Breeding Bird Community Composition in a Patch-burn and Modified Twice-over Rotational Grazing System

Cameron Duquette and Torre Hovick
North Dakota State University School of Natural Resource Sciences, Fargo, N.D.

Photo Credit: T.J. Hovick

We are evaluating the effect of a patch-burn grazing management strategy on avian breeding community composition. Our treatment structure includes four replicates of the following: (1) season-long grazing, (2) season-long grazing with dormant-season patch burning (one-fourth of the pasture) at a four-year return interval, (3) season-long grazing with dormant-season (one-eighth of the pasture) and growing-season (one-eighth of the pasture) patch burning at a four-year return interval, and (4) twice-over rotational grazing. Here we present preliminary results following three years of study.

Introduction

Broad-scale threats to grassland birds include habitat loss, agricultural intensification and climate change (Hill et al., 2014; McCauley et al., 2017; Pool et al., 2014). However, at finer scales, patch area and local vegetation structure are important factors governing grassland bird communities (Hovick et al., 2015; Davis, 2004). Specifically, diversity in vegetation structure mediates grassland bird density, abundance and diversity.

The majority of remnant grasslands in the U.S. are privately owned and thus often undergo managed grazing by herbivores (Ribic et al., 2009). Many privately-owned grasslands use a rotational grazing system designed to achieve a uniform foraging distribution (Briske et al., 2008). This minimizes selection by grazers and results in homogenization of vegetation structure and composition toward the middle of a disturbance gradient (Fuhlendorf and Engle, 2004).

A loss of structural heterogeneity causes associated declines in the diversity and stability of breeding bird communities (Hovick et al., 2015). Uniform grazing pressure can reduce the occurrence of bare patches on the landscape (Derner et al., 2008), which are important for migratory grassland species, most of which are insectivorous.

The absence of fire in grassland landscapes also can cause the expansion of woody cover. Many obligate grassland birds are less likely to use patches with woody vegetation due to declines in food resources and increased predation risk (Grant et al., 2004; Thompson et al., 2016).

The interaction of fire and grazing can prevent woody plant encroachment, as well as provide vegetation structure for grassland generalists and those that specialize on either end of the disturbance spectrum (Hovick et al., 2014; Ratajczak et al., 2012). Grasslands managed with patch-burn grazing are more likely to be source habitats for grassland birds and retain a higher temporal stability in community structure (Davis et al., 2016; Hovick et al., 2015).

In this study, we evaluate the impacts of patch-burn grazing on breeding season avian community composition using density estimates. We evaluate the densities of grassland species in each treatment, as well as study changes in the structure of the community among treatments and through time. We compare patch-burn grazing with season-long grazing and twice-over rotational grazing, two traditional management practices in the area. Results will allow managers to promote grassland bird conservation in a working landscape.

Procedures

Study Area

The Central Grasslands Research Extension Center (CGREC) is in North Dakota’s Kidder and Stutsman counties (46° 42’ 56” N, 99° 27’ 08” W) in the Missouri Coteau ecoregion of the northern mixed-grass prairie. The herbaceous community is dominated by native cool-season grasses such as green needlegrass (*Nassella viridula*), western wheatgrass (*Pascopyrum smithii*) and needle-and-thread grass (*Heterostipa comata*).

Common invasive grasses on site include Kentucky bluegrass (*Poa pratensis*) and smooth brome (*Bromus inermis*) (Patton et al., 2007). Western snowberry (*Symphoricarpos occidentalis*) is the dominant woody species at the CGREC, although silverberry (*Eleagnus commutata*) and wild rose (*Rosa arkansana*) are present.

The forb community is diverse and dominated by western ragweed (*Ambrosia psilostachya*), prairie coneflower (*Ratibida columnifera*), goldenrod (*Solidago* spp.), yarrow (*Achillea millefolium*) and Flodman's thistle (*Cirsium flodmanii*) (Rogers et al., 2005). The climate is characterized as temperate and experiences an average yearly rainfall of 40.28 centimeters (15.9 inches) and an average annual temperature of 4.94 C (40.9 F) (1991-2016, North Dakota Agricultural Weather Network).

Treatment Structure

Our treatment structure consists of four replicates, each consisting of a 160-acre pasture divided into eight sub-patches. The treatments include: (1) season-long grazing (SLG), (2) season-long grazing with dormant-season patch burning (one-fourth of the pasture) at a four-year return interval (PBG40), (3) season-long grazing with dormant-season (one-eighth of the pasture) and growing season (one-eighth of the pasture) patch burning at a four-year return interval (PBG20), and (4) modified twice-over rotational grazing (MTORG).

Annual burn plots in treatment 3 are two adjacent 20-acre sub-patches. Growing-season burns are incorporated to increase forage quality for livestock in the middle of the season (Scasta et al., 2016). Fire return intervals mirror the historical disturbance regime of mixed-grass prairie.

Cow-calf pairs graze freely within pastures from May 1 to Oct. 1 each year at a moderate stocking rate designed to achieve 30% forage utilization. Soil type and vegetation communities are similar among replicates, as defined by Natural Resources Conservation Service ecological site descriptions and equivalent land use histories.

Community Monitoring

From June 1 to July 15, we monitored the breeding season avian community in each of our experimental pastures. In each sub-patch (one-eighth of a 160-acre pasture) we conducted a 150-meter (m) transect survey four times during the season (384 surveys total). Each time a bird was detected, we recorded the species, sex and behavior of the bird, as well as the individual's straight-line distance from transect. Detections more than 50 m from transect were censored from analysis.

Vegetation Monitoring

Along each community transect, we performed vegetation surveys. On each side of the transect, we measured the cover of vegetation functional groups using a 1- by 0.5-m quadrat and modified Daubenmire cover classes (20 quadrats/transect, Daubenmire, 1959). The cover of vegetation functional groups was recorded. Additionally, at each plot, a Robel pole was used to quantify visual obstruction in each cardinal direction (Robel, 1970).

Statistics

We calculated the density of detected bird species using the R package *unmarked*. To determine the effect of grazing management on species-specific density estimates, we employed a hierarchical model-building approach (Hovick et al., 2012).

We first assessed the effect of survey year on density by comparing it with a null model in an AIC framework. The best model from this step was used as a null model to assess the effect of grazing treatment in a similar fashion. We analyzed these effects separately due to the fact that although our treatment structure likely affects the densities of many bird species in our community, these impacts may be more apparent via the effects of treatment structure on vegetation.

Following these steps, we combined the best model with all vegetation covariates. We then removed the vegetation covariate with the highest *p*-value (greater than 0.05) and tested the result against the model, including said covariate in an AIC framework (Burnham and Anderson, 1998). We continued this procedure until the smaller model did not outperform the larger model.

We analyzed differences in the breeding season community using nonmetric dimensional scaling using the R package VEGAN (Dixon, 2003). We used vegetation and management to describe variation in avian community composition. The significance of environmental variables was assessed using permutational analysis of variance (PERMANOVA, McArdle and Anderson, 2001). We used transect-level densities to compare differences among treatments.

Results

Following three years of study, we had 5,312 detections from 62 species. Here we present results from seven species of conservation concern and/or ecological interest (Figure 1 and Table 1).

The overall density of grasshopper sparrows (*Ammodramus savannarum*) at the CGREC was 1.65 individuals/hectare (ha) (± 0.15 SE). We did not see significant differences in abundance among treatments. We found a slight positive influence of smooth brome cover and native warm-season grass cover on densities.

We also found a weak positive influence of native forb cover and standing dead vegetation on density.

Introduced forbs - Canada thistle (*Cirsium arvense*) and wormwood (*Artemisia absinthium*) - have a negative effect on grasshopper sparrow density, as did bare ground.

The density of clay-colored sparrows (*Spizella pallida*) on-site was 1.75 individuals/ha (± 0.17 SE). Grazing treatments had a significant effect on density, and densities were highest in the MTORG treatment and the season-long grazing treatment, compared with the patch-burning treatments.

Interestingly, the patch-burn treatments differed from each other, with higher densities occurring in the PBG40 treatment. Introduced legumes such as sweetclover (*Melilotus officinalis*) and alfalfa (*Medicago sativa*) negatively affected clay-colored sparrow density, as did native forb cover and bare ground. Woody cover and litter depth increased densities.

Savannah sparrow (*Passerculus sandwichensis*) density was 1.06 individuals/ha (± 0.06 SE). Savannah sparrow density was higher in the MTORG treatment, compared with the other three, which were similar. Density increased with the cover of Kentucky bluegrass on the landscape as well as the cover of introduced forbs. Similarly, to clay-colored sparrow density decreased with bare ground cover.

Bobolink (*Dolichonyx oryzivorus*) density on-site was 0.78 individual/ha (± 0.11 SE). Bobolink density was slightly higher in the SLG pasture, compared with the patch-burn pastures, and significantly higher in the MTORG treatment. Litter depth was the only vegetation covariate that impacted bobolink densities. Bobolink were more abundant in areas with deeper litter.

Western meadowlark (*Sturnella neglecta*) density was 2.65 individuals/ha. Densities in the MTORG treatment were much lower than the other treatments, which were similar. Increases in bare ground and litter depth decreased the density of meadowlarks. Densities increased with the amount of standing dead material.

Longspur (*Calcarius ornatus*) density was 0.25 individual/ha (± 0.05 SE). Densities differed between all treatments, and were highest in the PBG20 treatment, followed by the PBG40 treatment, the SLG treatment and the MTORG treatment. Increasing visual obstruction, litter depth, native woody vegetation, native forbs, introduced legumes and Kentucky bluegrass all decreased the densities of longspurs.

Brown-headed cowbird (*Molothrus ater*) density was high but variable at the CGREC (12.90 individuals/ha ± 5.56 SE). Densities were lower in the patch-burn treatment, compared with the MTORG or the SLG treatment, which was the highest. Increases in bare ground and Kentucky bluegrass cover increased the density of cowbirds, while standing dead vegetation decreased cowbird density.

Community

We see significant overlap in bird communities among treatments. However, the patch-burn communities are more diverse and variable than the SLG treatment, which is in turn more variable than the MTORG treatment (Figure 2).

Discussion

Following three years of data collection, we demonstrate the distinct preferences for vegetation structure in the breeding bird community. In certain species, we show higher densities in certain treatments. Although species such as chestnut-collared longspur prefer the patch-burn treatment, we also show that the dense vegetation in SLG and MTORG treatments are preferred by species that need shrubs and thick litter for breeding, such as bobolinks and clay-colored sparrows.

We also see that brown-headed cowbird abundance is much higher in pastures that are not burned. During our final year of data collection, we expect to find a divergence in the breeding community as our treatment structure is further implemented (Pillsbury et al., 2011).

Photo credit: T.J. Hovick

Literature Cited

Briske, D.D., Derner, J.D., Brown, J.R., Fuhlendorf, S.D., Teague, W.R., Havstad, K.M., Gillen, R.L., Ash, A.J., Willms, W.D. 2008. Rotational grazing on rangelands: Reconciliation of perception and experimental evidence. Range Ecology and Management 61, 3-17.

Burnham, K.P., Anderson, D.R. 1998. Model selection and inference: a practical information-theoretic approach. Springer-Verlag, New York.

Daubenmire, R.F. 1959. A canopy coverage method of vegetational analysis. Northwest Science 33, 43-64.

Davis, C.A., Churchwell, R.T., Fuhlendorf, C.D., Engle, D.M., Hovick, T.J. 2016. Effect of pyric herbivory on source-sink dynamics in grassland birds. Journal of Applied Ecology 53, 1004-1012.

Davis, S.K. 2004. Area sensitivity in grassland passerines: Effects of patch size, patch shape, and vegetation structure on bird abundance and occurrence in southern Saskatchewan. The Auk 121, 1130-1145.

Derner, J.D., Lauenroth, W.K., Stapp, P., Augustine, D.J. 2008. Livestock as ecosystem engineers for grassland bird habitat in the western Great Plains of North America. Rangeland Ecology and Management 62, 111-118.

Dixon, P. 2003. VEGAN, a package of R functions for community ecology. Journal of Vegetation Science 14, 927-930.

Fuhlendorf, S.D., Engle, D.M. 2004. Application of the fire-grazing interaction to restore a shifting mosaic on tallgrass prairie. Journal of Applied Ecology 41, 604-614.

Grant, T.A., Madden, E., Berkey, G.B. 2004. Tree and shrub invasion in northern mixed-grass prairie: implications for breeding grassland birds. Wildlife Society Bulletin 32, 807-818.

Hill, J.M., Egan, J.F., Stauffer, G.E., Diefenbach, D.R. 2014. Habitat availability is a more plausible explanation than insecticide acute toxicity for U.S. grassland bird species declines. PLOS ONE 9, e98064.

Hovick, T.J., Elmore, R.D., Fuhlendorf, S.D. 2014. Structural heterogeneity increases diversity of non-breeding grassland birds. Ecosphere 5, 1-13.

Hovick, T.J., Elmore, R.D., Fuhlendorf, S.D., Engle, D.M., Hamilton, R.G. 2015. Spatial heterogeneity increases diversity and stability in grassland bird communities. Ecological Applications 25, 662-672.

Hovick, T.J., Miller, J.R., Dinsmore, S.J., Engle, D.M., Debinski, D.M., Fuhlendorf, S.D. 2012. Effects of fire and grazing on grasshopper sparrow nest survival. Journal of Wildlife Management 76, 19-27.

McArdle, B.H., Anderson, M.J. 2001. Fitting multivariate models to community data: A comment on distance-based redundancy analysis. Ecology, 82, 290–297.

McCauley, L.A., Ribic, C.A., Pomara, L.Y., Zuckerberg, B. 2017. The future demographic niche of a declining grassland bird fails to shift poleward in response to climate change. Landscape Ecology 32, 807-821.

Patton B.D., Dong X., Nyren P.E., Nyren, A. 2007. Effects of grazing intensity, precipitation, and temperature on forage production. Range Ecology and Management 60:656-665.

Pillsbury, F.C., Miller, J.R., Debinski, D.M., Engle, D.M. 2011. Another tool in the toolbox? Using fire and grazing to promote bird diversity in highly fragmented landscapes. Ecosphere 2, 1-14.

Pool, D.B., Panjabi, A.O., Macias-Duarte, A., Solhjem, D.M. 2014. Rapid expansion of croplands in Chihuahua, Mexico threatens declining North American grassland bird species. Biological Conservation 170, 274-281.

Ratajczak, Z., Nippert, J.B., Collins, S.L. 2012. Woody encroachment decreases diversity across North American grasslands and savannas. Ecology 93, 697-703.

Ribic, C.A., Guzy, M.J., Sample, D.W. 2009. Grassland bird use of remnant prairie and Conservation Reserve Program fields in an agricultural landscape in Wisconsin. The American Midland Naturalist 161, 110-122.

Robel, R.J., Briggs, J.N., Dayton, A.D., Hulbert, L.C. 1970. Relationships between visual obstruction measurements and weight of grassland vegetation. Journal of Range Management 23: 295-297.

Rogers, W.M., Kirby, D.R., Nyren, P.E., Patton, B.D., Dekeyser, E.S. 2005. Grazing intensity effects on northern plains mixed-grass prairie. Prairie Naturalist 37:73-83.

Scasta, J.D., Thacker, E.T., Hovick, T.J., Engle, D.M., Allred, B.W., Fuhlendorf, S.D., Weir, J.R. 2016. Patch-burn grazing (PBG) as a livestock management alternative for fire-prone ecosystems of North America. Renewable Agriculture and Food Ecosystems 31,550-567.

Thompson, S.J., Handel, C.M., Richardson, R.M., McNew, L.B. 2016. When winners become losers: Predicted nonlinear responses of arctic birds to increasing woody vegetation. PLoS ONE, 11:e0164755.

Table 1. Variables and directionality of the top performing univariate models influencing breeding season bird density at the Central Grasslands Research Extension Center near Streeter, N.D., in 2017, 2018 and 2019. Treatment variables (PBG40, SLG and MTORG) are displayed as comparisons with the PBG20 treatment.

Species	Density Model	Direction
Grasshopper sparrow	Smooth brome	+
	Native warm-season grasses	+
	Native forbs	+
	Introduced forb	-
	Bare	-
	Dead	+
Clay-colored sparrow	Introduced Legumes	-
	Native forbs	-
	Native woody	+
	Bare	-
	Litter depth	+
	PBG40	+
	SLG	+
	MTORG	+
Savannah sparrow	Kentucky bluegrass	+
	Introduced forbs	+
	Bare	-
	MTORG	+
Bobolink	Kentucky bluegrass	+
	Litter depth	+
	SLG	+
	MTORG	+
Western meadowlark	Bare	-
	Dead	+
	Litter depth	-
	MTORG	-
Chestnut-collared longspur	Smooth brome	-
	Introduced legume	-
	Native forb	-
	Native woody	-
	Visual obstruction	-
	Litter depth	-
	PBG40	-
	SLG	-
	MTORG	-
Brown-headed cowbird	Smooth brome	+
	Bare	+
	Dead	-
	SLG	+
	MTORG	+

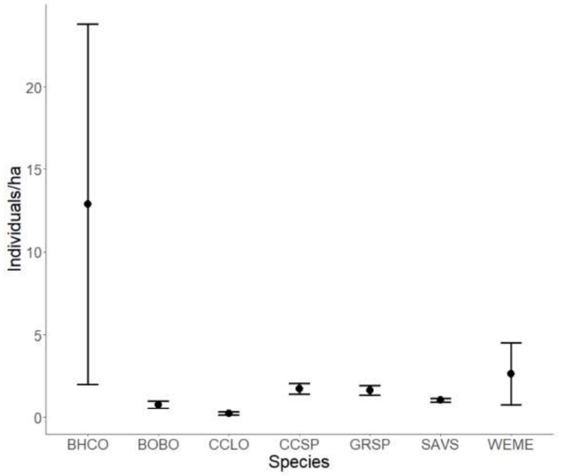

Figure 1. Estimates of the abundances of seven grassland bird species at the Central Grasslands Research Extension Center northwest of Streeter, N.D., in 2017, 2018 and 2019. Error bars represent ± 1 SE. See Figure 2 for species abbreviations.

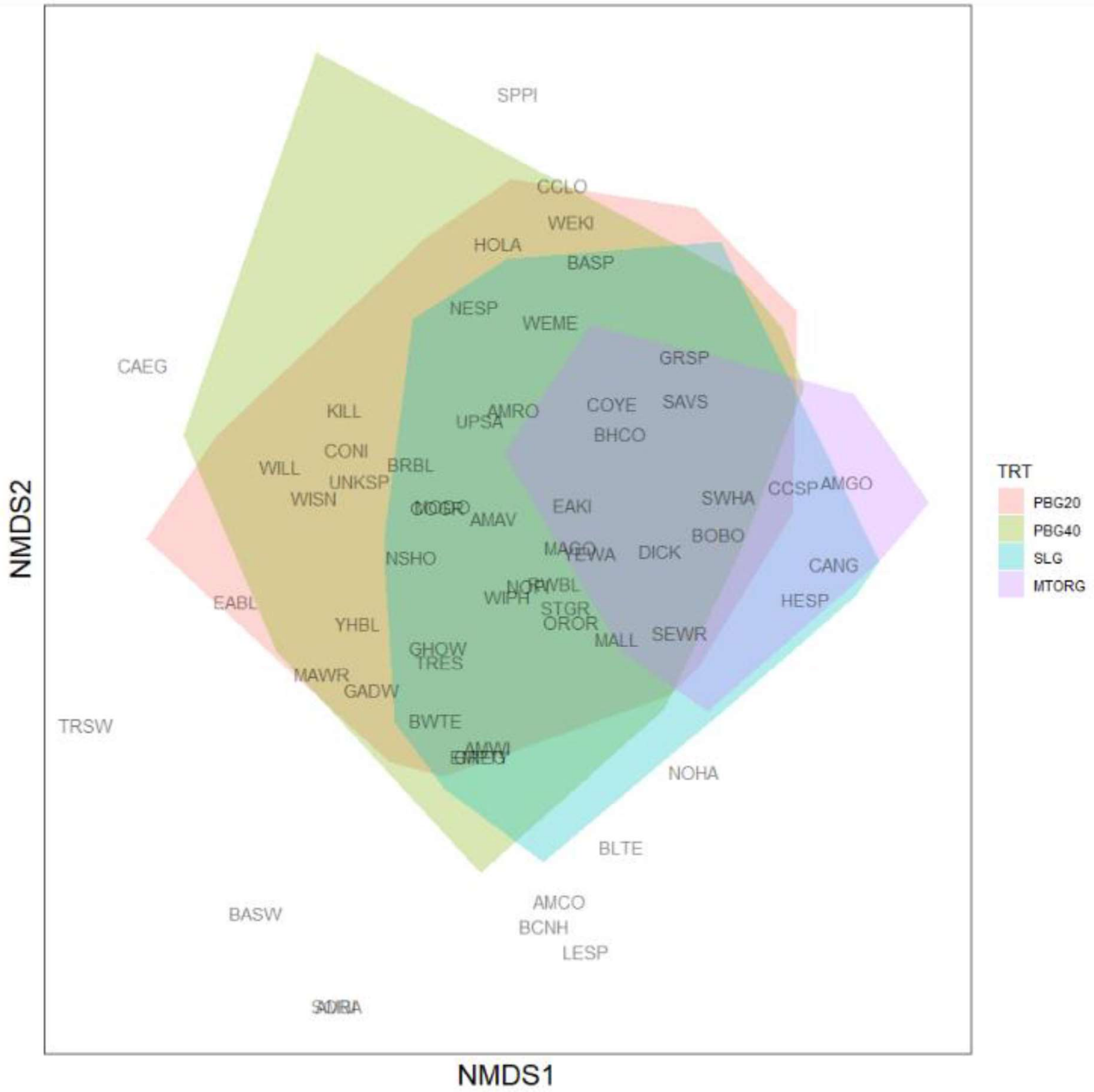

Figure 2. Nonmetric dimensional scaling (NMDS) ordination plot for abundances of six grassland bird species in a landscape managed with patch-burn grazing at the Central Grasslands Research Extension Center near Streeter, N.D. Species abbreviations are as follows: AMAV – American avocet; AMCO – American coot; AMGO – American goldfinch; AMRO – American robin; AMWI – American wigeon; BASP – Baird's sparrow; BASW – Barn swallow; BCNH – Black-crowned night heron; BHCO – Brown-headed cowbird; BLTE – Black tern; BOBO – Bobolink; BRBL – Brewer's blackbird; BWTE – Blue-winged teal; CAEG – Cattle egret; CANG – Canada goose; CCLO – Chestnut-collared longspur; CCSP – Clay-colored sparrow; COGR – Common grackle; CONI – Common Nighthawk; COYE – Common yellowthroat; DICK – Dickcissel; EABL – Eastern bluebird; EAKI – Eastern Kingbird; GADW – Gadwall; GHOW – Great-horned owl; GREG – Great egret; GRSP – Grasshopper sparrow; HESP – Henslow's sparrow; HOLA – Horned Lark; KILL – killdeer; LESP – Leconte's sparrow; MAGO – Marbled godwit; MALL – Mallard; MAWR – Marsh wren; MODO – Mourning dove; NESP – Nelson's sparrow; NOHA – Northern harrier; NOPI – Northern Pintail; NSHO – Northern shoveler; OROR – Orchard oriole; RWBL – Red-winged blackbird; SAVS – Savannah sparrow; SEWR – Sedge wren; SORA – Sora; SPPI – Sprague's pipit; STGR – Sharp-tailed grouse; SWHA – Swainson's hawk; TRSW – Tree swallow; UPSA – Upland sandpiper; WEKI – Western kingbird; WEME – Western Kingbird; WILL – Willet; WISN – Wilson's snipe; UNKSP – Unknown sparrow; YEWA – Yellow warbler; YHBL – Yellow-headed blackbird; WIPH – Wilson's phalarope.