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

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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

2nd Quarter Report
Reporting Period: 1 April – 30 June

## EXECUTIVE SUMMARY

Efforts this quarter focused on lek surveys, further data analysis, and preparing manuscripts for publication. During the quarter, we monitored 9 leks from 4–8 April and average attendance was 10.0 ± 8.0 birds. We also planned a landowner appreciation dinner on 19 June and had 8 landowners in attendance.

Data analysis this quarter focused on habitat selection. During the 2016–2018 breeding seasons, we collected a total of 7,178 locations and calculated 142 home ranges for 118 individual females (40 in 2016, 53 in 2017, 49 in 2018). Mean breeding season home range size for all females was 489 ± 41 ha but varied from 58 ha to 3,717 ha. Density of edge habitat within the home range was the best predictor of home range size and was negatively related to the size of breeding season home ranges for females. There was no evidence for an effect of grazing system on home range size. At the second order, females strongly selected for mixed grass prairie habitats, even though roughly 83% of the entire study area was composed of mixed grass prairie. Furthermore, females were strongly selecting against row crop agriculture, even though only 4% of the study area was cropland. Breeding season habitat use in relation to grazing system was ranked rest-rotation > season-long >> summer rotation, suggesting that females were selecting against pastures grazed in a summer rotation system when choosing home ranges, but not differentiating between pastures with rest-rotation and season-long systems. At the third order, preliminary analyses suggested that a grain size of 1,300 m for grassland, 1,300 m for wooded draws, 500 m for row crop agriculture, and 1,000 m for edge density best represented female habitat selection.

## OBJECTIVES

### Objectives 1 and 2: Investigate impacts of rest rotation grazing on sharp-tailed grouse fecundity, survival, and home ranges, movements and habitat selection.

*Accomplishments Since Last Quarter:*

Efforts this quarter focused on lek surveys, data analysis, planning a landowner appreciation dinner, and preparing manuscripts for publication. During the quarter, we monitored 9 leks from 4–8 April so that every lek was visited a minimum of two times to allow for the estimation of detection probability. Average attendance was 10.0 ± 8.0 birds. We held a landowner appreciation dinner on 19 June and had 8 landowners in attendance.

Data analysis this quarter focused on habitat selection. During 2016 – 2018, we captured grouse using walk-in funnel traps at 12 leks (5 in rest-rotation pastures, 3 in summer rotation pastures,

and 4 in season-long pastures) during March–May. Females were fitted with VHF radio-transmitters (model A4050; Advanced Telemetry Systems, Isanti, MN). Radio-marked females were located by triangulation or homing ≥ 3 times/week during the breeding season (15 March–15 August). 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 low estimation precision (>200 m error ellipse) were discarded.

Habitat selection is a hierarchical process and studies that evaluate selection at multiple spatial scales can improve understanding of wildlife-habitat relationships (Johnson 1980, McDonald et al. 2012). Therefore, we evaluated both second- and third-order selection of female grouse. We analyzed location data for the breeding season (15 March–15 August) and defined a home range as the space an individual needed to forage, reproduce, and survive. Previous studies have found that small sample sizes can bias home range estimates (Seaman et al. 1999), so analyses were restricted to birds with ≥ 30 locations and ≥ 20 locations not associated with a nest site. 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. We also calculated centroids for each home range by estimating the 1% volume contour of each home range and used the geographic center of that contour as the centroid. We used linear models to evaluate the effects of year, nest outcome, density of edge habitat, proportion grassland within the home range, grazing system at the home range centroid, and distance to nearest lek, grassland patch edge, road, and oil pad on home range size. We calculated the proportion grassland and edge density within each home range in ArcGIS and measured the distance from each centroid to the nearest lek, grassland patch edge, road and oil pad. Habitat classifications utilized the 30-m resolution LANDFIRE data depicting vegetation type (LANDFIRE 2013) and we digitized the location of oil pads and roads in the study area. We collected information on grazing management for every pasture in the study area by interviewing landowners to determine the number and class of animals stocked and the timing of stocking in order to determine the grazing system (rest-rotation, summer rotation, season-long) of each pasture.

We examined second-order habitat selection, or the selection of habitat for an individual's home range within the larger study area, using the adehabitat package in Program R to conduct compositional analysis of used versus available habitat (Johnson 1980, Aebischer et al. 1993). Available habitat was defined as the 95% home range calculated for all locations in a given year and each female's 95% home range represented the used space at an individual level. We used compositional analysis to compare used versus available vegetation types and grazing systems. Vegetation classifications were based on LANDFIRE data and were grouped into grassland, wooded draws, row crop agriculture, and other, which was composed primarily of ruderal grasslands (LANDFIRE 2013).

To evaluate third-order habitat selection, we used resource selection functions to compare used and available points following Design 3 of Manly et al. (2002). We identified nine landscape metrics *a priori* that could influence sharp-tailed grouse space use. Three of those metrics were related to rangeland management: grazing system (rest-rotation, summer rotation, season-long) and stocking rate (AUM $ha^{-1}$) during either the current or previous year, which is a measure of the number of animals in a grazing unit during the entire grazing season. Two additional

landscape metrics represented anthropogenic disturbance, including both oil pads and roads, and we calculated the distance to each from both used and available points. Four of the landscape variables were related to landcover: % grassland, % wooded draws, % agriculture, and the density of edge habitat (total landcover edge length / polygon area), which were based on the 30 m resolution LANDFIRE data depicting vegetation type (LANDFIRE 2013). We used FRAGSTATS 4.2 (McGarigal et al. 2012) to conduct a moving window analysis to calculate the proportion of each habitat type and the density of edge habitat within 8 buffer distances (30, 75, 125, 200, 500, 750, 1000, 1300 m) to evaluate the spatial grain for each habitat type that best predicted grouse space use (Laforge et al. 2015). We chose grain sizes to reflect a continuum of scales, with 30 m representing the minimum size as imposed by our spatial data and 1,300 m approximating the average size of the breeding season home range of a female sharp-tailed grouse in our study area. A grain size of 200 m was chosen as it represents the average distance moved daily by female sharp-tailed grouse during the breeding season in our study.

We conducted 1,000 simulations for each variable and each grain size of landcover variables to determine the number of available points required for coefficient estimates to converge (Northrup et al. 2013). Based on the simulations, available points were sampled at a 15:1 available:used ratio within each individual bird's home range. For all models, we used generalized linear mixed models in a Bayesian framework with a logit-link and female ID as a random effect to account for potential autocorrelation among sampling points (Gillies et al. 2006). We first selected the appropriate grain size at which to measure the four landcover variables, basing model selection on calculated deviance information criteria (DIC) to identify a top model *sensu* Laforge et al. (2015). Based on the top model, we calculated ΔDIC values and considered >5 DIC units to be a substantial difference in model fit (Thomas et al. 2006).

We fit models using Markov Chain Monte Carlo (MCMC) simulations with JAGS (version 4.2.0, mcmc-jags.sourceforge.net, accessed Dec 2018) implemented via the 'rjags' package (Plummer 2018) in Program R to approximate the posterior probability distribution of model parameters. Vague uniform or normal priors were used for all model parameters (Kéry 2010). To improve convergence, we standardized all continuous covariates. For the first step, we identified the top spatial grain model for each landcover variable from 20,000 samples from 3 independent MCMC chains, discarding 10,000 burn-in samples. We assessed convergence and MCMC chain mixing visually and based on Gelman-Rubin convergence statistics and considered sets of chains with values <1.1 and no trends across trace plots converged (Brooks and Gelman 1998, Gelman and Hill 2006).

During the 2016–2018 breeding seasons, we collected a total of 7,178 locations and calculated 142 home ranges for 118 individual females (40 in 2016, 53 in 2017, 49 in 2018). Mean breeding season home range size for all females was 489 ± 41 ha but varied from 58 ha to 3,717 ha (Table 1). Variation in home range size was greatest in the rest-rotation system and smallest in the summer rotation system (Figure 1), but there was no evidence for an effect of the grazing system at the centroid of a female's home range on home range size (Table 2). Density of edge habitat within the home range was the best predictor of home range size (Table 2) and was negatively related to the size of breeding season home ranges for females ($\beta = -5.26 \pm 1.48$; Figure 2).

At the second order, breeding season habitat use was ranked as follows: grassland > wooded draws >> other (primarily ruderal grasslands) >> row crop agriculture (Table 3), suggesting that females did not differentiate between grasslands and wooded draws with regards to preference but selected both habitat types over other habitats, including cropland. Females strongly selected for mixed grass prairie habitats, even though roughly 83% of the entire study area was composed of mixed grass prairie. Furthermore, females were strongly selecting against row crop agriculture, even though only 4% of the study area was cropland. Breeding season habitat use in relation to grazing system was ranked rest-rotation > season-long >> summer rotation (Table 4), suggesting that females were selecting against pastures grazed in a summer rotation system when choosing home ranges, but not differentiating between pastures with rest-rotation and season-long systems. At the third order, preliminary analyses suggested that a grain size of 1,300m for grassland, 1,300 m for wooded draws, 500 m for row crop agriculture, and 1,000 m for edge density best represented female habitat selection.

Additional efforts this quarter have focused on preparing and circulating a manuscript evaluating the effects of grazing management on the adult survival of sharp-tailed grouse (see 2019 1st Quarterly Report for results).

*Goals For Next Quarter:*
We will prepare for publication a manuscript evaluating the effects of grazing management on the space use of sharp-tailed grouse. We will also present results from our study at the annual conference of the Ecological Society of America.

We will also continue to work on data analysis, particularly with regards to habitat selection. After assessing correlations for each pair of explanatory variables ($r \geq 0.6$), we will evaluate support for all management and landscape variables in a full model using indicator variables. We will place Bernoulli(0.5) prior distributions on the indicator variables to represent no prior information about the importance of individual variables (O'Hara and Sillanpää 2009). Regression coefficients for each variable will be the product of binary indicator variables and continuous effect size parameters (Kuo and Mallick 1997, O'Hara and Sillanpää 2009, Hooten and Hobbs 2015) and we will use the joint posterior distributions of the indicator variables to identify the variables with the greatest posterior probability. We will assume that all variables with high posterior probability based on the joint posterior distributions of their indicator variables influenced habitat selection. The effect size parameters then represent the degree to which an individual or population utilize resources within the defined home range (Marzluff et al. 2004). We will use standardized coefficients of fixed effects to make population-level inferences about each habitat variable and standardized coefficients with 95% credible intervals that do not overlap zero will be considered significant. Inference from the full model will be based on a total of 50,000 samples from 3 independent MCMC chains, discarding the first 100,000 burn-in samples. To perform posterior predictive checks, we will calculate Bayesian *p*-values as a goodness-of-fit measure that compares attributes of the observed data to that of data generated by the model (Gelman et al. 1996).

**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 mesopredator communities**

Project completed. Please see:

Vold, S. T. 2018. Effects of livestock grazing management on the ecology of grassland birds and their predators in a northern mixed-grass prairie ecosystem. Thesis, Montana State University, Bozeman, Montana, USA.

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Table 1. Home range size (95% volume contour) for radio-marked female sharp-tailed grouse monitored in the 3 grazing systems.

| **Grazing System** | **# Females** | **Mean area (ha) ± SE** | **Min. area (ha)** | **Max area (ha)** |
|---|---|---|---|---|
| Rest-rotation | 48 | 595 ± 96 | 63.81 | 3717.45 |
| Summer rotation | 47 | 373 ± 37 | 86.13 | 1198.89 |
| Season-long | 41 | 518 ± 74 | 57.51 | 2265.66 |
| **Total** | 142 | 489 ± 41 | 57.51 | 3717.45 |

Table 2. Support for candidate models predicting the home range size of female sharp-tailed grouse during the breeding seasons of 2016-2018. The number of parameters (K), $AIC_c$ values, $AIC_c$ values, model weights ($w_i$), and log-likelihoods are reported.

| **Model** | **K** | **$AIC_c$** | **$\Delta AIC_c$** | **$AIC_c$ $w_i$** | **Cum. $w_i$** | **LogLik** |
|---|---|---|---|---|---|---|
| Edge density | 3 | 2157.27 | 0.00 | 0.93 | 0.93 | -1075.55 |
| Dist. to grassland edge | 3 | 2165.05 | 7.78 | 0.02 | 0.95 | -1079.44 |
| Nest outcome | 3 | 2165.25 | 7.98 | 0.02 | 0.97 | -1079.54 |
| Null | 2 | 2166.80 | 9.53 | 0.01 | 0.98 | -1081.36 |
| Year | 3 | 2167.47 | 10.20 | 0.01 | 0.98 | -1080.65 |
| Grazing system | 5 | 2167.51 | 10.24 | 0.01 | 0.99 | -1078.54 |
| Dist. to lek | 3 | 2168.65 | 11.38 | 0.00 | 0.99 | -1081.24 |
| Dist. to road | 3 | 2168.73 | 11.46 | 0.00 | 0.99 | -1081.28 |
| Dist. to oil pad | 3 | 2168.84 | 11.57 | 0.00 | 1.00 | -1081.33 |
| Prop. Grassland | 3 | 2168.88 | 11.61 | 0.00 | 1.00 | -1081.36 |

Table 3. Simplified ranking matrix of female sharp-tailed grouse breeding season habitat selection based on vegetation type in 2016-2018. Matrix is based on comparing proportional habitat use within home ranges with proportion of available habitat types. The 'other' habitat is composed primarily of ruderal grasslands. Habitat types with the same rank suggest that females did not differentiate between the two categories in habitat selection.

| | Grassland | Wooded draws | Other | Agriculture | RANK |
|---|---|---|---|---|---|
| Grassland | 0 | + | +++ | +++ | 1 |
| Wooded draws | - | 0 | +++ | +++ | 1 |
| Other | --- | --- | 0 | +++ | 3 |
| Agriculture | --- | --- | --- | 0 | 4 |

Table 4. Simplified ranking matrix of female sharp-tailed grouse breeding season habitat selection based on grazing system in 2016-2018. Matrix is based on comparing proportional habitat use within home ranges with proportion of available habitat types. Grazing systems with the same rank suggest that females did not differentiate between the two categories in habitat selection.

| | Rest-rotation | Season-long | Summer rotation | RANK |
|---|---|---|---|---|
| Rest-rotation | 0 | + | +++ | 1 |
| Season-long | - | 0 | + | 1 |
| Summer rotation | --- | - | 0 | 3 |

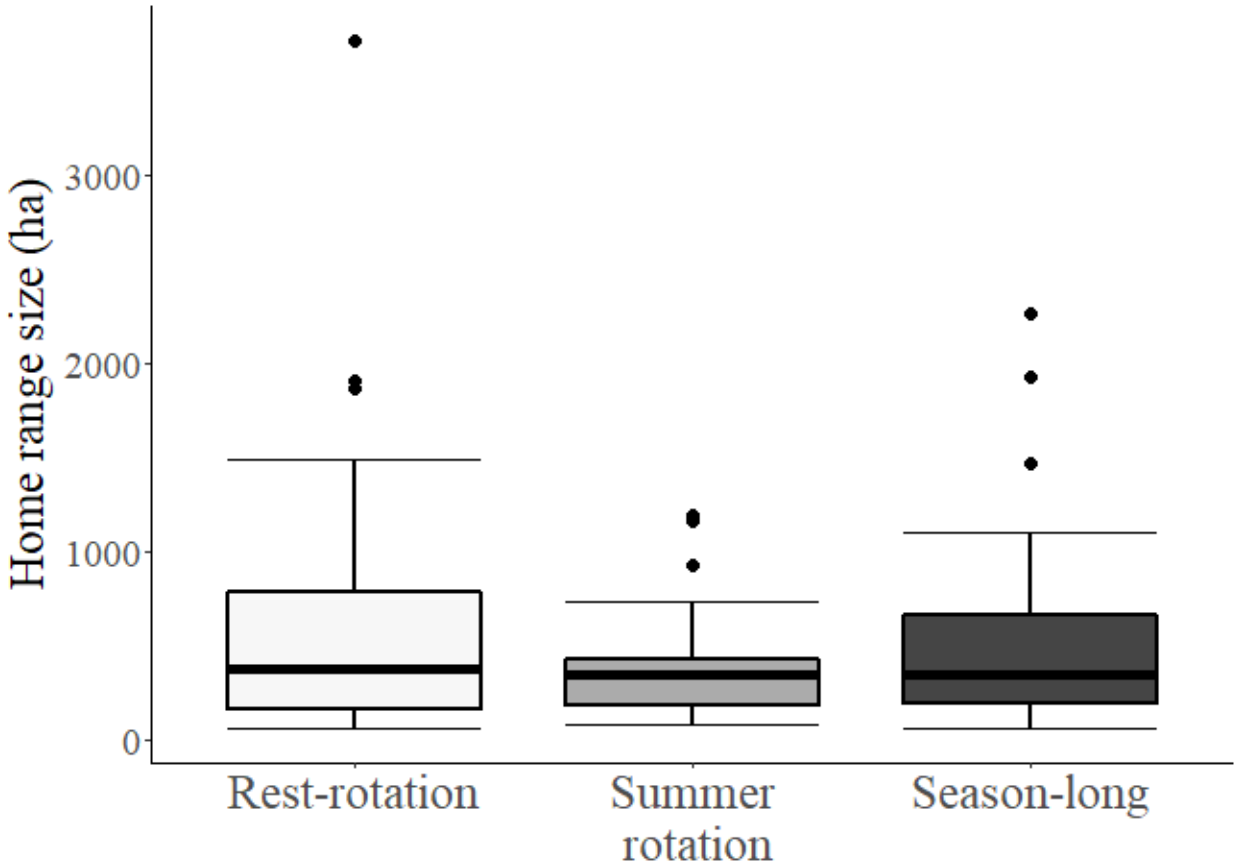


Figure 1. Female sharp-tailed grouse breeding season home range size (± SE) by grazing system. An individual female's home range was assigned to a grazing treatment according to the system at the home range centroid.

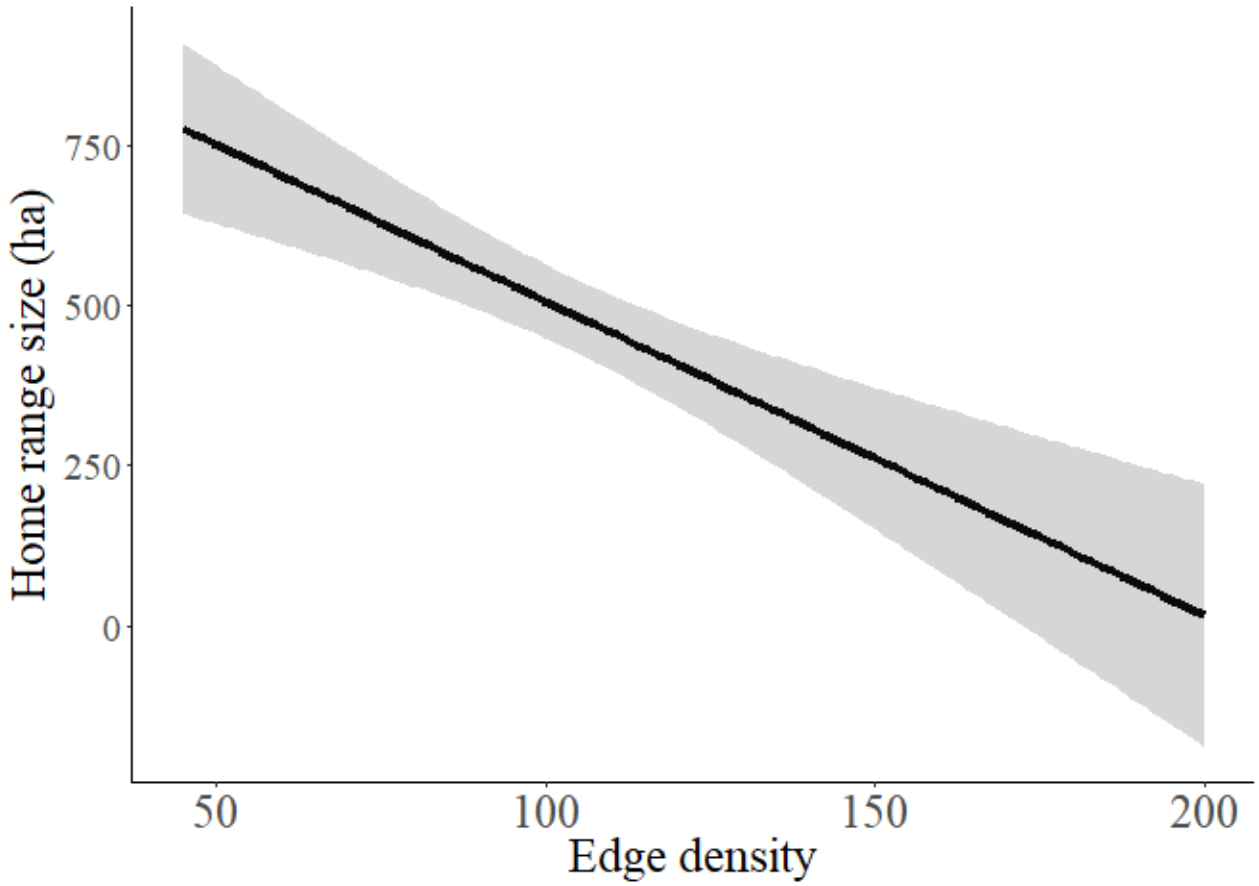


Figure 2. Relationship between the density of edge habitat (total landcover edge length / polygon area) and breeding season home range size for female sharp-tailed grouse.