The Grouse & Grazing Project:
Effects of cattle grazing on sage-grouse demographic traits
2022 Annual Report

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EXECUTIVE SUMMARY

We completed the 9th year of field work on the Grouse & Grazing Project. In 2022, we conducted field work at 4 study sites: Big Butte, Brown's Bench, Pahsimeroi Valley, and Sheep Creek. We did not conduct any field work at the Jim Sage study site in 2022. We had 26 technicians, crew leaders, and students that worked on the project in 2022, including 4 graduate students. We conducted field work in 16 BLM grazing pastures that are part of the grazing experiment, and numerous other pastures adjacent to the 16 BLM grazing pastures. We deployed and maintained 9 segments of temporary electric fences (~43.5 km total) on experimental pastures to implement experimental grazing treatments. We captured and marked an additional 137 female sage-grouse in 2022 and we followed 63 females that were captured in previous years and returned to our sites (200 radio-collared hens in 2022). We documented 68 mortalities of radio-marked hens in 2022. We located and monitored 176 sage-grouse nests and 42 sage-grouse broods. Apparent nesting success across all 4 study sites was 24% in 2022, which is lower than the project average of 34% across all 5 study sites. Nesting propensity was 100% and re-nesting propensity was 41% in 2022. Among the 42 broods, apparent survival was 43%, which is also lower than the project average across 9 years of 53%.

We conducted vegetation measurements at 471 plots in 2022 (119 nest plots, 320 random plots, and 32 brood plots). We measured grass height, percent biomass removed, and other metrics on 31,212 grass plants within those 471 plots. In addition, we collected 1,280 biomass measurements and 720 samples across our 320 random plots used in our vegetation measurement surveys. In 2022, we also walked 201 utilization transects throughout the 16 experimental pastures to estimate utilization, and we measured grass metrics at 2,946 sampling points along the 549 km of transects. Utilization measured with the landscape appearance method in the grazed study pastures averaged 22% in 2022, slightly more than the project average in these pastures (19%).

Across the 9 years of the project, we have measured 277,326 perennial grasses across 4,610 growing-season surveys (15 Apr – 18 Jul) and 175,465 perennial grasses across 2,838 post-growing season surveys (19 Jul – 15 Aug). We have also collected 12,183 pitfall samples and 6,218 sweep-net samples for arthropods across 787 plots. Within our grazed treatment pastures, cattle herds of 50-682 have been stocked and grazed 63 – 842 AUMs annually. Using data from the project, we have made 56 presentations and the data and funding has supported 9 graduate students and dozens of undergrads.

We collected the 7th year of post-treatment data at the Brown's Bench study site, the 6th year of post-treatment data at the Sheep Creek study site, the 5th year of post-treatment data at the Big Butte study site, and the 4th year of post-treatment data at the Pahsimeroi Valley site. We did not collect any data at the Jim Sage study site in 2022.

INTRODUCTION

The distribution of the greater sage-grouse (hereafter sage-grouse; *Centrocercus urophasianus*) has contracted (Schroeder et al. 2004) and abundance of males attending leks throughout the species' range has decreased substantially over the past 50 years (Garton et al. 2011, 2015; Western Association of Fish & Wildlife Agencies 2015; Coates et al. 2021). Livestock grazing is a common land use within sage-grouse habitat, and livestock grazing has been implicated as one of numerous factors contributing to sage-grouse population declines (Beck and Mitchell 2000, Schroeder et al. 2004). However, livestock grazing might benefit sage-grouse via numerous mechanisms (Beck and Michell 2000, Crawford et al. 2004). Livestock grazing on public lands is often restricted to try to minimize negative effects on populations of plants and animals (including sage-grouse), but we lack experimental studies that have explicitly examined the effects of livestock grazing on sage-grouse. The objective of the Grouse & Grazing Project is to implement randomized grazing treatments to better document the relationship between cattle grazing and sage-grouse demographic traits, nest-site selection, and habitat features. We focused particularly on spring cattle grazing because spring is thought to be the time when livestock grazing is most likely to adversely affect sage-grouse (Neel 1980, Pedersen et al. 2003, Boyd et al. 2014).

STUDY AREA

Our field work has occurred at 6 study sites in Idaho within Owyhee, Twin Falls, Cassia, Butte, Custer, Bingham, and Jefferson counties (Figure 1). All of these study sites are located in Sage-Grouse Management Zone IV: The Snake River Plain (Knick 2011). Elevations at the 6 study sites range from 1,400 m to 1,900 m. Wyoming big sagebrush (*Artemisia tridentata wyomingensis*) is common in the overstory at all study sites. Other overstory shrubs include low sagebrush (*Artemisia arbuscula*), three-tip sagebrush (*Artemisia tripartita*), rubber rabbitbrush (*Ericameria nauseosa*), and green rabbitbrush (*Chrysothamnus viscidiflorus*). The most common understory grasses are Sandberg bluegrass (*Poa secunda*), bottlebrush squirreltail (*Elymus elymoides*), bluebunch wheatgrass (*Pseudoroegneria spicata*), western wheatgrass (*Pascopyrum smithii*), and needlegrass (*Achnatherum spp.* and *Hesperostipa spp.*).

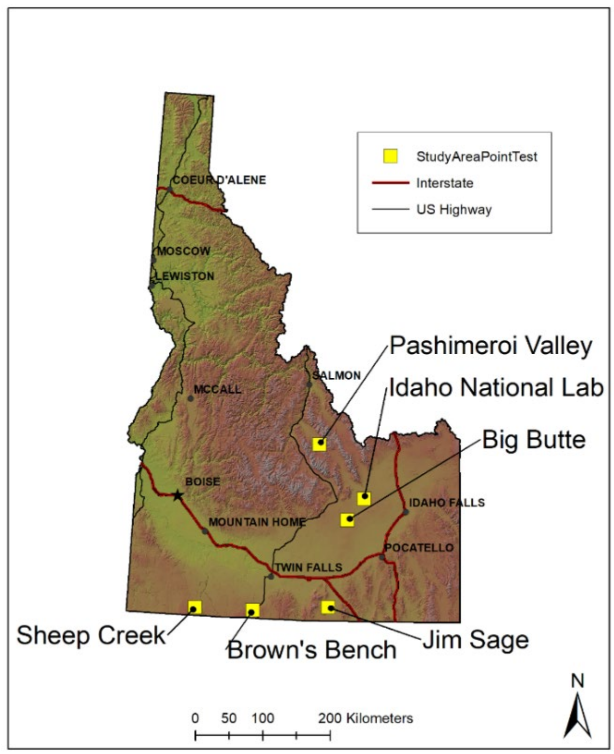

Figure 1. Location of 6 study sites where field work was conducted across southern Idaho (field work at Idaho National Lab was limited to one year; 2019).

METHODS

A detailed document containing all methods used in the Grouse & Grazing Project is available on the project website (https://idahogrousegrazing.wordpress.com/) (Conway et al. 2021). In the Methods sections below, we only mention changes to the methods that were implemented for the 2022 field season.

Experimental Design

We began field work at two study sites in 2014 (Brown's Bench, Jim Sage), two more in 2015 (Big Butte, Sheep Creek), one in 2017 (Pahsimeroi), and one in 2019 (Idaho National Lab), but we ceased field work at Idaho National Lab in March 2020 due to COVID-19 restrictions and the loss of sage-grouse habitat caused by a 2019 fire at INL. We also ceased field work at the Jim Sage study site after the 2021 season at the request of our permittees at that study site. More details regarding the study design for the Grouse & Grazing Project are in the "Experimental Design" section of the methods document posted on the project website (Conway et al. 2021).

Capture and Radio-marking

We captured sage-grouse via nighttime spotlighting methods detailed in *section 1* of Conway et al. (2021). We did not attempt to capture any females with rocket-nets on leks in 2022; we only captured grouse via nighttime spotlighting.

Nest Searching and Monitoring

We monitored radio-marked sage-grouse using methods described in *section 2* of Conway et al. (2021). We had no major changes to our nest searching and hen monitoring protocol in 2022.

Brood Monitoring

In 2022, we used 3 methods to monitor the fate of sage-grouse broods: daytime visual surveys, nighttime spotlight surveys, and nighttime fecal pellet surveys. We conducted daytime visual surveys at 7, 14, 28, and 42 days of age. In 2022, we reduced the number of fecal surveys to 4 surveys per brood, which were conducted at the same day and time as the 4 visual surveys. More details of these methods are in *section 5* of Conway et al. (2021).

Avian Point-Count Surveys (2016-2018)

We conducted avian point-count surveys at 5 of our study sites (Big Butte, Brown's Bench, Jim Sage, Pahsimeroi Valley, and Sheep Creek) from 2016-2018. Funding for these surveys expired in 2018. Methods for these surveys are detailed in our avian point-count protocol.

Short-Eared Owl Surveys (2018-2020)

We conducted surveys for short-eared owls (*Asio flammeus*) in 2018-2020 at 5 of our study sites (all except Idaho National Lab) during the months of March – May in collaboration with project WAfLS. The methods and results of the surveys are detailed in the 2018 and 2019 Short-Eared Owl Report (Meyers and Conway 2018, Meyers and Conway 2019), and the results were included as part of a report that included survey results from 8 western states (Miller et al. 2020).

Vegetation Sampling

From 2014-2022, we measured vegetation at sage-grouse nest plots and random plots within our experimental pastures (and at nests in adjacent pastures). Additional details on methods and results of our vegetation sampling are in our site-specific annual grazing reports. Methods for these vegetation surveys are also in *section 8* of Conway et al. (2021) or in our Vegetation Monitoring Protocol. From 2016-2022, we also took these same measurements at brood plots (i.e., at locations where we documented hens with broods), and from 2020-2021 we also conducted vegetation surveys at the sage-grouse leks within our experimental pastures. In 2021, we measured shrub cover and shrub height at 81 cattle use areas within 4 pastures where we had attached GPS collars to cattle at Jim Sage and Pahsimeroi Valley study sites, and we measured vegetation plots at 46 hen wintering locations in the Pahsimeroi Valley study site.

Biomass Clipping Sampling

Beginning in 2022, we began collecting grass and forb biomass at our random plots within our study pastures to measure fire fuels levels. Data from these clippings will allow us to analyze potential differences in fuels levels between the different grazing treatments. Details regarding these methods of fuels measurement can be found in *section 9* of Conway et al. (2021).

Utilization & Offtake

We used 3 methods to estimate the percent of above-ground perennial grass biomass removed by herbivores (Ocular Estimate, Landscape Appearance, and Grass Height Along Transects). Details regarding these 3 methods for measuring off-take are in *section 10* of Conway et al. (2021).

Stocking Rates

To effectively document the relationship between cattle grazing and sage-grouse demographic traits, we have been collecting stocking rate data of cattle in each of our 16 experimental pastures and for many of the surrounding pastures. Detailed summaries of stocking rates are in the 2022 site-specific Grazing Reports (available at https://idahograusegrazing.org/).

Cattle Movements

During 2018-2020, we collaborated with Dr. Jason Karl, a professor in the Department of Forestry, Rangeland, and Fire Sciences at the University of Idaho, to assess different measures of utilization. This work involved 2 Rangeland Ecology graduate students supervised by Dr. Karl (A. Laurence-Traynor and T. Fletcher). Their 2 objectives complemented the Grouse & Grazing Project:

1. Attach low-cost GPS collars to a subset of cattle within 5 of our experimental pastures (1 in 2018, 2 in 2019, and 2 in 2020) to track cattle movements and link cattle usage with all of our vegetation-based measurements of utilization and compare grouse use (e.g., nest-site selection) to cattle use in the same pastures.
2. Develop a model to assess utilization via remotely sensed images and link those estimates to our on-the-ground estimates of utilization.

Weather and Climate Monitoring

Since the beginning of the study, we obtained precipitation and temperature data at each study site. In 2021, we began using PRISM to collect and model weather data at the study sites. Detailed descriptions of where these weather data were collected are in *section 12* of Conway et al. (2021).

Arthropod Sampling

We conducted arthropod sampling from 2014-2021 across all 5 study sites. Detailed field methods for arthropod sampling are in *section 14* of Conway et al. (2021). The arthropod sampling will be part of Grace Overlie's M.S. thesis. The samples will also be used to create a reference collection for Ty Styhl's M.S. thesis.

STATISTICAL ANALYSIS

Age Ratios

We calculated the yearling-to-adult age ratio of female sage-grouse captured at all study sites in 2022: number yearling females/number adult females. We included all 2022 captured female sage-grouse in this ratio, including those that had been radio-marked from a previous season. This ratio provides an index of recruitment for the previous year. Higher ratios indicate a higher number of yearling females in the population and thus high annual recruitment from the prior year.

Nesting Propensity

We calculated nesting propensity as the number of radio-marked hens that initiated at least one nesting attempt divided by the number of radio-marked hens tracked (i.e., those that we monitored closely) during the nesting period. Past studies that have reported estimates of nesting propensity have not clearly defined a "tracked bird" (i.e., the denominator used in calculating nesting propensity). Selecting an explicit definition of a 'tracked bird' is particularly important for this project because we do not put forth the same tracking effort on all marked hens - we monitor the hens that stay within the experimental pastures closely whereas we largely ignore hens that completely leave the study area (and hens whose signals disappear). Hence, we used 2 approaches to define a "tracked bird" and calculated 2 measures of nesting propensity based on these 2 approaches: 1) a tracked bird = any hen that we either found a nest or we did not find a nest but obtained a location on the hen at least 1 time per week between the 14th and 23rd week of the year; and 2) a tracked bird = any hen that we either found a nest or we did not find a nest but we obtained a location on the hen for >50% of the weeks (i.e., located her at least once during >50% of the weeks) between the 14th and 23rd week of the year. The range of dates that we used for both approaches were based on the earliest and latest nest initiation dates by hens in the first 4 years of the study (2014-2017). We chose these two definitions for a tracked bird because they represent a more conservative definition (approach #1; should yield fewer tracked hens) and a more liberal definition (approach #2; should yield more tracked hens) of a tracked hen.

Nesting success

We calculated apparent nesting success by dividing the number of hatched nests by the total number of nests monitored (hatched nests/[hatched nests + failed nests]), excluding nests with unknown nest fate and those that were visited only once. We calculated apparent nesting success for each study site across all 9 years of the study. We also calculated daily survival of nesting attempts by using program RMark (White and Burnham 1999) to account for potential bias caused by low detection probability for nests that fail early in the nesting cycle (Mayfield 1975). We used the Julian day of the year for the start and end dates of each nesting attempt. We used daily survival estimates from RMark and raised that daily survival probability to the 37th power to estimate the probability that a nesting attempt would survive an entire 37-day nesting cycle (10-day laying period and 27-day incubation period). We included the egg-laying period in this estimate because we find and begin monitoring some nests prior to the onset of incubation. We used the delta method (Powell 2007) to calculate standard errors for 37-day survival estimates for nesting attempts.

Clutch Size & Average Hatch Date

We calculated average clutch size of hatched nests only because depredated nests have fewer eggshell fragments remaining than hatched nests (Schroeder 1997). Throughout the 9 years of our study, we detected eggshell fragments from fewer eggs at failed nests (mean=4.5 eggs) than at hatched nests (mean=6.5 eggs). We used only hatched nests when calculating average hatch date. We do not flush hens when we find a nest and hence, we cannot float eggs to determine their developmental stage. We excluded nesting attempts that we knew were re-nests (second nesting attempts) when calculating average hatch dates.

Hen Survival

We used the known-fate module in RMark to estimate hen survival each year from 2014-2022. We created weekly encounter histories based on telemetry, nest monitoring, and brood monitoring data. Radio-marked hens were coded as either alive, dead, or censored (not detected) for each week during the breeding season. To estimate survival, we focused on the period from week 9 of each year (~1 March) through week 29 (~15 July; a 20-week period) because that is the timeframe when we monitored hens consistently. These reflected our typical earliest and latest monitoring efforts each year (excluding infrequent winter and fall monitoring efforts in 2014-2015). Instead of using a staggered entry design, we coded the 9 years of the study as 9 different groups. If a female was tracked for multiple seasons, we used a separate encounter history for each year that a hen was monitored (with corresponding covariates).

Brood Success and Brood Survival

We calculated apparent brood success by dividing the number of females with ≥1 chick present through 42 days post-hatch by the total number of females whose nests were successful (≥1 egg hatched). We sometimes were unable to detect the signals for hens with a brood and, hence, could not determine the fate of some broods with 100% certainty. Therefore, we present our results using both a conservative estimate and a liberal estimate (based on how we assigned brood fate to hens whose signals disappeared prior to their chicks reaching 42 days of age). We also modeled daily brood survival to examine the effects of study site and year on brood survival by using a Cormack-Jolly-Seber model in RMark similar to methods described by Riley (2019).

2022 SUMMARY

Field Effort

In addition to the full-time project coordinator (C. Tisdale), we hired 4 crew leaders, 7 wildlife technicians, and 7 range technicians and they conducted field work at 4 study sites in 2022. In addition to the 19 University of Idaho/Idaho Cattle Association employees above, 4 graduate students and 2 IDFG biologists (C. Henderson, and S. Gennette) also worked on the project. Lynn Kinter and Jennifer Miller from IDFG provided field training on plant identification to all field personnel.

Electric Fencing

We deployed 9 separate electric fences (43.5 km of total fenceline) across 4 study sites in 2022 (Table 1). All permittees continued to give positive feedback regarding the effectiveness of the temporary electric fences and temporary cattle guard. Overall in 2022, we had very few issues with the electric fences and instances of unscheduled grazing were very minimal.

Table 1. Summary of electric fence deployment at 5 study sites for the Grouse & Grazing Project in southern Idaho from 2016 – 2022.

Year	# of Fences	Longest Fence (km)	Shortest Fence (km)	Total Length (km)
2016	5	5.3 (Brown's Creek East/West)	1.9 (Kane Springs - N/S Cottonwood)	17.2
2017	11	6.2 (Sunset North/South)	1.9 (Kane Springs - N/S Cottonwood)	43.5
2018	12	6.2 (Sunset North/South)	1.5 (Kane Springs North End)	45.9
2019	12	9.4 (River East/River West)	1.9 (Kane Springs/N & S Cottonwood)	54.6
2020	13	6.2 (Sunset North/South)	1.9 (Kane Springs/N & S Cottonwood)	52.4
2021	13	9.4 (River East/River West)	1.9 (Kane Springs/N & S Cottonwood)	59.4
2022	9	6.7 (West River Flat North/South)	2.9 (Corral Creek East/West)	43.5

Weather and Climate Monitoring

Precipitation and Temperature

Starting in 2021, we began to use PRISM to gather weather data for each of our study sites (PRISM Climate Group). PRISM is a program that interpolates weather for a precise area, which we believe will give us more accurate data than our previous method of selecting the closest weather station to the study pastures. While we did not conduct any field work at Jim Sage in 2022, we included the weather data here. In 2021, Idaho experienced a drought, which ended in October 2022 and was noticeable in our weather data (Figure 2). Precipitation leading up to the 2022 breeding season (1 Oct 2021 – 1 Mar 2022) increased in comparison to the months leading up to the 2021 breeding season at 3 study sites (30% increase at Big Butte, 63% increase at Brown's Bench, and 25% increase at Jim Sage) and decreased at the remaining 2 study sites (22% decrease at Pahsimeroi Valley, and 8% decrease at Sheep Creek). The precipitation prior to the 2022 breeding season was also at or slightly above the 30-year normal for all study sites. Comparing the growing season (1 Apr – 1 July) to 2021, all sites had an increase in precipitation (266% increase at Big Butte, 271% increase at Brown's Bench, 141% increase at Jim Sage, 442% increase at Pahsimeroi Valley, and 286% increase at Sheep Creek). Compared to the 30-year normal, Pahsimeroi received above-average precipitation, while the remaining 4 sites received slightly less than average precipitation across the 3-month growing season (Apr-Jul).

Temperatures at all 5 sites were well below average from January-June during the 2022 season, leading to our coldest field season of the project (Figure 3). Overall, the weather trend in 2022 was a colder, relatively wet season, especially during the peak months for grouse nesting of April-June (Figures 2 & 3).

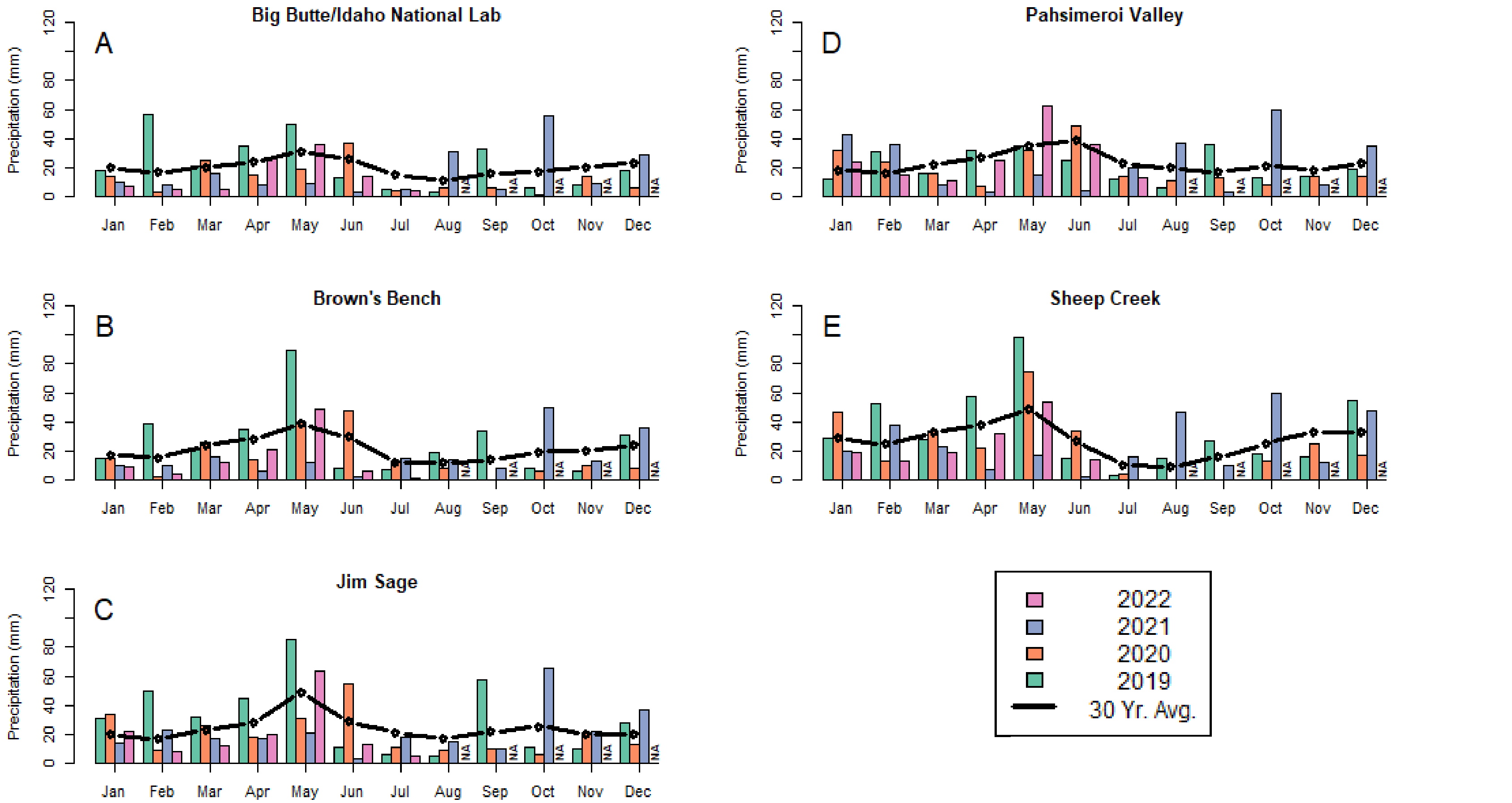

Figure 2. Precipitation (mm) by month for 5 study sites in southern Idaho from January 2019 – July 2022. Dark Lines in each plot represent 30-year average for comparison. NA denotes that weather data were not yet available for that particular month/year. We used PRISM to record and model weather data at each of our 5 study sites.

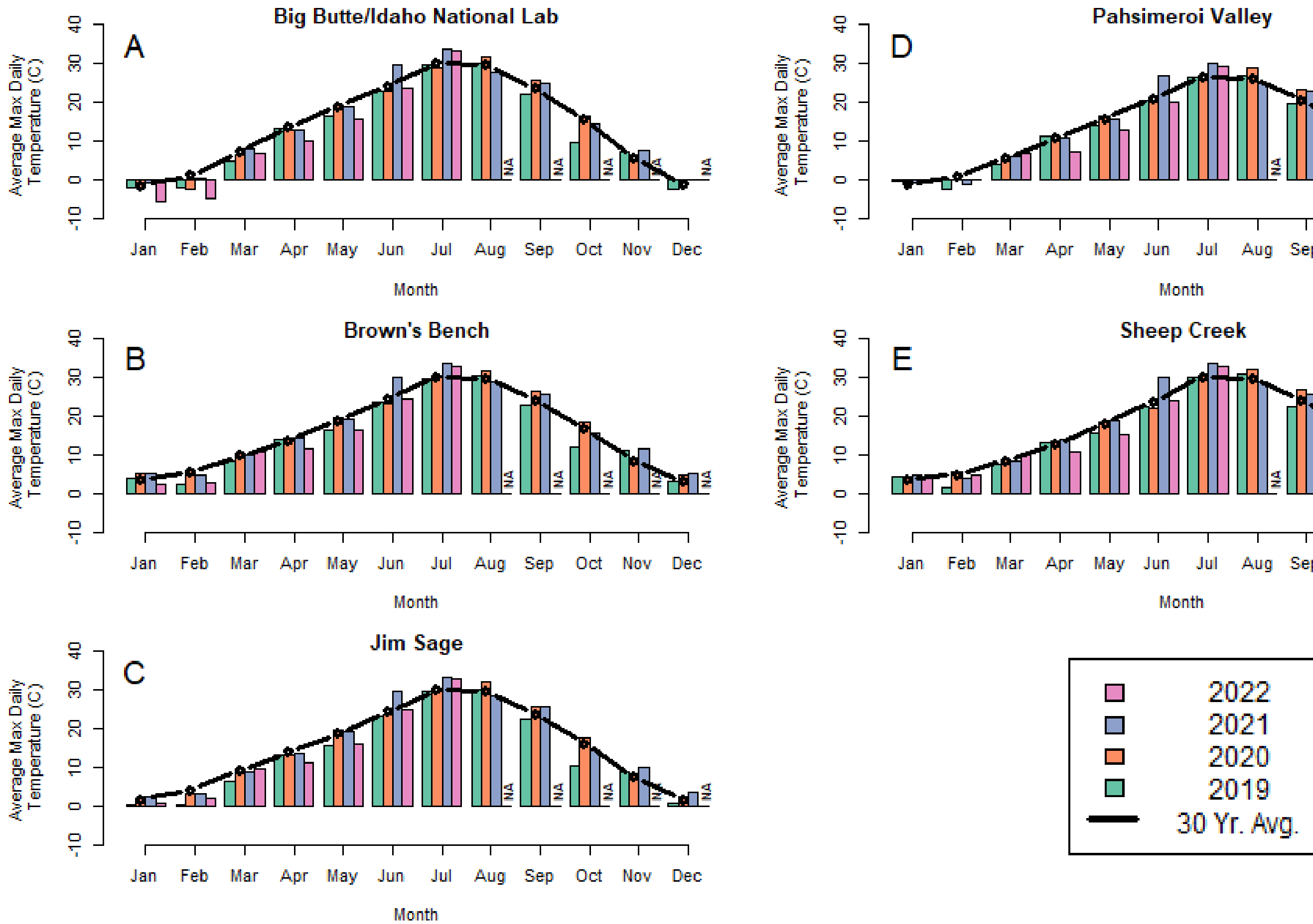

Figure 3. Average maximum daily temperature (°C) by month for 5 study sites in southern Idaho from January 2019 to July 2022. Dark Lines in each plot represent 30-year average for comparison. NA denotes that weather data were not yet available for that particular month/year. We used PRISM to record and model weather data at each of our 5 study sites.

Capture and Radio-marking

We deployed radio transmitters on 137 previously unmarked female sage-grouse across 4 study sites in spring 2022: 78 adults (57%), 58 yearlings (42%), and 1 unknown age (Tables 3-4). In addition to the 137 new females captured in 2022, we also monitored 63 females whose transmitters were deployed in prior years and had returned to the study sites in February 2022 (those with ≥5 detections; Table 2). Hence, we tracked 200 radio-marked hens in 2022.

Table 2. Number of radio-marked female sage-grouse that were initially caught prior to 2022 and were alive and monitored (≥5 detections) at the start of the 2022 field season at 4 study sites in southern Idaho.

	Year Initially Captured[a]					
Study Site	2015	2018	2019	2020	2021	Total Returning
Big Butte	0	0	0	3	16	19
Brown's Bench	0	1[b]	1[b]	1	8	11
Pahsimeroi	0	0	1[b]	4	15	20
Sheep Creek	1[b]	0	0	1	11	13
TOTAL	1	1	2	9	50	63[a]

[a]No hens initially captured in 2014 nor 2016-2017 were present in 2022.
[b]New transmitters were attached subsequent to capture year.

Relative to 2021, the number of new females captured in 2022 (those that had not been marked before 2022) increased slightly at 2 study sites (Big Butte and Sheep Creek) and decreased slightly at 2 study sites (Brown's Bench and Pahsimeroi Valley).

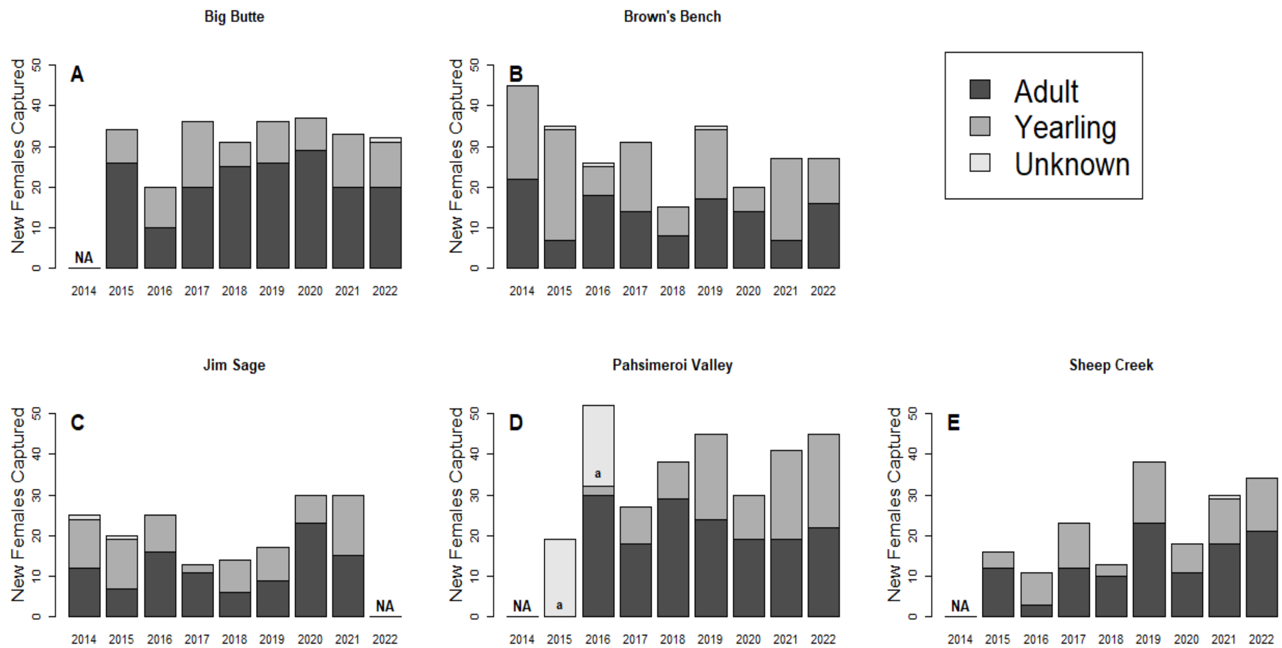

Figure 4. Number of new female sage-grouse captured (excludes any recaptures) at 5 study sites in southern Idaho from 2014-2022. 'NA' denotes that no capture activities occurred in that year. An 'a' at Pahsimeroi in 2015 and 2016 indicates that trapping efforts in those years were conducted by other entities, not by the Grouse & Grazing Project field crews in those years.

Age Ratios

The Yearling-to-Adult ratios we observed this year were lower than 2021 ratios and also lower than the project average at 3 sites. Only Pahsimeroi Valley had a Yearling-to-Adult ratio higher than 2021 (Table 3). The proportion of yearlings was highest at Pahsimeroi Valley (1.14) and lowest at Big Butte (0.39). The age ratios in 2022 correspond with the apparent brood success we observed in 2021 (See 2021 Annual Report; Conway et al. 2021) Overall, the age ratio we observed in 2022 was average compared to our 9-year ratio (Table 4).

Table 3. Number of yearling and adult female sage-grouse captured at 4 study sites across southern Idaho in 2022 and across all years and sites of the study. The numbers in this table include recaptures.

	Big Butte	Brown's Bench	Jim Sage	Pahsimeroi Valley	Sheep Creek	All Study Sites
2022						
#Yearling	11 (28%)	11 (35%)	-	25 (53%)	13 (36%)	60 (39%)
#Adult	28 (72%)	20 (65%)	-	22 (47%)	23 (64%)	93 (61%)
Yearling/ Adult Ratio	0.39	0.55	-	1.14	0.57	0.65
Entire Study (2014-2022)						
#Yearling	91 (32%)	140 (49%)	85 (39%)	101 (33%)	73 (38%)	494[a] (38%)
#Adult	201 (68%)	155 (51%)	133 (61%)	173 (67%)	120 (62%)	789[a] (62%)
Yearling/ Adult Ratio	0.45	0.90	0.64	0.58	0.61	0.63

[a]*Includes 4 yearlings and 7 adults captured at Idaho National Laboratory in 2019.*

Table 4. Number of yearling and adult female sage-grouse captured by year across 5 study sites in southern Idaho 2014-2022. This table includes recaptures and excludes hens whose age was uncertain at capture.

	2014	2015	2016	2017	2018	2019[a]	2020	2021	2022
#Yearling	40 (43%)	51 (47%)	38 (32%)	55 (42%)	33 (27%)	79 (41%)	39 (26%)	92 (49%)	60 (39%)
#Adult	52 (57%)	57 (53%)	82 (68%)	76 (58%)	90 (73%)	116 (59%)	110 (74%)	96 (51%)	93 (61%)
Yearling/Adult Ratio	0.77	0.89	0.46	0.72	0.37	0.68	0.35	0.96	0.65

[a]*Includes 4 yearlings and 7 adults that were captured at Idaho National Laboratory.*

Hen Survival and Mortality

Hen survival varied among years and study sites. Hen survival was lowest in 2017 (Figure 5B), which had a very harsh winter preceding the grouse breeding season. Our sample size for this analysis was higher than in Table 2 (and the text above it) because we included all hens rather than just those hens that were tracked ≥5 times. Our sample size of hens in 2022 decreased compared to 2021 because we only conducted field work at 4 study sites in 2022. Overall, sage-grouse survival has been highest at Jim Sage and lowest at Big Butte (Figure 5A). Survival in 2022 was similar to sage-grouse survival observed the last few years of the study but was lower compared to 2015 and 2016 (Figure 5B).

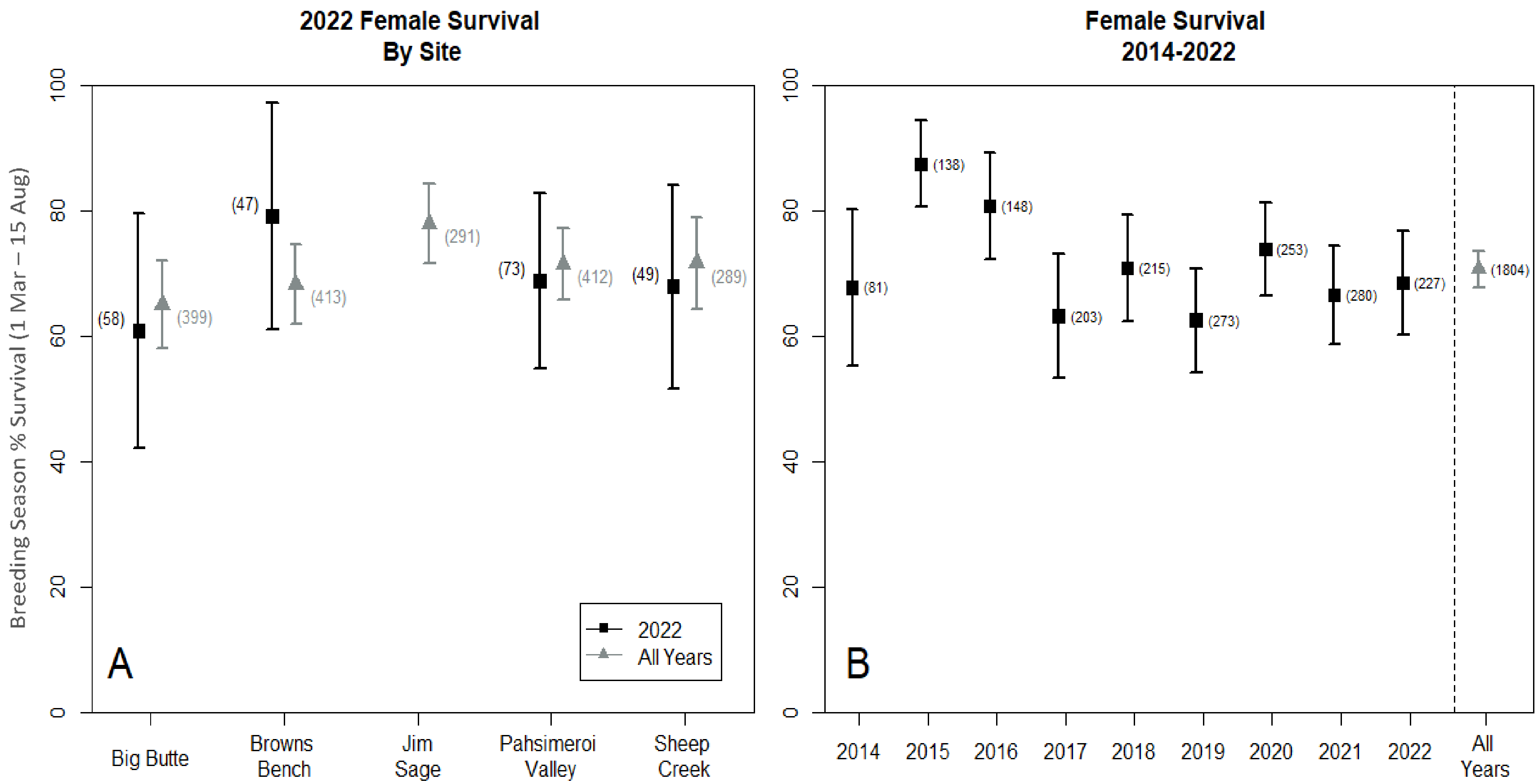

Figure 5. Survival estimates and 95% confidence intervals of female sage-grouse at 5 study sites in 2022 (A) and by year for all study sites pooled (B) during our field season (1 Mar – 15 Aug). Numbers in parentheses represent the number of hens whose encounter histories contributed to the estimate (hens tracked multiple years contribute multiple encounter histories-one for each year tracked).

We recovered 68 collars from apparent mortalities during the 2022 field season. Of these 68 mortalities, 29 (43%) occurred during the winter leading up to the 2022 breeding season (1 Oct 2021 – 29 Feb 2022) and 39 (57%) occurred during the breeding season (1 Mar – 31 Jul 2022). Overwinter mortality leading up to the 2022 breeding season was higher compared to the 2021 season, potentially indicating a more severe winter than previous years. Timing and quantity of mortalities varied across years and study sites (Figure 6). Mortalities were most frequent during April and May each year (during nesting and the early stages of brood rearing); this was again the case in 2022 (Figure 6G). During the 2022 field season, we recorded the most mortalities (22) at Pahsimeroi and the least (7) at Brown's Bench (Figure 6G). This difference in mortalities is due in part to more hens marked at Pahsimeroi than other sites. One major difference that began in 2019 was the number of overwinter mortalities recovered. Since 2019, we've contracted flights to locate radio-marked hens in early Feb just prior to the arrival of field crews. This allowed us to recover mortalities of hens that had died far from the experimental pastures and would not have otherwise been recovered. However, due to scheduling conflicts in 2022, we were only able to conduct a mid-winter flight (Dec-Jan) and were unable to get a flight scheduled for February/March like we had hoped (Table 5).

Table 5 Telemetry flights conducted to search for collared sage-grouse hens in 2014-2022, Idaho.

Year	Dates	Sites Searched
2014	3-18 Mar	JISA
	30-May	JISA
	2-Jul	JISA
	2-Aug	JISA
	4-Sep	BRBE
	31-Oct	BRBE
	9-Dec	BRBE
2015	5-Apr	BRBE, JISA, SHCR
	30-Apr	BRBE, SHCR
	1-4 Jun	BIBU, BRBE, JISA
	1-2 Jul	BIBU, BRBE, JISA, SHCR
2016	5-11 Jan	BIBU, BRBE, JISA, SHCR
	4-7 Apr	BIBU, BRBE, JISA, SHCR
	29 Nov & 12 Dec	BIBU, SHCR
2017	27-Apr	
	28-Jun	
2019	7-8 Feb	BIBU, BRBE, JISA, PAVA, SHCR
	12-Jun	BIBU, IDNL
	25-26 Jun	BIBU, BRBE, IDNL, SHCR
	8-Jul	BIBU, IDNL, PAVA
2020	27-28 Feb	BIBU, BRBE, IDNL, JISA, PAVA, SHCR
	21-May	BIBU, IDNL, PAVA
	15-Jul	PAVA
2021	1-2 Mar	BRBE, JISA, PAVA
	19-21 Jun	BIBU, BRBE
	20-23 Dec	BIBU, BRBE, JISA, PAVA, SHCR
2022	8-Jan	BRBE, SHCR
	20-Jul	BIBU, BRBE

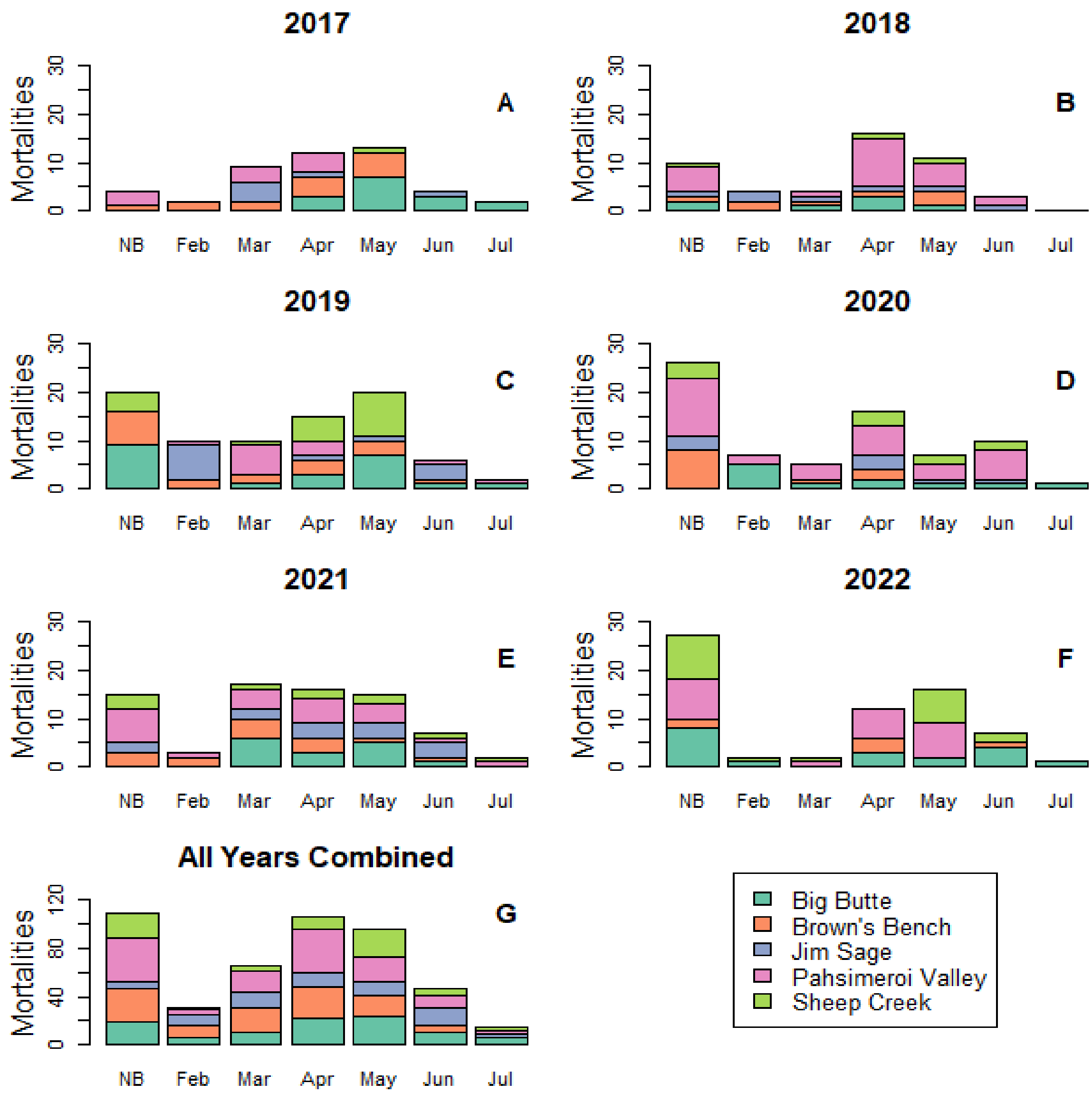

Figure 6. Mortalities of radio-marked female sage-grouse by month (and season) at 5 study sites across southern Idaho from 2014-2022. The value 'NB' on the x-axis represents the cumulative non-breeding months (Aug – Jan; these are also months that we do not monitor sage-grouse and cannot accurately identify the exact month of mortality). Field work was not started at Sheep Creek and Big Butte until 2015 and was not started at Pahsimeroi Valley until 2017. Data for 2014-2016 are included in Panel G but separate panels for those years were not included.

A few of our marked grouse are legally harvested by hunters each year in the September sage-grouse hunting season. In 2018, there was a 7-day hunting season (15 – 21 Sep.) with a daily bag limit of 1 grouse. In 2019, the season was reduced to a 2-day season (21 – 22 Sep) north of the Snake River and a 7-day season south of the Snake River (21 – 27 Sep). This season structure continued in 2020, with the 2-day season occurring 15-17 Sep and the 7-day season occurring 15-22 Sep. In 2021 & 2022, the length of the season was greatly expanded (18 Sept – 31 Oct, but tags were required, and hunters were limited to one or two grouse the entire season, depending on the area. Since 2017, 12 grouse banded by the Grouse & Grazing Project have been harvested (7 radio-collared females and 5 banded males; Table 6).

Table 6. Number of marked sage-grouse from the Grouse & Grazing Project that were harvested by hunters in southern Idaho from 2017-2022. No hunter harvests were reported for 2014-2016.

	2017		2018		2019		2020		2021		2022	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Brown's Bench	-	-	-	2	-	2	2	1	-	-	-	1
Big Butte	-	-	-	-	-	-	-	-	-	-	-	-
Jim Sage	1	-	-	-	1	-	-	-	-	-	-	-
Pahsimeroi Valley	-	-	-	-	-	-	-	-	1	-	-	-
Sheep Creek	-	-	-	1	-	-	-	-	-	-	-	-
All Sites (total)	**1**	**0**	**0**	**3**	**1**	**2**	**2**	**1**	**1**	**0**	**0**	**1**

Nest Searching and Monitoring

We located a total of 176 nests across 4 study sites in 2022 (including nests inside and outside of our experimental pastures; Figure 7). We were able to determine the fate for all 176 nests: 43 hatched at least 1 egg (24%) and 133 were un-successful (76%). Of the 176 nests monitored in 2022, 113 were thought to be initial nesting attempts, 33 were second attempts, and 4 were documented third attempts. We found 26 nests of uncollared hens, and we could not determine whether those were 1^{st}, 2^{nd}, or 3^{rd} nesting attempts. Of the 176 nests, 87 (49%) were in our experimental pastures and 89 (51%) were outside of our experimental pastures (Figure 7).

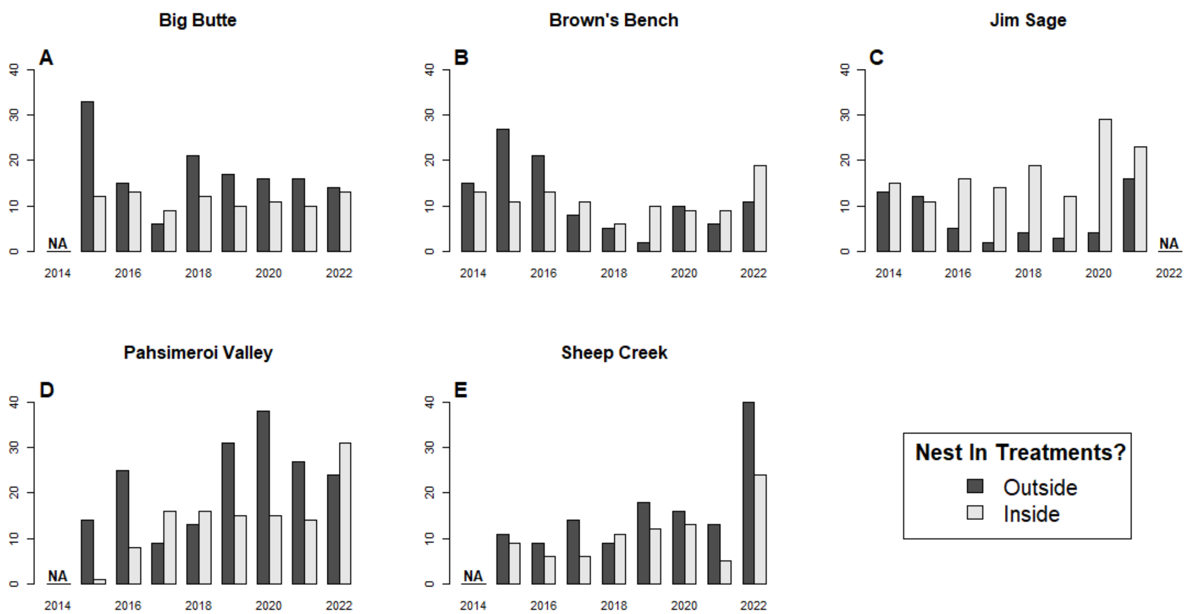

Figure 7. Number of sage-grouse nests inside and outside of experimental pastures at 5 study sites in southern Idaho, 2014-2022. Nests in 2015-2016 at Pahsimeroi Valley were collected by BLM and USFS personnel prior to inclusion in this study.

Nesting Propensity

Overall nesting propensity in 2022 was 100% (n = 113) for method 1 (liberal) and 87.6% (n = 129) for method 2 (conservative); the 2 methods differed in the number of hens included in the denominator that were effectively tracked (Tables 7-8). Nesting propensity was lower during the first few years of the study relative to the subsequent 6 years, likely due to improving our methods of tracking collared hens (Table 8).

Table 7. Nesting propensity of radio-marked sage-grouse hens based on 2 different methods for calculating the number of hens effectively tracked at 4 study sites across southern Idaho in 2022.

Study Site	Hens that Initiated >1 Nest[c]	Method 1[a]		Method 2[b]	
		Hens Tracked	Nesting Propensity	Hens Tracked	Nesting Propensity
Big Butte	22	22	100	30	73.3
Brown's Bench	19	19	100	23	82.6
Pahsimeroi Valley	36	36	100	40	90.0
Sheep Creek	36	36	100	36	100
Overall	113[d]	113	100	129	87.6

[a]Defined a tracked hen as "any hen that we either found a nest or we did not find a nest but obtained a location on the hen ≥1 time per week between the 14th and 23rd week of the year, and thus tracked at least 10 times within the nesting period".
[b]Defined a tracked hen as "any hen that we either found a nest or we did not find a nest but we obtained a location on the hen for >50% of the weeks (i.e., located her at least once during >50% of the weeks) between the 14th and 23rd week of the year and thus tracked at least 5 times within the nesting period".
[c]Number of hens that initiated at least one nest.
[d]26 incidental nests were found in 2022 and are not included in this total.

Table 8. Nesting propensity of radio-marked sage-grouse hens based on 2 different methods for calculating the number of hens effectively tracked for each of 9 years at 5 study sites (pooled) in southern Idaho, 2014-2022.

Year	Hens that Initiated >1 Nest[c]	Method 1[a]		Method 2[b]	
		Hens Tracked	Nesting Propensity	Hens Tracked	Nesting Propensity
2014	50	60	83.3	72	69.4
2015	110	119	92.4	134	82.1
2016	117	133	88.0	157	74.5
2017	81	87	93.1	111	73.0
2018	101	102	99.0	134	75.4
2019	123	128	96.1	149	82.6
2020	143	149	96.0	167	85.6
2021	124	129	96.1	157	79.0
2022	113 [d]	113	100	129	87.6
Overall	962	1,020	94.3	1,210	79.5

[a]Defined a tracked bird as "any hen that we either found a nest or we did not find a nest but obtained a location on the hen ≥1 time per week between the 14th and 23rd week of the year".
[b]Defined a tracked bird as "any hen that we either found a nest or we did not find a nest but we obtained a location on the hen for >50% of the weeks (i.e., located her at least once during >50% of the weeks) between the 14th and 23rd week of the year".
[c]Number of hens that initiated at least one nest, does not include incidentally found nests of uncollared hens.
[d]26 incidental nests were found in 2022 and are not included in this total.

Re-nesting propensity has varied across years. In 2022, we observed more re-nesting attempts than any previous year of the study. Nesting success of re-nesting attempts was slightly lower in 2022 than the 9-year project average.

Table 9. Re-nesting propensity for female sage-grouse at all 5 study sites combined in southern Idaho, 2014-2022.

Year	Failed 1st Attempt	Re-nested	Hatched	Re-nesting Propensity	Apparent Success of Re-nesting Attempts
2014	27	6	3	22.2	50.0
2015	67	12[a]	7	17.9	58.3
2016	59	13	7	22.0	53.8
2017	55	14	3	25.5	21.4
2018	70	11	5	15.7	45.5
2019	85	10	3	11.8	30.0
2020	85	18	7	21.2	38.9
2021	70	9	6	12.8	66.7
2022	84	37[a]	13	44.0	35.1
Total	602	130	54	21.6	41.5

[a]includes 3rd nesting attempts (1 attempt in 2015 and 4 in 2022)

Nesting success

Apparent nesting success was relatively low in 2022 at all study sites compared to previous years, and both Pahsimeroi Valley and Sheep Creek had their lowest apparent nesting success since the study began (Table 10). We also observed the lowest yearly total nesting success in 2022. RMark estimates of the probability of nesting success were lower than apparent nesting success at all study sites (Table 11). RMark estimates for 2022 ranged from 15% (Sheep Creek) to 25% (Brown's Bench; Figure 8A). These estimates of nesting success were the lowest they've been since 2017 (Figure 8B).

Table 10. Apparent nesting success at 5 study sites across southern Idaho (2014-2022).

Study Site	Apparent Nesting success (%)									
	2014	2015	2016	2017	2018	2019	2020	2021	2022	All Years
Big Butte	-[a]	36	29	36	27	26	48	58	30	36
Browns Bench	57	57	38	21	50	42	42	53	30	44
Jim Sage	28	43	33	23	32	20	45	34	-[a]	34
Pahsimeroi	-[a]	-[a]	-[a]	28	26	33	32	38	20	31
Sheep Creek	-[a]	30	33	30	40	30	34	39	23	31
Total	43	44	32	27	32	31	39	43	24	34

[a] We did not conduct field work at this study site during this year.

Table 11. Summary of sage-grouse nests by study site and pasture at 4 study sites in southern Idaho in 2022.

Study Site	Pasture Name	Failed	Hatched	Total	Apparent Nesting success	RMark Nesting success
Big Butte	Butte South	2	2	4		
	Serviceberry	4	0	4		
	Sunset North	2	0	2		
	Frenchman South	3	0	3		
	Other Pastures	8	6	14		
	Total	19	8	27	29.6	17.2
Brown's Bench	Browns Creek East	5	1	6		
	Corral Creek East	1	1	2		
	Indian Cave North	1	1	2		
	Indian Cave South	6	3	9		
	Other Pastures	8	3	11		
	Total	21	9	30	30.0	24.6
Pahsimeroi Valley	Goldburg NE - Big Gulch	13	3	16		
	Goldburg SE - Summit	6	1	7		
	Goldburg SW - Donkey Creek	2	0	2		
	River East	0	2	2		
	River West	2	0	2		
	West River Flat North	2	0	2		
	Other Pastures	19	5	24		
	Total	44	11	55	20.0	16.2
Sheep Creek	East Blackleg (North)	12	4	16		
	Slaughterhouse North	0	0	0		
	(North) Tokum-Bambi East	6	1	7		
	(North) Tokum-Bambi West	4	4	8		
	Other Pastures	27	6	33		
	Total	49	15	64	23.4	15.4
	2022 Overall Estimate	133	43	176	24.4	17.2

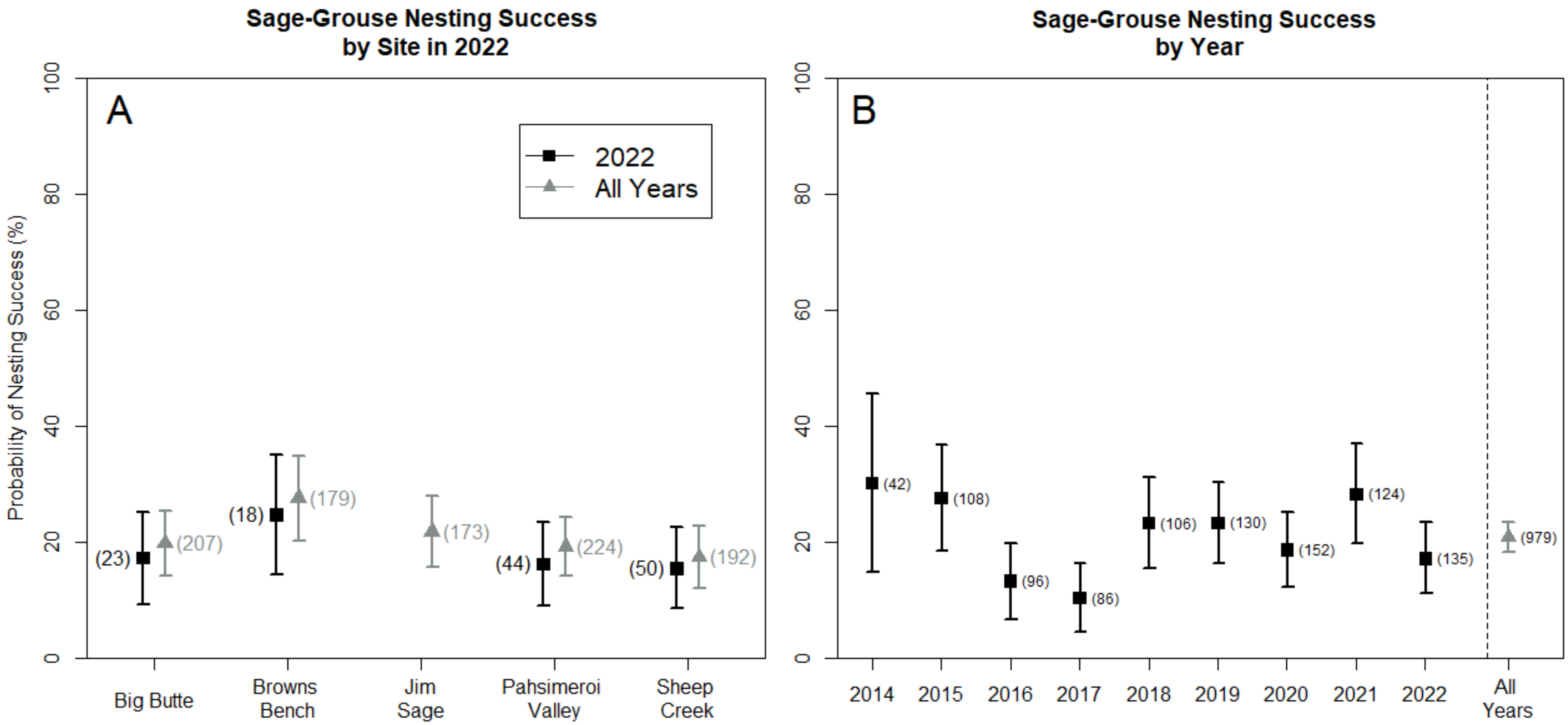

Figure 8. Probability of nest survival for each study site in 2022 as well as all years combined (A) and for each year (combined across all study sites) of the study as well as overall nesting success, 2014-2022 (B). All estimates were calculated using RMark. Estimates were extrapolated from daily survival to estimate the overall probability that a nesting attempt survives across the laying and incubation period (37 days). Bars represent 95% confidence intervals that were calculated using the delta method.

Critical Dates

Hatch Date

Mean hatch date in 2022 varied slightly among the 4 study sites: from 28-May (Brown's Bench) to 9-June (Pahsimeroi Valley; Table 12). Across all 4 study sites, mean hatch date in 2022 was over a week later than in 2021 and two weeks later than the 9-year project average (Table 13).

Table 12. Mean clutch size and hatch date of hatched nests at 4 study sites across southern Idaho in 2022.

Study Site	Clutch Size			Hatch Date		
	Mean	SE	n	Mean	SE	n
Big Butte	7.9	0.398	8	1-Jun	6.6	8
Brown's Bench	6.6	0.801	9	28-May	6.1	9
Pahsimeroi Valley	6.8	0.444	11	9-Jun	5.8	11
Sheep Creek	6.7	0.492	15	5-Jun	4.2	15
All Sites	6.9	0.275	43	3-Jun	2.7	43

Clutch Size

Mean clutch size at our 4 study sites ranged from 6.6 – 7.9 eggs per hatched nest in 2022 (Table 12). These represent minimum number of eggs at each hatched nest because they are based on the number of eggshells that we found at nest sites after hatch. The largest clutch we recorded was 10 eggs and the smallest was 3 eggs. Mean clutch size across all 4 study sites in 2022 was 6.9 eggs per hatched nest. The mean clutch size in 2022 was higher than the 9-year project average and the highest recorded since 2014 (Table 13).

Table 13. Mean clutch size and hatch date of hatched nests for each of the past 9 years (all study sites combined) across southern Idaho from 2014-2022.

Year	Clutch Size			Hatch Date		
	Mean	SE	*n*	Mean	SE	*n*
2014	7.0	0.330	23	22-May	2.7	20
2015	5.9	0.272	61	13-May	2.0	58
2016	6.4	0.273	42	23-May	2.3	41
2017	5.9	0.267	25	1-Jun	2.8	25
2018	6.4	0.237	36	27-May	1.9	36
2019	6.4	0.305	41	26-May	1.4	41
2020	6.6	0.235	63	24-May	1.6	63
2021	6.6	0.219	59	24-May	1.5	59
2022	6.9	0.275	43	3-Jun	2.7	43
All Years	6.5	0.091	393	25-May	0.7	393

Brood Monitoring

In 2022, we tracked broods for 42 of the 43 hatched nests. One hatched nest was from an uncollared hen that a technician found while in the field, so we could not determine the status of her brood. We conducted 182 brood surveys on these 42 broods: 130 visual surveys, 43 fecal surveys, and 9 spotlight surveys. We flushed the hen on 17 of 43 fecal surveys (40%), 1 of 9 (11%) spotlight surveys, and 116 of the 130 daytime visual surveys (89%).

Of the 42 brooding hens we tracked, 17 had at least one chick survive to 42 days of age (Table 14). As in previous years, we calculated a more conservative and a less conservative estimate of brood success to account for our lack of certainty regarding the fate of 4 broods. These 4 broods went missing before 42 days post-hatch due to sudden long-distance movements (or signals that disappeared entirely). Methods for estimating brood survival and the factors that affect brood survival were part of Ian Riley's graduate thesis (Riley 2019) and we incorporated results from Ian's thesis into our brood survey methods and analysis.

Table 14. Fate of sage-grouse broods at 4 study sites across southern Idaho in 2022.

Study Site	Hatched Nests	Lost Hen's Signal[a]	Brood Failed[b]	Brood Survived to 42 days	Brood Success[c]	Brood Success[d]
Big Butte	8	1	5	2	25%	29%
Brown's Bench	9	1	4	4	44%	50%
Pahsimeroi Valley	11	2	6	3	27%	33%
Sheep Creek	15	0	7	8	53%	53%
Overall	43	4	22	17	40%	44%

[a]The signal of the focal hen was lost, and we were unable to accurately determine the fate of the brood at 42 days post-hatch.
[b]The hen did not have a live brood during the brood survey at 42 days post-hatch.
[c]Brood success assuming the broods had failed for hens' signals that were lost prior to 42 days post-hatch.
[d]Brood success censoring the broods for hens' signals that were lost prior to 42 days post-hatch (i.e., they were not included in the denominator).

In 2022, apparent brood survival ranged from 25% at Big Butte to 53% at the Sheep Creek study site. Apparent brood success across the four sites was 40%, slightly lower than the average brood success observed in previous years.

Our model-based estimate of brood success was similar to previous years of the study (Figure 9B). Brood sample size is typically low each year compared to our other demographic measurements. However, after 9 years of tracking broods, we have known fates for 298 broods, and we continue to add more with each year of field work.

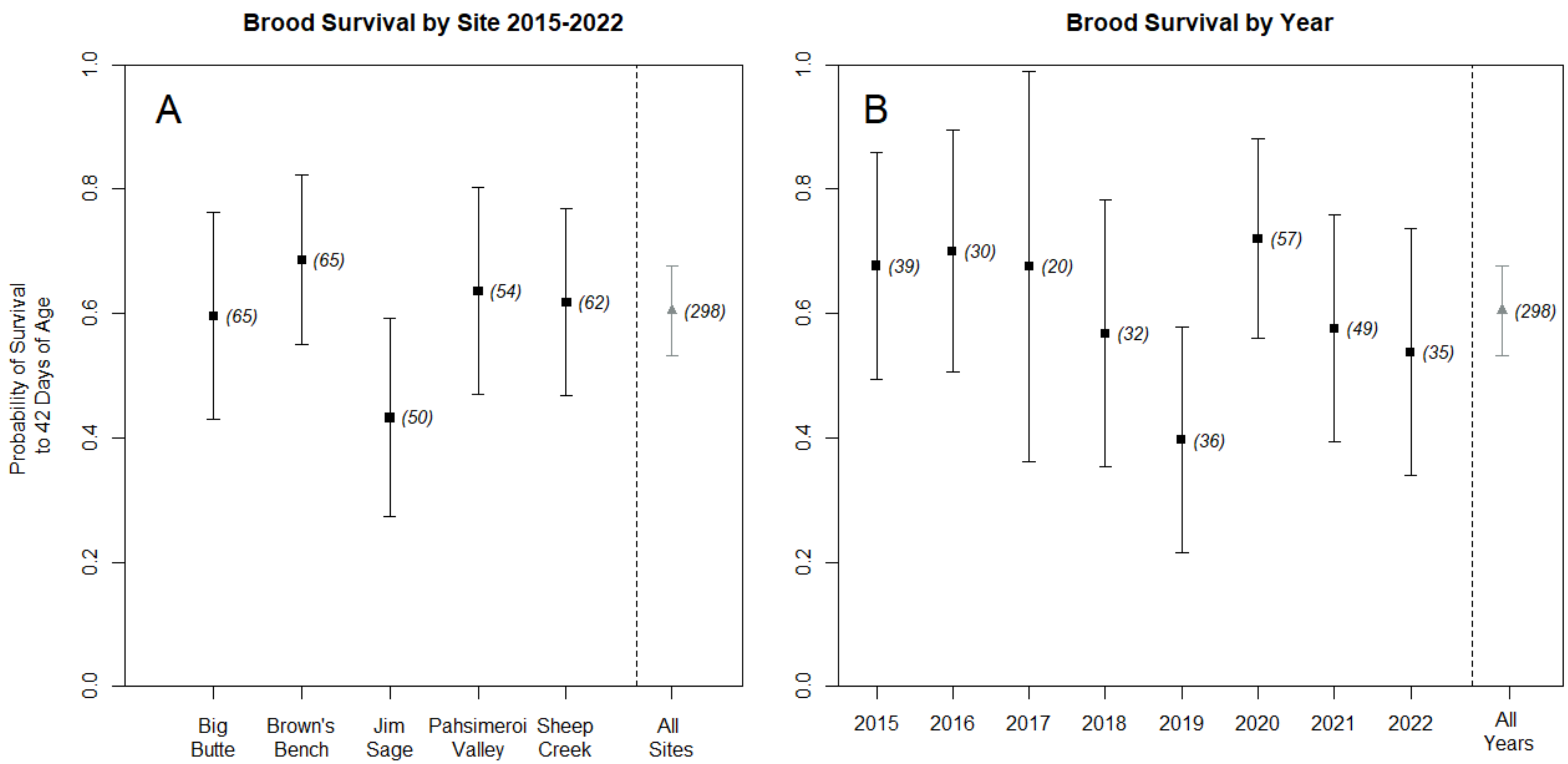

Figure 9. Probability of sage-grouse brood survival calculated using RMark from hatch to 42 days of age by site across all years (A) and by year (B) for 5 study sites across southern Idaho 2014-2022. Detection probability was held constant for each set of estimates and was 0.64 (SE=0.05).

Vegetation Sampling

In 2022, we measured vegetation metrics at 439 vegetation sampling plots (119 nest plots and 320 random plots) from 2 May – 11 July across 4 study sites (Table 15). We sampled grass height and grazing intensity metrics for 30,021 grass plants on the 439 vegetation sampling plots in 2022. We re-sampled 320 of the random plots again at the end of the growing season (19 July – 5 August). In 2022, we walked landscape appearance transects through all 16 experimental pastures to provide estimates of percent utilization (and the most common grass, the dominant shrub, and the percent cover of cheatgrass) at 2,946 sampling locations, and we used these data for pattern use mapping within the 16 experimental pastures. While conducting transects, we also measured height, species, and evidence of grazing for 7,720 individual grass plants across the 2,946 sampling locations. Summaries of these data are included in our site-specific grazing reports (see those reports here: https://idahogrousegrazing.wordpress.com/).

Table 15. Number of nesting and post-growing-season plots sampled each year and the earliest and latest date of completion of those plots at all 5 study sites, 2014-2022.

	Nesting Season						Post-Growing Season		
Year	Random Plots	Nest Plots	Dependent non-nest Plots	Total Plots	Earliest Survey	Latest Survey	Random Plots	Earliest Survey	Latest Survey
2014	39	54	54	147	20-May	2-Jul	0	-	-
2015	280	89	89	458	7-May	9-Jul	279	20-Jul	4-Aug
2016	367	97	61	525	17-Apr	5-Jul	346	18-Jul	18-Aug
2017	351	93	49	493	4-May	5-Jul	379	19-Jul	15-Aug
2018	385	102	0	487	7-May	3-Jul	360	19-Jul	10-Aug
2019	397	120	3	520	30-Apr	27-Jun	398	19-Jul	7-Aug
2020	395	144	0	539	2-May	14-Jul	379	21-Jul	10-Aug
2021	382	117	0	499	3-May	2-Jul	377	19-Jul	4-Aug
2022	320	119	0	439	2-May	11-Jul	320	19-Jul	5-Aug
Totals	2,916	935	256	4,107	30-Apr	14-Jul	2,838	18-Jul	18-Aug

Utilization, Offtake, and Grazing Metrics

We generated estimates of utilization, grass height, and grazing pressure (stocking rate) in all 16 experimental treatment pastures in 2022. These metrics are summarized in our annual site-specific grazing reports (i.e., one grazing report for each study site). In general, we observed average utilization levels in 2022 as compared to previous years at most study sites. Collecting these data will allow us to use utilization, grass height, and grazing pressure as covariates in subsequent analyses of sage-grouse demographic rates.

Arthropod Sampling

We discontinued arthropod sampling after the 2021 field season. Over the 7 years of arthropod sampling on the project, we collected a total of 12,151 pitfall samples and 6,217 sweep-net samples across 786 plots in our experimental pastures at our 5 sites. We also detected 1,511 ant mounds along the ant mound transects near the 786 sampled plots.

Table 16. Summary of arthropod sampling efforts at 5 study sites across southern Idaho, 2015-2021.

Year	Approx. Start Date	Approx. End Date	Study Sites Collected[a]	Total Plots	Pitfall Samples	Sweep-Net Samples	Ant Mounds Detected
2015	-[b]	-[b]	BIBU, BRBE, JISA, SHCR	59	263[b]	116[b]	106
2016	5-May	26-Jun	BIBU, BRBE, JISA, SHCR	120	3,556	1,958	354
2017	15-Jun	6-Jul	BIBU, BRBE, JISA, SHCR	92	1,100	-[c]	92
2018	31-May	30-Jun	BIBU, BRBE, JISA, PAVA, SHCR	178	2,540	1,728	309
2019[e]	23-May	13-Jun	BIBU, BRBE, JISA	129	1,960	1,105	264
2020	26-May	10-Jun	BRBE, JISA, SHCR	89	1,216	588	227
2021	19-May	3-Jun	BIBU, BRBE, JISA, SHCR	119	1,779	838	159
Overall	25-May	19-Jun	BIBU, BRBE[d], JISA[d], PAVA, SHCR	786	12,414	6,333	1,511

[a]BIBU = Big Butte, BRBE = Brown's Bench, JISA = Jim Sage, PAVA = Pahsimeroi Valley, SHCR = Sheep Creek.
[b]Part of David Gotsch's thesis research.
[c]We did not have sufficient funding to collect sweep-net samples in 2017.
[d]Data were collected at these study sites all 7 years in which we sampled arthropods.
[e]Arthropod sampling also occurred at Idaho National Lab during 2019.

FINAL SUMMARY & GOALS

Overall, 2022 was a very successful field season. Despite the drought that struck Idaho in 2021, age ratios of the captured hens were similar to the overall study average, indicating minimal effect on sage-grouse recruitment. In 2022, the project tracked more nests than any other year, despite only conducting field work at 4 study sites. Nesting success was below average in 2022, potentially due to the cool, wet spring in 2022 observed at our sites, but the high renesting propensity helped to increase the number of broods we tracked at each site. The study continues to increase sample sizes that will provide more precise estimates of demographic traits and allow us to better achieve our goal of documenting the relationship between cattle grazing and sage-grouse habitat and vital rates.

In 2023, we plan to conduct the 10th and final season of field research on the project. Once we conclude our data collection in August 2023, we will conduct extensive data analysis and write manuscripts, producing numerous products from the 10-year research effort. Due to the volume of data collected on the project, we expect many products to be produced beginning in 2024. We also plan to visit numerous locations in southern Idaho to meet with stakeholders and provide presentations of the results in fall 2023 and spring/summer 2024.

Assessment of 2022 Goals

In 2022, we had the following goals to improve our data and better address our objectives. Assessments are shown in blue text.

1. Begin to produce products in the form of management-related publications. The following manuscripts were recently published or have been submitted:

    a. We have several draft manuscripts that we plan to submit in 2023.

    And the following 4 graduate theses have been produced:

    a. Julson, J. 2017. Variation in perennial grass height within greater sage-grouse nesting habitat. M.S. Thesis, University of Idaho.
    b. Riley, I. 2019. Sampling methods for lek and brood counts of greater sage-grouse: accounting for imperfect detection. M.S. Thesis, University of Idaho.
    c. Laurence-Traynor, A.C.E. 2020. Evaluating field-based grazing intensity measurements for adaptive rangeland monitoring. M.S. Thesis, University of Idaho.
    d. Fletcher. T. 2021. Evaluating GPS-derived estimates of livestock use and their value in assessing impacts of spring cattle grazing on greater sage-grouse demographics. M.S. Thesis, University of Idaho.

2. Recruit another excellent field crew with as many returning members as possible.
    a. We had an excellent field crew this year that worked hard and accomplished everything we set out to do. The 2022 crew included 7 returnees from the 2021 field crew.

3. Secure full funding for the final years of the project so that we can focus more effort on the objectives above.
    a. We received full funding for the project.

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We would like to thank the following returning technicians and crew leaders who joined us again in the 2022 field season and helped make our trapping and monitoring efforts an overwhelming success: Seth Rifkin, Sky Gennette, Mikel Newberg, Natasha Nemmers, Ian Scott, Walker Field, and Josh Jaeger. The following new crew leaders and technicians provided invaluable data and we hope to have some of them return for 2022: Jessie Hamaker, Julian Smith, Nicole Dobrosky, Matt Zianni, Elizabeth Fedewa, Gordon Ross, Camille Brandt, Evan Williams, Olivia DeMarchi, Alexis Means, James Murphy, and Diego Milian. Thanks also to the countless agency (BLM, IDFG, and University of Idaho) personnel that helped provide training and logistical support to field crews.

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APPENDIX I. PRODUCTS FROM THE GROUSE & GRAZING PROJECT THUS FAR.

CONFERENCE CALLS

- Monthly conference calls with Planning Team, with agendas and minutes written and distributed
- Weekly conference calls during the field season (Feb-Aug) with the Technical Team and all field crew leaders

ANNUAL MEETINGS

2-day meetings every fall with Planning Team members

PROJECT WEBSITE

https://idahogrousegrazing.wordpress.com/

PROJECT PROSPECTUS

2-page summary of project

ANNUAL REPORTS

Detailed annual reports each year sent to all partners and stakeholders, and posted on project website

Conway, C. J., C.A. Tisdale, K. L. Launchbaugh, P. Makela, S. Roberts, and C. Henderson. 2022. The Grouse & Grazing Project: Effects of cattle grazing on sage-grouse demographic traits – 2022 Annual Report. College of Natural Resources, University of Idaho. (this report).

Conway, C. J., C. A. Tisdale, K. L. Launchbaugh, D. Musil, P. Makela, and S. Roberts. 2021. The Grouse & Grazing Project: Effects of cattle grazing on sage-grouse demographic traits – 2021 Annual Report. College of Natural Resources, University of Idaho.

Conway, C. J., C. A. Tisdale, K. L. Launchbaugh, A. Meyers, D. Musil, P. Makela, and S. Roberts. 2020. The Grouse & Grazing Project: Effects of cattle grazing on sage-grouse demographic traits – 2020 Annual Report. College of Natural Resources, University of Idaho.

Conway, C. J., A. Meyers, K. L. Launchbaugh, D. Musil, P. Makela, and S. Roberts. 2019. The Grouse & Grazing Project: Effects of cattle grazing on sage-grouse demographic traits – 2019 Annual Report. College of Natural Resources, University of Idaho.

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Conway, C. J., A. Meyers, K. L. Launchbaugh, D. Musil, P. Makela, and S. Roberts. 2017. The Grouse & Grazing Project: Effects of cattle grazing on sage-grouse demographic traits – 2017 Annual Report. College of Natural Resources, University of Idaho.

Conway, C. J., K. L. Launchbaugh, D. Musil, S. Roberts, P. Makela, A. Locatelli, and A. R. Meyers. 2016. Grouse & Grazing: 2016 Annual Report. Idaho Cooperative Fish & Wildlife Research Unit, Moscow, ID.

Locatelli, A., C. J. Conway, K. L. Launchbaugh, and D. Musil. 2015. Grouse & Grazing: 2015 Annual Report. Idaho Cooperative Fish & Wildlife Research Unit, Moscow, ID.

FIELD TOURS

1. October 2017 – Idaho Grouse & Grazing Project. A stop on the Rangeland Fall Forum Field Tour. A joint activity of the Idaho Rangeland Center and the Idaho McClure Center for Public Policy. About 80 participants

2. August 2017 – Grouse & Grazing Project in the Pahsimeroi. A stop on the Idaho Society for Range Management Field tour. About 80 participants.

3. June 2017 – Idaho Grouse & Grazing Project Update. A stop on the field tour of the Idaho Cattle Association Summer meeting. About 65 participants.

4. April 2017 – Idaho Grouse & Grazing Study Update. A stop on the field tour of the field tour for the Idaho University of Idaho President, College of Natural Resources Advisory Council, and Idaho Natural Resource Policy Leaders About 82 participants

5. August 2016 – Targeted grazing and influence on sage-grouse. A stop on the field tour of the 100-Year celebration of the U.S. Sheep Experiment Station. About 60 participants.

6. June 2016 – Grouse & Grazing on Jim Sage Allotment. About 25 participants.

7. June 2014 – Grouse & Grazing on Jim Sage Allotment About 38 participants.

MEDIA OUTREACH

1. Tiernan, C. 2021. Massive Idaho study hopes to explain impact of livestock on imperiled sage grouse. Times-News. 18 April 2021.

2. Conway, C.J. 2019. Grouse & Grazing Projects: information for land managers and ranchers. Video interview for Idaho Range Livestock Symposium. University of Idaho Extension Program.

MEETINGS WITH RANCHERS and SCHOOL GROUPS

1. Meyers, A. R., and E. Juers. Sage-grouse in schools program. Arco school. 24 April 2019.

2. Meeting with BLM, USFS, ranchers. Challis, ID. 26 Nov 2018.

GRAD STUDENTS ON PROJECT

1. David Gotsch, M.S. Student, Wildlife Sciences, University of Idaho, Thesis Title: *Effects of cattle grazing on abundance of arthropod prey of the greater sage-grouse*. Jan 2014- (medical leave of absence).

2. Janessa Julson, M.S. Student, Range Management, University of Idaho, Thesis Title: *Variation in perennial grass height within greater sage-grouse nesting habitat*. Jan 2015-2017.

3. Ian Riley, M.S. Student, Wildlife Sciences, University of Idaho, Thesis Title: *Sampling methods for lek and brood counts of greater sage-grouse: accounting for imperfect detection*. Aug 2015-2019.

4. Alex Laurence-Traynor, M.S. Student, Range Management, University of Idaho, Thesis Title: *Determining appropriate utilization measurements for multi-scale rangeland management*. Jan 2018-2019.

5. Ty Styhl, M.S. student, Wildlife Sciences, University of Idaho, Thesis Title: *Ontogenetic shifts in diet of sage-grouse chicks based on DNA metabarcoding*. May 2018-present.

6. Taylor Fletcher, M.S. Student, Range Management, University of Idaho, Thesis Title: *Using global positioning system collars to assess the impact of livestock grazing on the greater sage-grouse*. Aug 2019-May 2021.

7. Nolan Helmstetter, M.S. Student, Wildlife Sciences, University of Idaho, Thesis Title: *Effects of cattle grazing on sage-grouse nest predators*. Aug 2019-present.

8. Grace Overlie, Entomology, University of Idaho, Thesis Title: *Effects of cattle grazing on arthropod biomass*. Aug 2021-present.

9. J.B. Playfair, Rangeland Sciences, University of Idaho, Thesis Title: *Effects of cattle grazing on fuel biomass and fire*. Aug 2021-present.

PUBLICATIONS

1. Hohbein, R., and C. J. Conway. 2018. Pitfall traps: a review of methods for estimating arthropod abundance. *Wildlife Society Bulletin* 42:597-606.

2. Karl, J.W., and J.E. Sprinkle. 2019. Low-cost livestock global positioning system collar from commercial off-the-shelf parts. *Rangeland Ecology and Management* 72:954-958.

3. Riley, I. P., and C. J. Conway. 2020. Methods for estimating vital rates of greater sage-grouse broods: A review. *Wildlife Biology* 2020:wlb00700.

4. Riley, I. P., C. J. Conway, B. S. Stevens, and S. Roberts. 2021. Aural and visual detection of greater sage-grouse leks: Implications for population trend estimates. *Journal of Wildlife Management* 85:508-519.

5. Riley, I. P., C. J. Conway, B. S. Stevens, and S. Roberts. 2021. Survival of greater sage-grouse broods: survey method affects disturbance and age-specific detection probability. *Journal of Field Ornithology* 92:88-102.

6. Conway, C. J., et al. Habitat guidelines for sage-grouse. *Journal of Wildlife Management* (in preparation).

7. Stevens, B. S., et al. Comparison of transmitter attachment methods on survival of greater sage-grouse. Journal of Wildlife Management (in preparation).

COMPLETED THESES

Julson, J. 2017. Variation in perennial grass height within greater sage-grouse nesting habitat. M.S. Thesis, University of Idaho.

Riley, I. 2019. Sampling methods for lek and brood counts of greater sage-grouse: accounting for imperfect detection. M.S. Thesis, University of Idaho.

Laurence-Traynor, A.C.E. 2020. Evaluating field-based grazing intensity measurements for adaptive rangeland monitoring. M.S. Thesis, University of Idaho.

Fletcher, T. 2021. Evaluating GPS-derived estimates of livestock use and their value in assessing impacts of spring cattle grazing on greater sage-grouse demographics. M.S. Thesis, University of Idaho.

PRESENTATIONS

1. Helmstetter, N. A., C. J. Conway, S. Roberts, P. D. Makela, J. A. Adams, S. A. Nerkowski, and L. P. Waits. 2022. eDNA Applications for improving sage-grouse management: Detecting nest predators from eggshells after depredation events. Annual Conference of The Wildlife Society. Spokane, WA. 9 Nov 2022.

2. Overlie, G. 2022. Effects of grazing on pitfall-detectable arthropods in Idaho sagebrush systems. Department of Entomology, Plant Pathology and Nematology Seminar Series. 2 May 2022.

3. Conway, C. J., K. L. Launchbaugh, C. Tisdale, P. Makela, and S. Roberts. 2022. Effects of cattle grazing on demographic and behavioral traits of greater sage-grouse: a 10-year experimental study. 5th Gunnison Sage-grouse Summit. Gunnison, CO. 5 Apr 2022.

4. Helmstetter, N. A., C. J. Conway, S. Roberts, P. D. Makela, J. R. Adams, S. A. Nerkowski, and L. P. Waits 2022. Who Dunnit? A non-invasive method for identifying sage-grouse nest predators. Idaho Chapter of The Wildlife Society. Boise, ID. 24 Feb 2022.

5. Conway, C. J., C. Tisdale, K. L. Launchbaugh, P. Makela, and S. Roberts. 2021. Effects of cattle grazing on greater sage-grouse. USGS-BLM Sage and Fire Research Workshop. 9 Nov 2021.

6. Launchbaugh, K. L., and C. J. Conway. 2021. Relationships between Livestock Grazing & Greater Sage-grouse: the Grouse & Grazing Project. Public Lands Council Executive Committee Annual Meeting. Virtual. 27 Sep 2021.

7. Fletcher, T., J. Karl, C. J. Conway, V. Jansen, and E. Strand. 2021. Assessing the impacts of scale on estimates of grazing intensity derived from livestock global positioning system collars. Society of Range Management, annual conference. Virtual. 17 Feb 2021.

8. Conway, C. J., K. L. Launchbaugh, D. Musil, P. Makela, S. Roberts, A. Meyers, and C. Tisdale. 2020. Effects of cattle grazing on sage-grouse: The Grouse & Grazing Project. USGS Sagebrush and Fire Research - Info Transfer Workshop. Online Webinar. 10 Dec 2020.

9. Fletcher, T., J. Karl, C. Conway, V. Jansen E. Strand, S. Roberts, and P. Makela. 2020. Using global positioning system collars to assess the impact of livestock grazing on the greater sage-grouse. The Wildlife Society, virtual conference. 28 Sep 2020.

10. Launchbaugh, K. L., and C. J. Conway. 2020. Effects of livestock grazing on greater sage-grouse: the Grouse & Grazing Project. Public Lands Council Executive Committee Annual Meeting. Virtual. 22 Sep 2020.

11. Fletcher, T., J. Karl, C. J. Conway, V. Jansen, E. Strand, S. Roberts, and P. Makela. 2020. Use of global positioning system collars to assess the impact of livestock grazing on the Greater Sage-Grouse. Idaho Chapter of The Wildlife Society. Moscow, ID. 11 March 2020.

12. Laurence-Traynor, A., J. W. Karl, and V. S. Jansen. 2020. Determining appropriate utilization measurements for multiscale spatial analysis of Greater Sage-grouse habitat in southern Idaho. Annual Meeting of the Society for Range Management Annual Meeting. Denver, CO. 17 Feb 2020.

13. Launchbaugh, K. L., D. Musil, C. J. Conway, A. Meyers, P. Makela, and S. Roberts. 2019. Effects of cattle grazing on sage-grouse: an update on the Grouse & Grazing project. Jim Sage Grazing Association. Malta, ID. 20 Dec 2019.

14. Karl, J. W., C. J. Conway, and K. L. Launchbaugh. 2019. Effects of cattle grazing on sage-grouse: an update on the Grouse & Grazing project. Annual meeting of the Idaho Rangeland Resource Commission. Sun Valley, ID. 13 Nov 2019.

15. Karl, J. W., C. J. Conway, and K. L. Launchbaugh. 2019. Effects of cattle grazing on sage-grouse: an update on the Grouse & Grazing project. Annual meeting of the Idaho Rangeland Committee annual meeting. Sun Valley, ID. 11 Nov 2019.

16. Conway, C. J., K. L. Launchbaugh, A. Meyers, D. Musil, P. Makela, and S. Roberts. 2019. Summary of project goals and accomplishments. Briefing session for Idaho Agency Directors. Boise, ID. 31 Oct 2019.

17. Conway, C. J. A. Meyers, D. Musil, P. Makela, S. Roberts, and K. L. Launchbaugh. 2019. Relationship between grass height and nesting success of greater sage-grouse. Joint Meeting of The Wildlife Society and the American Fisheries Society, Reno, NV. 2 Oct 2019.

18. Launchbaugh, K. L., and C. J. Conway. 2019. Public Lands Endowment Board of Directors Annual Meeting. Great Falls, MT. 27 Sep 2019.

19. Musil, D., C. J. Conway, A. Meyers, P. Makela, S. Roberts, and K. L. Launchbaugh. 2019. Response of sage-grouse to spring grazing - Update: Year 6 of 10-year research project. Owyhee County Sage-Grouse Local Working Group. 17 Sep 2019.

20. Zuniga, Z., E. Cook, J. T. Styhl, K. T. Vierling, and C. J. Conway. 2019. Ant mound density estimation in greater sage-grouse habitat. Moscow Outdoor Science School, McCall, ID. 26 Jul 2019.

21. Cook, E., Z. Zuniga, J. T. Styhl, K. T. Vierling, and C. J. Conway. 2019. Modeling changes in grass height over time; implications for grazing effects studies. Moscow Outdoor Science School, McCall, ID. 26 Jul 2019.

22. Riley, I., and C. J. Conway. 2019. Estimating detection and survival probabilities of sage-grouse broods: a comparison of field methods. Idaho Chapter of The Wildlife Society, Boise, ID. 21 Mar 2019.

23. Laurence-Traynor, A., J. W. Karl, C. J. Conway, K. L. Launchbaugh, and A. R. Meyers. 2019. Determining appropriate utilization measurements for multiscale spatial analysis of wildlife-livestock interactions in southern Idaho. Society for Range Management, Minneapolis, MN. 11 Feb 2019.

24. Launchbaugh, K. L, and C. J. Conway. 2018. Grouse & Grazing: Effects of livestock grazing influence on sage-grouse populations. Public Lands Council Annual Meeting. Park City, UT. 27 Sep 2018.

25. Launchbaugh, K. L., and C. J. Conway. 2018. Grouse & Grazing Study: Effects of Spring Grazing on Sage-grouse Populations. Idaho Range Livestock Symposium. Rexburg, ID. 12 Jan 2018.

26. Launchbaugh, K. L., and C. J. Conway. 2018. Grouse & Grazing Study: Effects of Spring Grazing on Sage-grouse Populations. Idaho Range Livestock Symposium. Pocatello, ID. 11 Jan 2018.

27. Launchbaugh, K. L., and C. J. Conway. 2018. Grouse & Grazing Study: Effects of Spring Grazing on Sage-grouse Populations. Idaho Range Livestock Symposium. Twin Falls, ID. 10 Jan 2018.

28. Launchbaugh, K. L., and C. J. Conway. 2018. Grouse & Grazing Study: Effects of Spring Grazing on Sage-grouse Populations. Idaho Range Livestock Symposium. Marsing, ID. 9 Jan 2018.

29. Conway, C. J., K. L. Launchbaugh, A. R. Meyers, D. Musil, P. Makela, and S. Roberts. 2017. The Grouse & Grazing Project. Public Forum. Burley, ID. 27 Oct 2017.

30. Gotsch, D., C. J. Conway, D. D. Musil, and S. Roberts. 2017. Prey for sage-grouse: Impacts of livestock grazing. Annual Meeting of The Wildlife Society. Albuquerque, NM. 27 Sep 2017.

31. Meyers, A. R., C. J. Conway, D. D. Musil, K. L. Launchbaugh, and S. Roberts. 2017. Effects of spring cattle grazing on nest survival of greater sage-grouse in southern Idaho. Annual Meeting of The Wildlife Society. Albuquerque, NM. 27 Sep 2017.

32. Launchbaugh, K. L, and C. J. Conway. 2017. Grouse & Grazing: How does spring livestock grazing influence sage-grouse populations? Public Lands Endowment Board of Directors Annual Meeting. Flagstaff, AZ. 21 Sep 2017.

33. Musil, D., C. J. Conway, K. L. Launchbaugh, A. R. Meyers, P. Makela, and S. Roberts. 2017. Response of sage-grouse to spring grazing – project update. Shoshone Basin Sage-Grouse Local Working Group, Twin Falls, ID 19 Sep 2017.

34. Conway, C. J., K. L. Launchbaugh, A. Meyers, D. Musil, P. Makela, and S. Roberts. 2017. Effects of grazing on sage-grouse and other shrub-steppe birds: a collaborative project to inform management of sage-steppe rangelands. Great Basin Landscape Conservation Cooperative Webinar Series. 13 Sep 2017.

35. Conway, C. J., K. L. Launchbaugh, A. Meyers, D. Musil, P. Makela, and S. Roberts. 2017. Effects of cattle grazing on greater sage-grouse and other sagebrush-steppe birds. Special Symposium at the Annual Meeting of the American Ornithological Society. East Lansing, MI. 5 Aug 2017.

36. Conway, C. J., K. L. Launchbaugh, D. Musil, P. Makela, and S. Roberts. 2017. Effects of livestock grazing intensity on greater sage-grouse. BLM Idaho Leadership Team meeting, Boise, ID. 11 Apr 2017.

37. Conway, C. J., K. L. Launchbaugh, D. Musil, P. Makela, and S. Roberts. 2017. Effects of livestock grazing intensity on nesting success and brood movements in greater sage-grouse. Annual Meeting of the Idaho Chapter of The Wildlife Society, Boise, ID. 2 Mar 2017.

38. Gotsch, D., C. J. Conway, and D. Musil. 2017. Prey availability for sage-grouse chicks: effects of cattle grazing and vegetative structure. Annual Meeting of the Idaho Chapter of The Wildlife Society, Boise, ID. 2 Mar 2017.

39. Conway, C. J., K. L. Launchbaugh, D. Musil, P. Makela, and S. Roberts. 2017. The Idaho Grouse & Grazing Project: a collaborative, landscape-scale experiment to assess the effects of cattle grazing. Annual Meeting of the Idaho Bird Conservation Partnership, Boise, ID. 27 Feb 2017.

40. Julson, J., K. L. Launchbaugh, E. Strand, C. J. Conway, and A. Locatelli. 2017. Relationships among spring livestock grazing, sage-grouse nest fate, and climate in sagebrush-steppe communities. Society for Range Management Annual Conference. St. George, UT. 29 Jan 2017.

41. Julson, J., K. L. Launchbaugh, and C. J. Conway. 2017. How to estimate utilization of grasses: ocular estimation or height-weight method? Society for Range Management Annual Conference. St. George, UT. 29 Jan 2017.

42. Launchbaugh, K. L. and C. J. Conway. 2015. Livestock grazing and sage-grouse. Meeting of the Environment and Natural Resources Section of the Idaho Bar Association. Boise, ID. 2 Dec 2016.

43. Conway, C. J., and K. L. Launchbaugh. 2016. Grouse & Grazing: How does spring livestock grazing influence sage-grouse populations? Public Lands Endowment Board of Directors Annual Meeting. Boise, ID. 7 Sep 2016.

44. Conway, C. J., K. L. Launchbaugh, A. Locatelli, D. Musil, P. Makela, and S. Roberts. 2016. Effects of spring-season cattle grazing on greater sage-grouse. USGS/BLM Grazing Research Webinar. 13 Jul 2016.

45. Conway, C. J., K. L. Launchbaugh, A. Locatelli, D. Musil, P. Makela, and S. Roberts. 2016. Effects of spring-season cattle grazing on greater sage-grouse. Western Agencies Sage and Columbian Sharp-Tailed Grouse Workshop. Lander, WY. 14 Jun 2016.

46. Conway, C. J. 2016. Effects of cattle grazing on Greater Sage-Grouse: a 10-year experimental study. Invited Departmental Seminar. School of Natural Resources, University of Arizona. Tucson, AZ. 6 April 2016.

47. Conway, C. J., A. Locatelli, D. Musil, S. Roberts, K. L. Launchbaugh, and P. Makela. 2016. Effects of spring cattle grazing on greater sage-grouse: a 10-year experimental study to manipulate grazing regimes in Idaho. Sagebrush Ecosystem Conservation Conference: All Lands, All Hands. Salt Lake City, UT. 25 Feb 2016.

48. Conway, C. J., K. L. Launchbaugh, A. Locatelli, D. Musil, P. Makela, and S. Roberts. 2016. Large-scale field experiments to assess the effects of cattle grazing on greater sage-grouse. Annual Meeting of the Idaho Chapter of The Wildlife Society, Coeur d' Alene, ID. 23 Feb 2016.

49. Locatelli, A., C. J. Conway, D. Musil, K. L. Launchbaugh, S. Roberts, and D. Gotsch. 2016. Factors influencing nest survival of greater sage-grouse (*Centrocercus urophasianus*) in southern Idaho. Annual Meeting of the Idaho Chapter of The Wildlife Society, Coeur d' Alene, ID. 23 Feb 2016.

50. Conway, C. J., K. L. Launchbaugh, A. Locatelli, D. Musil, P. Makela, and S. Roberts. 2015. Large-scale field experiments to assess the effects of cattle grazing on greater sage-grouse. Tri-state coordination meeting for sage-grouse grazing research. Helena, MT. 4 Nov 2015.

51. Conway, C. J., K. L. Launchbaugh, A. Locatelli, W. Pratt, P. Makela, D. Kemner, D. Musil, and S. Roberts. 2015. Experimental study to assess effects of spring cattle grazing on sage-grouse. Annual Meeting of the Association of Fish and Wildlife Agencies, Tucson, AZ. 15 Sep 2015.

52. Launchbaugh, K. L., and C. J. Conway. 2015. Sage-grouse and livestock grazing. Public Lands Endowment Board of Directors Annual Meeting. Cody, WY. 9 Sept 2015.

53. Conway, C. J., J. W. Connelly, K. L. Launchbaugh, D. Gotsch, W. Pratt, P. Makela, D. Kemner, D. Musil, E. Strand, J. Robison, and J. Whiting. 2015. Effects of spring cattle grazing on sage-grouse: a project update. Annual Meeting of the Idaho Chapter of The Wildlife Society, Pocatello, ID. 11 Mar 2015.

54. Conway, C. J., and K. L. Launchbaugh. 2014. Cattle grazing effects on sage-grouse populations. Grouse & Grazing Planning Team Meeting. Twin Falls, ID. 18 Sep 2014.

55. Launchbaugh, K. L., and C. J. Conway. 2014. Sage-grouse and livestock grazing. Public Lands Endowment Board of Directors Annual Meeting. Ignacio, CO. 4 Sep 2014.

56. Conway, C. J., and K. L. Launchbaugh. 2014. How does spring livestock grazing influence sage-grouse populations? Idaho Sage-grouse Advisory Committee Meeting, Boise, ID. 28 May 2014.

57. Connelly, J. W., C. J. Conway, D. Kemner, K. L. Launchbaugh, W. Pratt, K. P. Reese, E. T. Rinkes, J. Robison, E. Strand, and J. Whiting. 2013. Grouse & Grazing in Idaho: a collaborative approach to answering difficult questions. Idaho Chapter of The Wildlife Society. Coeur d’Alene, Idaho. 13 Mar 2013.

<u>Updates at Regular Meetings of Research Partners:</u>

- Idaho Rangeland Center
- Idaho Cattle Association
- Idaho Rangeland Resource Commission
- Idaho Rangeland Committee