Rangeland Ecology & Management 68 (2015) 470–475

Contents lists available at ScienceDirect

Rangeland Ecology & Management

journal homepage: http://www.elsevier.com/locate/rama

Managing Mixed-Grass Prairies for Songbirds Using Variable Cattle Stocking Rates☆,☆☆

M.S. Sliwinski [a,*], N. Koper [b]

[a] PhD Student, School of Natural Resources, University of Nebraska-Lincoln, Lincoln, NE 68583, USA
[b] Associate Professor, Natural Resources Institute, University of Manitoba, Winnipeg, MB, Canada R3T 2M6

ARTICLE INFO

Article history:
Received 2 February 2015
Received in revised form 14 July 2015
Accepted 20 July 2015

Key words:
Baird's sparrow
cattle grazing
chestnut-collared longspur
ecological threshold
grassland management
Sprague's pipit
stocking rates

ABSTRACT

Most remaining grasslands are used for livestock grazing; stocking rates could be managed to help stop declining songbird populations. We examined the effects of stocking rates on grassland songbirds in northern mixed-grass prairies using a beyond–Before-After-Control-Impact manipulative experiment in Canada's Grasslands National Park and adjacent community pastures. The study area consisted of nine 300-ha pastures grazed at a range of stocking rates starting in 2008. We conducted songbird surveys at six upland plots in each pasture from 2006–2010 and measured vegetation structure within each plot from 2008–2010 ($n = 54$). We evaluated the effects of stocking rates on habitat structure and songbird abundance using linear and generalized linear mixed models. Baird's sparrow *(Ammodramus bairdii)* relative abundance declined with increasing stocking rates. Chestnut-collared longspur *(Calcarius ornatus)* relative abundance increased only at higher stocking rates, indicating a possible threshold effect. Savannah sparrow *(Passerculus sandwichensis)* relative abundance decreased with stocking rates above 0.4 AUM after a year of grazing. Sprague's pipit *(Anthus spragueii)* relative abundance declined with grazing, but the effect was weak and only significant in 1 year. Western meadowlark *(Sturnella neglecta)* abundance was unaffected by grazing. Stocking rates may be used to benefit grassland songbirds and may alter avian communities after as little as 1 month of livestock grazing. Applying a range of stocking rates regionally may provide habitat for many species.

Introduction

Grassland managers often promote structural homogeneity in grasslands, such as "management to the middle" in the case of private landowners, and exclusion of livestock and fire in the case of public landowners (Fuhlendorf et al., 2012). Unfortunately, this structural homogeneity may be contributing to declining grassland bird populations (Samson and Knopf, 1994; Brennan and Kuvlesky, 2005). To conserve grassland birds with different habitat needs, managers should focus on restoring multiscale heterogeneity (Fuhlendorf and Engle, 2004).

Stocking rates are a grazing tool that may be used to manage structural heterogeneity at different scales: low stocking rates will allow habitat structure measures to increase and heterogeneity to decrease because there is more forage available than cattle can consume; moderate stocking rates allow cattle to forage selectively, which should increase within-pasture heterogeneity (Hart et al., 1993); high stocking rates result in increased removal of vegetation from a pasture, resulting in decreased habitat structure and heterogeneity (Fritcher et al., 2004). The number of years a pasture is grazed may also have important consequences for habitat structure and heterogeneity because the effects of grazing can be cumulative across years (Johnson et al., 2011). Although managers understand the effects of stocking rates on vegetation structure, the effects of stocking rates on songbirds are not well understood.

To examine the effects of different cattle stocking rates and years of grazing on habitat structure and songbird abundance, we developed a large-scale beyond–Before-After-Control-Impact (BACI; Underwood, 1994) grazing experiment in a northern mixed-grass prairie. Using this design, we were able to determine if any effects of stocking rate were nonlinear, which could indicate an ecological threshold (the point at which an ecological measure begins to change in response to management; Johnson et al., 2011). Focal species for our study included Baird's sparrow *(Ammodramus bairdii)*, chestnut-collared longspur *(Calcarius ornatus)*, Savannah sparrow *(Passerculus sandwichensis)*, Sprague's pipit *(Anthus spragueii)*, and western meadowlark *(Sturnella neglecta)*. This group includes two species at risk in Canada (chestnut-collared longspur and Sprague's pipit; COSEWIC, 2010).

We predicted that habitat structure measures, including vegetation height, canopy height, visual obstruction, and litter depth, would decrease with increasing stocking rate and that habitat heterogeneity would be highest at moderate stocking rates because grazing removes

☆ Research was funded by Parks Canada, World Wildlife Fund, University of Manitoba, Natural Sciences and Engineering Research Council, Canadian Foundation for Innovation, Manitoba Research Innovations Fund, Clayton H. Riddell Endowment Fund, and the Government of Manitoba.

☆☆ At the time of research, Sliwinski was a Masters student, Natural Resources Institute, University of Manitoba, Winnipeg, Manitoba, Canada, R3T 2M6.

* Correspondence: M. Sliwinski, School of Natural Resources, University of Nebraska-Lincoln, Lincoln, NE 68583, USA.

E-mail address: maggi.sliwinski@gmail.com (M.S. Sliwinski).

http://dx.doi.org/10.1016/j.rama.2015.07.010
1550-7424/

vegetation and foraging selectivity is predicted to be highest at low and moderate grazing intensities (Hart et al., 1993). We expected abundances of Sprague's pipit and Baird's sparrow to decrease and chestnut-collared longspur to increase as stocking rates increased because of these species' habitat structure preferences. We did not expect to see a change in western meadowlark or Savannah sparrow abundance in response to stocking rate because they are generalist species (Mengel, 1970).

Methods

Study Site and Design

In 2006, a grazing experiment was implemented in the East Block of Grasslands National Park of Canada (GNP) in southwestern Saskatchewan (lat 49°01′00″N, long 106°49′00″W). GNP consists of rolling hills of native mixed-grass prairie and falls within the Missouri River drainage basin (Coupland, 1950). The uplands were dominated by grasses including *Hesperostipa comata, Elymus lanceolatus, Bouteloua gracilis, Koeleria macrantha,* and *Pascopyrum smithii* and forbs including *Artemesia frigida, Phlox hoodii,* and *Sphaeralcea coccinea; Selaginella densa* was the dominant groundcover (Coupland, 1950). The study site had never been cultivated and was ungrazed since 1992, when Parks Canada purchased the land.

We used a beyond-BACI study design, which included multiple control and treatment pastures, and baseline data collection before implementation of grazing (Underwood, 1994; Koper et al., 2008). Nine pastures (average size 296 ha, SD = 14 ha, range = 280–331 ha) were delineated in GNP encompassing equal proportions of upland habitat among pastures (Table A1). Six pastures were grazed treatments, and three pastures were ungrazed controls (for more information and map, see Koper et al., 2008). The uplands of each pasture included six 100-m radius (3.2 ha) permanent sampling plots (hereafter plots); each plot was at least 250 m from fences and other plots. There were 36 grazed plots and 18 ungrazed control plots inside GNP ($n = 54$).

In early 2008, fencing for the six grazed pastures within GNP was erected and each pasture was supplemented with two water troughs, one located in the lowland and one in the upland. These water troughs decreased grazing pressure on potentially sensitive riparian areas and encouraged more uniform grazing distribution consistent with the management of cattle on private lands (Reece et al., 2008), thus allowing us to make recommendations about grazing management both in the park and in rangelands managed for commercial purposes.

Cattle grazing typically aims for ~50% biomass removal (Abouguendia, 1990), which is estimated to require 0.63 AUM·ha^{-1} in this region (Parks Canada, 2006). GNP pastures were managed with six grazing intensities ranging from 0.23 AUM·ha^{-1} to 0.83 AUM·ha^{-1} (Table A2). Cattle were first reintroduced to GNP treatment pastures on 5 June 2008. In 2009 and 2010, cattle were placed in the treatment pastures on 15 and 26 of May, respectively. Grazing was season-long continuous and lasted approximately 4 months each year; no supplemental feed was provided to cattle.

Table 1
Parameter estimates (β), standard errors, *P* values, and 90% confidence intervals for the Baird's sparrow relative log (abundance) in Grasslands National Park, 2006–2010. Model: Baird's sparrow = Year + Stocking Rate + Year · Stocking Rate.

Parameter	β	SE	*P*	LCL, 90%	UCL, 90%
Intercept	2.68	0.05	<0.001	2.60	2.76
AUM	-0.03	0.09	0.749	-0.19	0.13
After 1 mo	0.16	0.10	0.100	-0.001	0.33
After 1 yr	-0.25	0.10	0.014	-0.42	-0.08
After 2 yr	0.11	0.09	0.194	-0.03	0.26
AUM·After 1 mo	-0.01	0.20	0.963	-0.33	0.31
AUM·After 1 yr	**-0.41**	**0.21**	**0.052**	**-0.75**	**-0.06**
AUM·After 2 yr	**-0.34**	**0.18**	**0.060**	**-0.63**	**-0.04**

Bolded text indicates a significant interaction; AUM, stocking rate (AUM·ha^{-1}).

Field Methods

In May and July 2008–2010, we measured habitat structure variables that tend to influence the abundance of grassland birds (Fisher and Davis, 2010). We took habitat measurements within a 1.0 × 0.5 m sampling quadrat made of polyvinyl chloride pipe that was placed on the ground at 50 m and 100 m from the center of each plot in the four cardinal directions (8 samples per plot). Habitat structure variables that we measured within each sampling quadrat included visual obstruction reading (estimate of vegetation biomass; see later), tallest vegetation height (i.e., grass, forb, or shrub; dead or alive), canopy height (height at which a 20 × 50 cm Styrofoam board rested when placed on top of the vegetation in the middle of the quadrat), and litter depth measured in the center of the quadrat. We measured visual obstruction as the height at which vegetation obscured 50% of a pole marked with 5-cm increments, when visualized from a height of 1 m and at 4 m distance (modified from Robel et al., 1970).

We visited each plot at least three times per year between mid-May and 30 June in 2006–2010 to quantify bird abundance. To assess the immediate impact of cattle reintroduction on songbirds in 2008, we completed two visits before and two visits after cattle reintroduction. We used 5-minute, 100-m radius point counts (modified following Hutto et al., 1986). All birds seen or heard during the 5 minutes were recorded, along with sex of individuals when possible. All point counts were conducted between sunrise and 1000 hours and each plot was surveyed by at least two observers in all years to lessen observer bias. No surveys were conducted on days with excessive wind (>15 km·h^{-1}) or rain.

Statistical Analysis

Because pasture was the treatment unit for livestock management, our habitat structure and songbird abundance analyses were conducted at the pasture scale. We calculated means and standard deviations of habitat structure measures within each pasture and year using data collected during the May sampling period. Standard deviations were used as an index of habitat heterogeneity (Fuhlendorf and Engle, 2004). Due to an error in measuring litter depth in May 2009, litter depth data were analyzed in May 2008, July 2009, and July 2010. We summed counts of male songbirds of each focal species within each pasture, visit, and year. We used unadjusted counts to measure relative abundance for several reasons, although we acknowledge that detectability of birds during point-count surveys is always imperfect. In northern mixed-grass prairies, dependent double-observer sampling has demonstrated that perceptibility of Baird's sparrow, chestnut-collared longspur, Sprague's pipit, and western meadowlark is high (Leston et al., 2015). In addition, assumptions of distance sampling are difficult to meet in the field (Efford and Dawson, 2009), and not meeting these assumptions can increase rather than decrease estimate bias (Johnson, 2008).

To assess the effects of stocking rate and number of years grazed on habitat and songbirds, we analyzed data from pregrazed years, grazed years, treatment pastures, and control pastures using a BACI design. This design accounts for preexisting trends in the data (e.g., due to topo-edaphic features of the study site) by using interactions to examine differences in pretreatment and post-treatment data and controls (Underwood, 1994). For example, a treatment effect alone (e.g., significant effect of stocking rate before grazing was implemented) could indicate that our pastures had a pattern before treatment. Only a significant interaction between the main effects of treatment and time indicates a true effect of treatment.

We used linear and generalized linear mixed models to test for significant ($\alpha = 0.10$) interactions between years grazed and stocking rate (Table A2) in R Statistical software version 9.3 (R Core Team, 2012). We included pasture as a random effect in each model. Years grazed was modeled as a categorical variable: pregrazed years (2006–May 2008) were combined as year "0," June 2008 was "after 1