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Migratory Songbird - Grazing

April 1, 2016 – March 31, 2017

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All of the information in this report is preliminary and subject to further evaluation. Manipulation of these data beyond what is contained in this report is discouraged.

Executive Summary

This is the annual interim report for Federal Aid in Wildlife Restoration Grant W-165-R to Montana Fish, Wildlife and Parks, for the period April 1, 2016 to March 30, 2017.

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 impacts include direct increase of sagebrush size, cover, and density; decrease of forb cover and density; and decrease of grass cover and density by altering its vegetation structure, composition, and productivity (Beck and Mitchell 2000). Most recently, livestock grazing has been recognized as a management tool to achieve desired vegetation conditions (Fuhlendorf and Engle 2001). As part of efforts to protect declining greater sage-grouse (*Centrocercus urophasianus*) populations, various conservation efforts have implemented management-based grazing systems. One of the grazing efforts introduced to the area is under the Sage-Grouse Initiative (SGI) by the Natural Resources Conservation Service (NRCS). In Montana, SGI provides incentives for landowners to implement sage-grouse friendly grazing systems as a way to improve sagebrush habitat for all wildlife that use it and prevent loss of habitat by keeping working ranches intact to discourage conversion of sagebrush rangelands to farmlands.

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 reproduce less per breeding season than other grouse species). In comparison, 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 (e.g., Lemoine et al. 2007), and effectiveness of conservation actions have been documented.

In 2012, we began a study to evaluate the relationship between grazing and avian community composition and demographic parameters as related to Sage Grouse Initiative (SGI)’s rest-rotation system compared to the varied grazing strategies of other private landowners (hereafter non-SGI). Rest-rotation grazing is defined as moving livestock through different paddocks or pastures for shorter grazing periods, varying the grazing time in each pasture over the years (Hormay 1970, Smith 2016). Other grazing in the area was considered to be “non-SGI” and may be grazed in through many alternative methods. However, most grazing that is non-SGI in the

area is season-long and can be defined as repeated livestock grazing in a pasture at the same time each year over multiple vegetation growing seasons.

Our objectives are to (1) compare migratory songbirds responses between SGI and non-SGI grazing systems by measuring species abundance/density, species richness, species diversity, and community composition and (2) investigate migratory songbird breeding performance of three focal songbird species in response to rest-rotation grazing as a conservation management tool. We do this by determining the breeding performance of three focal songbird species that represent the vegetation characteristics in sagebrush steppe between land with rest-rotation and season long grazing.

From 2013 - 2016 we assessed the relative response of migratory songbird populations during the breeding season to SGI and non-SGI grazing systems. We conducted avian count survey transects using a dependent double-observer method to sample the composition and abundance of species in the songbird community on randomly selected plots in SGI and non-SGI pastures. We monitored nesting activity of Brewer's sparrow (*Spizella breweria*, a shrub nester), vesper sparrow (*Pooecetes gramineus*; a generalist ground nester), and McCown's longspur (*Rhynchophanes mccownii*; a grassland ground nester).

Background

This is the annual interim report for Federal Aid in Wildlife Restoration Grant W-165-R to Montana Fish, Wildlife and Parks, for the period April 1, 2016 to March 30, 2017.

Approximately 76% of birds that are sagebrush-associated species are declining nationally (North American Bird Conservation Initiative 2009). Sagebrush-nesting species make up one of 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 breweri*), 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 respond quickly to habitat changes by shifting their distributions and adapting their reproductive performance and can therefore serve as an initial barometer for system integrity and assist in evaluating the effectiveness of management actions. 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 varying degrees 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, which use sagebrush for the majority of their life history needs.

Declines in sagebrush-associated avian species are congruent with significant losses of sagebrush (*Artemisia* spp.) habitat (Braun et al. 1976, Knick 1999). Conversion of sagebrush to agriculture; fragmentation resulting from energy or subdivision development; and modifications, such as prescribed fire, herbicides, and some grazing practices that lead to exotic, annual grass establishment are significant stressors on sagebrush systems (Rich et al. 2004, MTSWAP 2015). Big Sagebrush Steppe, the most widely distributed sagebrush system in Montana, is typically characterized by Wyoming big sage (*Artemisia tridentate* ssp. *wyomingensis*) with perennial grasses and forbs dominating at least 25% of 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 practitioners to private land owners. Through the consumption of vegetation, livestock grazing directly and indirectly affects the amount of vegetation in a system. Livestock grazing also provides a type of disturbance needed for many systems. There is a growing recognition that livestock grazing can be manipulated to positively affect sagebrush-associated birds. Depending on the timing of grazing and utilization 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). Heavy livestock grazing can also decrease invertebrate biomass (Krausman et al. 2009); an important food source for several bird species. Rest-rotation grazing is defined as moving livestock through different paddocks or pastures for shorter grazing periods, varying the grazing time in each pasture over the years (Hormay 1970, Smith 2016). Any other grazing in the area we considered to be "non-SGI" may be grazed using any regime. However, most grazing that is non-SGI in the area is season-long and can be defined as repeated livestock grazing in a pasture at the same time each year over multiple vegetation growing seasons.

Rest-rotation grazing is currently the most common grazing strategy used to improve habitat for wildlife in sagebrush systems (Krausman et al. 2009). While limited data suggest that rest-rotation grazing may not have large 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 as oppose to differing types of grazing (e.g., Bock & Webb 1984; Harrison et al. 2010; Nelson et al. 2011). Because livestock grazing is so prominent in the west, it would be more beneficial and realistic to know whether certain grazing strategies can optimize the benefits of grazing on the ecosystem, rather than pool all grazing in contrast to non-grazed systems.

In Montana, Montana Fish, Wildlife and Parks (FWP) manages 89,000 acres of grazed habitats on state-owned lands using rest-rotation grazing. 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 to control the location and timing of grazing on areas with relatively high sage-grouse densities. To date >400,000 acres have been enrolled across Montana. These efforts provide the infrastructural capacity to investigate the benefits of rest-rotation grazing on avian populations. Management strategies that incorporate monitoring of songbirds may be alerted to changes in habitat more quickly than if relying on only sage-grouse population responses.

The goal of this study is to determine the response of migratory songbird populations during the breeding season to rest-rotation grazing. Here we describe our findings to date 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 range of vegetation characteristics used by breeding songbirds (sagebrush obligate, mixed use of sagebrush and grasslands, and those species that prefer grasslands) in sagebrush steppe between SGI's rest-rotation regime and season long grazing. The three species we chose are: 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 provide information for years 1 - 4 (2013 to present) of this 8-year study. The 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. We provide a general summary of our field methods for each objective below.

Methods:

Avian count transect surveys were conducted using a dependent double-observer method (Nichols et al. 2000). This method has been proven to be efficient on grassland songbirds (Tipton et al. 2008 and 2009) and 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 uses a two-person team with a primary observer 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 also records any individuals detected that the primary observer misses. Auditory observations must be confirmed by sight to be recorded. Primary and secondary observers then alternate between surveys.

We conducted avian count transect surveys three times within each sample plot between late April and August of each year (Table 1). Transect surveys were completed between sunrise (~0530 Mountain Standard Time [MST]) and 1100 MST. Transect surveys did not take place during steady rains or when wind speeds exceeded 15 mph. The third sampling occasion for plots in 2015 was not completed due to an early nesting season and our lack of reliability in observers distinguishing between juveniles of the year and adults.

We also conducted nest searches within sampling plots and monitored nests at ~ 3 day intervals until their status was determined successful, ≥ 1 nestling left the nest, or failed.

Objective 1: Investigate migratory songbird *abundance, species richness, species diversity, and community composition* responses to rest-rotation grazing as a conservation management tool.

Accomplishments:

To examine species abundance/density, species richness, species diversity, and community composition we conducted the avian count transect surveys described above (Figure 2). We conducted three avian transect surveys within each sample plot between late April and August from 2013 – 2016 to account for differences in species specific breeding phenology (Table 1). In 2015, we only completed two surveys per sampling plot because breeding activity commenced relatively early that year. By the third survey (mid-June to early July) we did not feel we could reliably distinguish between adults and young of the year juveniles. Misidentifying juveniles as adults would decrease the accuracy of our abundance estimates. The dependent double-observer (DDO) method increases the probability of detecting individual birds, thus providing more accuracy in abundance estimates (Golding and Dreitz 2016). Our statistical analysis used the multispecies dependent double-observer abundance model (MDAM) that incorporates the dependent double-observer transect survey method to estimate abundance for multiple species (Golding 2015, Golding et al. in press).

Results:

The total number of individuals observed each year of the study during 2013 – 2016 were 13,525, 13,755, 6,016, and 10,246, respectively (Appendix A). We believe we observed fewer individuals in 2015 due to the earlier breeding season, resulting in only two avian count surveys per sample plot for that year. Observations of the avian community remained similar among years: 86 species in 2013, 75 species in 2014, 71 species in 2015, and 83 species in 2016 (Appendix A) suggesting a relatively stable diversity of species occupying our study area.

The migratory songbird species in which the most individuals were observed since 2013 were: Brewer's sparrow, vesper sparrow, western meadowlark, McCown's longspur, and horned lark (Table 2, Appendix A). Patterns in the number of observed individuals varied by species. For instance, individual Brewer's sparrows, vesper sparrows, and western meadowlarks were observed most often on season long grazing than rest-rotation grazing, while, McCown's longspurs and horned larks were observed most often on lands using rest-rotation grazing.

Estimates of abundance for the top five species suggest species-specific responses to the two grazing types (Table 3, Figure 3). McCown's longspurs were more abundant on lands with rest-rotation than season long grazing. In contrast, western meadowlarks were more abundant on lands with season long than rest-rotation grazing. There was no difference in abundance between abundances on grazing types for Brewer's sparrows, horned larks, and vesper sparrows. While we have not seen a clear response of all bird species within the community, our results suggest that rest-rotation grazing creates vegetation conditions that are more favorable for McCown's longspur and neutral for three other species. The diversity of responses across species is expected as these different species have varying life history characteristics. Because of that, each species will have a different response to changes in the environment. Further exploration of the fitness consequences of these grazing systems may provide more insight into these responses.

Objective 2: Investigate migratory songbird *breeding performance of three focal songbird species* in response to rest-rotation grazing as a conservation management tool.

Accomplishments:

Since 2013, we monitored nesting activity of songbird species within rest-rotation and season long grazing systems. We focused on three species that represent the range of vegetation characteristics used by breeding songbirds: 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 drag method (Higgins et al. 1969); 2) a systematic nest search using a dowel swept over the top of sagebrush bushes (Ruehmann et al. 2011); 3) an avian count transect survey in which a nest was quickly identified; and 4) an opportunistic location of a nest while walking through the sample plot (e.g., returning from nest monitoring visits). When a nest was initially located, we recorded location information (UTM coordinates) and marked with flagging about five meters away from the nest in each cardinal direction. Nests were monitored at approximately three day intervals, weather permitting. During each monitoring visit we recorded the status (active or inactive), stage of the young (eggs, nestling, or fledgling), and the number of young at each stage. A nest was determined successful when ≥ 1 nestling 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 attempted to determine if the cause of failure was predation, weather, or unknown.

Results:

A total of 371 nest searches were conducted over the 4 years of the study: 56 searches in 2013, 80 searches in 2014, 66 searches in 2015, and 169 searches in 2016 (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) and 83% (66 searches/80 plots) of the sample plots during 2013 and 2015 because we were establishing nest search methods and due to time constraints, respectively. In 2015, a total of seven sample plots were surveyed up to six 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 708 nests: 136 nests in 2013, 156 nests in 2014, 252 nests in 2015, and 164 nests in 2016 (Table 4). Nest counts were similar between grazing systems and among years, with an increase in 2016 due to an increase in nest search effort. We located 55% of the nests (390/708 nests) on lands using rest-rotation grazing, compared to 45% of the nests (318/708 nests) on lands using season long grazing.

In 2016, a total of 164 nests were detected and monitored across the three focus species, with 86 nests on plots with season long grazing and 76 on rest-rotation plots (Table 4). Rest-rotation grazed plots had higher nest numbers for vesper sparrows and McCown's longspurs in 2016, but lower nest numbers for Brewers. For previous seasons (2013-2015), Brewer's sparrow, McCown's longspur, and vesper sparrow combined nest totals we lower for season long grazing than rest-rotation grazing. The observed number of nests for each species was similar between the two grazing systems, except for McCown's longspur nests, for which we consistently detected more on rest-rotation grazing systems (Table 4).

Apparent nest success (number successful/total # nests) for all three species was 0.51. Nest success varied by species and year ranging from 0.28 – 0.75 (Table 4). Similarly, nest success also varied by grazing system (Table 4). Nest success was lowest for McCown's longspur on lands using rest-rotation in 2015 (0.28) and highest for Brewer's sparrow on lands using rest-rotation in 2016 (0.75).

Future Goals:

We will continue data collection for the next four years, 2017 – 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 grazing is known to affect vegetation heterogeneity. Therefore, we can follow 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 initial indicator of change in sagebrush systems to land 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. By doing this, we can ensure that we avoid unintentionally creating an ecological trap or sink in the population where individuals are not successfully breeding. If this happens, population numbers may fall in years following due to low reproductive rates, but this may be undetected with abundance estimates alone. We will continue to monitor the nesting activity of our three focal songbird species (Brewer's sparrow, vesper sparrow, and McCown's longspur) within rest-rotation and season long grazing systems. We will identify reproductive responses to SGI's rest-rotation grazing system of these three species. Variables that may be measured to 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 report the status of the deliverables, as listed in Federal Aid in Wildlife Restoration grant W-165-R to Montana Fish, Wildlife and Parks, for the period April 1, 2016- March 31, 2017.

1. Collect data on songbirds during the breeding season - **Completed**
2. Provide annual progress report by March 31, 2017 – **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: Golding and Dreitz 2016, Golding et al. In press**

4. Present research findings for the duration of the project (2013 to present) to at least one professional conference – **Presentation by MS student at Montana Chapter of the Wildlife Society meeting in Helena, Montana, March 8-10, 2017.**
5. Meet with local FWP and NRCS regional managers and biologists to discuss research project – **Completed during field season and at FWP's Sage-Grouse Grazing Study annual oversight meeting, Feb 2017 because we collaborate with that research group, which includes representatives from NRCS, BLM, USFWS, DNRC, FWP, Montana State University and the University of Montana.**
6. Participate in landowner outreach to provide information to landowners on our research objectives and results –**Information about the status of this project was included in landowner mailings, project staff participated in the annual landowner dinner in Nov 2016, and we interacted with landowners when we saw them in the field.**

7. Present research results to private landowners and wildlife and land management agencies as requested – **Presented our research at FWP's Sage-Grouse Grazing Study annual oversight meeting, Feb 2017. because we collaborate with that research group, which includes representatives from NRCS, BLM, USFWS, DNRC, FWP, Montana State University and the University of Montana**
8. Provide a research opportunity for a graduate (Masters) student. – **MS student was hired and began work on this project in 2016**.

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Table 1. The number of avian count transects surveyed and nest searches conducted on 500 m X 500 m sample plots during 2013 – 2016 in Golden Valley and Musselshell Counties, Montana.

Sampling Occasion	2013			2014			2015			2016		
	Date	Transect Survey	Nest Search	Date	Transect Survey	Nest Search	Date	Transect Survey	Nest Search	Date	Transect Survey	Nest Search*
1	Apr 26-Jun 1	80	56	May 22-July 12	80	30	May 21-Jun 6	80	19	May 7-Jun 14	80	80
2	Jun 4-Jul 31	80	30	Jun 3-Jul 8	80	30	Jun 6 – Jun 29	80	47	May 22-Jul 1	80	66
3	Jun 9-Aug 3	80	20	Jul 8-Jul 23	80	20	-	-	-	Jun 16-Jul 5	80	23
4		-	-		-	-	-	-	-	Jun 23-Jul 8	-	19
Totals		240	56		240	80		160	66		240	188

*Nest searching efforts in 2016 were increased as part of the MS student's research, resulting in increased effort to locate nests.

Table 2. Total number of individuals detected for the top five songbird species during avian count transect surveys during 2013 – 2016 in Golden Valley and Musselshell Counties, Montana.

Common Name	2013		2014		2015		2016	
	Season Long	Rest-Rotation	Season Long	Rest-Rotation	Season Long	Rest-Rotation	Season Long	Rest-Rotation
Brewer's sparrow	979	804	1,101	927	636	580	641	530
Horned lark	597	1,015	870	1,075	301	521	431	534
McCown's longspur	1,037	2,450	726	2,824	280	797	546	1882
Vesper sparrow	1,066	936	1,057	1,030	573	451	962	945
Western meadowlark	795	400	779	471	386	258	606	428
Totals	4,474	5,605	4,533	6,327	2,176	2,607	3,186	4,319

Table 3. Estimates of detection and abundance per 25 ha sample plot for top five songbird species observed during avian count transect surveys during 2013 – 2016 in Golden Valley and Musselshell Counties, Montana. Estimates are derived from the multispecies dependent double-observer abundance model. Values in parentheses represent the 95% Bayesian credible intervals.

		2013		2014		2015		2016	
Common Name	**Detection Probability**	**Season Long**	**Rest Rotation**	**Season Long**	**Rest Rotation**	**Season Long**	**Rest Rotation**	**Season Long**	**Rest Rotation**
Brewer's sparrow	0.5 (0.09-0.78)	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)
horned lark	0.55 (0.29-0.86)	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)
McCown's longspur	0.62 (0.26-0.85)	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)
vesper sparrow	0.46 (0.10-0.82)	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)
western meadowlark	0.47 (0.10-0.78)	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)

Table 4. Number of Brewer's sparrow, vesper sparrow, and McCown's longspur nests detected during nest search efforts during 2013 – 2016 in Golden Valley and Musselshell Counties, Montana. Apparent nest survival (number of successful nests / total number of nests) for each species on each grazing system is also provided.

	2013				2014				2015				2016			
	Season Long		Rest-Rotation		Season Long		Rest-Rotation		Season Long		Rest-Rotation		Season Long		Rest-Rotation	
Common Name	# Nests	Success	# Nests	Success	# Nests	Success	# Nests	Success	# Nests	Success	# Nests	Success	# Nests	Success	# Nests	Success
Brewer's sparrow	17	0.53	19	0.58	27	0.44	30	0.7	72	0.54	74	0.69	34	0.50	14	0.57
McCown's longspur	10	0.3	24	0.42	7	0.57	41	0.51	5	0.6	18	0.28	10	0.60	31	0.29
vesper sparrow	29	0.48	37	0.43	26	0.5	25	0.68	39	0.51	44	0.48	42	0.43	33	0.36
Totals	**56**		**80**		**60**		**96**		**116**		**136**		**86**		**78**	

Figure 1. Location of the study investigating the response of migratory songbird populations during the breeding season to rest-rotation versus season long grazing in Golden Valley and Musselshell Counties, Montana.

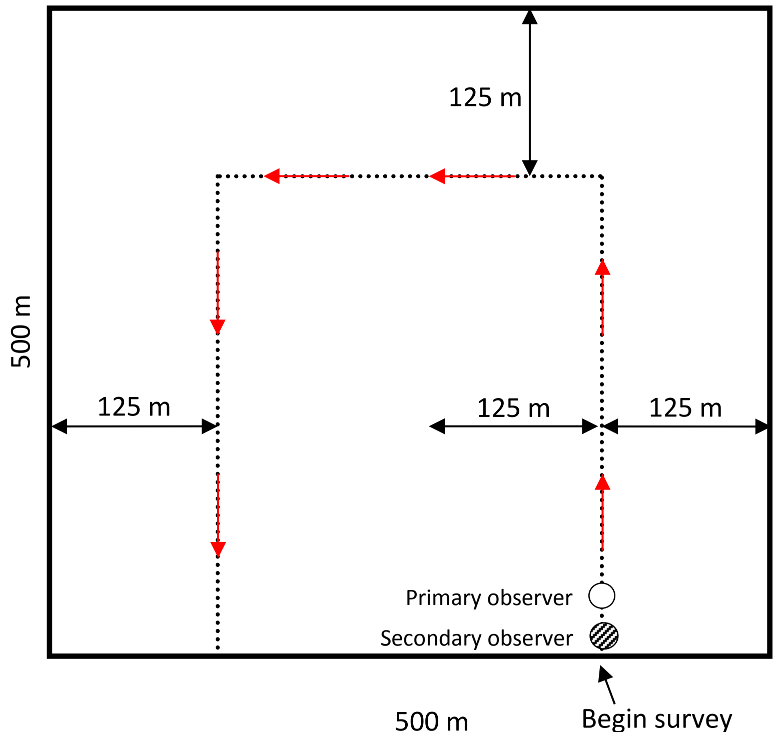

Figure 2. Schematic illustrating the dependent double-observer method used to estimate abundance of migratory songbirds in response to rest-rotation grazing in Golden Valley and Musselshell Counties, Montana. The primary (open circle) and secondary observer (dashed circle) walk single-file along the 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 (Southeastern) corner of the sample plot. Red arrows indicate direction of travel.

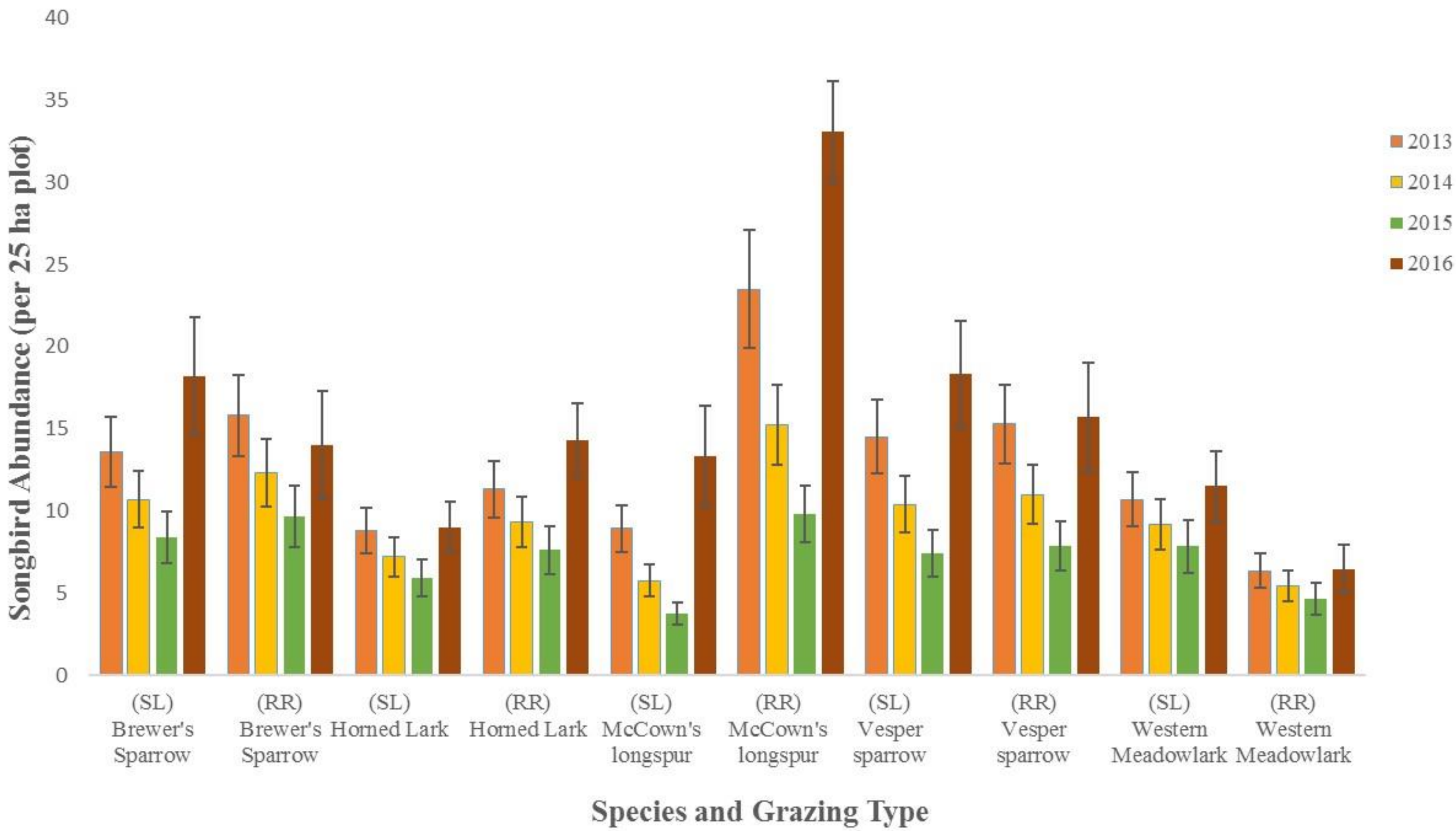

Figure 3. The estimated abundance for the top five songbird species observed on our study investigating the response of migratory songbird populations during the breeding season to rest-rotation (RR) versus season long (SL) grazing during 2013 – 2016 in Golden Valley and Musselshell Counties, Montana.

Appendix A. Total number of individuals per songbird species for all species detected on avian count transect surveys during 2013 – 2016 in Golden Valley and Musselshell Counties, Montana.

Common Name	Scientific Name	2013	2014	2015	2016
Totals		**13,529**	**13,755**	**6,016**	**10,246**
American avocet	*Recurvirostra americana*	28	31	5	1
American coot	*Fulica americana*	-	13	-	-
American crow	*Corvus brachyrhynchos*	13	1	-	9
American goldfinch	*Spinus tristis*	2	3	-	-
American kestrel	*Falco sparvarius*	46	12	3	8
American pipit	*Anthus rubescens*	-	-	1	-
American robin	*Turdus migratorius*	13	26	9	18
American wigeon	*Anas americana*	20	9	6	-
Baird's sparrow	*Ammodramus bairdii*	10	4	1	2
bank swallow	*Riparia riparia*	-	-	-	9
barn swallow	*Hirundo rustica*	16	20	6	19
black-billed magpie	*Pica hudsonia*	25	20	2	14
black-capped chickadee	*Poecile atricapillus*	6	3	1	7
blue-winged teal	*Anas discors*	17	3	13	6
Brewer's blackbird	*Euphagus cyanocephalus*	186	82	29	147
Brewer's sparrow	*Spizella breweri*	1,783	2,028	1,216	1,171
brown thrasher	*Toxostoma rufum*	-	1	-	-
brown-headed cowbird	*Molothrus ater*	290	323	197	341
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
Cassin's kingbird	*Tyrannus vociferans*	4	-	-	1
cedar waxwing	*Bombycilla cedrorum*	10	-	-	-
chestnut-collared longspur	*Calcarius ornatus*	440	406	226	327
chipping sparrow	*Spizella passerina*	15	1	3	31
cinnamon teal	*Anas cyanoptera*	8	4	1	4
Clark's nutcracker	*Nucifraga columbiana*	3	-	-	-
Clay-colored sparrow	*Spizella pallida*	2	6	5	46
cliff swallow	*Petrochelidon pyrrhonota*	487	222	2	566
common grackle	*Quiscalus quiscula*	1	-	1	1
common nighthawk	*Chordeiles minor*	5	21	2	5
common raven	*Corvus corax*	26	25	16	28
common yellowthroat	*Geothlypis trichas*	-	-	-	1
double-crested cormorant	*Phalacrocorax auritus*	3	24	5	-
eared grebe	*Podiceps nigricollis*	-	-	1	-

eastern kingbird	*Tyrannus tyrannus*	6	4	1	7
European starling	*Sturnus vulgaris*	27	1	10	41
ferruginous hawk	*Buteo regalis*	2	-	3	1
field sparrow	*Spizella pusilla*	-	-	-	2
Franklin's gull	*Leucophaeus pipixcan*	13	-	-	3
gadwall	*Anas strepera*	11	20	7	18
golden eagle	*Aquila chrysaetos*	3	-	2	2
grasshopper sparrow	*Ammodramus savannarum*	80	71	58	18
gray partridge	*Perdix perdix*	2	15	-	-
great blue heron	*Ardea herodias*	3	2	-	3
greater sage-grouse	*Centrocercus urophasianus*	5	-	9	25
green-winged teal	*Anas crecca*	-	3	3	2
herring gull	*Larus argentatus*	1	-	-	-
horned lark	*Eremophila alpestris*	1,612	1,945	822	965
house wren	*Troglodytes aedon*	1	-	-	-
killdeer	*Charadrius vociferus*	35	57	30	46
lark bunting	*Calamospiza melanocorys*	458	586	64	267
lark sparrow	*Chondestes grammacus*	76	89	36	46
Lazuli bunting	*Passerina amoena*	-	-	-	1
least sandpiper	*Calidris minutilla*	-	-	-	2
loggerhead shrike	*Lanius ludovicianus*	28	20	13	7
long-billed curlew	*Numenius americanus*	104	115	49	66
mallard	*Anas platyrhynchos*	30	16	25	27
marbled godwit	*Limosa fedoa*	9	7	2	4
McCown's longspur	*Rhynchophanes mccownii*	3,487	3,550	1,077	2,428
merlin	*Falco columbarius*	-	2	1	-
mountain bluebird	*Sialia currucoides*	19	7	5	19
mountain plover	*Charadrius montanus*	4	3	3	6
mourning dove	*Zenaida macroura*	173	279	95	166
northern flicker	*Colaptes auratus*	25	11	4	6
northern harrier	*Circus cyaneus*	29	9	3	13
northern pintail	*Anas acuta*	4	-	2	11
northern shoveler	*Anas clypeata*	4	4	5	1
Olive-sided flycatcher	*Contopus cooperi*	-	-	-	1
peregrine falcon	*Falco peregrinus*	1	-	-	-
pine grossbeak	*Pinicola enucleator*	-	-	-	-
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
red-winged blackbird	*Agelaius phoeniceus*	109	105	48	78
ring-billed gull	*Larus delawarensis*	3	8	1	-
ring-necked pheasant	*Phasianus colchicus*	-	-	-	-

rock pigeon	*Columba livia*	5	3	-	7
rock wren	*Salpinctes obsoletus*	7	9	6	-
rough-legged hawk	*Buteo lagopus*	1	-	-	1
sage thrasher	*Oreoscoptes montanus*	11	8	1	8
sandhill crane	*Grus Canadensis*	-	4	-	-
savannah sparrow	*Passerculus sandwichensis*	8	21	26	32
Say’s pheobe	*Sayornis saya*	24	10	5	7
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	-
song sparrow	*Melospiza melodia*	-	-	-	1
sora	*Porzana carolina*	-	-	1	-
spotted sandpiper	*Actitis macularius*	-	-	-	4
Sprauge's pipit	*Anthus spragueii*	6	8	4	1
Swainson’s hawk	*Buteo swainsoni*	1	-	-	1
tree swallow	*Tachycineta bicolor*	17	18	4	4
tundra swan	*Cygnus columbianus*	2	-	-	-
turkey vulture	*Cathartes aura*	10	-	1	1
upland sandpiper	*Bartramia longicauda*	33	28	10	9
vesper sparrow	*Pooecetes gramineus*	2,002	2,087	1,024	1,907
violet green swallow	*Tachycineta thalassina*	5	2	-	2
western kingbird	*Tyrannus verticalis*	2	3	1	3
western meadowlark	*Sturnella neglecta*	1,195	1,250	644	1,034
western wood-pewee	*Contopus sordidulus*	-	2	-	2
White-crowned sparrow	*Zonotrichia leucophrys*	3	1	-	7
white-faced ibis	*Plegadis chihi*	-	3	-	-
willet	*Tringa semipalmata*	19	6	3	3
Wilson’s phalarope	*Steganopus tricolor*	116	14	23	7
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
yellow-rumped warbler	*Setophaga coronata*	3	-	-	1