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Annual Report
Migratory Songbird - Grazing

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Executive Summary

Livestock grazing is the dominant land management practice in sagebrush systems in the western United States, but direct impacts of this land use on wildlife are poorly understood. Livestock grazing alters the structure, composition, and productivity of sagebrush vegetation through increases in sagebrush size, cover, and density; decreases in forb cover and density; and decreases in grass cover and density. Livestock grazing has been recognized as a management tool to achieve desired vegetation conditions. As part of efforts to protect declining greater sage-grouse (*Centrocercus urophasianus*; hereafter sage-grouse) populations, various conservation efforts have implemented grazing management. The most notable grazing efforts were developed under the Sage-Grouse Initiative (SGI) created by the Natural Resources Conservation Service (NRCS). In Montana, SGI provides incentives for landowners to implement sage-grouse friendly grazing systems to discourage conversion of sagebrush rangelands to farmlands or other development.

Sage-grouse may exhibit a "lag" effect in response to habitat management due to their life history strategy of investing more in survival and less in reproduction relative to other species (i.e., they live longer and produce less offspring per breeding season than other grouse species). In contrast to sage-grouse, sagebrush-associated migratory songbirds respond more quickly to habitat changes by shifting their distributions and adapting their reproductive performance. Thus, migratory songbirds can serve as a barometer for sagebrush ecosystem integrity and the impacts of grazing management designed to positively benefit avian communities. Migratory birds are among the few groups of organisms in which community reassembly and effectiveness of conservation actions have been documented.

In 2012, we began a study to evaluate the relationships among grazing, avian community composition, and demographic parameters as related to SGI's rest-rotation grazing regime. SGI's rest-rotational grazing strategies allow for periods of rest or deferment from grazing on the landscape. Non-SGI grazing involves multiple types of grazing systems, but was less intensively managed and involved slower rotations, usually lacking annual changes in use.

Within our study area, we randomly selected 40 plots per grazing system (SGI and Non-SGI) for a total of 80 plots of size 500 x 500 m (25 ha) to collect field data to address two specific objectives. Our first objective was to compare migratory songbird responses to SGI grazing, represented by species abundance/density, species richness, species diversity, and community composition. Avian count transect surveys were conducted using the dependent double-observer method. Our second objective was to determine the breeding performance of three focal songbird species that are obligates to the three most common vegetation characteristics in sagebrush steppe between SGI enrolled grazed and Non-SGI grazed land. We conducted nest searches and monitored nesting activity of Brewer's sparrow (*Spizella breweria*; sagebrush nester), vesper sparrow (*Pooecetes gramineus*; generalist ground nester), and McCown's longspur (*Rhynchophanes mccownii*; grassland ground nester).

During 2013 – 2017, the total number of individuals we observed ranged from 6,016 – 13,529 from 71 – 86 species. We observed low variation in avian community composition between years, suggesting a relatively stable diversity of individual species occupying our study area. The migratory songbird species of which we observed the most individuals since 2013 were: Brewer's sparrow, vesper sparrow, western meadowlark, McCown's longspur, and horned lark. Estimates of abundance for the five most common species suggest species-specific responses to the two grazing regimes.

For our three focal species, we located 47% of nests on lands using Non-SGI grazing, compared to 52% of the nests on lands using SGI grazing. Total nest numbers were lower on Non-SGI grazing systems than SGI grazing systems. The observed number of nests for each individual species varied between the two grazing systems in 2017, with the greatest difference being for McCown's longspur nests, where we found half as many nests on Non-SGI plots relative to SGI plots. Apparent nest success for all three species combined was 0.51. Nest success varied by species and year ranging from 0.28 - 0.71. Similarly, nests success also varied by grazing system. Nest success was lowest for McCown's longspur on lands using SGI in 2015 and highest for vesper sparrow on lands using SGI in 2017.

Background

Approximately 76% of sagebrush (*Artemisia* spp.) -associated bird species are declining nationally (Saab and Rich 1997; Paige and Ritter 1999; Dobkin et al. 2008). Sagebrush-nesting species make up the largest number of Species of Continental Importance within the Intermountain West (Rich et al. 2004). The Greater Sage-grouse (*Centrocercus urophasianus*; hereafter sage-grouse) has shown significant declines over the last 30-40 years (Garton et al. 2010). In addition, several other bird species that breed in Montana's sagebrush systems are declining and of conservation concern including: Brewer's sparrow (*Spizella breweria*), sage thrasher (*Oreoscoptes montanus*), McCown's longspur (*Calcarius mccownii*), chestnut-collared longspur (*Calcarius ornatus*), and lark bunting (*Calamospiza melanocorys*; Casey 2000, Rich et al. 2004). Songbirds are often used as indicators for ecosystem health in sagebrush steppe habitat because of their mobile and conspicuous nature (Bradford et al. 1998). Changes in songbird abundance are also of ecological importance because they interact with other species such as predators, prey, pollinators and seed dispersers (Murphy and Romanuk 2012). Specific to sagebrush systems, songbirds exhibit a varying degree of reliance on grassland vegetation, an important component of sagebrush ecosystems (Rich et al. 2004). They range from: grassland obligates such as McCown's longspur and chestnut-collared longspur, species that use grassland for the majority of their life history needs; to facultative grassland species (e.g., vesper sparrow, *Pooecetes gramineus*) which use grassland in addition to other vegetation to meet their life history needs; to sagebrush obligates such as Brewer's sparrow and sage thrasher, species that use sagebrush for the majority of their life history needs. Thus, sagebrush-associated songbirds can likely serve as an initial barometer for system integrity and assist in evaluating the effectiveness of management actions.

Declines in sagebrush-associated avian species are congruent with significant losses of sagebrush ecosystems (Braun et al. 1976, Knick 1999). Significant stressors on sagebrush systems include conversion of sagebrush lands to agriculture, and fragmentation resulting from energy or subdivision development. Modifications such as prescribed fire, herbicides, and some grazing practices that lead to exotic, annual grass establishment can also act as stressors (Rich et al. 2004, MTSWAP 2015). Big sagebrush steppe, the most widely distributed sagebrush system in Montana, is typically characterized by Wyoming big sagebrush (*Artemisia tridentate* ssp. *wyomingensis*) with perennial grasses and forbs dominating at least 25% of vegetation cover (Montana Natural Heritage Program 2011).

Livestock grazing is the most widespread land use across the range of sagebrush ecosystems (Knick et al. 2010) and offers many benefits to a variety of stakeholders, ranging from conservation advocates to private landowners. Depending on the timing and use rates of livestock, livestock grazing can directly increase sagebrush size, cover, and density; decrease forb cover and density; and decrease grass cover and density (Beck and Mitchell 2000, Crawford et al. 2004). There is a growing recognition that livestock grazing can be manipulated to positively affect sagebrush-associated bird habitat (Holechek et al. 1998, Coppedge et al. 2008, Lipsey and Naugle 2017). Heavy livestock grazing can decrease invertebrate biomass (Krausman et al. 2009); an important food source for several bird species.

Rest-rotation grazing is currently the most common grazing strategy used to improve habitat for wildlife in sagebrush systems (Briske et al. 2008). While limited data suggest that rest-rotation grazing may not have significant short-term effects on the density of songbirds (Lapointe et al. 2003), most studies that examine the effect of livestock grazing on wildlife compare areas with livestock grazing to areas without livestock grazing (e.g., Bock and Webb 1984; Harrison et al. 2010; Nelson et al. 2011). However, the vast majority of sagebrush ecosystems and landscapes are grazed by livestock (Knick et al. 2003). Thus, a clear need exists to evaluate and compare the benefits of different livestock grazing management strategies on sagebrush-associated songbird populations.

In Montana, Montana Fish, Wildlife and Parks (FWP) manages 200,000 acres (~81,000 ha) of grazed habitats on both private (through conservation easements and Upland Game Bird Enhancement program projects) and state-owned lands (FWP deeded lands such as Wildlife Management Areas or state land leased from the Department of Natural Resources and Conservation; L. Berkeley pers. comm.) using rest-rotation grazing (Hormay 1970). In addition, due to emphasis on conservation for the sage-grouse, the Natural Resources Conservation Service (NRCS) has developed a Sage-Grouse Initiative (SGI). A delivery of this initiative includes implementation of rest-rotation grazing management to control the location and timing of grazing on areas with relatively high sage-grouse densities, called “core” areas. To date 190,615 acres (~77,000 ha) have been enrolled in Golden Valley and Musselshell counties, where we are conducting this research. These efforts provided the infrastructural capacity to investigate the benefits of rest-rotation grazing on sage-grouse populations. In contrast to sage-grouse, migratory songbirds can respond relatively quickly to alterations in their habitats by shifting distributions or varying reproductive performance accordingly (Caro 2010, Hart et al. 2012). Thus, migratory birds are among the few groups of organisms in which community reassembly (e.g., Lemoine et al. 2007, Zuckerberg et al. 2009) can quickly and effectively evaluate conservation actions. Management strategies that incorporate monitoring of songbirds will be alerted to changes in habitat much more quickly through changes in these songbird populations than sage-grouse populations.

The overarching goal of this study is to determine the response of migratory songbird populations during the breeding season to SGI implemented grazing. Here we describe our findings to date on the effects of the SGI grazing management on 1) the species abundance/density, species richness, species diversity, and community composition, and 2) breeding performance of three focal songbird species that represent the different guilds of species using different niches of vegetation characteristics in sagebrush steppe. SGI's grazing involves rotational grazing strategies, allowing for periods of rest or deferment from livestock grazing on the landscape (Smith et al. 2018). Non-SGI grazing involved multiple types of grazing systems, but were less intensively managed and involved slower rotations, usually lacking annual changes in use (Smith et al. 2018). We provide information from the first five years of our long-term, 8-year study that began in 2013. This work is conducted near Lavina and Roundup, Montana (Figure 1), in which we sampled 80 plots (500 x 500 m, or 25 ha) or 40 per grazing regime (SGI versus Non-SGI). We provide a general summary of our field methods for each objective below. Funding provided by this agreement covered year five (April 1, 2017 to March 30, 2018).

Objective: Investigate migratory songbird *abundance, species richness, species diversity, and community composition* responses to SGI grazing as a conservation management tool.

Accomplishments:

To examine species abundance/density, species richness, species diversity, and community composition, we conducted avian count transect surveys using the dependent double-observer method (Nichols et al. 2000; Figure 2). This method has been proven to be efficient on grassland songbirds (Tipton et al. 2008 and 2009), to increase the probability of detecting individual birds, and be more accurate in estimating abundance in multiple songbirds in this study area compared to time-to-removal point counts (Golding and Dreitz 2016). The method requires a two-person team, a primary observer and a secondary observer. The primary observer walks ahead of the secondary observer, maintaining a distance of about 10 m. The primary observer communicates any visual observations of individual birds. The secondary observer records the primary observer's detections and records any individuals detected that the primary observer missed. Primary and secondary observers alternate roles between consecutive surveys on additional plots.

We conducted three surveys within each sample plot between late April and August from 2013 to 2017 to account for differences in species-specific breeding phenology (Table 1). Transect surveys were completed between sunrise (~0530 Mountain Daylight Time [MDT]) and 1100 MDT. Transect surveys did not take place during steady rains or when wind speeds exceeded 15 mph. In 2015, we only completed two surveys per sampling plot. Breeding activity commenced relatively early in 2015 and by the timing of the third survey (mid-June to early July) we did not feel we could reliably distinguish between adults and young of the year juveniles. Our statistical analysis used the multispecies dependent double-observer abundance model (MDAM) that incorporates the dependent double-observer transect survey method to estimate abundance estimates for multiple species (Golding et al. 2017).

Results:

The total number of individuals observed ranged from 6,016 – 13,529 during 2013 – 2017. (Appendix A). We believe lower observations of individuals in 2015 were due to the earlier breeding season resulting in only two avian count transect surveys that year. Observations of avian community composition ranged from 71 – 86 species during 2013 – 2017 with low variation between years (Appendix A), suggesting a relatively stable diversity of individual species occupying our study area.

The three species observed with highest frequencies across all years and both grazing types were Brewer's sparrow (7,927 observations), vesper sparrow (8,846 observations), and McCown's longspur (12,606 observations). The combined abundances of these three species across years per plot ranged from 5.9 to 91.8 individuals (Figure 3a). Individual species abundances for each plot varied from 0.4 individuals per plot (Brewer's sparrow) to 85.7 individuals per plot (McCown's longspur; Figures 3b-3d).

The migratory songbird species of which we observed the most individuals since 2013 were: Brewer's sparrow, vesper sparrow, western meadowlark, McCown's longspur, and horned lark (Table 2, Appendix A). Estimates of abundance for the five most common species suggest species-specific responses to the two grazing regimes (Table 3, Figure 4). For instance, western meadowlark were observed more often on Non-SGI grazed plots than SGI grazed plots, while McCown's longspur were observed most often on lands using SGI grazing (Table 2). There was no difference in abundance between the grazing types for Brewer's sparrow, horned lark, and vesper sparrow. While we have not seen a clear response of all bird species within the community, our results do suggest that SGI grazing creates vegetation conditions that are more favorable for McCown's longspur and neutral for Brewer's sparrow, horned lark, and vesper sparrow. Further exploration of the fitness consequences of these grazing systems may provide more insight into why patterns across species are not more consistent.

Objective: Investigate migratory songbird *breeding performance of three focal songbird species* responses to SGI and Non-SGI grazing as a conservation management tool.

Accomplishments:

Since 2013, we have monitored nesting activity of songbird species within both grazing systems. We focused on three species that represent guilds using specific vegetation characteristics in this sagebrush/grassland system: Brewer's sparrow (*Spizella breweria*; a shrub nester and sagebrush obligate), vesper sparrow (*Pooecetes gramineus*; a ground nester and a sagebrush and grassland facultative species), and McCown's longspur (*Rhynchophanes mccownii*; a ground nester and grassland obligate). We conducted nest searches in the same 80 sampling plots as the avian count transect surveys. We used one of three nest searching methods based on the vegetative characteristics of the plot: 1) a systematic nest search using a rope/chain; 2) a systematic nest search using a dowel swept over the top of sagebrush bushes (Ruehmann et al. 2011); and 3) an opportunistic location of a nest while walking through the sample plot (i.e., when returning from nest monitoring visits or surveys). When a nest was initially located, we recorded its location (UTM coordinates) and marked it from ~5 m away in each cardinal direction with flagging to facilitate nest monitoring. Nests were monitored at approximately three-day intervals, weather permitting. During each monitoring visit, we recorded the status of the nest (active or inactive), stage of the young (eggs, nestling, or fledgling), and number of young at each stage. A nest was determined successful when at least one nestling was confirmed as fledged from the nest. We assumed a nest had fledged if we observed nestlings of the appropriate age on the prior visit and observed an intact nest with signs of fledging (e.g., whitewash at the edge of the nest). When a nest failed, we recorded whether the cause of failure was predation, weather, or unknown.

Results:

A total of 570 nest searches were conducted over the 5 years of the study; 106 searches in 2013, 80 searches in 2014, 66 searches in 2015, 188 searches in 2016, and 130 searches in 2017 (Table 1). All sample plots were searched for nests at least once in 2014 and 2016. We were only able to nest search on 70% (56 searches/80 plots) of plots in 2013, 83% (66 searches/80 plots) of plots in 2015, and 78% (62 searches/80 plots) of plots in 2017 due to time constraints (Table 1). In 2015, a total of seven sample plots were surveyed up to 6 times as part of a side project on Brewer's sparrows (see below). In 2016, we were able to conduct a minimum of two nest searches per plot.

We located a total of 928 Brewer's sparrow, vesper sparrow, and McCown's longspur nests: 136 nests in 2013, 156 nests in 2014, 252 nests in 2015, 164 nests in 2016, and 220 nests in 2017 (Table 4). Nest counts were similar between grazing systems and years, with an increase in 2016 and 2017 due to an increase in nest search sampling efforts. We located 47% of the nests

(437/928 nests) on lands using Non-SGI grazing, compared to 52% of the nests (491/928 nests) on lands using SGI grazing.

Of the 220 nests found in 2017, 119 were located on Non-SGI plots and 101 were located on SGI plots (Table 4). For Brewer's sparrow, McCown's longspur, and vesper sparrow, total nest numbers were lower on Non-SGI grazing systems than SGI grazing systems. The observed number of nests for each individual species varied between the two grazing systems in 2017, with the greatest difference being for McCown's longspur nests, where we found half as many nests on Non-SGI plots relative to SGI plots (Table 4).

Apparent nest success (number of nests successful/total number of nests) for all three species combined was 0.51. Nest success varied by species and year ranging from 0.28 - 0.71 (Table 4). Similarly, nests success also varied by grazing system. Nest success was lowest for McCown's longspur on lands using SGI in 2015 and highest for vesper sparrow on lands using SGI in 2017.

Future Goals:

We propose to continue data collection for the next three years, 2018 - 2020, with final products completed in 2021. We will continue to assess how avian community composition changes using adult abundance of multiple avian species. Avian abundance is known to change with vegetation heterogeneity and annual precipitation. Grazing is known to affect vegetation heterogeneity. Therefore, we can track vegetative patterns that occur as a result of grazing by measuring changes in avian abundance. Ultimately, we will determine if the response of songbirds is an appropriate initial indicator of change in sagebrush systems resulting from grazing management actions.

In addition, we will link songbird abundance and breeding activity, including nest density and success, to understand the fitness consequences for avian communities with respect to grazing regimes. We will continue to monitor nesting activity of the three songbird species that represent the guilds that span the range of vegetation characteristics used by breeding songbirds in this sagebrush/grassland system (Brewer's sparrow, vesper sparrow, and McCown's longspur). Using these data, we will identify reproductive responses to SGI and Non-SGI grazing regimes for these three songbird species. Variables that may be measured and describe differences in the dependent variables include, but are not limited to, biotic factors (e.g., grazing treatment, arthropod densities/biomass, vegetation structure) and abiotic factors (e.g., soil, temperature, precipitation). Breeding effort can influence the persistence of populations and existing community structure. It is therefore important to understand how grazing can affect breeding activity. By altering vegetation that songbirds use for nesting, grazing may have a direct effect on breeding outcomes.

Status of Deliverables:

Here we state the status of the deliverables to date as proposed. Year 1 is from the issuance of grant W-165-R-1 to March 31, 2017, Year 2 is from April 1, 2017 to March 31, 2018.

1. Collect data on songbirds during the breeding season
    a. **Year 1 - Completed**
    b. **Year 2 – Completed**
2. Provide annual progress report by March 1 each year
    a. **Year 1 - Completed**
    b. **Year 2 – Completed (this report)**
3. Submit at least one manuscript to a peer-reviewed scientific journal for review and potential publication using 2013-2015 data already collected
   Completed – The following publications were sent to L. Berkeley:
    a. **Golding, J.D. and V.J. Dreitz. 2017. Songbird response to rest-rotation and season-long cattle grazing in a grassland sagebrush ecosystem. *Journal of Environmental Management* 204: 605-612.**
    b. **Golding, J.D., J.J. Nowak, and V.J. Dreitz. 2017. A multispecies dependent double-observer model: A new method for estimating multispecies abundance. *Ecology and Evolution* 7:3425–3435.**
4. Present research findings for the duration of the project (2013 to present) to at least one professional conference
    a. **Year 1 – Completed**
        i. **Presentation by MS student at Montana Chapter of the Wildlife Society meeting in Helena, Montana, March 8-10, 2017.**
    b. **Year 2 – Completed**
        i. **Presentation by MS student at Montana Chapter of the Wildlife Society meeting in Butte, Montana, February 21-23, 2018.**
5. Meet with local FWP and NRCS regional managers and biologists to discuss research project
    a. **Year 1** – **Completed during field season**
    b. **Year 2 – Completed during field season and sent brief summary of the 2017 field season in August.**
6. Participate in landowner outreach to provide information to landowners on our research objectives and results –
    a. **Year 1 - Provided L Berkeley with information for landowner mailings on project status and participated at landowner dinner in Nov 2016.**
    b. **Year 2 – Provided thank you letters to private landowners allowing land access. Letters included specific information on their individual properties and summary of overall field season data. L. Berkeley received copies of individual landowner letters.**

7. Conduct presentations of research results to private landowners and wildlife and land management agencies as requested
    a. **Year 1 - Presented at Annual Oversight Meeting in February 2017.**
    b. **Year 2 – MS student and PhD student presented at Annual Oversight Meeting in February 2018.**
8. Provide a research opportunity for graduate students.
    a. **Master Student – Individual officially enrolled at the University of Montana in August 2016 (year 1). Student participated in 2016 and 2017 field season, year 1 and 2 respectively.**
    b. **PhD Student – Selected PhD candidate in spring 2017 (Year 2). Individual officially enrolled at the University of Montana in August 2017 (year 2) and is on track to achieve their graduate degree.**

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Table 1. The number of avian count survey transects and nest search surveys on 500 m X 500 m sample plots near Lavina and Roundup, Montana.

Year	Sampling Occasion	Date	Transect Survey	Nest Search
2013	1	Apr 26-Jun 1	80	56
	2	Jun 4- Jul 31	80	30
	3	Jun 9-Aug 3	80	20
	4	-	-	-
	Total		240	106
2014	1	May 22-Jul 12	80	30
	2	Jun 3- Jul 8	80	30
	3	Jul 8- Jul 23	80	20
	4	-	-	-
	Total		240	80
2015	1	May 21- Jun 6	80	19
	2	Jun 6 – Jun 29	80	47
	3	-	-	-
	4	-	-	-
	Total		160	66
2016	1	May 7-Jun 14	80	80
	2	May 22-Jul 1	80	66
	3	Jun 16-Jul 5	80	23
	4	Jun 23-Jul 8	-	19
	Total		240	188*
2017	1	Apr 29- June 16	80	62
	2	May 11- Jul 5	80	43
	3	Jun 18- Jul 12	80	19
	4	Jun 24- Jul 12	-	6
	Total		240	130*

*Nest searching efforts in 2016-2017 increased as part of MS student research.

Table 2. Total number of individuals detected for the top five species observed most frequently during avian count transect surveys near Lavina and Roundup, Montana.

Common Name	2013		2014		2015		2016		2017		Total
	Non-SGI	SGI	Non-SGI	SGI	Non-SGI	SGI	Non-SGI	SGI	Non-SGI	SGI	
Brewer's Sparrow	979	804	1,101	927	636	580	641	530	889	840	**7,927**
Horned Lark	597	1,015	870	1,075	301	521	431	534	427	622	**6,393**
McCown's Longspur	1,037	2,450	726	2,824	280	797	546	1882	505	1559	**12,606**
Vesper Sparrow	1,066	936	1,057	1,030	573	451	962	945	1013	813	**8,846**
Western Meadowlark	795	400	779	471	386	258	606	428	550	400	**5,073**
Totals	4,474	5,605	4,533	6,327	2,176	2,607	3,186	4,319	3,384	4,234	**40,845**

Table 3. Estimates of detection and abundance per 25 ha sample plot for the top five most common avian species within Non-SGI or SGI enrolled grazing regimes near Lavina and Roundup, Montana. Estimates are derived from the multispecies dependent double-observer abundance model (MDAM). Values in parentheses represent the 95% Bayesian credible interval.

Common Name		**2013**		**2014**		**2015**		**2016**		**2017**	
	Detection Probability	**Non-SGI**	**SGI**	**Non-SGI**	**SGI**	**Non-SGI**	**SGI**	**Non-SGI**	**SGI**	**Non-SGI**	**SGI**
Brewer's Sparrow	**0.51** (0.45-0.56)	**13.64** (11.63-15.89)	**15.78** (13.46-18.38)	**10.67** (9.03-12.52)	**12.34** (10.42-14.52)	**8.35** (6.89-10.02)	**9.66** (7.94-11.64)	**18.23** (15.15-22.33)	**13.99** (11.23-17.78)	**13.16** (11.78-15.53)	**10.92** (9.60-13.18)
Horned Lark	**0.53** (0.46-0.60)	**8.78** (7.49-10.22)	**11.34** (9.69-13.2)	**7.2** (6.07-8.46)	**9.3** (7.85-10.93)	**5.9** (4.84-7.11)	**7.62** (6.27-9.19)	**9.01** (7.93-11.05)	**14.31** (12.575-16.98)	**6.29** (5.30-8.35)	**8.79** (7.50-11.05)
McCown's Longspur	**0.52** (0.47-0.57)	**8.92** (7.6-10.41)	**23.53** (20.14-27.31)	**5.76** (4.87-6.76)	**15.18** (12.9-17.76)	**3.72** (3.08-4.44)	**9.8** (8.17-11.67)	**13.25** (12.43-15.00)	**33.12** (30.48-36.60)	**6.02** (5.55-7.33)	**19.37** (17.88-21.88)
Vesper Sparrow	**0.49** (0.43-0.56)	**14.49** (12.37-16.88)	**15.3** (13.05-17.84)	**10.36** (8.77-12.16)	**10.95** (9.25-12.86)	**7.42** (6.11-8.94)	**7.84** (6.43-9.45)	**18.34** (15.50-22.03)	**15.74** (12.83-19.5)	**14.15** (12.18-16.95)	**11.68** (10.03-14.20)
Western Meadowlark	**0.48** (0.40-0.56)	**10.72** (9.13-12.48)	**6.35** (5.37-7.45)	**9.17** (7.71-10.82)	**5.43** (4.53-6.45)	**7.85** (6.37-9.59)	**4.65** (3.74-5.71)	**11.45** (9.83-14.08)	**6.47** (5.58-8.45)	**7.86** (6.53-10.20)	**5.94** (5.13-7.80)

Table 4. Number of Brewer's sparrow, vesper sparrow, and McCown's longspur nests detected during nest search efforts near Lavina and Roundup, Montana. Apparent nest survival (number of nests successful/total number nests) for each species on each grazing system is also provided.

Year	Common Name	Non-SGI		SGI		Total
		# Nests	Success	# Nests	Success	
2013	Brewer's Sparrow	17	0.53	19	0.58	36
	McCown's Longspur	10	0.3	24	0.42	34
	Vesper Sparrow	29	0.48	37	0.43	66
	Total	**56**		**80**		**136**
2014	Brewer's Sparrow	27	0.44	30	0.7	57
	McCown's Longspur	7	0.57	41	0.51	48
	Vesper Sparrow	26	0.5	25	0.68	51
	Total	**60**		**96**		**156**
2015	Brewer's Sparrow	72	0.54	74	0.69	146
	McCown's Longspur	5	0.6	18	0.28	23
	Vesper Sparrow	39	0.51	44	0.48	83
	Total	**116**		**136**		**252**
2016	Brewer's Sparrow	34	0.5	14	0.57	48
	McCown's Longspur	10	0.6	31	0.29	41
	Vesper Sparrow	42	0.43	33	0.36	75
	Total	**86**		**78**		**164**
2017	Brewer's Sparrow	49	0.59	29	0.55	78
	McCown's Longspur	16	0.44	37	0.68	53
	Vesper Sparrow	54	0.39	35	0.71	89
	Total	**119**		**101**		**220**
Total		**437**		**491**		**928**

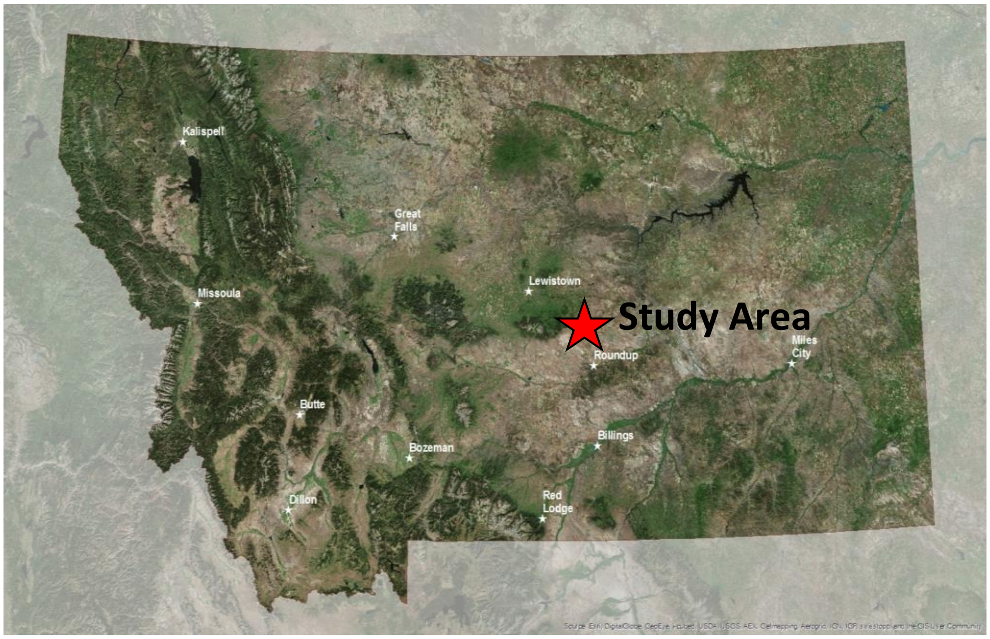

Figure 1. Location of the study investigating the response of migratory songbird populations during the breeding season near Roundup, MT.

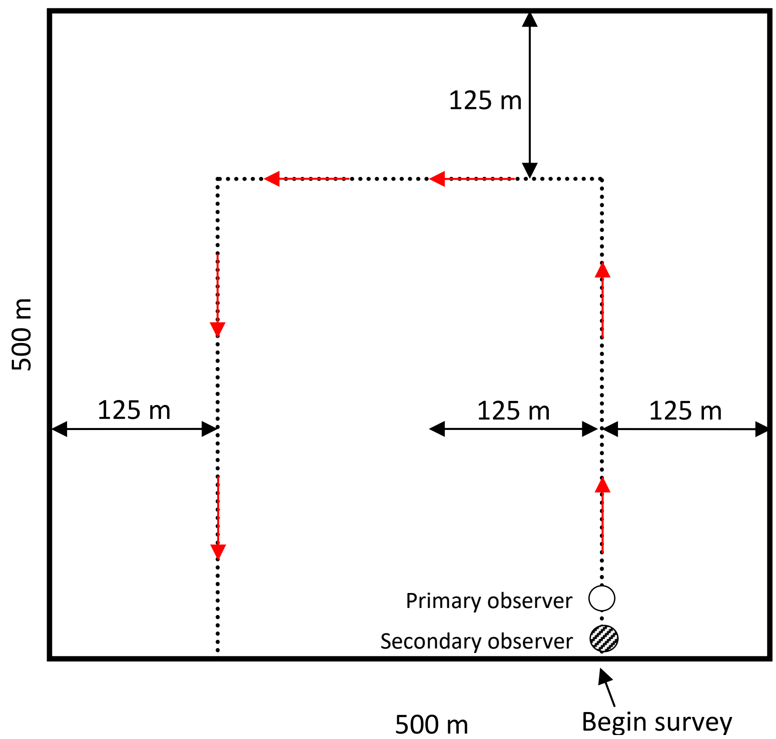

Figure 2. Schematic illustrating the dependent double-observer method used to estimate abundance of migratory songbirds in response to SGI grazing near Lavina and Roundup, MT. The primary (open circle) and secondary observer (dashed circle) walk single-file along the transect (dotted line) within a 500 m x 500 m sampling plot. Observers survey up to 125 m on either side of the transect (dotted line). All surveys start at the lower right corner of the sample plot. Red arrows indicate direction of travel.

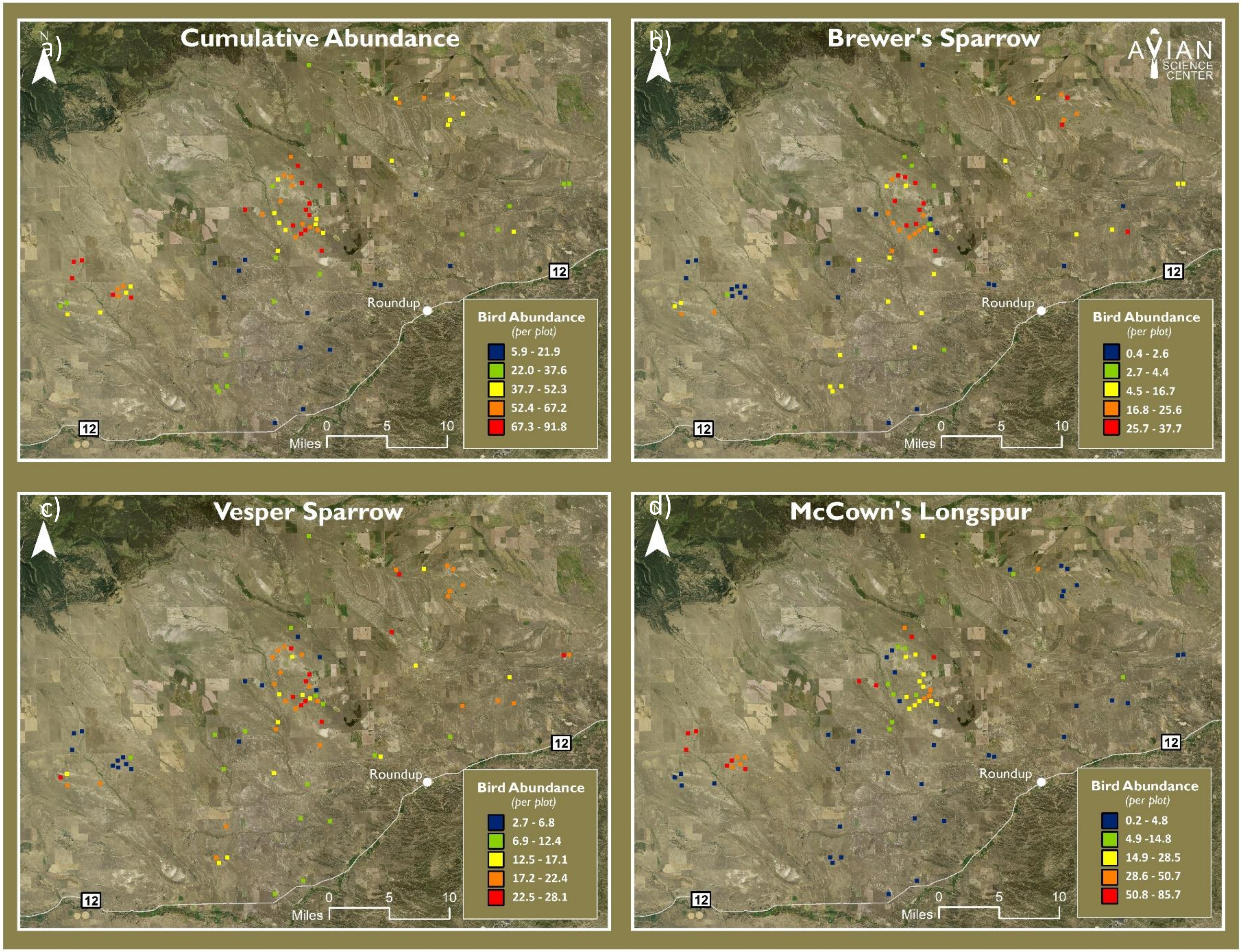

Figure 3. The mean estimated abundance for each sampling plot across all years (2013-2017) for the three most frequently observed migratory songbirds combined (a) and individually (b-d) near Lavina and Roundup, MT.

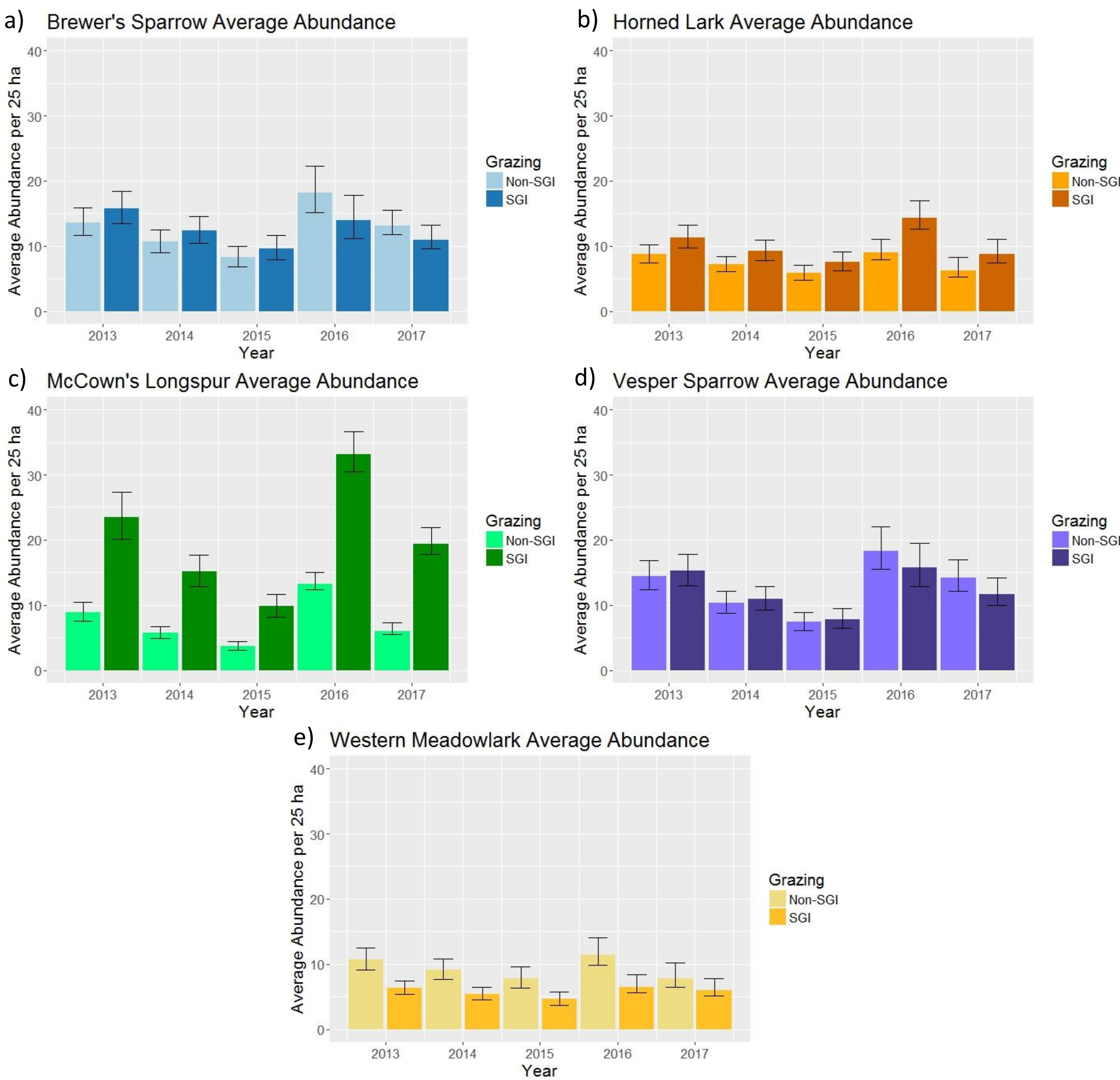

Figure 4. The estimated average abundance for the top five migratory songbirds observed on Non-SGI (lighter color) and SGI (darker color) plots near Lavina and Roundup, MT.

Appendix A. Total number of individuals per species for all species detected during avian count transect surveys near Lavina and Roundup, MT.

Common Name	Scientific Name	2013	2014	2015	2016	2017
Totals		**13,529**	**13,755**	**6,016**	**10,246**	**10,691**
American avocet	*Recurvirostra americana*	28	31	5	1	29
American coot	*Fulica americana*	-	13	-	-	0
American crow	*Corvus brachyrhynchos*	13	1	-	9	2
American goldfinch	*Spinus tristis*	2	3	-	-	1
American kestrel	*Falco sparvarius*	46	12	3	8	20
American pipit	*Anthus rubescens*	-	-	1	-	-
American robin	*Turdus migratorius*	13	26	9	18	23
American wigeon	*Anas americana*	20	9	6	-	7
Baird's sparrow	*Ammodramus bairdii*	10	4	1	2	2
Baltimore oriole	*Icterus galbula*	-	-	-	-	1
bank swallow	*Riparia riparia*	-	-	-	9	8
barn swallow	*Hirundo rustica*	16	20	6	19	10
black-billed magpie	*Pica hudsonia*	25	20	2	14	14
black-capped chickadee	*Poecile atricapillus*	6	3	1	7	10
blue-winged teal	*Anas discors*	17	3	13	6	5
bobolink	*Dolichonyx oryzivorus*	-	-	-	-	2
Brewer's blackbird	*Euphagus cyanocephalus*	186	82	29	147	185
Brewer's sparrow	*Spizella breweri*	1,783	2,028	1,216	1,171	1,729
brown thrasher	*Toxostoma rufum*	-	1	-	-	-
brown-headed cowbird	*Molothrus ater*	290	323	197	341	287
Bullock's oriole	*Icterus bullockii*	-	1	-	-	-
burrowing owl	*Athene cunicularia*	-	1	-	5	-
California gull	*Larus californicus*	19	-	3	6	-
Canada goose	*Branta canadensis*	167	46	121	137	8
canvasback	*Aythya valisineria*	-	-	-	-	2
Cassin's kingbird	*Tyrannus vociferans*	4	-	-	1	1
cedar waxwing	*Bombycilla cedrorum*	10	-	-	-	-
chestnut-collared longspur	*Calcarius ornatus*	440	406	226	327	636
chipping sparrow	*Spizella passerina*	15	1	3	31	5
cinnamon teal	*Anas cyanoptera*	8	4	1	4	-
Clark's nutcracker	*Nucifraga columbiana*	3	-	-	-	-
clay-colored sparrow	*Spizella pallida*	2	6	5	46	114
cliff swallow	*Petrochelidon pyrrhonota*	487	222	2	566	107
common grackle	*Quiscalus quiscula*	1	-	1	1	-
common nighthawk	*Chordeiles minor*	5	21	2	5	10

common raven	*Corvus corax*	26	25	16	28	30
common yellowthroat	*Geothlypis trichas*	-	-	-	1	-
double-crested cormorant	*Phalacrocorax auritus*	3	24	5	-	4
eared grebe	*Podiceps nigricollis*	-	-	1	-	-
eastern kingbird	*Tyrannus tyrannus*	6	4	1	7	2
Eurasian collared dove	*Streptopelia decaocto*	-	-	-	-	2
European starling	*Sturnus vulgaris*	27	1	10	41	22
ferruginous hawk	*Buteo regalis*	2	-	3	1	3
field sparrow	*Spizella pusilla*	-	-	-	2	-
Franklin’s gull	*Leucophaeus pipixcan*	13	-	-	3	-
gadwall	*Anas strepera*	11	20	7	18	32
golden eagle	*Aquila chrysaetos*	3	-	2	2	5
grasshopper sparrow	*Ammodramus savannarum*	80	71	58	18	83
gray catbird	*Dumetella carolinensis*	-	-	-	-	1
gray partridge	*Perdix perdix*	2	15	-	-	-
great blue heron	*Ardea herodias*	3	2	-	3	3
greater sage-grouse	*Centrocercus urophasianus*	5	-	9	25	1
green-winged teal	*Anas crecca*	-	3	3	2	4
herring gull	*Larus argentatus*	1	-	-	-	4
hooded merganser	*Lophodytes cucullatus*	-	-	-	-	1
horned lark	*Eremophila alpestris*	1,612	1,945	822	965	1,049
house wren	*Troglodytes aedon*	1	-	-	-	1
killdeer	*Charadrius vociferus*	35	57	30	46	61
lark bunting	*Calamospiza melanocorys*	458	586	64	267	606
lark sparrow	*Chondestes grammacus*	76	89	36	46	57
Lazuli bunting	*Passerina amoena*	-	-	-	1	-
least flycatcher	*Empidonax minimus*	-	-	-	-	1
least sandpiper	*Calidris minutilla*	-	-	-	2	-
loggerhead shrike	*Lanius ludovicianus*	28	20	13	7	20
long-billed curlew	*Numenius americanus*	104	115	49	66	69
mallard	*Anas platyrhynchos*	30	16	25	27	25
marbled godwit	*Limosa fedoa*	9	7	2	4	8
McCown's longspur	*Rhynchophanes mccownii*	3,487	3,550	1,077	2,428	2,064
merlin	*Falco columbarius*	-	2	1	-	2
mountain bluebird	*Sialia currucoides*	19	7	5	19	15
mountain plover	*Charadrius montanus*	4	3	3	6	3
mourning dove	*Zenaida macroura*	173	279	95	166	170
northern flicker	*Colaptes auratus*	25	11	4	6	19
northern harrier	*Circus cyaneus*	29	9	3	13	30
northern pintail	*Anas acuta*	4	-	2	11	12
northern shoveler	*Anas clypeata*	4	4	5	1	10
Olive-sided flycatcher	*Contopus cooperi*	-	-	-	1	-

peregrine falcon	*Falco peregrinus*	1	-	-	-	-
pinyon jay	*Gymnorhinus cyanocephalus*	8	-	-	-	-
prairie falcon	*Falco mexicanus*	2	2	3	4	-
redhead	*Aythya americana*	-	-	1	-	-
red-tailed hawk	*Buteo jamaicensis*	13	4	3	3	4
red-winged blackbird	*Agelaius phoeniceus*	109	105	48	78	91
ring-billed gull	*Larus delawarensis*	3	8	1	-	-
ring-necked pheasant	*Phasianus colchicus*	-	-	-	-	25
rock pigeon	*Columba livia*	5	3	-	7	12
rock wren	*Salpinctes obsoletus*	7	9	6	-	8
rough-legged hawk	*Buteo lagopus*	1	-	-	1	-
ruddy duck	*Oxyura jamaicensis*	-	-	-	-	1
sage thrasher	*Oreoscoptes montanus*	11	8	1	8	28
sandhill crane	*Grus Canadensis*	-	4	-	-	-
savannah sparrow	*Passerculus sandwichensis*	8	21	26	32	14
Say’s pheobe	*Sayornis saya*	24	10	5	7	10
semipalmated plover	*Charadrius semipalmatus*	22	-	-	-	-
sharp-shinned hawk	*Accipiter striatus*	1	-	-	-	-
sharp-tailed grouse	*Tympanuchus phasianellus*	1	-	1	2	-
short-eared owl	*Asio flammeus*	-	2	2	-	-
solitary sandpiper	*Tringa solitaria*	-	-	-	-	5
song sparrow	*Melospiza melodia*	-	-	-	1	-
sora	*Porzana carolina*	-	-	1	-	-
spotted sandpiper	*Actitis macularius*	-	-	-	4	-
Sprauge's pipit	*Anthus spragueii*	6	8	4	1	12
Swainson’s hawk	*Buteo swainsoni*	1	-	-	1	1
Townsend's solitaire	*Myadestes townsendi*	-	-	-	-	1
tree swallow	*Tachycineta bicolor*	17	18	4	4	5
tundra swan	*Cygnus columbianus*	2	-	-	-	-
turkey vulture	*Cathartes aura*	10	-	1	1	2
upland sandpiper	*Bartramia longicauda*	33	28	10	9	21
vesper sparrow	*Pooecetes gramineus*	2,002	2,087	1,024	1,907	1,826
violet green swallow	*Tachycineta thalassina*	5	2	-	2	6
western kingbird	*Tyrannus verticalis*	2	3	1	3	-
western meadowlark	*Sturnella neglecta*	1,195	1,250	644	1,034	950
western wood-pewee	*Contopus sordidulus*	-	2	-	2	1
White-crowned sparrow	*Zonotrichia leucophrys*	3	1	-	7	1
white-faced ibis	*Plegadis chihi*	-	3	-	-	-
willet	*Tringa semipalmata*	19	6	3	3	16
Wilson’s phalarope	*Steganopus tricolor*	116	14	23	7	11
Wilson’s snipe	*Gallinago delicata*	-	3	-	-	-
Wilson's warbler	*Cardellina pusilla*	-	-	-	1	-

yellow warbler	*Setophaga petechia*	-	-	-	1	-
yellow-headed blackbird	*Xanthocephalus xanthocephalus*	3	2	-	1	2
yellow-rumped warbler	*Setophaga coronata*	3	-	-	1	1