Grassland bird surveys and nest-monitoring in MDC patch-burn grazing study units 2015-2020

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Principal Investigators
Dana Ripper
Ethan Duke

Project Leader
Erik Ost

2020 Field Crew

Nick Wiram
Grassland Technician

Kyla Yuza-Pate
Grassland Technician

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On the cover: A fledgling Field Sparrow by MRBO staff.

Introduction

Patch-burn grazing (PBG) is a widely accepted management tool that is used to produce a diversity of vegetative structure, thus increasing both nesting and foraging habitat for a variety of grassland-obligate species (Churchwell et al. 2008, Coppedge et al. 2008, Hovick et al. 2011). The decline of grasslands has contributed to the decline of grassland-obligate bird species. Grassland-obligate bird use and nesting success on grasslands where PBG is used serves as an indicator of the health of this natural community.

In conjunction with the MDC Resource Science Division's (RSD) 15 year patch-burn grazing (PBG) study, the Missouri River Bird Observatory (MRBO) has initiated a parallel study to investigate the effects of PBG treatment on grassland bird densities and nesting success. Study areas include Diamond Grove, Kickapoo, Providence, Wah'Kon-Tah, Taberville, and Hi-Lonesome Prairies. Target grassland breeding species include Eastern Meadowlark (*Sturnella magna*), Dickcissel (*Spiza americana*), Field Sparrow (*Spizella pusilla*), Henslow's Sparrow (*Ammodramus henslowii*), Grasshopper Sparrow (*Ammodramus savannarum*), Northern Bobwhite (*Colinus virginianus*), Bell's Vireo (*Vireo bellii*), Loggerhead Shrike (*Lanius ludovicianus*), and Greater Prairie-Chicken (*Tympanuchus cupido*). However, all species detected during surveys are recorded and up until 2019 all species' nests that are found are monitored. In an effort to increase target species' nest sample sizes, only target species nests were searched for and monitored in 2020.

Format of this report

This report presents the results of 2015-2020 **transect surveys** on PBG study units. Data were combined across years to analyze and present grassland bird densities in grazed and ungrazed units.

Nest-monitoring results are provided in detail for 2020. Compiled data from all years was used for the bulk of the analyses.

More detailed descriptions of survey and nest-monitoring methodolgy are available in previous years' reports or upon request. Densities of grassland obligate species on all MDC properties surveyed in 2020 can be accessed in MRBO's comprehensive report (Duke and Ripper 2020).

Project Summary

- Survey data from 2015-2020 on all of the MDC's PBG units indicate that there is some preference for (e.g. higher density in) treatment units by Dickcissel, Eastern Meadowlark, Grasshopper Sparrow, Field Sparrow and Northern Bobwhite, while Bell's Vireo and Henslow's Sparrow show a preference for control units. Taken as a guild, Missouri's grassland obligates do not show significant differences in density between treatment and control units.

- MRBO technicians located and monitored 346 nests during the 2020 breeding season, bringing the 2016-2020 sample size to 1273 nests, 911 of which are grassland target species.

- Nest monitoring data to date suggest that most species' nests in the control units have higher rates of nest survival compared to nests in the treatment units, with Field Sparrows being the exception. Nest survival does not appear to be influenced by distance from woody edge. For all target species except for Dickcissel, cowbird parasitism rates are higher in nests closer to a woody edge. Dickcissels have higher cowbird parasitism rates in nests further from a woody edge.

Survey Reults: Grassland Bird density on PBG Units

The PBG study units are surveyed twice during the breeding season using the standardized line-transect methodology that is employed by MRBO throughout Missouri. Two visits on PBG units are conducted in order to bolster sample sizes for greater significance in resulting data.

These line-transect surveys were conducted within the months of May and June. All bird detections were marked with spatially explicit data using ArcGIS Collector and density estimates of grassland-obligate species are derived using the Program Distance. Density estimates were calculated if the sample size was ≥10 for a unit. Combined density estimates of all grassland-obligates from 2015 to 2020 show that there is a slight trend in preference for treatment versus control units (Table 1). Slight to significant species preferences for treatment units included Field Sparrow, Grasshopper Sparrow, and Northern Bobwhite. Slight to significant species preferences for the control units included Henslow's Sparrow, while results varied among sites for remaining grassland-obligate species.

Tables 1 & 2: Density of birds on patch-burn grazed and ungrazed units on Conservation Areas.
n = total number of observations during transect surveys. D = estimated density in birds/acre generated by Program Distance based on pooled data from all survey years and locations. Density calculated only if n >10 for a property. CV = coefficient of variance. 2020 density values of the entire property are shown for comparison.

Table 1 indicates Diamond Grove and Wah'Kon-Tah had significantly higher density values of obligate species in the control unit compared to the treatment unit. For all properties combined, density was not significantly different.

	All Years Grazed Sites*					All Years Ungrazed Sites					2020 Entire Property
	n	D	D-LCL	D-UCL	CV	n	D	D-LCL	D-UCL	CV	D
Diamond Grove	1029	1.302	1.160	1.461	0.06	1213	1.316	1.182	1.465	0.05	-
Hi-Lonesome	948	1.373	1.053	1.791	0.13	1259	1.183	1.01	1.386	0.08	1.02
Providence / Kickapoo	1205	1.293	1.095	1.525	0.08	612	1.069	0.887	1.29	0.09	0.809, 0.71
Taberville	918	1.414	1.191	1.677	0.09	752	1.283	1.132	1.454	0.06	1.084
Wah'Kon-Tah	769	1.061	0.909	1.238	0.08	830	1.258	1.043	1.517	0.09	1.003
All Properties	4869	6.442	5.855	7.087	0.05	4666	6.108	5.679	6.571	0.04	

indicates treatment unit where density was higher, but not significantly

indicates treatment unit where density was significantly higher.

**Only Hi-Lonesome was grazed in 2018*

**Diamond Grove not surveyed in 2020*

Table 2 indicates Wah'Kon-tah had significantly higher densities of Bell's Vireo than Kickapoo while Wah'Kon-Tah had significantly higher densities in the control unit than the treatment unit. Overall trend shows most control units host higher densities of Bell's Vireo.

Bell's Vireo	All Years Grazed Sites*					All Years Ungrazed Sites					2020 Entire Property
	n	D	D-LCL	D-UCL	CV	n	D	D-LCL	D-UCL	CV	D
Diamond Grove	40	0.054	0.032	0.091	0.26	37	0.045	0.033	0.062	0.16	-
Hi-Lonesome	84	0.13	0.105	0.16	0.1	129	0.136	0.101	0.183	0.15	0.139
Providence/Kickapoo	126	0.144	0.115	0.18	0.11	14	0.027	0.014	0.053	0.33	0.158, -
Taberville	84	0.138	0.11	0.175	0.12	82	0.157	0.122	0.201	0.12	0.182
Wah'Kon-Tah	106	0.156	0.127	0.191	0.1	144	0.245	0.195	0.307	0.11	0.267
All Properties	440	0.621	0.546	0.707	0.07	406	0.61	0.518	0.717	0.08	

indicates treatment unit where density was higher, but not significantly

indicates treatment unit where density was significantly higher.

**Only Hi-Lonesome was grazed in 2018*

**Diamond Grove not surveyed in 2020*

Only 5 Bell's Vireos at Kickapoo in 2020; density = 0.114 (marked as dash though due to sample size)

Table 3 indicates most properties had higher densities of Dickcissels in treatment units but only Taberville had significantly higher values than its control unit counterpart. Wah'Kon-Tah had significantly higher densities in the control unit compared to the treatment unit.

Dickcissel	All Years Grazed Sites*					All Years Ungrazed Sites					2020 Entire Property
	n	D	D-LCL	D-UCL	CV	n	D	D-LCL	D-UCL	CV	D
Diamond Grove	566	0.74	0.647	0.847	0.07	612	0.68	0.59	0.784	0.07	-
Hi-Lonesome	242	0.362	0.29	0.454	0.11	381	0.367	0.309	0.436	0.09	0.311
Providence/Kickapoo	739	0.82	0.681	0.987	0.09	429	0.768	0.618	0.954	0.11	0.482, 0.520
Taberville	413	0.658	0.536	0.807	0.1	339	0.593	0.512	0.685	0.07	0.449
Wah'Kon-Tah	144	0.205	0.153	0.276	0.15	249	0.387	0.297	0.504	0.13	0.347
All Properties	2104	2.786	2.543	3.051	0.05	2010	2.794	0.251	3.116	0.06	

indicates treatment unit where density was higher, but not significantly

indicates treatment unit where density was significantly higher.

**Only Hi-Lonesome was grazed in 2018*

**Diamond Grove not surveyed in 2020*

Table 4 indicates all properties combined as well as most PBG sites individually had significantly greater densities of Eastern Meadowlark in the treatment units. Wah'Kon-Tah had the opposite with significantly greater values in the control unit compared to the treatment unit.

Eastern Meadowlark	All Years Grazed Sites*					All Years Ungrazed Sites					2020 Entire Property
	n	D	D-LCL	D-UCL	CV	n	D	D-LCL	D-UCL	CV	D
Diamond Grove	212	0.222	0.186	0.264	0.09	258	0.242	0.198	0.296	0.1	-
Hi-Lonesome	200	0.24	0.141	0.406	0.27	194	0.158	0.133	0.188	0.09	0.124
Providence/Kickapoo	128	0.114	0.086	0.15	0.14	51	0.077	0.052	0.113	0.19	0.038, -
Taberville	129	0.164	0.123	0.219	0.14	90	0.133	0.108	0.163	0.10	0.069
Wah'Kon-Tah	88	0.1	0.073	0.139	0.16	107	0.140	0.106	0.187	0.14	0.049
All Properties	757	0.840	0.699	1.008	0.09	700	0.750	0.662	0.849	0.06	

indicates treatment unit where density was higher, but not significantly

indicates treatment unit where density was significantly higher.

**Only Hi-Lonesome was grazed in 2018*

**Diamond Grove not surveyed in 2020*

Kickapoo only had 8 detections, d = 0.076; not reported

Table 5 indicates Field Sparrow densities were significantly greater in the treatment units of Hi-Lonesome, Taberville, Wah'Kon-Tah, and all properties combined. Kickapoo showed greater densities compared to Providence but they are not significant. Diamond Grove had an insufficient sample size for comparison.

Field Sparrow	All Years Grazed Sites*					All Years Ungrazed Sites					2020 Entire Property
	n	D	D-LCL	D-UCL	CV	n	D	D-LCL	D-UCL	CV	D
Diamond Grove	7	-	-	-	-	4	-	-	-	-	-
Hi-Lonesome	108	0.173	0.121	0.247	0.18	110	0.096	0.057	0.161	0.27	0.05
Providence/Kickapoo	35	0.042	0.028	0.061	0.2	31	0.050	0.031	0.082	0.25	0.022, 0.079
Taberville	75	0.134	0.102	0.178	0.14	53	0.084	0.06	0.118	0.17	0.12
Wah'Kon-Tah	94	0.143	0.108	0.189	0.14	48	0.067	0.015	0.104	0.22	0.11
All Properties	319	0.502	0.416	0.605	0.1	246	0.302	0.235	0.387	0.13	

indicates treatment unit where density was higher, but not significantly

indicates treatment unit where density was significantly higher.

**Only Hi-Lonesome was grazed in 2018*

**Diamond Grove not surveyed in 2020*

Table 6 indicates Grasshopper Sparrow densities were greater in the treatment units of Diamond Grove, Hi-Lonesome, Wah'Kon-Tah, and all properties combined. Only Wah'Kon-Tah's treatment unit densities were significantly greater than its control unit. Kickapoo had significantly greater densities than Providence. Taberville had insufficient sample sizes for densities to be calculated

Grasshopper Sparrow	All Years Grazed Sites*					All Years Ungrazed Sites					2020 Entire Property
	n	D	D-LCL	D-UCL	CV	n	D	D-LCL	D-UCL	CV	D
Diamond Grove	92	0.166	0.114	0.24	0.19	117	0.144	0.106	0.200	0.16	-
Hi-Lonesome	90	0.185	0.079	0.437	0.45	70	0.075	0.025	0.222	0.59	0.11
Providence/Kickapoo	12	0.018	0.007	0.047	0.49	21	0.042	0.023	0.077	0.31	-, -
Taberville	3	-	-	-	-	7	-	-	-	-	-
Wah'Kon-Tah	53	0.104	0.065	0.167	0.24	21	0.036	0.019	0.068	0.32	-
All Properties	250	0.480	0.314	0.734	0.22	236	0.311	0.219	0.44	0.18	

indicates treatment unit where density was higher, but not significantly

indicates treatment unit where density was significantly higher.

**Only Hi-Lonesome was grazed in 2018*

**Diamond Grove not surveyed in 2020*

Table 7 indicates Henslow's Sparrow densities were greater in control units than treatment units with Diamond Grove, Hi-Lonesome and all properties combined having signficantly greater densities and Taberville and Wah'Kon-Tah having insignificant differences. Providence and Kickapoo had similar densities.

Henslow's Sparrow	All Years Grazed Sites*					All Years Ungrazed Sites					2020 Entire Property
	n	D	D-LCL	D-UCL	CV	n	D	D-LCL	D-UCL	CV	D
Diamond Grove	102	0.153	0.109	0.216	0.17	167	0.243	0.184	0.321	0.14	-
Hi-Lonesome	138	0.237	0.176	0.321	0.15	234	0.295	0.228	0.383	0.13	0.186
Providence/Kickapoo	110	0.14	0.096	0.205	0.19	54	0.127	0.075	0.214	0.26	0.113, -
Taberville	169	0.31	0.231	0.413	0.14	161	0.369	0.277	0.493	0.14	0.221
Wah'Kon-Tah	256	0.42	0.341	0.516	0.1	211	0.43	0.336	0.55	0.12	0.219
All Properties	775	1.260	1.101	1.442	0.07	827	1.46	1.27	1.680	0.07	

indicates treatment unit where density was higher, but not significantly

indicates treatment unit where density was significantly higher.

**Only Hi-Lonesome was grazed in 2018*

**Diamond Grove not surveyed in 2020*

Kickapoo had only 2 detections

Table 8 indicates Northern Bobwhite density differences were only signficant between Wah'Kon-Tah units with the control having higher densities than the treatment. All properties combined, higher densities were in the treatment unit but differences are not significant. Kickapoo had insufficient sample sizes for comparison with Providence.

Northern Bobwhite	All Years Grazed Sites*					All Years Ungrazed Sites					2020 Entire Property
	n	D	D-LCL	D-UCL	CV	n	D	D-LCL	D-UCL	CV	D
Diamond Grove	22	0.014	0.009	0.023	0.24	33	0.019	0.012	0.029	0.22	-
Hi-Lonesome	77	0.057	0.041	0.08	0.17	114	0.056	0.043	0.073	0.14	0.036
Providence/Kickapoo	71	0.039	0.029	0.052	0.15	13	0.012	0.007	0.019	0.25	0.014 -
Taberville	56	0.044	0.031	0.062	0.17	38	0.034	0.021	0.053	0.23	0.035
Wah'Kon-Tah	50	0.035	0.025	0.05	0.18	61	0.048	0.034	0.068	0.17	0.031
All Properties	276	0.189	0.152	0.234	0.11	259	0.168	0.139	0.204	0.1	

indicates treatment unit where density was higher, but not significantly

indicates treatment unit where density was significantly higher.

**Only Hi-Lonesome was grazed in 2018*

**Diamond Grove not surveyed in 2020*

Kickapoo only 4 detections

Dickcissel

Grasshopper Sparrow

Bell's Vireo

Eastern Meadowlark

Henslow's Sparrow

Field Sparrow

Northern Bobwhite

Wah'Kon-Tah Prairie

Nest monitoring Results: Effects of Patch-burn Grazing on the Nesting success of Grassland Birds

Eastern Meadowlark nest

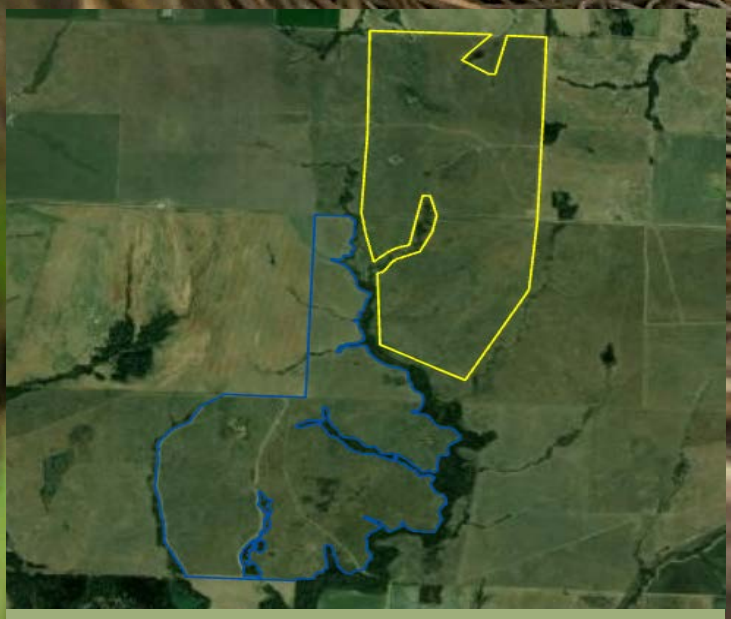

Figure 1. Taberville Prairie PBG study units: treatment (yellow) and control (blue).

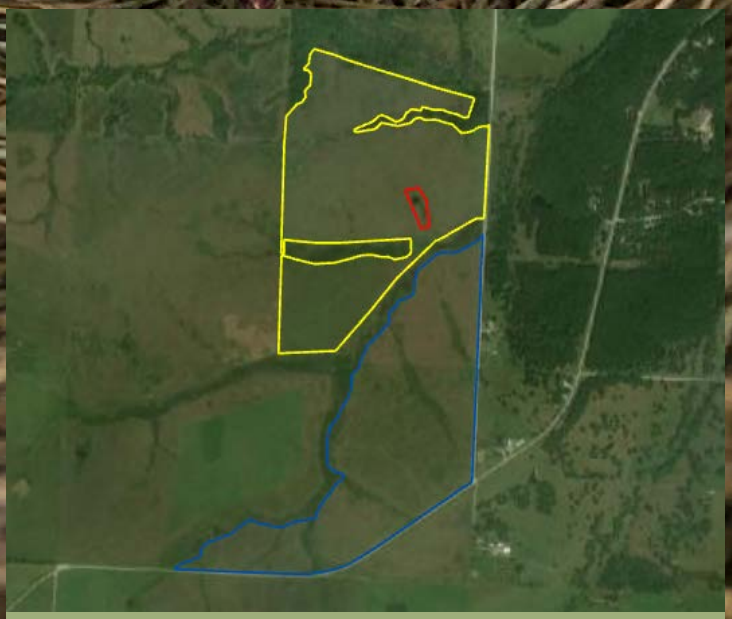

Figure 2. Wah'Kon-Tah Prairie and the PBG study units: treatment (yellow), control (blue), and internal riparian area excluded (red).

Since 2016, MRBO has been conducting a nest-monitoring study on the Taberville (2016, 2018, 2019, 2020) and Wah'Kon-Tah (2017, 2019, 2020) Prairies patch-burn grazing study units. The goal of the study is to measure the effects of patch-burn grazing management practices on nest success. There are two types of units in this study, a treatment unit and a control unit. The treatment unit typically has grazers present during the season while the control unit does not have grazers present. In addition, each unit typically has approximately one-third of its area burned every year. Therefore, for the purpose of this study, nests are categorized as either being in the treatment or control unit.

2020 Study Area Characteristics. Taberville Prairie (Figure 1) is a 1,360-acre remnant prairie located in the Upper Osage Grasslands Priority Geography and is characterized largely by native prairie (2,700 acres). Other components include warm season grass plantings, crop fields, prairie restoration, woodlots, and old fields. The PBG study area falls on the eastern side of the property and the treatment unit is approximately 199 acres while the control unit is approximately 195 acres. Wah'Kon-Tah Prairie (Figure 2) is a 3,030-acre parcel also located in the Upper Osage Grasslands Priority Geography and has other components including warm season grass plantings and wooded areas. The PBG study area falls on the northeastern side of Wah'Kon-Tah. The treatment unit is approximately 154 acres and the control unit is approximately 138 acres. All four units searched this year had ~one-third of its area burned prior to the start of the 2020 breeding season and both treatment areas had grazers present for most of the searching and monitoring season.

Methods. MRBO observers conducted nest searches at Taberville Prairie Conservation Area from the end of May until mid-July, 2016 and at Wah'Kon-Tah Prairie from mid-May until the end of July in 2017. In 2018, nest-searching went on from late-May until late-July at Taberville Conservation Area. In 2019 and 2020, both Taberville Conservation Area and Wah'Kon-Tah Prairie were searched from early-May to early-August. We note that four observers were employed on the project in 2016 and 2019, two in 2017, and three in 2018 and 2020.

Observers tried to spend equal time nest-searching in the treatment and control units, with the number of searchers in each unit varying per day to ensure search times were equal. Each unit was traversed by foot and observers focused on cues such as flushing adults, short flights, chipping adults, or adults with food or nesting material. Upon flushing a bird, observers immediately searched the area for a maximum of ten minutes to minimize disturbance. If the nest was not found during that time period, observers would return to that location later in the day or subsequent days to investigate further. Technicians primarily searched independent from one another but would occasionally search together, especially when implementing the rope-dragging technique. For this method, searchers held opposite ends of a rope that had cans dangling from portions of the rope and walked along the prairie while the rope dragged across the tops of the vegetation and the cans clanged against each other. This created disturbances that were very likely to cause any ground-nesting bird to flush from their nest when walking near them. Rope-dragging was used mainly in areas that had few sumac and other woody growth since this hardy vegetation caused the rope to snag often. In 2020, the use of a searching-pole was favored as the primary method to find nests. 10ft fishing poles were used as the searching-poles and searchers waved them to either side as they walked, mimicking the same type of disturbance the rope-dragging technique creates.

After a nest was found, they were marked electronically with spatially explicit information and marked physically by administering black, electrical tape on nearby vegetation. Photos and descriptions of nest locations were also recorded for reference. Nests were checked daily or every other day during the building stages and when close to fledging date. Nests were checked less frequently during the laying and incubation period to minimize disturbance.

Prior to 2020, only general nest fates including success, failure, unknown fate, active, and inactive were described in this report. However, detailed observations made during each nest check has allowed for a more in-depth nest fate classification than these general fates. Due to the variability of nest fates that have occurred in monitored nests, it is insightful to provide a more detailed description when sufficient information is available. 25 nest fate types have been recorded since the start of the project in 2016. Here are the descriptions for each nest fate classification:

Abandoned During Construction = Confirmed building but no further activity.
Abandoned with Cowbird Egg(s) = Active but never seen with host eggs and then a cowbird egg was found inside and no further activity.
Abandoned with Host and Cowbird Egg(s) = Active with host and cowbird egg(s) but never hatched.
Abandoned with Host Egg(s) = Active with host egg(s) but never hatched.
Abandoned with Host Young = Active with young but all nestlings appeared to starve to death.
Active when Monitoring Ended = Still active late in the season when no one was able to monitor it.
At Least One Host Species Fledged = The definition of a successful nest.
Both Host and Cowbird Fledged = One or more host young fledged as well as one or more cowbird young.
Host Egg(s) and then Cowbird Egg(s) = Active nest with host egg(s) and then cowbird egg(s) was substituted for one or more host egg, making the nest no longer have host eggs.
Host Fledged and Cowbird did not = Host young fledged while cowbird egg never hatched.
Human Disturbance Caused Failure = Vehicle drove over nest or destroyed nest substrate.
Inactive and Always Empty = An empty nest that was old but from current season.
Inactive with Cowbird Egg(s) = An old nest from current season with cowbird egg(s) inside.
Inactive with Host and Cowbird Egg(s) = An old nest from current season with cowbird egg(s) and host egg(s) inside.
Inactive with Host Egg(s) = An old nest from current season with host egg(s) inside.
Loss of Egg(s) Caused Abandonment = Active nest but after partial loss of egg(s) the nest was abandoned.
Mammal Predation = Evidence suggesting a mammal predated the nest (broken egg fragments, nest disheveled or torn, etc.).
Nest Collapsed = Weight of contents too much, precariously constructed, harsh weather dislodged placement, tipped over on its side, etc.
Nest Disappeared = Active nest that literally disappeared and could not be found. Likely a mammal removed it completely and carried it some distance.
Non-Target and not Monitored (2020) = In 2020, if a non-target nest was found it was marked in Collector application but not checked.
Only Cowbird Young Survived = Active nest that either only the cowbird egg(s) hatched or out-competed the host young and the host young died.
Reptile Predation = All eggs or young gone without disruption to nest.
Trampled by Cattle = Nest flattened and contents expired with evidence of cattle presence.
Unknown Cause of Failure = A fate that could not confidently be placed under one of the existing fate types or had a combination of failure types and the primary cause of failure could not be identified.
Unsure if Success or Failure = Could not confidently call the nest a success or a failure based on a variety of reasons like nestlings of age but no strong signs of success/failure or nest monitoring ended prematurely due to apparent inactivity.

Data analysis. R-Studio with packages library(lme4) and library(MASS) was employed to perform a Logistic Exposure analysis using PBG treatment units as covariates (Shaffer 2004). Required attribute data consisted of nest ID, status of the nest ('1' when the nest was active or fledged and '0' if the nest failed), the intervals between each day the nest was checked, and the nest's management unit. Logistic

Exposure analysis provides daily and full-cycle nest survival rates.

Target Species' nests distance to woody edge was explored as a variable affecting nest success. Using supervised classification techniques in ArcMap: Edges with mature trees surrounding the units and large riparian draws with substantial woody vegetation were classified as woody edges. Using the Near geoprocessing tool in ArcMap, the closest distance a nest was from a woody edge was obtained. Distance from woody edge bins were created and each nest was lumped into its nearest bin. Bins exist every 50m starting at 0m. For example, nests between 0m-25m are classified into the 0m distance bin, 25m-75m are considered part of the 50m bin, etc. Due to the different nesting preferences of target species, two groups were created for analysis. Eastern Meadowlarks, Grasshopper Sparrows, and Henslow's Sparrows all nest in open grasslands with no preference for woody nesting substrates and are one group. Bell's Vireos, Dickcissels, Field Sparrows, and Northern Bobwhites will often nest close to woody edges or use woodier vegetation for nest placement and are the other group.

Results. In 2020, MRBO observers spent 169 hours in the Wah'Kon-Tah control unit and 185 hours in the Taberville control unit. Observers spent 170 hours in the Wah'Kon-Tah treatment unit and 184 hours in the Taberville treatment unit. All searching took place from May 6th to August 8th. On Taberville, 124 nests were found in the control unit and 107 nests found in treatment unit. On Wah'Kon-Tah, 46 nests were found in the control unit and 69 nests found in the treatment unit, totaling to 346 nests found and monitored in 2020 (Table 1). Focusing only on finding and monitoring target species' nests resulted in greater numbers of target species' nests in 2020 compared to any previous year (Figure 3).

Of the total 346 nests monitored in 2020, 20 nest fate types were recorded (Table 2). The majority of nests were determined to have either failed due to reptile predation, successful in fledging at least one host young, or active prior to discovery. In total, from five seasons of searching, recording, and monitoring nests, MRBO technicians have recorded the fates of 1,273 nests, 911 belonging to target species. A breakdown of all 911 target species' nest fates are described in Table 3. The inclusion of detailed nest fates gives greater insight on the variables affecting grassland bird nest success. For example, our results show how Field Sparrow nests have higher rates of mammalian predation than any other target species' nests. The presence of grazers affecting grassland bird nests directly appears to be minimal. Although there is literature documenting grassland bird nest predation by cattle (Nack & Ribic, 2005), our data suggests human disturbances occurring on the grassland during breeding season negatively affects success more than cattle presence.

From the total 911 target species' nests found with described fates, 649 of them qualified for exposure analysis. The 262 nests that didn't qualify were excluded for a variety of reasons such as, never had host eggs or young during monitoring, uncertain nest fate, or the nest fate was determined upon discovery of nest (e.g., nestlings fledged upon finding, remnants of predation present). Full-cycle nest survival rates by unit type (Table 4 and Figure 4) show all species except Field Sparrow having higher survival rates in the control compared to the treatment unit. Despite Eastern Meadowlark and Henslow's Sparrow nest sample sizes not meeting the preferred sample size of at least 50 in each unit, survival rates were still calculated for comparison. Logistic exposure analysis excludes Grasshopper Sparrow and Northern Bobwhite due to extremely low sample sizes. Of analysis qualifying Grasshopper Sparrow nests, zero exist in the control unit and six exist in the treatment unit. For Northern Bobwhite nests, only one exists in the control unit and two exist in the treatment unit.

Nest initiation date, defined as the date the first host egg was laid, was

Site and Unit	Nests Monitored
Taberville	**231**
Control	124
Treatment	107
Wah'Kon-Tah	**115**
Control	46
Treatment	69
Total	**346**

Table 1. Target species' nests monitored in 2020.

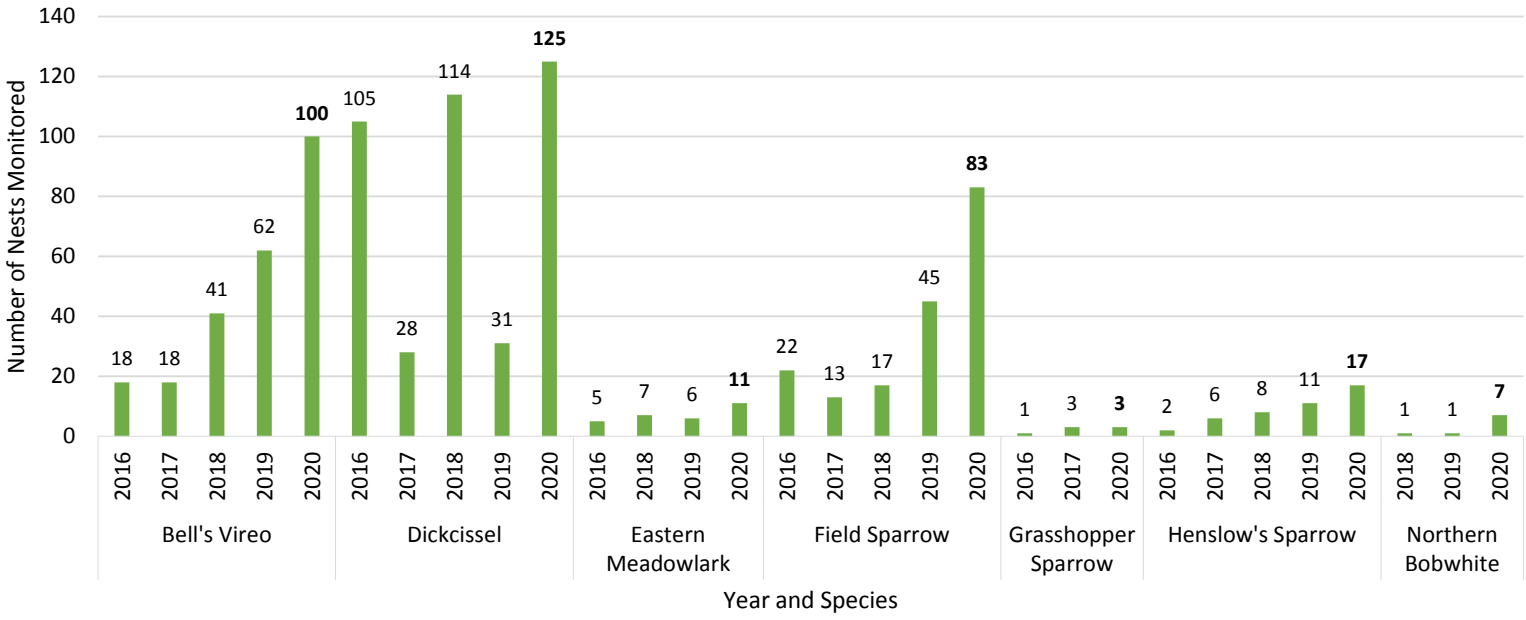

Figure 3. Number of target species' nests monitored by species and year.

initiation was the end of May (Figure 5). Nest initiation dates did not vary between treatment and control units and thus are not shown.

The open grassland nesters had the highest number of successes in the 50m-150m distance bins, with 29.11% of all nests from these species succeeding within these distances (Figure 6). The 150-m distance bin had more successful nests than failed nests with 8.86% and 5.06%, respectively. The grouping with less open grassland preferring species had the highest number of successes in the 100m distance bin with 7.22% of all nests belonging to this interval (Figure 7). Both Figures 6 and 7 show the greatest number of nests are being found in the 100m distance bin. However, the woodier preferring grassland species' group has much more evenly distributed proportion of nests than the open grassland preferring group. Both groups show scarce numbers of nests at distances of 300m and greater.

For target species' nests monitored from 2016-2020, cowbird parasitism was documented and rates of brood parasitism by Brown-headed Cowbirds are shown in Table 5. Northern Bobwhite nests are excluded due to being precocial. Out of 705 nests that could be accurately determined to have been parasitized or not, ~18% of them were parasitized. The species with the highest rate of parasitism was Bell's Vireo, with 31% in the control unit and 33% in the treatment unit. Dickcissels also had similar parasitism rates between units with 14% in the control and 16% in the treatment. Field Sparrows had higher parasitism rates in the control unit (19%) compared to the treatment unit (13%). Henslow's Sparrows had drastically different parasitism rates between the control unit (0%) and the treatment unit (22%). None of the Eastern Meadowlark and Grasshopper Sparrow nests that have been monitored have been parasitized. Brood parasitism rates as they relate to average distance to woody edge shows that for most of the target species, cowbird parasitism occurs at higher rates in nests closer to an edge than in nests further from an edge. The one discrepancy is in Dickcissels, which have higher rates of parasitism in nests further from an edge.

Species' Nest Fates 2020	Count
Bell's Vireo	**100**
Abandoned During Construction	1
Abandoned with Host and Cowbird Egg(s)	1
At Least One Host Species Fledged	25
Host Egg(s) and then Cowbird Egg(s)	1
Inactive and Always Empty	28
Inactive with Cowbird Egg(s)	4
Inactive with Host Egg(s)	7
Loss of Egg(s) caused Abandonment	6
Mammal Predation	2
Nest Disappeared	2
Only Cowbird Young Survived	1
Reptile Predation	19
Unknown Cause of Failure	3
Dickcissel	**125**
Abandoned with Host Egg(s)	5
Active	1
At Least One Host Species Fledged	29
Both Host and Cowbird Fledged	1
Human Disturbance caused Failure	1
Inactive and Always Empty	25
Inactive with Host Egg(s)	1
Mammal Predation	8
Reptile Predation	51
Unknown Cause of Failure	2
Unsure if Success or Failure	1
Eastern Meadowlark	**11**
At Least One Host Species Fledged	7
Reptile Predation	4

Species' Nest Fates 2020	Count
Field Sparrow	**83**
Abandoned with Host and Cowbird Egg(s)	1
Abandoned with Host Egg(s)	2
At Least One Host Species Fledged	20
Inactive and Always Empty	16
Inactive with Cowbird Egg(s)	1
Inactive with Host and Cowbird Egg(s)	1
Inactive with Host Egg(s)	1
Loss of Egg(s) caused Abandonment	3
Mammal Predation	6
Nest Collapsed	1
Only Cowbird Young Survived	2
Reptile Predation	26
Unknown Cause of Failure	3
Grasshopper Sparrow	**3**
At Least One Host Species Fledged	2
Reptile Predation	1
Henslow's Sparrow	**17**
At Least One Host Species Fledged	7
Inactive and Always Empty	3
Loss of Egg(s) caused Abandonment	1
Mammal Predation	1
Reptile Predation	5
Northern Bobwhite	**7**
At Least One Host Species Fledged	2
Mammal Predation	2
Unsure if Success or Failure	3
Total	**346**

Table 2. Nest fates and count by species in 2020.

Target Species' Nest Fates	Count
Abandoned During Construction	10
Abandoned with Cowbird Egg(s)	3
Abandoned with Host and Cowbird Egg(s)	4
Abandoned with Host Egg(s)	19
Abandoned with Host Young	1
Active	14
At Least One Host Species Fledged	229
Both Host and Cowbird Fledged	11
Host Egg(s) and then Cowbird Egg(s)	4
Host Fledged and Cowbird did not	3
Human Disturbance caused Failure	3
Inactive and Always Empty	169
Inactive with Cowbird Egg(s)	14

Target Species' Nest Fates	Count
Inactive with Host and Cowbird Egg(s)	3
Inactive with Host Egg(s)	16
Loss of Egg(s) caused Abandonment	22
Mammal Predation	49
Nest Collapsed	6
Nest Disappeared	3
Only Cowbird Young Survived	13
Reptile Predation	280
Trampled by Cattle	1
Unknown Cause of Failure	21
Unsure if Success or Failure	13
Total	**911**

Table 3. Target species' nest fates and count from 2016-2020.

	Treatment				Control			
Species	Sample Size	% Daily Survival	% Full Cycle Survival	SE	Sample Size	% Daily Survival	% Full Cycle Survival	SE
Bell's Vireo	63	94.8	24.8	0.0083	93	96.2	36.7	0.0053
Dickcissel	153	92.2	18.2	0.0076	134	92.5	19.6	0.0076
Eastern Meadowlark	21	94.2	22.5	0.0163	8	94.7	25.6	0.0255
Field Sparrow	83	91.7	19.4	0.0106	48	90.5	15.1	0.0148
Henslow's Sparrow	26	91.9	18.6	0.0177	11	92.3	20.1	0.0279
Target Species Combined	354	92.9	20.4	0.0046	295	93.9	24.8	0.0043

Table 4. Nest survival by species and target guild from 2016-2020.

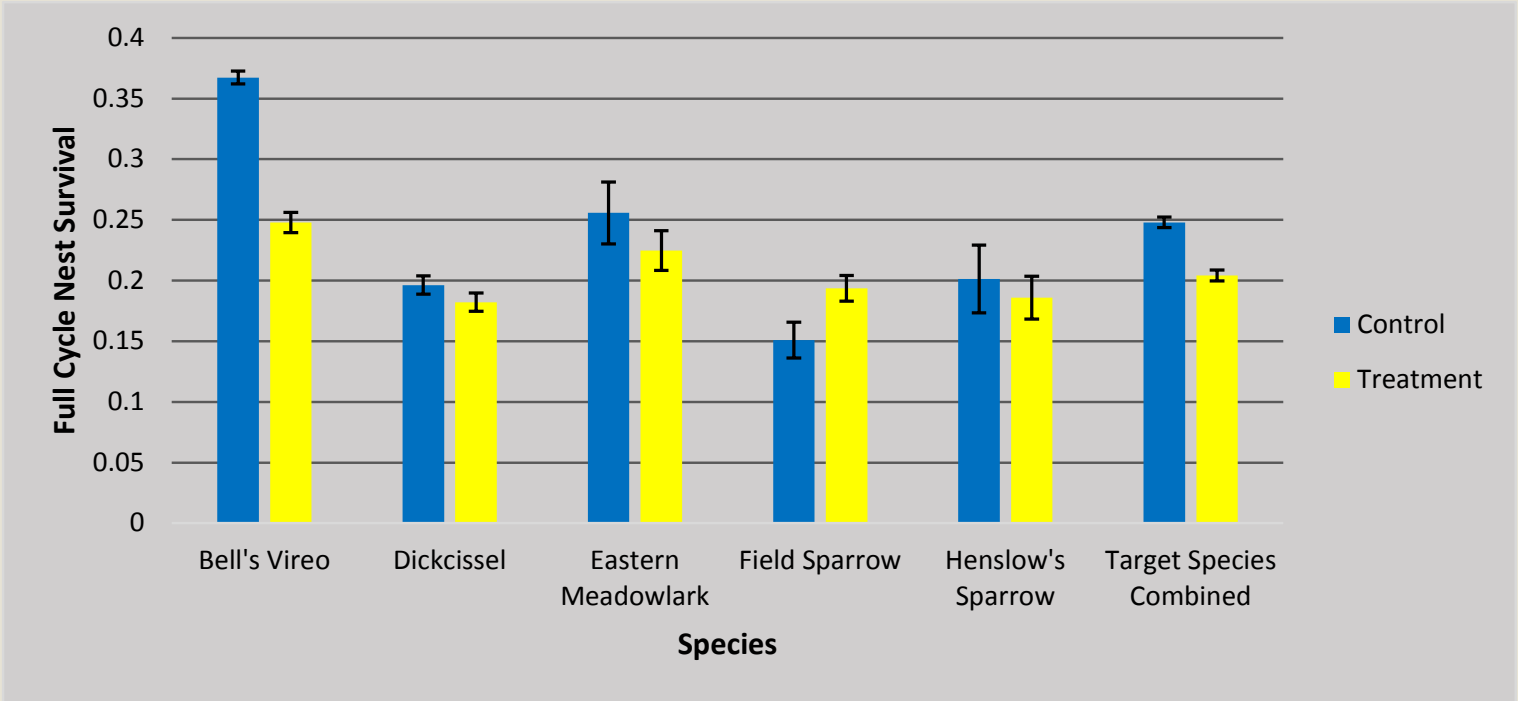

Figure 4. Full-cycle nest survival (with 95% confidence errror bars) by species and unit type from 2016-2020.

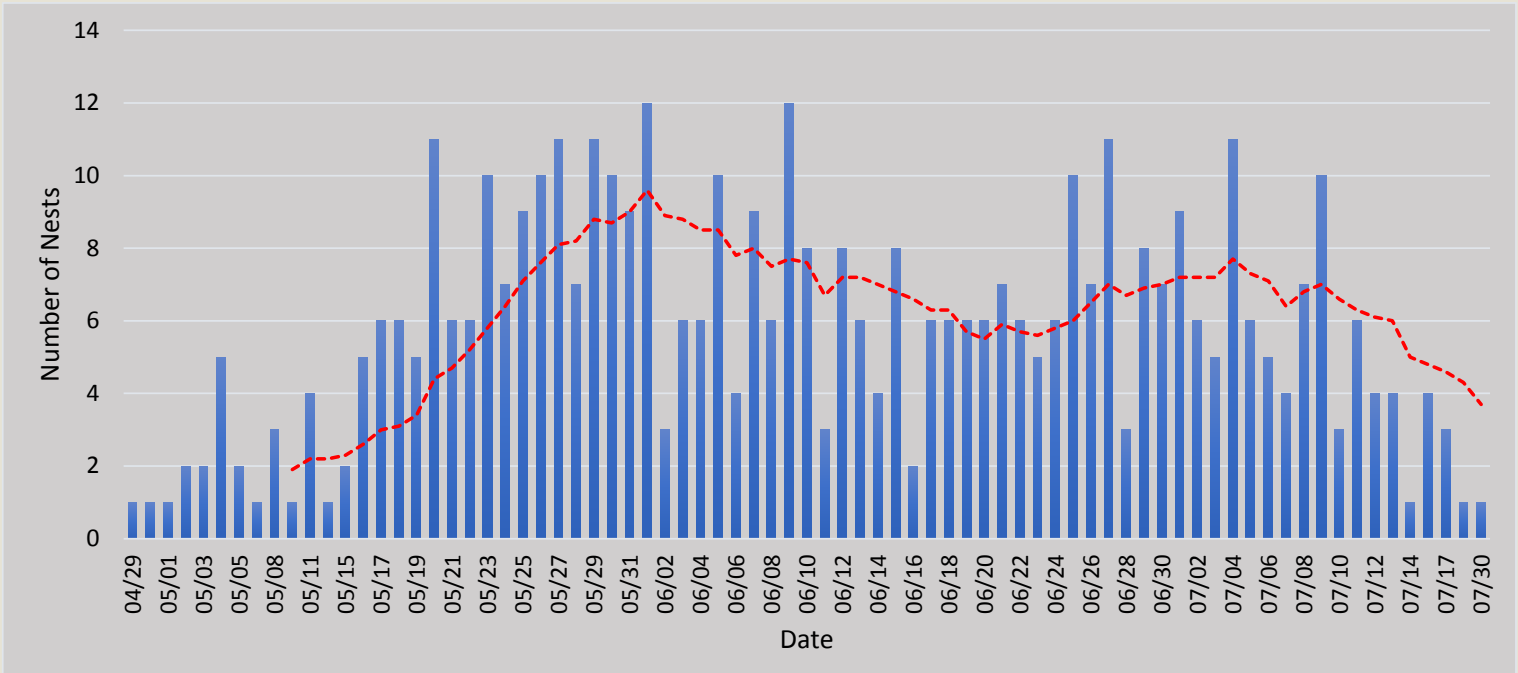

Figure 5. Nest initiation date with moving average of 10 (in red) for all target species from 2016-2020.

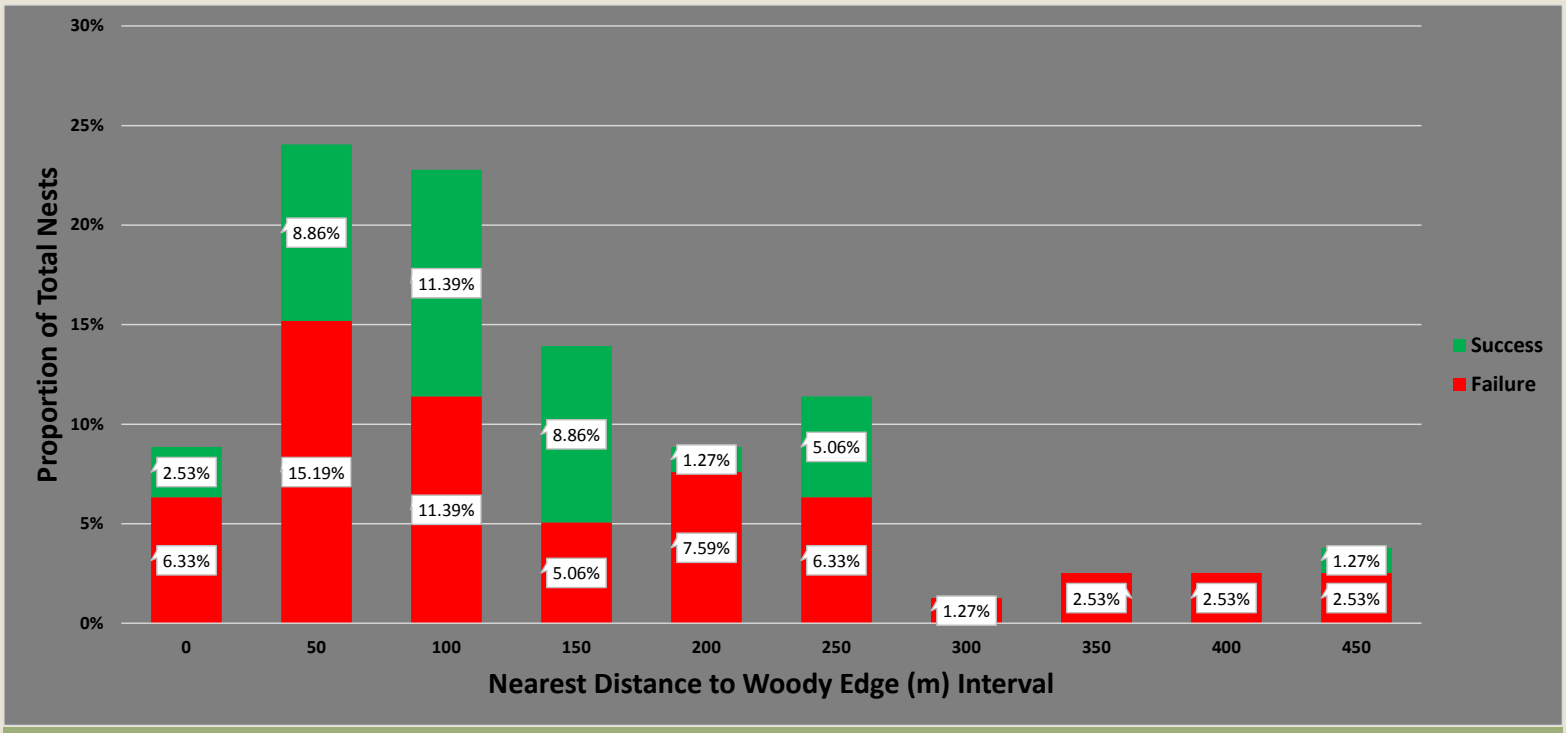

Figure 6. Nest fate of all Eastern Meadowlark, Grasshopper Sparrow, and Henslow's Sparrow nests by distance from woody edge.

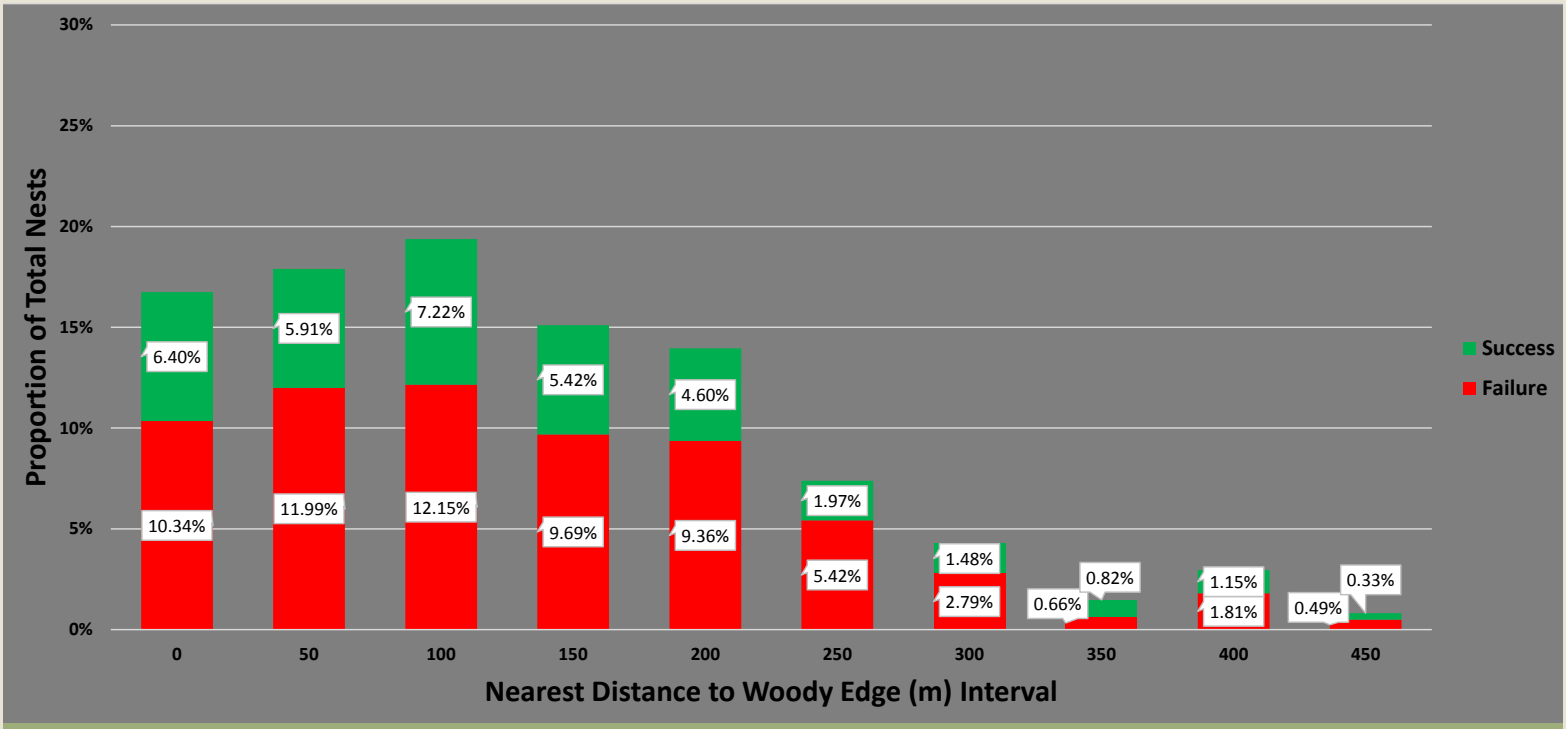

Figure 7. Nest fate of all Bell's Vireo, Dickcissel, Field Sparrow, and Northern Bobwhite nests by distance from woody edge.

DISCUSSION. The 2020 season was the first season that only target species' nests were searched for and monitored. Most of the target species' nests are harder to find than non-target species and although searching solely for target species reinforced this difficulty, our experienced and dedicated crew made this year the most productive to date in terms of number of target species' nests found. Although, it is worth noting that due to MRBO travel restrictions in response to the coronavirus pandemic, a greater percentage of our crew's time was allocated towards nest searching than in previous years.

This year was the second year that MRBO searched at both Taberville and Wah'Kon-Tah PBG study sites. Comparing the number of nests found from 2016-2018, in which only one PBG study site was searched, to those from 2019-2020, it is clear that continuing searching efforts on both sites in the future is manageable and will provide a much greater sample of nests to use in analysis. Compared to 2019, when MRBO searched both Taberville and Wah'Kon-Tah but spent twice the amount of search time at Wah'Kon-Tah, in 2020, MRBO spent roughly equal amount of time at both sites. The Taberville PBG unit has continued to show there is much more nesting activity present compared to its Wah'Kon-Tah counterpart. Not only is this trend due to the increased size of Taberville's units compared to Wah'Kon-Tah's, but it likely has to do with Taberville's units bordering landscapes favorable to grassland birds while much of the Wah'Kon-Tah unit borders mature woodlands. One observation our crews have made is that once the adjacent pastures on Taberville have been hayed there has been an increase in nesting activities in areas nearby

	Control					Treatment					Combined Units
Species	No.	Avg. Dist. to Edge	Yes	Avg. Dist. to Edge	Parasitism Rate (%)	No.	Avg. Dist. to Edge	Yes	Avg. Dist. to Edge	Parasitism Rate (%)	Parasitism Rate (%)
Bell's Vireo	71	83 m	32	66 m	31.07	48	188 m	24	125 m	33.33	32.00
Dickcissel	125	117 m	20	128 m	13.79	144	215 m	27	258 m	15.79	14.87
Eastern Meadowlark	8	128 m	0	-	0.00	21	179 m	0	-	0.00	0.00
Field Sparrow	43	92 m	10	40 m	18.87	77	147 m	11	57 m	12.50	14.89
Grasshopper Sparrow	0	-	0	-	-	6	234 m	0	-	0.00	0.00
Henslow's Sparrow	11	84 m	0	-	0.00	21	150 m	6	199 m	22.22	15.79
Total	258	102 m	62	82 m	19.38	317	188 m	68	173 m	17.66	18.44

Table 5. Target species' brood parasitism rates and distance from woody edge by unit type.

those pastures, suggesting these birds are relocating nesting efforts to areas within the PBG unit after pastures are hayed.

It is also important to address nesting activity that extends well into August. From the nest initiation graph, it is clear that many target species have active nests well into mid-August. Typically, once peak nesting season ends in mid-July, only one MRBO technician remains to search for and monitor nests into early-August. Despite Dickcissels nests being the majority of nests found in August, it might be worth having a full crew searching into August to more accurately investigate the duration of each species' nesting season as well as investigate nest survival in relation to summer senescence.

In terms of distance to woody edge being an influencing variable on nest success, nest sample size is still too low to conduct an exposure analysis. The graphs in Figures 6 and 7 are useful in showing where in relation to woody edge are grassland birds' nests being found and what is their ultimate fate at these distances. Due to sample sizes being low for nests at distances greater than 300m from an edge, one approach for analysis might be to lump all nests greater than 250m together into one distance bin. Due to the nature of the study sites, sample size of nests at closer distances from woody edges will be omnipresent.

Brood parasitism rates of Missouri grassland species have been linked to distance to woody edges (Winter et al. 2000). Our results support this trend and although the distance differences between parasitized and non-parasitized nests in target species as a guild are not that substantial (102 m vs 82 m in the control and 188 m vs 173 m in the treatment), at the species level there are greater differences. Most notably, Field Sparrow nests that were not parasitized are more than twice the distance from an edge as those that were parasitized. In the future, larger sample sizes of parasitized Eastern Meadowlark and Grasshopper Sparrow will afford analysis of distance to edge effects on brood parasitism rates for these two species which nest furthest from edges.

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Photo credits
All photos taken by MRBO field staff.

Background this page: Northern Bobwhite nest