Grassland bird species abundance on grazed and non-grazed land at Buena Vista Wildlife Area, Wisconsin

by

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CONTENTS

Executive Summary

Buena Vista Wildlife Area (hereafter Buena Vista WA) has mainly been managed for Greater Prairie Chicken (*Tympanuchus cupido*), but also hosts a number of grassland bird species of management concern. Grazing is used as a management strategy to create habitat disturbance and reduce woody brush presence needed to maintain prairie chicken habitat. There are currently two grazing regimes used at Buena Vista WA: continuous and managed intensive rotational grazing (MIRG). This case study provides a snapshot of grassland bird communities and vegetation structure with regard to these two grazing practices and on ungrazed sites. This information will assist WDNR managers in assessing the success of their conservation goals on Buena Vista WA.

Grassland bird species abundance varied among management types. Savannah Sparrow (*Passerculus sandwichensis*), a generalist grassland species, was the most commonly recorded species. Henslow's Sparrow (*Ammodramus henslowii*) was only found on ungrazed sites; this species prefers deep litter, which is not typically found on grazed sties. Grasshopper Sparrow (*Ammodramus savannarum*) was found on all sites but was most abundant at MIRG sites; this species is known to prefer sites with less dense vegetation, which is a common characteristic of grazed sites. Clay-Colored Sparrow (*Spizella pallida*), a shrub-dependent species, was most abundant on ungrazed sites. This suggests that grazing may be effective in reducing shrubs.

We used a pilot transect method to determine prairie chicken presence on a subset of the sites. Greater Prairie Chickens were found most frequently on the MIRG site, but at higher densities on the ungrazed site. They were never found on the continuously grazed site. The pilot procedure was successful for this case study, but should be revised to reduce the chance of not flushing birds if the procedure is going to be used in the future.

Vegetation across grazed sites, both litter depth and height density, was generally lower and increased more slowly over the season than on the ungrazed sites. This pattern was evident both among sites and within one site that was only partially grazed over the course of this study. This site (BK, MIRG) showed that bird abundances decreased directly following the introduction of cattle.

Based on these results, we suggest utilizing MIRG throughout Buena Vista WA. We suggest using MIRG similar to the BK site, where one section was left entirely ungrazed for a season, to allow nesting by species not tolerant of grazing. This will provide a mosaic of vegetation structures both among and within parcels at Buena Vista WA, which will provide forage for the grazier's cattle and habitat for grassland birds and Greater Prairie Chicken. Because cattle placement is under control of the managers, the MIRG system allows more targeted brush control compared to continuous grazing systems.

Introduction

Nestled in the heart of America's Dairyland, the green grass sways in the wind with distant bird calls on the breeze. Buena Vista Wildlife Area encompasses just over 5,139 ha (12,700 acres) that is home to grassland wildlife habitat and many threatened avian species. Buena Vista WA is located in the center of the Central Sands region of Wisconsin, where agricultural production dominates the landscape. In an effort to increase partnerships with the agricultural community, the Wisconsin Department of Natural Resources (WDNR) has implemented various programs for local citizens to rent and/or lease certain parcels of Buena Vista WA. Yet, the possible impact on wildlife communities from these actions has been relatively unstudied. The focus of this report is how continuous and rotational cattle grazing, as management activities used at Buena Vista WA, affect avian species abundance.

Across Wisconsin, two problems presented themselves: graziers (ranchers who graze their cattle) had limited land access and the WDNR needed to remove woody vegetation on public lands. Many beef herds in Wisconsin are grass-fed and pastured throughout the growing season. Grass-fed beef is produced mainly from cow-calf operations, with an average pasture size of about 24 ha (60 acres) and stocking rates of approximately one cow-calf pair per acre (CIAS 2008). However, with land prices and demand increasing, obtaining private land suitable for grazing is often difficult (Brannstrom 2017). At the same time, Buena Vista WA's goal is to uphold continuous grasslands and reduce woody vegetation (WDNR 2015). The grasslands are particularly important because Buena Vista WA boasts the state's largest population of Greater-Prairie Chickens (*Tympanuchus cupido*), a state threatened species. Maintaining this grassland habitat for Greater-Prairie Chickens and the other grassland-dependent wildlife species is a challenge. Mainly, budgetary and labor constraints have resulted in areas that are overrun with woody vegetation. Therefore, the opportunity to graze Buena Vista WA arose when ranchers needed land access and WDNR needed to control woody vegetation.

In an effort to align public needs, a collaborative project with the WDNR, private graziers, and researchers at the University of Wisconsin-Madison was created to understand the use of grazing to manage Wisconsin’s public grasslands. Similar programs have been implemented in Minnesota and by the United States Fish and Wildlife Service (USFWS) in various locations. Grazing grasslands can be utilized to achieve management goals, since it creates disturbance and can reduce the presence of woody vegetation (Sample & Mossman 1997). The goal of the collaborative project is to rent public lands (mainly grasslands) to private graziers in an effort to reduce woody vegetation and provide ranchers with land access.

Grazing outcomes, in relation to habitat structure, are dictated largely by specific grazing management. Continuous grazing is defined as a one-pasture system where livestock have unrestricted access throughout the season (Blanchet et al. 2003). A survey found this grazing system utilized by approximately ⅓ of Wisconsin cattle ranchers, but another 40% moved their cattle every 2 to 4 weeks (CIAS 2008). Continuously grazed pastures can produce various vegetation structures, depending on specific stocking rates. Vegetation can be low, medium, or high in height and erosion is often a problem with continuously grazed pastures, as the cattle will congregate in the same areas repeatedly (Undersander et al. 2002). This tramples the vegetation and often leaves bare ground that is not suitable habitat for wildlife. Other areas within a continuously grazed pasture may be less frequented by the cattle and become overrun with woody vegetation. Therefore, it is difficult to dictate the landscape outcomes when implementing a continuous grazing system.

Managed intensive rotational grazing (MIRG) is another type of grazing management. This is the system that the WDNR is focusing on when leasing public lands to graziers. MIRG is described as a system with many pastures, or paddocks, where livestock are moved from each paddock based on forage growth and utilization (Blanchet et al. 2003). Essentially, the herd is “rotated” between small paddocks within the entire pasture, to allow vegetation rest periods. By rotating cattle, managers have more flexibility in which areas are grazed and the structure of vegetation.

Buena Vista WA has leased parcels of land to graziers for many years in an effort to incorporate community members in the management of public grasslands. Until recently, all leased pastureland was continuously grazed. MIRG grazing began at Buiena Vista WA in the 2015 season. For both grazing systems, graziers sign a 2 to 5 year contract with WDNR that outlines goals prioritizing WDNR objectives without sacrificing cattle productivity. In this case, the WDNR’s goal is to use grazing as a conservation tool in supplement, or in place of, mowing, while the graziers’ goal is to have a profitable operation.

While the impacts of grazing public lands on bird communities has been extensively studied in the Western United States, it is less common in the Midwestern states because of the low percentage of Midwest public lands that are grasslands. The novelty of using grazing as a conservation practice on public lands in the Midwest begs the question, “How are bird communities responding?”

At Buena Vista WA, Greater-Prairie Chicken habitat management results in grasslands that can be used by other avian species such as Henslow’s Sparrow (*Ammodramus henslowii*), Grasshopper Sparrow (*Ammodramus savannarum*), and Bobolink (*Dolichonyx oryzivorus*). As a result, Buena Vista WA is designated as an Important Bird Area by the WDNR and is part of the

Central Wisconsin Grassland Conservation Area (CWGCA). Wisconsin has classified many grassland bird species as "special concern" and management efforts are focused on these species' sustainability. Grassland bird species can be sensitive to woody brush density, as well as vegetation height when selecting breeding habitat (Sample & Mossman 1997). Each species prefers a different vegetation structure. For example, Henslow's Sparrows prefer higher grass height-densities with a deeper litter layer (Sample & Mossman 1997; Herkert 1994; Jacobs et al. 2012). Grasshopper Sparrows, on the other hand, prefer more disturbance, shorter grass height densities, and more bare ground (Sample & Mossman 1997; Hubbard et al. 2006). Since grazing management and intensity influences vegetation structure, grazing may be a useful tool for grassland bird conservation.

It is widely accepted that a diversity of grassland type habitats is necessary for grassland bird conservation as a whole (Sample & Mossman 1997; Ribic et al. 2009a; Jacobs et al. 2012). Cattle stocking rates on pastures largely dictate the vegetation structure of the site and therefore grassland bird usage. Overstocking generally leads to overgrazing, which in turn leads to less litter depth and more bare ground (Manley et al. 1997). While continuous grazing may have a notoriously bad reputation for overstocking, low to medium stocking rates may create suitable habitat for grassland birds. These lower stocked pastures have been found to have spatially different but temporally stable areas with both high and low livestock use (Ranellucci et al. 2012). Thus, the cattle create their own heterogeneity of habitat structure within the pasture. MIRG systems allow greater rest periods, but do not necessarily support more bird species than continuous pastures (Renfrew & Ribic 2001). However, MIRG may be a management practice that can be beneficial for avian species, if used correctly. It allows those involved (i.e. ranchers, managers, DNR) to dictate where cattle graze and thus directly dictate habitat structure outcomes. Temple et al. (1999) found that setting aside ungrazed “paddocks” as bird refuges within the MIRG pasture would be most beneficial for both grassland bird species and rancher goals.

Greater Prairie Chicken response to grazing is largely unstudied in the Midwest. Availability (or lack of) nesting and brood rearing habitat is the largest limiting factor for prairie chicken populations in Wisconsin (Hamerstrom et al. 1957). Prairie chickens have been found to choose leks in areas of high nesting and breeding potential (Schroeder & White 1993). Leks are generally found in areas with higher proportions of grasses, shrubs, and pastures (Niemuth 2000). However, a study on the Sheyenne National Grasslands found that Greater Prairie Chickens nested in areas without cattle, with an average of 10 inches of residual cover height (Eng et al. 1988). Early intensive grazing combined with spring burning left only a few centimeters of residual cover for prairie chickens by mid-July (Robbins et al. 2002). Thus, since grazing reduces residual cover, the most important habitat factor for prairie chickens, it is extremely important to understand how Greater Prairie Chickens utilize pastures at Buena Vista WA.

The goal of this study was to understand how grazing might be a tool for managing grasslands at Buena Vista WA. Because of the legacy of European settlement and current land use practices, large expanses of grasslands in the state are rare (Sample et al. 2003). Many wildlife species’ survival depends on having available grassland habitat. This study focused on avian species, particularly obligate grassland birds, which are of state management concern and/or threatened. Obligate grassland birds *require* grasslands for breeding. Thus, grassland management is the most important factor for these bird species’ survival.

This study was designed to inform the WDNR on their future management decisions when choosing which management strategy to incorporate in their plan. This report will provide information on how a particular practice, grazing, influences the avian community within the Buena Vista property. Our main study objectives were to:

1) Identify the grassland bird species using each management type (continuous grazing, MIRG, and ungrazed) at Buena Vista WA and relate bird use to vegetation structure.

2) Assess efficacy of a pilot procedure for determining Greater Prairie Chicken usage on grazed and ungrazed areas.

3) Characterize vegetation structure (i.e., vegetation height-density and litter) for each management types.

Methods

Study Area

The Buena Vista WA is located in southwestern Portage County, Wisconsin. The WDNR owns 3,157 ha (7,800 acres) and manages an additional 1,781 ha (4,400 acres) that are owned mainly by conservation organizations. Most of Buena Vista WA is grassland habitat, ranging from blocks of 16 to 809 ha (40 to 2,000 acres). Buena Vista WA is dominated by a mixture of warm- and cool-season grasses with scattered woodlands, and represents one of the most extensive grasslands east of the Mississippi River (WDNR 2015). Management techniques include controlled burns, haying, and mechanical brush removal. Some parcels are also leased for conventional agriculture, in addition to the pastures.

Prior to settlement, Buena Vista WA was mainly marsh habitat until the marsh was drained for agriculture in the early 1900s (Sample et al. 2003). Farming practices soon failed, mainly due to the sandy soils. Blue grass seed production then took over, where spring burns were used and cultivation occurred in August. Thus, the practice was largely compatible with Greater Prairie Chicken survival because it provided limited nest and brood disturbance, as well as ample nestling cover with residual grass litter. With the rise of industrial, irrigated agriculture, row crop farms replaced the sod farms across the landscape and the prairie chicken's survival became threatened (Sample et al. 2003). Nearly 5,665.6 ha (14,000 acres) were bought as a collaborative effort for prairie chicken conservation between WDNR and stakeholders, such as the Dane County Conservation League and Society of Tympanuchus Cupido. Today, the main objective for this land remains: to improve grasslands through rotational disturbance, for the survival of prairie chicken and other grassland dependent species.

This study focuses on pastures and comparable non-grazed parcels within Buena Vista WA. We used 9 different sites: 4 continuously grazed, 2 MIRG, and 3 ungrazed (Fig. 1). The pastures represent all current grazing leases in the 2016 season. The ungrazed parcels were chosen in consultation with the WDNR to be comparable habitat to the grazed areas.

All sites were dominated by various cool-season grass species, such as smooth brome (*Bromus inermis*) and Kentucky bluegrass (*Poa pratensis*). The most common forbs were Canada goldenrod (*Solidago canadensis*) and thistles (tribe Cynareae). Remnants of marsh vegetation such as sedges (family Cyperaceae) were present on some of the sites. Woody vegetation and shrubs also occurred primarily on the ungrazed sites and often in patches.

Weather for the overall field season (May 2016 – August 2016) was slightly hotter with more precipitation than normal for the Stevens Point, Wisconsin area. Normal weather data are monthly averages from 1981 to 2010, computed by the National Centers for Environmental Information. All weather data was retrieved from the Midwestern Regional Climate Center. In May 2016, the average maximum temperature was 67.6°F (Fahrenheit; 19.8°C) and the minimum average was 45.9°F (7.7°C), which were both 1°F below normal. May precipitation was 2.6 inches (in; 6.6 centimeters, cm) and 1.2 in (3.0 cm) less than normal. June 2016 brought the most precipitation (6.5 in, 16.5 cm), which was 2.1 in (5.3 cm) above normal. The June maximum and minimum temperatures were 76.3°F (24.6°C) and 56.4°F (13.6°C), approximately 1°F above normal. In July 2016, precipitation was 4.9 in (12.4 cm) and 1 in (2.5 cm) above normal. Meanwhile, average maximum July temperature was near normal at 79.7°F (26.5°C) and minimum temperature was 61.3°F (16.3°C), which was 1.6°F above normal. August 2016 temperatures showed the greatest differences from normal, with the average maximum temperature at 79.3°F (26.3°C) and 1.5°F above normal. The average minimum temperature was 61.4°F (16.3°C) and 3.6°F above normal. August precipitation varied only slightly from the region's normal (0.2 in, 0.5 cm less), with a total of 3.7 in (9.4 cm). Total precipitation during the field season was roughly 17.8 in (45.2 cm), which is higher than normal (16 in, 40.6 cm.). Generally, the 2016 field season provided good growing conditions for the Buena Vista WA in comparison to past averages.

Field Methods

Passerine Surveys

Point counts were used to determine passerine species abundance. We followed the survey protocol developed by a previous Grassland Bird Conservation Area project. Passerine surveys were conducted in 4 rounds, between 15 May 2016 and 30 June 2016, to account for the various species peak breeding activity. To reduce observer variability, technicians were trained and tested for all protocols. They were also trained in grassland bird identification (by sight and sound), using material developed by a previous Grassland Bird Conservation Area (GBCA) project.

All survey plots were 100-m radius and at least 50 m from an edge of the public parcel (Fig. 1). The center of the survey plots were placed at random with the restriction that adjacent survey centers had to be at least 400 m apart to reduce double-counting birds. Surveys began as early as 30 min before sunrise and ended no later than 4 h after sunrise. Each survey was 10 min long, with data collected in five 2-min intervals. This allowed us to account for detectability in our analyses.

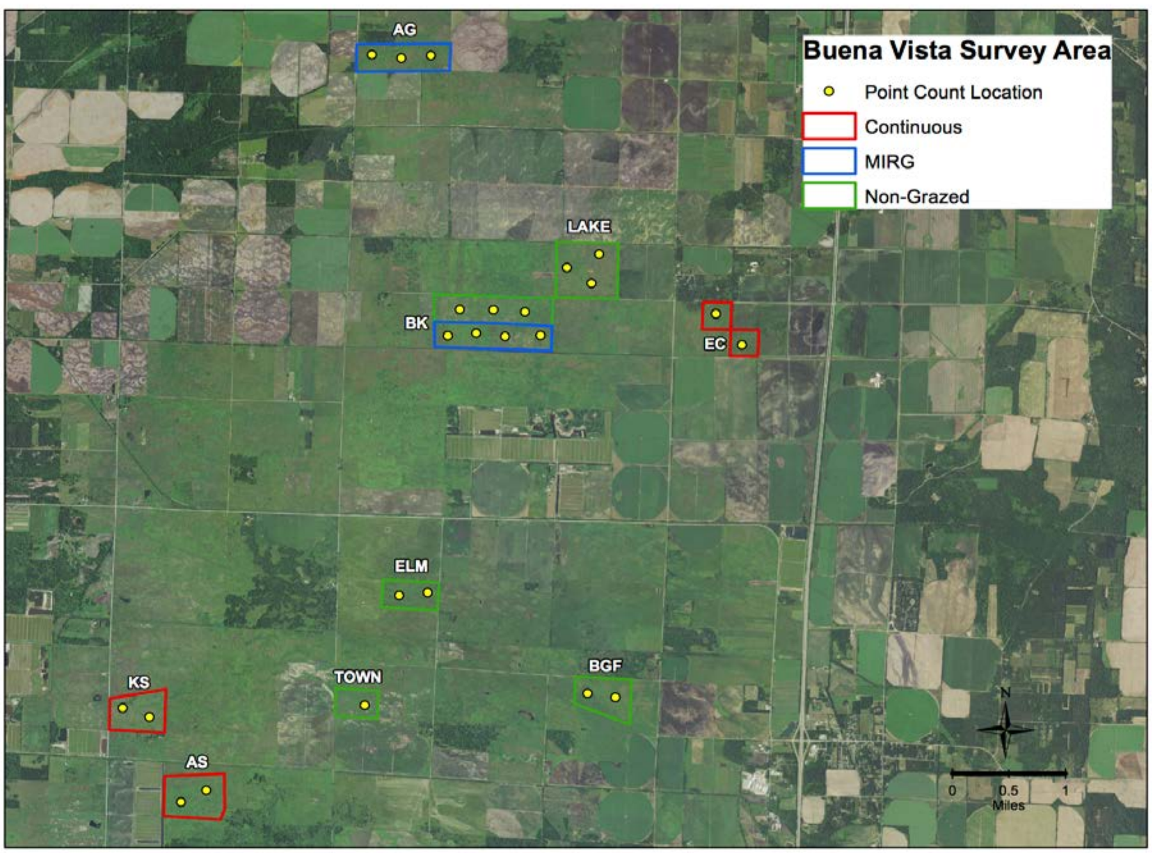

Figure 1: Point count locations within the study sites at Buena Vista Wildlife Area

After consultation with the WDNR, we focused on 10 species of interest for point-count surveys, 8 grassland obligate species and 2 shrub-dependent species. Henslow's Sparrow, Grasshopper Sparrow, Eastern Meadowlark (*Sturnella magna*), Western Meadowlark (*Sturnella neglecta*), Bobolink, Vesper Sparrow (*Pooecetes gramineus*), Horned Lark (*Eremophila alpestris*) and Savannah Sparrow (*Passerculus sandwichensis*) were the obligate grassland bird species (Sample and Mossman 1997). The 2 shrub-dependent specieswere Brewer's Blackbird (*Euphagus cyanocephalus*) and Clay-Colored Sparrow (*Spizella pallida*). These shrub-dependent species were of interest to the WDNR managers because their presence (or lack thereof) could provide insight to how effective grazing has been in reducing woody vegetation. All of the focal species were recorded if they were seen or heard within the survey plots. Other avian species present on the sites during surveys were noted. These species include Northern Harrier (*Circus cyaneau*), Upland Sandpiper (*Bartramia longicauda*), Greater Prairie-Chicken (*Tympanuchus cupido)*, and Sandhill Crane (*Grus canadensis*).

Observers recorded background data before each point count survey. Temperature (Fahrenheit) and percentage of cloud cover were recorded. Precipitation was noted as fog, light rain, or heavy rain, if present. Wind speed was recorded on a 1 to 5 scale, ranging from 0 to 25 miles per hour (mph). Background noise was also documented on a scale: 0= no noise, 1= faint noise, 2= moderate noise, 3= loud noise, and 4=intense noise. Background noise included outside factors, such as highways and machinery, as well as bird songs if they were hindering the detection of other birds. Number of cattle (adults and calves) and distance (m) of the herd from the survey point center were noted for pastures.

Observers recorded the management type as grazed or ungrazed. We further broke this down into grazing type: continuous, MIRG, or ungrazed. These classifications were determined at the time of the survey, and not generalized by site. We chose this method because some sites did not have pastured cattle until round 2. All survey plots within continuously grazed sites were always documented as grazed if cattle were present, since it was too difficult for surveyors to determine whether cattle had directly grazed within the survey plot or not. MIRG sites, on the other hand, could have had some survey plots that were grazed and others that were ungrazed if cattle had not been rotated into the area yet. This observation would allow us to analyze specific species usage differences within pastures.

Greater Prairie Chicken Surveys

A pilot procedure was developed to assess greater prairie chicken usage on the different management types. We modified a line-transect and spot-mapping method to best suit our goals. Greater Prairie Chicken surveys were conducted between 25 July 2016 and 23 August 2016, in 3 separate rounds. This time frame was chosen to achieve maximum sighting possibility, because Greater Prairie Chicken broods would be more mobile (E. Grossman, WDNR, pers. comm.).

Because this was a pilot, only one site per management type was surveyed. That is, one continuously grazed, one MIRG, and one ungrazed site were surveyed for all rounds. In rounds 1 and 2, we also surveyed another MIRG site. We used ArcMap to establish transects 25 m apart, with start and end points on the edges of each site. Sites were walked north-south, except site AG which was walked east-west. These directions were chosen to establish multiple short transects rather than few long ones. After initially surveying at 50 m apart, we determined that 25 m would remove excess space in between observers. Ensuring that transects were close together was vital because prairie chickens would not flush and could be missed. Closer distances were not used due to time and labor constraints. For each survey, there were between 4 and 8 surveyors. The surveyors walked transects, from one end of the pasture to the other. We essentially “swept” the entire site, in hopes of flushing a prairie chicken. When a Greater Prairie Chicken was located, the GPS coordinates of its exact location were noted. We also attempted to evaluate whether the bird was an adult or juvenile, and if multiple birds were a possible brood.

Vegetation Surveys

Vegetation measurement procedures were the same for both passerine and Greater Prairie Chicken surveys. Vegetation height density in decimeters (dm) and litter depth in centimeters (cm) were measured, since research has shown that grassland birds respond to these two vegetation characteristics (Ribic et al. 2009a). Vegetation height density was measured using a Robel pole. The reading of the pole was taken as the last band visible from a distance of 4 m away, at a height of 1 m (Robel et al. 1970). Litter depth was measured using a standard metric ruler, from the ground to the top of the residual litter. For the passerine surveys, both litter depth and vegetation height density were measured at the center of the survey plot (i.e., the exact location of the point-count). We then took an additional 3 measurements at random locations within the point count radius, measuring both vegetation height density and litter depth again. This resulted in a total of 4 measurements per point count survey, for litter depth and vegetation height density. The vegetation was surveyed within one week of each point-count survey round.

Vegetation for Greater Prairie Chicken surveys was recorded at each bird sighting location, using the same methods for height density and litter depth. These were taken within one week of the survey round. We also obtained vegetation measurements at each of the previous point count locations. For example, after Greater Prairie Chicken survey round 1, we would measure vegetation height-density and litter depth at all 7 point-count locations within the BK site. Again, an initial measurement at the point count location plus 3 random locations within the radius was taken for a total of 4 readings. This allows us to temporally match where the Greater Prairie Chicken was found in relation to vegetation structure available throughout the rest of the site.

Data Analysis

Site classification

Cattle presence on each site was not consistent across all rounds. Ranchers were able to choose when to put herds on the land. Therefore, we classified sites as "grazed" if there were cattle present during the time of the survey and "ungrazed" if they were not present. Site KS was classified as ungrazed for survey round 1 and 2, and grazed thereafter. Site BGF was classified as ungrazed across all rounds, as cattle were not placed on the pasture until after all point count surveys. A table in Appendix 1 shows during which round cattle appeared on each site.

Site BK was split into 2 different sites (BK: Grazed and BK: Ungrazed) for rounds 2, 3, and 4. Since this site was large and managed with MIRG, it was easy to see that the cattle never grazed survey points BK_2, BK_3, and BK_4 (North section) throughout the entire field season. Thus, these points are categorized into the "BK: Ungrazed" site and the remaining points are included in "BK: Grazed." Since it was a MIRG site, some point count locations in BK: Grazed were not grazed until the later survey rounds. However, we still classified the entire South section as "grazed". Site BK as a whole was left as ungrazed for round 1, since the cattle had not been put out on the pasture. Therefore, passerine survey analysis contained 9 sites in round 1 and 10 sites in rounds 2-4. For Greater Prairie Chicken survey rounds, BK was one single site because it had been entirely grazed by the time of these surveys. We used site BK as a natural experiment within our study for an indication of how bird species abundance is affected by cattle presence.

Passerine Surveys

We wanted to understand whether bird species were consistently found on different grazing types across our 4 survey rounds. For each round, we counted a species as present on individual sites if at least one bird was detected during any of the point count surveys. For example, if 1 Savannah Sparrow was recorded at point BK_1 during round 1, then Savannah Sparrows would be considered present on site BK for round 1, regardless of observations during other point count surveys. This allows us to look at site level usage. We then added the total number of times for all surveys that species were present at each site, according to grazing type. The total number of times a species could have been present on each grazing type was 10 for continuous, 7 for MIRG, and 22 for ungrazed. This comes to a grand total of 39 potential presences for the field season. We then divided the total presence by the total possible for each grazing type and species. This resulted in a proportion of times each species was present at each grazing type across the field season, ranging from 0 to 1. A proportion of 1 means the species was present at those sites for every round, and a proportion of 0 means they were never documented.

Probability of detection was modeled in relation to site-level variables (wind, date, time, temperature, and noise) while holding the abundance component of the hierarchical model constant. Data from all 4 surveys were used for this initial step of the analysis. Models were ranked using Akaike Information Criterion (AIC; Burnham and Anderson 2002). The detectability model was chosen from the minimum AIC model and competing models (those within 2 AIC units of the minimum model). The model with the fewest variables within that set was chosen as the detection model.

To determine adjusted abundances for each point count, we used the chosen detectability model for an individual species. We applied the adjustment to all survey rounds, for each species. These adjusted abundances were used to calculate densities per species (birds/ha) for each point count survey plot. Densities were then averaged across sites in order to obtain per round site-level density estimates. We then used these density estimates, across all rounds, to get an average density overall for MIRG, continuous, and ungrazed sites. This helps us understand general species patterns according to grazing type. This also compliments our site-level proportion data.

For further analysis, we used the round with the most birds for each species (Appendix 2). This turned out to be round 1 for Bobolink, Clay-Colored Sparrow, and Grasshopper Sparrow. Round 2 was used for Henslow's Sparrow and round 3 was used for Brewer's Blackbird, Eastern Meadowlark, and Vesper Sparrow. Only Savannah Sparrow was found most often in round 4. We used the R program for all statistical analysis.

Finally, to assess possible relationships between bird abundance and explanatory variables of vegetation structure and management, we used linear models ("lm" function) for each bird species. We used the site level density estimates for each species and only analyzed the round that had the most birds, as previously mentioned. Thus, for each species analysis, there were 9 or 10 data points for the linear model. Because bird densities at the site level are averages, by the Central Limit Theorem, the averages follow a Gaussian distribution and we did not transform our data.

We included explanatory variables that could potentially determine whether bird species were affected by management type or the vegetation structure resulting from the management. That is, do avian species respond directly to grazing or indirectly, based on vegetation structure? The variables included in the linear models were vegetation height density (dm), litter depth (cm), management type (grazed or ungrazed), grazing type (rotational, MIRG, or ungrazed), and log(site area (ha)). We used site area because some grassland bird species are area-sensitive and use larger sites preferentially over smaller sites (Ribic et al. 2009b) and our sites ranged widely in size (24.8 to 128.7 ha). Cattle distance was not included, as we determined that it played more of a role in the noise level, which was used in our detectability adjustments.

Relationships were determined significant using a 95% confidence level ($p<0.05$). Since our sample size was small, we also noted variables on a 90% confidence level ($p<0.10$) and considered these as trends that may possibly play a role in bird species abundance. We also ranked all the models using AIC_c (AIC corrected for small sample size).

To determine whether bird species reacted directly to cattle presence, we used the adjusted abundances for each point count survey plot at BK (Appendix 4). We considered the 4 most abundant species on this site: Bobolink, Clay-Colored Sparrow, Grasshopper Sparrow, and Savannah Sparrow. We then used ArcMap to plot species abundances within the survey plot, with each point being one individual. For example, if the adjusted abundance for bobolinks at BK_2 was 4.8, it was rounded to 5, and 5 individual points were plotted randomly within the survey plot. Each point does not depict exact bird locations, but rather allows us to graphically evaluate where birds may have moved when cattle came onto the site. We also noted on the map whether the specific survey plot had been grazed or not for each survey round.

Greater Prairie Chicken Surveys

The locations of flushed birds were mapped using ArcMap to visually evaluate where Greater Prairie Chickens were found. Because birds were not marked, we assumed that birds seen on the same site across the surveys were different birds. For each site, we calculated a sighting density (prairie chickens seen/ha) for each survey. We then averaged the sighting densities by site to give us an average density (birds/ha) for each management type. We ran t-tests using the R program to determine whether litter depth (cm) and vegetation height density (dm) were different between prairie chicken locations and random site vegetation points for each site. We used a 95% significance level ($p<0.05$) to evaluate possible differences and determine whether prairie chickens were using vegetation similar to available vegetation on the site.

Vegetation Surveys

For both vegetation height density and litter depth, we averaged the 4 measurements (center point and 3 random) to achieve an overall measurement per survey. We used these single averages for further analysis.

To understand the impact of grazing on vegetation structure, we used boxplots to plot the measurements by survey round for ungrazed and grazed sites. All plots were created using the same scale for the individual vegetation metric so comparisons of vegetation height density or litter depth among ungrazed and grazed sites could be done visually. The summary statistics for vegetation height density and litter depth for grazed and ungrazed sites can be found in Appendix 3, according to survey round.

Results

Grassland Bird Density

Observations at each grazing type varied greatly among species (Table 1). Savannah Sparrows were the only grassland bird species recorded on all grazing types (continuous, MIRG, and ungrazed). They were recorded at least once at every site, during every round (total proportion = 1.0). Clay-Colored Sparrow had a high proportion for MIRG and ungrazed sites (1.0), but a slightly lower proportion for continuously grazed sites (0.80). Grasshopper Sparrows had a proportion of 1.0 only on MIRG sites. Henslow's Sparrow was only recorded on ungrazed sites (0.55 proportion) and Western Meadowlark was never found on continuously grazed sites. Horned Lark was entirely absent from surveys and is thus excluded from all further analysis.

Species	Continuous (n=10)	MIRG (n=7)	Ungrazed (n=22)	Total (n=39)
Savannah Sparrow	1.00	1.00	1.00	1.00
Clay-Colored Sparrow	0.80	1.00	1.00	0.95
Bobolink	0.80	0.43	0.86	0.77
Grasshopper Sparrow	0.50	1.00	0.45	0.56
Eastern Meadowlark	0.30	0.14	0.50	0.38
Vesper Sparrow	0.50	0.43	0.23	0.33
Henslow's Sparrow	0.00	0.00	0.55	0.31
Brewer's Blackbird	0.10	0.43	0.14	0.18
Western Meadowlark	0.00	0.29	0.18	0.15
Horned Lark	0.00	0.00	0.00	0.00

Table 1: Proportion of species presence on study sites, according to grazing type

Species with proportions of 1.0 from above generally had higher densities at these given grazing types (Fig. 2). For example, Clay Colored Sparrow had the highest density for ungrazed sites (0.92 birds/ha, SE = 0.08), Savannah Sparrow had the highest for continuously grazed areas

(0.92 birds/ha, SE = 0.08) and Grasshopper Sparrow had the highest average for MIRG sites (0.88 bird/ha, SE = 0.09) (Fig. 3). All of these species also had a proportion of 1.0 for site surveys on these grazing types (Table 1). While Clay-Colored Sparrows were found during every survey on MIRG and continuous sites, their densities were higher for ungrazed and lower for MIRG. Bobolinks had the highest densities on ungrazed sites (0.79 birds/ha, SE = 0.10) followed by continuously grazed sites (0.56 birds/ha, SE = 0.14) and MIRG (0.19 birds/ha, SE = 0.10).

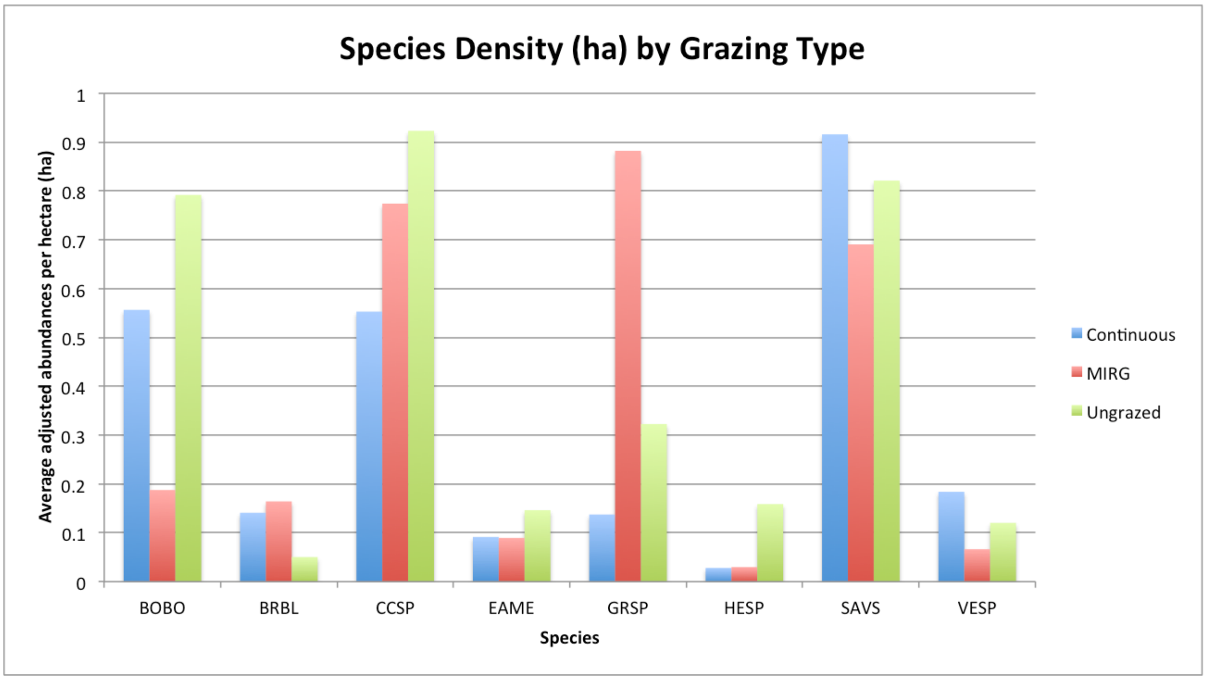

Figure 2: Adjusted bird densities (in hectares) based on grazing type

Bird density in relation to management and vegetation structure

Of the 10 species of interest, only Henslow's Sparrow density varied by management type. Specifically, they were never detected on any grazed site. Henslow's Sparrow significantly preferred ungrazed sites, according to both management type (coefficient = 0.224, SE = 0.067, p = 0.01) and grazing type (coefficient = 0.227, SE = 0.091, p = 0.04).

Of the 10 species of interest, only Bobolink and Brewer's Blackbird densities varied by vegetation structure. Bobolinks had a tendency to prefer sites with deeper litter (coefficient = 0.083, SE = 0.041, p = 0.08). Bobolinks were primarily found on sites that had litter depths between 1.67 cm and 7.12 cm. The range of litter depths available to Bobolinks during round 1 was between 0.30 cm and 14.18 cm. Conversely, Brewer's Blackbird was found on sites with shallower litter (coefficient = -0.151, SE = 0.074, p = 0.08). They were mainly found on sites with litter depths between 1.34 cm and 3.96 cm. The highest density of Brewer's Blackbirds during round 3 occurred on the site with the minimum available litter depth of 0.47 cm while the maximum litter depth available was 4.86 cm.

Effect of cattle on the spatial distribution of passerines

On site BK, adjusted bird abundances were highest in Round 1 and lowest in Round 3. A complete breakdown of species abundances at site BK can be seen in Appendix 4. Figures 3-6 illustrate those abundances of individual birds within site BK. When cattle grazed a point count area, bird abundances often dropped noticeably. Ungrazed points stayed relatively constant for total abundances, but varied by species.

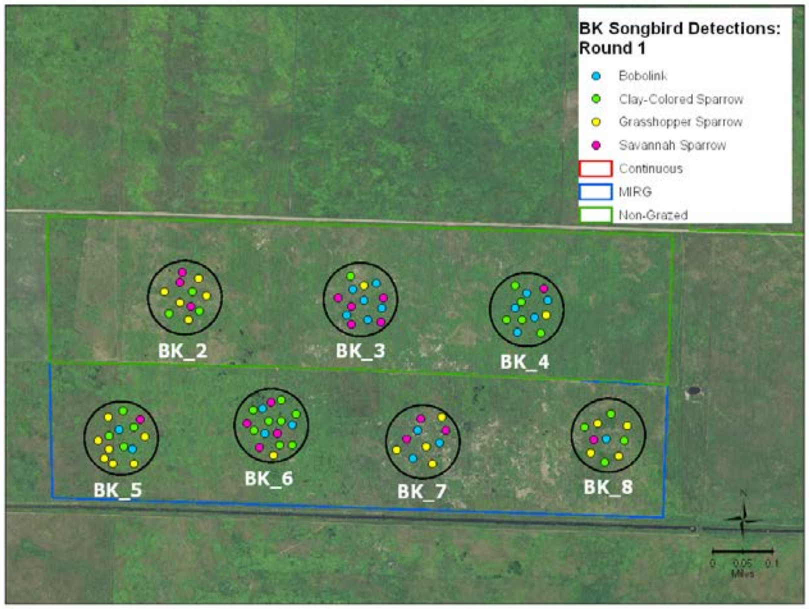

Figure 3: Species observations on site BK during round 1. Black circles are ungrazed survey plots and white circles are grazed

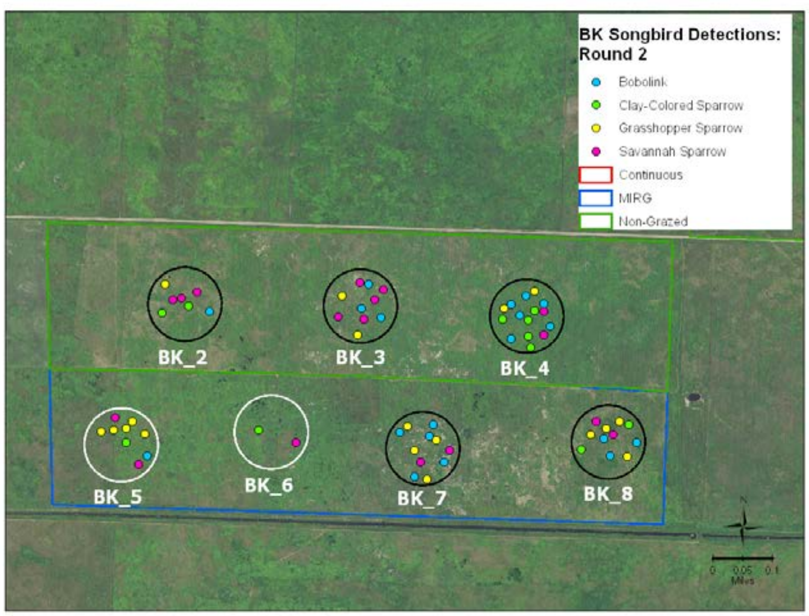

Figure 4: Species observations on site BK during round 2. Black circles are ungrazed survey plots and white circles are grazed

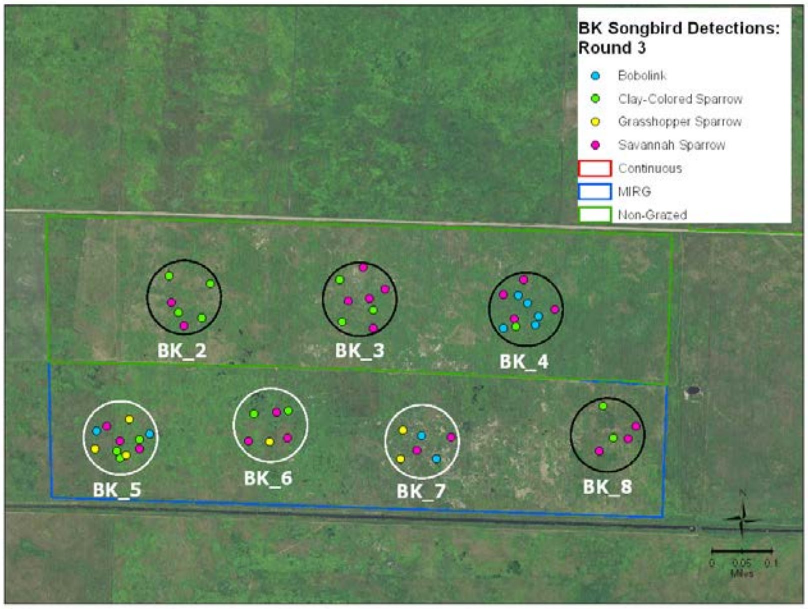

Figure 5: Species observations on site BK during round 3. Black circles are ungrazed survey plots and white circles are grazed

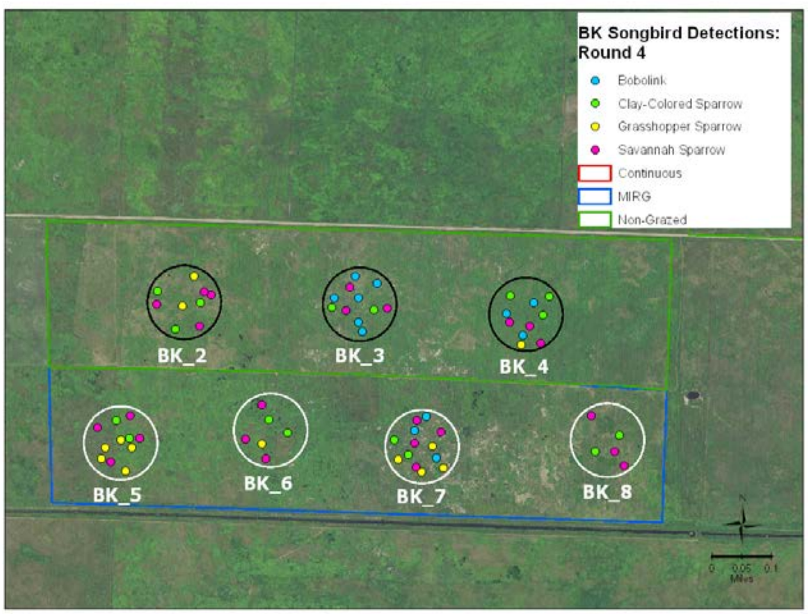

Figure 6: Species observations on site BK during round 4. Black circles are ungrazed survey plots and white circles are grazed

Greater Prairie Chicken in relation to management

Greater Prairie Chickens were detected only on MIRG and ungrazed sites (Fig. 7). They were never found on the continuously grazed area (site EC).

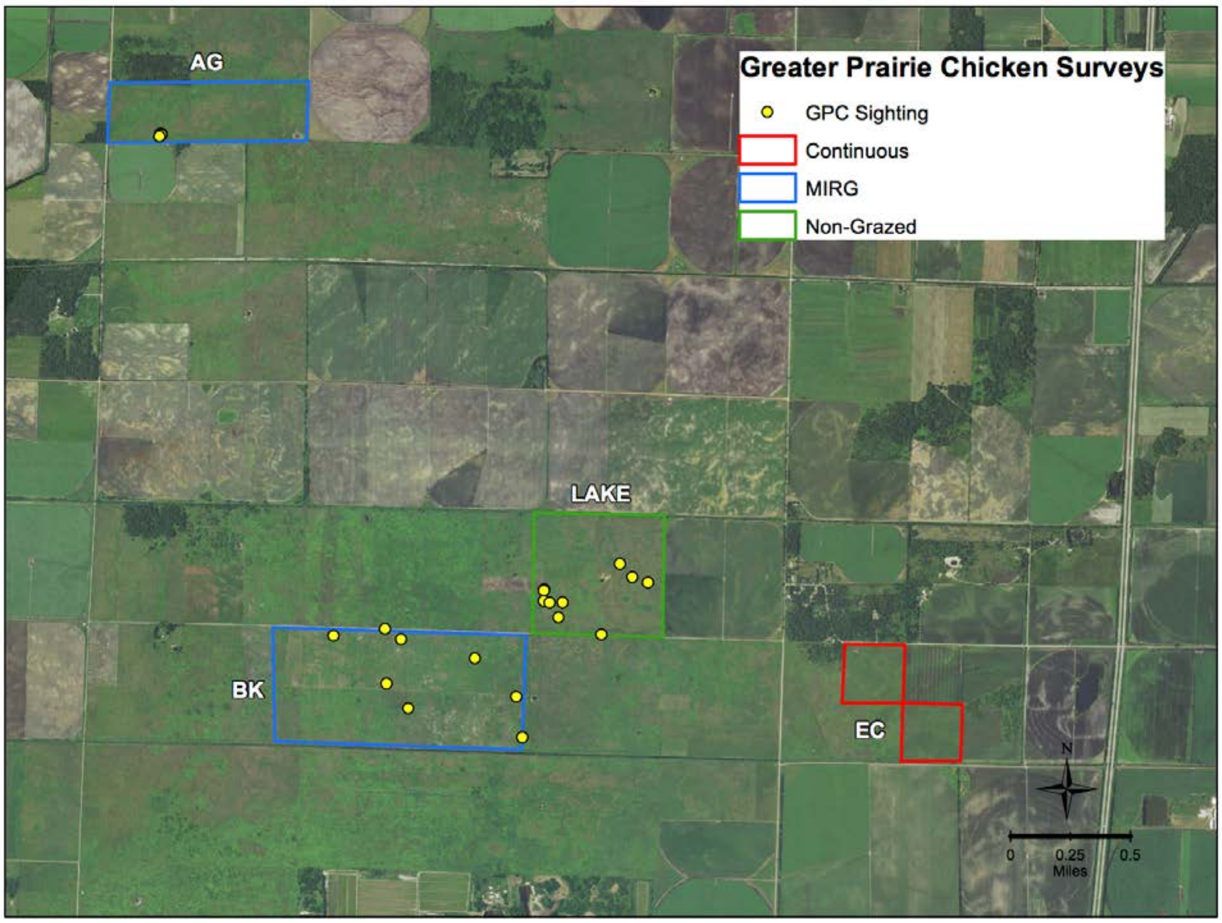

Figure 7: Greater Prairie Chicken sighting (>1 bird) locations for all survey rounds

Across all rounds, we found the most prairie chickens at site BK (18), followed by Lake (13), and AG (7) (Table 2). Site AG site had an average of 0.065 birds/ha (SE = 0.065), Lake had an average of 0.066 birds/ha (SE = 0.013) and BK averaged 0.047 birds/ha (SE = 0.012). It is important to note that site AG was only surveyed during rounds 1 and 2, with birds only found during round 1.

Site Name	Site Area (ha)	Grazing Type	Round 1	Round 2	Round 3	Total	Average Density
Lake	66.03	Ungrazed	4	3	6	18	0.066
AG	53.56	MIRG	7	0	X	13	0.065
BK	128.7	MIRG	7	8	3	7	0.047
EC	31.41	Continuous	0	0	0	0	0.000

Table 2: Number of Greater Prairie Chickens (individual birds) observed during surveys, according to site and round. X = site not surveyed

There was no difference between litter depth or vegetation height density of where the prairie chickens were found and available vegetation on site BK (litter depth: t = 1.40, df = 9.02, p = 0.19; vegetation height density: t = -0.16, df = 11.14, p = 0.8). Prairie chickens on the BK site were found on an average litter depth of 1.6 cm (SE = 0.5, n = 8) and average height density of 1.2 dm (SE = 0.3, n =8). Overall, the BK site had an average litter depth of 0.9 cm (SE = 0.2, n = 20) and height density of 1.3 dm (SE = 0.2, n = 20). The Lake site showed a similar pattern for litter depth between the site and where prairie chickens were found (t = -0.80, df = 16.76, p = 0.43). However, there was a tendency for prairie chickens on the Lake site to be found in areas with lower vegetation height density (t = -1.87, df = 14.29, p = 0.08). Prairie chickens on the Lake site were found on an average litter depth of 2.5 cm (SE = 0.8, n = 10) and an average height density of 1.0 dm (SE = 0.2, n = 10). Vegetation on the Lake site had an average litter depth of 3.4 cm (SE = 0.67, n = 9) and an average height density of 1.45 dm (SE = 0.12, n = 9). Site AG was similar to site BK with no differences for litter depth (t = 0.05, df = 5, p = 0.96) and vegetation height density (t = 0.89, df = 4.74, p = 0.42).

Vegetation Structure

Sites that were ungrazed at the time of the bird surveys had higher litter depths throughout all 4 survey rounds. Appendix 3 contains a summary of vegetation statistics by site. Figure 10 depicts the average litter depths for grazed and ungrazed sites, according to survey round. Grazed sites generally started at much lower litter depths than the ungrazed sites (Fig. 8). They then decreased over time and became less variable on average. On the other hand, the ungrazed sites stayed relatively the same across all 4 rounds. The maximum litter depth recorded on grazed sites was 5.37 cm (site AG, round 1) and the minimum was 0.05 (site KS, round 4). For ungrazed sites, the maximum litter depth recorded was 15.15 cm (site BGF, round 1) and the minimum was 0.55 cm (site Lake, round 4).

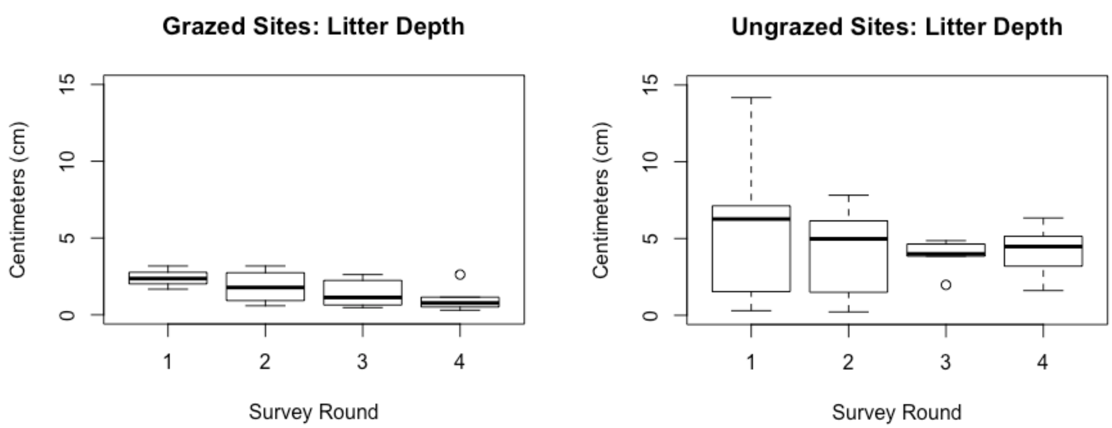

Figure 8. Distribution of average litter depth for grazed and ungrazed sites, across all 4 survey rounds

Vegetation height densities, according to site averages, were also higher on ungrazed sites (Fig. 9). For both grazed and ungrazed sites, there was generally an increase in height density between rounds 1 and 2, due to the grass-growing season. As the season progressed, vegetation height density increased more rapidly on ungrazed sites than the grazed sites, particularly between rounds 2 and 3. Round 4 sees a leveling off or slight decrease in height densities for both grazed and ungrazed sites.

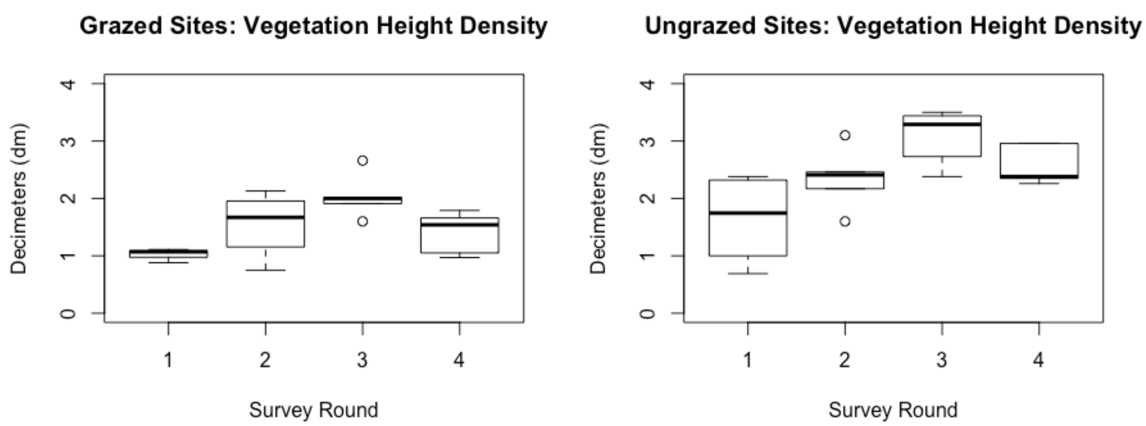

Figure 9. Distribution of average vegetation height density for grazed and ungrazed sites, across all 4 survey rounds

While the previous figures show patterns across sites, similar patterns are illustrated within pasture on site BK (Fig. 10). The southern section of site BK was grazed after the first survey round. The vegetation height density on the ungrazed section of site BK increased across rounds 1 to 3 with the increase slowing between rounds 3 and 4. The pattern of vegetation height density on the grazed section of site BK is different from the ungrazed section, with a smaller increase in rounds 2 and 3 and a decrease in round 4. The maximum average vegetation height density for BK: ungrazed was 3.75 dm (round 3) while the grazed section had a maximum average height density of 3.19 dm (round 2).

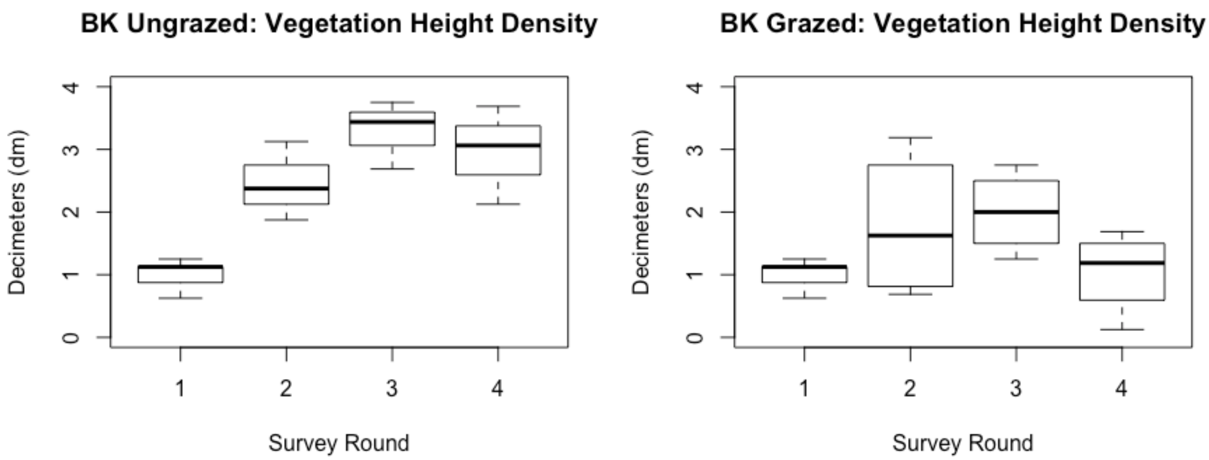

Figure 10. Vegetation height density for the ungrazed and grazed sections of site BK, across all survey rounds. Survey round 1 is ungrazed for both sections and added as reference on the grazed plot.

Discussion

Grassland Birds

We found that most of the focal grassland birds we studied used all of the sites on Buena Vista WA regardless of management. However, the complete absence of Horned Lark indicates that there is little bare ground among the sites. Brewer's Blackbird was not very common on our study sites. Brewer's Blackbird requires woody vegetation for nesting or perching (Sample & Mossman 1997), habitat not readily available on our sites. While we found that Brewer's Blackbird may prefer lower litter depths, those results may be largely driven by one survey where we found a high number of birds on a grazed site with low litter depth.

We found that Clay-Colored Sparrows were relatively abundant on our study sites. This species also requires some woody vegetation and is considered more of a shrub-bird than forest-bird (Sample & Mossman 1997). Clay-Colored Sparrows were most abundant on study sites that were overrun with brush. Particularly, the Lake site (an ungrazed site) was dominated by large shrubs on at least half of the study area. The large presence of Clay-Colored Sparrows on ungrazed areas rather than grazed pastures suggests that the intended goal to reduce brush by utilizing grazing may be effective. However, Clay-Colored Sparrows had higher averages per hectare on MIRG sites versus continuous grazing sites, suggesting that continuous grazing may be more effective at eliminating brush. Because we did not focus on the brush component of sites, further research on brush densities, grazing, and birds would need to be done.

The most common species on the sites was Savannah Sparrow. This was not unusual since Savannah Sparrows are known to occur at higher densities in pastures compared to other grassy habitats (Ribic et al. 2009a). They have been found at similar densities in MIRG and continuously grazed pastures in southwest Wisconsin (Renfrew & Ribic 2001), but have been found to be more abundant on MIRG locations in southwest Manitoba, Canada (Ranellucci et al. 2012). Our study found a higher Savannah Sparrow density on continuous pastures compared to MIRG. A lack of available MIRG pastures in our study may account for this difference.

Henslow's Sparrow was the only species that appeared to avoid grazed sites. Because our grazed sites had very little litter compared to the ungrazed sites, this was not surprising. Henslow's Sparrows require a well-developed litter layer for nesting (Herkert et al. 2002), conditions not found on grazed sites.

Bobolinks were detected most often on ungrazed sites, which was expected. Past research has shown that Bobolinks prefer higher litter depths and vegetation height density (Dechant et al.

1999 (revised 2001)). We found that Bobolinks tended to prefer sites with higher litter depths, which is consistent with past research. Oddly, Bobolinks were detected more often on continuously grazed sites than MIRG sites. This was mainly caused by their presence on one specific site. This site was naturally “split” into two square fields, connected only by one corner. In the early rounds (1-2), observers noticed that cattle had barely grazed the southern portion of this site and litter depth was often higher. This is where most Bobolink detections on continuously grazed sites occurred.

Overall, the importance of vegetation structure (litter depth) in our study indicates that, while management type and cattle presence may be a factor in bird species abundance, the resulting vegetation structure *caused* by the management is more relevant. This aligns with previous research documenting grassland birds’ sensitivity toward vegetation structure (Renfrew & Ribic 2001; Sample & Mossman 1997).

Bird species detections for the BK site illustrate what effect cattle presence may have on species abundance. While this portion of our study was a natural experiment, it illustrates possible trends of decreasing bird abundance with increasing cattle presence. More importantly, it exemplifies the direct decrease of species immediately after cattle are pastured. This can be extremely important in future management decisions, when deciding when and where to place cattle within a certain site.

Greater Prairie Chicken

Greater Prairie Chickens were not seen very often overall. They were more common on the ungrazed site, which could be attributed to variables such as the absence of cattle and fewer human disturbances. Even with low averages, our study suggests that prairie chickens do use the pasture areas, although, it is unknown as to what extent and purpose that use may be. We know that our ungrazed sites had higher vegetation height density overall and this may indicate that prairie chickens are choosing areas with lower height densities. Plus, we found a trend for prairie chickens to use lower vegetation height densities on the ungrazed site. Our results are consistent with past research showing Greater Prairie Chicken preference toward mid-range litter depths and height densities (Niemuth 2000; Eng et al. 1988). Most importantly, Greater Prairie Chicken habitat depends on residual cover. Eng et al. (1988) suggest having 15-50 cm of residual grass cover height within 1.6 km of a lek for sufficient prairie chicken habitat. We specifically did our study after the Greater Prairie Chicken nesting season, while most studies are conducting during the lekking and/or nesting season. It would be most helpful, for population success, to understand how cattle affect prairie chicken nesting and survival rates. Cattle at the Buena Vista WA were not present until after nesting season (approx. April-May), thus leaving the cattle's effect on breeding and survival unknown. A designed study to investigate prairie chicken use of pastures throughout the species' breeding season would be warranted.

The pilot procedure method for prairie chicken surveys had mixed results. While we did end up flushing some birds, prairie chickens are a typical Galliform which avoid detection by hunkering down and not moving until the threat (e.g., surveyors) are extremely close. This makes transect surveys likely prone to error when humans are doing the searching, since it is possible that other prairie chickens simply sat unnoticed in between transects and/or ran when approached and were never spotted. We believe that this time in August, when broods were more mobile, did give us the best chance to flush birds given our constraints. We suggest that upland bird hunting dogs would be the most effective at flushing prairie chickens, if this method were to be utilized in the future. Otherwise, more surveyors would need to be used with closer transects (10-15 m apart) to mitigate false absences. However, our pilot study was successful in that it gave us some indication of what areas prairie chickens may be using at Buena Vista WA.

Grazing and Site Vegetation Structure

In our study, litter depth started much lower on grazed sites than the ungrazed counterparts. Previous studies have shown that grazing decreases litter depth, due to cattle trampling (Naeth et al. 1991). In our study, litter depth stayed generally the same for grazed sites, with slight increases over time. While ungrazed sites were expected to show increases in litter depth, our survey rounds showed a slight decrease or litter depths staying relatively similar. This may be because the ungrazed sites were very diverse in their vegetation structure. Since the sites were essentially unmanaged, some areas were completely overrun with brush and had little to no litter depth while others had large amounts of litter. This may be effective at attracting multiple bird species, but without disturbance, the site will most likely be overtaken by brush.

Conclusions & Management Considerations

Grassland bird abundance at Buena Vista WA, and the survival of the Greater Prairie Chicken, will largely depend on vegetation structure. Grazing has been implemented for many years, but MIRG has been a recent choice to better control brush encroachment. Management of woody vegetation could improve habitat quality for grassland birds of Wisconsin (Sample & Mossman 1997). Our study suggests that continuous grazing may be more effective at removing woody vegetation, based on the presence of Clay-Colored Sparrows. However, the use of MIRG gives wildlife managers more flexibility to manage disturbance on large sites. Providing habitat diversity throughout Buena Vista WA, as well as the surrounding areas, will be crucial in conserving grassland birds.

Buena Vista WA encompasses a wide variety of habitats and offers sanctuary to many different grassland bird species. The area is particularly unique, being the home to the only population of Greater Prairie Chickens in Wisconsin. This fact alone makes management complicated, as efforts are focused on prairie chicken habitat needs first. Although our prairie chicken survey was strictly a pilot procedure, we found prairie chickens at higher averages on the MIRG site than the continuously grazed sites. While ungrazed and undisturbed lands may be required for Greater Prairie Chicken nesting, scattered parcels of MIRG pastures may provide other beneficial habitat, such as feeding areas.

Based on our study, we suggest scattering MIRG pastures throughout Buena Vista WA, while keeping the current number of continuously grazed pastures. We also suggest that the future MIRG management be modeled after the BK pasture, where one entire parcel is ungrazed. In this modified rest rotation system, a paddock within a pasture would be left ungrazed throughout the entire year to provide maximum bird conservation but allowing grazier's use of the rest of the site (Hormay & Talbot 1961, Temple et al. 2009). We believe that the implementation of a MIRG system will also be useful for Greater Prairie Chickens. It will prevent cattle from entering some areas, where prairie chickens may find shelter, and also provide birds with an area that has lower vegetation height density where the cattle have been. Thus, we suggest that a mosaic of vegetation structure (Sample & Mossman 1997), both within and among pastures, would provide the most beneficial management for avian species at Buena Vista WA.

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Appendices

Appendix 1

A. Date when cattle were placed on each site, according to passerine survey round

*(X= cattle never present; *= only for BK grazed section)*

Site	First Survey Round With Cattle	Date of Survey Round Start
AG	1	May 16, 2016
AS	1	May 16, 2016
BGF	X	X
BK	2*	June 1, 2016
EC	1	May 16, 2016
Elm	X	X
KS	3	June 12, 2016
Lake	X	X
Town	X	X

Appendix 2

A. Survey round with highest bird detections, by species

(Note: Western Meadowlark and Horned Lark are excluded due to small sample size)

Species	**Survey Round**
Bobolink	1
Brewer's Blackbird	3
Clay-Colored Sparrow	1
Eastern Meadowlark	3
Grasshopper Sparrow	1
Henslow's Sparrow	2
Savannah Sparrow	4
Vesper Sparrow	3

Appendix 3

A. Summary statistics for vegetation structure during survey round 1 of passerine point counts (St. Dev. = standard deviation)

Grazed		**Veg Height Density**			**Litter Depth**		
Site	**n**	**Mean**	**St. Dev.**	**Interquartile Range**	**Mean**	**St. Dev.**	**Interquartile Range**
AG	3	1.1	0.2	1.0-1.2	4.1	1.1	3.5-4.5
AS	2	0.9	0.5	0.7-1.1	1.7	0.3	1.6-1.8
EC	2	1.1	0.6	0.8-1.3	2.3	1.7	1.8-2.9

Ungrazed		Veg Height Density			Litter Depth		
Site	**n**	**Mean**	**St. Dev.**	**Interquartile Range**	**Mean**	**St. Dev.**	**Interquartile Range**
BGF	2	2.3	0.2	2.3-2.4	14.2	1.4	13.7-14.7
BK	7	1	0.2	0.9-1.1	1.5	1.1	0.9-1.7
Elm	2	1.6	0.5	1.4-1.7	5.4	3.4	4.2-6.6
KS	2	0.7	0	0.7-0.7	0.3	0	0.3-0.3
Lake	3	1.9	0.1	1.8-2.0	7.1	2.9	5.6-8.5
Town	1	2.7	0	2.7-2.7	7.1	0	7.1-7.1

B. Summary statistics for vegetation structure during survey round 2 of passerine point counts (St. Dev. = standard deviation)

Grazed		**Veg Height Density**			**Litter Depth**		
Site	**n**	**Mean**	**St. Dev.**	**Interquartile Range**	**Mean**	**St. Dev.**	**Interquartile Range**
AG	3	1.6	0.9	1.2-2.1	2.2	0.6	1.9-2.5
AS	2	0.7	0.7	0.5-1	0.6	0.1	0.5-0.6
BK: Grazed	4	1.8	1.2	0.9-2.5	1.3	0.5	1.1-1.5
EC	2	2.1	1.1	1.7-2.5	2.3	1.1	1.9-2.7

Ungrazed		**Veg Height Density**			**Litter Depth**		
Site	**n**	**Mean**	**St. Dev.**	**Interquartile Range**	**Mean**	**St. Dev.**	**Interquartile Range**
BGF	2	3.1	0.7	2.9-3.3	7.8	2.6	6.9-8.7
BK: Ungrazed	3	2.5	0.6	2.1-2.7	1.5	0.7	1.1-1.8
Elm	2	2.4	0	2.4-2.4	5.2	1.1	4.8-5.6
KS	2	0.7	0	0.7-0.7	0.2	0.2	0.1-0.3
Lake	3	2.2	0.6	1.8-2.4	4.8	3.1	3.7-6.6
Town	1	2.1	0	2.1-2.1	6.1	0	6.1-6.1

C. Summary statistics for vegetation structure during survey round 3 of passerine point counts (St. Dev. = standard deviation)

Grazed		**Veg Height Density**			**Litter Depth**		
Site	**n**	**Mean**	**St. Dev.**	**Interquartile Range**	**Mean**	**St. Dev.**	**Interquartile Range**
AG	3	2.0	0.7	1.8-2.4	4.0	1.3	3.5-4.7
AS	2	1.6	0.8	1.3-1.9	0.6	0.3	0.5-0.7
BK: Grazed	4	2	0.6	1.62-2.4	1.1	0.0	1.1-1.2
EC	2	2.7	0.4	2.5-2.8	2.2	0.7	2.0-2.5
KS	2	1.9	0.9	1.6-2.2	0.5	0.3	0.3-0.6

Ungrazed		**Veg Height Density**			**Litter Depth**		
Site	**n**	**Mean**	**St. Dev.**	**Interquartile Range**	**Mean**	**St. Dev.**	**Interquartile Range**
BGF	2	3.4	0.4	3.3-3.6	4.9	1.3	4.4-5.3
BK: Ungrazed	3	3.3	0.5	3.1-3.6	2.0	0.8	1.6-2.4
Elm	2	3.5	0.4	3.3-3.7	4.6	1.0	4.3-5.0
Lake	3	2.7	0.2	2.7-2.8	3.8	2.5	3.1-5.3
Town	1	1.6	0	1.6-1.6	4.0	0	4.0-4.0

D. Summary statistics for vegetation structure during survey round 4 of passerine point counts (St. Dev. = standard deviation)

Grazed		**Veg Height Density**			**Litter Depth**		
Site	**n**	**Mean**	**St. Dev.**	**Interquartile Range**	**Mean**	**St. Dev.**	**Interquartile Range**
AG	3	1.5	0.9	1.2-2.0	1.2	0.4	1.0-1.4
AS	2	1.0	0.7	0.7-1.2	0.5	0.5	0.3-0.7
BK: Grazed	4	1.0	0.7	0.8-1.4	0.8	0.5	0.4-1.1
EC	2	1.7	0.2	1.6-1.7	1.1	0.4	1.0-1.3
KS	2	1.8	0.1	1.7-1.8	0.3	0	0.3-0.3

Ungrazed		**Veg Height Density**			**Litter Depth**		
Site	**n**	**Mean**	**St. Dev.**	**Interquartile Range**	**Mean**	**St. Dev.**	**Interquartile Range**
BGF	2	5.8	3.9	4.5-7.2	6.3	1.6	5.8-6.9
BK: Ungrazed	3	3.0	0.8	2.6-3.4	1.6	0.7	1.3-2.0
Elm	2	2.2	0.2	2.2-2.3	3.2	2.8	2.2-4.2
Lake	3	2.4	0.4	2.2-2.5	4.5	3.4	3.2-6.4
Town	1	1.5	0	1.5-1.5	5.1	0	5.1-5.1

Appendix 4

A. Adjusted abundances at the ungrazed section of site BK, according to survey location

	BK_2				BK_3			
Species	**Round 1**	**Round 2**	**Round 3**	**Round 4**	**Round 1**	**Round 2**	**Round 3**	**Round 4**
Bobolink (BOBO)	0	1.2	0	0	5.7	3.0	2.7	5.8
Clay-Colored Sparrow (CCSP)	3.1	2.1	3.5	3.1	1.0	0	3.2	2.2
Grasshopper Sparrow (GRSP)	5.9	1.2	0	2.3	1.0	2.1	0	0
Savannah Sparrow (SAVS)	2.7	3.5	2.3	4.0	5.4	5.1	4.7	3.0
Total	**11.7**	**7.9**	**5.8**	**9.4**	**13.1**	**10.2**	**10.6**	**11.0**

	BK_4			
Species	**Round 1**	**Round 2**	**Round 3**	**Round 4**
Bobolink (BOBO)	5.5	5.8	1.5	3.0
Clay-Colored Sparrow (CCSP)	4.9	5.1	1.1	3.2
Grasshopper Sparrow (GRSP)	1.0	2.1	0	1.4
Savannah Sparrow (SAVS)	1.4	2.1	4.2	3.1
Total	**12.8**	**15.2**	**6.8**	**10.7**

B. Adjusted abundances at the grazed portion of site BK, according to survey location.

(Italicized = cattle currently or previously grazed point)

	BK_5				**BK_6**			
Species	**Round 1**	***Round 2***	***Round 3***	***Round 4***	**Round 1**	***Round 2***	***Round 3***	***Round 4***
Bobolink (BOBO)	2.3	*1.2*	*1.5*	*0*	3.0	*0*	*0*	*0*
Clay-Colored Sparrow (CCSP)	4.2	*1.0*	*2.8*	*2.0*	7.7	*1.1*	*2.4*	*2.0*
Grasshopper Sparrow (GRSP)	6.7	*4.7*	*3.3*	*4.8*	1.1	*0*	*1.3*	*1.2*
Savannah Sparrow (SAVS)	1.3	*2.1*	*3.1*	*4.1*	3.9	*1.0*	*3.3*	*3.0*
Total	**14.5**	***9.0***	***10.7***	***10.8***	**15.7**	***2.1***	***7.0***	***6.2***

	BK_7				**BK_8**			
Species	**Round 1**	**Round 2**	***Round 3***	***Round 4***	**Round 1**	**Round 2**	**Round 3**	***Round 4***
Bobolink (BOBO)	2.6	4.6	*2.1*	*3.3*	1.4	3.2	0	*0*
Clay-Colored Sparrow (CCSP)	0	0	*0*	*2.1*	3.5	2.0	2.4	*2.2*
Grasshopper Sparrow (GRSP)	4.0	4.2	*2.1*	*4.3*	3.6	4.3	0	*0*
Savannah Sparrow (SAVS)	2.7	2.2	*2.0*	*4.1*	1.2	2.3	3.4	*3.0*
Total	**9.4**	**10.9**	***6.2***	***13.7***	**9.7**	**11.9**	**5.7**	***5.2***