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Annual Report

Sharp-tailed Grouse Ecology & Grazing Evaluation

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EFFECTS OF LIVESTOCK GRAZING MANAGEMENT ON THE ECOLOGY OF SHARP-TAILED GROUSE, GRASSLAND BIRDS, AND THEIR PREDATORS IN NORTHERN MIXED GRASS PRAIRIE HABITATS

2016 Annual Report

EXECUTIVE SUMMARY

Our study examines the effects of grazing management on the ecology of sharp-tailed grouse by comparing the rest-rotation grazing system implemented by Montana Fish, Wildlife and Parks on conservation easements to surrounding pastures managed primarily with either season-long or rotation grazing. Field efforts this year focused on tracking radio-marked female grouse, monitoring nests, conducting habitat surveys at nest and brood locations as well as random points in the study area.

We monitored 62 radio-marked females from April–December (or until a bird died or was censored from the study). Reproductive effort was high. Radio-marked females initiated 73 nests (51 first nests, 21 renests, 1 third nest). Nesting frequency was 1 (all females available for monitoring initiated nests), while the probability of renesting (± SE) after first nest failure was 0.733 ± 0.05. Average clutch sizes were 12.16 ± 2.7 and 9.0 ± 2.4 eggs for first and renesting attempts, respectively. Twenty-seven nests successfully hatched and 46 failed (36 depredated, 3 abandoned, 7 female mortalities). Daily nest survival was 0.962 ± 0.006 and overall nest survival calculated as DSR^{37} was 0.24 ± 0.05. Preliminary analyses suggest that variables at the home-range scale, including grazing system and grassland shape complexity, were better predictors of nest survival than variables at the nest-scale.

We monitored 27 broods this season. Eight broods spent the majority of the time (>70% of locations) on the easement, 12 spent the majority of time in the reference area, and 7 split time between the two areas. Brood success, calculated as the proportion of broods fledging ≥1 chick to 14-d of age, was 0.50 ± 0.18, 0.58 ± 0.14, and 0.42 ± 0.19 for broods located on the easement, reference, and both areas, respectively. Of broods that survived to fledging, the proportion of chicks that survived was 0.41 ± 0.18, 0.32 ± 0.07, and 0.90 ± 0.25 for broods located on the easement, reference, and both areas, respectively.

Of the 66 females originally radio-marked, 28 have been depredated (17 mammalian, 8 avian, 3 unknown predation). Four females were right censored from the study when their transmitters were found with no sign of death and an additional 5 females were right censored after they could not be relocated for more than 2 months.

From April–December, we located the 62 radio-marked females 2,868 times, including locations of birds at nests; 37 females had at least 25 unique locations and allowed for breeding season home range estimation. Eleven females spent the majority of their time during the breeding

season (>70% of locations) on the easement, while 15 spent the majority of their time in the reference area. The remaining 11 females split time between the two areas. Mean breeding season home range size was 543 ± 165 m^2, 330 ± 68 m^2, and 918 ± 354 m^2 for easement females, reference females, and females that split time between the two areas, respectively. Mean distance of the centroid of a female's home range from lek of capture was 840 ± 99 m, 1,801 ± 318 m, and 1,080 ± 150 m for easement females, reference females, and females that split time between the two areas, respectively.

The second aspect of the study evaluates the effects of grazing management on the abundance and diversity of grassland birds and mesopredators in a northern mixed-grass prairie habitat. We focus on comparing a rest-rotation grazing system implemented within Montana Fish Wildlife and Parks conservation easements to surrounding reference properties managed under summer rotation or season-long grazing. Grassland bird point count surveys were conducted from 30 May – 23 June 2016 at 305 points located on the Buxbaum conservation easement and surrounding private and federal lands south of Sidney, Montana. We detected a total of 5,953 birds of 57 species during our point count surveys. We identified three focal species, which depend on the quality of the rangeland for breeding, recruitment, and survival: the grasshopper sparrow (*Ammodramus savannarum*), Baird's sparrow (*A. bairdii*), and vesper sparrow (*Pooecetes gramineus*). Habitat information was collected at bird survey points. Following late spring point counts, we sampled invertebrates via sweep-netting along two 20-m transects associated with 305 grassland bird survey locations for a total of 610 invertebrate samples.

We deployed and monitored remote camera traps for mesopredators at 90 independent locations within the study area from 13 May – 22 July during three survey periods. Cameras were rebaited every week, and after three weeks, moved to new random locations. We analyzed all photos from the cameras, identifying predators based on body shape and coloration. Five focal predator species were identified, coyote (*Canis latrans*), badger (*Taxidea taxus*), raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), and short-tailed weasel (*Mustela ermine*). Analyses of photos revealed that coyote (*Canis latrans*) occupied 41 sites, badger (*Taxidea taxus*) occupied 16 sites, raccoon (*Procyon lotor*) occupied 9 sites, striped skunk (*Mephitis mephitis*) occupied 7 sites, and short-tailed weasel (*Mustela ermine*) occupied one site. We observed predators at 69% of the camera sites within the easement pastures and 66.7% of the camera sites within reference pastures. Four predator species were detected on both the easement and reference pastures.

OBJECTIVES

Objective 1: Investigate rest rotation grazing as a rangeland management technique to improve sharp-tailed grouse fecundity and survival.

Accomplishments:

Initial efforts this year focused on securing access to the necessary private lands in the study area, obtaining research materials and equipment, and hiring field technicians. Subsequent efforts focused on capturing and radio-marking female sharp-tailed grouse and intensive monitoring of radio-marked females to locate nests and broods and monitor survival and space use.

Grouse were captured using funnel traps at lek sites in March and April. We recorded standard morphometrics including body mass, wing chord, tarsus length, and culmen length, and fitted all birds with a uniquely numbered metal leg band. Birds were sexed and aged by plumage characteristics. Males were fitted with a unique combination of color bands to allow for resighting on leks next year. We fitted captured females with 18-g necklace-style radio-transmitters with a 6-8 hour mortality switch and an expected battery life of 12 months (model A4050; Advanced Telemetry Systems, Insanti, MN). Previous work found no impact of necklace-style radio-transmitters on prairie grouse (Hagen et al. 2006).

Radio-marked females were located by triangulation or homing ≥3 times/week using portable radio receivers and handheld Yagi antennas during the nesting and brood-rearing period (April–August) and ≥ 2 times/week during the rest of the year (September—March). When females localized in an area and their estimated location did not change for 3 successive days, we used portable radio receivers and handheld Yagi antennas to locate and flush the female so eggs could be counted and nest location recorded with a handheld GPS unit. We marked nest locations with natural landmarks at a distance ≥ 25 m to aid in relocation. If the nest was first found during egg-laying, nest sites were visited again in <2 weeks to determine final clutch size and nest status. During the second visit, eggs were removed and carried >200 m from the nest and floated in a small container of lukewarm water to assess stage of incubation, estimate hatch date, and estimate the date of clutch initiation by backdating. Nest sites were not visited again until it was determined that female had departed (i.e., was located away from the nest for ≥ 2 days during incubation and ≥ 1 day after expected hatch date) due to successful hatching of the clutch or failure due to either predation or abandonment. Nesting females were otherwise monitored by triangulation from a distance > 25 m. Thus, nest sites were only disturbed by the presence of an observer a maximum of 2 times during the laying and incubation period.

Once the female departed the nest, we classified nest fate as successful (≥1 chick produced), failed, depredated, or abandoned. Nests were considered abandoned if eggs were cold and unattended for >5 days. Nests were considered failed if the eggs were destroyed by flooding, trampling by livestock, or construction equipment. Nests were considered depredated if the entire clutch disappeared before the expected date of hatching, or if eggshell and nest remains indicated that the eggs were destroyed by a predator. When a depredation event occurred, the egg remains were evaluated and the area was searched for predator sign. For successful nests, hatchability was calculated as the percentage of eggs that hatched and produced chicks. Eggs that failed to hatch were opened to determine stage of development and possible timing of embryo failure.

Successful broods were relocated ≥4 times per week, including one nighttime roosting location per week, until failure or brood break-up in the fall. Pre-fledging brood survival was estimated by conducting flush counts between 14 and 16 days post hatch. Flush counts were conducted at dawn or dusk when chicks were close to radio-marked females to determine the number of surviving chicks in the brood. After females were flushed, the area was systematically searched and the behavior of the female observed to assess whether chicks were present but undetected. For counts of 0 chicks, the brood female was flushed again the following day to be certain no chicks remained in the brood. Broods were considered successful if ≥ 1 chick survived until fledging (14-d post-hatch). Fledging success was calculated as the percentage of chicks that survived until fledging within a successful brood. Flush counts were repeated at 14, 30, and 60 days post-hatch or until we were confident that no chicks remained with the female. We used spotlights and a large net to capture >35 day old chicks by relocating radio-marked females at night. We recorded morphometrics and equipped 1-2 fledglings/brood with radio-transmitters attached with glue and sutures (model A2400; Advanced Telemetry Systems, Isanti, MN). Radio-marked fledglings were monitored ≥3 times per week until death or transmitter failure or loss.

We monitored radio-marked females ≥2 times per week to estimate survival. Transmitters were equipped with a mortality switch that activated after 6–8 hours of inactivity. Once the mortality switch activated, transmitters were located and the area searched to determine probable cause of death. Mortality events were classified as either predation, hunter, other, or unknown. Predation mortalities were further identified as either mammal, avian, or unknown predator. A mortality event was classified as mammalian predation if bite marks, chewed feathers, or mammalian tracks were present. Mortality was determined to be avian predation if the carcass had been decapitated and/or cleaned of the breast muscle with no bite marks, or if the feathers had been plucked. If none of these signs were present or if there were conflicting signs of mortality, the event was classified as unknown predation. Females were censored from the study if their collars were found with no sign of death or if they could not be located for ≥2 months.

We evaluated habitat conditions at each nest and brood flush site within 3 days of hatching/flushing or expected hatch date in the case of failure (Figure 1). We recorded visual obstruction readings (VOR) at the nest bowl and at four points 8 m from the nest in each cardinal direction. At each point, VOR was measured in each cardinal direction from a distance of 2 m and a height of 0.5 m using a Robel pole (Robel et al. 1970). We estimated non-overlapping vegetation cover (percent new grass, residual grass, forbs, shrubs, bare ground, and litter) at 16 subsampling locations within 8 m of the nest using a 20 x 50 cm sampling frame (Daubenmire

1959). At each subsampling plot, we measured the heights of new grass, residual grass, forbs, and shrubs. We also estimated shrub cover using the line-intercept method, recording the species, height, and length of each shrub intersecting the transect. In addition, we estimated slope from LANDFIRE data using ArcMap 10.4. We conducted parallel sampling at randomly selected points (n=71) within a study area defined by a minimum convex polygon placed around the leks of capture and buffered to 2 km. Random points that fell within unsuitable habitat (i.e., water, cultivation, etc.) or were located on properties to which we did not have access were replaced.

We also measured habitat at the home range scale (540 ha, based on estimated home range sizes of sharp-tailed grouse during the breeding season, see below) under the assumption that the home range contained the resources used by a female during the nesting season. The home range area was defined as a circular plot with a 1,300 m radius centered on each nest, brood and random location. We calculated habitat variables at the home range scale using remotely sensed data and ArcMap 10.4. We included road datasets for both Montana and North Dakota and calculated the density of paved and gravel roads within each home range (Montana State Library, North Dakota GIS Hub Data Portal). Paved roads, including state highways, had higher traffic volumes and were assumed to represent a different level of disturbance than gravel roads. We also included the locations of oil pads which represented another form of disturbance in the study area and calculated the distance to the nearest oil pad from the center of each home range. Landcover analyses utilized the 30 m resolution LANDFIRE data depicting vegetation type (LANDFIRE 2013). We measured the distance from the center of each home range to the nearest patch of non-grassland habitat. In addition, we used the Patch Analyst Extension in ArcMap to calculate the proportion of grassland, the density of edge habitat, and grassland shape complexity. We also included grazing system (rest-rotation, rotation, season-long, winter) as a variable at the home range scale.

Nesting frequency was calculated as the percentage of females that attempted a nest. The probability of renesting was calculated as the number of observed renesting attempts divided by the number of unsuccessful first nests minus the number of females that had first nests but were unavailable to renest. A female was considered unavailable if she was killed during the first nest attempt.

Nest success is the proportion of nests that produce ≥1 chick. We constructed nest survival models using the RMARK package in Program R to calculate maximum likelihood estimates of daily nest survival and evaluate the effects of habitat conditions on daily nest survival during a 70-d nesting period from 28 April to 6 July (White and Burnham 1999, Dinsmore et al. 2002). Before fitting models, we examined correlations for each pair of variables and if a pair was highly correlated ($r \geq 0.5$, $p < 0.05$), we used single-factor models to determine which of the two variables accounted for the largest proportion of variation. We considered the variable with the lowest model deviance to be the primary variable.

Models were compared using Akaike's Information Criterion adjusted for small sample sizes (AIC_c) and models with large model weights (w_i) and AIC_c values ≤ 2 from the best-fit model were considered equally parsimonious (Burnham et al. 2011). We first assessed main-effects models including variables of nest attempt, laying date, female age and female mass compared to a null model of constant daily nest survival (Goddard and Dawson 2009). Using the best main effects model based on AIC_c, we then selected the most parsimonious models at each of the different spatial scales (nest- and home range level) and assessed them in the final candidate model set. Variables considered at the nest level included slope, VOR, at the nest bowl and within the 8 m radius plot, new grass height and the percentage of shrubs, new grass, and bare ground. Both linear and exponential effects of VOR were included. Variables considered at the home range level included the proportion of grassland habitat, distance to nearest non-grassland habitat, density of edge habitat, grassland shape complexity, grazing system (rest-rotation, rotation, season-long, and winter grazing) and gravel road density. The density of paved roads within a 1,300 m radius was > 0 for only three nests and so was not included in analyses.

We calculated the overall nest survival probability by raising the daily nest survival estimate from the most parsimonious model to an exponent equal to the mean laying plus incubation interval for grouse at our study sites (37-d). Variance of overall nest survival was estimated with the delta approximation (Powell 2007). The average duration of incubation period (27-d) was determined from observations of our sample of successful nests and from previous work (Connelly et al. 1998).

Initial brood size was determined by the number of chicks that were known to hatch based on nest observations. Brood success was calculated as the proportion of broods that successfully fledged ≥1 chick. Fledging success was calculated as the proportion of chicks that survived until fledging among successful broods. Broods were included in the easement category if >70% of female locations were within the easement boundaries, in the reference category if >70% of locations were in the reference area, and in the category "both" if they split their time between the two areas.

We used the nest survival model in Program MARK to calculate maximum likelihood estimates of daily brood survival and examine differences in daily survival rate between chicks that were radio-tagged and those that were not during the 37-d monitoring period from 30 June to 5 August (White and Burnham 1999, Dinsmore et al. 2002). The monitoring period was considered the time from when chicks were captured at 35-d post-hatch to the final flush at 60-d post-hatch. We compared a null model with constant daily survival with models that included the binomial variable of whether a chick was radio-tagged and/or the identity of the female to account for correlation in survival within a single brood.

Results.–Fourteen sharp-tailed grouse leks were located in the study area (7 on the easement and 7 on surrounding private and state lands). Sharp-tailed grouse were trapped at 5 easement and 3 reference leks during 15 March – 23 April 2016. Mean overall lek attendance was 21.6 birds (average of 18.9 males and 2.4 females) during this period (Table 1). We captured a total of 221 grouse (126 males, 95 females) and sixty-six females were radio-marked (Table 2). Three females were never relocated and one died within a week of capture, so 62 females were monitored regularly.

We located 73 nests (51 first nests, 21 renests, 1 third nest; Tables 3, 4, Figure 2). Eleven females died or were censored from the study before initiating a nest. Median nest initiation date for all nests was 1 May (28 April for first nests, 27 May for renests; range: April 22 – June 9). Twenty-seven nests successfully hatched and 46 failed (36 depredated, 3 abandoned, 7 female mortalities). Hatch rate of eggs (± SE) for first nests and renests was 95.8 ± 5.7% and 82.6 ± 21.5%, respectively. Mean clutch size for all nest attempts was 11.2 ± 0.35 eggs. Mean clutch size for first nest and renests was 12.16 ± 2.7 and 9.0 ± 2.4 eggs, respectively.

Daily nest survival was 0.962 ± 0.006 and overall nest survival calculated as DSR^{37} was 0.24 ± 0.05. The main-effects model that best predicted nest survival included female age ($\Delta AIC_c = 0$, $w_i = 0.37$). The model including female age and lay date also had some support ($\Delta AIC_c < 2$, $w_i = 0.22$), but confidence intervals for lay date overlapped zero, so the more parsimonious model including only female age was included in all further analyses. At the nest-level, female age was again in the top model ($\Delta AIC_c = 0$, $w_i = 0.23$; Table 5) followed by a model with both female age and the proportion of shrubs around the nest ($\Delta AIC_c = 0.19$, $w_i = 0.21$). However, there was model uncertainty and all models with $\Delta AIC_c < 2$ (n = 7) were included in the final candidate model set. At the home-range level, nest survival was best predicted by the combination of female age and grazing system ($\Delta AIC_c = 0$, $w_i = 0.27$; Table 6), followed by a model that included female age and grassland shape complexity ($\Delta AIC_c = 0.55$, $w_i = 0.21$). When variables from both spatial scales were included in the final candidate model set, variables at the home-range scale received more model support (Table 7). The top model included female age and grazing system ($\Delta AIC_c = 0$, $w_i = 0.24$), followed by a model including female age and grassland shape complexity ($\Delta AIC_c = 0.54$, $w_i = 0.18$). Nest survival declined with female age, and was higher for nests located in pastures managed with season-long grazing than for pastures managed with rotation and rest-rotation grazing (Figure 3). However, confidence intervals of effects overlapped 0 (Figure 3), suggesting the effect of grazing system on nest survival during our first year of study may have been spurious. With the exception of the visual obstruction measured at the nest bowl (Figure 4), vegetation measured at nest sites and random sites in the study area were similar (Figures 4, 5).

We monitored 27 broods to estimate survival and document habitat use (Table 8). Eight broods spent the majority of the time (>70% of locations) on the easement, 12 spent the majority of time in the reference area, and 7 split time between the two areas. Brood success, calculated as the proportion of broods fledging ≥1 chick to 14-d of age, was 0.50 ± 0.18, 0.58 ± 0.14, and 0.42 ± 0.19 for broods located on the easement, reference, and both areas, respectively. Of broods that survived to fledging, the proportion of chicks that survived was 0.41 ± 0.18, 0.32 ± 0.07, and 0.90 ± 0.25 for broods located on the easement, reference, and a mix of both areas, respectively. We captured 23 fledglings from 7 broods and attached radio-transmitters to 9 fledglings. None of the radio-marked fledglings survived until 60-d and 67% of mortalities were due to predation. In the analysis examining the effects of radio-transmitters on chick survival, the null model that included only a constant survival weight received the most support ($\Delta AIC_c = 0$, $w_i = 0.60$; Table 9). However, the model that included whether or not a chick was radio-tagged also received some support ($\Delta AIC_c < 2$). Being radio-tagged reduced a chick's daily survival rate by ~0.03, which resulted in an overall survival rate during the monitoring period that was nearly two-thirds lower for radio-tagged chicks (0.09 vs 0.22).

Field investigations revealed that 28 females were killed by predators: 17 and 8 by mammalian and avian predators, respectively, and 3 by an unknown predator. Four females were right censored from the study when their transmitters were found with no sign of death. An additional 5 females were right censored after they could not be relocated for more than 2 months.

Goals For Next Quarter:

We will continue to monitor radio-marked females ≥ 1 time/month through the non-breeding season (Sept – March) until death or transmitter failure/loss. We will continue analyses of nest and brood survival from the 2016 breeding season to estimate fecundity. In January and February, we will prepare for the 2017 field season by securing additional access to private lands, procuring research materials and field equipment, and hiring technicians. Three technicians will be hire to start in March/April and beginning March, we will conduct lek surveys to identify new leks for trapping to expand the study area to areas further from the easement area. We will also begin trapping and radio-marking new females in mid-March.

Objective 2: Investigate impacts of rest-rotation grazing on sharp-tailed grouse home ranges, movements and habitat selection.

Accomplishments:

Radio-marked females were located via triangulation or homing ≥ 3 times/week using portable radio receivers and handheld Yagi antennas during the nesting and brood-rearing period (April—August) and ≥ 2 times/week during the rest of the year (September—March). Females with broods were located ≥4 times/week, including one nighttime roosting location per week.

Coordinates for triangulated locations were calculated using Location of a Signal software (LOAS; Ecological Software Solutions LLC, Hegymagas, Hungary) and examined for spatial error. All locations with excessive error (>200 m error ellipse) were discarded for initial analysis, but the level of acceptable error will be examined on a case-by-case basis in the future. Previous studies have found that small sample sizes can bias home range estimates (Seaman et al. 1999), so analyses were restricted to birds with ≥25 unique locations after excluding multiple relocations of a female at the same nest. We used the fixed kernel method (Worton 1989) with the default smoothing parameter to calculate 95% home ranges for the breeding season (April – August) using the adehabitatHR package in Program R (R Core Team 2014, Vienna, Austria). We also calculated centroids for each home range using the 'rgeos' package in Program R and calculated the distance each female traveled from lek of capture to the home range centroid in ArcGIS 10.4 (Environmental Systems Research Institute, Redlands, CA). Females were included in the easement category if >70% of their locations were within the easement boundaries, in the reference category if >70% of locations were in the reference area, and in the category "both" if they split their time between the two areas. We compared home range sizes and movement distances between easement females, reference females, and those that split time between the two areas using a Kruskal-Wallis rank sum test and considered groups to be significantly different at $p < 0.05$. If either home range size or movement distances differed significantly between the three groups, we performed a Wilcoxon rank-sum test to determine if there was a significant difference between either variable for easement and reference females.

We collected a total of 2,868 locations from 62 females (2,048 breeding season locations, 820 non-breeding locations). Twenty-eight females died during the year and an additional 9 females were censored from the study (see above). Seven females were located irregularly due to loss of field access. During the 2016 breeding season (April – August), 37 females had ≥25 unique locations. Eleven females spent the majority of their time (>70% of locations) on the easement, while 15 spent the majority of their time in the reference area. The remaining 11 females split time between the two areas. Mean breeding season home range size for all 37 females was 569 ± 122 ha, but varied from 77 m^2 to 4,077 ha (Figure 6). Mean breeding season home range size (Table 10) did not differ significantly between the three groups (H = 3.52, df=2, $P = 0.17$). However, the distance traveled by a female from the lek of capture (Table 10) differed between the three groups (H = 11.33, df=2, $P = 0.003$) and was significantly higher for reference females compared to easement females (W = 19, $P = 0.0005$). The minimum distance from home range centroid to lek of capture for all females was 168 m, while the maximum was 5,446 m.

Goals For Next Quarter:

We will continue to monitor radio-marked females ≥1 time/month during the non-breeding season (September – March) until death or transmitter failure or loss. We will focus efforts in the next quarter on implementing initial resource selection models to estimate space use and habitat selection.

Objective 3: Develop a mechanistic understanding of the ecological effects of various grazing treatments with a focus on rest rotation grazing by examining abundance and space use of the grassland bird and meso-predator communities

Accomplishments:

Efforts this past year were focused on collecting data to test primary hypotheses regarding effects of grazing management on abundance, diversity, and space use of grassland birds and meso-predators. During 13 May through 25 July, 2016, we conducted grassland bird and meso-predator surveys, sampled invertebrates, and surveyed vegetation at bird survey sites. We randomly generated 305 points across gradients of habitat conditions within the conservation easement and on adjacent private and federal lands managed with alternative grazing methods (Figure 7). We randomly generated 150 points on the easement with 50 points in each of the three rotational pasture types. We generated 155 points in reference pastures adjacent to the easement, with 60 points located in season-long grazing systems and 95 points in summer rotational grazing systems, where cattle are turned out at the end of May and are moved between pastures after 6–8 weeks. To avoid double counting of individuals and assure statistical independence, points were spaced ≥ 300m apart. Points were located ≥ 200 m from pasture boundaries to avoid counting birds using multiple treatments, ≥ 400 m from oil pads, and ≥ 250 m from gravel roads to control for bird avoidance of these areas (Thompson et al. 2015).

We interviewed landowners to acquire stocking information for pastures in the study. In 2015, rest-rotation pastures A1, B1, and C1 were grazed from mid-May through seed ripe (~Aug 1), pastures A2, B2, and C2 were grazed from seed ripe through mid-November, and pastures A3, B3, and C3 were rested from grazing during the entire year (Figure 8, Table 11). In 2016, A1, B1, and C1 pastures were grazed from seed ripe to mid-November; A2, B2, and C2 pastures were rested from grazing the entire year, and A3, B3, and C3 pastures were grazed from mid-May through seed ripe (Figure 8, Table 11). Stocking rates within easement pastures ranged from 0 (rested pastures) to 3.73 AU ha^{-1} (Table 11).

Avian point count surveys began 30 May 2016, after all breeding species had arrived. Surveys needed to be completed within a 5-week period to assure population closure, and all surveys were completed by 23 June 2016. At each point, grassland birds were surveyed with three replicated 5-minute point count surveys. A single trained observer identified and tallied all birds detected visually or aurally within 100 m of the point, noting the time of first detection and the distance from observer to the bird when it was first detected (0–25m, 26–50m, 51–75m, 76–100m). Other data recorded included sex (dichromatic species only), group size, vocalization, and behavior of each species identified. At each survey location, the observer recorded the point and pasture to be surveyed, date and time, percent overcast, precipitation, temperature, and wind speed. Bird point counts needed to be conducted from one-half hour before sunrise through no later than 1000h MDT. All of our surveys were completed by 0840 h MDT on mornings without heavy rainfall and winds <15 kph.

We detected a total of 5,953 birds of 57 species during our point count surveys; 3,000 birds of 52 species were detected in rest-rotation pastures on the easement and 2,953 birds of 50 species were detected on reference properties adjacent to the easement (Tables 12, 13, 14). The average number of total birds detected per point was similar among easement and reference pastures (Figures 9, 10). Within the easement, pastures deferred from grazing in 2015 had slightly more birds per point on average than pastures grazed during the 2015 growing season and pastures grazed post seed-ripe (Figure 9). Within the reference pastures, the second and third pastures managed with intensive summer rotational grazing had slightly more birds per point than the first rotational grazed pasture and the pastures grazed season-long, although confidence intervals overlapped (Figure 9). Of the 57 total species detected, 21 were obligate grassland birds (Tables 13, 14). Raw species counts were similar across easement and reference pastures (Figure 11). Easement pastures had 12.0 ± 0.3 bird species per point, rotational pastures had 11.5 ± 0.5 species per point, and season-long pastures had 12.3 ± 0.4 species per point.

Following spring point count surveys, we identified three grassland birds as focal species, which depend on the quality of the rangeland for breeding, recruitment, and survival: the grasshopper sparrow (*Ammodramus savannarum*), Baird's sparrow (*A. bairdii*), and vesper sparrow (*Pooecetes gramineus*). These three species have specific habitat and life history requirements of native grasslands for breeding activities throughout the season. These species also have adequate sample sizes for further analysis after the first year of data collection.

The mean number of birds detected per point count survey was similar between pasture types (Table 15). We observed 628 grasshopper sparrows (mean = 5.71 ± 0.29 per point) on the easement and 838 (mean = 6.26 ± 0.24 per point) on the reference pastures, 236 vesper sparrows (mean = 1.81 ± 0.23 per point) on easement and 248 (mean = 1.77 ± 0.11) on reference, and 58 Baird's sparrows (mean = 1.81 ± 0.23) detected on the easement and 115 (mean = 1.77 ± 0.11) on the reference pastures. Pastures deferred from grazing in 2015 had the highest abundance of grasshopper sparrows relative to all other pasture and system types (Figure 12). Pastures with season-long grazing, and two rotational grazed pastures had slightly lower mean abundance of grasshopper sparrows than pastures deferred from grazing in 2015 (Figure 12). The mean totals for Baird's sparrow detected per point were similar (Figure 13). Of the focal species, Baird's sparrow had the fewest total detections. The mean number of Baird's sparrow per point ranged from 1 to 3 for all easement and reference pastures. The mean totals for vesper sparrow detected per point were also similar between easement and reference grazing systems and across pasture types within a system (Figure 14). The mean number of vesper sparrow per point ranged from 2 to 4, with the highest mean within the second rotationally grazed pasture.

Habitat conditions were measured within survey areas the same day point counts were conducted. Three 20-m transects were established within 100 m of each survey point, with one transect originating at the point and oriented in a random direction, and two transects in a random direction and distance from the point. Subplots were spaced 5 m apart along each transect. At each subplot, visual obstruction was measured from the north at a distance of 2 m and a height of 0.5 m (Robel et al. 1970), and non-overlapping vegetation coverages were measured using methods of Daubenmire (1959). Percent coverage of new growth grass, residual grass, litter, shrub, forb, tree, bare ground, rock, and cowpie were measured in percentage classes (0-5, 5-25, 25-50, 50-75, 75-95, and 95-100%). Heights (cm) of the nearest plant were measured for each new growth grass, residual grass, litter, shrub, forb, and tree. We estimated shrub cover using line intercept surveys, where the species of each shrub intersecting the transect was recorded, as well as the height and length of the shrub as it crossed the transect.

Following completion of the bird point count surveys at the end of June, we sampled invertebrates for each point count area with a sweep net. Within 100-m of each bird survey point, we sampled two 20-m sweep-net transects for invertebrates, each at a random bearing and distance (0-80m) from the survey point. We recorded survey conditions at each point, including the time of day, temperature, wind speed, and precipitation. We did not sample invertebrates if the vegetation was wet from morning dew or precipitation, or if the average wind speed exceeded 15 kph.

To evaluate relationships between vegetation conditions and invertebrate abundance and diversity, we measured 5 subplots of vegetation along each 20-m sweep-net transects. We followed the same habitat protocol for the insect habitat sampling as we used in the grassland bird habitat sampling. With the addition of two insect habitat transects to our original three habitat transects surveyed during point counts, each established bird survey point includes five 20-m transects consisting of 25 vegetation subplots that correspond to the breeding and nesting seasons for grassland birds.

To estimate abundance and evaluate space use of the mesopredator community, passive infrared remote field cameras (Browning BTC 5HD) were used to survey 90 random locations within the study area. Remote cameras have been cited as the best survey method for detecting medium and large sized carnivores in most habitats (Silveira et al. 2003). Automated cameras also record the time and date for every photographic event captured, making them useful for temporal associations, such as daily and seasonal activity patterns. Ninety predator survey points were randomly selected within the study site, with 45 points in rest-rotation pasture treatments (easement) and 45 in season-long and summer rotation grazing pasture treatments (reference areas). Cameras were set in the most optimal location within 200 m of the point, where detection of predators was maximized, and spaced ≥ 600m apart to ensure independence. Cameras were often set at heavy use areas along a habitat edge, where land cover changes on the landscape at the intersection of water, grassland, agriculture, and/or trees and shrubs (Burr 2014). Habitat edges and game trails were used with a goal of increasing detection probabilities, as mammalian predators are thought to prefer such edges while traveling and foraging (Andrén 1995).

Cameras were programmed to be active 24 hours per day with a 1-minute delay between photographic events and a two photo burst for each event. For each photographic event, the date and time of the event were recorded, along with the temperature (°C), barometric pressure, moon phase, and camera ID. Cameras were secured to tree trunks or, if not available, mounted on metal stakes, and positioned approximately 0.5m above the ground and 2m in front of a scent or bait lure. When present, cameras were faced toward game trails to maximize detections.

For each of the three sampling periods, first (13 May – 8 June 2016), second (9 June – 30 June 2016), and third (1 July – 22 July), camera sites were revisited weekly to replenish scent attractants, download and clear memory cards of digitally recorded images, change camera batteries, and remove any obstructive vegetation. Following the 3-week survey period, cameras were moved to new random points for another 3 weeks. Thus, 30 camera traps were used to survey 90 sites throughout the three sampling periods.

For the first and second sampling periods, during the first week of deployment, camera stations were baited with fatty acid scent disks (U.S. Department of Agriculture Pocatello Supply Depot, Pocatello, ID). The second week of deployment, stations were revisited and scent disks were replaced by a sardine bait. The third week of deployment was a combination of fatty acid scent disks and sardine bait. For the third sampling period (1 July – 22 July), we baited all the camera traps with different trapping lure than previous sampling periods (Gusto; Minnesota Trapline Products, Inc.), in an attempt to increase detection frequencies of predators.

Following the field season, we analyzed all photos from the remote camera traps and identified predators based on body shape and coloration. Of the 87 sites surveyed, coyote (*Canis latrans*), were present at 41 sites, badger (*Taxidea taxus*) were present at 16 sites, raccoon (*Procyon lotor*) were present at 9 sites, striped skunk (*Mephitis mephitis*) were present 7 sites, and short-tailed weasel (*Mustela ermine*) were present at one site. We observed predators at 69% of the camera sites within the easement pastures and 66.7% of the camera sites within reference pastures (Table 16). The raw counts of predators detected on the easement compared to predators detected off the easement were similar, as well as the number of sites that were used by predators within the 3 week timeframe at each site (Table 16). The mean number of predators per site was also very similar across easement and reference pastures (Figure 15).

Goals for Next Quarter:

Further analyses of the grassland bird point counts will be conducted, relating bird abundances to vegetation measurements. Preliminary associations with habitat conditions, grazing intensity, and grassland bird presence may then be evaluated. We will build and evaluate models of mesopredator occupancy that account for site- and species-specific detection probabilities. We will also begin analyzing invertebrate samples and identifying invertebrates to the family level. Bird surveys will begin late-May 2017.

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Table 1. Average attendance on 8 leks from 15 March - 23 April 2016.

Lek	Average Total Attendance	Minimum Total Attendance	Maximum Total Attendance	Average Male Attendance	Average Female Attendance
EasState1	24.0	11	33	21.2	2.8
Iversen1	25.7	17	32	22.1	3.2
JohnBuxbaum1	23.2	21	25	21.7	1.6
Laumeyer1	13.6	11	19	11.9	1.8
Laumeyer2	26.6	18	37	23.0	3.6
OilpadLek	18.7	14	25	16.0	2.7
Prewitt1	18.2	10	22	17.4	0.8
State1	18.0	13	29	15.4	2.6
Total	21.6	10	37	18.9	2.4

Table 2. Total number of sharp-tailed grouse captured and radio-marked at easement and reference areas in 2016

	Males	Females	Radio-marked Females
Easement	84	64	40
Reference	42	31	26
Total	126	95	66

Table 3. Overview of nests in the easement and reference sections of the study area. Egg hatch rate is the percentage of eggs that hatched from the initial clutch size.

	Median Initiation Date	Clutch Size	First Nests	Renests	Nests Hatched	Median Hatch Date	Egg Hatch Rate
Easement	30-Apr	11.5 ± 0.50	26	8	11	10-Jun	0.88 ± 0.04
Reference	6-May	10.9 ± 0.49	24	14	15	23-Jun	0.92 ± 0.04
Total	1-May	11.2 ± 0.35	50	22	26	15-Jun	0.90 ± 0.03

Table 4. Overview of nests in pastures managed with different grazing systems. Egg hatch rate is the percentage of eggs that hatched from the initial clutch size.

	Median Initiation Date	**Clutch Size**	**First Nests**	**Renests**	**Nests Hatched**	**Median Hatch Date**	**Egg Hatch Rate**
Rest-rotation	29-Apr	11.8 ± 0.36	23	6	11	13-Jun	0.88 ± 0.05
Winter	2-May	10.5 ± 1.88	5	3	1	10-Jun	1.00
Rotation	16-May	10.0 ± 0.97	8	5	4	17-Jun	0.89 ± 0.14
Season-long	4-May	11.3 ± 0.56	14	8	10	27-Jun	0.93 ± 0.04
Total	1-May	11.2 ± 0.35	50	22	26	15-Jun	0.90 ± 0.03

Table 5. Support for candidate models evaluated nest survival at the nest site scale for the 2016 breeding season. The number of parameters (K), AIC_c values, ΔAIC_c values, model weights (w_i) and model deviances are reported.

Model	**K**	**AIC_c**	**ΔAIC_c**	**w_i**	**Deviance**
Female Age	2	321.3	0	0.21	317.3
Female Age + Prop. Shrub	3	321.5	0.19	0.19	315.5
Female Age + Slope	3	322.2	0.87	0.14	316.2
Female Age + Grass Height	3	322.8	1.49	0.10	316.8
Female Age + Prop. Bare	3	323.2	1.85	0.084	317.2
Female Age + Prop. New Grass	3	323.2	1.87	0.083	317.2
Female Age + New VOR	3	323.2	1.91	0.082	317.2
Null	1	323.3	1.96	0.080	321.3
Female Age × Nest VOR	4	325.2	3.93	0.030	317.2

Table 6. Support for candidate models predicting nest survival at the home range scale for the 2016 breeding season. The number of parameters (K), AIC_c values, ΔAIC_c values, model weights (w_i) and model deviances are reported.

Model	**K**	**AIC_c**	**ΔAIC_c**	**w_i**	**Deviance**
Female Age + Grazing System	5	320.2	0.00	0.26	310.2
Female Age + Grassland Shape Complexity	3	320.8	0.55	0.20	314.7
Female Age	2	321.3	1.12	0.15	317.3
Female Age + Prop. Grassland	3	322.4	2.21	0.09	316.4
Female Age + Edge Density	3	322.5	2.26	0.08	316.5
Female Age + Distance to Grassland	3	323.2	3.01	0.06	317.2
Female Age + Road Density	3	323.3	3.07	0.06	317.3
Null	1	323.3	3.08	0.06	321.3
Female Age + Distance to Oilpad	3	323.3	3.12	0.05	317.3

Table 7. Support for final candidate models predicting nest survival at both the home range and nest site level for the 2016 breeding season. The number of parameters (K), AIC_c values, ΔAIC_c values, model weights (w_i) and model deviances are reported.

Model	**K**	**AIC_c**	**ΔAIC_c**	**w_i**	**Deviance**
Female Age + Grazing System	5	320.2	0.00	0.23	310.2
Female Age + Grassland Shape Complexity	3	320.8	0.55	0.17	314.7
Female Age	2	321.3	1.12	0.13	317.3
Female Age + Prop. Shrub	3	321.5	1.31	0.12	315.5
Female Age + Slope	3	322.2	1.98	0.08	316.2
Female Age + Grass Height	3	322.8	2.60	0.06	316.8
Female Age + Prop. Bare	3	323.2	2.97	0.05	317.2
Female Age + Prop. New Grass	3	323.2	2.99	0.05	317.2
Female Age + Nest VOR	3	323.2	3.03	0.05	317.2
Null	1	323.3	3.08	0.05	321.3

Table 8. Brood survival (± SE) to 14-d post hatch at the easement and reference sections of the study area. Brood survival was estimated using the nest survival model in Program MARK. Fledging rate is the proportion of chicks within broods that survived to fledging at 14 days.

	Brood Survival	**Fledging Rate**
Easement	0.455 ± 0.15	0.418 ± 0.14
Reference	0.563 ± 0.12	0.568 ± 0.16
Total	0.518 ± 0.10	0.504 ± 0.11

Table 9. Support for candidate models examining the effects of radio-tags on chick survival. The number of parameters (K), AIC_c values, ΔAIC_c values, model weights (w_i) and model deviances are reported.

Model	**K**	**AIC_c**	**ΔAIC_c**	**w_i**	**Deviance**
Null (constant)	1	79.88	0.00	0.60	77.86
Radio-tagged	2	80.87	0.99	0.37	76.81
Female ID	7	86.49	6.61	0.02	71.99
Radio-tagged + Female ID	8	87.46	7.58	0.01	70.81

Table 10. Mean breeding season home range size (±SE) and mean distance of the centroid of a female's home range from lek of capture for females in the easement, reference and both sections of the study area.

Group	**Home range size (ha)**	**Distance traveled from capture lek (m)**
Easement	543 ± 165	840 ± 99
Reference	330 ± 68	1,801 ± 318
Both	918 ± 354	1,080 ± 150
Total	569 ± 122	1,301 ± 154

Table 11. Stocking information for the pastures in the study site, along with area (ha). Stocking rates are based on animal unit months (AUMs) per hectare.

		2015				2016			
Pasture	Area (ha)	Head	Turn-in Date	Turn-out Date	Stocking rate (AUM/ha)	Head	Turn-in Date	Turn-out Date	Stocking rate (AUM/ha)
A1[a]	211	NA	NA	NA	NA	150	8/1	11/15	2.51
A2[a]	256	NA	NA	NA	NA	0	ungrazed		0.00
A3[a]	263	NA	NA	NA	NA	150	6/15	8/1	0.89
B1	364	150	6/15; 10/5	8/15; 11/25	3.73	170	8/1	11/15	1.65
B2	434	150	8/15	10/5/2015	0.59	0	ungrazed		0.00
B3	310	0	ungrazed		0.00	170	6/14	8/1	0.88
C1	453	170	6/15; 10/5	8/15; 11/25	1.40	150	8/1	11/15	1.17
C2	346	170	8/15	10/5	0.84	0	ungrazed		0.00
C3	371	0	ungrazed		0.00	150	6/14	8/1	0.65
Rotation1a	547	240	6/1	7/15	0.64	280	6/1	7/15	0.75
Rotation1b	1375	240	7/15	12/1	0.81	280	7/15	11/15	0.83
Rotation2a	252	85	5/25; 10/25	7/15; 12/1	0.99	155	6/1	7/15	0.90
Rotation2b	298	85	7/15; 10/25	9/30; 12/1	1.08	155	6/1	7/15	0.76
Rotation3a	128	58	7/16	9/13	0.89	42	7/16	NA	NA
Rotation3b	150	58	6/2	7/16	0.57	7	6/7	NA	NA
Rotation4a	110	60	6/1; 10/10	7/1; 11/1	0.95	65	6/1; 10/10	7/1; 11/1	1.02
Rotation4b	220	60	7/1	10/10	0.92	65	7/1	10/10	0.99
Rotation5a	58	6	2/1	6/15	0.65	6	2/1	6/15	0.47
Rotation5b	30	28	10/1	11/15	1.12	0	ungrazed		0.00
Rotation5c	132	65	6/1	10/1	2.00	0	ungrazed		0.00
Rotation6a	92	50	9/15	10/31	0.83	60	7/1	8/5	0.76
Rotation6b	90	0	ungrazed		0.00	60	8/5	10/31	1.93
Rotation6c	102	50	6/1	9/15	1.73	0	ungrazed		0.00

Rotation7	120	160	4/15	5/30	2.00	160	10/1	10/31	1.33
Season-long1	413	70; 42; 80	5/1; 6/1; 10/20	6/1; 10/20; 1/1/16	1.24	40	5/15	11/15	0.59
Season-long2	857	180	6/1	10/28	1.04	180	6/1	11/1	1.07
Season-long3	36	2	1/1	12/31	0.84	2	1/1	12/31	0.84
Season-long4		0	ungrazed		0.00	0	ungrazed		0.00
Season-long5[a]	NA	NA	NA	NA	NA	NA	NA	NA	NA
Season-long6[a]	NA	NA	NA	NA	NA	NA	NA	NA	NA
Season-long7[a]	NA	NA	NA	NA	NA	NA	NA	NA	NA

[a] NAs represent pastures for which stocking information is still being collected.

Table 12. Bird abundance and species diversity detected from 305 point count surveys on the Buxbaum conservation easement and adjacent reference properties in eastern Richland County, Montana in 2016.

	Buxbaum Conservation Easement[a]				Reference Pastures[b]					
	[1] Pastures	[2] Pastures	[3] Pastures	**Subtotal**	Season-long	Rotation1	Rotation2	Rotation3	**Subtotal**	**Total**
Number points	50	50	50	**150**	60	59	21	15	**155**	305
Total birds	971	923	1106	**3000**	1068	1121	413	351	**2953**	5953
Mean birds / Point	19.4	18.5	22.1	**20**	17.8	19	19.7	23.4	**19.1**	19.5
Number species	40	36	39	**52**	33	43	27	31	**50**	57

[a] Easement pasture designations: [1] A1, B1, C1; [2] A2, B2, C2; [3] A3, B3, C3
[b] Reference Pastures include 2 pastures that are grazed annually during the growing season (season-long), and three pastures managed with intensive summer rotational grazing.

Table 13. Total bird species detected on 305 point count surveys on the Buxbaum conservation easement and adjacent reference properties and number of each species in each pasture.

	Buxbaum Conservation Easement[a]				Reference Pastures[b]					
	Growing-season 2015	Post Seed-ripe 2015	Rested 2015	**Easement**	**Season-long**	Rotation1	Rotation2	Rotation3	**Rotation**	**Total**
AMCR	0	0	0	**0**	**0**	2	0	0	**2**	2
AMGO	30	8	13	**51**	**2**	10	7	2	**21**	72

AMRO	8	7	0	**15**	**0**	3	0	2	**5**	20
AMWI	0	0	0	**0**	**0**	0	2	0	**2**	2
BAIS*	8	29	21	**58**	**50**	53	1	11	**115**	173
BANS	3	2	28	**33**	**0**	1	0	0	**1**	34
BARS	0	1	1	**2**	**0**	3	0	0	**3**	5
BBMA	3	1	0	**4**	**0**	1	0	0	**1**	5
BEKI	1	0	0	**1**	**0**	0	0	0	**0**	1
BHCO	152	78	65	**295**	**76**	53	69	33	**231**	526
BHGR	1	1	0	**2**	**0**	0	0	0	**0**	2
BOBO*	0	1	17	**18**	**9**	0	0	8	**17**	35
BRBL	4	10	6	**20**	**30**	6	0	2	**38**	58
BRTH	6	3	11	**20**	**8**	8	8	5	**29**	49
BUOR	3	3	0	**6**	**1**	1	0	1	**3**	9
CAGO	2	0	0	**2**	**0**	0	0	0	**0**	2
CCSP*	43	6	6	**55**	**10**	32	0	7	**49**	104
CEDW	10	0	52	**62**	**0**	0	10	4	**14**	76
CLSW	0	0	0	**0**	**0**	2	0	0	**2**	2
COGR	4	2	2	**8**	**0**	2	0	1	**3**	11
CONI	13	7	4	**24**	**4**	3	0	0	**7**	31
EABL*	0	1	0	**1**	**0**	0	1	0	**1**	2
EAKI*	43	46	40	**129**	**32**	48	34	16	**130**	259
EUST	2	0	3	**5**	**1**	1	4	0	**6**	11
FISP*	45	20	54	**119**	**11**	46	18	5	**80**	199
GRCA	2	0	2	**4**	**1**	3	5	1	**10**	14
GRSP*	111	244	273	**628**	**354**	368	26	91	**839**	1467
HOLA*	4	11	13	**28**	**30**	1	2	0	**33**	61
HOWR	44	20	19	**83**	**7**	26	6	11	**50**	133
KILL	0	0	1	**1**	**1**	13	0	0	**14**	15
LARB*	11	2	0	**13**	**0**	1	0	0	**1**	14
LASP*	9	1	2	**12**	**0**	12	5	0	**17**	29
LEFL	3	3	2	**8**	**0**	3	6	3	**12**	20

LOSH*	1	0	5	**6**	**20**	1	0	1	**22**	28
MALL	3	0	0	**3**	**2**	4	1	0	**7**	10
MOBL*	6	0	5	**11**	**0**	3	0	0	**3**	14
MODO*	25	38	30	**93**	**23**	23	18	13	**77**	170
NOFL	16	8	7	**31**	**17**	8	7	7	**39**	70
NOHA*	0	0	2	**2**	**1**	0	1	1	**3**	5
Oriole spp.	0	0	2	**2**	**0**	1	0	0	**1**	3
OROR	0	1	3	**4**	**3**	1	2	2	**8**	12
RHPH	0	0	0	**0**	**1**	0	0	1	**2**	2
ROPI	0	0	0	**0**	**2**	0	0	0	**2**	2
ROWR	0	0	2	**2**	**0**	0	0	0	**0**	2
RTHA	6	0	0	**6**	**0**	3	0	0	**3**	9
RWBL*	4	1	0	**5**	**25**	0	0	2	**27**	32
SAPH	9	0	1	**10**	**0**	1	0	0	**1**	11
SPPI*	0	2	0	**2**	**0**	0	0	0	**0**	2
SPTO	58	19	43	**120**	**13**	18	27	6	**64**	184
STGR*	0	0	3	**3**	**1**	2	0	2	**5**	8
Swallow spp.	0	0	0	**0**	**0**	3	0	0	**3**	3
TRES	0	1	6	**7**	**0**	0	0	0	**0**	7
UNSP	6	2	5	**13**	**2**	12	6	1	**21**	34
UPSA*	0	6	2	**8**	**9**	13	2	4	**28**	36
VESP*	57	92	87	**236**	**86**	106	41	15	**248**	484
WEKI*	17	3	11	**31**	**8**	8	6	7	**29**	60
WEME*	114	220	230	**564**	**211**	164	71	75	**521**	1085
YBCH	7	0	0	**7**	**0**	6	0	0	**6**	13
YHBL*	0	0	1	**1**	**0**	0	0	0	**0**	1
YWAR	76	25	26	**127**	**17**	42	27	11	**97**	224

*Designates grassland obligate species.

[a] Easement pasture designations: In 2015, the pastures in each system grazed during the growing season, post-seed ripe, and rested.

[b] Reference pastures include 2 annually grazed during the growing season (season-long), and three pastures managed with intensive summer rotational grazing.

Table 14. Species observed during 2016 bird point count surveys.

4-letter Code	Common Name	Scientific Name
AMCR	American Crow	*Corvus brachyrhynchos*
AMGO	American Goldfinch	*Carduelis tristis*
AMRO	American Robin	*Turdus migratorius*
AMWI	American Widgeon	*Anas americana*
BAIS*	Baird's Sparrow	*Ammodramus bairdii*
BANS	Bank Swallow	*Riparia riparia*
BARS	Barn Swallow	*Hirundo rustica*
BBMA	Black-billed Magpie	*Pica hudsonia*
BEKI	Belted Kingfisher	*Megaceryle alcyon*
BHCO	Brown-headed Cowbird	*Molothrus ater*
BHGR	Black-headed Grosbeak	*Pheucticus melanocephalus*
BOBO*	Bobolink	*Dolichonyx oryzivorus*
BRBL	Brewer's Blackbird	*Euphagus cyanocephalus*
BRTH	Brown Thrasher	*Toxostoma rufum*
BUOR	Bullock's Oriole	*Icterus bullockii*
CAGO	Canada Goose	*Branta canadensis*
CCSP*	Clay-colored Sparrow	*Spizella pallida*
CEDW	Cedar Waxwing	*Bombycilla cedrorum*
CLSW	Cliff Swallow	*Petrochelidon pyrrhonota*
COGR	Common Grackle	*Quiscalus quiscula*
CONI	Common Nighthawk	*Chordeiles minor*
EABL*	Eastern Bluebird	*Sialia sialis*
EAKI*	Eastern Kingbird	*Tyrannus tyrannus*
EUST	European Starling	*Sturnus vulgaris*
FISP*	Field Sparrow	*Spizella pusilla*
GRCA	Gray Catbird	*Dumetella carolinensis*
GRSP*	Grasshopper Sparrow	*Ammodramus savannarum*
HOLA*	Horned Lark	*Eremophila alpestris*

HOWR	House Wren	*Troglodytes aedon*
KILL	Killdeer	*Charadrius vociferus*
LARB*	Lark Bunting	*Calamospiza melanocorys*
LASP*	Lark Sparrow	*Chondestes grammacus*
LEFL	Least Flycatcher	*Empidonax minimus*
LOSH*	Loggerhead Shrike	*Lanius ludovicianus*
MALL	Mallard	*Anas platyrhynchos*
MOBL*	Mountain Bluebird	*Sialia currucoides*
MODO*	Mourning Dove	*Zenaida macroura*
NOFL	Northern Flicker	*Colaptes auratus*
NOHA*	Northern Harrier	*Circus cyaneus*
OROR	Orchard Oriole	*Icterus spurius*
RHPH	Ring-necked Pheasant	*Phasianus colchicus*
ROPI	Rock Pigeon	*Columba livia*
ROWR	Rock Wren	*Salpinctes obsoletus*
RTHA	Red-tailed Hawk	*Buteo jamaicensis*
RWBL*	Red-winged Blackbird	*Agelaius phoeniceus*
SAPH	Say's Phoebe	*Sayornis saya*
SPPI*	Sprague's Pipit	*Anthus spragueii*
SPTO	Spotted Towhee	*Pipilo maculatus*
STGR*	Sharp-tailed Grouse	*Tympanuchus phasianellus*
TRES	Tree Swallow	*Hirundo nigricans*
UNSP	Unidentified Sparrow	*Passeridae*
UPSA*	Upland Sandpiper	*Bartramia longicauda*
VESP*	Vesper Sparrow	*Pooecetes gramineus*
WEKI*	Western Kingbird	*Tyrannus verticalis*
WEME*	Western Meadowlark	*Sturnella neglecta*
YBCH	Yellow-breasted Chat	*Icteria virens*
YHBL*	Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*
YWAR	Yellow Warbler	*Dendroica petechia*

*Designates grassland obligate species.

Table 15. Focal species detected on 305 point count surveys on the Buxbaum conservation easement and adjacent reference properties in eastern Richland County, Montana in 2016, and the mean number per survey in each of the pastures.

	Buxbaum Conservation Easement[a]				Reference Pastures[b]					
	[1] Pastures	[2] Pastures	[3] Pastures	**Subtotal**	Season-long	Rotation1	Rotation2	Rotation3	**Subtotal**	**Total**
Grasshopper Sparrow	111	244	273	**628**	354	368	26	91	**839**	1467
Mean birds / survey	2.2	4.9	5.5	**4.2**	5.9	6.2	1.2	6.1	**5.4**	4.8
Baird's Sparrow	8	29	21	**58**	50	53	1	11	**115**	173
Mean birds / survey	0.2	0.6	0.4	**0.4**	0.8	0.9	0.0	0.7	**0.7**	0.6
Vesper Sparrow	57	92	87	**236**	21	106	41	15	**248**	484
Mean birds / survey	1.1	1.8	1.7	**1.6**	1.1	1.8	2.0	1.0	**1.6**	1.6

[a] Easement pasture designations: [1] A1, B1, C1; [2] A2, B2, C2; [3] A3, B3, C3

[b] Reference Pastures include 2 pastures that are grazed annually during the growing season (season-long), and three pastures managed with intensive summer rotational grazing.

Table 16. Predator abundance and species diversity detected from remote camera trap surveys on the Buxbaum conservation easement and adjacent reference properties in eastern Richland County, Montana in 2016.

	Buxbaum Conservation Easement[a]				Reference Pastures[b]					
	Growing-season 2015	Post Seed-ripe 2015	Rested 2015	**Easement**	**Season-long**	Rotation1	Rotation2	Rotation3	**Rotation**	**Total**
Number sites w/Cameras	11	14	17	**42**	**22**	13	4	6	**23**	87
Number sites occupied	9	10	10	**29**	**16**	7	3	4	**14**	59
Number Species	4	3	3	**4**[c]	**4**[d]	4	2	3	**4**[e]	5
Total encounters[f]	18	28	16	**52**	**33**	9	5	13	**27**	112

[a] Easement pasture designations: In 2015, the pastures in each system grazed during the growing season, post-seed ripe, and rested.

[b] Reference pastures include 2 pastures that are grazed annually during the growing season (season-long), and three pastures managed with intensive summer rotational grazing.

[c] Easement pastures predator species detected include coyote, badger, striped skunk, and raccoon

[d] Season-long pastures predator species detected include coyote, badger, raccoon, and short-tailed weasel

[e] Rotational pastures predator species detected include coyote, badger, raccoon, and striped skunk

[f] Total encounters include all predators that were detected by cameras, excluding predators of the same species detected within an hour of initial detection

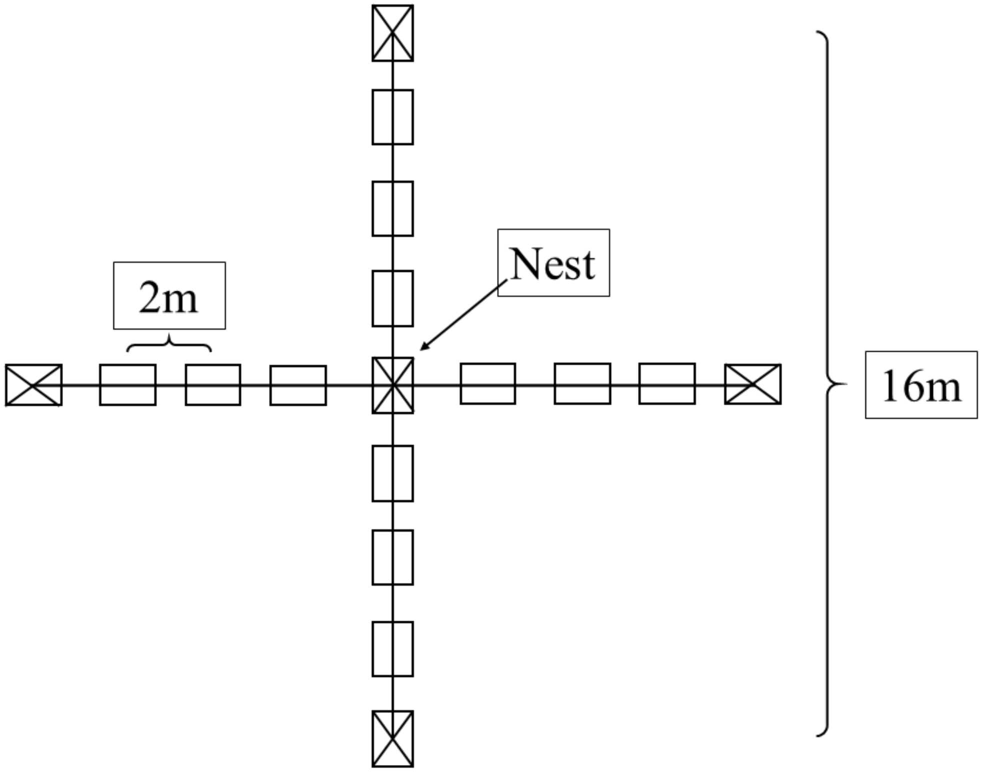

Figure 1. Setup of a vegetation plot. Vegetation cover and height were measured using a Daubenmire frame at each rectangle and visual obstruction with a Robel pole at each X.

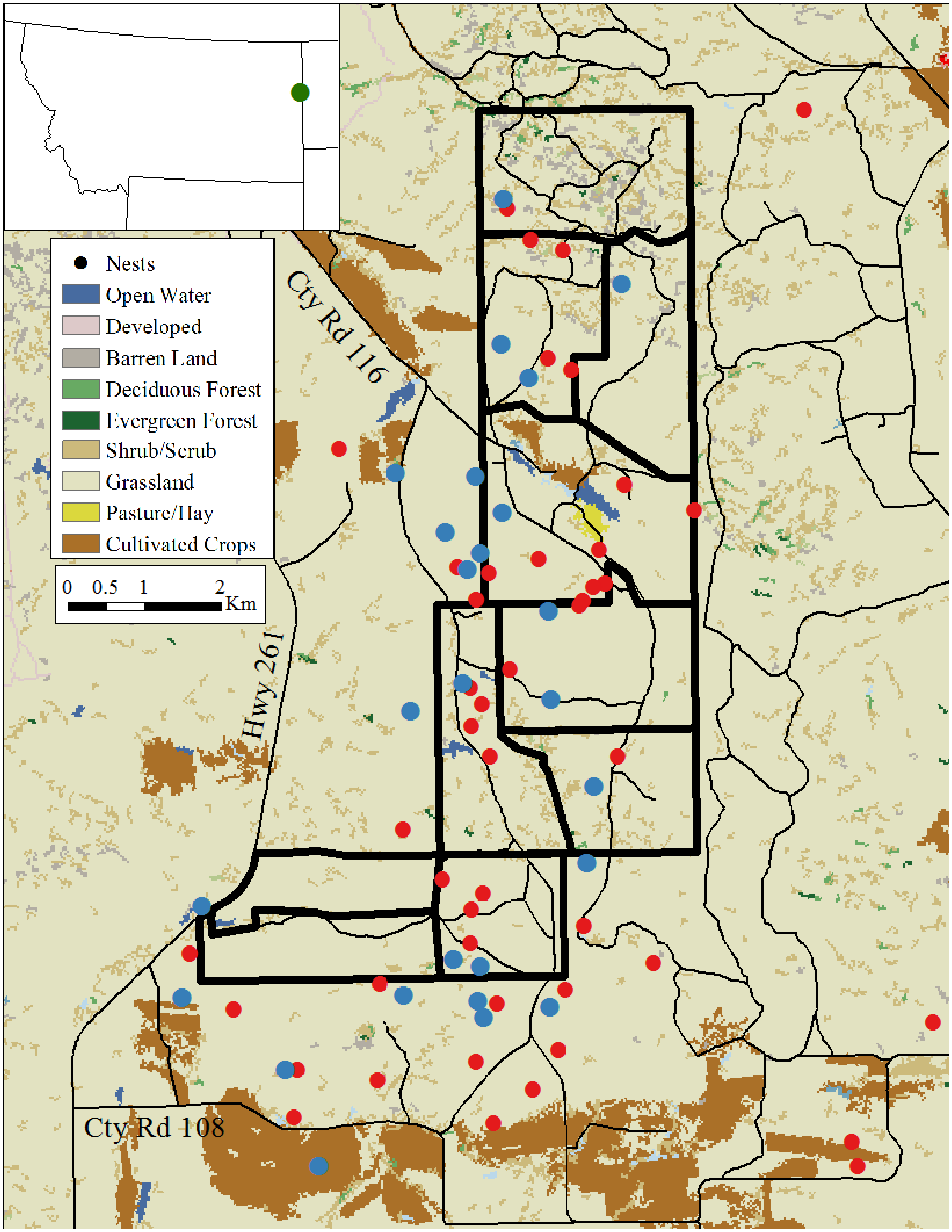

Figure 2. Locations of successful (blue) and failed (red) nests in relation to the easement boundaries outlined in black.

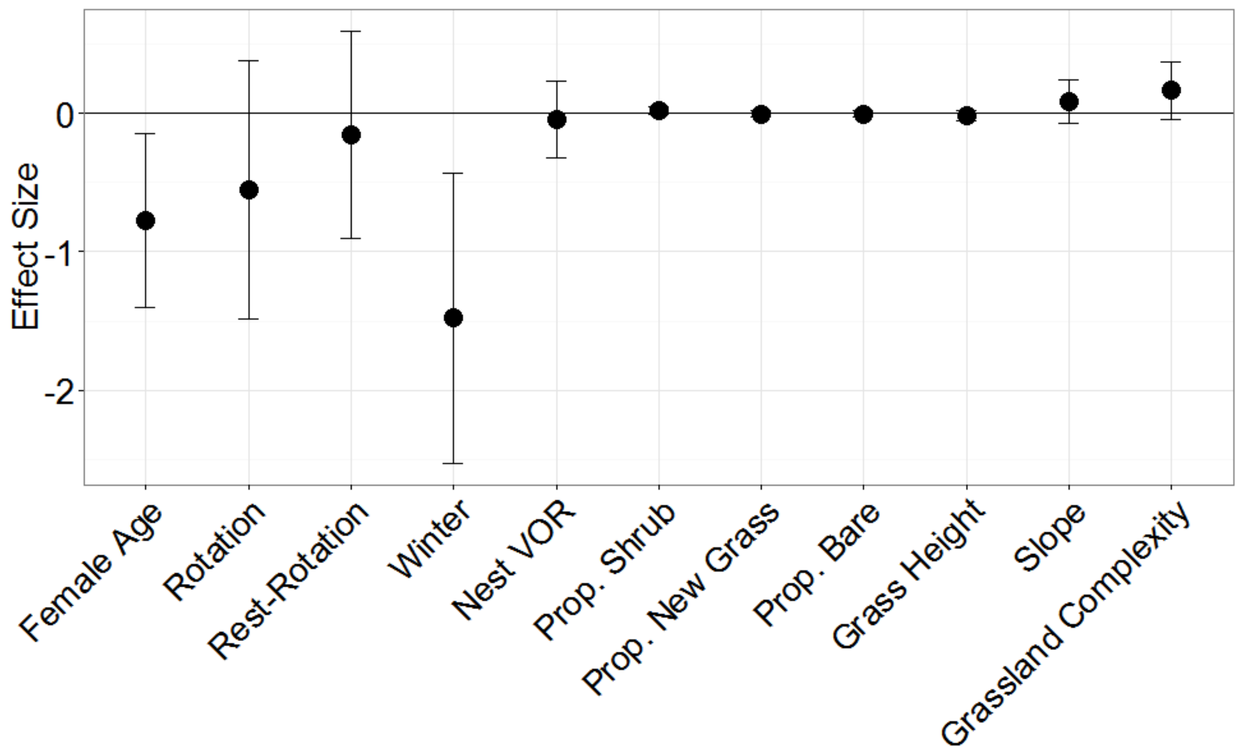

Figure 3. Effect size (β ±95% confidence intervals) for each variable in the nest survival analysis. Parameters for each grazing system represent effect sizes in relation to the reference category of season-long grazing. E.g., Daily nests survival was significantly lower for nests laid in winter pastures than those laid in summer pastures managed with season-long grazing.

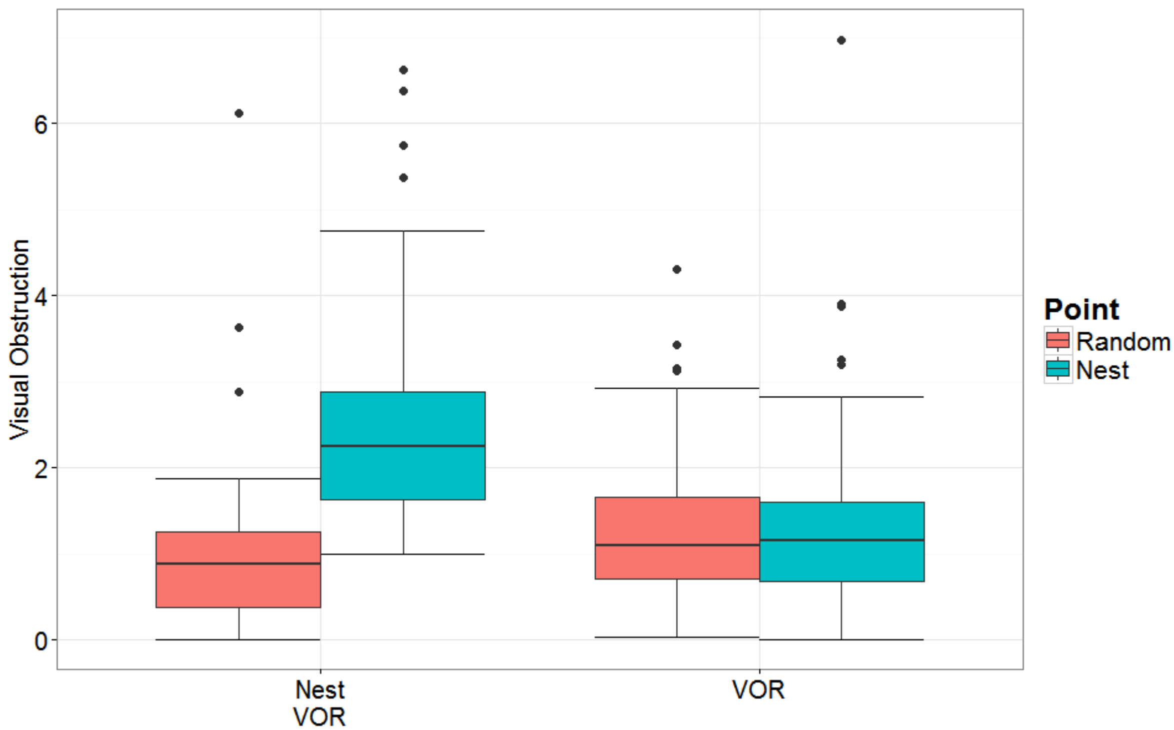

Figure 4. Visual obstruction measurements at nest sites and random locations in the study area. Nest VOR represents measurements taken directly at the nest bowl, whereas VOR represents mean VOR taken at 16 sampling plots located within 8 meters of a nest.

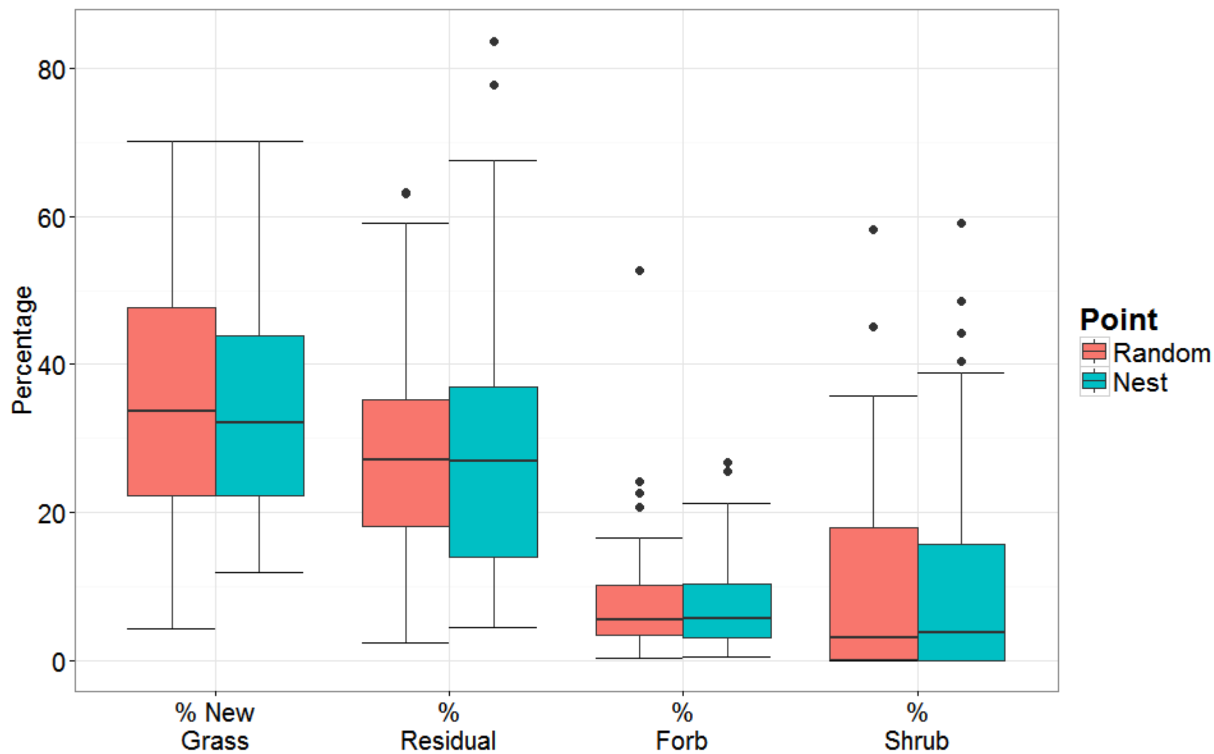

Figure 5. Vegetation measurements at nest sites and random locations in the study area.

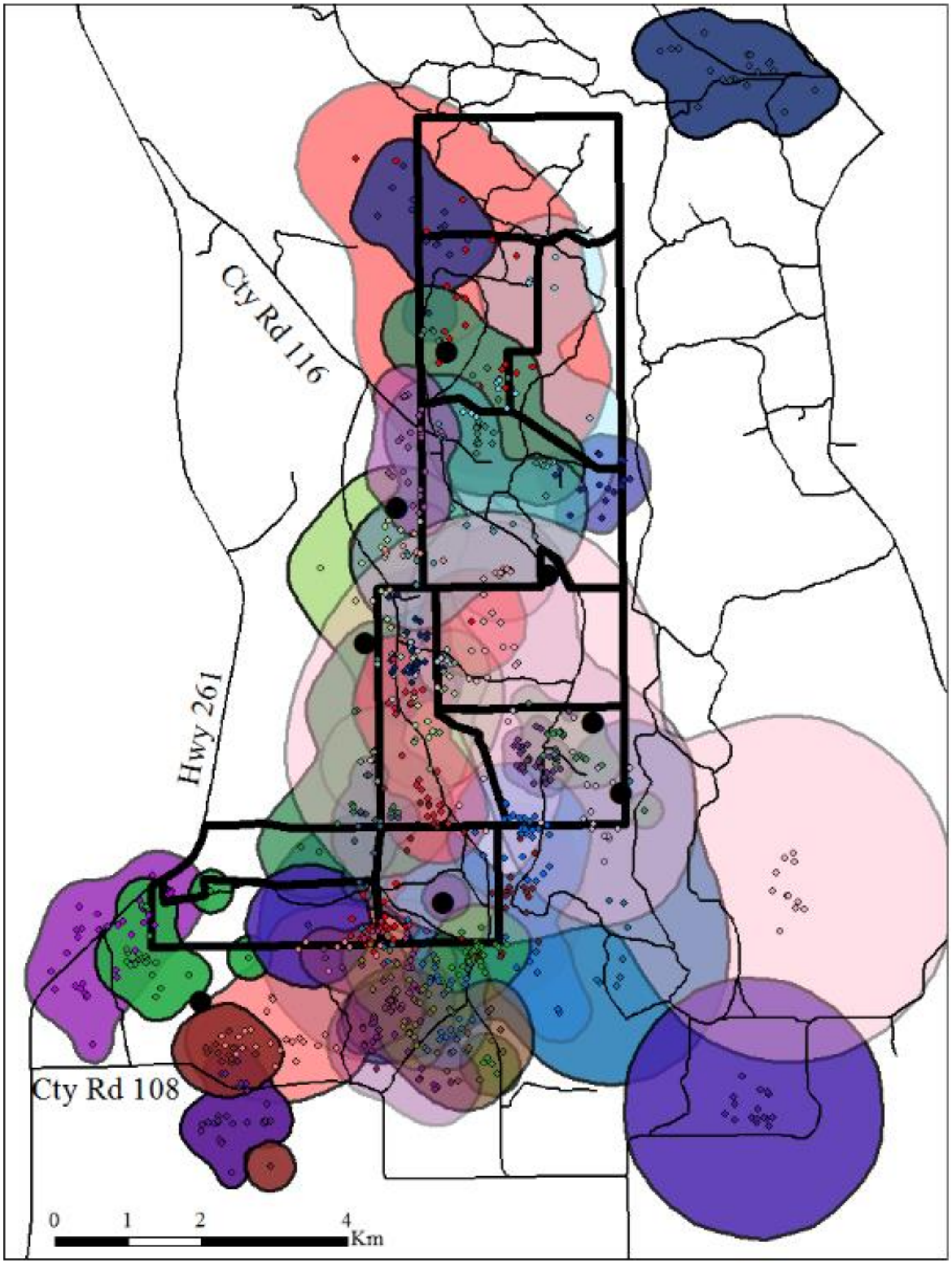

Figure 6. Breeding season home ranges of 37 sharp-tailed grouse. Points used to construct the home ranges are overlaid in the same color as the home ranges to which they correspond. The boundaries of the easement are represented by dark black lines and leks of capture are shown as large black circles.

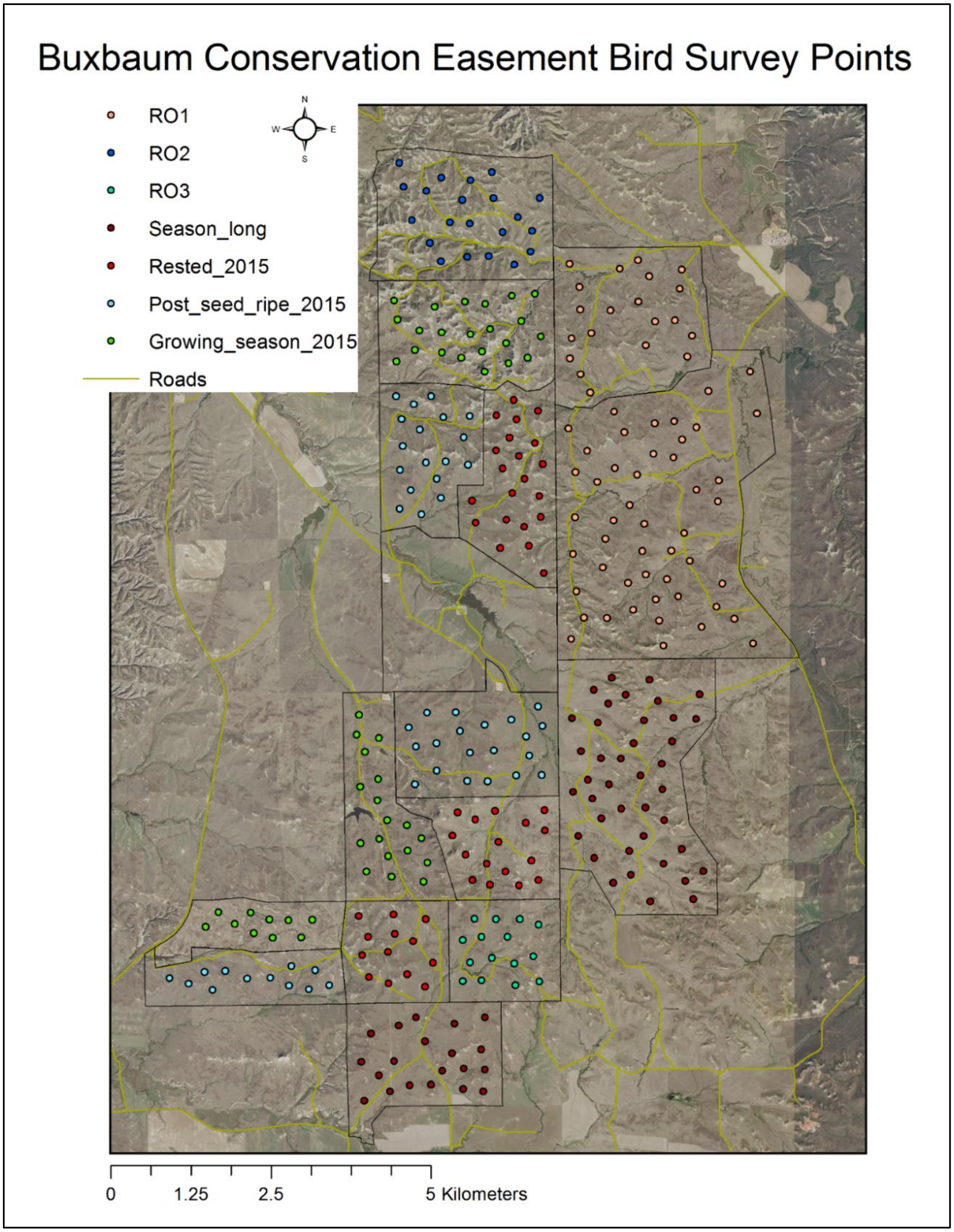

Figure 7. All bird point count survey locations on the Buxbaum conservation easement and on adjacent private and federal lands managed under traditional grazing methods in Richland County, Montana surveyed in 2016. RO1, RO2, and RO3 indicate points in summer rotational grazing systems, where cattle are turned out at the end of May and are moved between pastures after 6–8 weeks.

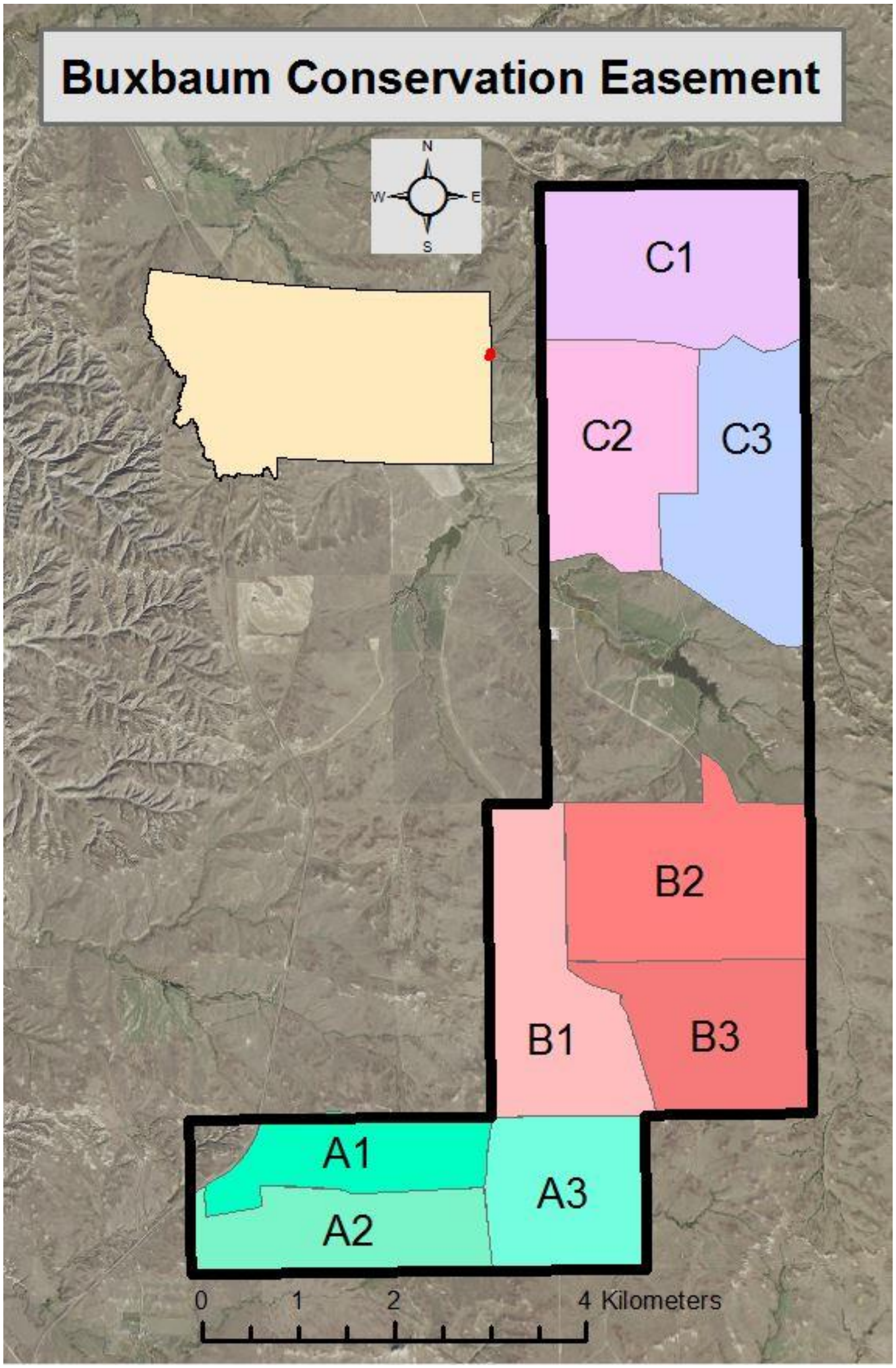

Figure 8. Buxbaum conservation easement pasture designations. In 2015, rest-rotation pastures A1, B1, and C1 were grazed from mid-May through seed ripe (~Aug 1), pastures A2, B2, and C2 were grazed from seed ripe through mid-November, and pastures A3, B3, and C3 were rested from grazing during the entire year.

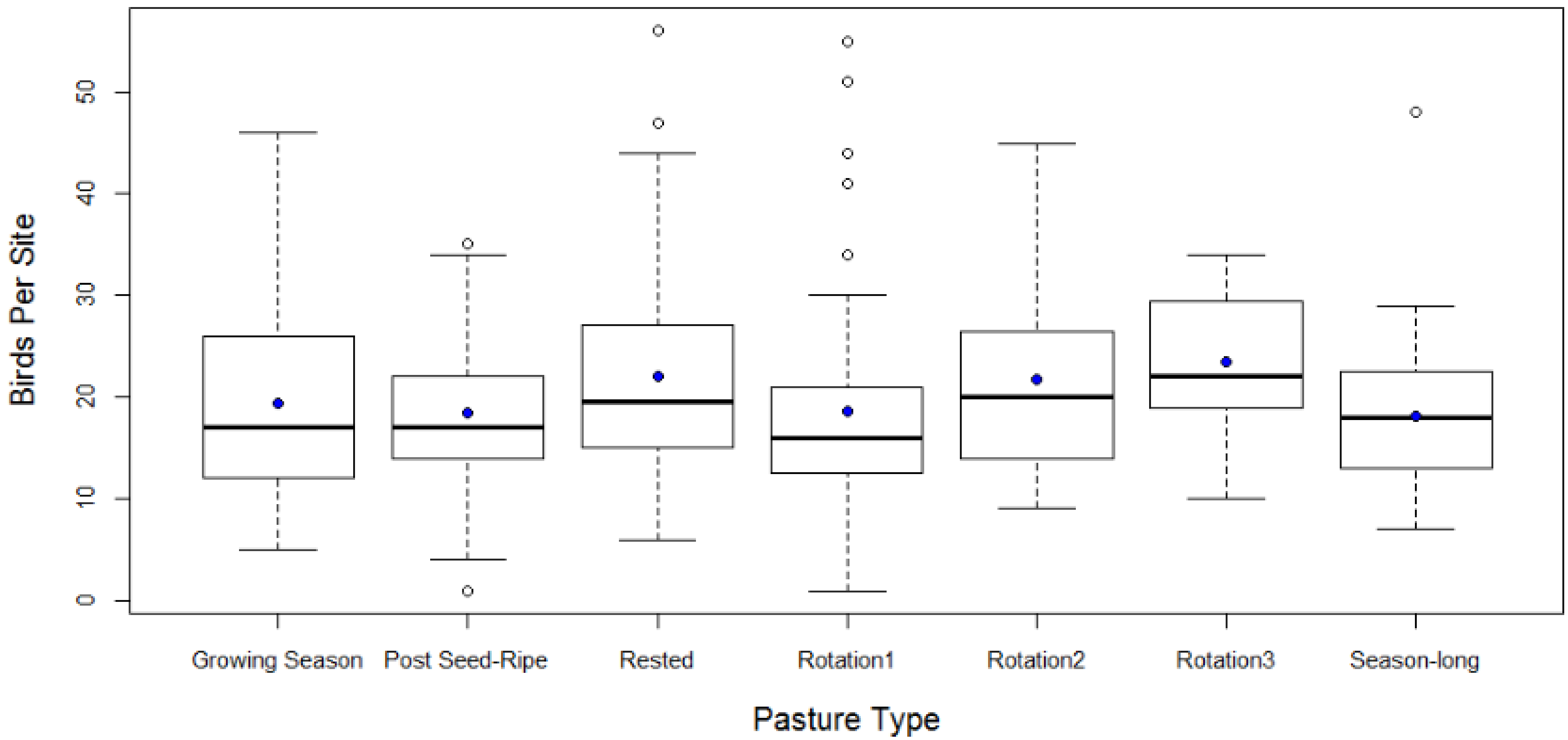

Figure 9. Mean (blue dot) and median (black bar) number of birds detected per point over three visits during late spring point count surveys on the Buxbaum conservation easement and adjacent reference properties in eastern Richland County, Montana in 2016. Easement pastures are grazed from the beginning of the growing season through seed ripe, from seed ripe through the end of the grazing season, and rested from grazing for the year. Reference pastures include 2 pastures that are grazed annually during the growing season, and three pastures managed under intensive summer rotational grazing.

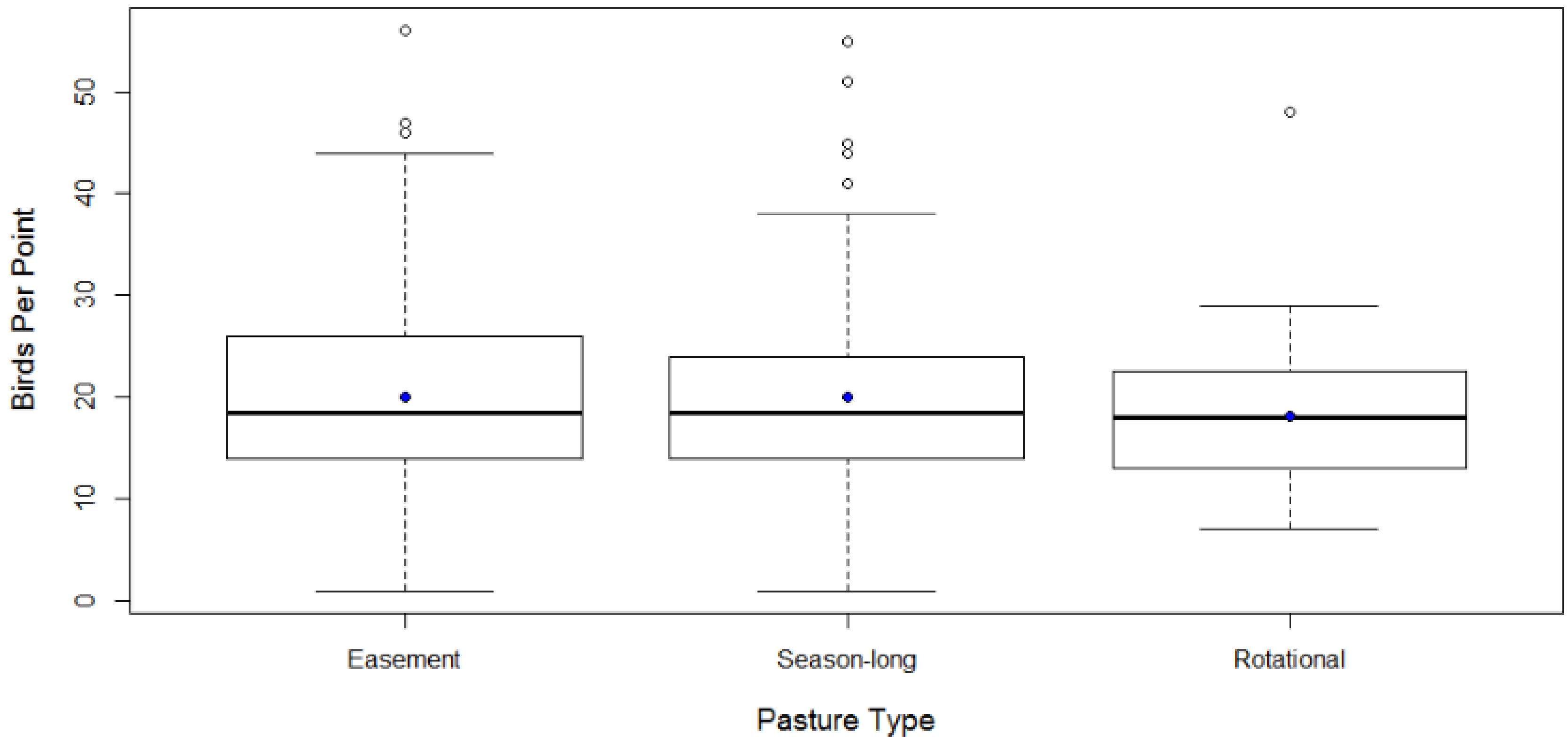

Figure 10. Mean (blue dot) and median (black bar) number of birds detected per point over three visits during late spring point count surveys on the Buxbaum conservation easement and adjacent reference properties in eastern Richland County, Montana in 2016. Easement pastures are grazed from the beginning of the growing season through seed ripe, grazed from seed ripe through the end of the grazing season, and rested from grazing for the year. Reference pastures include 2 pastures that are grazed annually during the growing season, and three pastures managed under intensive summer rotational grazing.

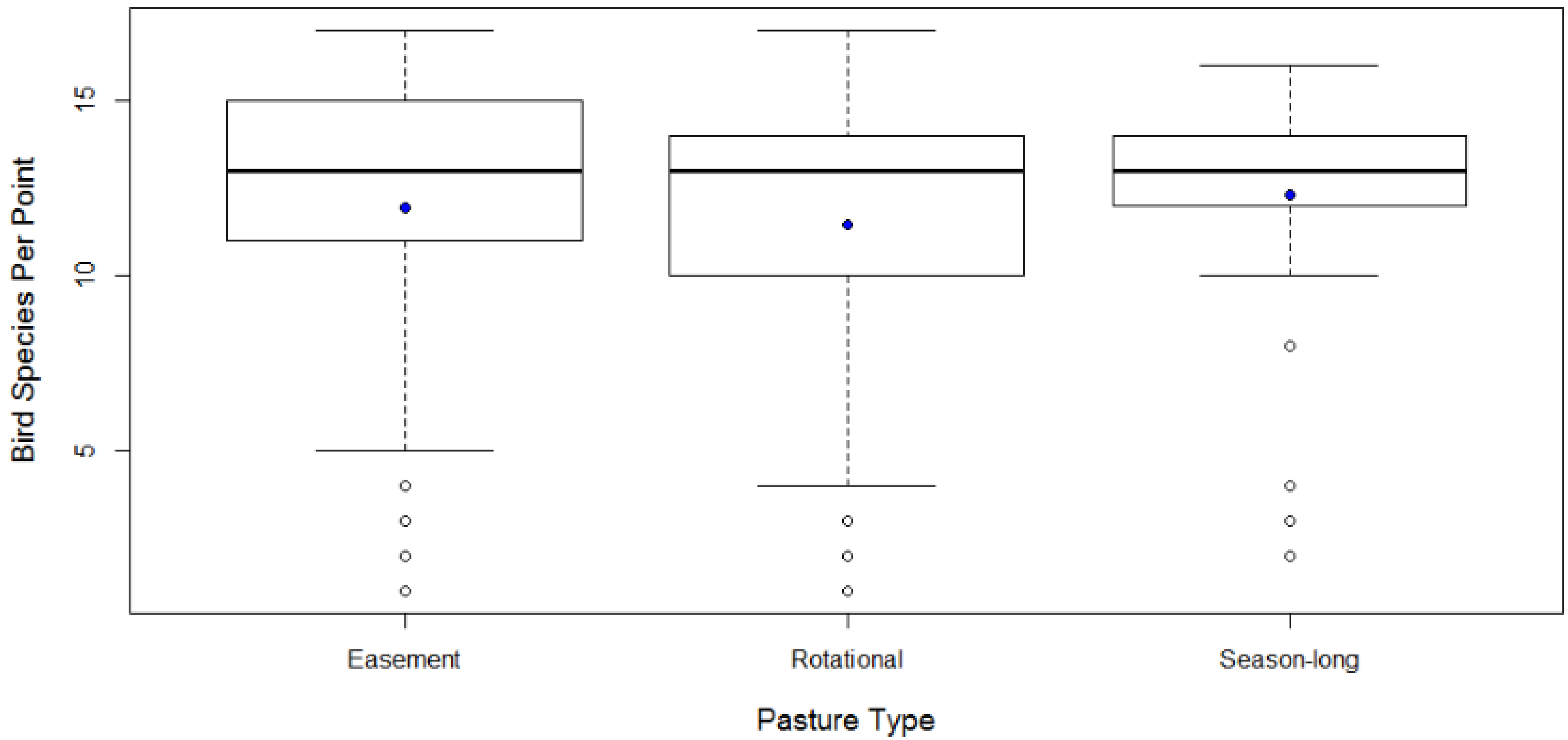

Figure 11. Mean (blue dot) and median (black bar) number of bird species detected per point over three visits during late spring point count surveys on the Buxbaum conservation easement and adjacent reference properties in eastern Richland County, Montana in 2016. Easement pastures are grazed from the beginning of the growing season through seed ripe, grazed from seed ripe through the end of the grazing season, and rested from grazing for the year. Reference pastures include 2 pastures that are grazed annually during the growing season, and three pastures managed under intensive summer rotational grazing.

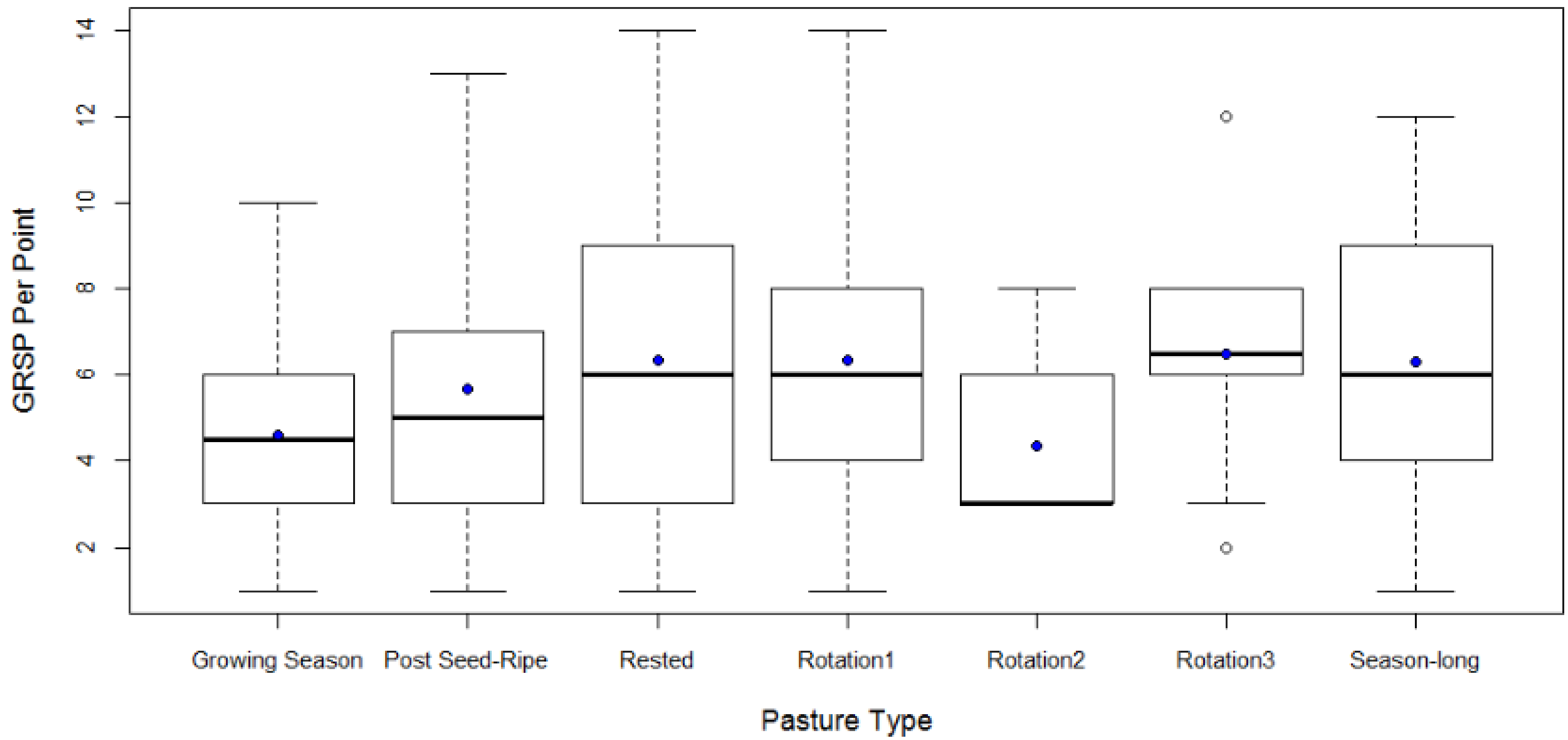

Figure 12. Mean (blue dot) and median (black bar) number of grasshopper sparrows (*Ammodramus savannarum*) detected per point over three visits during late spring point count surveys on the Buxbaum conservation easement and adjacent reference properties in eastern Richland County, Montana in 2016. Easement pastures are grazed from the beginning of the growing season through seed ripe, from seed ripe through the end of the grazing season, and rested from grazing for the year. Reference pastures include 2 pastures that are grazed annually during the growing season, and three pastures managed under intensive summer rotational grazing.

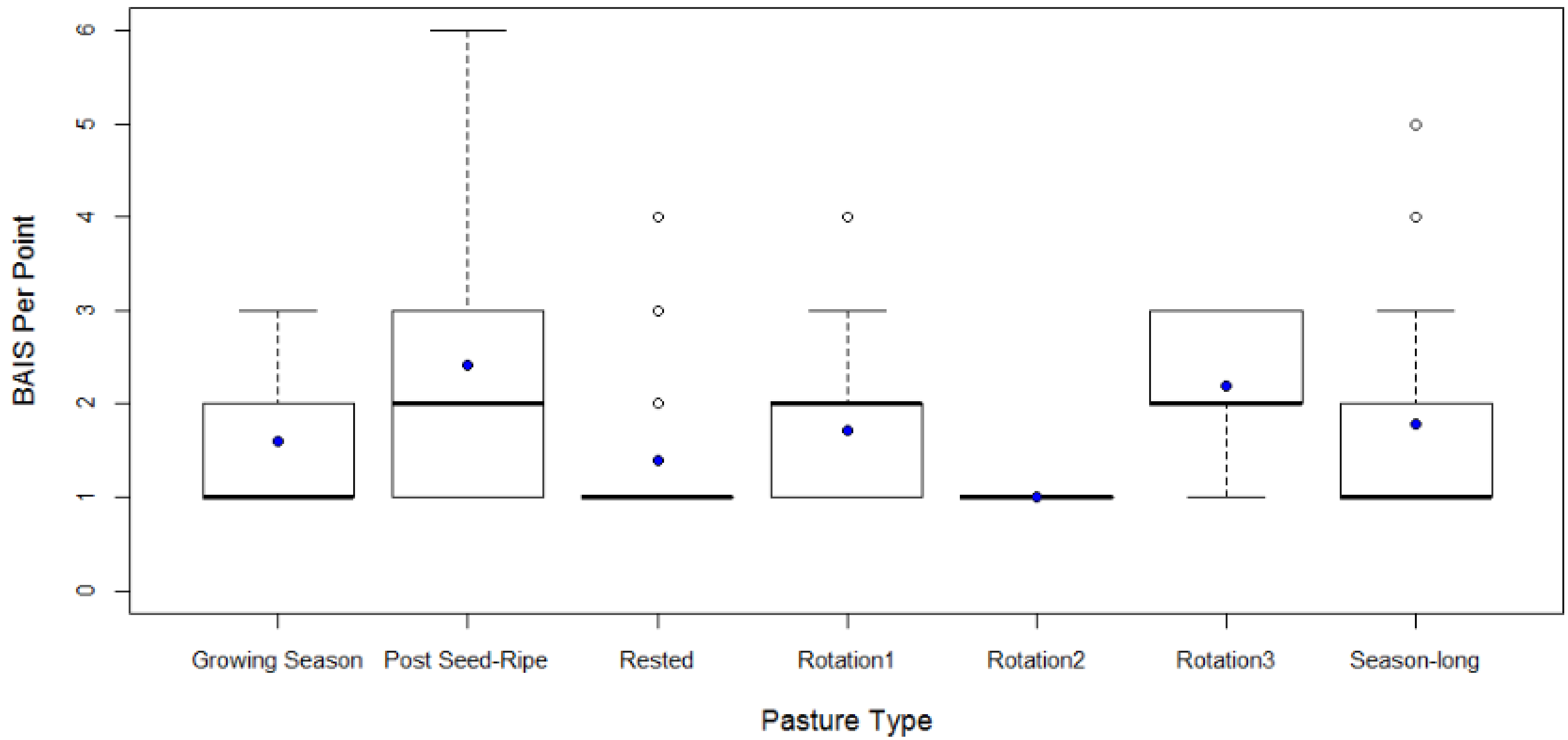

Figure 13. Mean (blue dot) and median (black bar) number of Baird's sparrows (*A. bairdii*) detected per point over three visits during late spring point count surveys on the Buxbaum conservation easement and adjacent reference properties in eastern Richland County, Montana in 2016. Easement pastures are grazed from the beginning of the growing season through seed ripe, from seed ripe through the end of the grazing season, and rested from grazing for the year. Reference pastures include 2 pastures that are grazed annually during the growing season, and three pastures managed under intensive summer rotational grazing.

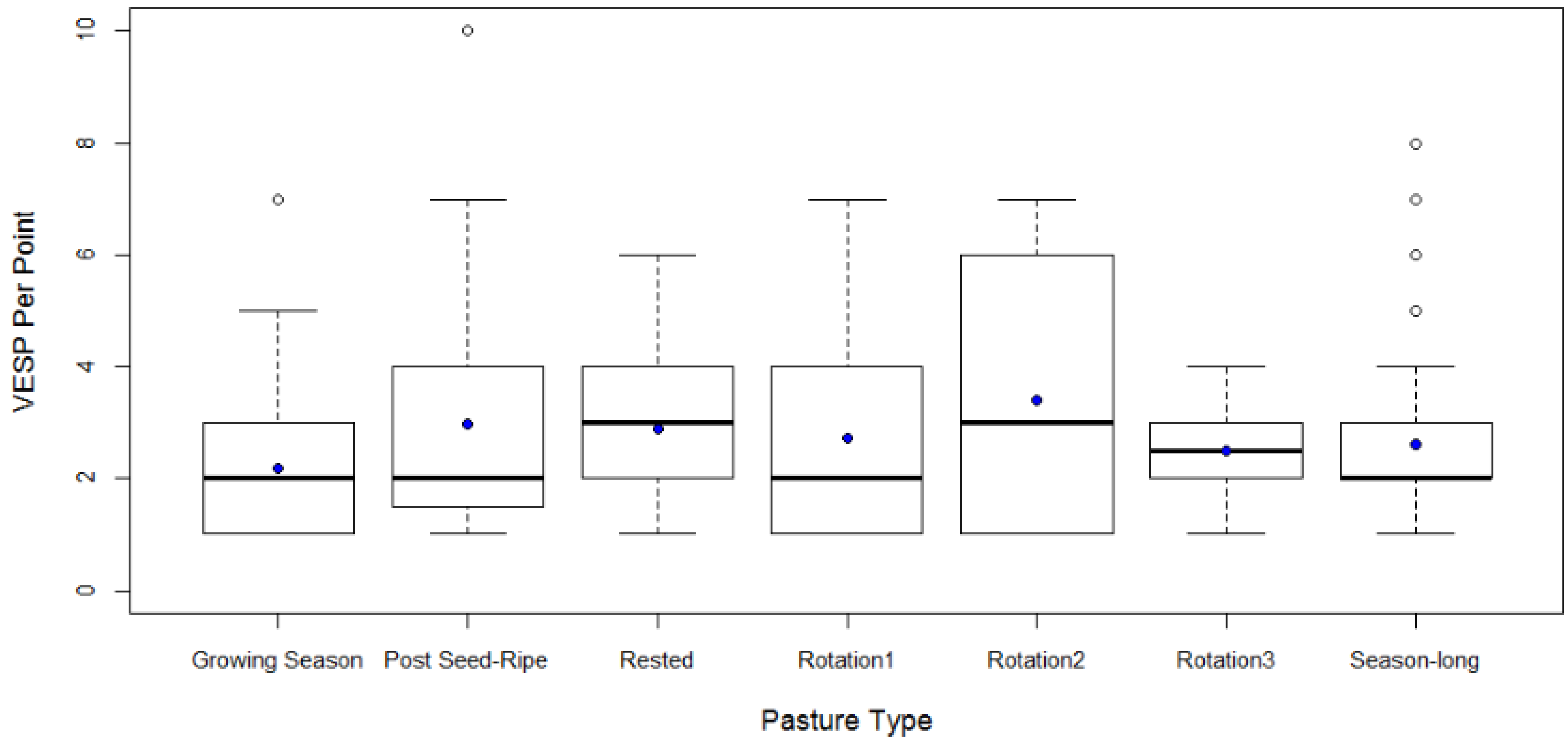

Figure 14. Mean (blue dot) and median (black bar) number of vesper sparrows (*Pooecetes gramineus*) detected per point over three visits during late spring point count surveys on the Buxbaum conservation easement and adjacent reference properties in eastern Richland County, Montana in 2016. Easement pastures are grazed from the beginning of the growing season through seed ripe, grazed from seed ripe through the end of the grazing season, and rested from grazing for the year Reference pastures include 2 pastures that are grazed annually during the growing season, and three pastures managed under intensive summer rotational grazing.

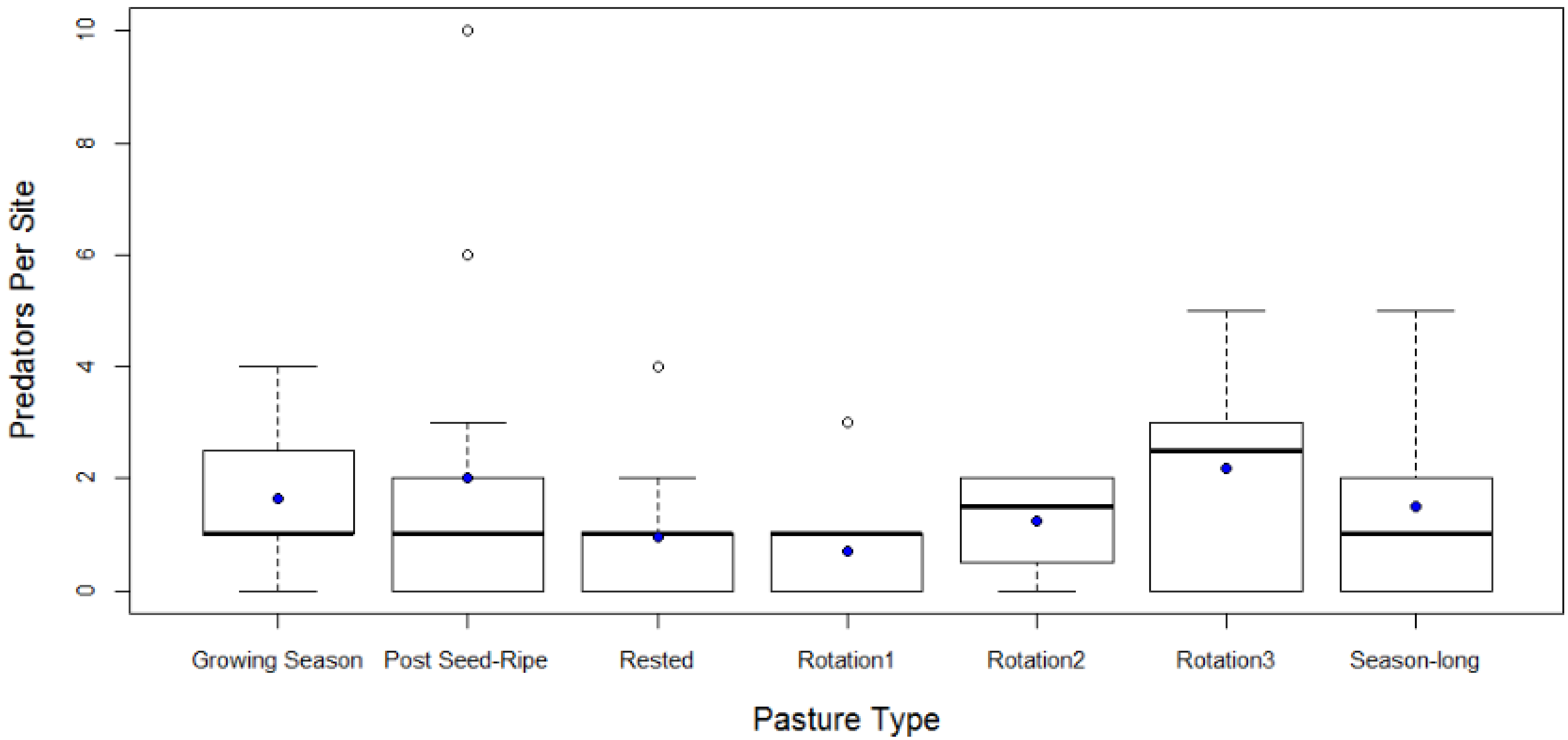

Figure 15. Mean (blue dot) and median (black bar) number of predators detected from remote camera trap surveys on the Buxbaum conservation easement and adjacent reference properties in eastern Richland County, Montana in 2016. Easement pastures are grazed from the beginning of the growing season through seed ripe, grazed from seed ripe through the end of the grazing season, and rested from grazing for the year. Reference pastures include 2 pastures that are grazed annually during the growing season, and three pastures managed under intensive summer rotational grazing.