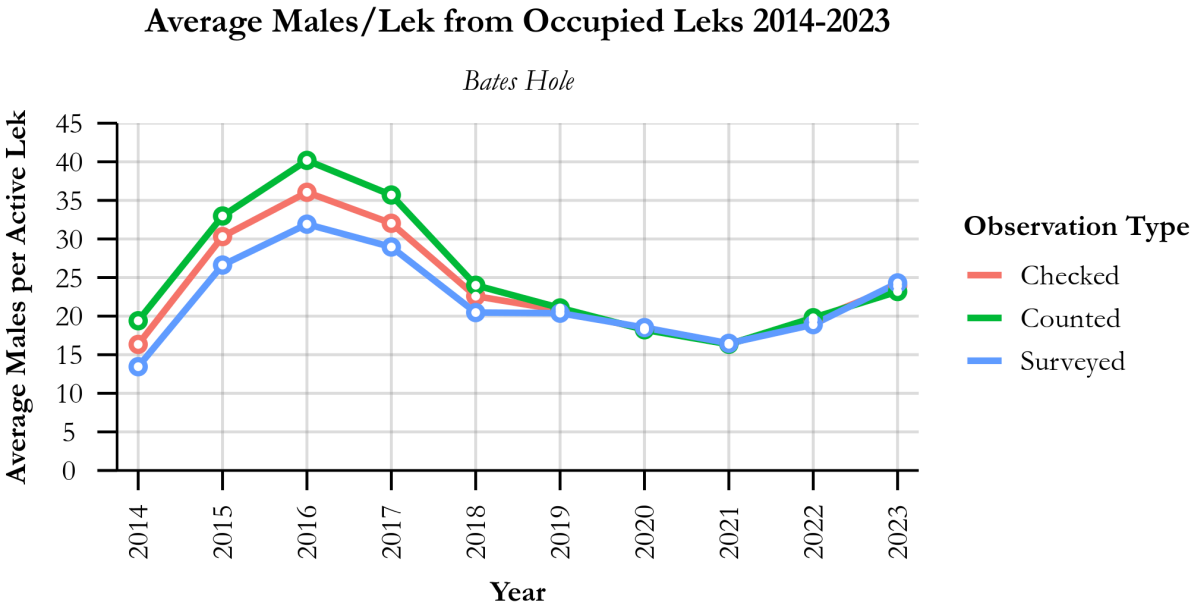


Figure 2: Average Peak Males

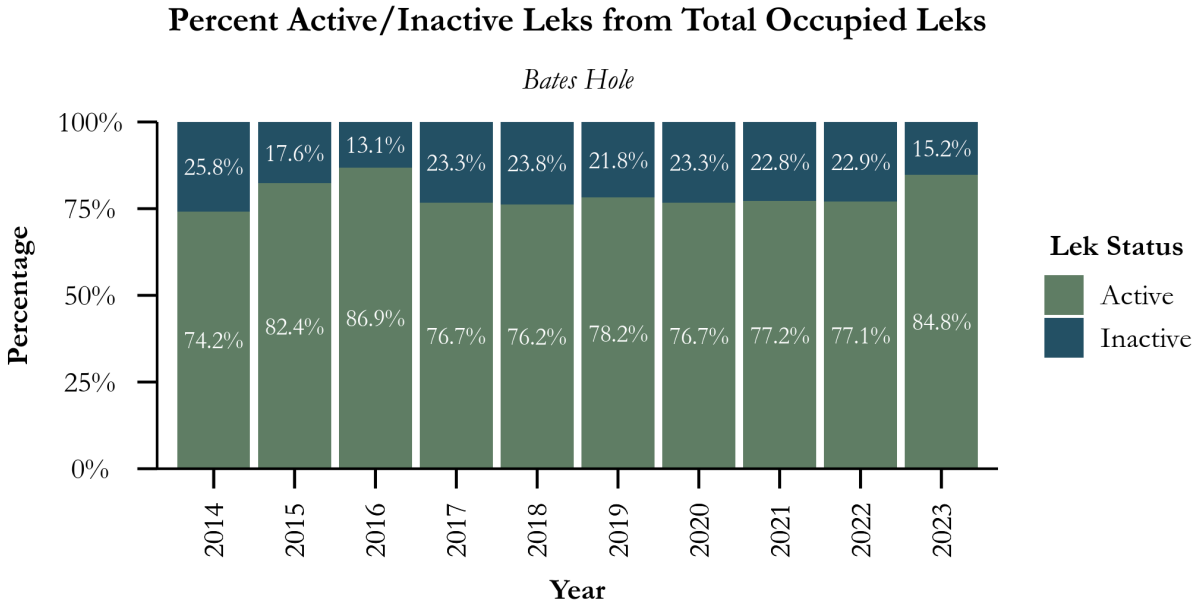


Figure 3: Lek Status

Table 6: Harvest Season

Year	Season Start	Season End	Length	Bag/Possession Limit
2013	Sep-21	Sep-30	10	2/4
2014	Sep-20	Sep-30	11	2/4
2015	Sep-19	Sep-30	12	2/4
2016	Sep-17	Sep-30	14	2/4
2017	Sep-16	Sep-30	15	2/4
2018	Sep-15	Sep-30	16	2/4
2019	Sep-21	Sep-30	10	2/4
2020	Sep-19	Sep-30	12	2/4
2021	Sep-18	Sep-30	13	2/4
2022	Sep-17	Sep-30	14	2/4

Table 7: Harvest Totals

Year	Harvest	Hunters	Days	Birds/Day	Birds/Hunter	Days/Hunter
2013	488	399	670	0.7	1.2	1.7
2014	588	352	804	0.7	1.7	2.3
2015	837	380	889	0.9	2.2	2.3
2016	869	466	869	1.0	1.9	1.9
2017	621	315	688	0.9	2.0	2.2
2018	805	464	993	0.8	1.7	2.1
2019	723	403	736	1.0	1.8	1.8
2020	252	212	595	0.4	1.2	2.8
2021	1,071	513	1,195	0.9	2.1	2.3
2022	1,397	631	1,561	0.9	2.2	2.5
Average	**765**	**414**	**900**	**0.8**	**1.8**	**2.2**

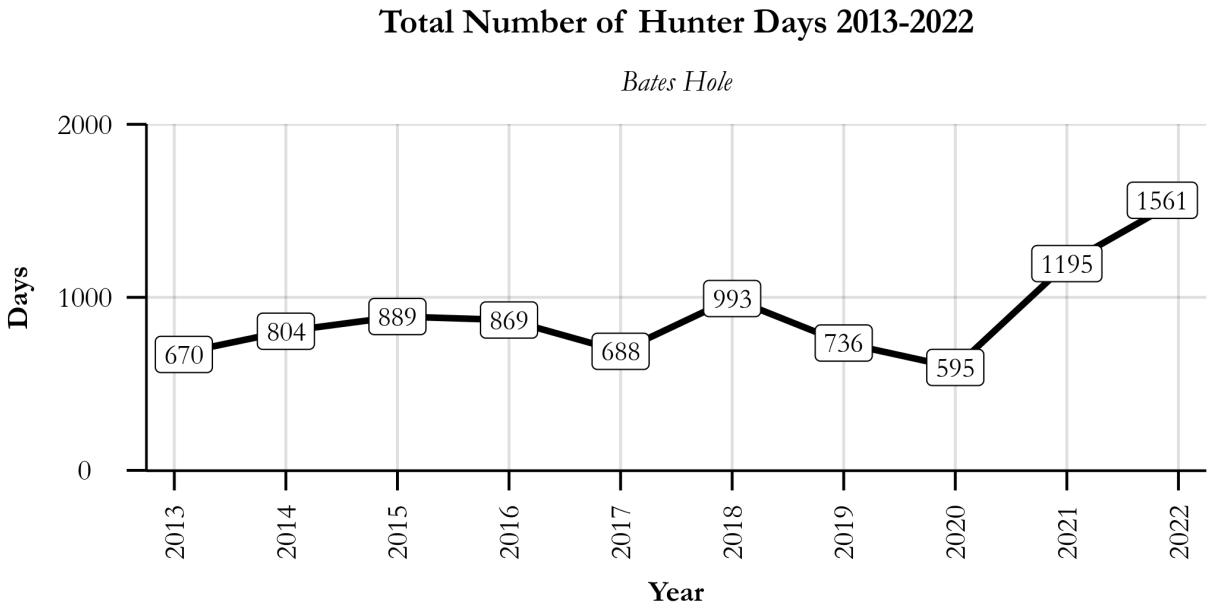


Figure 4: Harvest Days

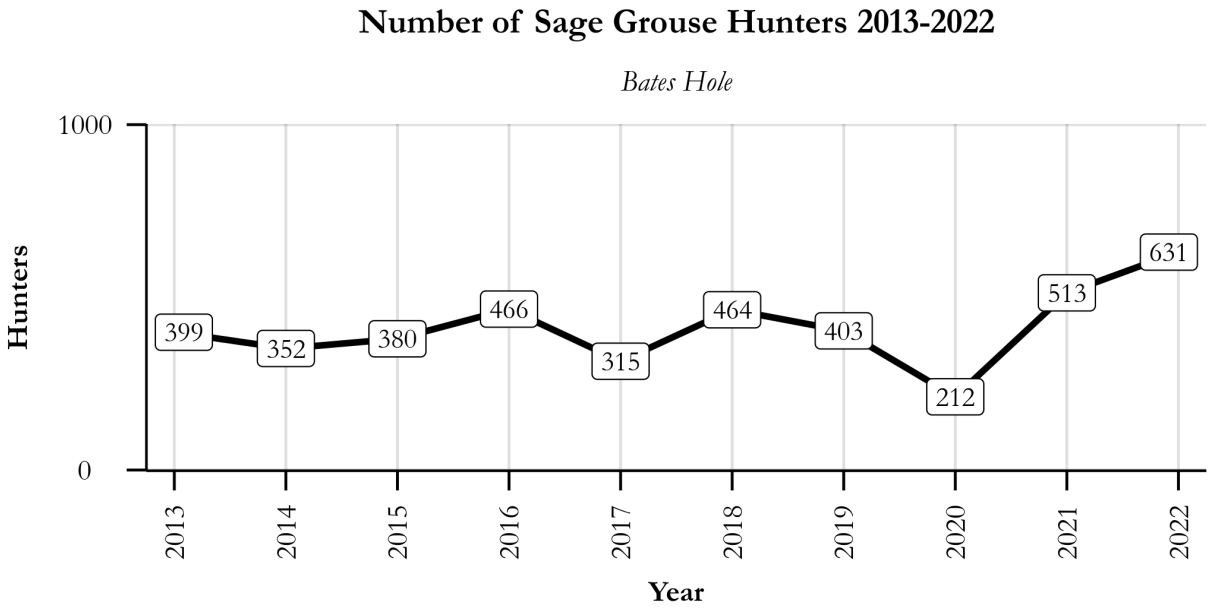


Figure 5: Hunters

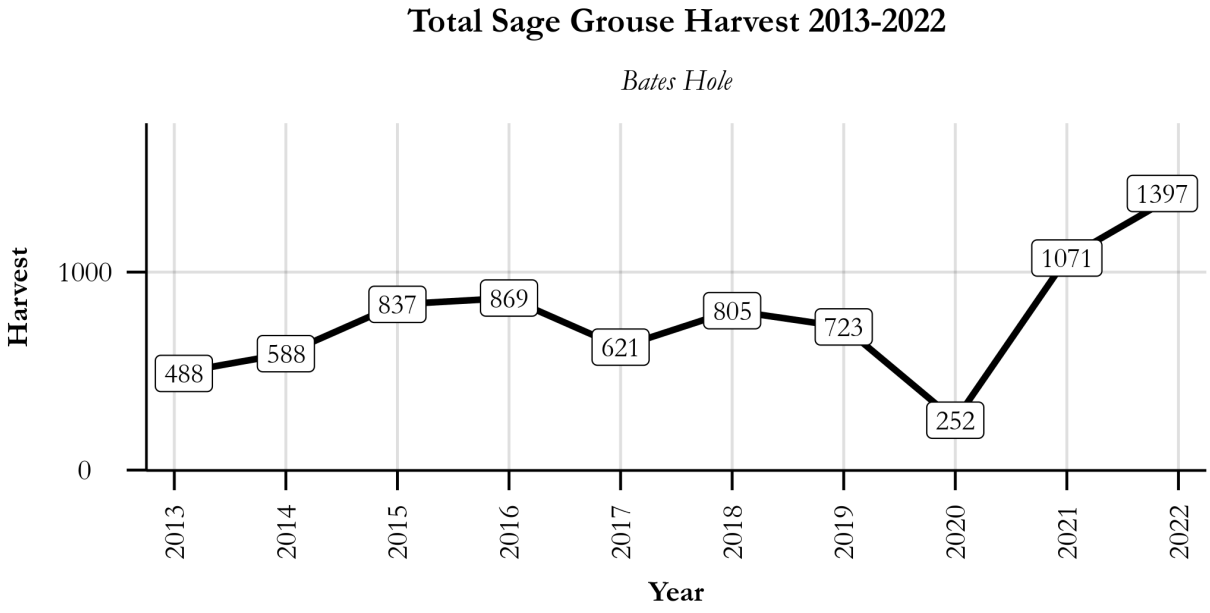


Figure 6: Total Harvest

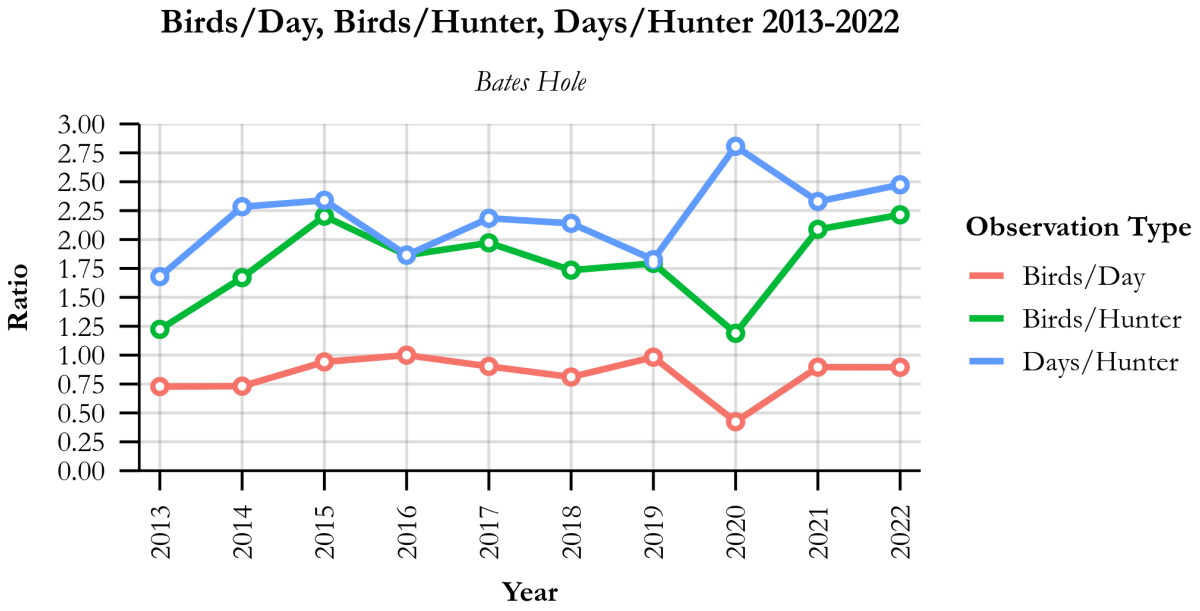


Figure 7: Harvest Ratios

Table 8: Harvest Composition

		Percent Adult		Percent Yearling		Percent Chick		
Year	Sample Size	Male	Female	Male	Female	Male	Female	Chicks/Hens
2013	187	9.1%	26.2%	4.3%	16.6%	24.1%	19.8%	1.0
2014	190	10.5%	16.8%	2.1%	10.5%	30.5%	29.5%	2.2
2015	253	14.6%	31.6%	5.5%	6.7%	22.9%	18.6%	1.1
2016	217	19.4%	33.2%	10.1%	16.6%	11.5%	9.2%	0.4
2017	145	20%	23.4%	4.8%	6.9%	20%	24.8%	1.5
2018	168	15.5%	25%	4.2%	7.7%	19%	28.6%	1.5
2019	212	13.2%	32.5%	3.8%	14.6%	12.3%	23.6%	0.8
2020	273	8.8%	30.8%	4.8%	11.7%	10.6%	33.3%	1.0
2021	195	8.7%	31.8%	3.1%	10.8%	21%	24.6%	1.1
2022	300	5.7%	24.7%	3%	14.3%	21.3%	31%	1.3

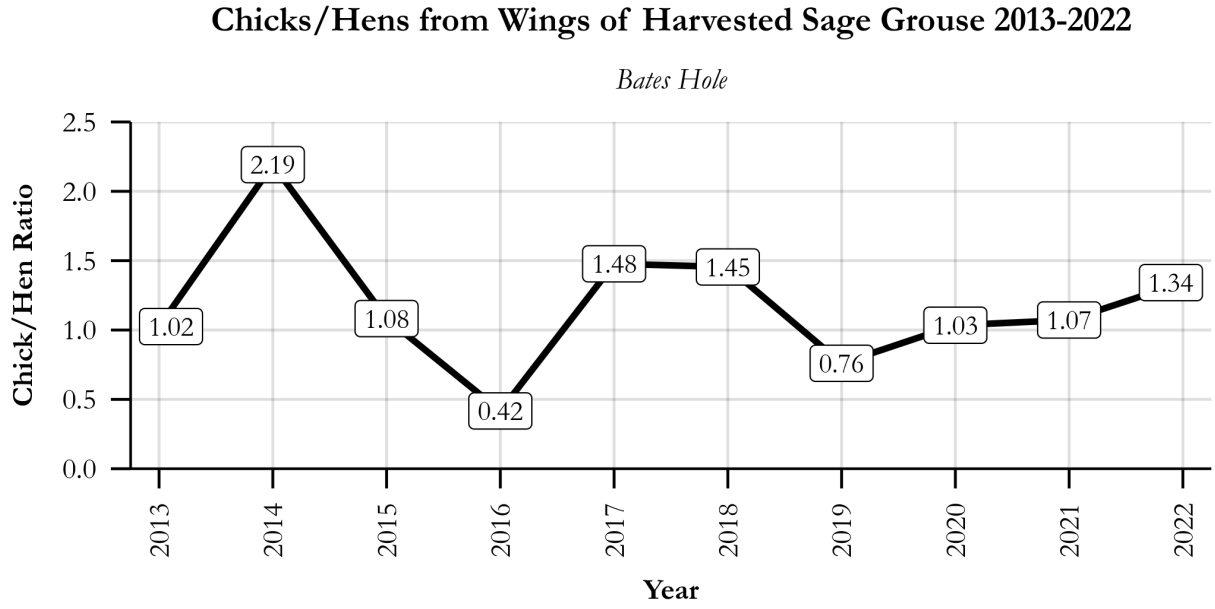


Figure 8: Chick/Hen Ratio

Lek Monitoring:

As of spring 2023, there are 202 known occupied leks, 96 unoccupied leks, and 24 leks of an undetermined classification within the Bates Hole/ Shirley Basin Local Working Group (BHSBLWG) area (**Table 1)**. In 2023, WGFD personnel, BLM personnel, volunteers, and consultants combined efforts to check 92.2% of known occupied leks in the BHSBLWG area (**Table 4)**. A total of 60 occupied leks were counted while 129 were surveyed, with annual status being confirmed on 145 occupied leks in 2023. Of these, 123 (84.8%) were active and 22 (15.2%) were inactive (**Table 5)**.

In April 2023, Owyhee Air Research LLC conducted a lek census survey with an infrared imaging system. The survey area occurred in Shirley Basin, 40 miles south of Casper, Wyoming. Flights were conducted from one hour before sunrise and lasted up to two hours after sunrise. Survey transects covering the study area were spaced at 0.25 miles to maximize likelihood of detection of sage-grouse. In total 1,139 greater sage-grouse were detected in the survey area. Of the 40 known lek locations surveyed, 20 were found to be active. 13 detections beyond one mile from the nearest known lek were determined to be potential new lek locations, including one location with 132 individuals and another with 206 individuals. Managers will work over the next lek monitoring season to verify these potential new leks that were detected during the survey. This survey was considered a success and was especially beneficial during a year when ground access to leks in the survey area was very limited due to prolonged snow cover.

Production:

Sage-grouse populations exhibit cyclical patterns. The 2023 average males/ lek from all (counts and surveys) occupied lek observations (23.9) was similar to the average males/ lek in 2018. The last cyclical peak occurred in 2016, with 36 males per lek on average. Male lek attendance then declined

sharply from 2016-2021 and has been slowly increasing since (**Figure 1**; **Figure 2)**. Anecdotal field observations by managers have reported increased numbers of birds as well.

Harvest:

In general, chick/hen ratios of about 1.5:1 result in relatively stable lek counts the following spring, while chick/hen ratios of 1.8:1 or greater result in subsequent increased lek attendance and ratios below 1.2:1 result in decline. Over the last 10 years, estimated productivity from wing-barrel data has fluctuated between 0.4 and 2.2 chicks per hen within the BHSBLWG area. Wing barrel data within the BHSBLWG area show that the 2022 chicks/hen ratio was 1.3. In the past 10 years, chick/hen ratios have only exceeded 1.5 one time, in 2014 (**Table 8)**. However, populations have appeared to stabilize and begin to increase. Managers are unsure why chick ratios from wing barrel data remain so low given other signs of population increase. The chick to hen value was calculated using a sample of 300 wings, which represents 21% of the estimated harvest based on hunter surveys (**Figure 6)**.

Total sage-grouse harvest (1397) and number of hunters (631) are higher than any time in the past 10 years, and are similar to levels experienced in the mid to late 2000s (**Figure 5; Figure 6)**. When assessing harvest, it's important to note that there was a survey error in 2020 which resulted in inaccurate and unreliable data obtained for that year.

Habitat:

The BHSBLWG area has many of the same habitat quality concerns that occur throughout sage-grouse range including habitat alteration, development and fragmentation, drought, noxious and invasive weeds, especially annual invasive grasses, declines in mesic habitat, and improper livestock grazing in some areas. In recent years, managers are most concerned about on-going large-scale industrial wind development projects as well as the potential for expansion of wind development within Shirley Basin. The transmission lines within the BHSBLWG area have also been a recent and on-going large scale disturbance within prime sage-grouse habitat.

Sagebrush condition throughout some portions of the area may also be of concern. Past sagebrush transects have repeatedly shown high levels of browse utilization by pronghorn and domestic sheep. These issues likely continue in some areas.

The RR316 wildfire burned 14,200 acres outside of Hanna, Wyoming in late summer 2020. High fire severity resulted in substantial loss of sagebrush cover in the Hanna Core Area. Over ten miles of woven wire/barbed combination fence were replaced with four-wire wildlife-friendly fence in 2021 and marked with reflective markers in spring 2022. At least two tire tanks with associated pipes and wildlife access modifications will be constructed in 2024. The fire scar continues to recover while native, perennial ground cover continues to increase. A lack of invasive grasses within the burn scar area is promising for recovery. To date, no sagebrush shrub seedling establishment has been witnessed.

The Pedro Mountain Fire burned about 19,000 acres in 2019. However, very little of the fire was in suitable sage-grouse habitat. The very southern portion of the burn is of most concern to sage-grouse managers. Sagebrush restoration efforts have not occurred. However, the area has been sprayed for cheatgrass, but recent on-the-ground observations of large areas of cheatgrass are

concerning to managers. Managers will continue to assess options to re-treat the Pedro Mountains and adjacent sagebrush habitats.

Extensive habitat work is occurring in the Upper Bates Hole portion of this working group area and includes conifer removal, mountain big sagebrush treatments to increase vegetation diversity and production, wet meadow/riparian/mesic improvements, fence marking, and cheatgrass treatments. Planned cheatgrass treatments extend into the Shirley Basin and will address sources of cheatgrass which threaten large, intact portions of high-quality sagebrush habitat.

Disease:

There were no confirmed cases of West Nile virus (WNv) in sage-grouse within the BHSBLWG area during this reporting period. While WGFD field personnel, other agency personnel and the public are requested to recover and submit carcasses of dead birds to the Wyoming State Vet Lab for necropsy, very few, if any birds are submitted. Sage-grouse carcasses typically do not persist in the field for very long, making it difficult for timely discovery and submission. The extent of WNv infection and its effects on sage-grouse populations throughout the BHSBLWG area is unknown, but potentially significant in years when outbreaks occur.

Conservation Planning:

Sage-grouse Core Area revisions were recommended in 2023. It is currently unknown what the final outcome of this process will be.

Management Recommendations:

Managers are looking forward to changes to regulations which will require sage-grouse hunters to obtain a permit. This will allow for the acquisition of more accurate harvest data to inform management and hunting seasons. Managers believe there may be some areas within the BHSGLWG area that have unsustainably high concentrations of hunters throughout the course of the season, and are awaiting improved harvest data to more accurately assess the situation.

Big Horn Basin

Job Completion Report

Prepared By: Sam Stephens, Greybull Wildlife Biologist

Period Covered: 6-1-2022 to 5-31-2023

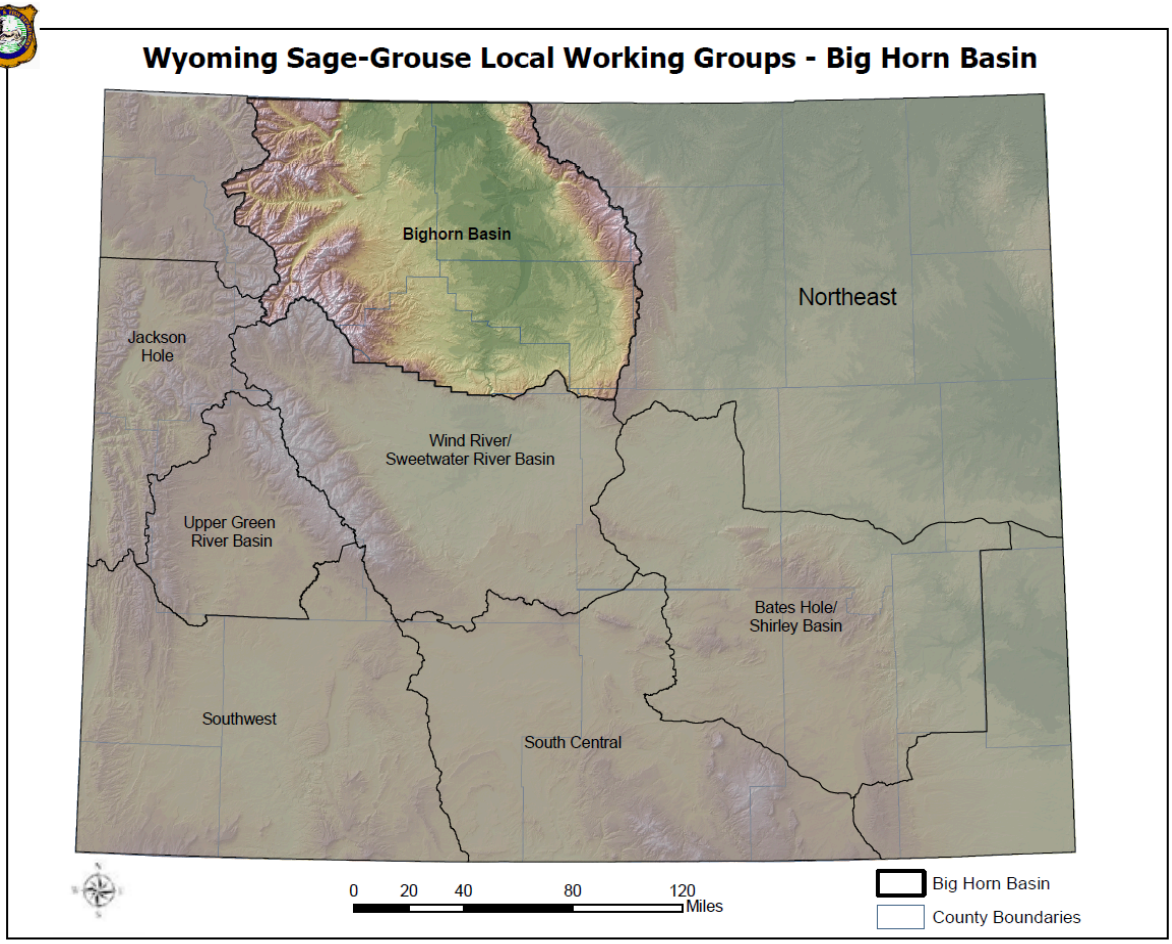


Table 1: Sage-Grouse Lek Characteristics

	Group	N	Percent
BLM Office			
	Cody	117	37.3%
	Worland	197	62.7%
Biologist			
	Cody	88	28%
	Greybull	52	16.6%
	Worland	174	55.4%
Classification			
	Occupied	216	68.8%
	Undetermined	44	14%
	Unoccupied	54	17.2%
County			
	Big Horn	48	15.3%
	Hot Springs	57	18.2%
	Park	107	34.1%
	Washakie	102	32.5%
Land Status			
	BOR	3	1%
	State	19	6.1%

	Group	N	Percent
Land Status			
	BLM	209	66.6%
	Private	83	26.4%
Lek Status			
	Active	142	45.2%
	Inactive	101	32.2%
	Unknown	71	22.6%
Management Area			
	B	314	100%
Region			
	Cody	314	100%
Warden			
	Greybull	23	7.3%
	Lovell	31	9.9%
	Meeteetse	32	10.2%
	North Cody	26	8.3%
	Powell	13	4.1%
	South Cody	29	9.2%
	Ten Sleep	54	17.2%
	Thermopolis	48	15.3%
	Worland	58	18.5%

Table 2: Leks Counted

Year	Occupied	Counted	Percent Counted	Peak Males	Average Peak Males
2014	234	67	28.6%	823	14.4
2015	244	53	21.7%	1,108	26.4
2016	250	86	34.4%	2,258	30.5
2017	252	56	22.2%	1,636	34.8
2018	243	60	24.7%	1,115	24.2
2019	243	59	24.3%	897	17.2
2020	234	70	29.9%	894	16.9
2021	233	113	48.5%	1,082	14.2
2022	230	79	34.3%	815	15.7
2023	227	80	35.2%	1,168	19.1

Occupied - Must have been active once during previous 10 years, calculated based on the official definitions

Average Peak Males - Includes only those leks where one or more strutting males were observed. Does not include "Active" leks where only sign was documented

Table 3: Leks Surveyed

Year	Occupied	Surveyed	Percent Surveyed	Peak Males	Average Peak Males
2014	234	91	38.9%	517	9.2
2015	244	141	57.8%	2,297	20.3
2016	250	140	56%	2,053	23.3
2017	252	175	69.4%	2,286	19.2
2018	243	153	63%	1,434	14.2
2019	243	139	57.2%	835	9.6
2020	234	127	54.3%	617	7.9
2021	233	82	35.2%	313	7.8
2022	230	122	53%	622	10.0
2023	227	110	48.5%	654	10.5

Occupied - Must have been active once during previous 10 years, calculated based on the official definitions

Average Peak Males - Includes only those leks where one or more strutting males were observed. Does not include "Active" leks where only sign was documented

Table 4: Leks Checked

Year	Occupied	Checked	Percent Checked	Peak Males	Average Peak Males
2014	234	158	67.5%	1,340	11.9
2015	244	194	79.5%	3,405	22.0
2016	250	226	90.4%	4,311	26.6
2017	252	231	91.7%	3,922	23.6
2018	243	213	87.7%	2,549	17.3
2019	243	198	81.5%	1,732	12.5
2020	234	197	84.2%	1,511	11.5
2021	233	195	83.7%	1,395	12.0
2022	230	201	87.4%	1,437	12.6
2023	227	190	83.7%	1,822	14.8

Occupied - Must have been active once during previous 10 years, calculated based on the official definitions

Average Peak Males - Includes only those leks where one or more strutting males were observed. Does not include "Active" leks where only sign was documented

Table 5: Lek Status

Year	Occupied	Active	Inactive	Unknown	Known Status	% Active	% Inactive
2014	234	115	23	20	138	83.3%	16.7%
2015	244	156	27	11	183	85.2%	14.8%
2016	250	173	26	27	199	86.9%	13.1%
2017	252	171	35	25	206	83%	17%
2018	243	152	34	27	186	81.7%	18.3%
2019	243	149	42	7	191	78%	22%
2020	234	137	58	2	195	70.3%	29.7%
2021	233	125	53	17	178	70.2%	29.8%
2022	230	117	60	24	177	66.1%	33.9%
2023	227	126	53	11	179	70.4%	29.6%

Occupied - Must have been active once during previous 10 years, calculated based on the official definitions

Inactive - Confirmed no birds/sign present (see official definitions)

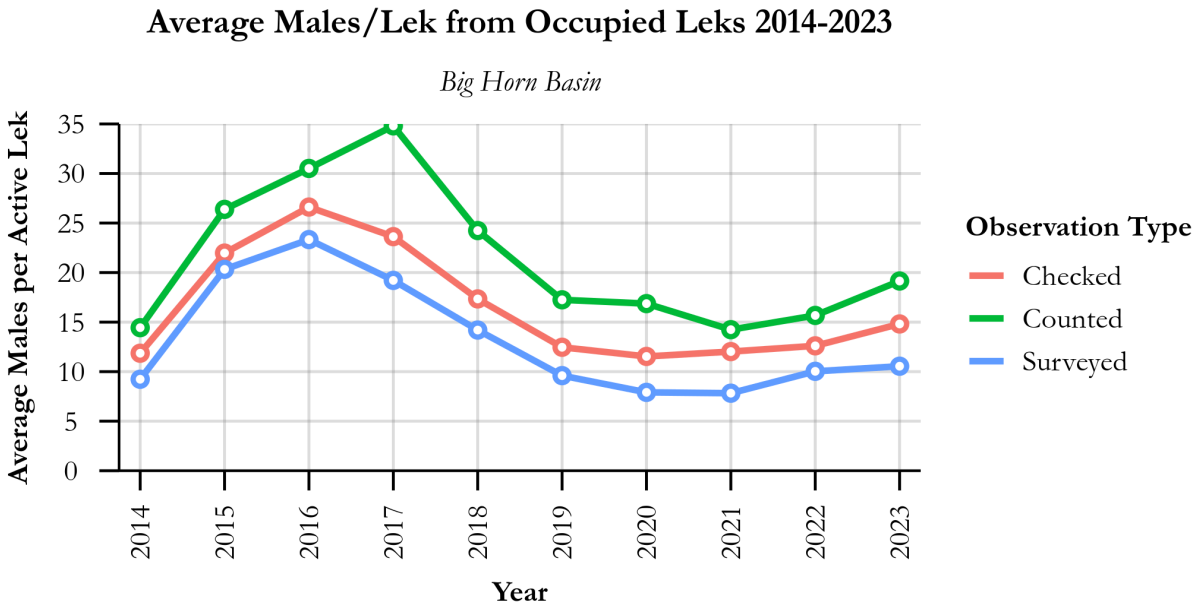


Figure 1: Average Peak Males

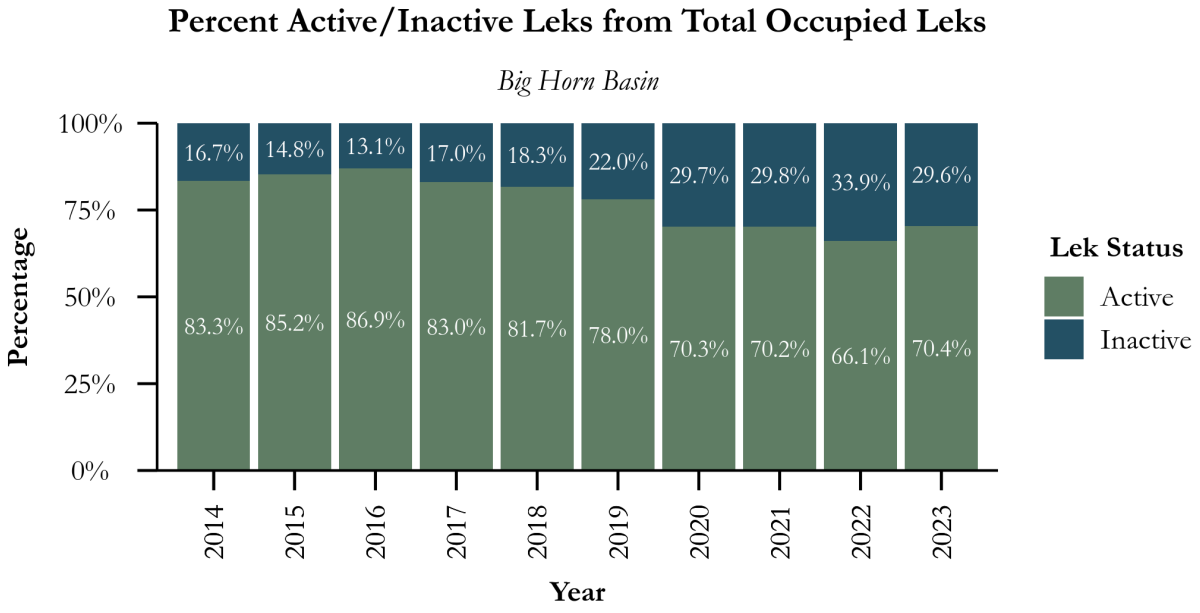


Figure 2: Lek Status

Table 6: Harvest Season

Year	Season Start	Season End	Length	Bag/Possession Limit
2013	Sep-21	Sep-30	10	2/4
2014	Sep-20	Sep-30	11	2/4
2015	Sep-19	Sep-30	12	2/4
2016	Sep-17	Sep-30	14	2/4
2017	Sep-16	Sep-30	15	2/4
2018	Sep-15	Sep-30	16	2/4
2019	Sep-21	Sep-30	10	2/4
2020	Sep-19	Sep-30	12	2/4
2021	Sep-18	Sep-30	13	2/4
2022	Sep-17	Sep-30	14	2/4

Table 7: Harvest Totals

Year	Harvest	Hunters	Days	Birds/Day	Birds/Hunter	Days/Hunter
2013	206	206	513	0.4	1.0	2.5
2014	524	303	708	0.7	1.7	2.3
2015	729	411	947	0.8	1.8	2.3
2016	594	302	868	0.7	2.0	2.9
2017	635	300	745	0.9	2.1	2.5
2018	648	418	1,351	0.5	1.6	3.2
2019	312	244	463	0.7	1.3	1.9
2020	767	331	1,037	0.7	2.3	3.1
2021	586	493	1,290	0.5	1.2	2.6
2022	497	674	1,731	0.3	0.7	2.6
Average	**550**	**368**	**965**	**0.6**	**1.6**	**2.6**

Table 8. Brood survey data collected by Wyoming Game & Fish Department personnel in the Bighorn Basin, 2014-23.

Year Observed	Broods	Chicks	Hens	Chicks/brood	Chicks/hen
2014	6	31	27	5.2	1.1
2015	13	69	24	5.3	2.9
2016	8	21	5	2.6	4.2
2017	5	32	7	6.4	4.6
2018	5	22	6	4.4	3.7
2019	4	15	4	3.8	3.8
2020	4	22	4	5.5	5.5
2021	4	22	4	5.5	5.5
2022	11	56	13	5.0	4.3
2023	5	32	6	6.4	5.3
2014-23 average	**6.5**	**32**	**10**	**5**	**4.1**

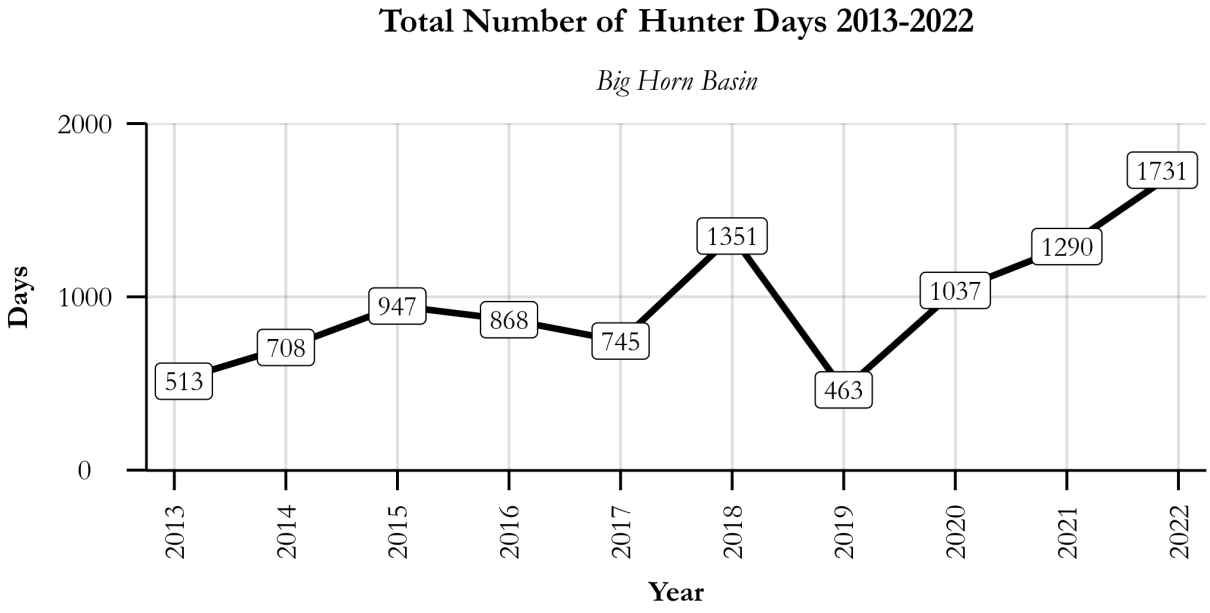


Figure 3: Harvest Days

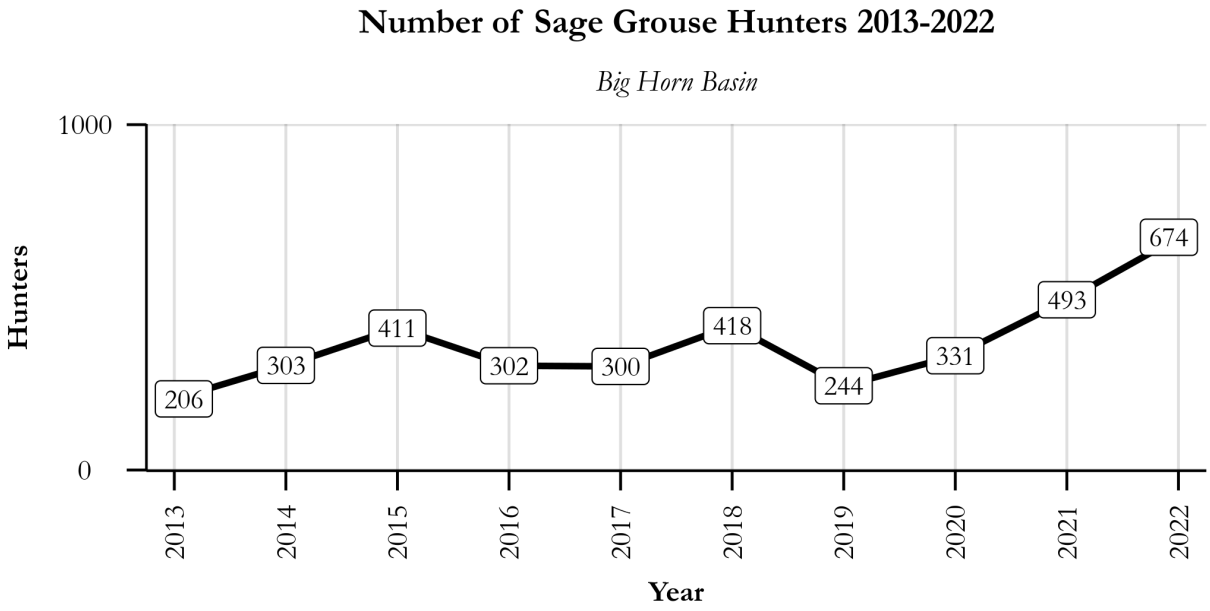


Figure 4: Hunters

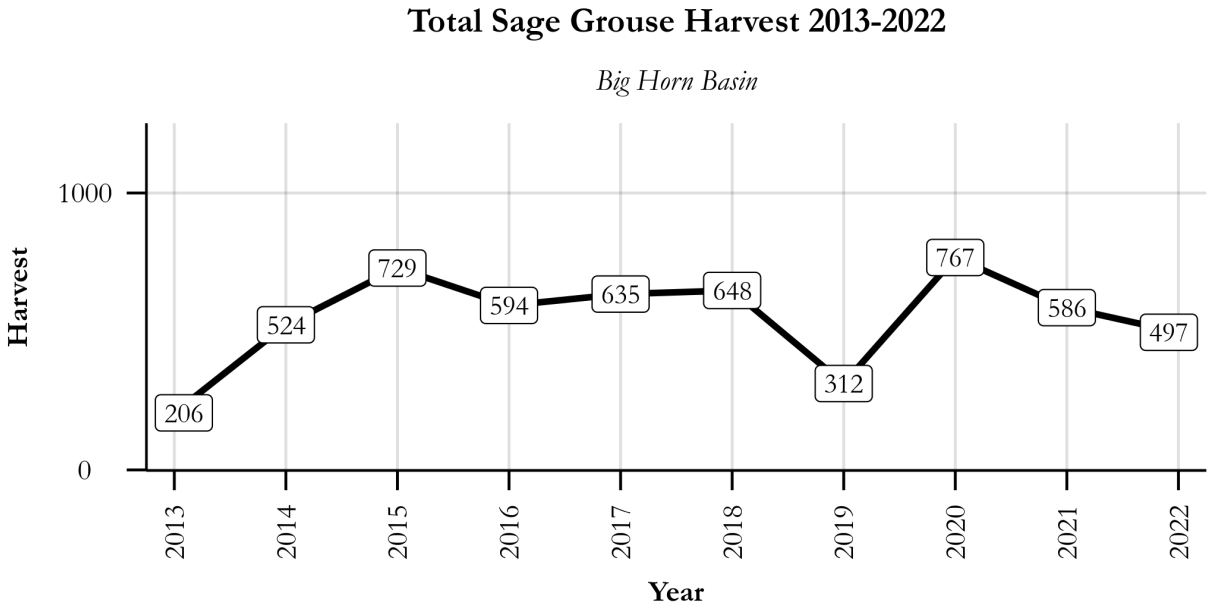


Figure 5: Total Harvest

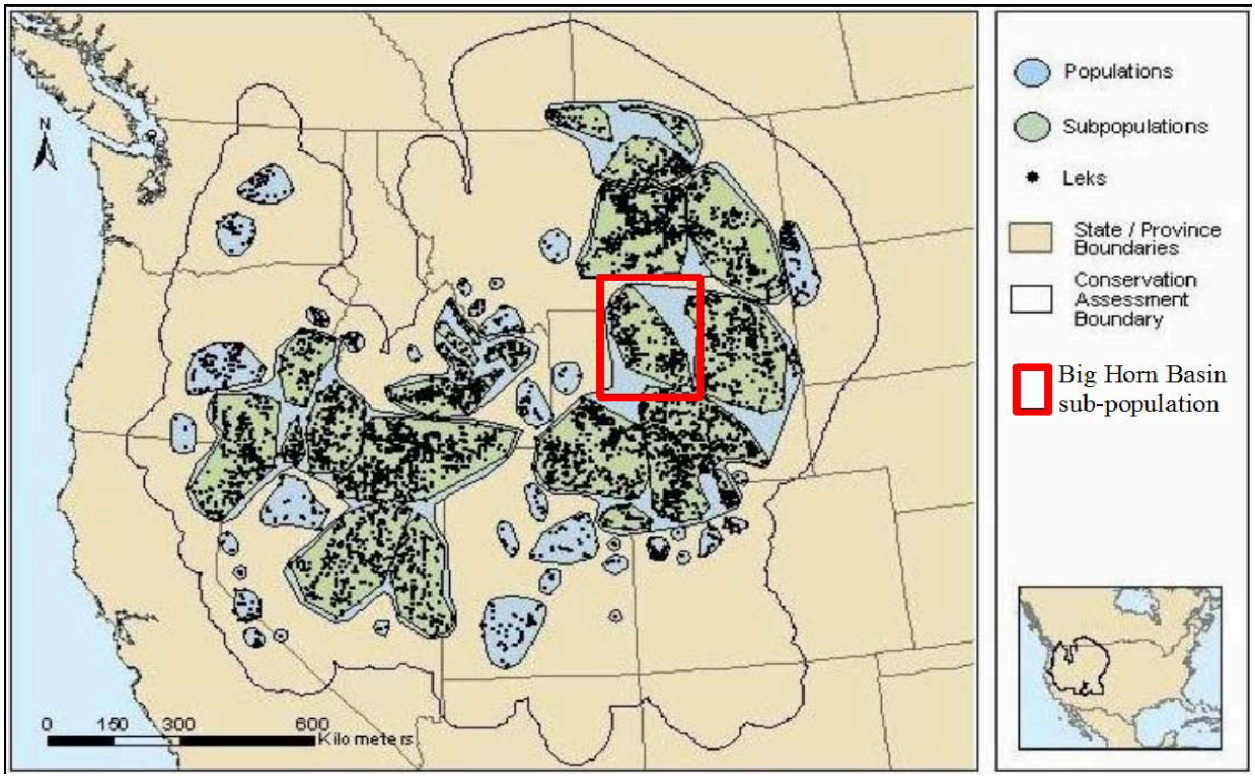


Figure 7. Discrete populations and subpopulations of sage-grouse in western North America, with the Big Horn Basin sub-population surrounded by the red rectangle. (Adapted from Connelly et. al. 2004).

Lek Monitoring:

In spring 2023, 80 occupied leks were counted in the Basin, resulting in an average of 19.1 males per lek (Table 2). We surveyed 110 leks for a total of 190 leks checked during the 2023 season (2014-23 average=200; **Table 2**). To evaluate long-term population trends, we combine and average survey and count lek data since the count protocol was not used during the late 1980s and early 1990s. Fortunately, long-term data sets from Wyoming and neighboring states indicate similar trends from both counts and surveys (Fedy and Aldridge 2011).

The average number of male sage-grouse on all occupied leks showed an increase from the 2022 count of 12.6 to 14.8 in 2023 (**Table 2**). Sage-grouse populations cycle on approximate 7 to 10-year intervals (Fedy and Doherty 2010). The number of inactive leks increased significantly over the past four years (2020-23 average: 56). In 2023, the number of inactive leks showed a slight decrease from 60 (2022) to 53.

Production:

Five sage-grouse broods were documented in 2023 (**Table 8**). Low sample sizes are likely a product of lack of effort by field personnel, because sage-grouse brood data is opportunistically collected while performing other duties during July, August, and early September. A direct connection between effort (time spent surveying for broods) and number of broods observed was presented in previous Job Completion Reports.

Harvest:

Average (1982-1994) annual harvest in the Basin was 3,756 sage-grouse taken by 1,300 hunters during 3,118 hunter days (2.8 birds/hunter, 2.4 days/hunter). During 1995-2001 an average of 549 hunters took 1,056 sage-grouse during 1,567 days of hunting (1.9 birds/hunter, 2.8 days/hunter). During the most recent period (2014-2022), hunters averaged 1.6 birds/hunter and 2.6 days/hunter. In 2022, 674 hunters in the Big Horn Basin harvested 497 sage-grouse (0.7 birds/hunter) (**Table 7**); spending 1731 hunter-days afield (2.6 days/hunter) during the 14-day hunting season (**Table 6**). The significant decrease in sage-grouse harvest over the past several years is likely due to decreased sage-grouse abundance. Hunters who visited with regional staff expressed a desire to harvest sage-grouse while the opportunity still exists relative to other states where harvest has been more restricted. This likely contributed to the marked increase of sage-grouse hunters in 2022 (674).

Habitat:

Sage-grouse habitat within the Bighorn Basin exists predominantly in low precipitation zones ranging from 5-9" to 7-12" annually. Vegetation communities within the Basin are diverse and vary according to soil type, annual precipitation, and elevation. Major vegetation communities in the Basin include sagebrush steppe, saltbush badlands, irrigated agricultural lands, cottonwood dominated riparian corridors, mixed mountain shrub, and mixed conifer forests with interspersed aspen stands at higher elevations.

Connelly et al. (2004) recognized sage-grouse in the Basin as a distinct sub-population (**Figure 7**). Mountain ranges to the east and west restrict most sage-grouse movement due to unsuitable habitat. There are several leks near the Wyoming/Montana state line with movement between states occurring. Copper Mountain, the Owl Creek Mountains, and the southern Bighorn Mountains provide suitable habitat serving as travel corridors to adjacent populations.

In 2023, 314 sage-grouse leks are known to occur in the conservation area with 216 leks known to be occupied and 54 leks known to be unoccupied (**Table 1**). Undetermined leks (n=44) need additional observations before being reclassified as occupied or unoccupied. A majority of leks (67%) occur on BLM managed land and 26% of leks occur on private land (**Table 1**). There are potentially other leks in the Basin not yet discovered.

Conservation Planning:

The BHBLWG was formed in September 2004 to develop and implement a local conservation plan for sage-grouse and sagebrush habitats. The BHBLWG's mission statement is, "*Through the efforts of local concerned citizens, recommend management actions that are based on the best science to enhance sagebrush habitats and ultimately sage-grouse populations within the Big Horn Basin*."

The BHBLWG's local plan identifies factors and impacts that may influence sage-grouse populations in the Basin, and outlines goals and objectives to address habitats, populations, research and education. Strategies and commitments in the local plan are designed to improve sage-grouse habitats and populations in the Basin. The local plan was updated in 2014 and highlights completed and ongoing projects in the Basin in addition to summarizing state- and nation-wide policy and programs. The updated plan can be viewed at the WGFD website: **https://wgfd.wyo.gov/Habitat/Sage-Grouse-Management**.

Most recently, the BHBLWG met in 2023 to discuss project funding allocation to sage-grouse research and habitat improvement projects. The group agreed to grant $44,012 to Oregon State University and the USDA for research conducted in Park County investigating the interactive effects of livestock, predators, and habitat on sage-grouse demography. Additionally $15,000 was granted to fund researchers conduct a comprehensive literature review and create a publicly available repository of information that summarizes the successes and failures of different habitat projects: namely weed management, grazing management, conifer control, wildfire restoration, and energy development site reclamation.

Management Recommendations:

For the 2022 biological year sage-grouse populations in the Bighorn Basin appear to be on an upward trend from the previous two years. Peak male attendance in 2023 indicates a reversal of negative trends in the population. Although the sample size is limited the 2023 brood count survey data suggest that for the following biological year, sage-grouse populations in the Bighorn Basin will likely continue along the same increasing trend. Sage-grouse in the Basin face threats, but are not in danger of foreseeable extirpation, and on-going conservation efforts are intended to mitigate some anthropogenic impacts. Research and monitoring are important to help identify limiting factors, important habitats, and to track populations.

Literature Cited:

Christiansen, T. 2012. Chapter 12: Sage-grouse (*Centrocercus urophasianus*). Pages 12-1 to 12-55 in S.A. Tessmann (ed). Handbook of Biological Techniques: third edition. Wyoming Game and Fish Department. Cheyenne, WY.

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. Unpublished Report. Cheyenne, Wyoming.

Fedy, B. C. and C. L. Aldridge. 2011. The importance of within-year repeated counts and the influence of scale on long-term monitoring of sage-grouse. Journal of Wildlife Management 75:1022-1033.

Fedy, B. C. and K. E. Doherty. 2010. Population cycles are highly correlated over long time series and large spatial scales in two unrelated species: greater sage-grouse and cottontail rabbits. Oecologia 165:915-924.

Hess, J. E. 2010. Greater sage-grouse (*Centrocercus urophasianus*) habitat response to mowing and prescribed burning Wyoming big sagebrush and the influence of disturbance factors on lek persistence in the Big Horn Basin, Wyoming. Thesis, University of Wyoming, Laramie, USA.

Hess, J. E. and J. L. Beck. 2012a. Burning and mowing Wyoming big sagebrush: Do treated sites meet minimum guidelines for greater sage-grouse breeding habitats? Wildlife Society Bulletin 36:85-93.

Hess, J. E., and J. L. Beck. 2012b. Disturbance factors influencing greater sage-grouse lek abandonment in north-central Wyoming. Journal of Wildlife Management 76:1625-1634.

Orning, E. K. 2013. Effect of predator removal on greater sage-grouse (Centrocercus urophasianus) ecology in the Bighorn Basin conservation area. Thesis, Utah State University, Logan, USA.

Orning, E. K. and J. K. Young. 2012. Bighorn Basin greater sage-grouse project. Annual Report, Utah State University, Logan, USA.

Orning, E. K. and J. K. Young. 2012a. Bighorn Basin greater sage-grouse project. Summary report for Major Basin, Utah State University, Logan, USA.

Pratt, A. C. and J. L. Beck. 2012. Greater sage-grouse migration ecology and response to bentonite mining in the Bighorn Basin, Wyoming. Annual Report, University of Wyoming, Laramie, USA.

Taylor, J. D. 2016. Monitoring causes of mortality, predation rates, and space use of greater sage-grouse in the Bighorn Basin. Final report to the Meeteetse Conservation District, USDA APHIS Wildlife Services, National Wildlife Research Center, Oregon Field Station, Corvallis, USA.

Taylor, J. D. and R. D. Holt. 2016. An assessment of greater sage-grouse (Centrocercus urophasianus) population demographics in the Bighorn Basin, Wyoming, 2011-2014. Report to the Wyoming Wildlife and Natural Resources Trust, Oregon State University, Corvallis, USA.

Northeast

Job Completion Report

Prepared By: Erika Peckham, Gillette Wildlife Biologist

Period Covered: 6-1-2022 to 5-31-2023

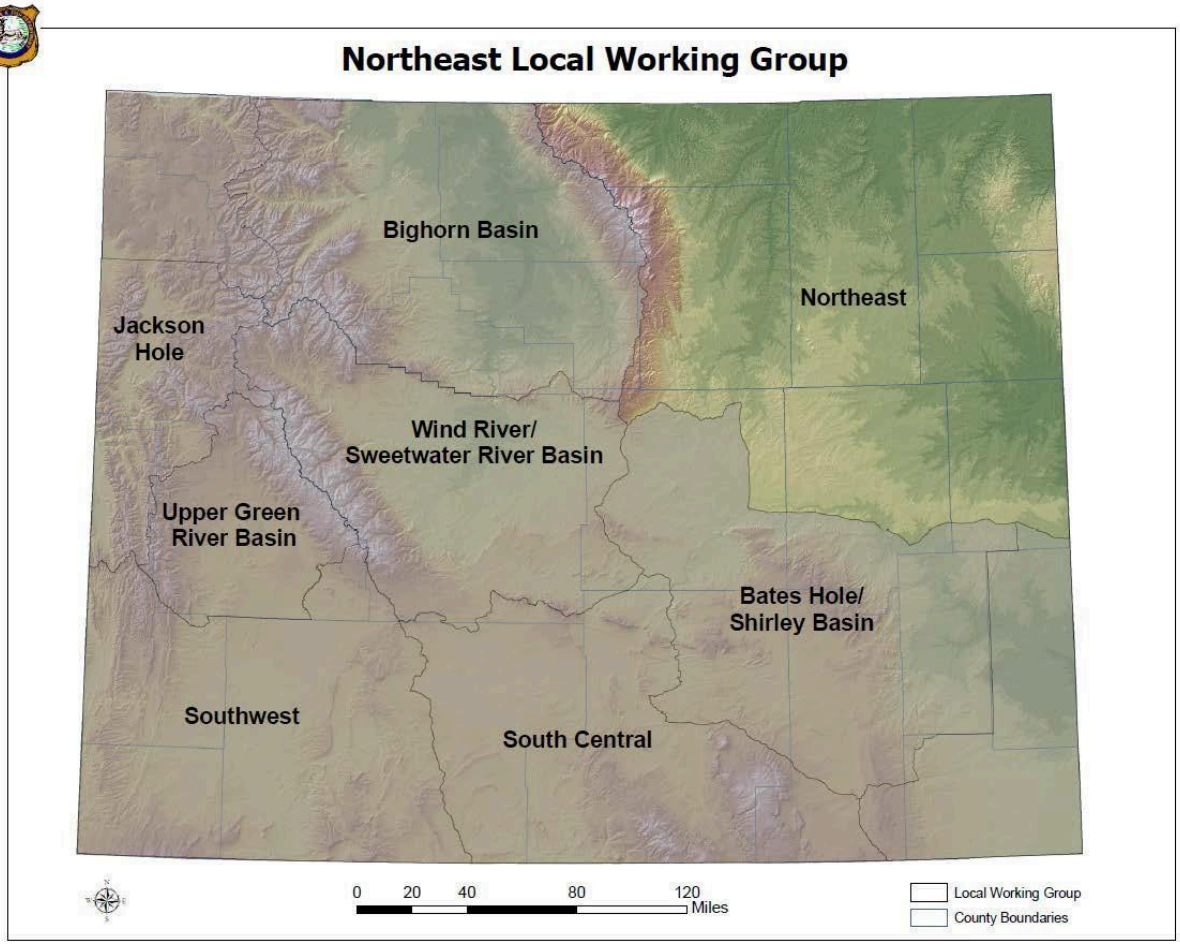


Table 1: Sage-Grouse Lek Characteristics

	Group	N	Percent
BLM Office			
	Buffalo	395	65.6%
	Casper	74	12.3%
	Newcastle	133	22.1%
Biologist			
	Buffalo	77	12.8%
	Casper	15	2.5%
	Douglas	65	10.8%
	Gillette	274	45.5%
	Newcastle	80	13.3%
	Sheridan	91	15.1%
Classification			
	Occupied	327	54.3%
	Undetermined	82	13.6%
	Unoccupied	193	32.1%
County			
	Big Horn, MT	1	0.2%
	Campbell	212	35.2%
	Carter, MT	1	0.2%
	Converse	58	9.6%
	Crook	27	4.5%
	Johnson	147	24.4%
	Natrona	16	2.7%
	Niobrara	26	4.3%
	Powder River, MT	1	0.2%
	Sheridan	34	5.6%
	Weston	79	13.1%

	Group	N	Percent
Land Status			
	BLM	54	9%
	Private	466	77.4%
	State	44	7.3%
	USFS	38	6.3%
Lek Status			
	Active	165	27.4%
	Inactive	236	39.2%
	Unknown	201	33.4%
Management Area			
	C	602	100%
Region			
	Casper	160	26.6%
	Sheridan	442	73.4%
Warden			
	Buffalo	78	13%
	Dayton	24	4%
	Douglas	27	4.5%
	East Casper	6	1%
	Glenrock	30	5%
	Kaycee	61	10.1%
	Lusk	26	4.3%
	Moorcroft	78	13%
	Newcastle	64	10.6%
	North Gillette	68	11.3%
	Sheridan	12	2%
	South Gillette	121	20.1%
	Sundance	6	1%
	West Casper	1	0.2%

Table 2: Leks Counted

Year	Occupied	Counted	Percent Counted	Peak Males	Average Peak Males
2014	403	197	48.9%	932	9.7
2015	395	188	47.6%	1,933	16.2
2016	390	166	42.6%	1,961	20.4
2017	373	162	43.4%	1,845	20.1
2018	368	175	47.6%	1,376	13.8
2019	360	153	42.5%	1,116	12.3
2020	357	159	44.5%	1,516	15.5
2021	351	147	41.9%	1,044	13.9
2022	349	133	38.1%	1,004	13.8
2023	344	154	44.8%	1,398	15.2

Occupied - Must have been active once during previous 10 years, calculated based on the official definitions

Average Peak Males - Includes only those leks where one or more strutting males were observed. Does not include "Active" leks where only sign was documented

Table 3: Leks Surveyed

Year	Occupied	Surveyed	Percent Surveyed	Peak Males	Average Peak Males
2014	403	161	40%	700	10.0
2015	395	146	37%	1,057	16.3
2016	390	179	45.9%	1,708	19.2
2017	373	163	43.7%	1,375	16.4
2018	368	107	29.1%	654	12.3
2019	360	142	39.4%	829	11.5
2020	357	81	22.7%	495	13.4
2021	351	140	39.9%	848	13.0
2022	349	150	43%	623	9.6
2023	344	114	33.1%	462	10.7

Occupied - Must have been active once during previous 10 years, calculated based on the official definitions

Average Peak Males - Includes only those leks where one or more strutting males were observed. Does not include "Active" leks where only sign was documented

Table 4: Leks Checked

Year	Occupied	Checked	Percent Checked	Peak Males	Average Peak Males
2014	403	358	88.8%	1,632	9.8
2015	395	334	84.6%	2,990	16.2
2016	390	345	88.5%	3,669	19.8
2017	373	325	87.1%	3,220	18.3
2018	368	282	76.6%	2,030	13.3
2019	360	295	81.9%	1,945	11.9
2020	357	240	67.2%	2,011	14.9
2021	351	287	81.8%	1,892	13.5
2022	349	283	81.1%	1,627	11.8
2023	344	268	77.9%	1,860	13.8

Occupied - Must have been active once during previous 10 years, calculated based on the official definitions

Average Peak Males - Includes only those leks where one or more strutting males were observed. Does not include "Active" leks where only sign was documented

Table 5: Lek Status

Year	Occupied	Active	Inactive	Unknown	Known Status	% Active	% Inactive
2014	403	168	135	55	303	55.4%	44.6%
2015	395	187	94	53	281	66.5%	33.5%
2016	390	191	108	46	299	63.9%	36.1%
2017	373	179	98	48	277	64.6%	35.4%
2018	368	157	97	28	254	61.8%	38.2%
2019	360	165	79	51	244	67.6%	32.4%
2020	357	137	87	16	224	61.2%	38.8%
2021	351	145	84	58	229	63.3%	36.7%
2022	349	141	94	48	235	60%	40%
2023	344	138	97	33	235	58.7%	41.3%

Occupied - Must have been active once during previous 10 years, calculated based on the official definitions

Inactive - Confirmed no birds/sign present (see official definitions)

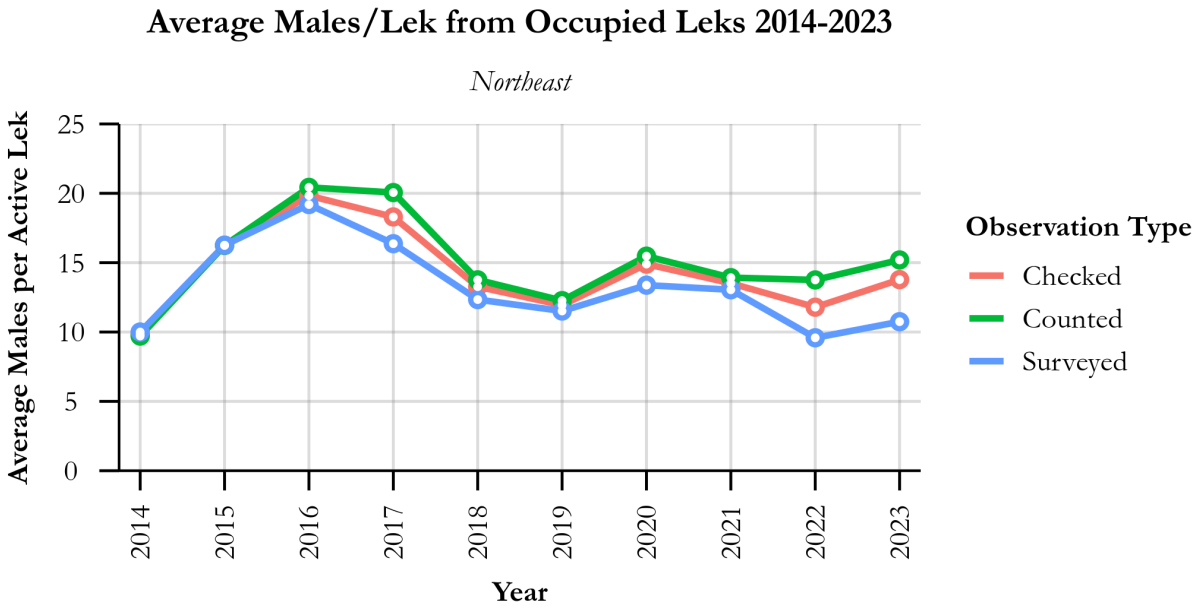


Figure 1: Average Peak Males

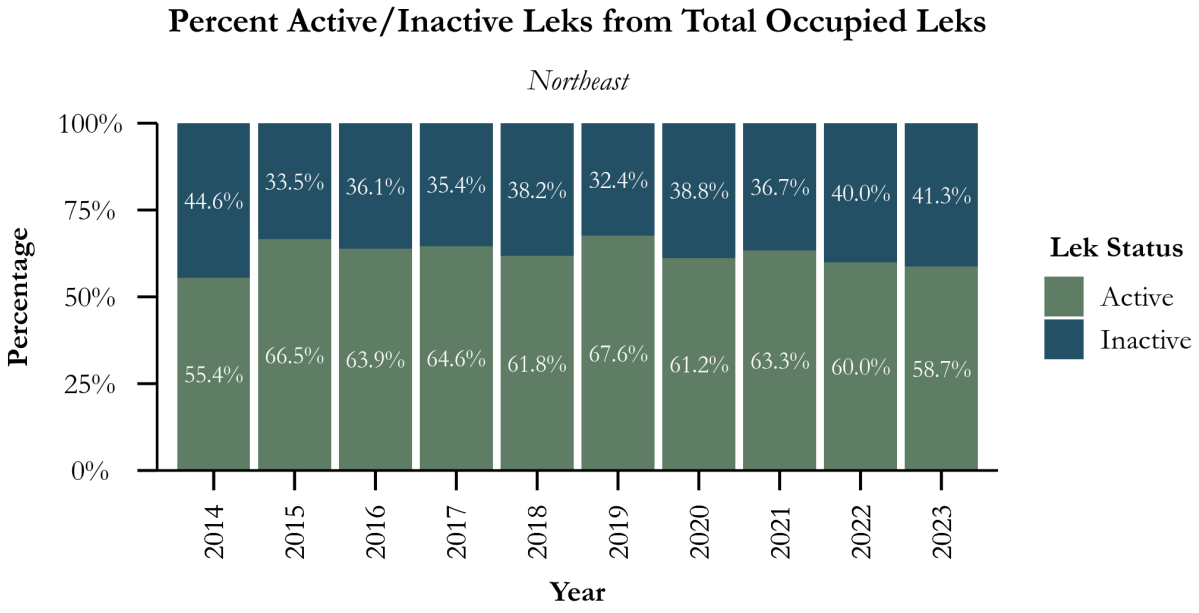


Figure 2: Lek Status

Table 1: Hunting Seasons

Year	Season Start	Season End	Length	Bag/Possession Limit
2013	Sep-21	Sep-23	3	2/4
2014	Sep-20	Sep-22	3	2/4
2015	Sep-19	Sep-21	3	2/4
2016	Sep-17	Sep-19	3	2/4
2017	Sep-16	Sep-18	3	2/4
2018	Sep-15	Sep-17	3	2/4
2019	Sep-21	Sep-23	3	2/4
2020	Sep-19	Sep-21	3	2/4
2021	Sep-18	Sep-20	3	2/4
2022	Sep-17	Sep-19	3	2/4

Table 2: Harvest Totals

Year	Harvest	Hunters	Days	Birds/Day	Birds/Hunter	Days/Hunter
2013	27	82	249	0.1	0.3	3.0
2014	123	137	242	0.5	0.9	1.8
2015	314	228	400	0.8	1.4	1.8
2016	89	129	265	0.3	0.7	2.1
2017	118	145	344	0.3	0.8	2.4
2018	245	200	479	0.5	1.2	2.4
2019	129	122	203	0.6	1.1	1.7
2020	126	168	798	0.2	0.8	4.8
2021	404	205	755	0.5	2.0	3.7
2022	429	217	698	0.6	2.0	3.2
Average	**200**	**163**	**443**	**0.4**	**1.1**	**2.7**

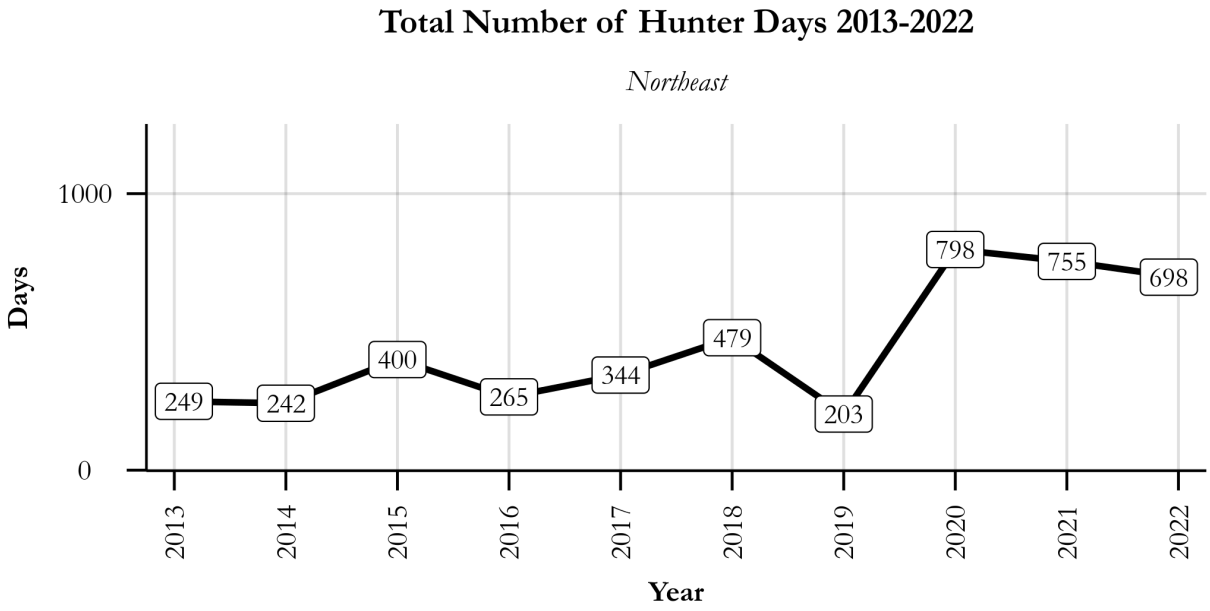


Figure 1: Harvest Days

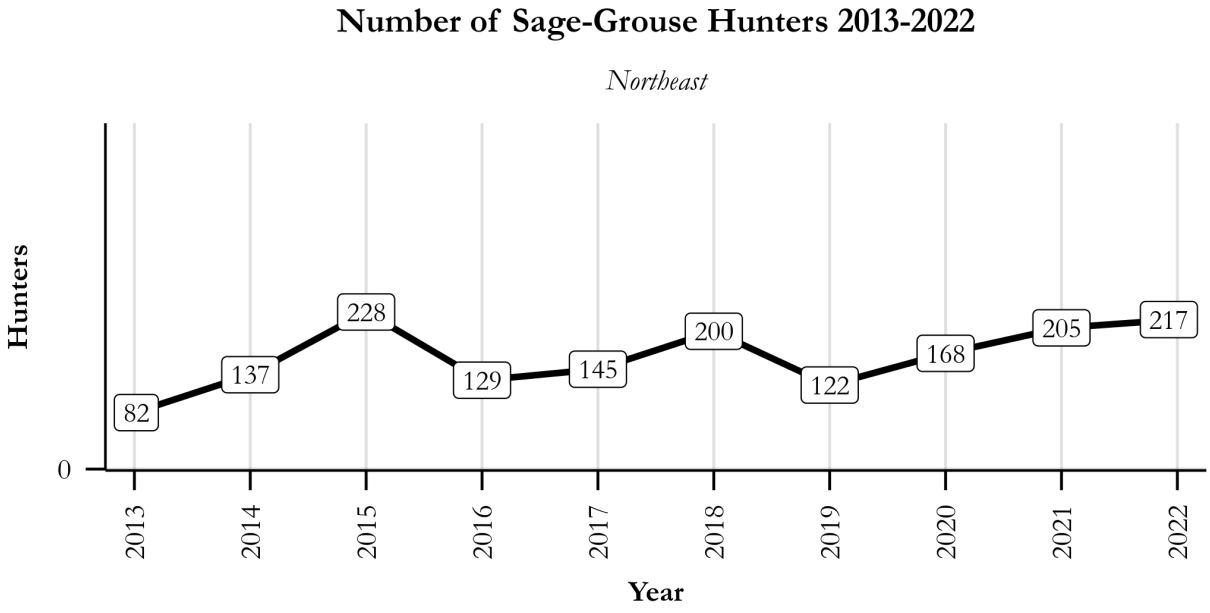


Figure 2: Hunters

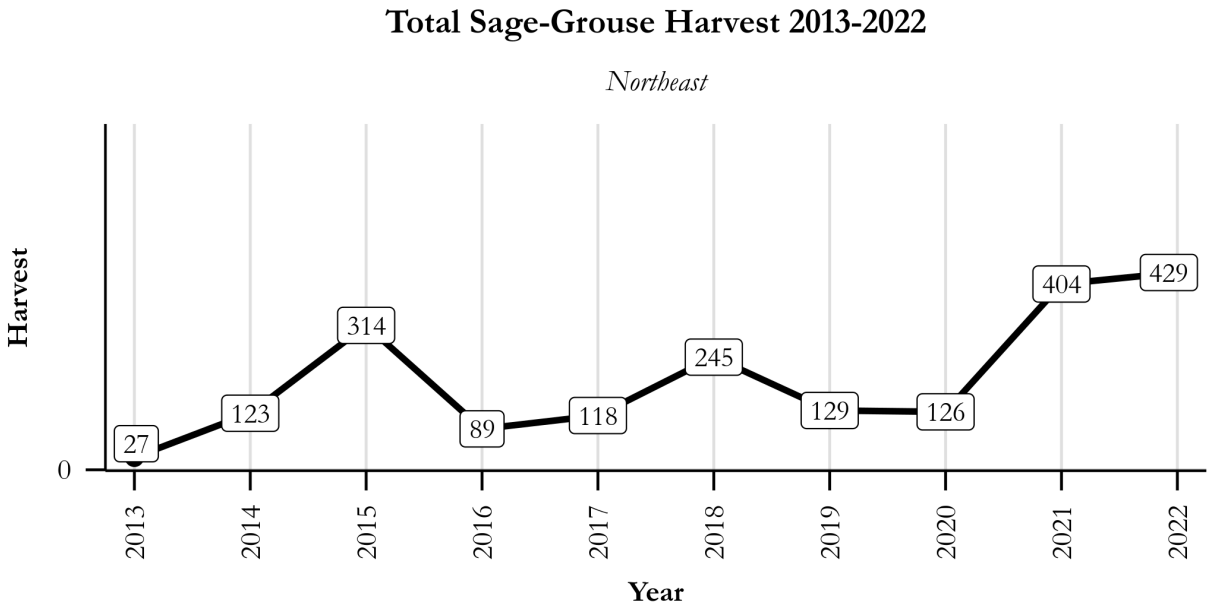


Figure 3: Total Harvest

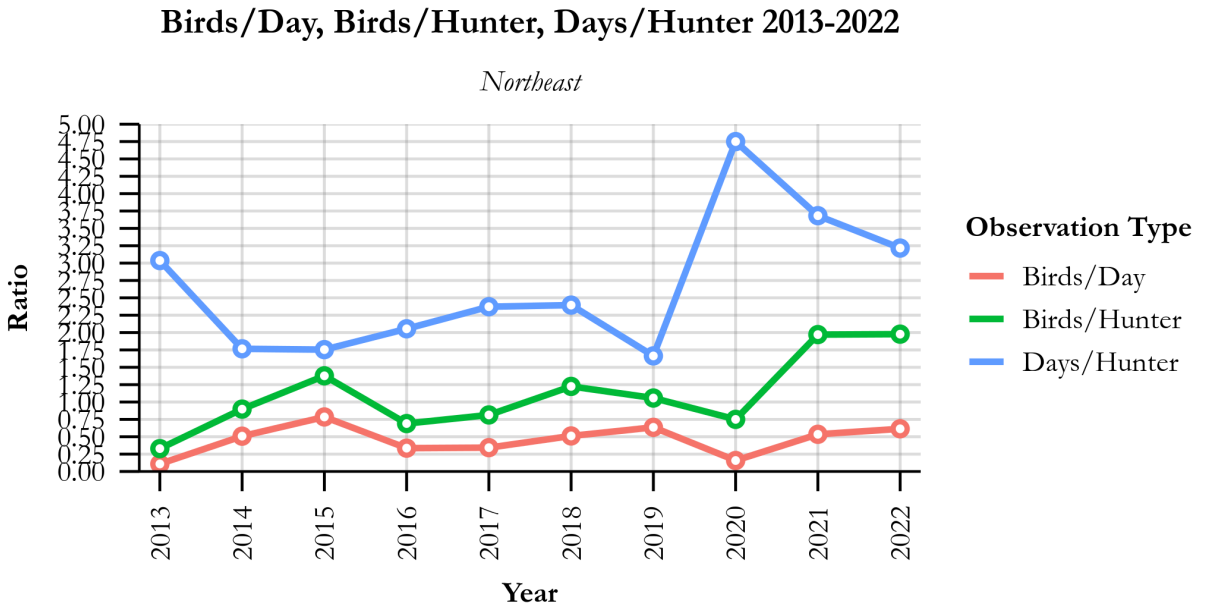


Figure 4: Harvest Ratios

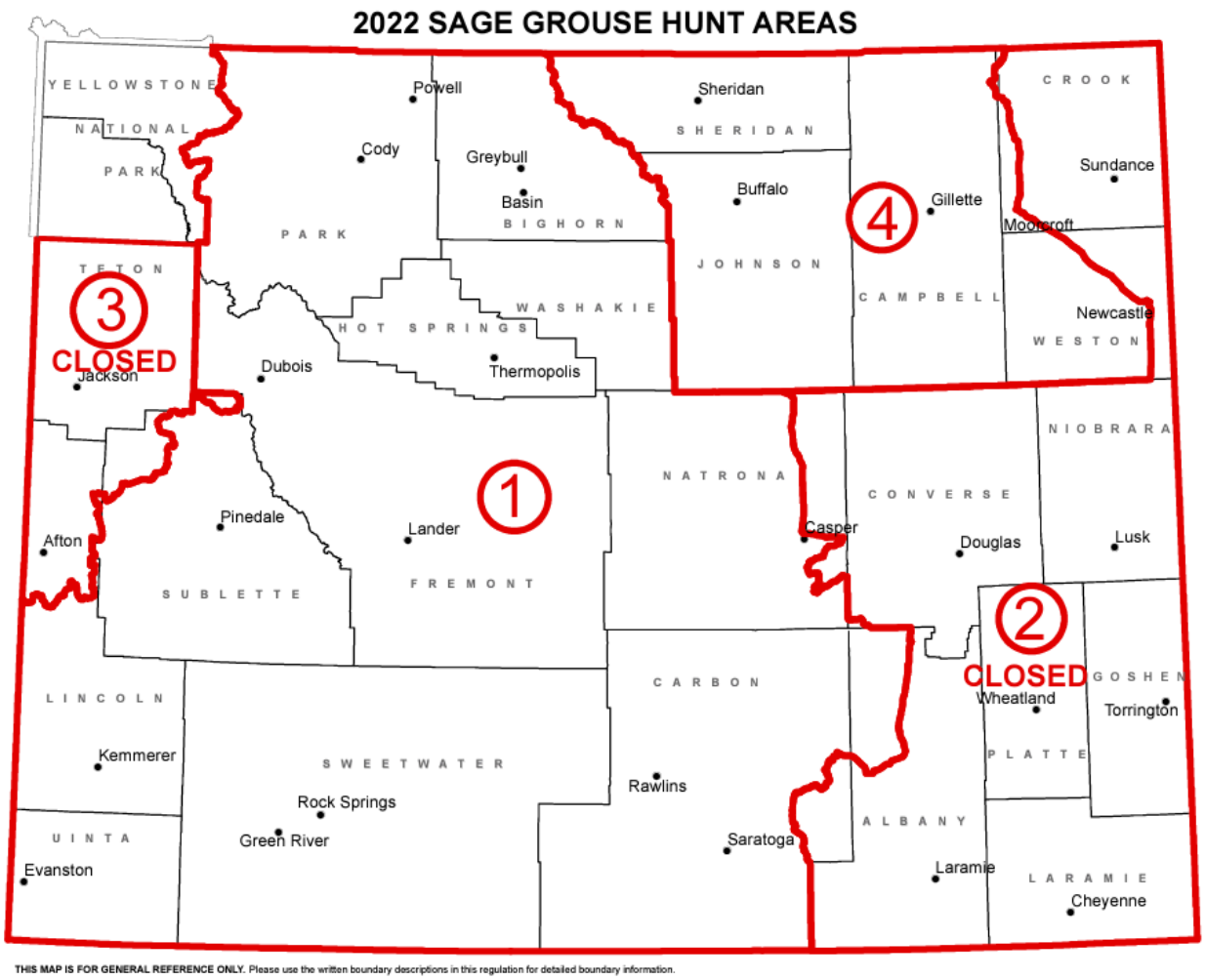


Figure 5. Wyoming Sage-grouse Hunt Areas

Lek Monitoring:

The number of males per active lek provides a reasonable index of abundance of the sage-grouse population over time, particularly given the rigorous methods and long-term nature of the dataset in Wyoming. However, it should be noted that lek data must be interpreted with caution for several reasons: 1) the survey effort and the number of leks surveyed/counted has varied over time; 2) it is assumed that not all leks in the area have been located; 3) sage-grouse populations can exhibit cyclic patterns over approximately a decade; 4) the effects of unknown or unmonitored leks that have become inactive cannot be quantified or qualified; and 5) lek sites may change over time.

In the Northeast Working Group area, lek monitoring efforts increased substantially in 2000 due to concerns over range wide declines in sage-grouse populations. Additionally, coalbed natural gas (CBNG) development in the Powder River Basin resulted in extensive survey work to meet federal permitting requirements. Surveys in relation to CBNG were extensive from roughly 2000-2008. The Wyoming Game and Fish Department (WGFD), Bureau of Land Management (BLM), U.S. Forest Service (USFS), private consultants, landowners, and volunteers participate in annual lek monitoring. A significant portion of leks in northeast Wyoming are checked using a fixed-wing airplane. Many leks are on private land where access might be difficult to attain. Although aerial surveys are not as accurate as ground counts, sometimes this is the only available method to monitor leks in this part of the state. CBNG development tapered off around 2008, resulting in a continued reduction of lek survey work being completed by private consultants. Conventional oil wells have increased in some parts of this area resulting in an increase in monitoring in those areas. WGFD personnel have re-examined our annual coordination efforts with the goals of increasing consistency with the leks that are counted each year. Additionally, WGFD is putting forth effort to target undetermined and long-term inactive occupied leks. The ultimate goal is to collect sufficient data on these leks to ensure the appropriate designated management status, based on our lek monitoring protocols and definitions.

Following the 2023 lek monitoring period, there were 602 documented leks in the Northeast Working Group area. Of this total, 327 (54%) were occupied and of those, 165 (27%) were active during the 2023 breeding season. There were 82 (14%) undetermined leks and 193 (32%) unoccupied leks (**Table 1**).

The number of known occupied leks checked by lek counts and lek surveys combined was 268 leks, or 78% of the known occupied leks, below the objective of 80% of occupied leks checked (**Table 4**). The number of occupied leks counted peaked at 197 in 2014 within the preceding 10 year reporting period. It has overall declined since then. In 2023, 154 occupied leks were counted (**Table 2**). The percentage of occupied leks counted has varied between 38% and 49% since 2014. In 2023, 45% of occupied leks were counted.

Northeast Wyoming has one of the lowest average male lek attendance rates in the state, averaging only 15 males per active lek in 2023 compared to the statewide average of 21 males per active lek. Most leks in northeast Wyoming are small, with less than 20 males. In years when grouse are at the apex of their population cycle less than 10% of the active leks have greater than 50 males at peak count. Four leks exceeded 50 males in 2023. No lek has exceeded 100 males since 2007. This is important because regular population fluctuation presents small leks with a greater risk of becoming inactive in poor years and greater difficulty rebounding in productive years.

Average male lek attendance in northeast Wyoming has decreased significantly over time, decreasing by more than half over the last 30 years. With the exception of the 2006 peak,

subsequent peaks in the average male lek attendance are usually lower, or similar, to previous peaks. Likewise, periodic lows in the average male attendance are generally lower, or similar, to the previous low. The long- term trend suggests a steadily declining population. This concern is confounded by the decreasing number of occupied leks, despite new leks still being discovered.

The 2023 lek count suggests the sage-grouse population decreased after peaking in 2016 at 20 males per active lek. The previous cycle peaked at 28 males per active lek in 2006. With 15 males per active lek in 2023, lek attendance was slightly higher than last year.

It is worth noting that the spring of 2023 experienced snowfall well into April. This resulted in difficulty in accessing some leks that were being surveyed from the ground, as some of these areas were impossible to access until later in April. In some instances this resulted in not getting three planned counts within the acceptable timeframe for lek surveys and counts. Some of these surveys could have been completed aerially, however, airplanes and pilots are often booked up for the spring and not available for unplanned flights. The late moisture could have had an impact on the number of leks that were surveyed in 2023.

Production:

Composition of the harvest, as determined by analysis of wings deposited by hunters in wing barrels, can provide insight into current year's chick production. Although there are other areas in the state that garner considerable data from wing barrels, these data are lacking for northeast Wyoming. In past years a limited number of sage-grouse wings were collected during the hunting season, primarily in the eastern portion of the area. Sample sizes were small due to the low harvest and the difficulty in strategically placing enough collection barrels along the many roads and highways within the area. As such, production information is not available for northeast Wyoming.

Harvest:

The Northeast Working Group area comprises Hunt Area 4 and portions of Hunt Areas 1 and 2 (**Figure 5**). Hunt Area 2 is closed to hunting. Hunt Area 4 has a very conservative hunting season that has been in place since 2010 due to continuing concerns of decreasing lek attendance trends. In 2023 the hunting season will be closed in Hunt Area 4.

The 2022 harvest survey estimated 429 sage-grouse were harvested by 217 hunters, which is almost double the ten-year averages of estimated harvested birds. There are challenges with obtaining statistically valid harvest survey data with a very small sample size of hunters. Given current survey methods and license structures it is difficult to target sage-grouse hunters specifically.

Habitat:

Most occupied habitat for sage-grouse is held in private ownership. Approximately 75 percent of known leks are found on private land with the remaining 25 percent found on BLM, USFS and State owned lands. Because most sage-grouse are found on private land, little direct control exists to protect important habitats, including breeding and nesting areas, brood rearing areas, and major wintering areas.

The primary economic uses of lands currently or historically providing sage-grouse habitat are agriculture and energy. Livestock grazing, mainly cattle along with some sheep production, is the primary agriculture use. Some crop production occurs as irrigated and dry land hay and some small grains. Historically, large parcels of sagebrush habitat were converted either to grasslands or crops.

Limitations of remote sensing technology have prevented quantifying and mapping these conversions.

Oil and natural gas production has occurred in much of the area since the early 20th century. Oil production has remained a constant with cycles of increased and then decreased activity at times. An unprecedented energy boom began in the Powder River Basin in the late 1990's with the exploration and development of CBNG reserves. Although much of the active CBNG extraction has ceased there are still wells, roads, power lines and other structures on the landscape that are relics of the development. Deep well oil and gas development has increased in recent years with new technologies enabling horizontal and directional drilling.

In addition to oil and gas development, vast coal reserves continue to be developed with surface pit mines in eastern Campbell County and northern Converse County.

Considerable debate has occurred on the effects of energy development on sage-grouse. Peer reviewed research findings show significant impacts (Walker et al. 2007, Doherty et al. 2008, Doherty et al. 2010, Harju et al. 2010 and others). These findings have yet to be accepted by some and this has contributed to uncertainty in the public and political arenas as to the real effects of energy development. Furthermore, many continue to blame predation or harvest for sage-grouse population declines, which have much lower population impacts than habitat fragmentation, direct loss, and indirect loss. A population viability analysis by Taylor et al. (2012) found that energy development had the greatest influence on male grouse lek attendance within 12.4 miles of a lek. At 8 wells per section (80 acre spacing), only 39% of males persisted while the number of large leks significantly decreased.

More recent research provides further insight into sage-grouse and development. Kirol and Fedy (2023) found that hens that successfully raised chicks demonstrated a strong avoidance of overhead power line corridors (~1/4 mile on each side of the line) and man-made reservoirs. It was also found that successful brooding females were spending most of their time in sagebrush cover and not using disturbed surfaces, such as roads, and reclaimed surfaces such as pipeline corridors. Older and more experienced brood-rearing hens were showing stronger avoidance of infrastructure and converted surfaces than first-year hens.

The growing season of 2023 experienced moderate moisture levels throughout much of the Northeast Wyoming Working group area. Cheatgrass continues to thrive in the Powder River Basin, competing with native grasses and forbs in sagebrush understory. The increased wildfire risk due to cheatgrass invasion is being realized, with several fires having occurred in the preceding several years, some within core and connectivity areas. Sagebrush restoration has not occurred following these fires due to lack of interest from private landowners. Invasive species management following fires has occurred on some, but not all recent burns.

Disease:

West Nile virus (WNv) was documented by the Wyoming State Veterinary Laboratory in northeast Wyoming in 2023, however no major mortality events to sage-grouse have been documented since 2003 when WNv was first documented in sage-grouse in the Powder River Basin. Because of the difficulty in monitoring WNv in sage-grouse, human and livestock cases can provide an indication of WNv prevalence in a given year. (Wyoming State Vet Lab, https://www.uwyo.edu/wyovet/index.html).

Taylor et al. (2012) predicted that the low elevation population of northeast Wyoming is susceptible to WNv outbreaks which can decrease a population by more than 50%. Furthermore, even with no additional energy development the authors predict that one outbreak year could result in the extirpation of some local populations due to the small lek sizes in the area.

A highly pathogenic form of avian influenza (HPAI) was again documented through large portions of the sage-grouse range in 2023. Although no sage-grouse were documented having contracted this disease, several other avian species were lab verified in the northeast corner of the state. It is unknown how this disease may effect sage-grouse, but it is of concern and should continue to be closely monitored as this strain of HPAI continues to surface.

Conservation Planning – Northeast Working Group

In 2021, the Northeast Working Group (NEWG) was asked to review multiple 2020 datasets to assess if adaptive management triggers had been tripped and the group identified multiple soft triggers and one hard trigger. The NEWG also highlighted concerns with the process, particularly related to the lack of response to the NEWG's and Technical Team's work related to the 2018 soft trigger.

Sage-grouse are influenced by many factors, both individually and cumulatively. Habitat loss and fragmentation, direct mortality and disturbance affect sage-grouse populations. In 2006, the NEWG identified and ranked those factors believed to be most influencing the northeast Wyoming sage-grouse population, as well as actions that might provide the greatest benefit for sage-grouse conservation in northeast Wyoming. In the opinion of the group, conservation efforts targeting oil, gas and CBNG development, vegetation management, invasive plants, local residential land use, and livestock grazing would be most effective in benefiting sage-grouse. As a follow-up, in 2021 the NEWG initiated a GIS mapping exercise to spatially overlay these key factors influencing sage-grouse populations under their area of responsibility. The goal is to have a tool to solicit more funding applications that address the most pressing needs for regional sage-grouse populations as well as create project ranking priorities.

In 2023, prior to funding being available, the NEWG worked with Conservation Districts and the Pheasants Forever Upland Biologist to do outreach and try to solicit funding applications that fit the priorities of the working group.

Conservation Planning – Sage-grouse Implementation Team

In the spring of 2023 the Sage-grouse Implementation Team (SGIT) commenced a core area review. Input was requested from WGFD field personnel. Working Groups presented an initial core revision proposal at various locations around the state. Attendance at some of these meetings was high and much public input was received. The SGIT is currently reviewing draft proposal #5, with no decision as of December 2023.

Management Recommendations:

<u>Habitat management</u>

The concern of invasive annual grasses and wildfire frequencies in sagebrush habitats is an immediate threat to the long-term viability of sage-grouse habitats in northeast Wyoming. Managers need to figure out how to effectively treat cheatgrass in viable sagebrush habitats at a large scale. This is vital for the long-term viability of sagebrush habitats in northeast Wyoming. Often sage

brush plantings cannot be done at scale to make up for what is lost after wildfires, and private landowner interest in such plantings is low. Thus proactive efforts must take place to control high levels of cheatgrass infestation in key sage-grouse habitats to reduce the frequency and severity of wildfires to preserve existing sagebrush habitat. This will require managers to find ways to engage with landowners on a massive scale. Additionally, work to increase brood-rearing habitats would help address low chick recruitment rates reported (Kirol 2021).

Conifer encroachment, particularly juniper, is an increasing threat to sage-grouse habitat in NE Wyoming particularly in portions of the Thunder Basin, Natrona, and North Gillette. Conifer encroachment reduces available habitat to sage-grouse through predator avoidance. Identifying areas of sage-grouse habitat threatened by conifer encroachment is the first that could benefit by conifer removal projects is key to addressing this threat. During the summer of 2023, WGFD partnered with UNL to put on a conifer encroachment workshop in Gillette, Wyoming. The purpose of the workshop was to discuss the woody encroachment problem in the Northern Great Plains and to introduce a spatial tool that could be used to identify encroachment areas in eastern Wyoming.

There are also many different opportunities to reclaim or mitigate existing infrastructure that is currently on the landscape that is effectively limiting sage-grouse habitat, such as energy infrastructure. Efforts should focus on locating opportunities where overhead powerlines, and other energy infrastructure can be removed and or mitigated (i.e. locating power lines underground) in key sage-grouse habitats. Other potential projects include reclaiming defunct livestock stock dams and cropland/pasture reclamation to native rangeland where possible. Areas of critical habitat to sage-grouse should be evaluated for the potential to exercise these reclamation activities.

Mesic draws have been identified as a very critical and often overlooked component of habitat. A mesic habitat restoration workshop was hosted by Pheasants Forever in the fall of 2023. Focusing on mesic restoration could be a relatively simple and cost-effective method of gaining critical habitat for sage-grouse, particularly in brood-rearing habitat.

Lek monitoring coordination

In recent years, CBNG development has slowed, resulting in a reduction of lek survey work being completed by private consultants. In response, WGFD personnel are spearheading efforts to re-examine the annual coordination efforts with the goals of increasing consistency with the leks that are counted each year and the number of leks that are counted each year, as well as targeting undetermined and long-term inactive occupied leks to update management status to unoccupied as appropriate based on our lek monitoring protocols and definitions. This project should be conducted with the cooperation of the BLM and the NEWG. This effort was commenced in 2021 and will occur on an annual basis to ensure maximization of personnel time and minimization of duplicated efforts.

General Recommendations – Continue Long-Term Work

1. Assist the BLM with developing and implementing the sage-grouse monitoring program as prescribed by the Powder River Basin CBNG EIS Record of Decision (April 2003).
2. Annually monitor 80% of the occupied leks in the local working group area.
3. WNv monitoring.

4. Assist the BLM with coordinating sage-grouse population monitoring efforts with the private consultants doing work for energy development companies.

5. Use any additional flight money for lek searches and surveys. Check all leks at least once every three years. All leks should be recorded in UTMs (NAD 83) using GPS.

6. Review the sage-grouse database to eliminate leks without adequate documentation to support a lek designation.

7. The Working Group should continue to solicit habitat projects on private lands that will benefit sage-grouse.

8. The WGFD Regions should continue to recommend protection of occupied sage-grouse leks during environmental commenting and promote their protection on private land projects.

9. Additional effort is needed to document the status of undetermined leks. Encourage reporting of lek activity from the public and landowners.

10. Better document wintering sage-grouse locations and develop a seasonal range map for sage-grouse for the Working Group Area.

11. Continue to map lek perimeters to ensure adequate buffer distance in protecting leks.

Report Notice

Variation in this report from previous years' reports is expected because of new data added to the lek database. Old records are added each year as data become available and newly discovered leks are added to the database. New lek count routes may also be added. Data adjustments should be taken into consideration when the current report and tables are compared to previous editions.

Relevant Research

The following publications have been conducted in the Powder River Basin of Wyoming and Montana.

Copeland, H.E., K.E. Doherty, D. E. Naugle, A. Pocewicz, and J.M. Kiesecker. 2009. Mapping Oil and Gas Development Potential in the US Intermountain West and Estimating Impacts to Species. PLoS ONE 4(10): e7400. doi:10.1371/journal.pone.0007400.

Doherty, K. E., D. E. Naugle and B. L. Walker. 2010. Greater sage-grouse nesting habitat: The importance of managing at multiple scales. Journal of Wildlife Management 74(7):1544– 1553.

Doherty, K. E. 2008. Sage-grouse and Energy Development: Integrating Science with Conservation Planning to Reduce Impacts. Ph.D. Dissertation. Fish and Wildlife Biology, University of Montana. 125 pp.

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

Doherty, K. E, D. E. Naugle and J. S. Evans. 2010. A currency for offsetting energy development impacts: horse trading sage-grouse on the open market. PLoS ONE 5(4):e10339.

Doherty, K. E., J. L. Beck and D. E. Naugle. 2011. Comparing ecological site descriptions to habitat characteristics influencing greater sage-grouse nest site occurrence and success. Rangeland Ecology and Management 64(4):344-351.

Doherty, M.K. 2007. Comparison of Natural, Agricultural and Effluent Coal Bed Natural Gas Aquatic Habitats. Master of Science. Montana State University. Bozeman, MT.

Fedy, B. C. and K. E. Doherty. 2010. Population cycles are highly correlated over long time series and large spatial scales in two unrelated species: greater sage- grouse and cottontail rabbits. Oecologia 165:915-924.

Fedy, B.C. and C.L. Aldridge. 2011. The importance of within-year repeated counts and the influence of scale on long-term monitoring of sage-grouse. Journal of Wildlife Management 75(5): 1022-1033.

Foster, M. A.. J. T. Ensign, W. N. Davis, and D. C. Tribby. 2014. Monitoring Greater Sage- Grouse in the Southeast Montana Sage-grouse Core Area. Final Report. February 2014. Montana Fish Wildlife and Parks *in partnership* with the Bureau of Land Management. Miles City, MT. 108 pp.

Gregory, A. J. and J. L. Beck. 2014. Spatial Heterogeneity in Response of Male Greater Sage- Grouse Lek Attendance to Energy Development. PLoS ONE 9(6): e97132. doi:10.1371/journal.pone.0097132

Harju, S.M., M.R. Dzialak, R.C. Taylor, L.D. Hayden-Wing, and J.B. Winstead. 2010. Thresholds and Time Lags in Effects of Energy Development on Greater Sage- Grouse Populations. Journal of Wildlife Management 74:437- 448.

Naugle, D. E., C. L. Aldridge, B. L. Walker, T. E. Cornish, B. J. Moynahan, M. J. Holloran, K. Brown,

G. D. Johnson, E. T. Schmidtmann, R. T. Mayer, C. Y. Kato, M. R. Matchett, T. J. Christiansen, W. E. Cook, T. Creekmore, R. D. Falise, E. T. Rinkes, M. S. Boyce. 2004. West Nile virus: pending crisis for Greater Sage-grouse. Ecology Letters. Volume 7, Issue 8, p. 704- 713.

Kirol, C. P. 2014. Powder River Basin Radio-Marked Greater Sage-Grouse Study— Mammal Nest Predator DNA Identification. Project Report *prepared for the* Northeast Wyoming Sage- grouse Local Working Group. 13 pp.

Kirol, C. P. 2021. Patterns of nest survival, movement, and habitat use of sagebrush-obligate birds in an energy development landscape. Thesis presented to the University of Waterloo. **https://uwspace.uwaterloo.ca/handle/10012/16844. Accessed December 2021**.

Kirol, C.P. and Fedy, B. 2023. Using individual-based habitat selection analyses to understand the nuances of habitat use in an anthropogenic landscape: a case study using greater sage-grouse trying to raise young in an oil and gas field. Wildlife Biology: e01111

Kirol, C. P., Sutphin, A.L., Bond, L.S., Maechtle, T.L., Fuller, M.R., 2015. Mitigation effectiveness for improving nesting success of greater sage-grouse influenced by energy development. DOI-10.2981/wlb.00002: Wildlife Biology, v. 21, p. 98-109.

Kirol, C. P., K. T. Smith, N. E. Graf, J. B. Dinkins, C. W. LeBeau, T. L. Maechtle, A. L. Sutphin, and J. L. Beck. 2020. Greater Sage-grouse Response to the Physical Footprint of Energy Development. Journal of Wildlife Management 84: 989-1001.

Naugle, D. E., C. L. Aldridge, B. L. Walker, K. E. Doherty, M. R. Matchett, J. McIntosh, T. E. Cornish, and M. S. Boyce. 2005. West Nile virus and sage-grouse: What more have we learned? Wildlife Society Bulletin, 33(2):616-623.

Naugle D. E., K. E. Doherty, B. L. Walker, M. J. Holloran, and H. E. Copeland. 2011. Energy development and greater sage-grouse. Pages 489-529 in Greater sage- grouse: ecology and conservation of a landscape species and its habitats, S. T. Knick, J. W. Connelly, C. E. Braun (editors). Studies in Avian Biology, Number 38, University of California Press, Berkeley, CA, USA.

Taylor, R. L., D. E. Naugle, and L. S. Mills. 2010. Viability analyses for conservation of sage- grouse populations. Completion report, Miles City Field Office, Montana, USA.

Taylor, R. L., D. E. Naugle, and L. Scott Mills. 2012. Viability analyses for conservation of sage-grouse populations: Buffalo Field Office, Wyoming Final Report 27 February 2012. BLM Contract 09-3225-0012 Number G09AC00013 (8/10/10). University of Montana, Missoula.

Taylor, R. L., B. L. Walker, D. E. Naugle, and L. Scott Mills. 2012. Managing multiple vital rates to maximize greater sage-grouse population growth. Journal of Wildlife Management 76:336- 347.

Walker, B. L., D. E. Naugle, K. E. Doherty, and T. E. Cornish. 2004. Outbreak of West Nile Virus in Greater Sage-grouse and Guidelines for Monitoring, Handling, and Submitting Dead Birds. Wildlife Society Bulletin 32(3): 1000–1006.

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

Walker, B.L. D.E. Naugle, K.E. Doherty, and T.E. Cornish. 2007b. West Nile Virus and greater sage‐grouse: estimating infection rate in a wild bird population. Avian Diseases 51:691‐696.

Zou, L., S.N. Miller, and E.T. Schmidtmann. 2006. Mosquito larval habitat mapping using remote sensing and GIS: Implications of coalbed methane development and West Nile virus. Journal of Medical Entomology 43:1034–41.

South Central

Job Completion Report

Prepared By: Teal Cufaude, Saratoga Wildlife Biologist

Period Covered: 6-1-2022 to 5-31-2023

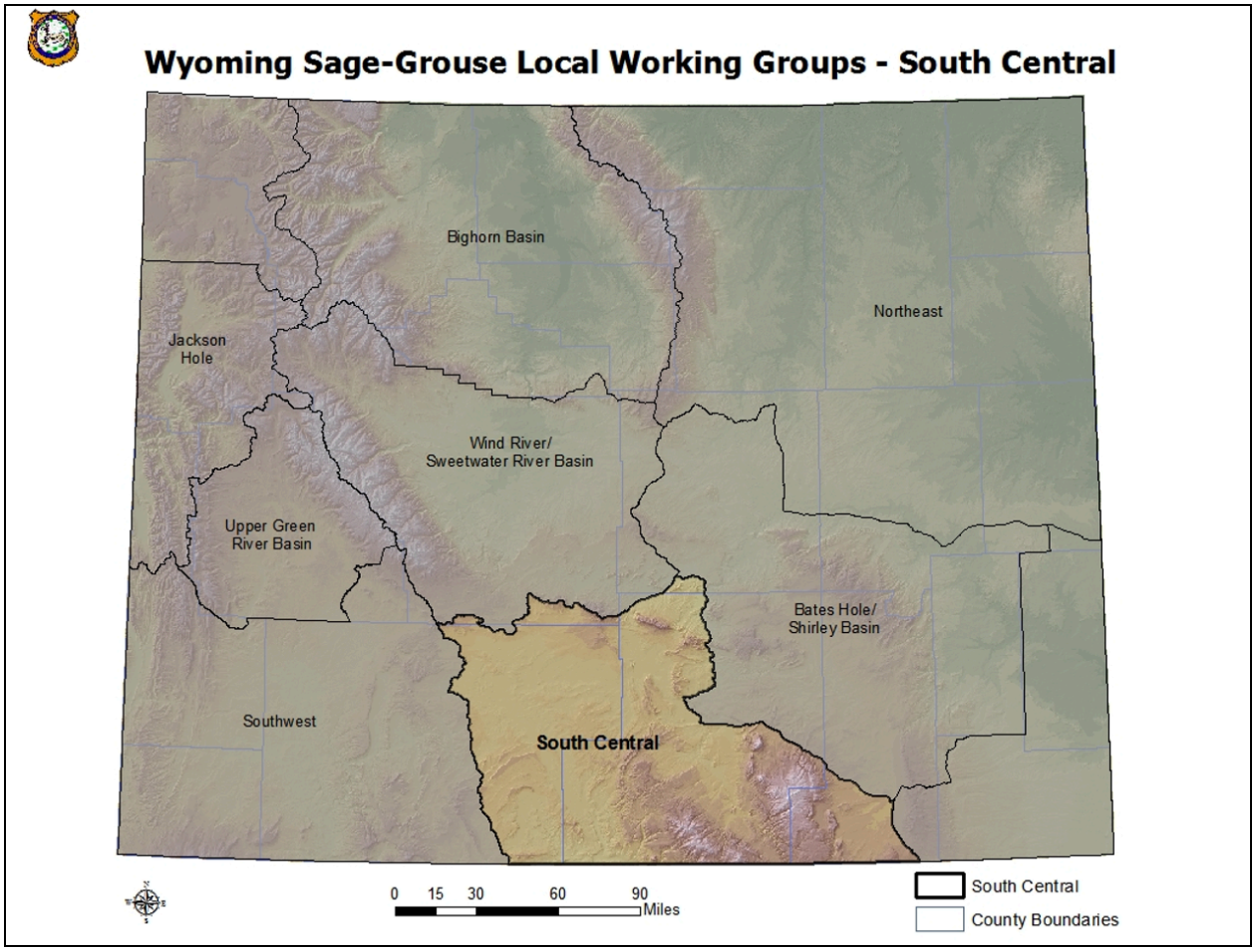


Table 1: Sage-Grouse Lek Characteristics

	Group	N	Percent
BLM Office			
	Casper	2	0.5%
	Lander	26	6.4%
	Rawlins	364	89%
	Rock Springs	17	4.2%
Biologist			
	Baggs	126	30.8%
	Green River	14	3.4%
	Lander	15	3.7%
	Laramie	5	1.2%
	Saratoga	54	13.2%
	Sinclair	195	47.7%
Classification			
	Occupied	251	61.4%
	Undetermined	48	11.7%
	Unoccupied	110	26.9%
County			
	Albany	5	1.2%
	Carbon	271	66.3%
	Fremont	13	3.2%
	Natrona	2	0.5%
	Sweetwater	118	28.9%

	Group	N	Percent
Land Status			
	BLM	229	56%
	LocalGov	1	0.2%
	Private	148	36.2%
	State	30	7.3%
	USFWS	1	0.2%
Lek Status			
	Active	166	40.6%
	Inactive	87	21.3%
	Unknown	156	38.1%
Management Area			
	H	409	100%
Region			
	Green River	139	34%
	Lander	211	51.6%
	Laramie	59	14.4%
Warden			
	Baggs	125	30.6%
	East Rawlins	106	25.9%
	Elk Mountain	6	1.5%
	Lander	2	0.5%
	Rock Springs	14	3.4%
	Saratoga	48	11.7%
	South Laramie	5	1.2%
	West Rawlins	103	25.2%

Table 2: Leks Counted

Year	Occupied	Counted	Percent Counted	Peak Males	Average Peak Males
2014	281	101	35.9%	1,607	21.4
2015	282	90	31.9%	1,915	32.5
2016	286	73	25.5%	2,381	39.0
2017	286	96	33.6%	2,176	29.4
2018	285	113	39.6%	2,210	24.6
2019	278	131	47.1%	2,419	22.0
2020	272	146	53.7%	2,584	22.7
2021	272	91	33.5%	1,604	21.7
2022	267	82	30.7%	1,470	23.0
2023	261	20	7.7%	344	26.5

Occupied - Must have been active once during previous 10 years, calculated based on the official definitions

Average Peak Males - Includes only those leks where one or more strutting males were observed. Does not include "Active" leks where only sign was documented

Table 3: Leks Surveyed

Year	Occupied	Surveyed	Percent Surveyed	Peak Males	Average Peak Males
2014	281	175	62.3%	2,016	17.8
2015	282	170	60.3%	3,224	27.8
2016	286	192	67.1%	3,707	28.1
2017	286	162	56.6%	2,465	22.6
2018	285	153	53.7%	1,961	20.9
2019	278	126	45.3%	1,078	16.8
2020	272	101	37.1%	875	18.6
2021	272	160	58.8%	1,285	15.7
2022	267	150	56.2%	1,668	19.6
2023	261	188	72%	2,581	21.7

Occupied - Must have been active once during previous 10 years, calculated based on the official definitions

Average Peak Males - Includes only those leks where one or more strutting males were observed. Does not include "Active" leks where only sign was documented

Table 4: Leks Checked

Year	Occupied	Checked	Percent Checked	Peak Males	Average Peak Males
2014	281	276	98.2%	3,623	19.3
2015	282	260	92.2%	5,139	29.4
2016	286	265	92.7%	6,088	31.5
2017	286	258	90.2%	4,641	25.4
2018	285	266	93.3%	4,171	22.7
2019	278	257	92.4%	3,497	20.1
2020	272	247	90.8%	3,459	21.5
2021	272	251	92.3%	2,889	18.5
2022	267	232	86.9%	3,138	21.1
2023	261	208	79.7%	2,925	22.2

Occupied - Must have been active once during previous 10 years, calculated based on the official definitions

Average Peak Males - Includes only those leks where one or more strutting males were observed. Does not include "Active" leks where only sign was documented

Table 5: Lek Status

Year	Occupied	Active	Inactive	Unknown	Known Status	% Active	% Inactive
2014	281	198	71	7	269	73.6%	26.4%
2015	282	185	54	21	239	77.4%	22.6%
2016	286	198	54	13	252	78.6%	21.4%
2017	286	188	55	15	243	77.4%	22.6%
2018	285	192	53	21	245	78.4%	21.6%
2019	278	189	48	20	237	79.7%	20.3%
2020	272	172	68	7	240	71.7%	28.3%
2021	272	172	64	15	236	72.9%	27.1%
2022	267	163	45	24	208	78.4%	21.6%
2023	261	143	15	50	158	90.5%	9.5%

Occupied - Must have been active once during previous 10 years, calculated based on the official definitions

Inactive - Confirmed no birds/sign present (see official definitions)

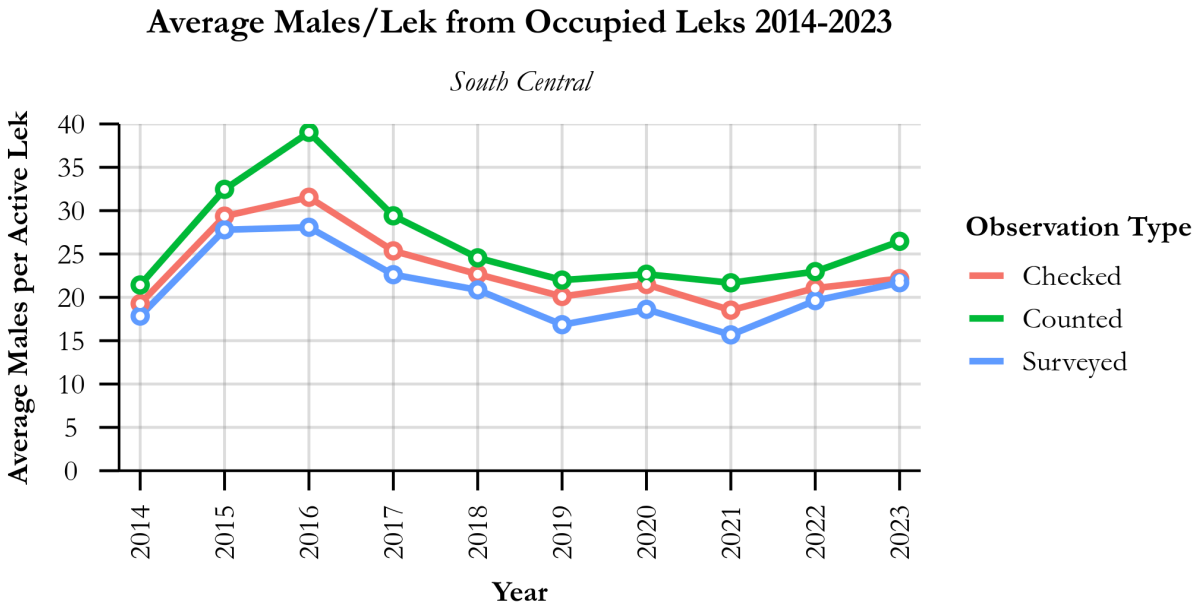


Figure 1: Average Peak Males

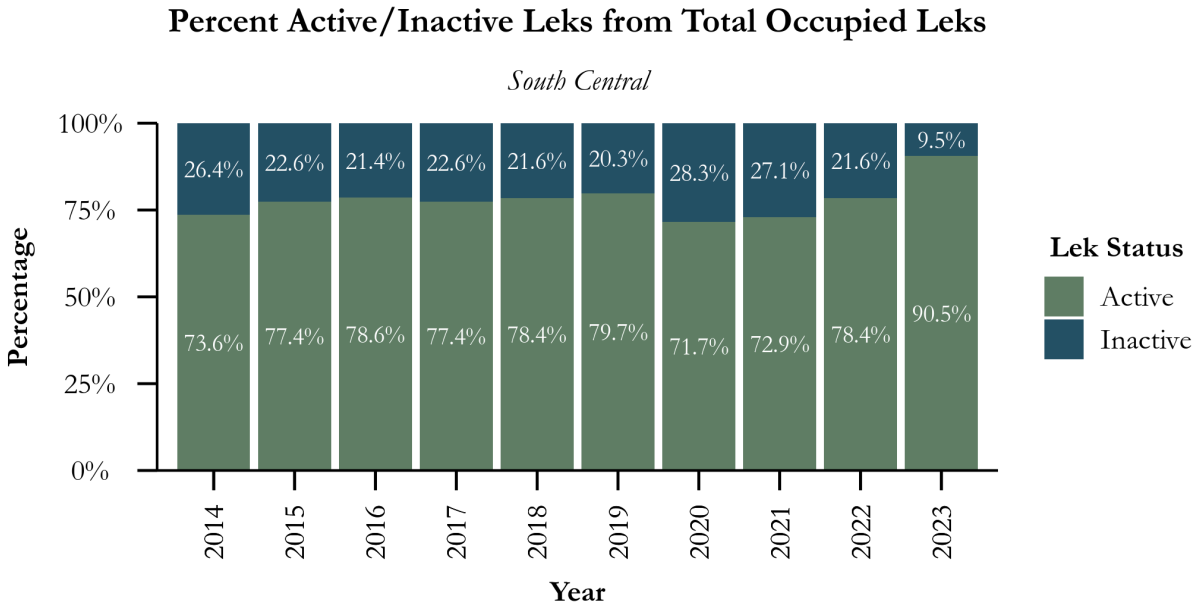


Figure 2: Lek Status

Table 6: Harvest Season

Year	Season Start	Season End	Length	Bag/Possession Limit
2013	Sep-21	Sep-30	10	2/4
2014	Sep-20	Sep-30	11	2/4
2015	Sep-19	Sep-30	12	2/4
2016	Sep-17	Sep-30	14	2/4
2017	Sep-16	Sep-30	15	2/4
2018	Sep-15	Sep-30	16	2/4
2019	Sep-21	Sep-30	10	2/4
2020	Sep-19	Sep-30	12	2/4
2021	Sep-18	Sep-30	13	2/4
2022	Sep-17	Sep-30	14	2/4

Table 7: Harvest Totals

Year	Harvest	Hunters	Days	Birds/Day	Birds/Hunter	Days/Hunter
2013	624	437	928	0.7	1.4	2.1
2014	612	391	934	0.7	1.6	2.4
2015	776	457	963	0.8	1.7	2.1
2016	911	477	1,162	0.8	1.9	2.4
2017	501	363	846	0.6	1.4	2.3
2018	903	500	1,245	0.7	1.8	2.5
2019	1,052	584	1,186	0.9	1.8	2.0
2020	1,023	465	1,250	0.8	2.2	2.7
2021	1,080	691	2,178	0.5	1.6	3.2
2022	1,510	983	2,564	0.6	1.5	2.6
Average	**899**	**535**	**1,326**	**0.7**	**1.7**	**2.4**

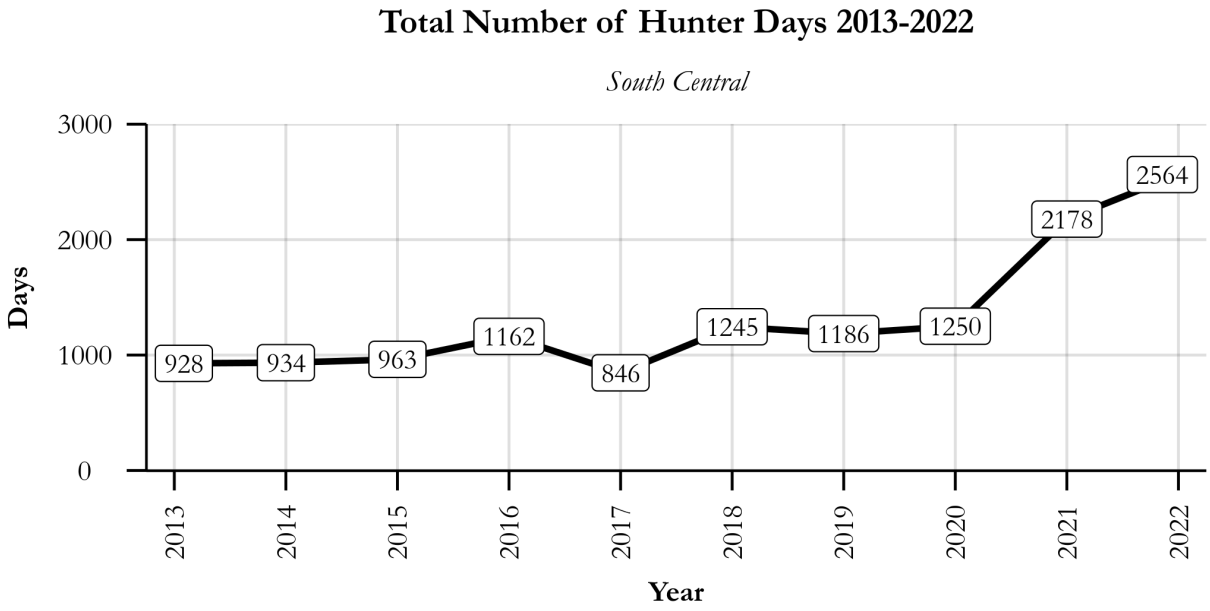


Figure 3: Harvest Days

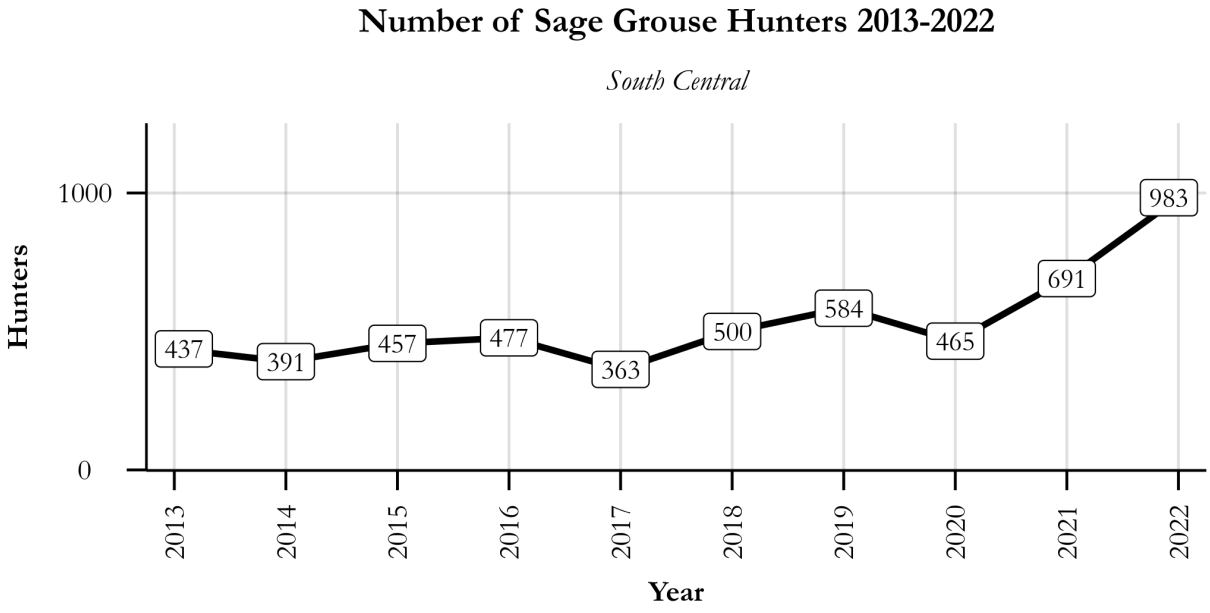


Figure 4: Hunters

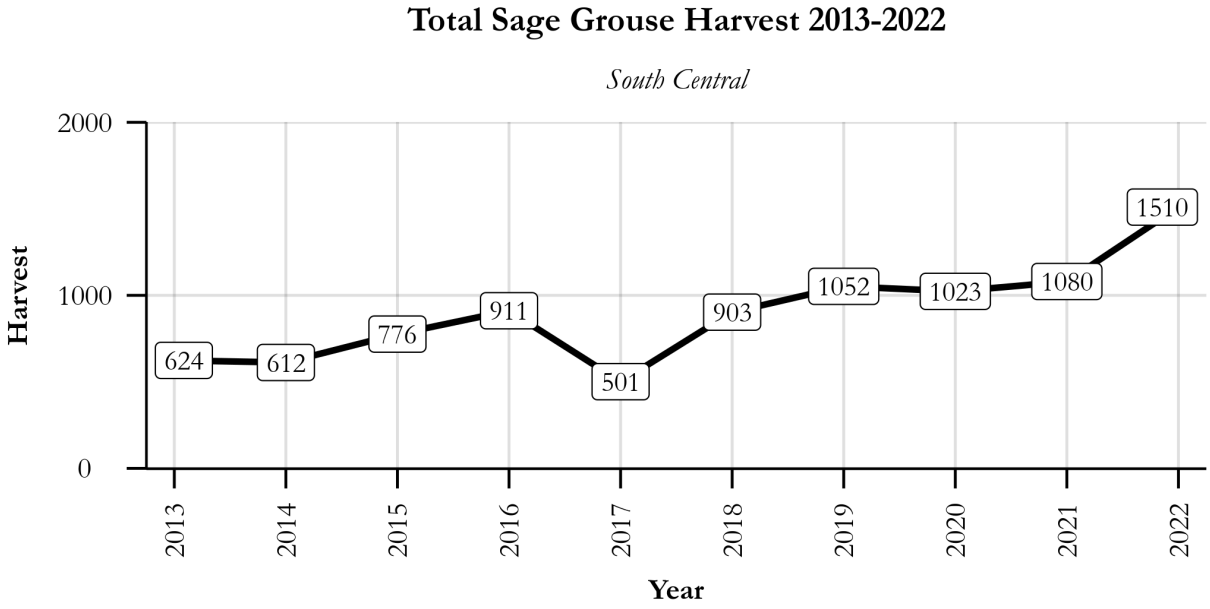


Figure 5: Total Harvest

Table 8: Harvest Composition

		Percent Adult		Percent Yearling		Percent Chick		
Year	Sample Size	Male	Female	Male	Female	Male	Female	Chicks/Hens
2013	107	14%	36.4%	1.9%	1.9%	15.9%	27.1%	1.1
2014	146	10.3%	23.3%	3.4%	4.8%	30.8%	27.4%	2.1
2015	192	10.4%	30.7%	2.6%	5.7%	24.5%	26%	1.4
2016	174	21.8%	27%	4%	5.7%	16.1%	25.3%	1.3
2017	123	13.8%	39.8%	5.7%	8.9%	16.3%	15.4%	0.7
2018	131	20.6%	26.7%	6.1%	8.4%	20.6%	17.6%	1.1
2019	196	13.8%	25%	6.6%	9.7%	13.8%	31.1%	1.3
2020	258	11.6%	27.1%	5.8%	16.7%	13.2%	25.6%	0.9
2021	201	10%	26.4%	4.5%	12.4%	23.9%	22.9%	1.2
2022	257	7.8%	17.5%	5.4%	9.3%	26.1%	33.5%	2.2

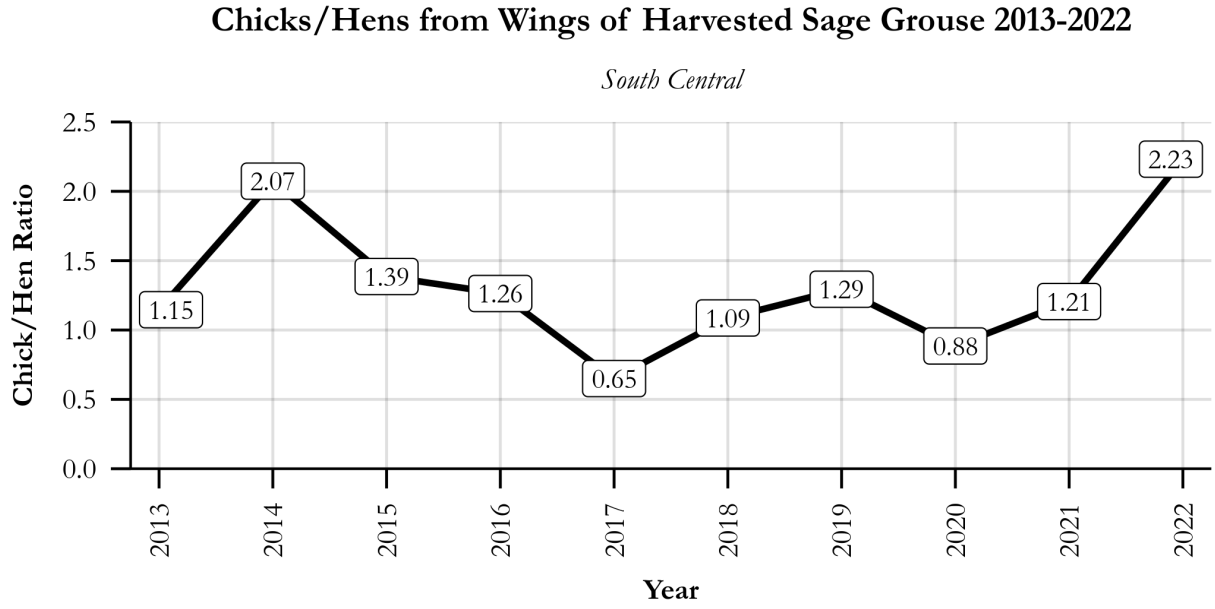


Figure 6: Chick/Hen Ratio

Lek Monitoring:

For biological year 2022, 409 sage-grouse leks were known to occur in the South-Central Conservation Area (SCCA). In the SCCA, the majority of known leks (56%) occur on Bureau of Land Management (BLM) managed lands and 36% occur on private land (**Table 1**).

During the 2023 lekking season, Wyoming Game and Fish Department (WGFD), United States Forest Service (USFS) and BLM personnel, environmental consultants, and volunteers monitored 208 leks. This represented checking 79.7% of the occupied status leks in the SCCA. This rate of effort was 7% less than in 2022; and was below the 10-year average rate of effort (**Table 4)**. This reduced effort was largely due to environmental conditions prohibiting ground visits to leks early in the lekking season.

A total of 20 leks were *counted* (compared to 82 in 2022) in the SCCA, resulting in an average of 26.5 males per lek (**Table 2**). A total of 188 leks were *surveyed* (compared to 150 in 2022) resulting in an average of 21.7 males per lek (**Table 3**). Across the SCCA, more leks were monitored with *survey* protocol and fewer were monitored with *count* protocol. To evaluate long-term population trends, average lek *survey* and *count* data are combined, because the more stringent count protocol was not used during the early 1990s. Fortunately, long-term data sets from Wyoming and neighboring states indicate similar trends from both *counts* and *surveys*. In 2023, the peak male lek attendance with the SCCA totaled 2,925 males. The average number of male sage-grouse on both *counted* and *surveyed* leks increased from 23 and 19.6 in 2022 to 26.5 and 21.7 in 2023. **Figure 1** illustrates the trends in average peak males per lek for SCCA from 2014-2023. Sage-grouse populations in Wyoming cycle on approximately 6 to 8-year intervals. The proportion of occupied leks which were considered inactive decreased from 21.6% in 2022 to 9.5% in 2023. During an upswing in the sage-grouse population, we would expect a decrease in the number of inactive leks. Although the number of

inactive leks decreased in 2023, the management status for 50 leks (19%) was unknown because they were not monitored or monitoring protocol requirements were not met (**Table 5**).

Due to extreme snowpack and difficulty in accessing leks on the ground, many leks only received one timely visit in the Baggs and Saratoga WGFD Biologist Districts. In the Baggs Biologist District, many of these single lek checks were via aerial survey. The number of birds counted during these aerial surveys was likely biased low, which may have accounted for the "decrease" in lek attendance. In Baggs, there was also disparity in lek attendance between leks located west and east of Highway 789. Relatively poor lek performance was noted west of Highway 789 in lower elevations and precipitation zones, while improved lek performance east of Highway 789 was observed. In the Rawlins Biologist District, LWR Consultants used aerial infrared (IR) flights to monitor several leks within the Lost Creek Uranium area. The IR numbers were consistent with later ground visits. This survey effort provided useful second or third observations earlier in the lekking season. Across the SCCA, sage-grouse strutting appeared to be delayed and extended with substantial hen numbers seen into May and good male numbers observed into late May.

No reliable method for estimating the sage-grouse population for the SCCA exists at this time, however the number of males per lek provides a reasonable index of abundance of the population over time. The increase in peak male lek attendance, along with the observed chick per hen ratios in hunter submitted wings indicated a stable to slightly increasing sage-grouse population across the SCCA during biological year 2022.

Harvest:

The 2022 sage-grouse hunting season was from 17 September to 30 September (14 days), and allowed for the harvest of 2 sage-grouse per day and 4 in possession (**Table 6**). The 2022 upland harvest survey estimated 983 hunters spent 2,564 days to harvest 1,510 sage-grouse in the SCCA. The average number of birds harvested per hunter day was 0.6. The average number of sage-grouse harvested per hunter was 1.5 and the average number of days hunted was 2.6 (**Table 7**). Compared to the last 10 years, when hunting regulations were similar with the exception of small changes to hunting season length; 2022 hunter numbers were almost double the 10-year average number of hunters, the birds/day was 32% lower than the 10-year average, and the days/hunter was 9% higher than the 10-year average. These harvest statistics could be indicating hunters were less successful and harvesting sage-grouse required more effort than previous years. These statistics could also be pointing to more sage-grouse hunters (non-resident and/or residents), spending more time afield in pursuit of "trophy" (adult male) sage-grouse. Generally, during the past 10 years, overall harvest appeared to be correlated to both hunter numbers and sage-grouse abundance. Based on check station observations hunter participation and success appeared to vary across the SCCA, with lower success in the northern portions (Red Desert/ Ferris) and higher success in the southern portions (Saratoga, south Rawlins, Baggs). Lower hunter participation was noted in the Baggs area, likely because of lower bird numbers being observed.

Production:

Hunter-harvested sage-grouse wings have been collected annually and are used for estimating productivity. Wings were collected in barrels set out at major road junctions where hunters are most likely to pass, and can provide a relatively consistent source of productivity data. Wings are gathered and then aged/sexed by molt patterns, and numbers of chicks per hen are calculated and used as a measure of productivity. While there are biases associated with the hunter selectivity of different

age/sex groups of sage-grouse, trends still provide yearly comparisons of relative chick production. During the 2022 hunting season, WGFD collected 257 wings from wing barrels within the SCCA, which was 17% of the estimated harvest of 1,510 birds. This was a 28% increase in the total number of wings when compared to the 201 wings collected in 2021. Age and sex composition of the wings indicated the proportion of chicks per hen increased from 1.2 in 2021 to 2.2 in 2022 (**Table 8**). Statewide analyses of wing data from harvested sage-grouse have suggested chick per hen ratios of 1.4-1.7 typically results in relatively stable populations as determined by lek counts the following year. We observed this increase in 2023 lek attendance, following good chick per hen ratios in 2022.

Habitat:

Sage-grouse habitat within the SCCA is comprised of relatively intact sagebrush communities. The health of these communities is predominately dependent on the type, amount, and timing of annual precipitation. Spring precipitation is an important factor in the quantity and quality of grass and forb production, which have been linked to sage-grouse nest success and chick survival. Much of the sagebrush habitat in the SSCA is trending towards older, decadent age classes. While mature sagebrush stands are important to sage-grouse for both forage and cover, a monoculture of older and decadent stands may lead to lower nutrient content of this key forage. We continue to see the proliferation of cheatgrass throughout sagebrush communities within the SCCA, reducing native plant density and diversity as well as increasing the risk of large fires that have the potential to devastate sage-grouse habitat.

Primary land use in the SCCA is livestock grazing and energy development. In the first half of the 20th century, much of the sage-grouse habitat in the SCCA provided winter grazing for hundreds of thousands of both domestic sheep and cattle. Sheep numbers have since declined and cattle have become the primary species of livestock grazing in the SCCA. Improved grazing management on both public and private lands during the last few decades has generally led to improved habitat for sage-grouse and other sagebrush obligate species. Feral horses continue to inhabit the western and northern portions of the SCCA.

Energy development and mineral extraction continue to be a primary use of sage-grouse habitat within the SCCA, with a majority of the energy development focused on producing natural gas from both deep gas and coalbed methane sources. Large-scale wind farm developments and transmission lines have begun over the past few years in the northern part of the SCCA, introducing new challenges within sage-grouse habitat. Development for the Chokecherry/Sierra Madre Wind Energy Project continued throughout 2022-2023. Past and present uranium mining has also contributed to reducing sage-grouse habitat in the SCCA. Energy development has, directly and indirectly, reduced the functionality of sage-grouse habitat in portions of the SCCA. The Interstate 80/Union Pacific Railroad transportation corridor bisects the SCCA east to west and is a major cause of habitat fragmentation. Continued urban/rural development within sagebrush communities also continues to fragment sage-grouse habitat.

The 2022 growing season precipitation (April –July) within the SCCA was below normal. Spring precipitation diminished in early June 2022. By late July and early August, monsoonal moisture patterns resulted in some green-up of herbaceous vegetation. The resulting herbaceous vegetation provided sage-grouse additional forage opportunities and likely provided better hiding cover from predators. Through fall and early winter 2022, conditions remained mild, with no persistent snow accumulations. However, winter conditions became severe and led to one of the worst winters the state has seen in many decades. Snow depths were above normal over much of the SCCA and

persisted until early May 2023. Spring moisture was above normal and cooler temperatures resulted in a delayed green up of herbaceous vegetation. Once snow melted and temperatures finally increased, herbaceous growth utilized by sage-grouse for nesting cover was excellent and likely improved brood rearing success in 2023.

Winter mortality was a concern, even with the sage-grouse's propensity to survive winters well, due to most sagebrush being completely covered by snow. Sage-grouse were observed in traditional wintering areas, but concentrated in small sections of steeper wind swept slopes or locations with taller shrub canopies. Lek observations in spring seemed to indicate sage-grouse did not suffer substantial winter mortality. Males were observed strutting and congregating several miles off of leks when lek conditions were not suitable for breeding activity prior to snowmelt. Hens may have delayed nesting activity due to deep snowpacks, particularly in higher elevation nesting and brood rearing habitats.

WGFD continues to plan and implement habitat projects including cheatgrass control, sagebrush mowing, juniper removal, and wet meadow restoration within the SCCA to improve sage-grouse habitat. To mitigate habitat issues related to cheatgrass in sage-grouse habitats, aerial herbicide treatments continue to be conducted throughout the SCCA. Rejuvra cheatgrass treatments from fall 2021 (areas north of Horse Mountains, around Big Gulch Road, and east of Savery Creek, totaling about 6,000 acres) showed little to no cheatgrass control during the 2022 growing season, with perhaps one of the worst flushes of cheatgrass ever seen in the area occurring during that time. The effectiveness of these treatments was re-assessed in 2023, and the results were much more promising, with very little to no cheatgrass germinating in those plots. This effort continues through existing collaborations between the Department, the Little Snake River Conservation District, Carbon County Weed and Pest, WWNRT, BLM, USFS, NRCS, SCSGLWG, and private landowners. Carbon County Weed and Pest was awarded a large grant from the mitigation fund for the Gateway South Transmission Project to continue to treat cheatgrass in western Carbon County. This award will be used as leverage to match additional funding opportunities. Large-scale sagebrush thinning with Spike herbicide began in fall 2022 around High Savery Reservoir in higher elevation, mountain big sagebrush stands that exceeded 50% canopy cover. These projects should improve conditions for nesting and brood-rearing sage-grouse. Lawson aerator treatments in similar habitats are scheduled to begin fall 2023.

There is no quantified data, but reclamation success of the first sagebrush planting on the Chain Lakes Wildlife Habitat Management Area appears to be less than 5-10% after three years. The second planting is similar, with approximately 50-80 live shrubs after ~1,600 seedlings planted, but growth on the surviving plants was extensive this year following the spring moisture, with most taller than the protective cages and many having heavy seed production in 2023.

In the coming years, WGFD plans to focus efforts on low-tech process-based restoration techniques to restore wet meadows within sage-grouse core. Low-tech structures, such as zeedyks, can re-connect floodplains and increase the quality and quantity of brood-rearing habitat.

Disease:

There were no cases of West Nile Virus in sage-grouse, or other diseases detrimental to sage-grouse documented within the SCCA in biological year 2022.

Conservation Planning:

The South Central Local Working Group (SCLWG) held three meetings during this reporting period but had not allocated their Fiscal Year 2023 funds at the time of this report.

Local Working Group Adaptive Management Trigger Identification

Executive Order 2019-3 Appendix I calls for sage-grouse local working groups to evaluate sage-grouse lek data annually to determine if anything unexpected was happening in the Conservation Areas which may be cause for suspected soft or hard triggers.

In February 2022, the SCLWG met to review areas of concern that were brought forward by WGFD biologists. The group answered a series of questions developed by the Statewide Adaptive Management Working Group (SAMWG) in regards to the identified areas of concern. After receiving feedback from the local working groups, SAMWG decided to take a more analytical look at the issues that led to soft triggers in 17 core areas across the state. SAMWG formed a single Strike Team (technical team) which included representatives from federal, state, conservation districts, and industry. The Strike Team met with SCLWG to discuss potential causal factors for declines in sage-grouse in the South Rawlins and Hanna Core Areas and outlined possible solutions in a report sent to SAMWG.

After receiving the report from the Strike Team, SAMWG submitted recommendations to address the issues identified. No single "causal factor" was identified to explain the sage-grouse population declines that initiated the review. SAMWG explained that maintaining and restoring high quality sagebrush habitats in core areas throughout the State was/is critical. SAMWG described the actions that could be taken to address the issues identified by the Strike Team. SAMWG made several recommendations including treatment of invasive annual grasses, fire management/response, post-fire rehabilitation, and proper grazing management in sage-grouse core areas. SAMWG also recommended funding the disturbance calculation tool and recommended the Sage-Grouse Implementation Team (SGIT) consider analyzing the core area boundaries (Version 4) and make adjustments using local knowledge and best available science.

Core Area Revisions

In 2023, BLM began developing a Resource Management Plan Amendment for sage-grouse. It was determined that it would be necessary to revisit the State's Core Area Map (Version 4) and provide BLM an updated version as an option for their Amendment. A SGIT Subcommittee was appointed to complete a state Sage-Grouse Core Area Map review. In Phase 1 (March/April), SGIT Subcommittee requested WGFD biologists provide biologically relevant additions and subtractions to Core Area. In Phase 2, the SGIT subcommittee considered anthropogenic factors and gathered feedback from stakeholders through a series of local working group meetings, interested stakeholder meetings, and public comment periods. The Sage-Grouse Implementation Team's proposed core area map is available on the SGIT page of the WGFD website. It is currently unknown what the final outcome of this process will be.

Management Recommendations:

1. Continue to monitor a minimum of 80% of the occupied leks in the SCCA.
2. Update all lek observers on WGFD survey protocols, and familiarize them with standardized datasheets.
3. Expand lek searches to ensure all active leks within the SCCA have been identified.

4. Seek out opportunities to increase flight money for lek searches and surveys in hard to access portions of the SCCA.
5. Support WGFD and BLM efforts to address mitigation and reclamation issues.
6. Support research efforts to identify seasonal habitats, especially winter concentration habitat.
7. Coordinate with BLM and USFS to ensure development and habitat treatments in Sage-grouse Core Area comply with WY-EO-2019-3.
8. Continue to build partnerships with private landowners to maintain or improve sage-grouse habitat on private lands through mutually beneficial habitat projects.

Southwest

Job Completion Report

Prepared By: Patrick Burke, Green River Wildlife Biologist

Period Covered: 6-1-2022 to 5-31-2023

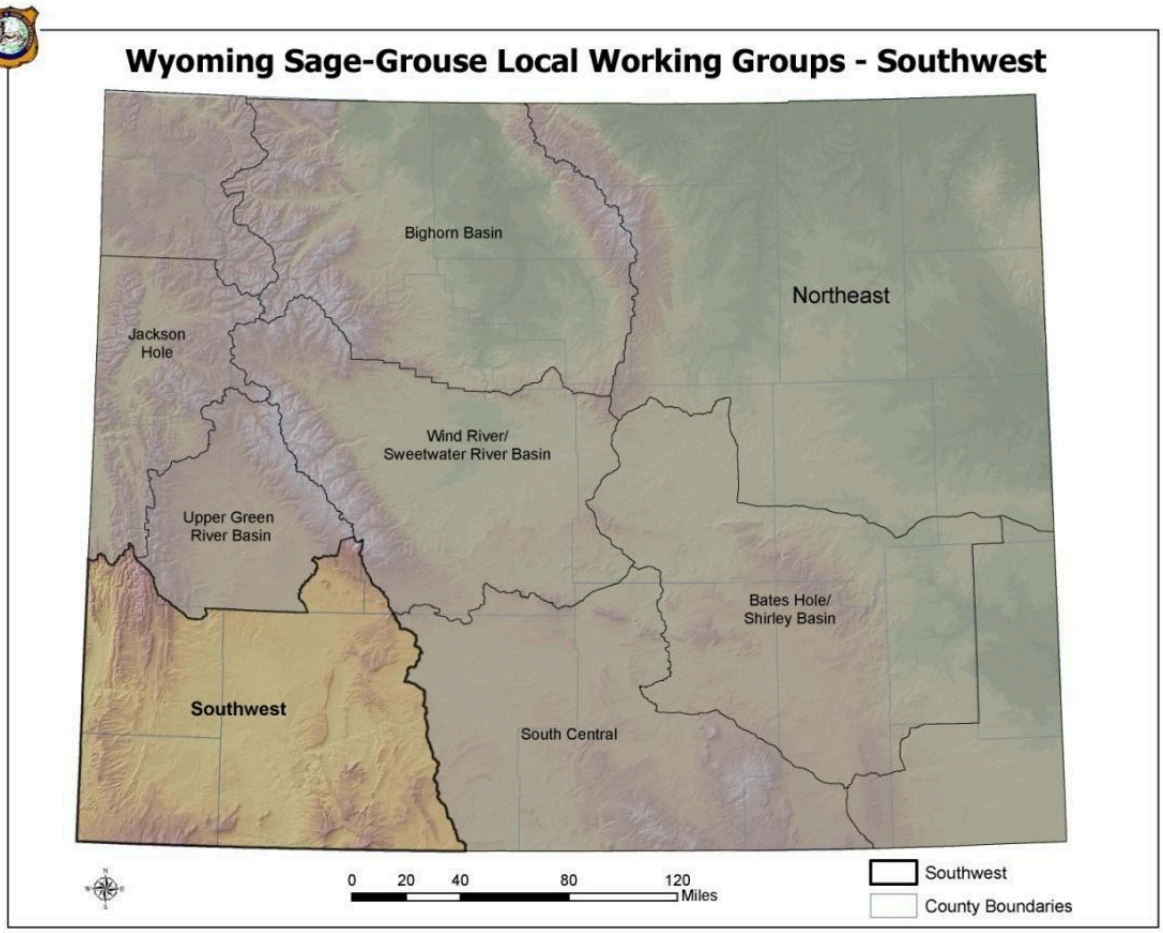


Table 1: Sage-Grouse Lek Characteristics

	Group	N	Percent
BLM Office			
	Kemmerer	198	43.6%
	Pinedale	14	3.1%
	Rawlins	4	0.9%
	Rock Springs	238	52.4%
Biologist			
	Green River	170	37.4%
	Lander	1	0.2%
	Mountain View	229	50.4%
	Pinedale	54	11.9%
Classification			
	Occupied	323	71.1%
	Undetermined	9	2%
	Unoccupied	122	26.9%
County			
	Fremont	4	0.9%
	Lincoln	136	30%
	Sublette	35	7.7%
	Sweetwater	212	46.7%
	Uinta	67	14.8%

	Group	N	Percent
Land Status			
		1	0.2%
	BLM	314	69.2%
	BOR	15	3.3%
	National Park	2	0.4%
	Private	106	23.3%
	State	15	3.3%
	USFS	1	0.2%
Lek Status			
	Active	198	43.6%
	Inactive	73	16.1%
	Unknown	183	40.3%
Management Area			
	G	454	100%
Region			
	Green River	400	88.1%
	Pinedale	54	11.9%
Warden			
	Cokeville	55	12.1%
	Evanston	36	7.9%
	Green River	75	16.5%
	Kemmerer	71	15.6%
	Mountain View	51	11.2%
	Rock Springs	112	24.7%
	South Pinedale	54	11.9%

Table 2: Leks Counted

Year	Occupied	Counted	Percent Counted	Peak Males	Average Peak Males
2014	310	96	31%	1,613	19.9
2015	316	70	22.2%	2,197	34.9
2016	325	94	28.9%	3,744	44.0
2017	334	97	29%	2,950	34.3
2018	338	102	30.2%	2,654	30.2
2019	337	87	25.8%	1,433	19.4
2020	336	73	21.7%	1,224	20.4
2021	337	90	26.7%	1,207	17.2
2022	335	80	23.9%	804	14.4
2023	331	44	13.3%	725	20.7

Occupied - Must have been active once during previous 10 years, calculated based on the official definitions

Average Peak Males - Includes only those leks where one or more strutting males were observed. Does not include "Active" leks where only sign was documented

Table 3: Leks Surveyed

Year	Occupied	Surveyed	Percent Surveyed	Peak Males	Average Peak Males
2014	310	190	61.3%	3,177	21.2
2015	316	222	70.3%	6,256	35.7
2016	325	211	64.9%	6,488	40.5
2017	334	203	60.8%	5,991	38.9
2018	338	210	62.1%	5,357	32.1
2019	337	201	59.6%	3,068	23.6
2020	336	212	63.1%	3,003	20.0
2021	337	183	54.3%	1,933	14.6
2022	335	206	61.5%	2,242	16.0
2023	331	176	53.2%	1,886	21.7

Occupied - Must have been active once during previous 10 years, calculated based on the official definitions

Average Peak Males - Includes only those leks where one or more strutting males were observed. Does not include "Active" leks where only sign was documented

Table 4: Leks Checked

Year	Occupied	Checked	Percent Checked	Peak Males	Average Peak Males
2014	310	286	92.3%	4,790	20.7
2015	316	292	92.4%	8,453	35.5
2016	325	305	93.8%	10,232	41.8
2017	334	300	89.8%	8,941	37.3
2018	338	312	92.3%	8,011	31.4
2019	337	288	85.5%	4,501	22.1
2020	336	285	84.8%	4,227	20.1
2021	337	273	81%	3,140	15.5
2022	335	286	85.4%	3,046	15.5
2023	331	220	66.5%	2,611	21.4

Occupied - Must have been active once during previous 10 years, calculated based on the official definitions

Average Peak Males - Includes only those leks where one or more strutting males were observed. Does not include "Active" leks where only sign was documented

Table 5: Lek Status

Year	Occupied	Active	Inactive	Unknown	Known Status	% Active	% Inactive
2014	310	236	24	26	260	90.8%	9.2%
2015	316	251	20	21	271	92.6%	7.4%
2016	325	263	26	16	289	91%	9%
2017	334	253	30	17	283	89.4%	10.6%
2018	338	262	31	19	293	89.4%	10.6%
2019	337	230	46	12	276	83.3%	16.7%
2020	336	225	31	29	256	87.9%	12.1%
2021	337	219	33	21	252	86.9%	13.1%
2022	335	223	28	35	251	88.8%	11.2%
2023	331	163	31	26	194	84%	16%

Occupied - Must have been active once during previous 10 years, calculated based on the official definitions

Inactive - Confirmed no birds/sign present (see official definitions)

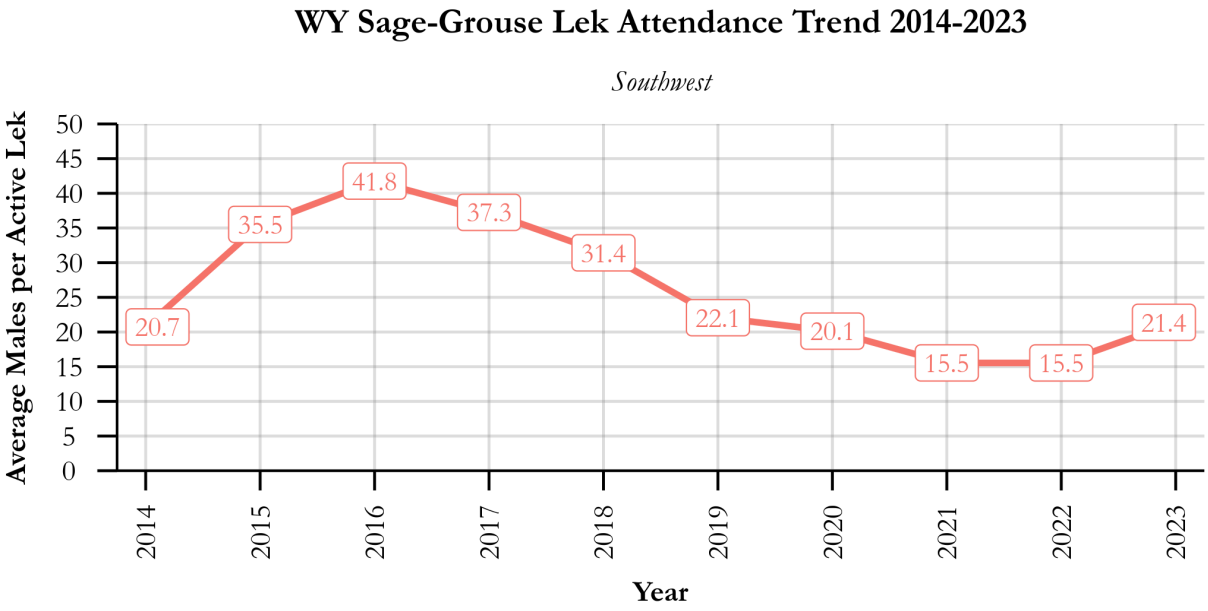


Figure 1: Average Peak Males

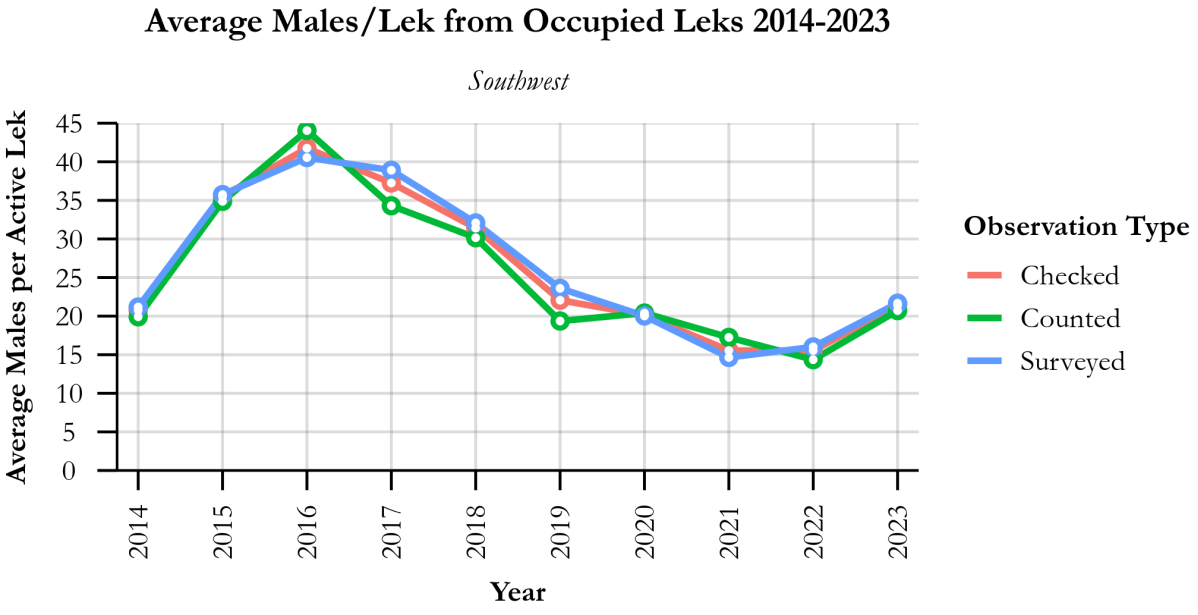


Figure 2: Average Peak Males

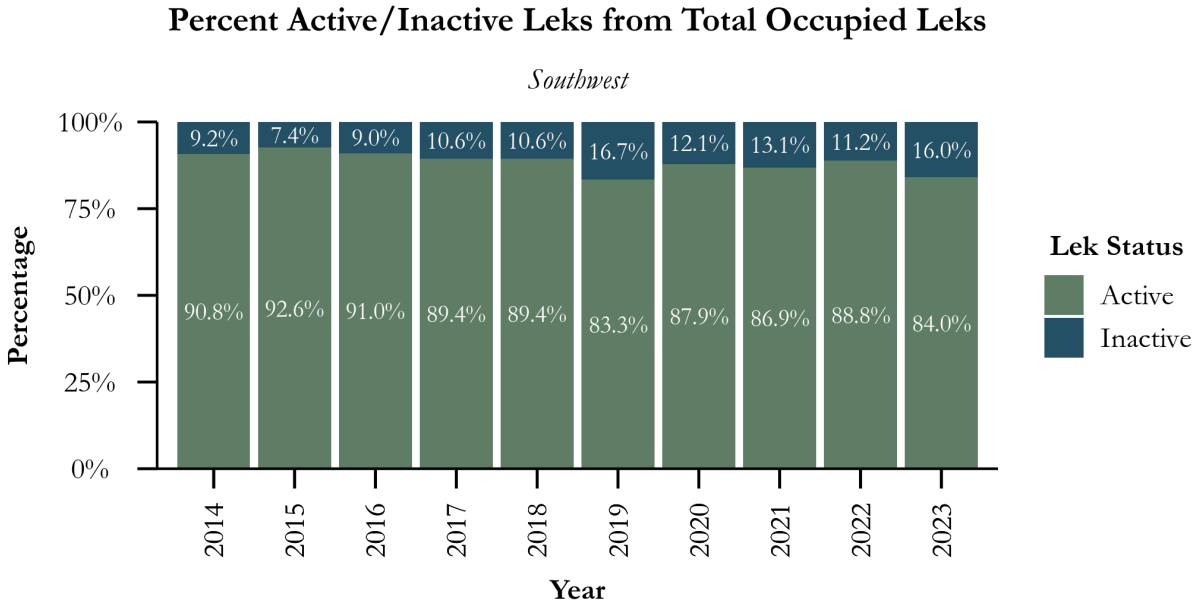


Figure 3: Lek Status

Table 6: Harvest Season

Year	Season Start	Season End	Length	Bag/Possession Limit
2013	Sep-21	Sep-30	10	2/4
2014	Sep-20	Sep-30	11	2/4
2015	Sep-19	Sep-30	12	2/4
2016	Sep-17	Sep-30	14	2/4
2017	Sep-16	Sep-30	15	2/4
2018	Sep-15	Sep-30	16	2/4
2019	Sep-21	Sep-30	10	2/4
2020	Sep-19	Sep-30	12	2/4
2021	Sep-18	Sep-30	13	2/4
2022	Sep-17	Sep-30	14	2/4

Table 7: Harvest Totals

Year	Harvest	Hunters	Days	Birds/Day	Birds/Hunter	Days/Hunter
2013	2,513	1,307	3,139	0.8	1.9	2.4
2014	2,645	1,165	2,835	0.9	2.3	2.4
2015	4,479	1,586	4,057	1.1	2.8	2.6
2016	4,163	1,672	4,036	1.0	2.5	2.4
2017	3,590	1,421	3,675	1.0	2.5	2.6
2018	3,410	1,630	3,873	0.9	2.1	2.4
2019	2,821	1,514	3,746	0.8	1.9	2.5
2020	1,491	737	2,336	0.6	2.0	3.2
2021	2,937	1,650	5,022	0.6	1.8	3.0
2022	3,968	1,974	5,371	0.7	2.0	2.7
Average	**3,202**	**1,466**	**3,809**	**0.8**	**2.2**	**2.6**

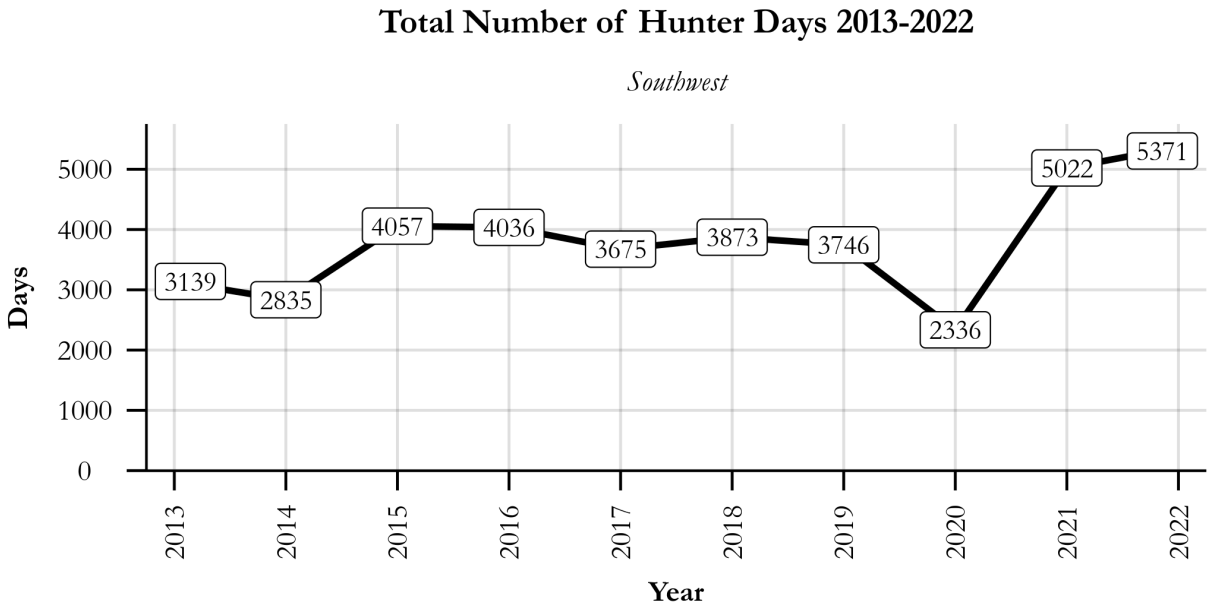


Figure 4: Harvest Days

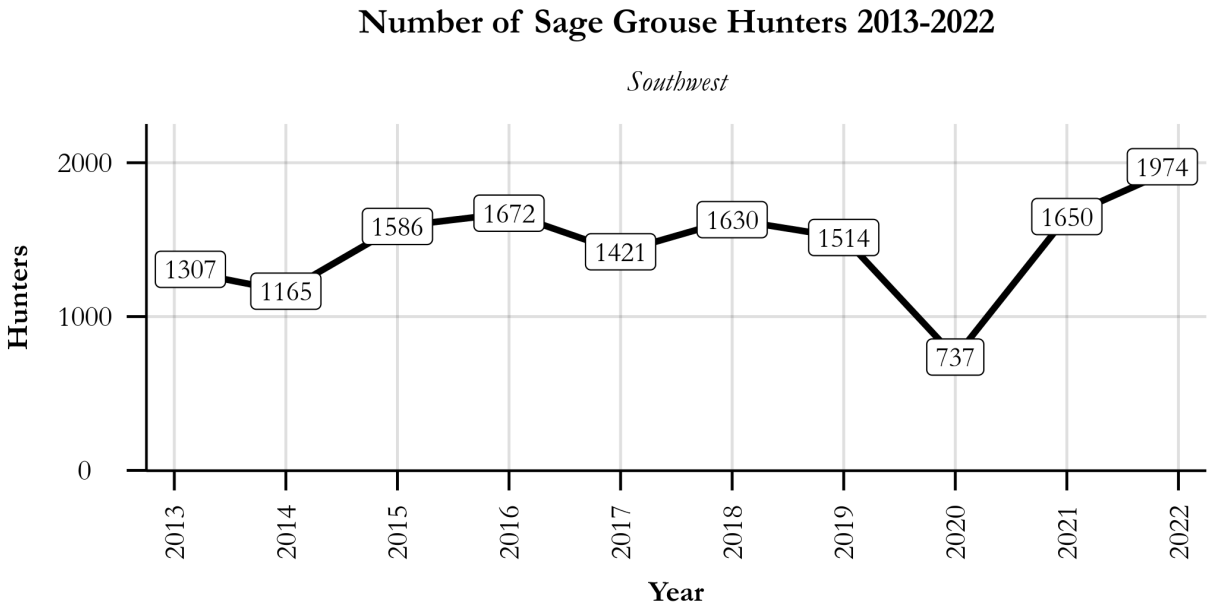


Figure 5: Hunters

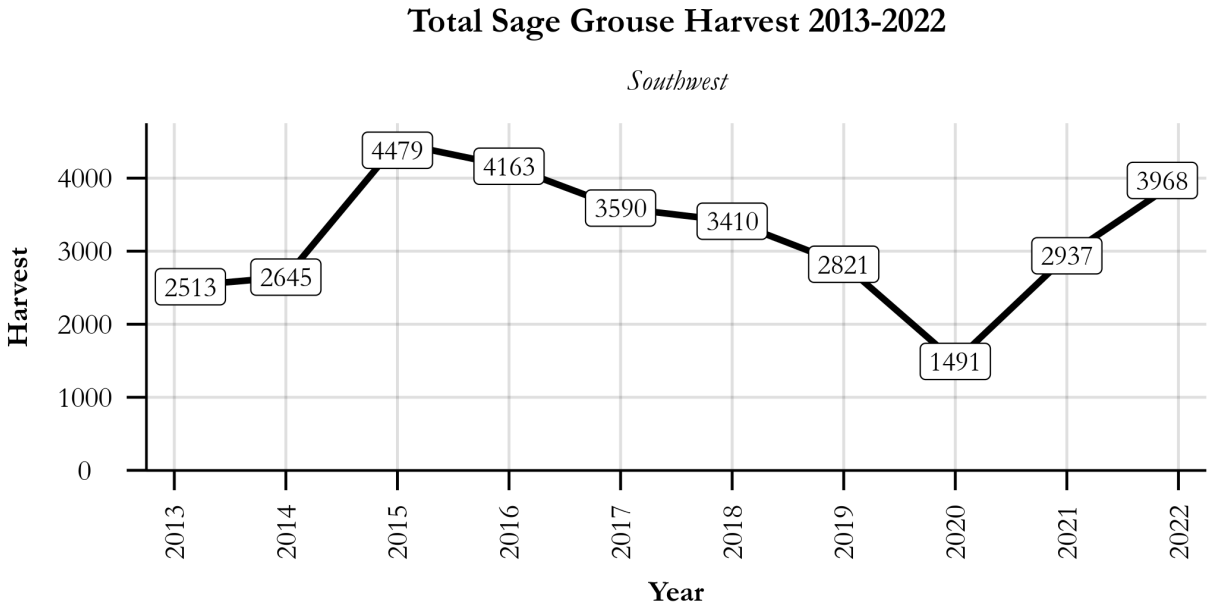


Figure 6: Total Harvest

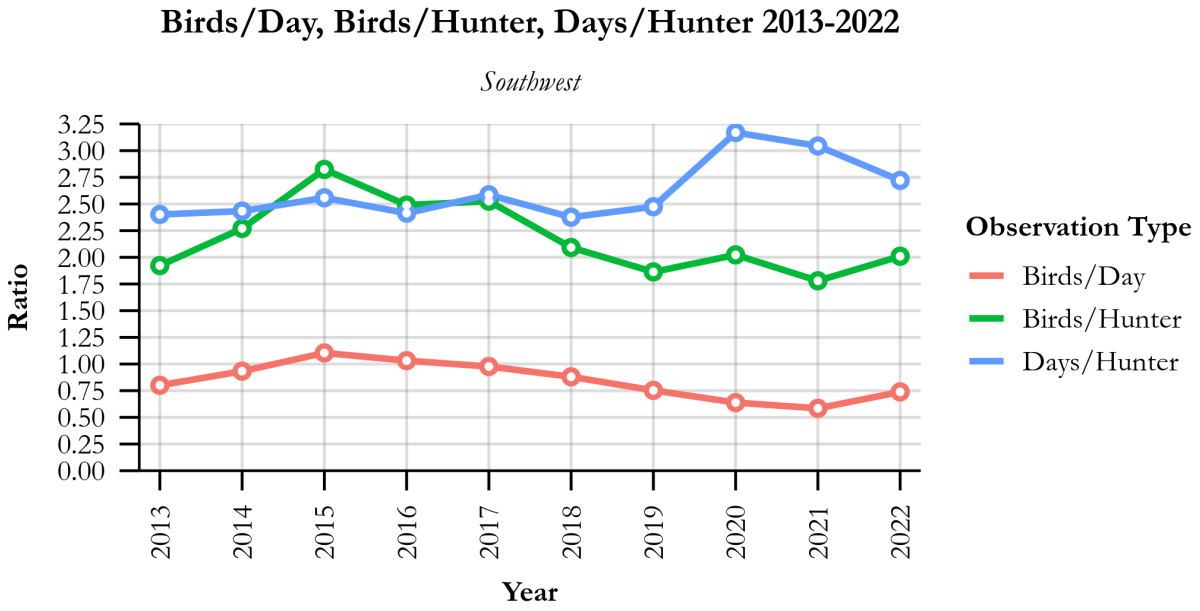


Figure 7: Harvest Ratios

Table 8: Harvest Composition

		Percent Adult		Percent Yearling		Percent Chick		
Year	Sample Size	Male	Female	Male	Female	Male	Female	Chicks/Hens
2013	390	9.2%	38.5%	1.5%	2.3%	20.5%	27.9%	1.2
2014	517	5.6%	20.7%	2.3%	7%	33.5%	30.9%	2.3
2015	860	13.5%	25.1%	3.1%	4.3%	27.4%	26.5%	1.8
2016	949	15.2%	30.5%	4.2%	5.6%	19.9%	24.7%	1.2
2017	813	9.5%	31%	2.8%	7%	22.6%	27.1%	1.3
2018	827	12%	33.4%	6.5%	13.4%	13.1%	21.6%	0.7
2019	570	7.9%	37.5%	2.1%	6.3%	14.4%	31.8%	1.1
2020	779	7.8%	31.3%	3.6%	6.4%	20.5%	30.3%	1.3
2021	447	12.8%	46.1%	1.6%	6.9%	15%	17.7%	0.6
2022	677	7.4%	30.1%	1.9%	4.6%	25.3%	30.7%	1.6

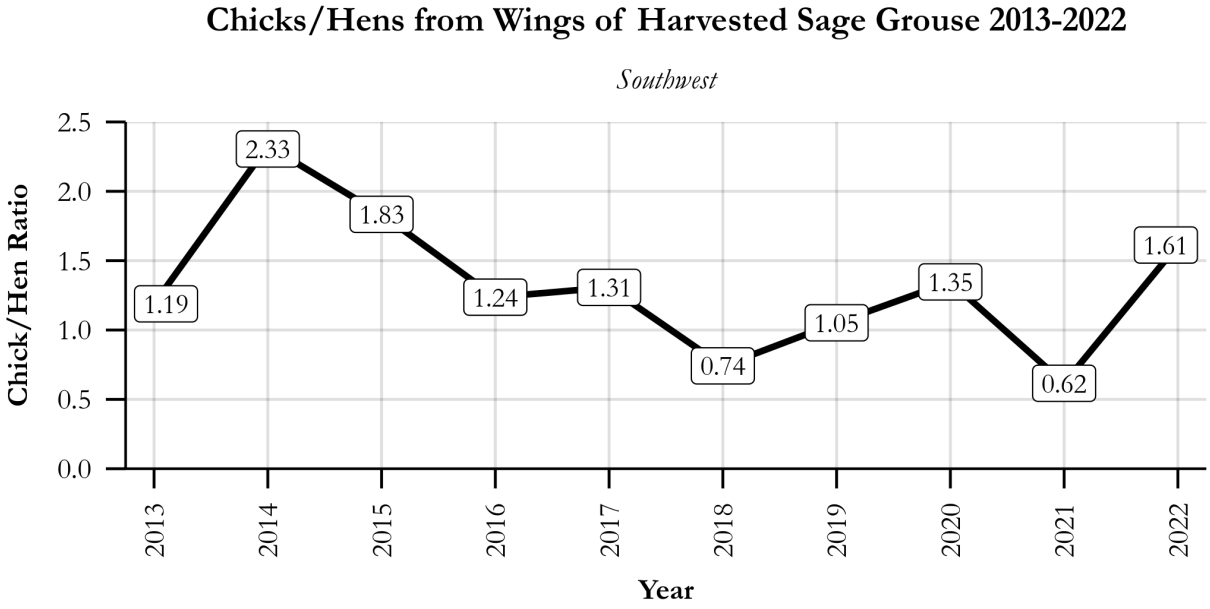


Figure 8: Chick/Hen Ratio

Table 9: Spring precipitation compared to fall chick:hen ratios in the SWSGCA 2012-2022. Precipitation data from: **http://www.wrcc.dri.edu/index.html** (Click on Monitoring – under Monitoring click on Drought Monitoring then click on **Monthly divisional precipitation or temperature** – click on the map in the relevant portion of Wyoming, in this case division #3 Green and Bear Drainage Division – set up the plot as desired including "List the data for the points plotted?" Option – add the percentages listed under March through June of the year of interest and divide by four).

Year	% of Average March-June Precipitation	Chicks:Hen
2012	41%	0.7
2013	64%	1.2
2014	79%	2.3
2015	128%	1.8
2016	145%	1.2
2017	105%	1.3
2018	96%	0.7
2019	125%	1.1
2020	91%	1.3
2021	67%	0.6
2022	91%	1.6

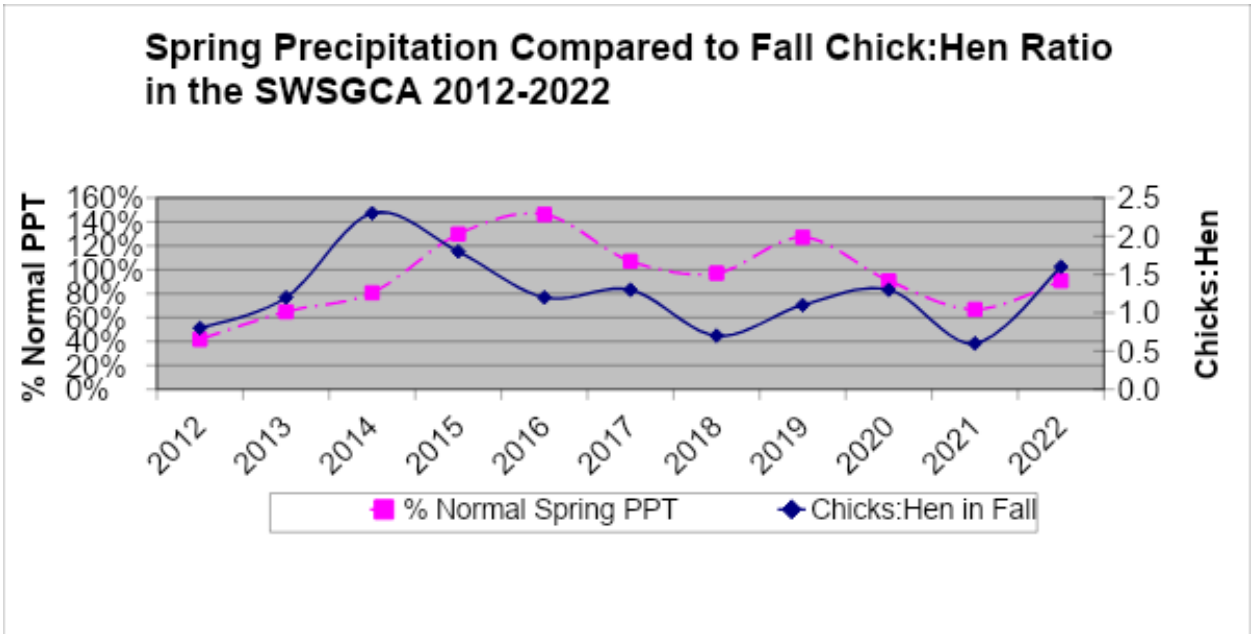


Figure 9: Spring precipitation compared to fall chick:hen ratios in the SWSGCA 2012-2022.

Lek Monitoring:

A total of 331 occupied leks were known to exist in the Southwest Wyoming Sage-grouse Conservation Area (SWSGCA) during the 2023 lekking season. Of these 331 occupied leks, 220 of them were checked, with 44 of those checks being lek counts with three or more visits during the breeding season, with the remaining 176 checks consisting of lek surveys where less than three lek visits were made during the breeding season. The percentage of the known sage-grouse leks that were visited during the 2023 lekking season was 66.5%, which is a significantly lower visitation rate than a typical year, when over 90% of the known leks in the SWSGCA are checked (**Table 4**). However due to the significantly above average winter of 2022-2023, and the resulting deep snow conditions that persisted well into spring, many leks were simply inaccessible during the 2023 lekking season.

Of the 331 known occupied lek sites in the SWSGCA in 2023, 163 of them were classified as being active, 31 were classified as being inactive, and 111 leks were of an unknown status. All lek monitoring data from 2023, along with data from the past nine years for comparison are summarized in **Tables 1**-5.

Because of the quantity of leks in the SWSGCA, data collection efforts have focused on lek surveys, which involved at least one visit to the lek during the breeding season over lek counts, which are more labor intensive and involve three or more visits during the breeding season. Fedy and Aldridge (2011) determined that population trends demonstrated by lek surveys are the same as those indicated by lek counts as long as the number of leks surveyed exceeds 50 leks in an area.

Since only "occupied" leks are being reported on **Tables 1**-5, it is important to consider trends in the numbers of active versus inactive leks in addition to the average size of active leks. During a period of population decline, the size of active leks typically declines and the number of inactive leks increases. The converse is typically true of an increasing population. Therefore the magnitude of both increases and decreases is usually greater than what is indicated by the average lek size alone. The proportion of known status leks that were active in the SWSGCA has remained relatively steady over the 10-year reporting period varying from 83-93% active. The proportion of active leks for the 2023 lekking season was in line with, though at the lower end, of typical values having 84% of the known occupied leks being active.

Monitoring the total number of males on a lek is used as an index of trend, but these data should be viewed with caution for several reasons: 1) the survey effort and the number of leks surveyed/counted has varied over time, 2) it can be safely assumed that not all leks in the area have been located, 3) sage-grouse populations can exhibit cyclic patterns over approximately a decade long period, 4) the effects of un-located or un-monitored leks that have become inactive cannot be quantified or qualified, 5) lek sites may shift over time, and 6) new leks may be created. Both the number of leks and the number of males attending these leks must be quantified in order to estimate population trend.

The average number of males per active lek for all leks checked (both counted and surveyed) during the 2023 lekking season was 21.4 males per active lek. This is down from the high observations of 35 to 42 males per active lek observed from 2015 to 2017, and slightly below the 10 year average of 26.6 males per active lek. The average number of males in attendance on the 44 count leks in 2023 was 20.7 males per lek. This number is below the 10 year average of 26.1 males per lek, but is the highest number observed in the SWSGCA since 2018. For the 176 leks

that were surveyed in 2023, the average lek had 21.7 males in attendance; which is below the 10 year average of 27 males per lek, and down substantially from 2016's and 2017's observed values of 40.3 and 38.7 males per survey lek. It is however an increase from the 14.6 and 16.0 males per lek observed in 2021 and 2022.

It is important to note that data collection efforts have increased considerably since the early 2000's. In 2000, only 63% of known occupied leks were checked, but in recent years, the number annually checked is usually around 80-90% of the known occupied leks. In addition, efforts by WGFD personnel, volunteers, and other government and private industry biologists have led to increased numbers of known leks.

Currently, no method exists to estimate total sage-grouse population size in a statistically significant way. However, the recent male per lek averages along with the observed chick per hen ratios in hunter submitted wings indicate that the sage-grouse population in southwest Wyoming had been slightly decreasing during this reporting period.

Production:

Sage-grouse wings are collected each hunting season via voluntary hunter submission to allow for the determination of the sex and age of harvested birds. Successful hunters submitted 677 grouse wings from the 2022 hunting season (**Table 8**). This represents just over 17% of the estimated total harvest for 2022, which is slightly below the average submission rate of around 18%-19% of reported harvest.

The most important ratio obtained from the wing analysis is the chick to hen ratio; this ratio provides a general indication of chick recruitment. Assuming that hen and chick harvest is proportional to the actual makeup of the population, chick production for that year can be estimated by comparing the proportion of chicks to hens in the sample of submitted wings. Even if the rate of harvest between age/sex groups is not random, the information can be used as a tool for looking at population trends as long as any biases are relatively consistent across years.

In general it appears that chick:hen ratios of about 1.3:1 to 1.7:1 result in relatively stable grouse populations, while chick:hen ratios of 1.8:1 or greater result in increasing grouse numbers and ratios below 1.2:1 result in subsequent declines. The chick:hen ratio as determined from hunter submitted wings for the 2022 hunting season was 1.6 chicks/hen (**Table 8**). This ratio suggests a stable to slightly increasing grouse population, which corresponds well with the increased male lek attendance seen in the spring of 2023.

Harvest:

The 2022 hunting season for sage-grouse in the SWSGCA ran from September 17 to September 30 and allowed for a daily take of 2 birds with a limit of 4 grouse in possession (**Table 6**). The 2022 season was consistent with how the season has been run since 2002 when the season opening date was moved to the third Saturday in September and the daily bag limit was reduced to 2 birds and a possession limit of 4 birds. The sage-grouse season had historically started as early as September first and ran for 30 days; during this time the daily limit was 3 grouse with a possession limit of up to 9 birds. Over time, the season was gradually shortened and the daily bag and possession limits reduced because of concern over declining sage-grouse populations. The opening date was moved back from the first of September to the third weekend because research suggested that hens with broods were concentrated near water sources earlier in the fall and

therefore more susceptible to harvest. The later opening date allowed more time for those broods to disperse and therefore reduced hunting pressure on those hens that were successful breeders and on young of the year birds.

The data for grouse harvested in the SWSGCA are reported under Sage-Grouse Management Area G for the 2013 through 2022 hunting seasons in this report (**Table 7**). Based on harvest survey estimates, 1,974 hunters harvested 3,968 sage-grouse during the 2022 hunting season. This number is down from the 4,479 birds reported harvested in 2015, but is generally in line with recent harvest estimates for the SWSGCA. The trends in harvest statistics over the last 10 years are not well correlated with average male lek attendance due to changes in hunting season structure, weather conditions, and hunter participation levels over that period.

Habitat:

Spring habitat conditions are one of the most important factors in determining nesting success and chick survival for sage-grouse. Specifically, shrub height and cover, live and residual grass height and cover, and forb production, all have a large impact on sage-grouse nesting and brood rearing success. The shrubs and grasses provide screening cover from predators and weather, while the forbs provide forage and insects that reside in the forbs, which are an important food source for chicks. Spring precipitation is an important determinant of the quality and quantity of these vegetation characteristics. Residual grass height and cover depends on the previous year's growing conditions and grazing pressure while live grass and forb cover are largely dependent on the current year's precipitation.

In general, winter weather has not been shown to be a limiting factor to sage-grouse except in areas with persistent snow cover that is deep enough to limit sagebrush availability. This condition is rarely present in the SWSGCA even during severe winters.

The spring (March-June) precipitation and fall chick:hen ratios (as determined by hunter submitted wings) are given in **Table 9** and **Figure 9**. Generally speaking, when spring precipitation is at or above 90% of average, chick to hen ratios are above average, but when spring precipitation is below average, chick:hen ratios also tend to be below average. However, periods of prolonged or poorly timed cold, wet weather may have adverse effects on hatching success, plant and insect phenology and production and chick survival.

Disease:

No cases of West Nile Virus (WNv) or other avian diseases are known to have occurred in sage-grouse in the SWSGCA in 2022.

Conservation Planning:

The Southwest Local Working Group (SWLWG) was established in September of 2004 and they completed their Sage-grouse Conservation Plan (Plan) in 2007. In 2014, the SWLWG adopted an addendum to their Plan which is available at **https://wgfd.wyo.gov/Habitat/Sage-Grouse-Management/Sage-Grouse-Local-Working-Groups**. This addendum documented conservation action such as research and habitat projects the SCLWG had supported since their Plan was completed, as well as how these projects addressed the goals and action items identified in the Plan.

Two projects funded by the SWLWG completed work during the 2023 calendar year. Those two projects were the Albert Creek allotment wet meadow restorations II, and the Monument Draw wet meadow restoration project.

-Albert Creek Allotment Wet Meadow Restorations II

Stream incision and bank instability on Albert Creek and its tributaries is degrading the wet meadow riparian habitat used by greater sage-grouse for brood-rearing. Numerous non-functional stock dams built on the creek channels 40+ years ago have eroded their spillways and formed new, incised channels across the floodplains. The historic creek channels are left dry below the dams. Because the slope and dimensions of the new channels are far outside the range of conditions expected for stable channels of this stream type, they are not repairing themselves even with good vegetation management.

This phase (Phase 6) was an expansion of previous work that began in 2015. With the previous work raising the water table it is estimated that to date, this work has restored approximately 150 acres of riparian habitat.

Project 6 enhanced about 700 feet of Meadow Draw, a seasonal Albert Creek tributary, by connecting the draw to a relic channel on the Albert Creek floodplain. The project will bring the elevation of Meadow Draw down more gradually, stopping the head cut and creating more mesic habitat.

-Monument Draw Wet Meadow Restoration Project

Implementation of the Monument Draw Project began in 2022 with 16 Zeedyk structures being installed. In 2023, the structures were monitored and evaluated by a wet meadow restoration specialist and were modified based on recommendations to improve performance. Additional structures are being planned in 2024 pending approval of private landowners, as well as, the potential further expansion to adjacent BLM lands. In addition to the Zeedyk structures, several spring protection fence sites were also monitored and maintained.

Several tasks were completed during 2023 which included monitoring and continued implementation of the Monument Draw Wet Meadow Restoration Project in partnership with the White Acorn Ranch, the Office of State Lands, WGFD, and numerous volunteers. A field trip was conducted with a wet meadow restorations specialist, Shawn Conner. From this visit modifications were suggested and implemented, with more planned in 2024. A proposal was prepared for the consideration of the White Acorn Ranch to install Zeedyk structures on private land portions of Monument Draw. There was continuation of maintenance performed on spring sites being protected by steel-jack fencing in the Little Prospect Allotment.

Management Recommendations:

1. Continue to monitor a minimum of 80% of the known occupied leks in the SWSGCA
2. Update all lek observers on WGFD survey protocols in order to ensure that established lek monitoring protocols are followed
3. Continue to collect sage-grouse wings in wing barrels placed across the landscape in order to obtain an adequate and representative sample to derive sex/age and harvest trend information

4. Work with land management agencies to reduce negative impacts to crucial sage-grouse habitats

5. Work to increase the mapping of seasonal sage-grouse habitats

Literature Cited:

Fedy, B. C. and K. E. Doherty. 2010. Population cycles are highly correlated over long time series and large spatial scales in two unrelated species: greater sage-grouse and cottontail rabbits. Oecologia 165:915-924.

Upper Green River

Job Completion Report

Prepared By: Dean Clause, Pinedale Wildlife Biologist

Period Covered: 6-1-2022 to 5-31-2023

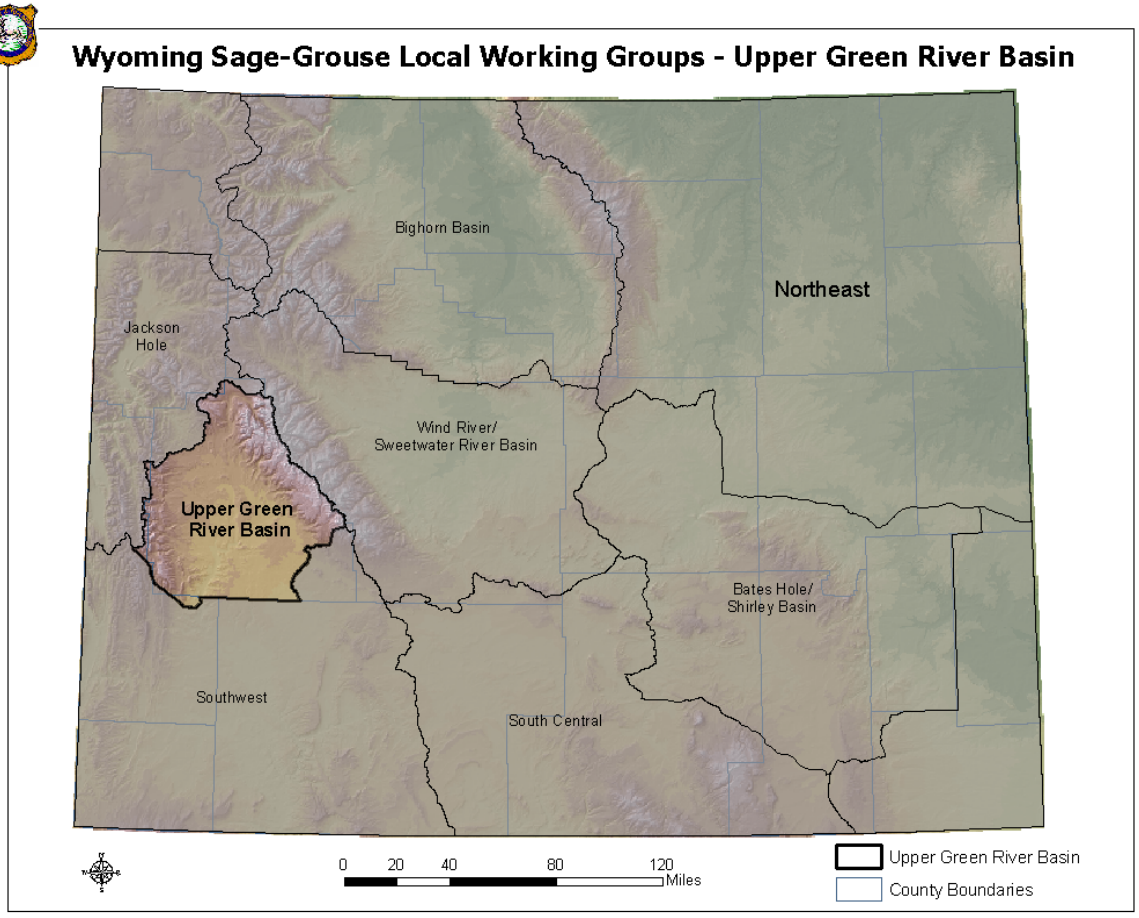


Table 1: **Sage-Grouse Lek Characteristics**

	Group	N	Percent
BLM Office			
	Pinedale	154	92.2%
	Rock Springs	13	7.8%
Biologist			
	Pinedale	94	56.3%
	Thayne	73	43.7%
Classification			
	Occupied	127	76%
	Unoccupied	40	24%
County			
	Lincoln	2	1.2%
	Sublette	165	98.8%

	Group	N	Percent
Land Status			
	BLM	137	82%
	Private	21	12.6%
	State	9	5.4%
Lek Status			
	Active	99	59.3%
	Inactive	36	21.6%
	Unknown	32	19.2%
Management Area			
	D	167	100%
Region			
	Pinedale	167	100%
Warden			
	Big Piney	85	50.9%
	North Pinedale	24	14.4%
	South Pinedale	58	34.7%

Table 2: Leks Counted

Year	Occupied	Counted	Percent Counted	Peak Males	Average Peak Males
2014	130	111	85.4%	3,207	36.9
2015	134	109	81.3%	4,667	53.6
2016	138	117	84.8%	5,229	55.0
2017	137	97	70.8%	4,206	54.6
2018	140	116	82.9%	4,039	41.6
2019	138	69	50%	2,071	34.5
2020	135	100	74.1%	2,423	31.5
2021	130	115	88.5%	2,497	26.0
2022	130	103	79.2%	1,944	23.1
2023	128	20	15.6%	372	20.7

Occupied - Must have been active once during previous 10 years, calculated based on the official definitions

Average Peak Males - Includes only those leks where one or more strutting males were observed. Does not include "Active" leks where only sign was documented

Table 3: Leks Surveyed

Year	Occupied	Surveyed	Percent Surveyed	Peak Males	Average Peak Males
2014	130	14	10.8%	290	29.0
2015	134	22	16.4%	923	48.6
2016	138	19	13.8%	886	63.3
2017	137	30	21.9%	1,091	52.0
2018	140	18	12.9%	484	40.3
2019	138	62	44.9%	1,489	30.4
2020	135	29	21.5%	498	23.7
2021	130	10	7.7%	105	15.0
2022	130	23	17.7%	418	29.9
2023	128	102	79.7%	1,849	26.0

Occupied - Must have been active once during previous 10 years, calculated based on the official definitions

Average Peak Males - Includes only those leks where one or more strutting males were observed. Does not include "Active" leks where only sign was documented

Table 4: Leks Checked

Year	Occupied	Checked	Percent Checked	Peak Males	Average Peak Males
2014	130	125	96.2%	3,497	36.1
2015	134	131	97.8%	5,590	52.7
2016	138	136	98.6%	6,115	56.1
2017	137	127	92.7%	5,297	54.1
2018	140	134	95.7%	4,523	41.5
2019	138	131	94.9%	3,560	32.7
2020	135	129	95.6%	2,921	29.8
2021	130	125	96.2%	2,602	25.3
2022	130	126	96.9%	2,362	24.1
2023	128	122	95.3%	2,221	25.0

Occupied - Must have been active once during previous 10 years, calculated based on the official definitions

Average Peak Males - Includes only those leks where one or more strutting males were observed. Does not include "Active" leks where only sign was documented

Table 5: Lek Status

Year	Occupied	Active	Inactive	Unknown	Known Status	% Active	% Inactive
2014	130	98	27	0	125	78.4%	21.6%
2015	134	106	25	0	131	80.9%	19.1%
2016	138	109	24	3	133	82%	18%
2017	137	98	29	0	127	77.2%	22.8%
2018	140	109	24	1	133	82%	18%
2019	138	109	22	0	131	83.2%	16.8%
2020	135	98	31	0	129	76%	24%
2021	130	104	21	0	125	83.2%	16.8%
2022	130	98	28	0	126	77.8%	22.2%
2023	128	96	18	8	114	84.2%	15.8%

Occupied - Must have been active once during previous 10 years, calculated based on the official definitions

Inactive - Confirmed no birds/sign present (see official definitions)

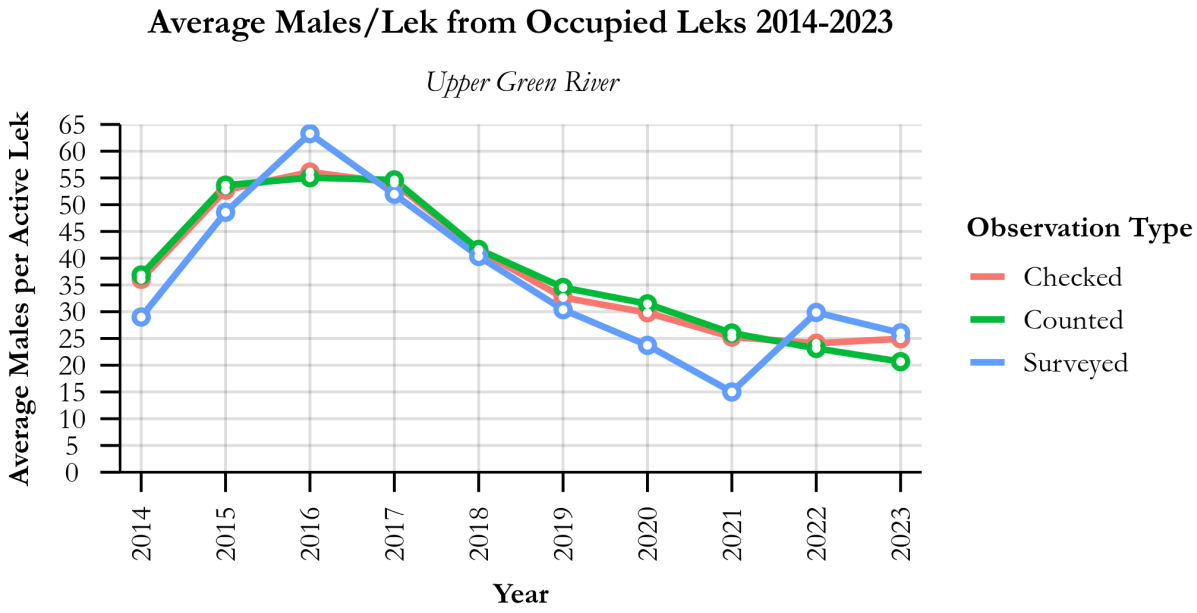


Figure 1: Average Peak Males

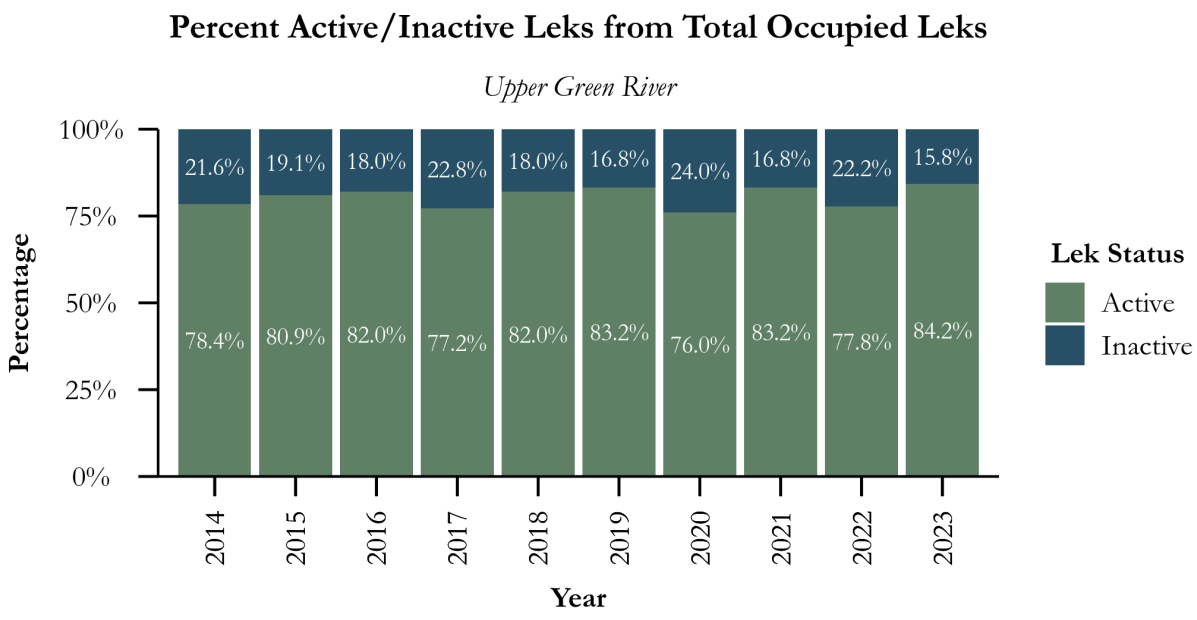


Figure 2: Lek Status

Table 6: Harvest Season

Year	Season Start	Season End	Length	Bag/Possession Limit
2013	Sep-21	Sep-30	10	2/4
2014	Sep-20	Sep-30	11	2/4
2015	Sep-19	Sep-30	12	2/4
2016	Sep-17	Sep-30	14	2/4
2017	Sep-16	Sep-30	15	2/4
2018	Sep-15	Sep-30	16	2/4
2019	Sep-21	Sep-30	10	2/4
2020	Sep-19	Sep-30	12	2/4
2021	Sep-18	Sep-30	13	2/4
2022	Sep-17	Sep-30	14	2/4

Table 7: Harvest Totals

Year	Harvest	Hunters	Days	Birds/Day	Birds/Hunter	Days/Hunter
2013	628	387	848	0.7	1.6	2.2
2014	1,056	406	1,266	0.8	2.6	3.1
2015	1,205	500	1,129	1.1	2.4	2.3
2016	1,990	706	2,012	1.0	2.8	2.8
2017	988	402	921	1.1	2.5	2.3
2018	2,161	853	2,632	0.8	2.5	3.1
2019	1,053	548	1,248	0.8	1.9	2.3
2020	1,770	704	1,922	0.9	2.5	2.7
2021	1,238	772	1,998	0.6	1.6	2.6
2022	1,502	673	1,551	1.0	2.2	2.3
Average	**1,359**	**595**	**1,553**	**0.9**	**2.3**	**2.6**

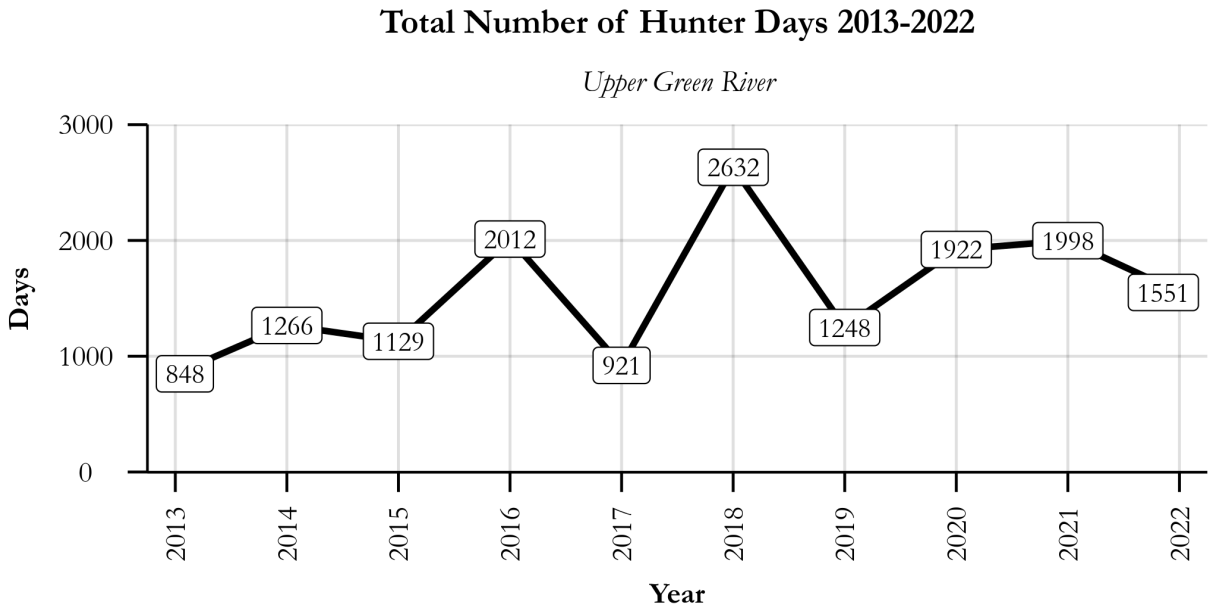


Figure 3: Harvest Days

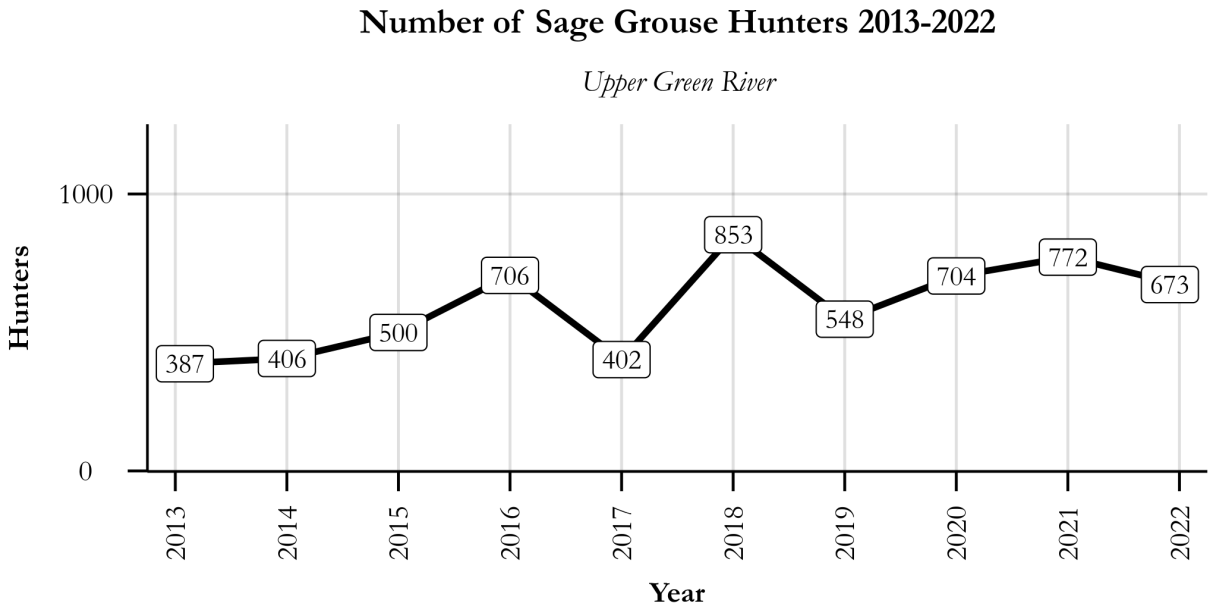


Figure 4: Hunters

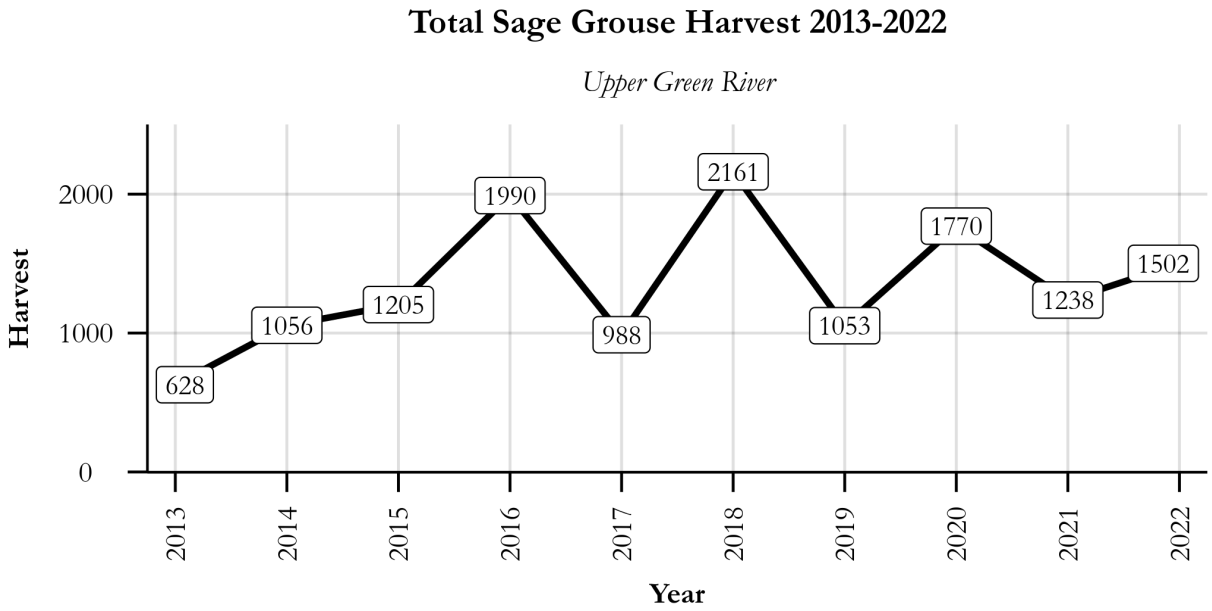


Figure 5: Total Harvest

Table 8: Harvest Composition

		Percent Adult		Percent Yearling		Percent Chick		
Year	Sample Size	Male	Female	Male	Female	Male	Female	Chicks/Hens
2013	372	12.1%	40.9%	3.2%	5.6%	17.2%	21%	0.8
2014	337	13.4%	33.8%	3%	8.3%	18.1%	23.4%	1.0
2015	482	12.4%	27%	2.1%	5.4%	24.7%	28.4%	1.6
2016	450	17.6%	43.1%	3.1%	5.8%	12.4%	18%	0.6
2017	573	15%	35.1%	3.3%	6.3%	18.8%	21.5%	1.0
2018	466	11.8%	38.8%	5.8%	10.7%	11.8%	21%	0.7
2019	342	7.3%	32.5%	1.8%	12%	14.3%	32.2%	1.0
2020	471	10.2%	37.6%	3%	7.9%	18.3%	23.1%	0.9
2021	410	11.2%	47.1%	2.9%	5.9%	12.2%	20.5%	0.6
2022	310	12.3%	41.3%	1.6%	8.1%	13.5%	23.2%	0.7

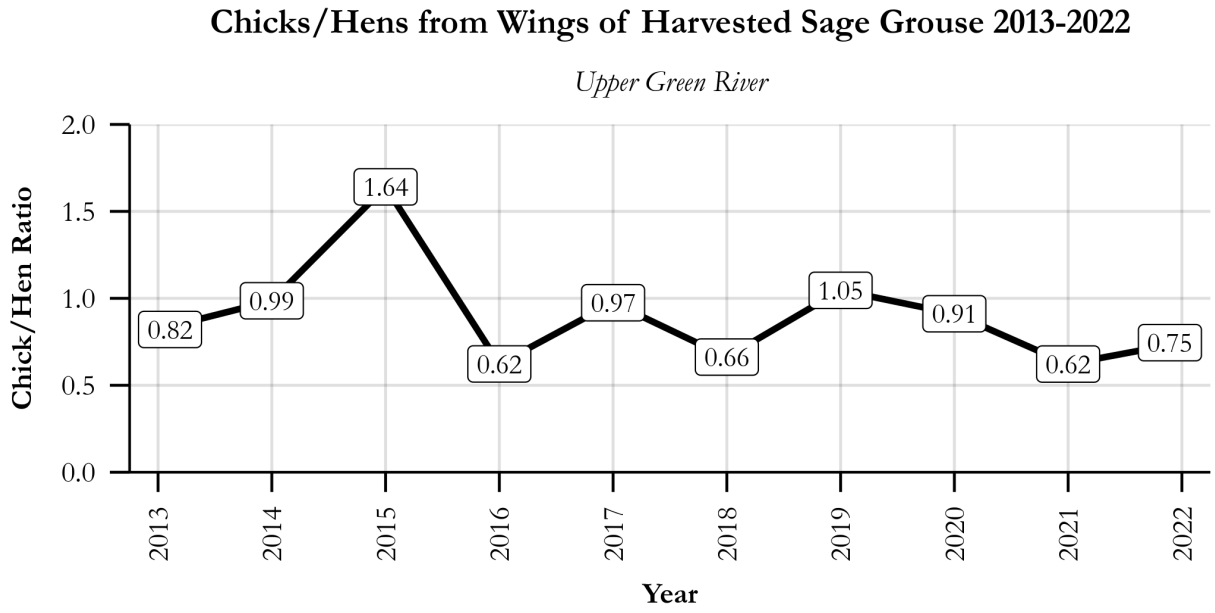


Figure 6: Chick/Hen Ratio

Lek Monitoring:

A total of 167 leks are currently documented in the Upper Green River Basin Working Group Area (UGRBWGA). These leks are classified as follows; 127 occupied, 40 unoccupied, and 0 undetermined. During 2023, a total of 123 occupied leks (95%) were checked (survey or count). Lek monitoring efforts in 2023 resulted in a high proportion of surveys (80%) verses counts (16%), completely opposite to most years due to persistent snow through most of the lek monitoring season. Results from lek monitoring in 2023 showed 84% were active and 16% inactive of those leks classified as occupied. The average number of males/lek for all active leks was similar at 25 in 2023, compared to the past two years of 24 in 2022, and 25 in 2021. This results in a 55% decrease since the last peak in 2016 (**Table 4**).

The highest documented average peak male attendance occurred in 2007 at 69 for this UGRBWGA. Since 2007, the observed average peak males has declined through 2010, stabilized from 2011-2014, and increased in 2015, stabilized in 2016-2017, declined in 2018-2021, and stabilized during 2022-2023. The 2023 male lek attendance is 64% lower compared to the peak in 2007 using all occupied leks within the UGRBWGA. This trend is likely a combination of the cyclic nature of sage-grouse populations (Fedy and Doherty 2010), drought, and influences from habitat fragmentation in the Upper Green River Basin. Caution is warranted when analyzing long-range data sets (20+ years) within the UGRBWG area as the number of known (documented) leks have more than doubled during the past 20 years. Since many of these newly documented leks probably existed but were not monitored, there is some speculation in regards to what the average number of males/lek actually was prior to the mid 1990's.

The proportion of leks checked that are confirmed "active" has stayed relatively stable during the past 10 years, ranging from 76% to 84% (**Figure 2**). Although, there has been increased lek inactivity and abandonment in areas associated with gas development activity. Additional lek monitoring efforts and searches have resulted in locating new or undiscovered leks (66 new leks since 2004) mathematically negating the downward trend in the proportion of active leks in the UGRBWGA.

Harvest:

The 2022 sage-grouse season was September 17 through September 30, a 14-day hunting season, similar seasons since 2004 (**Table 6**). Hunting seasons since 2002 have allowed the season to remain open through two consecutive weekends. From 1995 – 2001 hunting seasons were shortened to a 15-16 day season that typically opened during the third week of September and closed in early October. Prior to 1995, the sage-grouse seasons opened on September 1 with a 30 day season. Seasons have been shortened with later opening dates to increase survival of successful nesting hens (as they are usually more dispersed later in the fall) and to reduce overall harvest.

Bag limits from 2003 to 2022 have been 2 per day and 4 in possession. 2003 was the first year that bag/possession limits had been this conservative. Bag limits traditionally (prior to 2003) were 3 birds/day with a possession limit 9 (changed to 6 birds from 1994-2002). Prior to 2010, harvest estimates in the UGRBWGA were only reported from UGBMA 3 and not in that portion of UGBMA 7 that lies within the UGRBWGA. New Sage-grouse Management Areas (SGMA) were developed in 2010, where SGMA D covers all of the UGRBWGA and has been reported that way since 2010.

The 2022 harvest survey estimated that 673 hunters bagged 1502 sage-grouse and spent 1551 days hunting (**Table 7**). The average number of birds per day was 1.0, the average number of birds per hunter was 2.2, and the number of days spent hunting per hunter was 2.3 during 2022. During the past 10 year period, hunter participation and harvest metrics have varied somewhat, probably attributed to a combination of population trends, yearly bird recruitment, weather conditions, and season length (**Table 7**). Overall, hunter participation and harvest was lowest during 2013 (387 hunters and 628 birds harvested) and highest in 2018 (853 hunters and 2161 birds harvested) during the past 10-year period. Birds/day and days/hunter appears to be the most stable harvest statistic averaging 0.9 birds/day and 2.6 days/hunter in the UGRBWGA. From 1995 to 2002, overall harvest and harvest rates significantly declined following altered seasons (shortened and moved to a later date).

Wing Collections

Eighteen sage-grouse wing barrels were distributed throughout Sublette County in 2022 within SGMA D. Barrels were placed prior to the sage-grouse hunting season opener and were taken down following the closing date. Wing collections were typically made following each weekend of the hunting season. The wings are used to determine age and sex based on molting patterns and feather characteristics.

A total of 310 sage-grouse wings were collected from barrels in the UGRBWGA during 2022, compared to 410 in 2021, 471 in 2020 and 342 in 2019. The number of wings collected during the past 10-year period ranged from 310 to 573 (**Table 8**). Of the 310 wings collected in 2022, 37% were juvenile birds and 49% were adult and yearling hens. The overall composition of wings in 2022

indicated a ratio of 0.7 chicks/hen (adult and yearling females), which typically results in lower lek counts the following spring. The 2016 and 2021 wing collections showed a 0.6 chicks/hen ratio, representing the lowest production during the past 10-year period. Conversely, wing collections during 2015 showed 1.6 chicks/hen, resulting in the highest production during the past 10-year period (**Figure 6**). The combination of low chick production during the past several years explains the recent declines male lek attendance. This chick/hen ratio derived from wing collections has been a relatively good indicator to predict future population trends, as male lek attendance trends have broadly correlated with chick production in the UGRBWGA.

Winter Distribution Surveys:

No specific winter sage-grouse surveys were conducted during the 2021-2022 winter within the UGRBWG Area. Winter surveys were initially conducted in 2004 and continued through 2013 within portions of the Upper Green River Basin. This winter data has been used to develop winter concentrations area maps (first map developed in 2008). Additional analysis methods such as Resource Selection Function (RSF) models have recently been utilized with winter survey data to help refine previously identified winter concentration areas (WCA). Although, WCA have been identified throughout the UGRBWG Area, the Sage-Grouse Implementation Team has recognized one area located in the Alkali Draw & Alkali Creek Area as of 2019. Efforts to re-delineate WCA's throughout the UGRBWGA are planned for completion in 2024.

Sage-Grouse Research Projects:

From 1998-2009 there were several research projects initiated and completed that have provided information on sage-grouse demographics and effects of natural gas development on sage-grouse populations. See UGRBWGA 2010 JCR for a summary of past sage-grouse research in the Pinedale area.

Significance of Geophagy:
There has been on-going study (initiated in 2013) looking into the significance of geophagy by sage-grouse within the UGRBWGA. The field work was completed in the fall of 2021 with a summary report anticipated in 2023.

Sage-grouse geophagy, or intentional ingestion of soil, was documented in Sublette County Wyoming during the winter of 2012 – 2013. While it is well-known for a variety of other birds and mammals, it represents a behavior that has not been described for sage-grouse. The goal of this project is to assess the importance of "soil-eating" areas in describing winter habitat selection by sage-grouse. Currently, within the Upper Green River Basin researchers have identified 24 confirmed locations of geophagy behavior. An additional 20+ potential locations have also been identified. Past collaborators on the project have been the BLM, Teton Raptor Center, Wyoming Wildlife Consultants, and Sublette County Conservation District. Soil has been collected and tested at each confirmed location and compared to soil at random locations in order to identify the potential target mineral or compound responsible for the behavior. Soil tests indicate higher sodium, pH, and clay content at the documented geophagy sites.

A Utah State University graduate student is currently assessing habitat selection for wintering sage-grouse in the presence of geophagy sites. This resource selection analysis will not only help determine how geophagy sites influence winter habitat selection, but also help predict areas of

importance to wintering sage-grouse in these areas. A second graduate student from Utah State University is continuing research and data collection efforts for this geophagy project specifically to evaluate how geophagy behavior may influence reproduction during the breeding season.

Ecology of Greater Sage-grouse in Alkali Creek and the Upper Green River Basin:
There are additional questions that would aid managers about the ecology of sage-grouse in the new 140,000 acre Normally Pressured Lance (NPL) Gas Field with a potential for up to 3,500 wells. Although there are large winter flocks and documentation of sage-grouse movement to the NPL in winter, it is unknown what proportion of birds survive while using the area. It is possible to have a great deal of human use or development of an area, without any impacts to survival. Instead, animals can be displaced or avoid an area, which might not result in any population-level impacts, but would reduce the carrying capacity. However, if survival is compromised, it becomes necessary to understand the timing and causes of bird mortality. Therefore, it is necessary to assess survival rates of sage-grouse in the region to better understand the utility of the area in sage-grouse conservation. In addition to the importance of movements, resource selection, and survival, it has been documented that sage-grouse in the area are geophagic. If geophagy plays an important role in winter resource selection, resulting in high use of the NPL site during winter, we might be missing a key parameter in RSF models and WCA delineations on the site, because we have not considered geophagy. Last, we know very little about the mobility of these flocks, their fidelity to certain areas, and the stability of group membership within Alkali Creek and Alkali Draw. The intensive aerial flights that were conducted on the site capture sage-grouse distributions in late January and February but key areas during November, December and March (i.e., current timing restriction for the WCA are in effect from November 15 to March 15), could go unknown if we rely solely on flight data. Because delineation of a WCA requires 50 birds, it becomes important to understand how flock numbers change over time.

Collectively, these issues require a comprehensive research project which will provide information to help manage sage-grouse populations in the NPL region. Specifically, this study will provide movements, resource selection, survival, and sites selected by sage-grouse for geophagic behavior. Because these questions require fine-scale observations of sage-grouse, global positioning systems transmitters combined with solar-powered Argos platform transmitter terminals (GPS-PTTs), along with infrared flights are being used which have been shown to effectively monitor activities of sage-grouse in other parts of Wyoming (J. Millspaugh, unpublished data). This study is focused within the Alkali Creek and Alkali Draw regions of the NPL that was initiated in 2019, portions of the study were put on hold during 2020-2023, except deployment of transmitter in control and treatment areas, due to lack of funding.

A 2023 Pre-development Progress Report (Pratt et al. 2023) reports location data has been collected from 263 female sage-grouse (treatment and control birds) from 2019-2022. A winter range fidelity at 76%, median date of arrival to winter range of November 23, median departure date of March 28, and survival probability 0.880 was documented from these GPS transmittered birds. Future collection and continuation of this NPL study is unknown as of January of 2024.

Sage-Grouse Working Group:

The UGRBWG was formed in March of 2004. The group is comprised of representatives from agriculture, industry, sportsmen, public at large, conservation groups, and government agencies (federal and state). The purpose of the UGRBWG is to work towards maintaining or improving

sage-grouse populations in the Upper Green River basin. The group is directed to formulate plans, recommend management actions, identify projects, and allocate available funding to support projects that will benefit sage-grouse. The Upper Green River Basin Sage-Grouse Conservation Plan was finalized in May of 2007 and can be found on the WGFD website (https://wgfd.wyo.gov/Habitat/Sage-Grouse-Management). This plan identified past, proposed, and ongoing projects; recommended management activities; funding sources; and other relevant sage-grouse information within the UGRBWGA intended to maintain and/or increase sage-grouse populations. The Working Group completed an addendum to this 2007 plan (Upper Green River Basin Sage-Grouse Conservation Plan Addendum – 2014) that provides updated information on activities, projects, and management strategies within the UGRBWGA. Appropriation of State monies approved for sage-grouse projects during past years have been allocated to the UGRBWG for local conservation measures that benefit sage-grouse. Raven control, water windmill to solar pump conversion, and cheatgrass inventory/control projects continue to account for the majority of allocated funds granted to the UGRBWG in recent years.

Management Summary:

Data collected and reported in this 2023 Sage-Grouse Job Completion Report (June 2022 thru May 2023) gives insight to population trends. Analysis of lek trend data indicates that the sage-grouse populations steadily increased from 2003 to 2007, dropped slightly in 2008, continued to decline through 2011, stabilized through 2014, increased significantly in 2015, followed by a relatively stable population in 2016 and 2017, population decline in 2018-2021, and stabilized in 2022-2023. Lek trend data suggest grouse populations were at the lowest level with the highest level occurring in 2007.

Lek monitoring in the UGRBWGA showed a 146% increase in the peak number of males per lek from 2003 to 2007 as males increased from 28 males/lek to 69 males/lek. This trend reversed after 2007, as the number of males/lek declined by 48% dropping to 36 males/lek by spring of 2014. During 2015, lek counts showed a 47% (53 males/lek) increase followed by an 8% increase in 2016, 4% decrease in 2017, 23% decrease in 2018, 21% decrease in 2019 a decrease of 9% in 2020 (30 males/lek), a continued decrease of 15% in 2021(25 males/lek), and remained static in 2022 and 2023. Sage-grouse leks within developing gas fields continue to show declines and lek abandonment regardless of lek trends outside of gas development, indicating negative impacts to sage-grouse in and near natural gas fields. Existing leks within non-core habitats and within gas development fields will be subject to further impacts.

Sage-grouse hunting season dates, season length, and bag limits have remained similar since 2002, running from mid to late September for 9-15 days with a daily bag limit of 2 birds and a possession limit of 4 birds. Although season length and bag limits have remained similar since 2002, overall harvest and hunter participation has varied somewhat, while harvest rates (# birds taken/day, #birds taken/hunter, and # days/hunter) have remained similar on most years. With grouse numbers steadily increasing from 2003-2007, declining from 2007-2014, increasing in 2015-2016, and decreasing in 2017-2022, the progression of hunter participation was expected to show similar trends. Variation in hunter participation can be affected by hunting season structure, weather conditions, population trends, and hunter perceptions of sage-grouse populations.

Wing collection from barrels (drop locations) continues to provide good sample sizes to determine overall chick survival trends within the UGRBWGA. During 2008-2022 wing collections ranged

from 21% to 58% of the reported harvest. The sample size of 310 wings in 2022 accounted for 21% of the reported harvest. These annual wing samples can vary significantly based on weather conditions affecting hunter participation, especially during the weekend days of hunting season. Overall, some correlation exists between trends in wing sample sizes and harvest, and provides managers the most reliable data for determining annual reproductive rates in the UGRBWGA.

Trends in chicks/hen derived from wing collections continue to show a correlation with following year lek trends. An increase (or decrease) in the number of chicks/hen in the harvest typically results in similar trends documented on leks the following year(s). In general, a chick/hen ratio below 1.1 has shown declines in overall male lek attendance the following spring, 1.1 to 1.3 chicks/hen has shown stable attendance, and a chick/hen ratio greater than 1.3 has shown increases in lek attendance in the UGRBWGA. During the past 5 years (2018-2022) the chicks/hen ratio has varied from 0.6 to 1.0 and averaging 0.8 chicks/hen, correlating to the persistent decline in male lek attendance.

Above normal precipitation during 2004 and 2005 during key periods (specifically in the spring and early summer) contributed to increased sage-grouse numbers due to enhanced production and juvenile survival in the Upper Green River Basin. Declining chick survival was documented in 2006 and 2007 caused by spring and summer drought conditions in the Upper Green River Basin. Male sage-grouse lek numbers declined from 2007-2011 and remained stable from 2012-2014. Good to above average spring precipitation during 2008-2011 led to good herbaceous production, which should have helped turn around the recent declining trends in the UGRBWGA. It appears the cold temperatures during the spring of 2009 and 2010 impacted reproduction resulting in further declines in lek numbers in 2010. Spring moisture in 2011 resulted in very good habitat production, and most likely contributing to the slight increase in bird numbers documented during the spring of 2012. Drought conditions in 2012 and 2013 most likely attributed to poor chick survival as spring temperatures were near normal, resulting in little change on spring lek counts in 2014. In 2014, good forage production was the result of increased precipitation during the fall of 2013 and spring of 2014 which likely contributed to increased male lek counts in 2015. Although the winter of 2014-15 was mild with low precipitation, the spring of 2015 had above average precipitation, primarily attributed to a very wet May, apparently resulting in very good chick production. The 2015-2016 winter and 2016 spring conditions were very similar to the previous year with dry winter and wet spring conditions, but resulted in poor chick production and similar lek counts. The 2016-17 winter conditions were severe with heavy snow loads and cold temperatures followed by a dry spring, yet lek counts in 2017 were similar to those recorded in 2016. The 2017-18 winter was mild with low snow accumulations and above average temperatures followed by a relatively wet spring, and a decline in 2018 lek counts. The 2018-19 winter resulted in late persistent snow and cold temperatures through the spring of 2019, and a decline in 2019 lek counts. The 2019-20 winter had average snow and cold temperatures with a slight decline in 2020 lek counts. The 2020-2021 winter had very low snow and average temperatures with a decline in 2021 lek counts. The 2021-2022 winter had below average snow and average temperatures followed by dry spring conditions and a slight decline in 2022 lek counts. The 2022-2023 winter had well above average snow and below average temperatures with similar 2023 lek counts. The predictability of factors that determine nest success and chick survival remains complex and is likely more dynamic than just climate conditions such as precipitation and temperature trends, although cold and wet weather events around nest hatch appears to influence chick production and survival in the UGRBWGA located at relatively higher elevation than most other breeding habitat range-wide.

The current amount and rate of natural gas development in the Upper Green River Basin has and will continue to impact sage-grouse habitat and localized populations. Lek monitoring data has shown lower male attendance and a high rate of lek abandonment within and adjacent to developing gas fields. Sage-grouse studies and research conducted in the UGRBWGA has also documented impacts to grouse from gas development (Doherty el al. 2008, Green et al. 2016, Holloran et al. 2006, Holloran et al. 2007, Kaiser 2006, Kirol et al. 2020, Walker et al. 2007). Direct, indirect, and cumulative impacts to sage-grouse from gas and residential development will continue to challenge managers to maintain current grouse numbers.

Recommendations:

1. Continue to monitor sage-grouse leks and look for new and previously undocumented ones.
2. Continue to monitor and provide input on natural gas development/sage-grouse projects being conducted.
3. Continue to place wing barrels in enough locations to obtain an adequate and representative sample to derive sex/age and harvest trend information.
4. Continue existing efforts and encourage new efforts to document and identify important sage-grouse areas (breeding, brood rearing, and winter).
5. Continue to work with GIS personnel and land managers to create and update seasonal range maps (breeding, summer/fall, and winter) to aid land managers in protecting and maintaining important sage-grouse habitats. Delineation of winter concentration areas will be a priority.
6. Continue to identify needed sage-grouse research, data collection efforts, project proposals, development mitigation, and funding.
7. Implement proposals and management recommendations identified in the Upper Green River Basin Sage-Grouse Working Group Conservation Plan and Plan Addendum where possible.

Literature Cited:

Doherty, K.E., D.E. Naugle, B.L. Walker, J.M. Graham. 2008. Greater sage-grouse winter habitat selection and energy development. Journal of Wildlife Management. 72-1.

Fedy, B. C. and K. E. Doherty. 2010. Population cycles are highly correlated over long time series and large spatial scales in two unrelated species: greater sage-grouse and cottontail rabbits. Oecologia 165:915-924.

Fedy, B. C. and C. L. Aldridge. 2011. The importance of within-year repeated counts and the influence of scale on long-term monitoring of sage-grouse. Journal of Wildlife Management 75(5): 1022-1033.

Green, A.W., C.L. Aldridge, and M.S. O'Donnell. 2016. Investigating Impacts of Oil and Gas Development on Greater Sage-Grouse. Journal of Wildlife Management. DOI: 10.1002/jwmg.21179.

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

Holloran, M. J., R. C. Kaiser, and W. A. Hubert. 2007. Population response of yearling greater sage-grouse to the infrastructure of natural gas fields in southwestern
Wyoming. Completion report. Wyoming Cooperative Fish and Wildlife Research Unit, Laramie, WY, USA.

Kaiser, R. C. 2006. Recruitment by greater sage-grouse in association with natural gas development in western Wyoming. Thesis. University of Wyoming. Laramie, USA.

Kirol, C.P., K.T. Smith, N.E. Graf, J.B. Dinkins, C.W. LeBeau, T.L. Maechtle, A.L. Sutphin, J.L. Beck. 2020. Greater Sage-Grouse Response to the Physical Footprint of Development. Journal of Wildlife Management. DOI: 10.1002/jwmg.21854

Pratt, A.C., J.J. Millspaugh, and J.L. Beck. 2023. Adaptive management of the Normally Pressured Lance Natural Gas Development Project for greater sage-grouse: 2023 progress report for pre-development data collection.

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

Whitford, N. W. Bish. 2022. Chapter 12: Sage-Grouse (*Centrocercus urophasianus*). Pages 12-1 to 12-43 in Handbook of Biological Techniques: third edition. Wyoming Game and Fish Department. Cheyenne, WY.

Upper Snake River Basin

Job Completion Report

Prepared By: Alyson Courtemanch, North Jackson Wildlife Biologist

Period Covered: 6-1-2022 to 5-31-2023

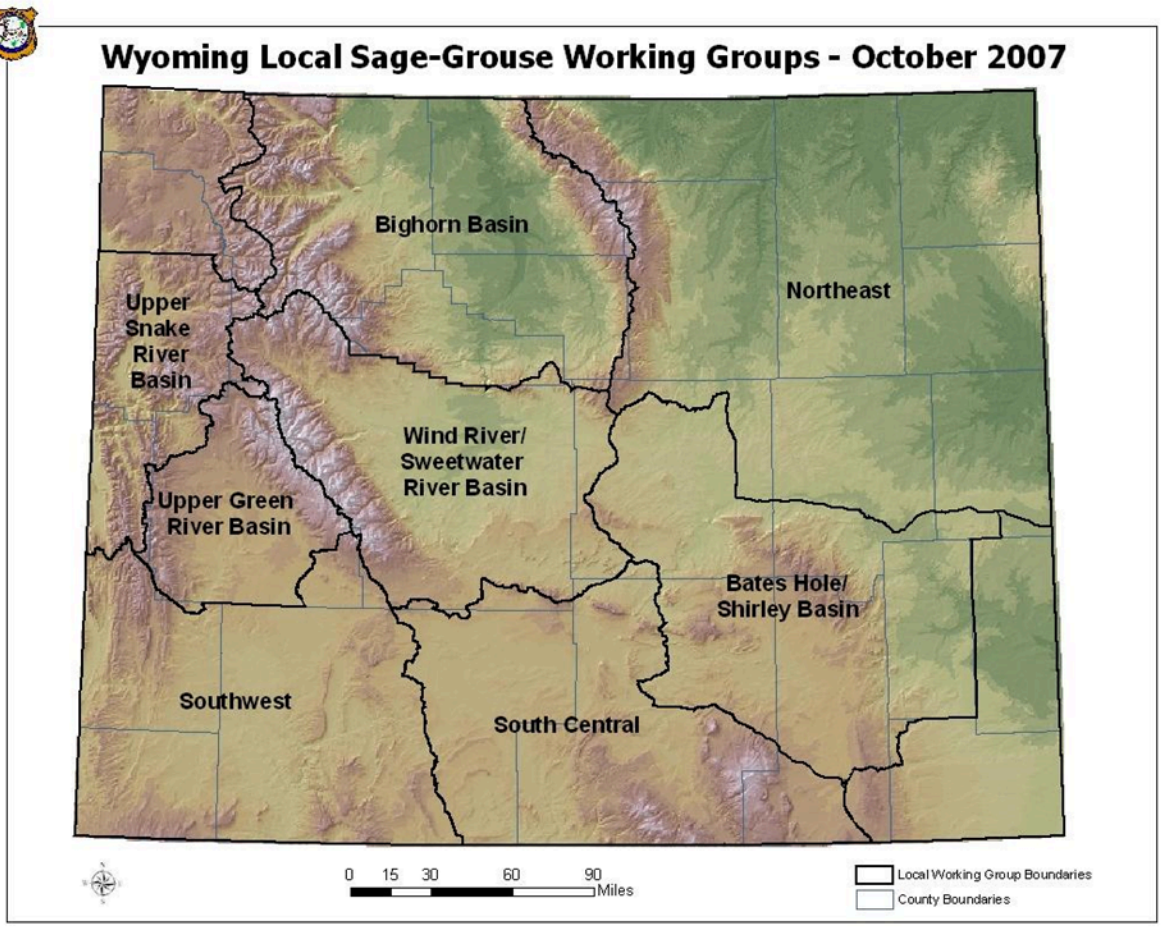


Table 1: Sage-Grouse Lek Characteristics

	Group	N	Percent
BLM Office			
	Pinedale	19	100%
Biologist			
	Jackson	17	89.5%
	Thayne	2	10.5%
Classification			
	Occupied	14	73.7%
	Undetermined	1	5.3%
	Unoccupied	4	21.1%
County			
	Sublette	2	10.5%
	Teton	17	89.5%

	Group	N	Percent
Land Status			
	National Park	12	63.2%
	USFS	4	21.1%
	USFWS	3	15.8%
Lek Status			
	Active	10	52.6%
	Inactive	5	26.3%
	Unknown	4	21.1%
Management Area			
	A	19	100%
Region			
	Jackson	17	89.5%
	Pinedale	2	10.5%
Warden			
	Big Piney	2	10.5%
	North Jackson	15	78.9%
	South Jackson	2	10.5%

Table 2: Leks Counted

Year	Occupied	Counted	Percent Counted	Peak Males	Average Peak Males
2014	16	13	81.2%	163	16.3
2015	16	14	87.5%	227	25.2
2016	15	15	100%	227	20.6
2017	15	15	100%	176	16.0
2018	15	15	100%	108	10.8
2019	15	15	100%	62	5.6
2020	15	12	80%	67	8.4
2021	15	15	100%	61	8.7
2022	14	14	100%	92	11.5
2023	14	13	92.9%	99	11.0

Occupied - Must have been active once during previous 10 years, calculated based on the official definitions

Average Peak Males - Includes only those leks where one or more strutting males were observed. Does not include "Active" leks where only sign was documented

Table 3: Leks Surveyed

Year	Occupied	Surveyed	Percent Surveyed	Peak Males	Average Peak Males
2014	16	0	0%		
2015	16	0	0%		
2016	15	0	0%		
2017	15	0	0%		
2018	15	0	0%		
2019	15	0	0%		
2020	15	0	0%		
2021	15	0	0%		
2022	14	0	0%		
2023	14	1	7.1%	2	2

Occupied - Must have been active once during previous 10 years, calculated based on the official definitions

Average Peak Males - Includes only those leks where one or more strutting males were observed. Does not include "Active" leks where only sign was documented

Table 4: Leks Checked

Year	Occupied	Checked	Percent Checked	Peak Males	Average Peak Males
2014	16	13	81.2%	163	16.3
2015	16	14	87.5%	227	25.2
2016	15	15	100%	227	20.6
2017	15	15	100%	176	16.0
2018	15	15	100%	108	10.8
2019	15	15	100%	62	5.6
2020	15	12	80%	67	8.4
2021	15	15	100%	61	8.7
2022	14	14	100%	92	11.5
2023	14	14	100%	101	10.1

Occupied - Must have been active once during previous 10 years, calculated based on the official definitions

Average Peak Males - Includes only those leks where one or more strutting males were observed. Does not include "Active" leks where only sign was documented

Table 5: Lek Status

Year	Occupied	Active	Inactive	Unknown	Known Status	% Active	% Inactive
2014	16	10	3	0	13	76.9%	23.1%
2015	16	9	5	0	14	64.3%	35.7%
2016	15	11	4	0	15	73.3%	26.7%
2017	15	11	4	0	15	73.3%	26.7%
2018	15	11	4	0	15	73.3%	26.7%
2019	15	11	4	0	15	73.3%	26.7%
2020	15	8	4	0	12	66.7%	33.3%
2021	15	7	8	0	15	46.7%	53.3%
2022	14	9	5	0	14	64.3%	35.7%
2023	14	10	4	0	14	71.4%	28.6%

Occupied - Must have been active once during previous 10 years, calculated based on the official definitions

Inactive - Confirmed no birds/sign present (see official definitions)

Table 6. Maximum male counts at sage-grouse leks in the Upper Snake River Basin Conservation Area, 1995-2023. "NC" denotes the lek was not checked that year, "0" denotes the lek was checked but no birds were seen, and grey cells denote the lek had not been discovered yet.

Year	3 Bar H Road	Airport	Airport Pit	Antelope Flats	Bark Corral East	Bark Corral West	Beacon	Breakneck Flats	Clark Draw	Dry Cottonwood	McBride	Moulton East	Moulton West	NER-North Gap	NER-Simpson	Ollie's Draw	RKO	Spread Creek	Timbered Island	**Total Peak Males**	**Average # males/ active lek**
1995	NC	18		4	10		15				6	59	4	6	NC					122	15.3
1996	NC	18		2	8		8				4	32	1	19	NC					92	11.5
1997	NC	15		0	1		1				6	0	48	10	NC					81	13.5
1998	NC	14		0	0		0				4	29	0	7	NC					54	13.5
1999	NC	17		0	0		0				0	21	0	9	NC					47	15.7
2000	NC	18		0	NC		NC	21			0	28	0	5	NC					72	18.0
2001	NC	15		0	NC		NC	19			0	30	0	6	NC					70	17.5
2002	NC	19		0	NC		24	9			0	28	0	4	NC					84	16.8
2003	NC	25		0	NC		0	7			0	35	0	3	NC				8	78	15.6
2004	NC	17		0	2		0	14			0	54	0	4	NC				15	106	17.7
2005	NC	17		0	NC		0	16		6	NC	49	0	18	NC				17	123	20.5
2006	NC	23	6	0	0		4	21		9	0	44	0	30	0				20	157	19.6
2007	0	23	0	NC	1		NC	30		4	1	41	0	9	0			4	20	133	14.8
2008	0	16	0	NC	2	8	0	22		13	0	38	0	23	NC		12	5	26	165	16.5
2009	NC	10	2	0	5	NC	0	21		1	0	33	0	11	0		15	4	22	124	12.4
2010	NC	10	0	0	24	0	0	24	13	4	0	40	0	13	0		13	5	18	164	16.4
2011	0	11	0	0	0	10	0	5	13	0	0	27	0	21	0		10	15	0	112	14.0
2012	0	17	0	0	3	NC	0	14	14	0	0	44	14	18	3		8	0	7	142	14.2
2013	NC	17	0	0	0	0	NC	14	13	5	NC	46	NC	8	0		6	24	16	149	16.6
2014	NC	11	3	NC	10	0	NC	18	7	0	NC	61	NC	21	0		8	8	16	163	16.3
2015	NC	12	0	NC	0	11	NC	27	17	0	0	103	NC	10	0	NC	21	15	11	227	25.2
2016	NC	7	0	0	0	13	0	34	12	8	0	21	53	7	0	NC	48	6	18	227	20.6
2017	NC	10	0	NC	0	4	NC	22	13	0	0	36	46	4	0	5	15	5	16	176	16.0
2018	NC	13	0	NC	0	7	NC	8	5	0	NC	28	0	6	0	8	16	5	12	108	10.8
2019	NC	8	0	NC	0	1	NC	7	6	0	NC	14	5	1	0	4	8	1	7	62	5.6
2020	NC	7	0	NC	0	6	NC	3	NC	0	NC	24	0	12	0	NC	4	4	7	67	8.4
2021	NC	3	0	NC	0	0	NC	7	8	0	NC	22	0	1	0	0	10	0	10	61	8.7
2022	NC	2	0	NC	0	0	NC	4	16	0	0	23	0	0	0	6	20	6	15	92	11.5
2023	NC	2	0	NC	0	12	NC	3	6	0	NC	27	0	3	0	2	19	7	20	101	10.1
Max		63	6	10	24	13	24	34	17	13	27	103	63	30	54	8	48	24	26	227	30.6

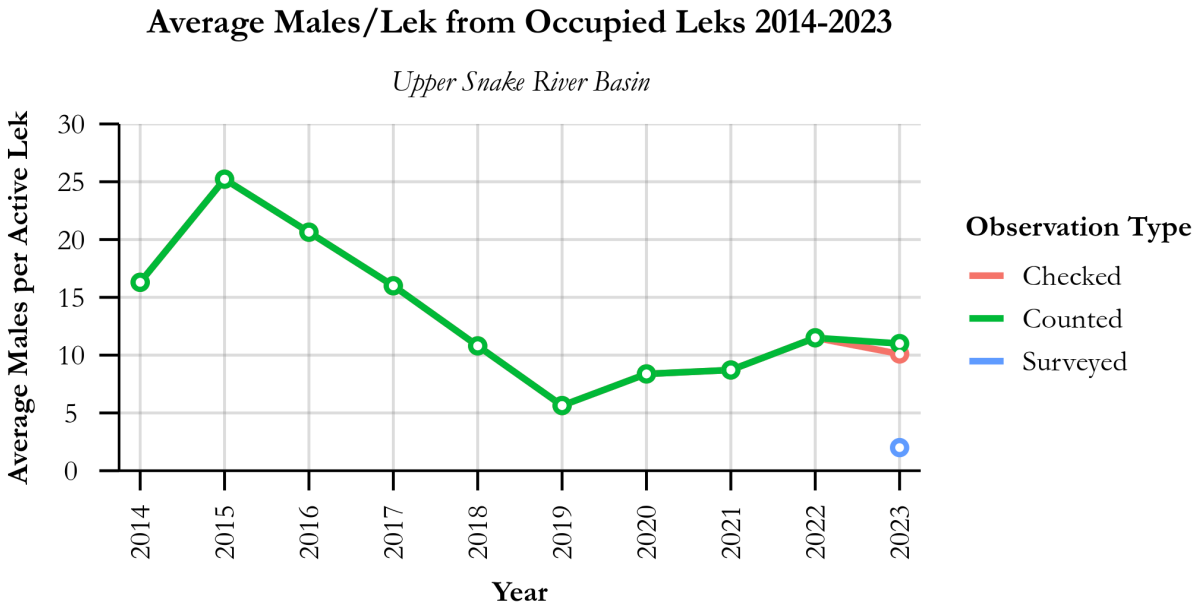


Figure 1: Average Peak Males

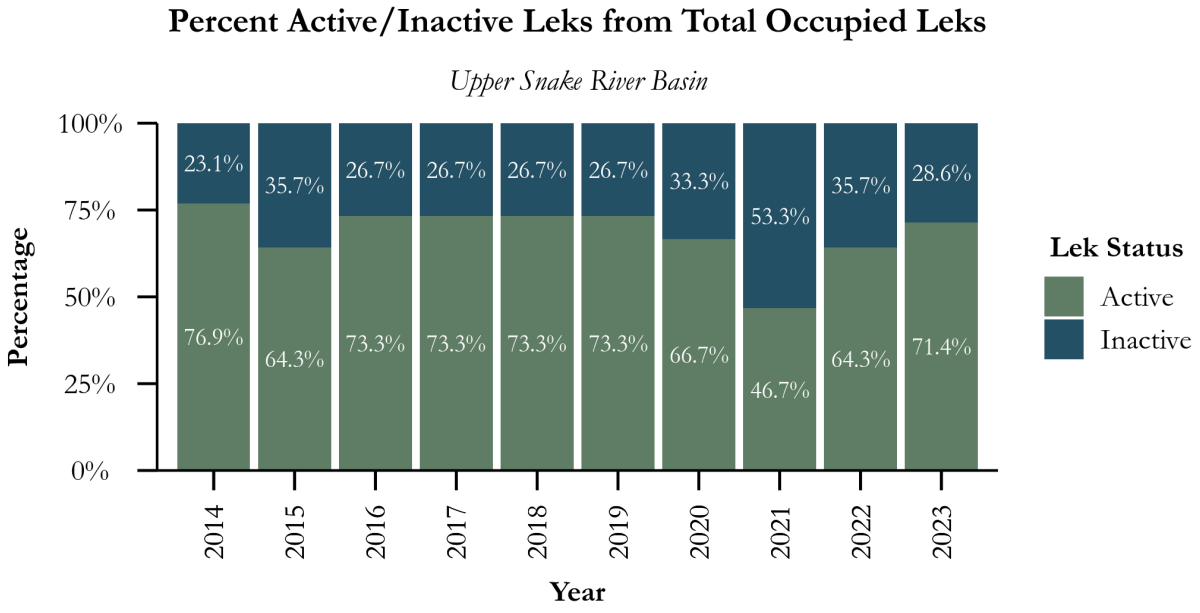


Figure 2: Lek Status

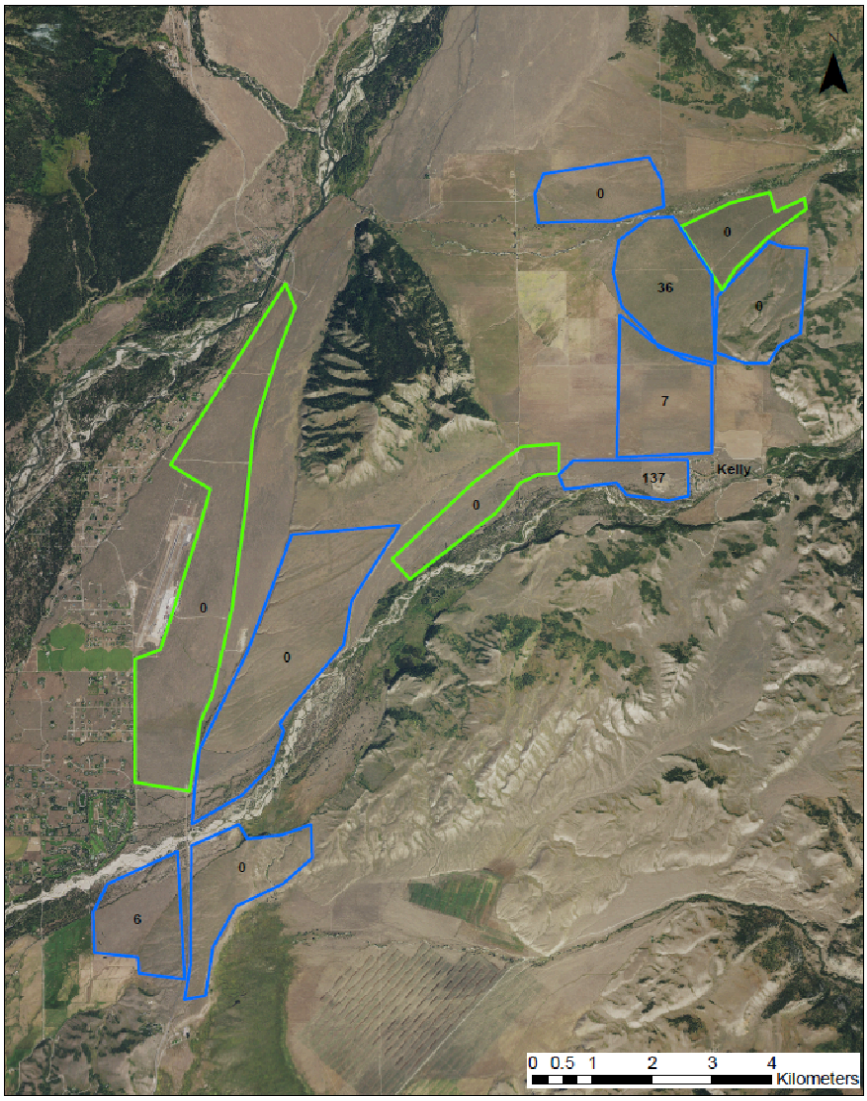


Figure 3: Count blocks surveyed by ground observers in February 2023. Numbers indicate the number of sage-grouse seen in the count block.

Lek Monitoring:

Sage-grouse data collection within the Upper Snake River Basin Conservation Area (USRBCA) focuses on lek counts. Starting in 2005, lek counts in Grand Teton National Park (GTNP) and to some extent on the National Elk Refuge (NER), were coordinated to occur on the same days when it was logistically possible. This presumes that all leks in Jackson Hole constitute a sub-population and the leks in the Gros Ventre drainage constitute a second sub-population. No marked birds from the Gros Ventre leks have appeared on the Jackson Hole leks (Holloran and Anderson 2004, Bryan Bedrosian *pers. comm.*) and there is no evidence of current genetic flow from the Gros Ventre to Jackson Hole (Schulwitz et al. 2014). This approach allows us to census the breeding population by counting all leks simultaneously on the same days. This approach is beneficial in this population because past research has shown that sage-grouse attend different leks in the early season compared to the peak. A census approach prevents double-counting the same birds on different leks at different times during the season and potentially over-estimating peak males in the population.

There are a total of 19 leks in the USRBCA: 14 leks are occupied (10 of these were active this year), 4 are unoccupied, and 1 is undetermined (**Table 1**, **Figure 2**). The peak number of males and average number of males per lek are used as the main measures of population trend over time in the USRBCA. The total peak males in 2023 was 101 and the average males per active lek was 10.1 (**Table 4**, **Figure 1**). Average peak number of males per active lek declined in the early 1990's but then rebounded in the early 2000s. Counts from 2009-2016 showed a generally increasing trend, however there was a sharp decrease from 2017–2019 (**Table 4**, **Figure 1**). The average peak males per lek dropped to 5.6 in 2019, 8.4 in 2020, and 8.7 in 2021. Numbers improved slightly in 2022 (11.5 average peak males) and 2023 (10.1 average peak males) but still remain well below the high of 25.2 average peak males in 2015 (**Table 4**, **Figure 1**). The total number of males is also concerning. During the population low from 2019-2021, total peak males was 61-67 (**Table 4**). It has increased to 92 in 2022 and 101 in 2023. Leks were difficult to access this year due to very late snow melt. The Gros Ventre leks were visited twice on the ground and once via helicopter. Ollie's Draw lek could only be checked once due to snow conditions and visibility conditions during the one visit were suboptimal. Therefore, this lek was recorded as surveyed instead of counted this year (**Table 3**).

The sub-population in the Gros Ventre drainage is particularly concerning because these birds breed on only two known leks (Breakneck Flats and Dry Cottonwood). The Dry Cottonwood lek was last active in 2016. The Breakneck Flats lek had a high of 34 males in 2016, but since then has steadily declined, with only 3 males observed in 2023 (Table 6).

Helicopter Survey

Lek counts in the Gros Ventre drainage have been very low in recent years. These leks are challenging to survey due to time-consuming and difficult spring access conditions as well as topography and sagebrush that birds often hide in. In order to improve lek counts and search for additional leks, managers conducted two mornings of helicopter surveys on April 26 and 27, 2023. Flights lasted for approximately 3 hours each morning and surveyed the two known leks as well as all other known sage-grouse spring habitat in the Gros Ventre drainage. 3 males were observed on the Breakneck lek and 0 birds on the Dry Cottonwood lek. Additionally, a group of ~20 sage-grouse (mostly males) were flushed from the west end of Bacon Ridge. Unfortunately, the observers did not see the group of grouse before they flushed and therefore it is unknown if they were strutting. This is an area where a single sage-grouse was flushed during other helicopter surveys and an unknown lek could be located. Later attempts were made to access this lek on the ground, but it was blocked

by high water from the Gros Ventre River and Fish Creek during this time of year. Efforts will be made in winter 2024 to set up remote cameras and sound recorders at this site while rivers are frozen and passable, prior to the 2024 breeding season. A helicopter survey is also planned for spring 2024 and will focus on this potential lek site.

Winter Ground Counts

Members of the local working group have been organizing winter ground counts for several years in southern Jackson Hole where the majority of winter habitat is located. In February 2023, 14 people cross-country skied through count blocks to look for sage-grouse (Figure 3). A total of 156 sage-grouse were observed. This is about 50% of the numbers observed during the population peak (239 in winter 2009, 298 in 2010, and 287 in 2011). In recent years, numbers have been 120 in 2022, 151 in 2021, and 154 in 2020.

Production:

No productivity data were collected on the population this year.

Harvest:

There are no sage-grouse hunting seasons in the USRBCA.

Habitat:

The majority of sage-grouse habitat in the USRBCA is located within GTNP. There is also habitat in the Gros Ventre drainage on Bridger-Teton National Forest and the northern NER. Little habitat occurs on private lands. The majority of habitat on private lands is located on East and West Gros Ventre Buttes, the Spring Gulch area, and west of the Jackson Hole Airport.

No wildfires or prescribed burns occurred in significant areas of sagebrush habitat in sage-grouse core areas within the USRBCA during the reporting period. The Kelly Hayfields restoration project continued this year in GTNP, which is a project to remove smooth brome hayfields and reestablish a sagebrush community. There were no other significant human developments or surface disturbances in the core area during this reporting period.

Winter 2022/2023 conditions were severe with long stretches of very cold temperatures and deep snow. However, snow was light and powdery for most of the winter; there were no significant crusting events. Snow melt was very late in spring 2023 and therefore the lekking season was delayed. The peak lek activity was approximately 2 weeks later than average. Many sage-grouse were observed strutting on leks that were 100% snow-covered in April.

Disease:

No disease data were collected on the population this year. No dead sage-grouse were found to test for highly pathogenic avian influenza (HPAI).

Conservation Planning:

The Upper Snake River Basin Sage-Grouse Conservation Plan was updated in March 2014 and can be found on the Wyoming Game and Fish Department (WGFD) website at:

https://wgfd.wyo.gov/WGFD/media/content/PDF/Habitat/Sage%20Grouse/SG_USR_CONSERVPLAN.pdf

The Upper Snake River Basin Sage-Grouse Working Group met several times during the reporting period to plan lek monitoring schedules, review lek survey data, discuss and fund special projects, and review other issues affecting sage-grouse in the area. The group met with the Sage-Grouse Implementation Team (SGIT) in June 2023 to review proposed changes to the core area map. A small area in GTNP west of Triangle X Ranch was proposed to be added to the core area due to more recent sage-grouse GPS tracking data that showed substantial sage-grouse use of this area. The final recommendations from SGIT on the core area update are still forthcoming.

Management Recommendations:

Following a population rebound in 2015 and 2016, the population underwent a significant decline from 2019-2021. Lek counts in spring 2019 were the lowest on record for this population. Numbers have increased slightly in 2022 and 2023, but the population remains very low. Data collection, monitoring, and discussions are continuing regarding which potential actions may or may not be pursued by the respective land management agencies and WGFD.

Limited winter habitat continues to be the primary issue for this population. Therefore, protecting winter habitat is a priority. Additional documentation of sage-grouse distribution and habitat condition would be helpful to confirm seasonal distribution, movements, and habitat use. Key areas on public lands used by sage-grouse should be protected from management actions which could have adverse impacts on that habitat, including recreation disturbance. Wildfire suppression should be considered in occupied sage-grouse habitat in Jackson Hole and the Gros Ventre drainage. Restoration of native sagebrush habitats on lands formerly hayed in GTNP and the Gros Ventre drainage appears to have the greatest potential to expand and enhance habitat used by sage-grouse in the USRBCA. Protecting sagebrush habitat on private lands from rapidly expanding residential development is also important. Sagebrush restoration on private lands may also be an option in the future.

Past and current sage-grouse research by local researchers provides essential information to manage this sage-grouse population and its habitat in Jackson Hole. Managers should continue to prioritize funding and in-kind support to these research efforts.

Management Recommendations:

1. Continue to help coordinate lek surveys across jurisdictional boundaries using the lek survey protocols adopted by the WGFD.
2. Continue coordinating with other agencies to ensure periodic monitoring of historic, unoccupied or inactive leks. Continue to coordinate with other agencies to search for new leks.
3. Continue to document sage-grouse observations to improve occupied habitat mapping.
4. Support GTNP's sagebrush habitat restoration projects in the Mormon Row and Hayfields areas which could be used as winter, nesting, and brood-rearing habitats for sage-grouse.
5. Continue to work with land management agencies during the implementation of habitat improvement projects to minimize impacts to sage-grouse occupied habitats.
6. Implement the USRBWG Sage-Grouse Conservation Plan (2014). Work to implement the strategies and projects identified in the plan.

7. Continue to work with the Upper Green River Basin LWG and the Department Sage-Grouse working group to evaluate the shared LWG boundary related to the two Bondurant leks.

Literature Cited:

Holloran, M. J. and S.H. Anderson. 2004. Greater sage-grouse seasonal habitat selection and survival in Jackson Hole, Wyoming. Wyoming Cooperative Fish and Wildlife Research Unit, University of Wyoming, Laramie, USA.

Schulwitz, S., B. Bedrosian, and J.A. Johnson. 2014. Low neutral genetic diversity in isolated Greater Sage-Grouse (Centrocercus urophasianus) populations in northwest Wyoming. The Condor 116:560-573.

Wind River/Sweetwater River

Sage-Grouse Job Completion Report

Prepared By: Stan Harter, Lander Wildlife Biologist

Period Covered: 6-1-2022 to 5-31-2023

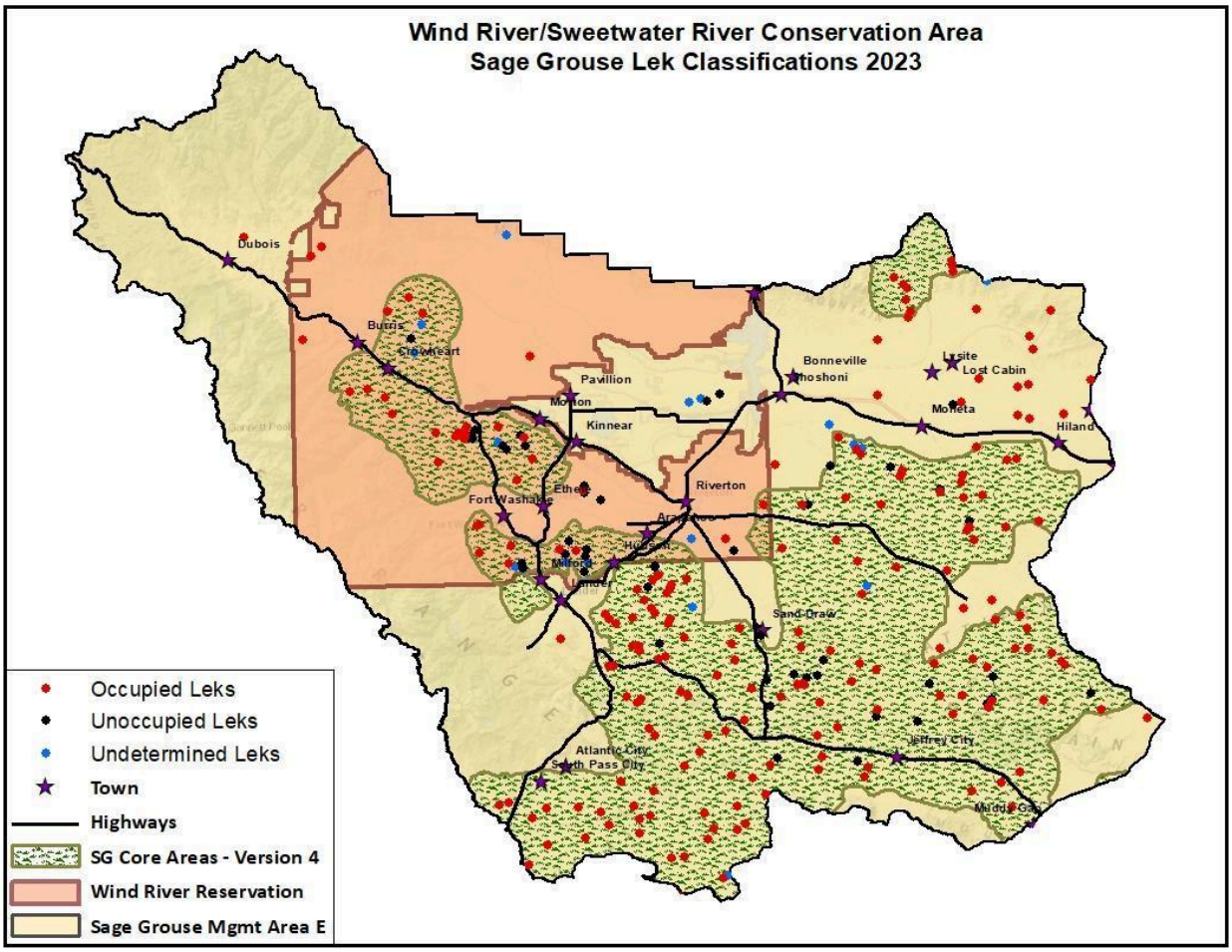


Table 1: Sage-Grouse Lek Characteristics

	Group	N	Percent
BLM Office			
		62	23.2%
	Casper	12	4.5%
	Lander	184	68.9%
	Rock Springs	7	2.6%
	Worland	2	0.7%
Biologist			
	WRR-USFWS	62	23.2%
	Casper	2	0.7%
	Dubois	69	25.8%
	Lander	132	49.4%
	Sinclair	1	0.4%
	Worland	1	0.4%
Classification			
	Occupied	202	75.7%
	Undetermined	17	6.4%
	Unoccupied	48	18%
County			
	Carbon	1	0.4%
	Fremont	237	88.8%
	Hot Springs	4	1.5%
	Natrona	24	9%
	Sweetwater	1	0.4%

	Group	N	Percent
Land Status			
	BLM	156	58.4%
	BOR	4	1.5%
	Private	31	11.6%
	Reservation	60	22.5%
	State	16	6%
Lek Status			
	Active	134	50.2%
	Inactive	35	13.1%
	Unknown	98	36.7%
Management Area			
	E	205	76.8%
	WR	62	23.2%
Region			
	Casper	2	0.7%
	Lander	203	76%
	WRIR	62	23.2%
Warden			
	Shoshone-Arapahoe Tribal	62	23.2%
	Dubois	1	0.4%
	Lander	77	28.8%
	North Riverton	27	10.1%
	South Riverton	63	23.6%
	West Casper	2	0.7%
	West Rawlins	35	13.1%

Table 2: Leks Counted

Year	Occupied	Counted	Percent Counted	Peak Males	Average Peak Males
2014	199	101	50.8%	1,860	21.6
2015	215	116	54%	4,589	44.1
2016	213	95	44.6%	4,694	55.2
2017	208	87	41.8%	3,499	44.3
2018	210	110	52.4%	3,678	38.7
2019	207	97	46.9%	2,416	31.4
2020	205	104	50.7%	2,181	26.3
2021	203	85	41.9%	1,503	23.1
2022	204	108	52.9%	2,264	28.7
2023	208	67	32.2%	1,592	31.8

Occupied - Must have been active once during previous 10 years, calculated based on the official definitions

Average Peak Males - Includes only those leks where one or more strutting males were observed. Does not include "Active" leks where only sign was documented

Table 3: Leks Surveyed

Year	Occupied	Surveyed	Percent Surveyed	Peak Males	Average Peak Males
2014	199	87	43.7%	976	17.7
2015	215	85	39.5%	1,595	25.3
2016	213	105	49.3%	2,748	33.9
2017	208	103	49.5%	2,542	33.4
2018	210	87	41.4%	1,402	22.3
2019	207	100	48.3%	1,195	17.1
2020	205	68	33.2%	605	15.1
2021	203	105	51.7%	874	14.3
2022	204	88	43.1%	723	14.8
2023	208	120	57.7%	2,098	27.6

Occupied - Must have been active once during previous 10 years, calculated based on the official definitions

Average Peak Males - Includes only those leks where one or more strutting males were observed. Does not include "Active" leks where only sign was documented

Table 4: Leks Checked

Year	Occupied	Checked	Percent Checked	Peak Males	Average Peak Males
2014	199	188	94.5%	2,836	20.1
2015	215	201	93.5%	6,184	37.0
2016	213	200	93.9%	7,442	44.8
2017	208	190	91.3%	6,041	39.0
2018	210	197	93.8%	5,080	32.2
2019	207	197	95.2%	3,611	24.6
2020	205	172	83.9%	2,786	22.7
2021	203	190	93.6%	2,377	18.9
2022	204	196	96.1%	2,987	23.3
2023	208	187	89.9%	3,690	29.3

Occupied - Must have been active once during previous 10 years, calculated based on the official definitions

Average Peak Males - Includes only those leks where one or more strutting males were observed. Does not include "Active" leks where only sign was documented

Table 5: Lek Status

Year	Occupied	Active	Inactive	Unknown	Known Status	% Active	% Inactive
2014	199	142	22	24	164	86.6%	13.4%
2015	215	167	17	17	184	90.8%	9.2%
2016	213	168	11	21	179	93.9%	6.1%
2017	208	156	8	26	164	95.1%	4.9%
2018	210	158	14	25	172	91.9%	8.1%
2019	207	148	20	29	168	88.1%	11.9%
2020	205	126	21	25	147	85.7%	14.3%
2021	203	128	21	41	149	85.9%	14.1%
2022	204	130	30	36	160	81.2%	18.8%
2023	208	126	18	43	144	87.5%	12.5%

Occupied - Must have been active once during previous 10 years, calculated based on the official definitions

Inactive - Confirmed no birds/sign present (see official definitions)

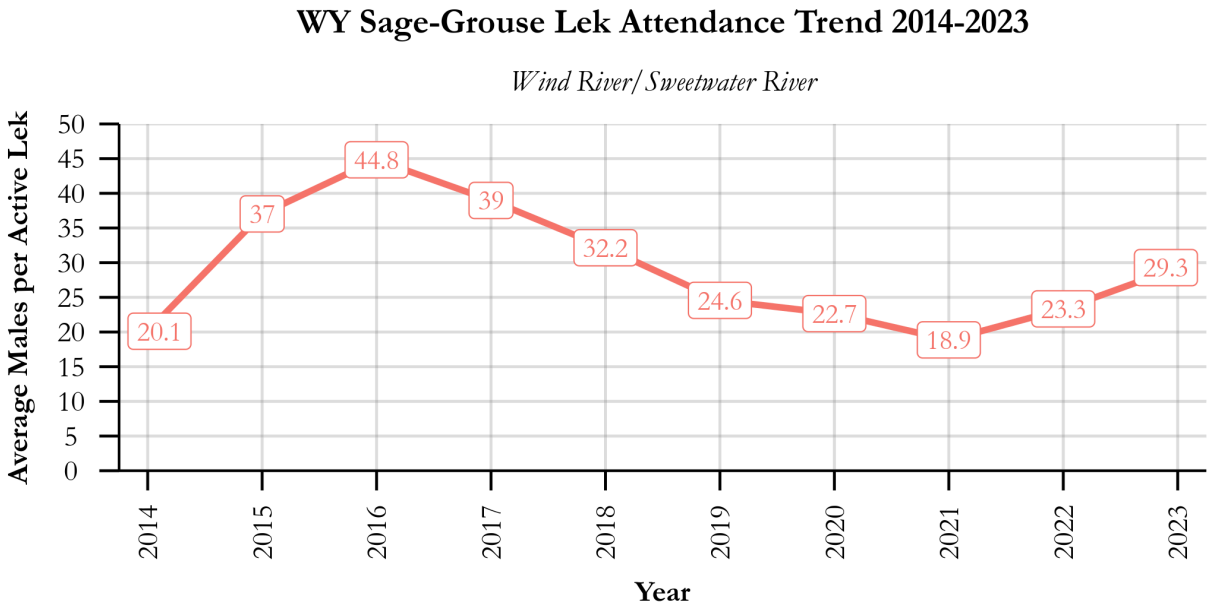


Figure 1: Average Peak Males

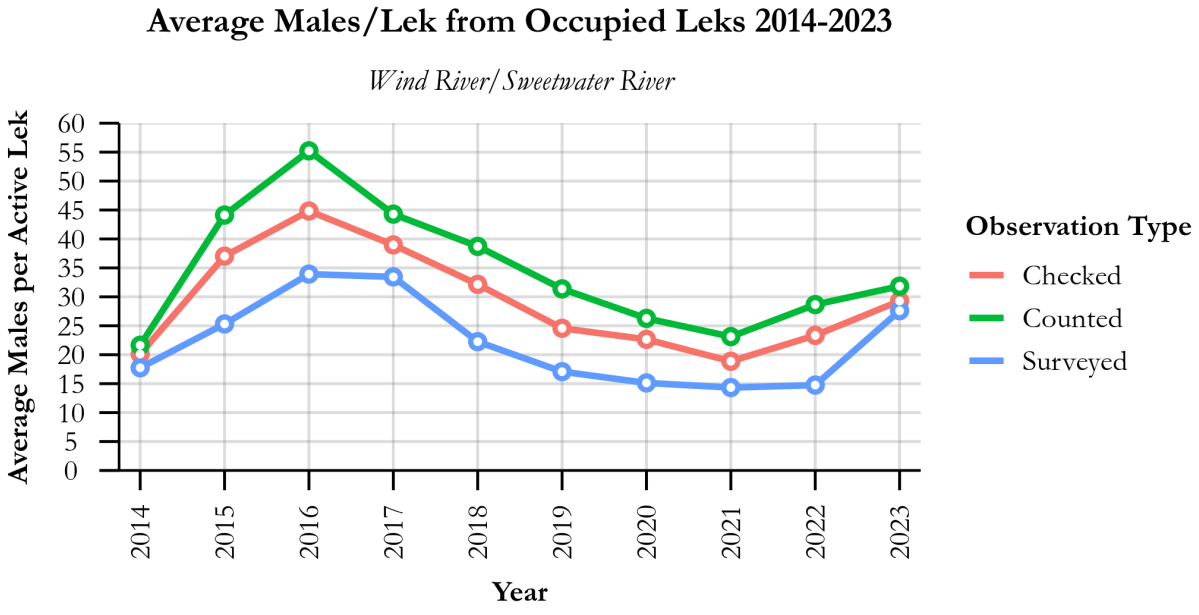


Figure 2: Average Peak Males

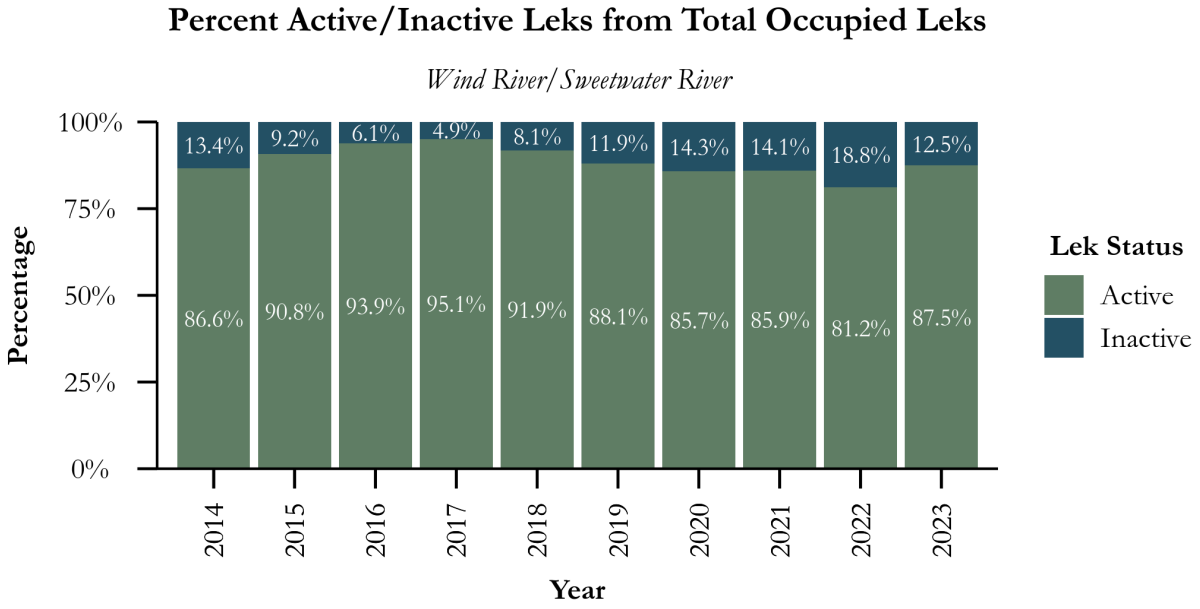


Figure 3: Lek Status

Table 6: Hunting Seasons

Year	Season Start	Season End	Length	Bag/Possession Limit
2013	Sep-21	Sep-30	10	2/4
2014	Sep-20	Sep-30	11	2/4
2015	Sep-19	Sep-30	12	2/4
2016	Sep-17	Sep-30	14	2/4
2017	Sep-16	Sep-30	15	2/4
2018	Sep-15	Sep-30	16	2/4
2019	Sep-21	Sep-30	10	2/4
2020	Sep-19	Sep-30	12	2/4
2021	Sep-18	Sep-30	13	2/4
2022	Sep-17	Sep-30	14	2/4

Table 7: Harvest Totals

Year	Harvest	Hunters	Days	Birds/Day	Birds/Hunter	Days/Hunter
2013	1,240	565	1,325	0.9	2.2	2.3
2014	1,546	772	1,853	0.8	2.0	2.4
2015	2,158	737	1,846	1.2	2.9	2.5
2016	1,910	922	2,264	0.8	2.1	2.5
2017	1,364	630	1,427	1.0	2.2	2.3
2018	2,250	970	2,519	0.9	2.3	2.6
2019	1,525	814	1,891	0.8	1.9	2.3
2020	1,115	610	1,767	0.6	1.8	2.9
2021	1,141	783	2,027	0.6	1.5	2.6
2022	2,337	1,209	2,991	0.8	1.9	2.5
Average	**1,659**	**801**	**1,991**	**0.8**	**2.1**	**2.5**

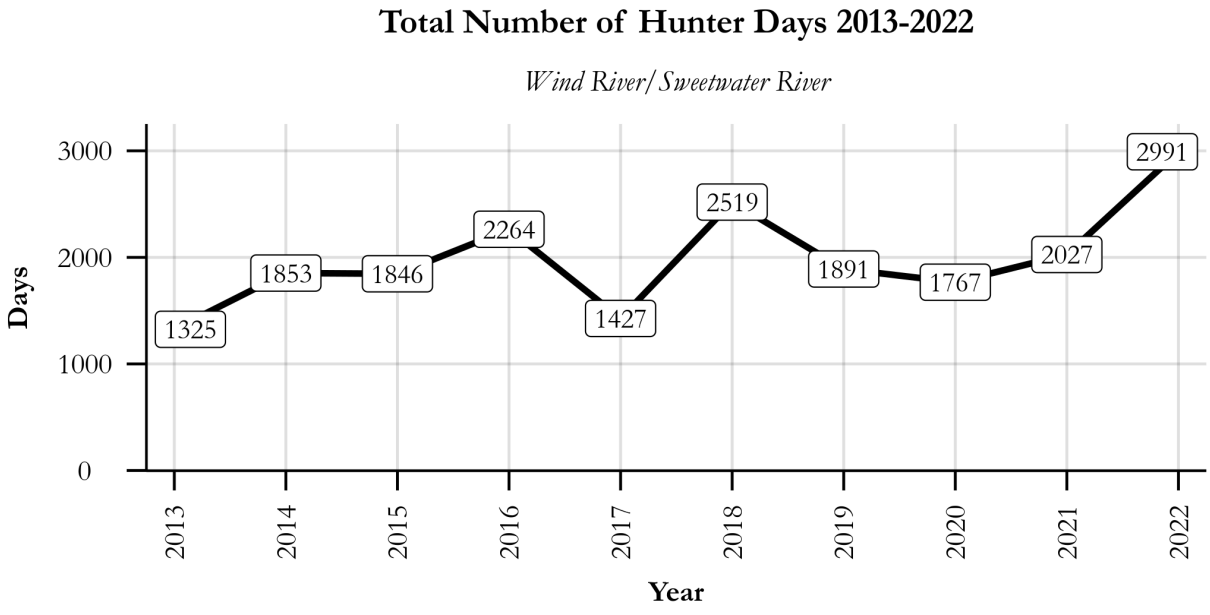


Figure 4: Harvest Days

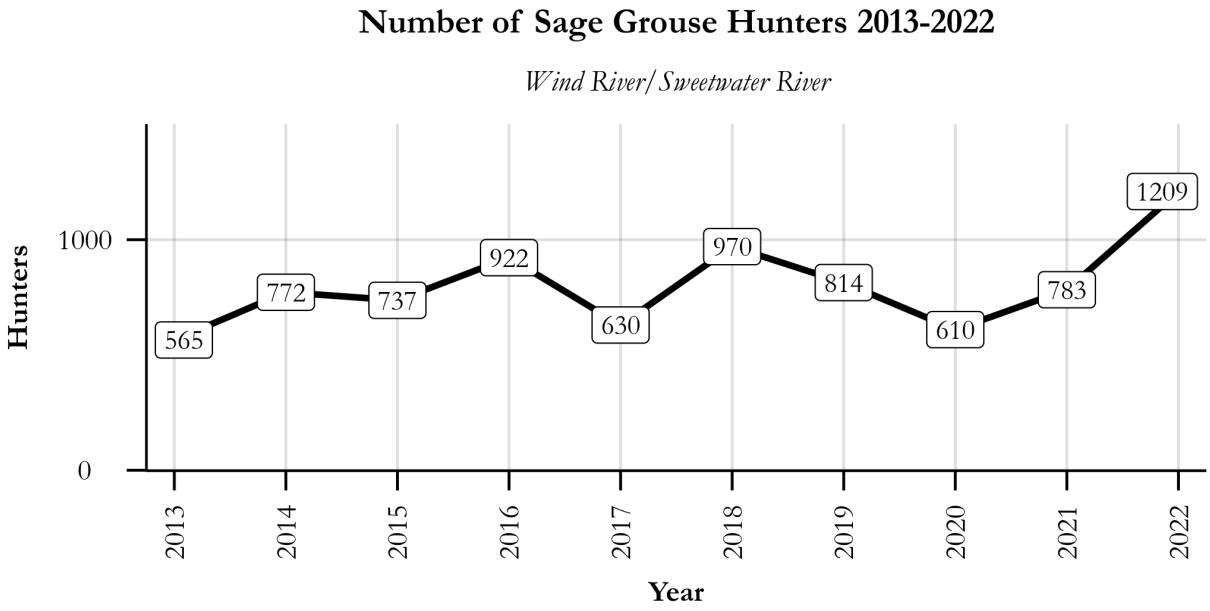


Figure 5: Hunters

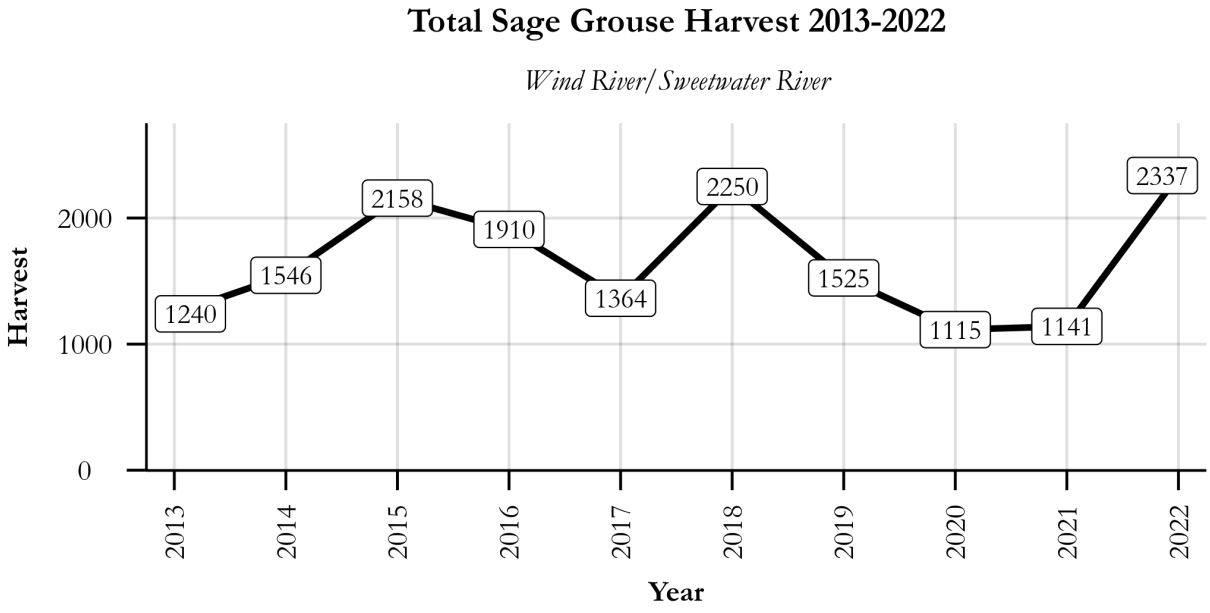


Figure 6: Total Harvest

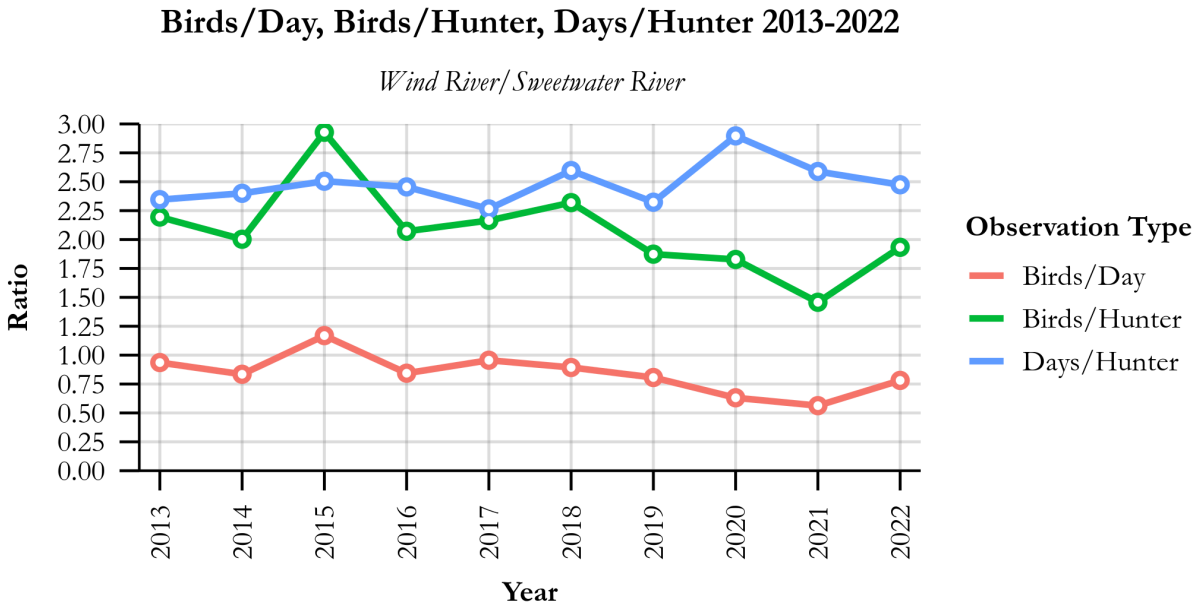


Figure 7: Harvest Ratios

Table 8: Harvest Composition

		Percent Adult		Percent Yearling		Percent Chick		
Year	Sample Size	Male	Female	Male	Female	Male	Female	Chicks/Hens
2013	202	18.8%	29.7%	0.5%	9.4%	14.9%	26.7%	1.1
2014	343	10.5%	23.3%	2.3%	8.5%	30.3%	25.1%	1.7
2015	513	11.3%	21.2%	5.3%	6.6%	21.4%	34.1%	2.0
2016	307	16.9%	29.6%	3.9%	11.1%	16.9%	21.5%	0.9
2017	393	18.8%	28.5%	2.8%	2%	20.9%	27%	1.6
2018	520	17.9%	29%	6.5%	10.4%	13.7%	22.5%	0.9
2019	311	14.5%	22.5%	4.2%	10%	19%	29.9%	1.5
2020	390	12.8%	27.9%	5.1%	9%	17.4%	27.7%	1.2
2021	289	6.2%	34.6%	3.1%	8%	14.2%	33.9%	1.1
2022	285	9.1%	30.9%	2.5%	7.4%	21.8%	28.4%	1.3

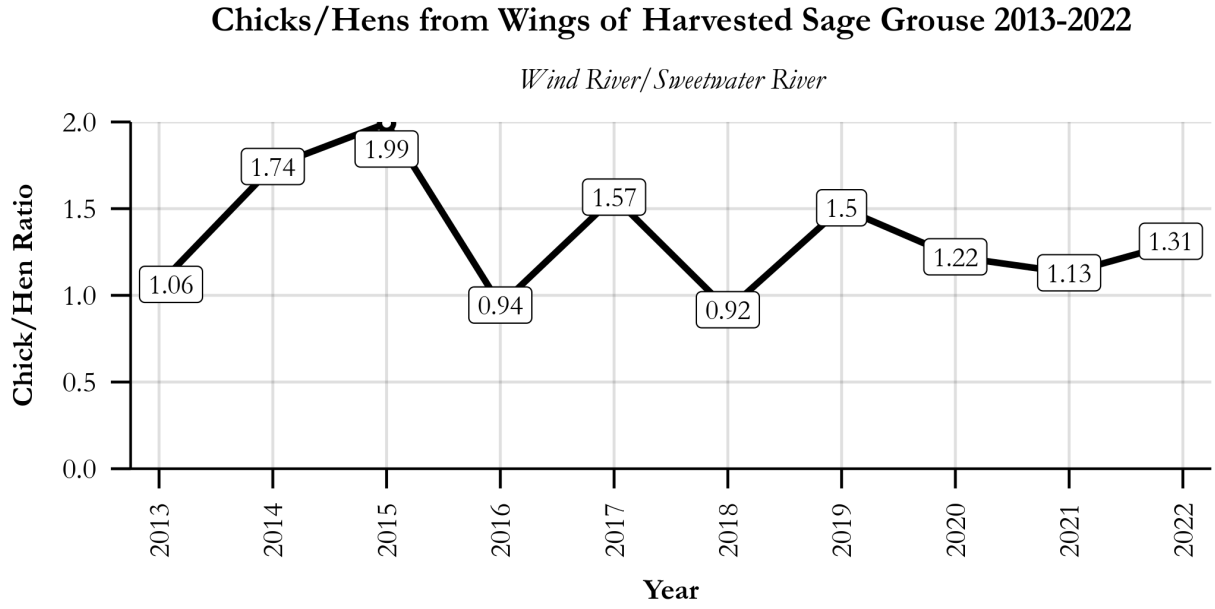


Figure 8: Chick/Hen Ratio

Lek Monitoring:

Sage-grouse are generally found throughout the Wind River Sweetwater River Conservation Area (WRSRCA), except in heavily forested, agriculturally developed, or urbanized areas. Sage-grouse leks in the WRSRCA are located within the Lander WGFD Region, 4 BLM Resource Areas, 5 Wyoming counties, and the WRR. According to the lek characteristics report (Table 1), there were 202 known occupied leks within the conservation area in 2023, along with 48 unoccupied and 17 undetermined leks. The majority of leks of all 3 classification levels occur within the 3 core areas that are partially or entirely within the WRSRCA (Crowheart, Greater South Pass, and Washakie). It is highly likely there are leks within the WRSRCA that have not yet been documented, as evidenced by at least 141 (average 6 per year) new or newly discovered leks being documented in the WRSRCA through intensive monitoring and search efforts since 1995. Similarly, there likely are leks that have been abandoned or destroyed that are undocumented. Lek attendance at all leks checked generally increased between 1995 and 2006, declined until 2013, increased again for 3 years, only to decline from 2017 through 2021, with a 24% uptick in 2022 and another gain of 26% in 2023. These lek attendance data mimic Wyoming's statewide trends, but with generally higher numbers than the Wyoming averages. While increases in 2022 and 2023 are encouraging, it should be noted the 2021 level was the 4th lowest level since 1995 in the WRSRCA.

Personnel from WGFD, BLM, USFWS, and Shoshone-Arapahoe Tribal Fish and Game (SATFG), assisted by consultants and volunteers, checked 187 (90%) of the 208 known occupied leks in the WRSRCA in 2023. Winter 2022-2023 was more severe than in recent years, and restricted access to many leks until late in the strutting season. Although the overall number of leks checked was similar to recent years, the percentage of count leks was the lowest in over a decade because of the inability to access many count leks on multiple visits. Of those leks checked, 67 were counted and 120 were surveyed. Of the 144 leks where status was confirmed in 2023, 126 (87.5%) were active and 18

(12.5%) were inactive. Six new leks were discovered and a previously discovered lek was confirmed in 2023.

Average male attendance for all leks checked improved from 23.3 males per active lek checked in 2022 to 29.3 in 2023. Average maximum male attendance at count leks also increased from 28.7 males per active lek in 2022 to 31.8 in 2023, remaining below the count lek average since 2014 (34.5), and 55% below the long-term peak observed in 2006 (76.0).

A subset of 17 leks in the Government Draw area east of Lander which have been counted since 1995 also had a lek attendance increase in 2023, with a 29% increase in male attendance from 38.3 males per active lek in 2022 to 49.5 males per active lek in 2023. This area has outperformed the attendance averages for the entire WRSRCA over the last few years, with the average males at all leks checked in this subset in 2023 being the best since 2014 and 7th best since 1995, while the WRSRCA overall average lek attendance in 2023 was only the 5th best since 2014.

Production:

Summer brood data are very limited in the WRSRCA, so wing data collected from harvested sage-grouse provide a more reliable indicator of recruitment than do brood survey data. Wings are collected from hunters at 7 wing barrels placed annually at exit roads from major hunting destinations in Sage-Grouse Management Area E and at the Lander Game Check Station. These wings typically provide significant data, due to a relatively high number of sage-grouse hunters in the area, yet the number of wings collected in recent years has declined, with the 2022 sample being the 2nd lowest in the last 10 years (mimicking lek attendance trends). Wing data are summarized for the WRSRCA for hunting seasons 2013 – 2022 (Table 8 and Figure 8). Wings collected from harvested birds during the 2022 hunting season yielded an average brood size of 1.3 chicks per hen, equaling the average of 1.3 chicks per hen observed over the last 10 years. Population growth typically requires 1.7 chicks/hen or more based on historic statewide averages. However, with chick survival in 2022 being below that threshold, male lek attendance still increased 26% in 2023 in the WRSRCA.

Hunting Season and Harvest:

Sage-grouse hunting season in Management Area E lies entirely within Wyoming Hunt Area 1, which has been "standardized" since 2009, keeping opening day on the 3rd Saturday in September and ending on September 30. The 2022 sage-grouse hunting season was 14 days long (Sept. 17 – 30). As reported in the annual small game and upland game bird harvest survey (SMUG), a total of 2,337 sage-grouse were harvested in Management Area E in 2022 (twice as many as in the 2021 harvest and the highest since 2013). Hunter numbers were 54% higher and hunter days were 48% higher (both being significantly above the 10-year averages), compared with the 2021 hunting season. Hunter effort (days/hunter) and success (birds/hunter and birds/day) statistics equaled the average over the last 10 hunting seasons (Table 7). The 2022 harvest survey data, particularly the number of sage-grouse harvested, hunter numbers, and days hunted, seem quite elevated compared with wing barrel sample size, which was lower than in 2021 and the 2nd lowest in 10 years. In addition, lek attendance in 2022 and 2023 and productivity as indicated by chick/hen ratios in 2022 lack the level of increases typically needed to support such a robust harvest.

Sage-grouse hunting on tribal lands within the Wind River Reservation is minimal and data are not included in this report.

Habitat:

Long-term sage-grouse habitat conditions have been affected by long-term drought throughout the WRSRCA. Disturbance (i.e., localized energy development, season-long grazing by livestock and wildlife, etc.) combined with lengthy drought periods and sagebrush eradication programs in many areas have negatively impacted sage-grouse and their habitats. In an effort to improve conditions for sage-grouse, habitat improvement projects are being planned and/or implemented throughout the WRSRCA to address declining sage-grouse habitat conditions. In addition, research projects in the WRSRCA are continuing to provide more insight to sage-grouse movements and habitat use. Habitat conditions vary greatly within the WRSRCA, due to climatic differences, soil types, land use, and elevation.

Habitat Monitoring/Inventory

Habitat monitoring is discussed in past WRSRCA JCRs, and in the 2007 WRSRCA Local Sage-Grouse Conservation Plan and 2014 Addendum. No habitat monitoring transects were measured in 2022 specifically for sage-grouse. However, implementation of Rapid Habitat Assessments (RHAs) continued as part of the South Wind River and Sweetwater Mule Deer Initiatives, to develop a baseline from which to gauge overall habitat condition. Several RHAs covering shrub/rangeland habitats were completed within the WRSRCA in 2022, and offer insight as to the condition of sage-grouse habitats within the South Wind River and Sweetwater Mule Deer herd units that overlap a portion of the WRSRCA.

Winter Habitat Use Survey

Limited winter sage-grouse observations were collected in 2022-23, mostly as opportunistic observations during deer, elk, and moose classification flights or random ground surveys. Reports from USDA Wildlife Services personnel during coyote removal flights in March and April 2023 anecdotally indicated high numbers of sage-grouse in several areas near the Sweetwater Rocks in the Sweetwater River drainage.

Habitat Treatments

Since adoption of the WRSR LWG plan in 2007, a number of vegetation treatments have been implemented with the intention of improving habitats for sage-grouse, mule deer, and other wildlife. Summaries of these treatments are reported in past JCRs and in the 2007 WRSRCA Local Sage-Grouse Conservation Plan and 2014 Addendum. No new treatments in sage-grouse habitats occurred during 2022.

Conservation Easements

Within the WRSRCA, several privately owned properties have been placed under conservation easements with deed restrictions ranging from minimal to no new construction of houses, barns, or other buildings. Conservation easements are mostly located in the Lander Foothills, Sweetwater River, Twin Creek, Dubois, and Ervay Basin areas. At present, over 32,000 acres of private lands are permanently protected by conservation easements within the WRSRCA, and provide protection of crucial wildlife habitat, water quality, maintain migration routes, and continue traditional agricultural land uses.

Disease:

No new cases of West Nile Virus (WNv) or other avian diseases are known to have occurred in sage-grouse in the WRSRCA in 2022.

Conservation Planning:

In 2022 and 2023, the Wind River/Sweetwater local working group (WRSR LWG) funded projects to enhance sage-grouse habitats and reduce risk of collisions with fences. These projects are covered by Recommended Actions in the Wind River/Sweetwater River Local Sage-Grouse Conservation Plan and Addendum (2007, 2014).

BLM Fence Marker Project – Approximately 5.83 miles of fences were marked near 3 sage-grouse leks, with enough markers remaining to mark an additional 7.6 miles of fence.

Antelope Springs Snow Fence Repairs – an old snow fence was rebuilt and repaired at Antelope Springs Reservoir on Beaver Rim to enhance snow catchment which in turns helps fill the reservoir, providing water for sage-grouse and other wildlife, as well as livestock. There are several sections left to rebuild, but issues with water levels may require moving some of the remaining sections to avoid flood damages. This snow fence was originally constructed via a Water for Wildlife Foundation project.

Fremont County Weed & Pest - The Government Draw Leafy Spurge and Cheatgrass Management project is a continuation of the aerial treatment efforts which began in the fall of 2017 within Zone 2 & 3 of the greater Lander-South Hudson Invasive Weed Control and Management program area. In addition, FRWP conducts annual herbicide applications to curtail the spread of noxious weeds, including cheatgrass in many other parts of the WRSRCA.

Management Recommendations:

1. Continue to collect age and sex composition of the harvest via wing collection and analyses.
2. Continue intensive lek counts in the Government Draw area south of Hudson.
3. Continue ground checks of all non-intensively monitored leks.
4. Continue to search for new or undiscovered leks in remote areas of WRSRCA.
5. Continue to cooperate with private landowners and Federal/State land managers to reduce negative impacts to crucial sage-grouse habitats.
6. Continue to coordinate research projects within or applicable to the WRSRCA.

Attachment A:

Project #	Project Name	Fiscal Year	Local Working Group	Total Cost of Project	Sage-grouse Funds	Project Description	Partners
315	Gas Pile Driver - Mark Cufaude	2023	South Central	$3,200	$3,200	fence conversion projects	WGFD
316	Shirley Basin IR Flights - Teal Cufaude	2023	Bates Hole	$68,500	$40,000	IR Lek serches, awarded in $40k and $28.5k pieces	WGFD, BLM
317	Antelope Springs Reservoir - Snow Fence Repairs - Stan Harter	2023	Wind River/Sweetwater	$7,950	$7,950	Snow fence repair for habitat	WGFD
318	Zeedyk Structures for Riparian Areas/Wet Meadows: Workshop Field Day ($3A1)	2023	Northeast	$5,000	$5,000	Zeedyk Structures for Riparian Areas/Wet Meadows: Workshop Field	Clear Creek Conservation District, WGFD
319	Assessment of Cheatgrass Treatments and Restoration for Sage Grouse ($3B1)	2023	Upper Snake	$52,000	$23,000	Assessment of Cheatgrass Treatments and Restoration	UW, TNC
320	Stewart Creek Grouse Water Exclosure Fencing ($3C1)	2023	South Central	$5,000	$2,500	Water Exclosure Fencing	BLM
321	Private Land Enhancement Program ($3D1)	2023	Upper Green	$14,500	$10,000	Improve vegetation diversity and productivity throughout Sublette County.	Sublette County Conservation District
322	Lowham Ranch Yellow Creek and Spring Exclosure ($3E1)	2023	Southwest	$58,500	$24,725	Proposed fence will exclude livestock and wildlife ungulates from about 2.9 acres of habitat and create a refugia of shrubs, forbs, and grasses. Continued from FY22	Wyoming Wildlife Federation, WGFD
323	Cheatgrass Management in Greater-Sage Grouse Core Areas, Sublette County ($3F1)	2023	Upper Green		$25,000	cheatgrass treamtents	Sublette County Weed and Pest
324	Drop-Fence Conversion and Maintenance on Pinedale BLM Allotments ($3G1)	2023	Upper Green		$30,000	saving sage-grouse with modifying and dropping fences	Jackson Hole Wildlife Foundation
325	Building Capacity for Proactive Sagebrush Conservation in Northeast Wyoming ($3I1)	2023	Northeast	$365,500	$63,500	Help fund position to evaluiate project areas and help landowners with projects	Pheasants Forever, USFWS PFW, WWF, NGPJV
326	Adaptive Management of the NPL Gas Field for Sage-grouse ($1K1)	2023	South Central/Southwest/ Upper Green	$631,225	$43,500	Continuation of NPL Winter Concetration use study	WGFD, BLM, Jonah Energy, UW
327	Interactive Effects of Predators, Habitat, and Livestock Presence on Sage-Grouse ($1H1a)	2023	Bighorn Basin	$519,287	$55,700	Continuing to Evaluate predator influence, evaluate predator abundance, evaluate seasonal habitat use and survival	BLM, WGFD
328	Enos Creek Riparian Restoration - Jerry Altermatt	2023	Bighorn Basin	$56,000	$10,000	BDA Analog inbstallation with beaver translocation	BLM, WGFD, LU Ranch
329	Stock Tank Excape Ramp Consturction $3J1	2023	South Central	$8,000	$6,000	Local schools to construct a 200-250 expanded metal escape ramps. NRCS and SERCD to disperse for use in existing tanks.	NRCS, SERCD, Encampment High School, Saratoga High School
330	Teton Cheatgrass $3k1	2023	Upper Snake	$350,500	$45,500	Retreatment of areas treated in 2020 as well as mapping and surveying cheatgrass infestations	Teton County Weed and Pest, National Fish and Widlife Foundation, WWNRT, Teton Conservation District, WYBGLC, WGFD
331	Big Creek Well $3P1	2023	South Central	$41,000	$31,000	Drill well along Big Creek to implement phase 2 which is to supply water to several tanks in multiple pastures within the allotment	SERCD, Big Creek Ranch
332	Diamond Spring Protection Fence	2023	Wind River	$107,067	$94,567	Fence 30 acres around spring to exclude feral horses and livestock to allow grass and forbs to flourish for benefit of sage-grouse and other wildlife	Water for Wildlife Foundation, Split Rock Ranch, WGFD
333	Fence Markers - BLM	2023	Wind River	$8,358	$8,358	Purchase and install fence markers near leks to make fence safer and more visable to sage-grouse. BLM will install markers	BLM

Attachment B:
Wyoming Sage-Grouse Research Reports (through May 31, 2023)

Part I. Final research reports from Wyoming sage-grouse research or theses and dissertations from university research efforts. It does not include annual agency monitoring reports or popular press articles.

Part II. Wyoming sage-grouse research articles published in peer-reviewed journals or books.

Only research reports concerning Wyoming sage-grouse are included. Studies on related subjects, (e.g. sagebrush, cheatgrass, other geographical areas) are important, but too numerous to include in this attachment.

Part I. Research theses, dissertations and reports.

Bedrosian, B. and D Craighead. 2010. Jackson Hole sage grouse project completion report: 2007-2009. Craighead Beringia South. Kelly, Wyoming. Includes 4 appended reports: A: Common raven activity in relation to land use in western Wyoming: Implications for greater sage grouse reproductive success. B: Critical winter habitat characteristics of greater sage-grouse in a high altitude environment. C: Sage grouse baseline survey and inventory at the Jackson Hole Airport. D: Sage-grouse chick survival rates in Jackson Hole, Wyoming.

Brooks, M.L., J.R. Matchett, D.J. Shinneman and P.S. Coates. 2015. Fire patterns in the range of greater sage-grouse, 1984–2013 - Implications for conservation and management: U.S. Geological Survey Open-File Report 2015-1167, 66 p., http://dx.doi.org/10.3133/ofr20151167.

Brown, K. G. and K. M. Clayton. 2004. Ecology of the greater sage-grouse (*Centrocercus urophasianus*) in the coal mining landscape of Wyoming's Powder River Basin. Final Technical Report. Thunderbird Wildlife Consulting, Inc. Gillette, WY.

Bui, T.D. 2009. The effects of nest and brood predation by common ravens (*Corvus corax*) on greater sage-grouse (*Centrocercus urophasianus*) in relation to land use in western Wyoming. Thesis. University of Washington, Seattle.

Cagney J., E. Bainter, B. Budd, T. Christiansen, V. Herren, M. Holloran, B. Rashford, M. Smith and J. Williams. 2010. Grazing influence, objective development, and management in Wyoming's greater sage-grouse habitat. University of Wyoming College of Agriculture Extension Bulletin B-1203. Laramie. Available on-line at: http://www.wyomingextension.org/agpubs/pubs/B1203.pdf

Chambers, J.C., J.L. Beck, S. Campbell, J. Carlson, T.J. Christiansen, K.J. Clause, J.B. Dinkins, K.E. Doherty, K.A. Griffin, D.W. Havlina, K.E. Mayer, J.D. Hennig, L.L. Kurth, J.D. Maestas, M. Manning, B.A. Mealor, C. McCarthy, M.A. Perea and D.A. Pyke. 2016. Using resilience and resistance concepts to manage threats to sagebrush ecosystems, Gunnison sage-grouse, and

greater sage-grouse in their eastern range—A strategic multi-scale approach: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, General Technical Report RMRS-GTR-356, 143p. https://www.fs.fed.us/rmrs/publications/using-resilience-and-resistance-concepts-manage-threats-sagebrush-ecosystems-gunnison.

Christiansen, T. 2006. Monitoring the impacts and extent of West Nile virus on sage-grouse in Wyoming – final report. Wyoming Game and Fish Department, Cheyenne.

Christiansen, T. 2010. Hunting and sage-grouse: a technical review of harvest management on a species of concern in Wyoming. Wyoming Game and Fish Department, Cheyenne.

Christiansen, T.J. (*in press*). Wyoming's approach to sage-grouse Conservation – a shotgun wedding of science and policy. Transactions of the 82nd North American Wildlife and Natural Resources Conference. Wildlife Management Institute.

Clarke, L. F., H. Rahn and M.D. Martin. 1942. Seasonal and sexual dimorphic variations in the so-called "air sacs" region of the sage grouse. Sage Grouse Studies Part II. Wyoming Game and Fish Department Bulletin No. 2. Wyoming Game and Fish Department, Cheyenne.

Courtemanch, A., G. Chong and S. Kilpatrick. 2007. A remote sensing analysis of sage-grouse winter habitat in Grand Teton National Park and Bridger-Teton National Forest, Wyoming.

Crist, M.R., S.T. Knick and S.E. Hanser. 2015, Range-wide network of priority areas for greater sage-grouse—A design for conserving connected distributions or isolating individual zoos?: U.S. Geological Survey Open-File Report 2015-1158, 34 p., http://dx.doi.org/10.3133/20151158.

Daniel, J. 2007. Spring precipitation and sage grouse chick survival. Thesis. Department of Statistics – University of Wyoming, Laramie.

Deibert, P. A. 1995. Effects of parasites on sage-grouse mate selection. Dissertation. University of Wyoming, Laramie.

Dinkins, J.B. 2013. Common raven density and greater sage-grouse nesting success in southern Wyoming: potential conservation and management implications. Dissertation. Utah State University, Logan.

Doherty, K.E. 2008. Sage-grouse and energy development: integrating science with conservation planning to reduce impacts. Dissertation. University of Montana, Missoula.

Doherty, M.K. 2007. Mosquito populations in the Powder River Basin, Wyoming: a comparison of natural, agricultural and effluent coal-bed natural gas aquatic habitats. Thesis. Montana State University, Bozeman.

Erickson, H.J. 2011. Herbaceous and avifauna responses to prescribed fire and grazing timing in a high-elevation sagebrush ecosystem. Thesis. Colorado State University, Ft. Collins.

Gamo, R.S. 2016. Effectiveness of Wyoming's Sage-Grouse Core Areas in conserving greater sage-grouse and mule deer and influence of energy development on big game harvest. Dissertation, University of Wyoming, Laramie.

Girard, G.L. 1935. Life history, habits, and food of the sage-grouse. Thesis. University of Wyoming, Laramie.

Girard, G.L. 1937. Life history, habits, and food of the sage-grouse. University of Wyoming Publication 3. University of Wyoming, Laramie.

Heath, B.J., R. Straw, S. Anderson and J. Lawson. 1996. Proceedings of the sage-grouse workshop, Pinedale, Wyoming, 6-7 September 1996. Wyoming Game and Fish Department. Cheyenne.

Heath, B. J., R. Straw, S.H. Anderson and J. Lawson. 1997. Sage-grouse productivity, survival and seasonal habitat use near Farson, Wyoming. Research Completion Report. Wyoming Game & Fish Dept., Cheyenne.

Heath, B.J., R. Straw, S.H. Anderson, J. Lawson and M. Holloran. 1998. Sage-grouse productivity, survival, and seasonal habitat use among three ranches with different livestock grazing, predator control, and harvest management practices. Research Completion Report. Wyoming Game & Fish Dept., Cheyenne.

Hess, J.E. 2010. Greater sage-grouse (*Centrocercus urophasianus*) habitat response to mowing and prescribed burning Wyoming big sagebrush and the influence of disturbance factors on lek persistence in the Bighorn Basin, Wyoming. Thesis. University of Wyoming, Laramie.

Hnilicka, P. and D. Skates. 2010. Movements and survival of sage-grouse on the Wind River Reservation, Wyoming. Completion Report. U. S. Fish and Wildlife Service Lander, Wyoming.

Holloran, M. J. 1999. Sage-grouse seasonal habitat use near Casper, WY. Thesis. University of Wyoming, Laramie.

Holloran, M.J. and S.H. Anderson. 2004. Greater Sage-grouse seasonal habitat selection and survival in Jackson Hole, Wyoming. Research Completion Report. University of Wyoming Cooperative Fish and Wildlife Research Unit, Laramie.

Holloran, M.J. 2005. Sage-grouse population response to natural gas field development in western Wyoming. Dissertation. University of Wyoming, Laramie.

Holloran, M.J. and S.H. Anderson. 2005a. Spatial distribution of Greater Sage-grouse nests in relatively contiguous sagebrush habitats. Attachment A in Holloran 2005 Dissertation.

University of Wyoming, Laramie.

Holloran, M.J. and S.H. Anderson. 2005c. Greater Sage-grouse research in Wyoming: an overview of studies conducted by the Wyoming Cooperative Fish and Wildlife Research Unit between 1994 and 2005. Attachment C in Holloran 2005. Dissertation. University of Wyoming, Laramie.

Honess, R.F. and W.J. Allred. 1942. Structure and function of the neck muscles in inflation and deflation of the esophagus in the sage grouse. Sage Grouse Studies Part I. Wyoming Game and Fish Department Bulletin No. 2. Wyoming Game and Fish Department, Cheyenne.

Honess, R. F. and G. Post. 1968. History of an epizootic in sage-grouse. Science Monograph 14. University of Wyoming Agricultural Experiment Station, Laramie.

Jensen, B.M. 2006. Migration, transition range and landscape use by greater sage-grouse (*Centrocercus urophasianus*). Thesis, University of Wyoming, Laramie.

Johnson, G. 2010. Field evaluation of larvivorous fish for mosquito management in the Powder River Basin, Wyoming. Grant summary completion report. Montana State University, Bozeman.

Johnson, G.D. 1987. Effects of rangeland grasshopper control on sage-grouse in Wyoming. Thesis, University of Wyoming, Laramie.

Kaiser, R.C. 2006. Recruitment by greater sage-grouse in association with natural gas development in Western Wyoming. Thesis, Department of Zoology and Physiology, University of Wyoming, Laramie.

King, L. and J. Petty. 2008. Investigations of a gravity-fed supplemental irrigation system to enhance sagebrush seedling establishment on reclaimed bentonite mine lands in Wyoming's Big Horn Basin. Shell Valley Consulting Associates, Inc. Shell, WY.

King, L., E. Dunklee and J. Petty. 2009. Use of supplemental watering gels to enhance Wyoming big sagebrush establishment on Big Horn Basin bentonite reclamation. Shell Valley Consulting Associates, Inc. Shell, WY.

Kirol, C.P. 2012. Quantifying habitat importance for greater sage-grouse (*Centrocercus urophasianus*) population persistence in an energy development landscape. Thesis. University of Wyoming, Laramie.

Kirol, C.P. 2021, Patterns of nest survival, movement and habitat use of sagebrush-obligate birds in an energy development landscape.Thesis. University of Waterloo, Ontario, Canada.

Klott, J.H. 1987. Use of habitat by sympatrically occurring sage-grouse and sharptailed grouse with broods. Thesis. University of Wyoming, Laramie.

Kuipers, J.L. 2004. Grazing system and linear corridor influences on Greater Sage-grouse habitat selection and productivity. Thesis. University of Wyoming, Laramie.

LeBeau, C.W. 2012. Evaluation of greater sage-grouse reproductive habitat and response to wind energy development in South-Central, Wyoming. Thesis. University of Wyoming, Laramie.

LeBeau, C., G. Johnson, M. Holloran, J. Beck, R. Nielson, M. Kauffman, E. Rodemaker, and T. McDonald. 2016. Effects of a Wind Energy Development on Greater Sage-Grouse Habitat Selection and Population Demographics in Southeastern Wyoming. Unpublished report. Prepared for: National Wind Coordination Collaborative, Washington, DC. Prepared by: Western EcoSystems Technology, Inc., Cheyenne, WY.

LeVan, J.R. 2018. Habitat selection and short-term demographic response of greater sage-grouse to habitat treatments in Wyoming big sagebrush. Thesis, University of Wyoming, Laramie.

Lyon, A.G. 2000. The potential effects of natural gas development on sage grouse near Pinedale, Wyoming. Thesis, University of Wyoming, Laramie.

Mabray, S.T. 2015. Microhabitat Selection by Greater Sage-Grouse Hens in Southern Wyoming. Thesis. Utah State University, Logan.

Mandich, C.A. 2011. Seasonal habitat distribution and parasite survey of greater sage-grouse in western Natrona County, Wyoming. Thesis. University of Wyoming, Laramie.

McDonald, D.B. 2006. Demographic population assessment of greater sage-grouse in Jackson Hole Wyoming. University of Wyoming Department of Zoology, Laramie.

Orning, E.K. 2013. Effect of predator removal on greater sage-grouse (*Centrocercus urophasianus*) ecology in the Bighorn Basin Conservation Area of Wyoming. Thesis. Utah State University. Logan.

Parsons, L.A. 2019. Greater sage-grouse survival, breeding ecology, resource selection, and West Nile virus prevalence on the eastern fringe of their range. Dissertation. South Dakota State University. Brookings, SD.

Patricelli, G.L., J.L. Blickley and S.L. Hooper. 2012. The impacts of noise on greater sage- grouse: A discussion of current management strategies in Wyoming with recommendations for further research and interim protections. Prepared for: The Bureau of Land Management, Lander Field Office and Wyoming State Office, Cheyenne and Wyoming Game and Fish Department.

Patterson, R.L. 1952. The sage grouse in Wyoming. Sage Books.

Peebles, L.W. 2015. Winter ecology of common ravens in southern Wyoming and the effects of raven removal on greater sage-grouse populations. Paper 4617. Thesis. Utah State University, Logan, UT.

Pratt, A.C. 2017. Partial migration, habitat selection, and the conservation of greater sage-grouse in the Bighorn Basin of Montana and Wyoming. Dissertation, University of Wyoming, Laramie.

Postovit, B.C. 1981. Suggestions for sage grouse habitat reclamation on surface mines in northeastern Wyoming. Thesis. University of Wyoming, Laramie.

Revekant, C.L. 2021. Comparison of Common Ravens in Sage-grouse Core and Non-Core. Oregon State University, Corvallis.

Rothenmaier, D. 1979. Sage-grouse reproductive ecology: breeding season movements, strutting ground attendance and site characteristics, and nesting. Thesis. University of Wyoming, Laramie.

Schmidtmann, E. 2007. Mosquitoes, West Nile virus and Wyoming Wildlife – Powder River Basin. Arthropod-Borne Animal Diseases Research Laboratory, USDA, ARS, Laramie, WY.

Schmidtmann, E. 2007. Mosquitoes, West Nile virus and Wyoming Wildlife – Fremont and Sublette Counties. Arthropod-Borne Animal Diseases Research Laboratory, USDA, ARS, Laramie, WY.

Schreiber, L.A. 2013. Greater sage-grouse nest site selection, brood-rearing site selection and chick survival in Wyoming. Thesis, Univ. of Missouri, Columbia.

Slater, S.J. 2003. Sage-grouse use of different aged burns and the effects of coyote control in southwestern Wyoming. Thesis. University of Wyoming, Laramie.

Smith, K.T. 2016. Identifying habitat quality and population response of greater sage-grouse to treated Wyoming big sagebrush habitats. Dissertation. University of Wyoming, Laramie.

Spurrier, M.F. 1989. Courtship behavior in *Centrocercus urophasianus*. Thesis. University of Wyoming, Laramie.

Schulwitz, S.E. 2016. Informing conservation management using genetic approaches: greater sage-grouse and Galápagos short-eared owls as case studies. Dissertation. University of North Texas, Denton.

Taylor, R.L., D.E. Naugle and L.S. Mills. 2012. Viability analyses for conservation of sage-grouse populations: Buffalo Field Office, Wyoming Final Report 27 February 2012. BLM Contract 09-3225-0012 Number G09AC00013 (8/10/10). University of Montana, Missoula.

Thompson, K.M., M.J. Holloran, S.J. Slater, J.L. Kuipers and S.H. Anderson. 2005. Greater Sage-grouse early brood-rearing habitat use and productivity in Wyoming. Attachment B in Holloran 2005. Dissertation. University of Wyoming, Laramie.

Walker, B.L. 2008. Greater sage-grouse response to coal-bed natural gas development and West Nile virus in the Powder River Basin, Montana and Wyoming, U.S.A.. Dissertation. University of

Montana, Missoula.

Wanner, Caitlyn, P. 2022. Validation of winter concentration area guidelines and winter habitat ecology for greater sage-grouse in the Red Desert, Wyoming. Thesis, University of Wyoming, Laramie, Wyoming, USA. 130 pages.

Watchorn, R. 2015. Biological control of disease vectors: a case study evaluating the efficacy of fathead minnows (*Pimephales promelas*) for mosquito control in northeast Wyoming. Thesis. University of Waterloo. Waterloo, Ontario, Canada.

Wetzel, W., G. Chong, A. Courtemanch and N. Pope. 2007. Composition and structure of sage grouse winter habitat in the Upper Snake River Basin, Wyoming.

Wiley, R.H. 1970. Territoriality and non-random mating in sage grouse *Centrocercus urophasianus*. Dissertation. The Rockefeller University, New York, New York.

Wilms, D. and A. Alexander. 2014. The North American model of wildlife conservation in Wyoming: understanding it, preserving it, and funding its future. Wyoming Law Review 14(2).

Wyoming Wildlife Consultants, LLC. 2012. Greater sage-grouse winter habitat selection relative to natural gas field infrastructure in northern portions of the Pinedale Anticline Project Area Sublette County, Wyoming. Final report. Prepared for*:* Shell Western Exploration and Production, LP, QEP Energy Company and Ultra Petroleum.

Part II. Peer reviewed journal articles or book chapters.

Allen, S.E., M. R. Kunkel, and N. M. Nemeth "Using Opportunistic Samples to Monitor West Nile Virus Infection Status in Greater Sage-Grouse (Centrocercus urophasianus) in Wyoming, USA (2020–22)," Journal of Wildlife Diseases 59(4), 774-779, (24 October 2023). https://doi.org/10.7589/JWD-D-22-00164

Ambrose, S, C. Florian, J. Olnes, J. Macdonald, T. Hartman. 2021. Sagebrush Soundscapes and the effects of gas-field sounds on greater sage-grouse. Western Birds 52:23-46.

Applegate, D.H. and N.L. Owens. 2014. Oil and gas impacts on Wyoming's sagegrouse: summarizing the past and predicting the foreseeable future. Commentary. Human–Wildlife Interactions 8(2):284–290.

Barlow, N. L., C. P. Kirol, K. E. Doherty, and B. C. Fedy. 2019. Evaluation of the umbrella species concept at fine spatial scales. The Journal of Wildlife Management 84:237–248.

Barlow, N. L., C. P. Kirol, and B. C. Fedy. 2020. Avian community response to landscape-scalehabitat reclamation. Biological Conservation 252:108850.

Beck, J.L., J.W. Connelly and C.L. Wambolt. 2012. Consequences of treating Wyoming big sagebrush to enhance wildlife habitats. Rangeland Ecology & Management 65(5):444-455.

Beck, J.L., D.T. Booth and C.L. Kennedy. 2014. Assessing greater sage-grouse breeding habitat with aerial and ground imagery. Rangeland Ecology and Management 67(3):328-332.

Bergquist, E., P. Evangelista, T. J. Stohlgren and N. Alley. 2007. Invasive species and coal bed methane development in the Powder River Basin, Wyoming. Environmental Monitoring and Assessment 128:381-394.

Blickley, J.L. and G.L. Patricelli. 2010. Impacts of anthropogenic noise on wildlife: research priorities for the development of standards and mitigation. Journal of International Wildlife Law & Policy 13:274-292.

Blickley, J.L. and G.L. Patricelli. 2012. Potential acoustical masking of greater sage-grouse display components by chronic industrial noise. Ornithological Monographs 74:23-35.

Blickley, J.L., D. Blackwood and G.L. Patricelli. 2012. Experimental evidence for the effects of chronic anthropogenic noise on abundance of greater sage-grouse at leks. Conservation Biology 26: 461-471.

Blickley, J.L., K.R. Word, A.H. Krakauer, J.L. Phillips, S.N. Sells, J.C. Wingfield and G.L. Patricelli.. 2012. Experimental chronic noise is related to elevated fecal corticosteroid metabolites in lekking male greater sage-grouse (*Centrocercus urophasianus*). PLoS ONE 7(11): e50462. doi:10.1371/journal.pone.0050462

Boyce, M.S. 1990. The red queen visits sage-grouse leks. American Zoologist 30:263-270.

Boyd, C.S., J.L. Beck and J.A. Tanaka. 2014. Livestock grazing and sage-grouse habitat: impacts and opportunities. Journal of Rangeland Applications 1:58-77.

Brussee, B. E., P.S. Coates, S. T. O'Neil, M. A. Ricca, J. E. Dudko, S. P. Espinosa, S. C. Gardner, M. L. Casazza, D. J. Delehanty. 2023. Influence of fine-scale habitat characteristics on sage-grouse nest site selection and nest survival varies by mesic and xeric site conditions.Volume 125, Issue 1. https://doi.org/10.1093/ornithapp/duac052.

Bui, T-V. D., J.M. Marzluff and B. Bedrosian. 2010. Common raven activity in relation to land use in Western Wyoming: implications for greater sage-grouse reproductive success. The Condor 112(1):65-78.

Burkhalter, C., M.J. Holloran, B.C. Fedy, H.E. Copeland, R.L. Crabtree, N.L. Michel, S.C. Jay, B.A. Rutledge, and A.G. Holloran. 2018. Landscape-scale habitat assessment for an imperiled avian species. Animal Conservation 21:241-251.

Cardinal, C.J. and T.A. Messmer. 2016. Ecology of greater sage-grouse populations inhabiting the northwestern Wyoming Basin: Human-Wildlife Interactions 10(2):188–204.

Carlisle, J. D., K.T. Smith, J.L. Beck, M.A. Murphy, A.D. Chalfoun. 2023. Beyond overlap:considering habitat preference and fitness outcomes in the umbrella species concept. Animal Conservation. https://doi.org/10.1111/acv.12899

Christiansen, T.J. and L.R. Belton. 2017. Wyoming sage-grouse working groups: Lessons learned. Human-Wildlife Interactions 11:274-286.

Conover, M.R., J.S. Borgo, R.E. Dritz, J.B. Dinkins and D.K. Dahlgren. 2010. Greater sage- grouse select nest sites to avoid visual predators but not olfactory predators. The Condor 112(2):331-336.

Copeland, H.E., K.E. Doherty, D.E. Naugle, A. Pocewicz and J.M. Kiesecker. 2009. Mapping oil and gas development potential in the US intermountain west and estimating impacts to species. PLoS ONE 4(10): e7400. doi:10.1371/journal.pone.0007400. 7 pp.

Copeland, H.E., A. Pocewicz, D.E. Naugle, T. Griffiths, D. Keinath, et al. 2013. Measuring the effectiveness of conservation: a novel framework to quantify the benefits of sage-grouse conservation policy and easements in Wyoming. PLoS ONE 8(6): e67261.

Cross, T.B., M.K. Schwartz, D.E. Naugle, B.C. Fedy, J.R. Row, S.J. Oyler-McCance. 2018. The genetic network of greater sage‐grouse: Range‐wide identification of keystone hubs of connectivity. Ecology and Evolution 8:1-19.

Dahlgren, D.K., R.T. Larsen, R. Danvir, G. Wilson, E.T. Thacker, T. Black, D.E. Naugle, J.W. Connelly and T.A. Messmer. 2015. Greater sage-grouse response to range management: insights from a 25-year case study in Utah. Rangeland Ecology & Management: 68:375-382. (Corrigendum in Rangeland Ecology & Management 69:235).

Dahlgren, D.K., E.J. Blomberg, C.A. Hagen, and R.D. Elmore. 2021. Upland game bird harvest management. Chapter 21 in K.L. Pope and L.A. Powell eds. Harvest of fish and wildlife: new paradigms for sustainable management. CRC Press, Taylor and Francis Group, LLC, Boca Raton, FL, USA.

Decker, K.L., A. Pocewicz, S. Harju, M. Holloran, M.M. Fink, T.P. Toombs, and D.B. Johnston. 2017. Landscape disturbance models consistently explain variation in ecological integrity across large landscapes. Ecosphere 8(4):e01775. 10.1002/ecs2.1775.

Deibert, P.A. and M.S. Boyce. 1997. Heritable resistance to malaria and the evolution of lek behaviour in sage-grouse. Wildlife Biology 3:284.

Dinkins, J.B., M.R. Conover, C.P. Kirol and J.L. Beck. 2012. Greater sage-grouse (*Centrocercus urophasianus*) select nest-sites and brood-sites away from avian predators. The Auk 129:600–610.

Dinkins, J.B., M.R. Conover and S.T. Mabray. 2013. Do artificial nests simulate nest success of greater sage-grouse? Human–Wildlife Interactions 7(2):299–312.

Dinkins, J.B., M.R. Conover, C.P. Kirol, J.L. Beck and S.N. Frey. 2014. Greater sage-grouse (Centrocercus urophasianus) hen survival: effects of raptors, anthropogenic and landscape features, and hen behavior. Canadian Journal of Zoology. doi:10.1139/cjz-2013-0263

Dinkins, J.B., M.R. Conover, C.P. Kirol, J.L. Beck and S.N. Frey. 2014. Greater Sage-Grouse (Centrocercus urophasianus) select habitat based on avian predators, landscape composition, and anthropogenic features. The Condor 116 (4), 629-642.

Dinkins, J.B., K.T. Smith, J.L. Beck, C.P. Kirol, A.C. Pratt and M.R. Conover. 2016. Microhabitat conditions in Wyoming sage-grouse core areas: effects on selection and nest success. PLoS ONE 11:e0150798.

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.

Dinkins, J.B., K.J. Lawson, K.T. Smith, J.L. Beck, C.P. Kirol, A.C. Pratt, M.R. Conover, and F.C. Blomquist. 2017. Quantifying overlap and fitness consequences of migration strategy with seasonal habitat use and a conservation policy. Ecosphere 8(11):e01991.

Dinkins, J.B., K.J. Lawson, and J.L. Beck. 2021. Influence of environmental change, harvest exposure, and human disturbance on population trends of greater sage-grouse. PLOS ONE.

Dinkins, J.B., C.J. Duchardt, J.D. Hennig, and J.L. Beck. 2021. Changes in hunting season regulations (1870s-2019) reduce harvest exposure on greater and Gunnison sage-grouse. PLOS ONE.

Doherty, K.E., D.E. Naugle and B.L. Walker. 2008. Sage-grouse winter habitat selection and energy development. Journal of Wildlife Management 72:187-195.

Doherty, K.E., D.E. Naugle and B.L. Walker. 2010. Greater sage-grouse nesting habitat: the importance of managing at multiple scales. Journal of Wildlife Management 74(7):1544-1553.

Doherty, K.E, D.E. Naugle and J.S. Evans. 2010. A currency for offsetting energy development impacts: horsetrading sage-grouse on the open market. PLoS ONE 5(4):e10339.

Doherty, K.E., J.L. Beck and D.E. Naugle. 2011. Comparing ecological site descriptions to habitat characteristics influencing greater sage-grouse nest site occurrence and success. Rangeland Ecology and Management 64(4):344-351.

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(6):320-325.

Donnelly, J.P., B.W. Allred, D. Perret, N.L. Silverman, J.D. Tack, V.J. Dreitz, J.D. Maestas, D.E. Naugle. 2018. Seasonal drought in North America's sagebrush biome structures dynamic

mesic resources for sage-grouse. Ecology and Evolution 8:12492-12505.

Duchardt, C. J. A.P. Monroe, D.R. Edmunds, M.J. Holloran, A.G. Holloran, C.L. Aldridge. 2023. Using neutral landscape models to evaluate the umbrella species concept in an ecotone. Landscape Ecology 8: 1447-1462.

Dzialak, M.R., C.V. Olson, S.M. Harju, S.L. Webb, J.P. Mudd, J.B. Winstead and L.D. Hayden-Wing. 2011. Identifying and prioritizing greater sage-grouse nesting and brood rearing habitat for conservation in human-modified landscapes. PLoS ONE 6(10): e26273.

Dzialak, M.R., C.V. Olson, S.L. Webb, S.M. Harju and J.B. Winstead. 2012. Temporal and hierarchical spatial components of animal occurrence: conserving seasonal habitat for greater sage-grouse. Ecosphere 3:art30.

Dzialak, M.R., S.L. Webb, S.M. Harju, C.V. Olson, J.B. Winstead and L.D. Hayden-Wing. 2013. Greater sage-grouse and severe winter conditions: identifying habitat for conservation. Rangeland Ecology and Management 66:10-18.

Dzialak, M.R., C.V. Olson, S.L. Webb, S.M. Harju and J.B. Winstead. 2015. Incorporating within- and between-patch resource selection in identification of critical habitat for brood-rearing greater sage-grouse. Ecological Processes v.4 art. 5. https://doi.org/10.1186/s13717-015-0032-2.

Edmunds, D.R., C.L. Aldridge, M.S. O'Donnell, and A.P. Monroe. 2017. Greater sage-grouse population trends across Wyoming. Journal of Wildlife Management 82:397-412.

Fedy, B.C. and K.E. Doherty. 2010. Population cycles are highly correlated over long time series and large spatial scales in two unrelated species: greater sage-grouse and cottontail rabbits. Oecologia 165:915-924.

Fedy, B.C. and C.L. Aldridge. 2011. The importance of within-year repeated counts and the influence of scale on long-term monitoring of sage-grouse. Journal of Wildlife Management 75(5): 1022-1033.

Fedy, B.C., C.L. Aldridge, K.E. Doherty, M. O'Donnell, et al. 2012. Interseasonal movements of greater sage- grouse, migratory behavior, and an assessment of the core regions concept in Wyoming. Journal of Wildlife Management 76:1062–1071.

Fedy, B.C., K.E. Doherty, C.L. Aldridge, M. O'Donnell, et al. 2014. Habitat prioritization across large landscapes, multiple seasons, and novel areas: an example using greater sage-grouse in Wyoming. Wildlife Monographs 190:1–39.

Fedy, B.C., C. P. Kirol, A.L. Sutphin and T.L. Maechtle. 2015. The influence of mitigation on sage-grouse habitat selection within an energy development field. PLoS ONE 10(4): e0121603. doi:10.1371/journal.pone.0121603

Fedy, B.C., M.S. O'Donnell and Z.H. Bowen. 2015. Large-scale control site selection for population monitoring - An example assessing sage-grouse trends: Wildlife Society Bulletin 39:700–712.

Fedy, B.C., J.R. Row, and S.J. Oyler-McCance. 2017. Integration of genetic and demographic data to assess population risk in a continuously distributed species. Conservation Genetics 18:89-104.

Forbey, J.S., G.L. Patricelli, D.M. Delparte, A.H. Krakauer, P.J. Olsoy, M.R. Fremgen, J.D. Nobler, L.P. Spaete, L.A. Shipley, J.L. Rachlow, A.K. Dirksen, A. Perry, B.A. Richardson, and N.F. Glenn. 2017. Emerging technology to measure habitat quality and behavior of grouse: examples from studies of greater sage-grouse. Wildlife Biology 10.2981.

Fremgen, A.L., C.P. Hansen, M.A. Rumble, R.S. Gamo and J.J. Millspaugh. 2016. Male greater sage-grouse detectability on leks. Journal of Wildlife Management 80:266–274.

Fremgen, A.L., C.T. Rota, C.P. Hansen, M.A. Rumble, R.S. Gamo, and J.J. Millspaugh. 2017. Male greater sage-grouse movements among leks. Journal of Wildlife Management 81:498-508.

Gamo, R.S. and J.L. Beck. 2017. Effectiveness of Wyoming's sage-grouse core areas: Influences on energy development and male lek attendance: Environmental Management 59(2)189-203.

Gerringer, M. B. K. T. Smith, K.L. Kosciuch. Observations of Greater Sage-Grouse at a Solar Energy Facility in Wyoming. 2022. Western North American Naturalist, 82(1):196-200. https://doi.org/10.3398/064.082.0121.

Green, A.W., C.L. Aldridge and M.S. O'Donnell. 2017. Investigating impacts of oil and gas development on greater sage-grouse: Journal of Wildlife Management 81:46-57.

Gregory, A.J. and J.L. Beck. 2014. Spatial heterogeneity in response of male greater sage- grouse lek attendance to energy development. PLoS ONE 9(6):e97132. doi:10.1371/journal.pone.0097132

Harju, S.M., M.R. Dzialak, R.C. Taylor, L.D. Hayden-Wing., J.B. Winstead. 2010. Thresholds and time lags in effects of energy development on greater sage-grouse populations. Journal of Wildlife Management 74:437-448.

Hansen, C.P., L.A. Schreiber, M.A. Rumble, J.J. Millspaugh, R.S. Gamo, J.W. Kehmeier and N. Wojcik. 2016. Microsite selection and survival of greater sage-grouse nests in south-central Wyoming: Journal of Wildlife Management 80:862–876.

Harju, S.M., C.V. Olson, M.R. Dzialak, J.P. Mudd, J.B. Winstead. 2013. A flexible approach for assessing functional landscape connectivity, with application to greater sage-grouse (*Centrocercus urophasianus*). PLoS ONE 8(12): e82271. doi:10.1371/journal.pone.0082271

Harju, S.M., C.V. Olson, L. Foy-Martin, S.L. Webb, M.R. Dzialak, J.B. Winstead and L.D. Hayden-Wing. 2013. Occurrence and success of greater sage-grouse broods in relation to insect vegetation community gradients. Human–Wildlife Interactions 7(2):214–229.

Harmon, L. and D. Hirchert. 2016, Managing safety and wildlife at Jackson Hole Airport: Journal of Airport Management 10:381–401.

Heinrichs, J.A., C.L. Aldridge, M.S. O'Donnell, and N.H. Schumaker. 2017. Using dynamic population simulations to extend resource selection analyses and prioritize habitats for conservation. Ecological Modelling 359:449-459.

Heinrichs, J.A., M.S. O'Donnell, C.L. Aldridge, S.L. Garman, and C.G. Homer. 2019. Influences of potential oil and gas development and future climate on sage-grouse declines and redistribution. Ecological Applications 0(0):e01912.

Hennig, J. D., J. D. Scasta, A. C. Pratt, C. P. Wanner, and J. L. Beck et al. 2022. Habitat selection and space use overlap between feral horses, pronghorn, and greater sage-grouse in cold arid steppe. Journal of Wildlife Management. https://doi.org/10.1002/jwmg.22329.

Hess, J.E. and J.L. Beck. 2012. Disturbance factors influencing Greater Sage-grouse lek abandonment in north-central Wyoming. Journal of Wildlife Management 76:1625-1634.

Hess, J. E. and J. L. Beck. 2012. Burning and mowing Wyoming big sagebrush: do treated sites meet minimum guidelines for greater sage-grouse breeding habitats? Wildlife Society Bulletin 36:85–93.

Hess, J.E and J.L. Beck. 2014. Forb, insect, and soil response to burning and mowing Wyoming big sagebrush in greater sage-grouse breeding habitat. Environmental Management 53:813-822.

Holloran, M.J. and S.H. Anderson. 2003. Direct identification of Northern sage-grouse, *Centrocercus urophasianus*, nest predators using remote sensing cameras. Canadian Field- Naturalist 117:308-310.

Holloran, M.J., and S.H. Anderson. 2005. Spatial distribution of greater sage-grouse nests in relatively contiguous sagebrush habitats. Condor 107:742-752.

Holloran, M.J., B.J. Heath, A.G. Lyon, S.J. Slater, J.L. Kuipers and S.H. Anderson. 2005. Greater sage-grouse nesting habitat selection and success in Wyoming. Journal Wildlife Management 69:638-649.

Holloran, M.J., R.C. Kaiser and W.A. Hubert. 2010. Yearling greater sage-grouse response to energy development in Wyoming. Journal of Wildlife Management 74:65-72.

Holloran, M.J., B.C. Fedy and J. Dahlke. 2015. Winter habitat use of greater sage-grouse relative to activity levels at natural gas well pads. Journal of Wildlife Management 79:630-640.

Hopken, M.W., E.K. Orning, J.K. Young, and A.J. Piaggio. 2016, Molecular forensics in avian conservation—A DNA-based approach for identifying mammalian predators of

ground-nesting birds and eggs: BMC Research Notes v.9, art.14, https://doi.org/10.1186/s13104-015-1797-1.

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.

Kiesecker, J.M., J.S. Evans, J. Fargione, K. Doherty, K.R. Foresman, T.H. Kunz, D. Naugle, N.P. Nibbelink, N.D. Neimuth. 2011. Win-win for wind and wildlife: a vision to facilitate sustainable development. PLoS ONE 6(4): e17566. doi:10.1371/journal.pone.0017566

Kirol, C.P., J.L. Beck, J.B. Dinkins and M.R. Conover. 2012. Microhabitat selection for nesting and brood-rearing by the greater sage-grouse in xeric big sagebrush. The Condor 114:75-89.

Smith, K. T., C. P. Kirol, J. L. Beck, and F. C. Blomquist. 2014. Prioritizing winter habitat quality for greater sage-grouse in a landscape influenced by energy development. Ecosphere 5(2):15.

Kirol, C.P., A.L. Sutphin, L. Bond, M.R. Fuller and T.L. Maechtle. 2015. Mitigation effectiveness for improving nesting success of greater sage-grouse influenced by energy development. Wildlife Biology 21: 98-109.

Kirol, C.P., J.L.Beck, S.V. Huzurbazar, M.J. Holloran, S.N. Miller. 2015. Identifying greater sage-grouse source and sink habitats for conservation planning in an energy development landscape. Ecological Applications 25:968–990.

Kirol, C. P., K. L. Pilgrim, A. L. Sutphin, and T. L. Maechtle. 2018. Using DNA from Hairs Left at Depredated Greater Sage-grouse Nests to Detect Mammalian Nest Predators. Wildlife Society Bulletin. 42(1):160-165 Available at https://www.fs.fed.us/rm/pubs_journals/2018/rmrs_2018_kirol_c001.pdf.

Kirol, C.P., K.T. Smith, N.E. Graf, J.B. Dinkins, C.W. LeBeau, T.L. Maechtle, A.L. Sutphin, J.L. Beck. 2020. Greater Sage-grouse Response to the Physical Footprint of Energy Development. Journal of Wildlife Management 84:989-1001.

Kirol, C. P., and B. C. Fedy. 2021. Does habitat reclamation following energy development benefit songbird nest survival? Avian Conservation and Ecology 16.

Klott, J.H., and F.G. Lindzey. 1989. Comparison of sage and sharp-tailed grouse leks in south central Wyoming. Great Basin Naturalist 49:275-278.

Klott, J.H. and F.G. Lindzey. 1990. Brood habitats of sympatric sage grouse and Columbian

sharp-tailed grouse in Wyoming. Journal of Wildlife Management 54:84-88.

Koch, R.E., A.H. Krakauer and G.L. Patricelli. 2015. Investigating female mate choice for mechanical sounds in the male greater sage-grouse. The Auk 132:349-358.

Krakauer, A. H., M. Tyrrell, K. Lehmann, N. Losin, F. Goller and G. Patricelli. 2009. Vocal and anatomical evidence for two-voiced sound production in greater sage-grouse *Centrocercus urophasianus*. Journal of Experimental Biology 212:3719-3727.

Krakauer, A.H., M.A. Blundell, T.N. Scanlan, M.S. Wechsler, E.A. McCloskey, J.H. Yu and G.L. Patricelli. 2016. Successfully-mating male sage-grouse show greater laterality in courtship and aggressive interactions. Animal Behaviour. 111: 261-267.

Lazenby, K.D., P.S. Coates, S.T. O'Neil, M.T. Kohl, 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 78:522-530.

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

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. 2017. Greater sage-grouse habitat selection, survival, and wind energy infrastructure. Journal of Wildlife Management 81:690–711.

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

Lyon, A.G. and S.H. Anderson. 2003. Potential gas development impacts on sage grouse nest initiation and movement. Wildlife Society Bulletin 31:486-491.

Mabray, S.T. and M.R. Conover. 2015, Microhabitat selection by greater sage-grouse hens during brood rearing: Human-Wildlife Interactions, 9(2)219–228.

McCaffery, R. and P.M. Lukacs. 2016. A generalized integrated population model to estimate greater sage-grouse population dynamics. Ecosphere 7(11) art. e01585. http://doi.org/10.1002/ecs2.1585.

Meyerpeter, M.B., K.D. Lazenby, P.S. Coates, M.A. Ricca, S.R. Mathews, S.C. Gardner, D.K. Dahlgren, D.J. Delehanty. 2021. Field methods for translocating female greater sage-grouse (*Centrocercus urophasianus*) with their broods. Wildlife Society Bulletin, DOI: 10.1002/wsb.1199.

Monroe, A.P., Edmunds, D.R. and Aldridge, C.L. 2016. Effects of lek count protocols on greater sage-grouse population trend estimates. Journal of Wildlife Management, 80:667–678.

Monroe, A.P., C.L. Aldridge, T.J. Assal, K.E. Veblen, D.A. Pyke and M.L. Casazza. 2017. Patterns in greater sage-grouse population dynamics correspond with public grazing records at broad scales: Ecological Applications 27:1096–1107, https://doi.org/10.1002/eap.1512.

Monroe, A.P., C.L. Aldridge, M.S. O'Donnell, D.J. Manier, C.G. Homer, and P.J. Anderson. 2019. Using remote sensing products to predict recovery of vegetation across space and time following energy development. Ecological Indicators 110: e105872.

Monroe, A.P., G.T. Wann, C.L. Aldridge, and P.S. Coates. 2019. The importance of simulation assumptions when evaluating detectability in population models. Ecosphere e02791.

Monroe, A.P., C.L. Aldridge, M.S. O'Donnell, D.J. Manier, C.G. Homer, and P.J. Anderson. 2020. Using remote sensing products to predict recovery of vegetation across space and time following energy development. Ecological Indicators 110:105872. https://doi.org/10.1016/j.ecolind.2019.105872

Naugle, D.E., C.L. Aldridge, B.L. Walker, T.E. Cornish, B.J. Moynahan, et al. 2004. West Nile virus: pending crisis for Greater Sage-grouse. Ecology Letters 7:704-713.

Naugle, D. E., C. L. Aldridge, B. L. Walker, K. E. Doherty, M. R. Matchett, J. McIntosh, T. E. Cornish and M. S. Boyce. 2005. West Nile virus and sage-grouse: What more have we learned? Wildlife Society Bulletin 33:616-623.

Naugle, D.E., K.E. Doherty, B. Walker, M. Holloran and H. Copeland. 2011. Greater sage- grouse and energy development in western North America. Pp 489-503 in S.T. Knick and J.W. Connelly (editors). Greater Sage-Grouse: ecology and conservation of a landscape species and its habitats. Studies in Avian biology (vol. 38). University of California Press, Berkeley, CA.

Naugle, D.E., K.E. Doherty, B.L. Walker, H.E. Copeland, M.J. Holloran, and J. D. Tack. 2011. Sage-grouse and cumulative impacts of energy development. Pp. 55-70 in D.E. Naugle, (editor). Energy development and wildlife conservation in western North America. Island Press, Washington, D.C., USA

O'Donnell, M.S., D. R. Edmunds, C. L. Aldridge, J. A. Heinrichs, A. P. Monroe, P. S. Coates, B. G. Prochazka, S. E. Hanser, and L. A. Wiechman. 2022. Defining fine-scaled population structure among continuously distributed populations. Methods in Ecology and Evolution. https://doi.org/10.1111/2041-210X.13949

O'Donnell, M. S., D. R. Edmunds, C. L. Aldridge, J. A. Heinrichs, A. P. Monroe, P. S. Coates, B. G. Prochazka, S. E. Hanser, L. A. Wiechman, T. J. Christiansen, A. A. Cook, S. P. Espinosa, L. J. Foster, K. A. Griffin, J. L. Kolar, K. S. Miller, A. M. Moser, T. E. Remington, T. J. Runia, L.

A. Schreiber, M. A. Schroeder, S. J. Stiver, N. I. Whitford, and C. S. Wightman. 2021. Synthesizing and analyzing long-term monitoring data: A greater sage-grouse case study: Ecological Informatics, v. 63, p. 1-16, https://doi.org/10.1016/j.ecoinf.2021.101327.

O'Donnell, Michael S. and D. J. Manier. 2022. Spatial estimates of soil moisture for understanding ecological potential and risk: a case study for arid and semi-arid ecosystems. Land, 11(10): 1-37. https://doi.org/10.3390/land11101856.

Oh, K.P., C.L. Aldridge, J.S. Forbey, C.Y. Dadabay, and S.J. Oyler-McCance. 2019. Conservation genomics in the sagebrush sea: population divergence, demographic history, and local adaptation in sage-grouse (*Centrocercus* spp.). Genome Biological Evolution 11(7):2023-2034.

Orning, E.K., and J.K. Young, 2016. Impacts of coyote removal on space use by greater sage-grouse: Human-Wildlife Interactions 10(2):144–156.

Orning, E.K., and J.K. Young. 2017. Coyote removal: can the short-term application of a controversial management tool improve female greater sage-grouse survival or nest success? Wildlife Biology: wlb.00345. doi: 10.2981/wlb.00.45.

Oyler-McCance, S.J., S.E. Taylor and T.W. Quinn. 2005. A multilocus population genetic survey of Greater sage-grouse across their range. Molecular Ecology 14:1293-1310.

Oyler-McCance, S.J., R.S. Cornman, K.L. Jones, J.A. Fike. 2015. Genomic single-nucleotide polymorphisms confirm that Gunnison and greater sage-grouse are genetically well differentiated and that the Bi-State population is distinct: The Condor 117:217–227, https://doi.org/10.1650/CONDOR-14-174.1.

Oyler-McCance, S.J., T. B. Cross, J. R. Row, M.K. Schwartz, D. E. Naugle, J. A. Fike, K. Winiarski, B. C. Fedy. 2022. PLOS One. New strategies for characterizing genetic structure in wide-ranging, continuously distributed species: A Greater Sage-grouse case study. https://doi.org/10.1371/journal.pone.0274189.

Patricelli, G.L. and A.H. Krakauer. 2010. Tactical allocation of effort among multiple signals in sage grouse: an experiment with a robotic female. Behavioral Ecology 21:97-106.

Patricelli, G.L., J.L. Blickley and S.L. Hooper. 2013. Recommended management strategies to limit anthropogenic noise impacts on greater sage-grouse in Wyoming. Journal of Human-Wildlife Interactions 7: 230–249.

Peebles, L.W. and M.R. Conover. 2016. Effectiveness of the toxicant DRC-1339 in reducing populations of common ravens in Wyoming: Wildlife Society Bulletin 40:281–287.

Peebles, L.W., M.R. Conover, and J.B. Dinkins. 2017. Adult sage-grouse numbers rise following raven removal or an increase in precipitation. Wildlife Society Bulletin 41:471-478.

Picardi, S., P. Coates, J. Kolar, S. O'Neil, S. Mathews, D. Dahlgren. 2021. Behavioral

state-dependent habitat selection and implications for animal translocations. 2021. Journal of Applied Ecology 2021:00:1-12.

Picardi, S., N. Ranc, B.J. Smith, P.S. Coates, S.R. Mathews, D.K. Dahlgren. 2021. Individual Variation in Temporal Dynamics of Post-release Habitat Selection. Frontiers in Conservation Science. Vol 2. Article 703906.

Post, G. 1951. Effects of toxaphene and chlordane on certain game birds. Journal of Wildlife Management 15:381-386.

Pratt, A.C., K.T. Smith, and J.L. Beck. 2017. Environmental cues used by greater sage-grouse to initiate altitudinal migration. Auk 134:628-643.

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

Pratt, A.C., K.T. Smith, and J.L. Beck. 2019. Prioritizing seasonal habitats for comprehensive conservation of a partially migratory species. Global Ecology and Conservation 17: e00594.

Row, J.R., S.J. Oyler-McCance, J.A. Fike, M.S. O'Donnell, K.E. Doherty, C.L. Aldridge, Z.H. Bowen and B.C. Fedy. 2015. Landscape characteristics influencing the genetic structure of greater sage-grouse within the stronghold of their range: a holistic modeling approach. Ecology and Evolution 5(10): 1955–1969.

Row, J.R., S.J. Oyler-McCance and B.C. Fedy. 2016, Differential influences of local subpopulations on regional diversity and differentiation for greater sage-grouse (*Centrocercus urophasianus*): Molecular Ecology 25:4424–4437.

Row, J.R. and B.C. Fedy. 2017. Spatial and temporal variation in the range-wide cyclic dynamics of greater sage-grouse. Oecologia 185:687-698.

Schreiber, L.A., C.P. Hansen, M.A. Rumble, J.J. Millspaugh, R.S. Gamo, J.W. Kehmeier, N. Wojcik. 2015. Microhabitat selection of brood-rearing sites by greater sage-grouse in Carbon County, Wyoming. Western North American Naturalist 75: 348–363.

Schreiber, L.A., C.P. Hansen, M.A. Rumble, J.J. Millspaugh, S. Gamo, J. Kehmeier and N. Wojcik. 2016. Greater sage-grouse apparent nest productivity and chick survival in Carbon County, Wyoming. Wildlife Biology 22:37-44.

Schulwitz, S., B. Bedrosian and J.A. Johnson. 2014. Low neutral genetic diversity in isolated Greater Sage-Grouse (*Centrocercus urophasianus*) populations in northwest Wyoming. The Condor 116:560-573.

Severson, J.P., P.S. Coates, B.G. Prochazka, M.A. Ricca, M.L. Casazza, and D.J. Delehanty. 2019. Global positioning system tracking devices can decrease greater sage-grouse survival.

Condor, DOI: 10.1093/condor/duz032.

Smith, K.T., C.P. Kirol, J.L. Beck and F.C. Blomquist. 2014. Prioritizing winter habitat quality for greater sage-grouse in a landscape influenced by energy development. Ecosphere 5(2):15.

Smith, J.T., J.S. Evans, B.H. Martin, S. Baruch-Mordo, J.M. Kiesecker and D.E. Naugle. 2016. Reducing cultivation risk for at-risk species—Predicting outcomes of conservation easements for sage-grouse: Biological Conservation 201:10–19.

Smith, K.T., J.L. Beck and A.C. Pratt. 2016. Does Wyoming's core area policy protect winter habitats for greater sage-grouse? Environmental Management 58:585–596.

Smith, K.T. and J.L. Beck. 2017. Sagebrush treatments influence annual population change for greater sage-grouse. Restoration Ecology 26:497-505.

Smith, K.T., J.L. Beck, C.P. Kirol. 2018. Reproductive state leads to intraspecific habitat partitioning and survival differences in greater sage-grouse: implications for conservation. Wildlife Research 45:119-131.

Smith, K.T., J.L. Beck. 2018. Sagebrush treatments influence annual population change for greater sage-grouse. Restoration Ecology 26:497-505.

Smith, K.T., J.S. Forbey, and J.L. Beck. 2018. Effects of mowing and tebuthiuron on the nutritional quality of Wyoming big sagebrush. Rangeland Ecology and Management 2018:417-423.

Smith, K.T., A.C. Pratt, J.R. LeVan, A.M. Rhea, and J.L. Beck. 2019. Reconstructing greater sage-grouse chick diets: diet selection, body condition, and food availability at brood-rearing sites. Condor 121:1-12.

Smith, K.T., J.R. Levan, A.D. Chalfoun, T.J. Christiansen, S.R. Harter, S. Oberlie, J.L. Beck. 2023. Response of greater sage-grouse to sagebrush reduction treatments in Wyoming big sagebrush. Wildlife Monographs. https://doi.org/10.1002/wmon.1075.

Spence, E.S, J.L. Beck, and A.J. Gregory. 2017. Probability of lek collapse is lower inside sage-grouse Core Areas: Effectiveness of conservation policy for a landscape species. PLos ONE 12(11): e0185885. https://doi.org/10.1371/journal.pone.0185885.

Spurrier, M.F., M.S. Boyce and B.F. Manly. 1994. Lek behaviour in captive sage grouse *Centrocercus urophasianus*. Animal Behaviour 47:303-310.

Spurrier, M.F., M.S. Boyce and B.F. Manly. 1991. Effects of parasites on mate choice by captive Sage Grouse. Pages 389-398 *in* J. E. Loye and M. Zuk, editors. Bird-Parasite Interactions: Ecology, evolution, and behaviour. Oxford Ornithological Series 2.

Slater, S.S. and J.P. Smith. 2010. Effectiveness of raptor perch deterrents on an electrical transmission line in southwestern Wyoming. Journal of Wildlife Management 74:1080-1088.

Taylor, R.L., B.L. Walker, D.E. Naugle and L.S. Mills. 2012. Managing multiple vital rates to maximize greater sage-grouse population growth. Journal of Wildlife Management 76:336-347.

Taylor, R.L., J.D. Tack, D.E. Naugle, L.S. Mills. 2013. Combined effects of energy development and disease on greater sage-grouse. PLoS ONE 8(8): e71256. doi:10.1371/journal.pone.0071256

Thompson, K.M., M.J. Holloran, S.J. Slater, J.L. Kuipers and S.H. Anderson. 2006. Early brood-rearing habitat use and productivity of greater sage-grouse in Wyoming. Western North American Naturalist 66:332-342.

Tredennick, A. T., A.P. Monroe, T. Prebyl, J. Lombardi, C.L. Aldridge. 2023. Dynamic spatiotemporal modeling of a habitat-defining plant species to support wildlife management at regional scales. Ecosphere. https://doi.org/10.1002/ecs2.4534.

Tyrrell, E. A., B. G. Prochazka, B. E. Brussee, S.P. Espinosa, J. M. Hull. 2023. Wildfire immediately reduces nest and adult survival of greater sage-grouse. Nature Scientific Reports. 13 (10972).

Walker, B.L., D.E. Naugle, K.E. Doherty and T.E. Cornish. 2004. Outbreak of West Nile virus in greater sage-grouse and guidelines for monitoring, handling, and submitting dead birds. Wildlife Society Bulletin 32:1000-1006.

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

Walker, B.L., D.E. Naugle, K.E. Doherty and T.E. Cornish. 2007. West Nile virus and greater sage-grouse: estimating infection rate in a wild bird population. Avian Diseases 51:691- 696.

Webb, S.L., C.V. Olson, M.R. Dzialak, S.M. Harju, J.B. Winstead and D. Lockman. 2012. Landscape features and weather influence nest survival of a ground-nesting bird of conservation concern, the greater sage-grouse, in human-altered environments. Ecological Processes 1:art4.

Wiley, R.H. 1973. The strut display of male Sage Grouse: A "fixed" action pattern. Behaviour 47:129-152.

Wiley, R.H. 1973. Territoriality and non-random mating in sage grouse, *Centrocercus urophasianus*. Animal Behavior Monographs 6:87-169.

Wiley, R.H. 1974. Evolution of social organization and life-history patterns among grouse. Quarterly Review of Biology 49:201-227.

Wiley, R.H. 1978. The lek mating system of the sage grouse. Scientific American 238:114-125.

Zabihi, K., G.B. Paige, A.L. Hild, S.N. Miller, A. Wuenschel and M.J. Holloran. 2017. A fuzzy logic

approach to analyze the suitability of nesting habitat for greater sage-grouse in western Wyoming. Journal of Spatial Science 62:215–234.

Zou, L., S. Miller and E. Schmidtmann. 2006. Mosquito larval habitat mapping using remote sensing and GIS: implications of coal-bed methane development and West Nile virus. Journal of Medical Entomology 43:1034-1041.