SHARP-TAILED GROUSE RESPONSE TO FALL PRESCRIBED FIRE AND MOWING

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SUMMARY OF FINDINGS

We examined sharp-tailed grouse (i.e., sharptail, *Tympanuchus phasianellus*) responses to prescribed fire and mechanical treatment (i.e., mowing) in the fall (mid-August through November) during 2015-2017 in northwest Minnesota. We surveyed sharp-tailed grouse use at sites and measured vegetation before and after management at 9 mowing treatments and 12 prescribed burns, ranging in size from 12 to 664 ac (5–269 ha) and totaling 2,495 ac (1,010 ha). We also surveyed 17 control sites ranging in size from 19 to 460 ac (8–186 ha) and totaling 1,455 ac (589 ha) using a similar survey schedule. We surveyed sharp-tailed grouse use 0–28 (mean 8.7) days before (PRE), 1 week after (1WK), 1 month after (1MO), and 1 year after (1YR) management by conducting fecal pellet transects and documenting sharptails observed at the site. We detected sharp-tailed grouse pellets at 4 of the 21 treatment sites and 4 of the 17 control sites prior to treatment. Following treatment, sharp-tailed grouse pellets were detected in $\geq$1 fall survey (1WK or 1MO) at 13 treatment sites and 4 control sites. Sharptails were observed at only 1 treatment site and at no control sites in PRE surveys, but in later fall surveys (1WK or 1MO), sharptails were observed at 4 treatment and 2 control sites. In 1YR surveys, a naïve estimate of occupancy of sites treated in fall 2015 and 2016 was higher than before management, whereas control sites remained unchanged from pre-treatment values. Our results thus far indicate that sharptail pellets provide a more useful indicator of site use than observations of grouse, and that 1 year after management sharp-tailed grouse use is greater at treated sites than control sites. Another field season is planned to increase sample sizes and improve statistical estimation of differences in occupancy, detection, and vegetation metrics.

INTRODUCTION

Sharp-tailed grouse rely on early successional habitats of open grass and brushland. Historically, these habitats were created and maintained through periodic wildfire. More recently, fire suppression has played a role in reducing habitat for sharp-tailed grouse (Berg 1997). Prescribed fire has become an important management tool for maintaining open grass and brushland habitats, but it can be difficult to implement effectively or safely under many conditions (e.g., too wet, windy, humid, dry) and can require considerable staff and resources to execute. Thus, wildlife managers supplement prescribed burning with mechanical habitat management tools (e.g., shearing, mowing) to maintain early successional habitats. Although mechanical treatments set succession back, they may not produce the same wildlife response as fire does. Wildlife managers have expressed concern that sharp-tailed grouse are not responding to management in the way they would expect if habitat were limiting.

Fall may be a particularly important season for management because juvenile sharptails disperse to surrounding habitat in the fall. Currently, most prescribed burns on state and other lands in the sharp-tailed grouse range occur in the spring (Roy and Shartell, unpubl. data from DNR Wildlife Managers). Region 1 (R1) regularly conducts fall burning, however Regions 2 and

3 (R2/3) have not been burning in the fall because of concerns about peat fires during drier conditions and challenges mobilizing a large number of fire-qualified staff on short notice during the fall (R1 has a Roving Crew to assist with prescribed fire treatments and R2 does not). This study aims to measure the response of sharptails to prescribed burning and mechanical treatments in the fall, as compared to untreated controls.

Historically, fires occurred throughout the year and maintained early successional habitats, such as open grass and brushland, on the landscape. Grassland fires were started by lightning during the growing season, and Native Americans set fires during both the spring and fall dormant seasons in both grasslands and forests to aid hunting (see review in Knapp et al. 2009). Stand replacing fires occurred at 0-10 year intervals in grass and shrub vegetation types, and in forest and woodland types, understory fires occurred at 0-10 year intervals, with more severe, stand-replacement fires occurring at less frequent intervals in Minnesota (Brown and Smith 2000).

Native Americans referred to the sharp-tailed grouse as the “fire grouse” or “fire bird” because of their association with habitats frequently burned, and kept open, by fire. Sharptails have been shown to respond to prescribed fire treatments. Kirsch and Kruse (1973) found that the numbers of broods hatched per 100 acres was higher in 2 burned areas compared to an unburned control 1 year after spring prescribed fires. Sexton and Gillespie (1979) reported that sharptails switched leks just 2 days after a spring burn, abandoning the former dancing ground in favor of the recently burned site 480 m to the north. Sharptails have also been observed returning to leks to dance the day after a burn (J. Provost, pers. comm.).

Burn season may have an effect on the response of sharptails to prescribed fire treatments. Burns conducted in the fall might attract dispersing juveniles searching for habitat. Numerous bird species are known to be attracted to fire, smoke, and recently burned areas (Smith 2000); smoke, flames, and dark burned ground could provide strong visual cues about habitat creation and its direction from a large distance. Young sharptails disperse during September and October (Gratson 1988), typically <6 km from brood rearing areas near nest sites. Sites burned in the fall are not followed by regrowth of vegetation during winter (Kruse and Higgins 1990) and could serve as lek sites the following spring. Sharp-tailed grouse also resume dancing at leks in the fall; Hamerstrom and Hamerstrom (1951) suggested that these fall dances, which include young males, might establish leks for the following spring.

Similar long-distance cues to habitat creation and maintenance are not provided by mechanical treatments. Thus, we might expect wildlife responses to management lacking these cues to be delayed or muted. In Florida shrub-grassland, burned plots were colonized by birds sooner than the mechanically treated plots, in which shrubs were chopped (Fitzgerald and Tanner 1992); birds were observed in burned plots the next day but not for months in chopped plots. Species richness and abundance remained lower in winter chop plots than in burned and control plots throughout this study. Fitzgerald and Tanner (1992) suggested that this was because burned plots provided more complex structure than mechanically treated plots.

Sharp-tailed grouse densities and responses to management treatments have been measured with numerous methods, but pellet counts are the simplest to execute. Pellet counts along transects have been shown to be indicative of the relative abundance of sage grouse (*Centrocercus urophasianus*, Hanser et al. 2011), density of red grouse (*Lagopus lagopus scoticus*, Evans et al. 2007), and habitat use of red grouse (Savory 1978). Pellet counts along transects in plots have been used to compare sage-grouse responses to mechanical and chemical treatments (Dahlgren et al. 2006). Schroeder and Vander Haegen (2014) used pellet counts along circular transects to examine the effects of wind farms on sage-grouse.

OBJECTIVES

- To compare sharp-tailed grouse use prior to and following fall management within burn, mow, and control treatments.
- To relate vegetation metrics to differences in sharp-tailed grouse use of burn, mow, and control treatments.

Hypotheses

- Sharp-tailed grouse use will increase following burning or mowing, with burned sites showing a greater increase in sharptail use than mowed sites, and both treatments having greater sharptail use than controls.
- Vegetation composition and structure will influence the use of treatment and control sites by sharp-tailed grouse, with increased use in early successional habitats.

METHODS

Study Areas

Our study was focused in the northwest sharp-tailed grouse region of Minnesota. Treated study sites were mainly on state lands, however 1 site owned and managed by The Nature Conservancy (TNC) and 3 private land sites were included. In 2015, we conducted pre-treatment surveys at 16 sites that were planned to be managed and 15 control sites. Of these, 10 sites (6 mows and 4 prescribed burns) were treated (Table 1). In 2016 we conducted pre-treatment surveys at 9 sites that were planned for management and 6 control sites. Of these, 4 sites (1 mow and 3 prescribed burns) were treated (2016 was an unusually wet year which restricted management opportunities). In 2017, we conducted pre-treatment surveys at 13 sites that were planned for management and 8 control sites. Seven sites were managed (2 mows and 5 prescribed burns).

Data Collection & Experimental Design

Treatment sites varied in size, date of management, vegetative composition, surrounding landscape, and local sharp-tailed grouse density. We attempted to match treatments in each DNR work area or sub-work area (some work areas are very large) with a control site of similar size and successional stage (e.g., crude habitat classification, visual assessment of percent cover shrubs and herbaceous vegetation, and average shrub height) *a priori* as determined by inspection of aerial imagery, conversations with managers, and site visits. Control sites were identified $\leq$6 km from treatment sites when possible (based on dispersal distances of young males in the fall; Gratson 1988). Control sites helped account for changes related to seasonal progression (i.e., changes in habitat use, social behavior, and vegetation) not related to management. Dahlgren et al. (2006) implemented a similar design to account for temporal differences in the application of management treatments for sage grouse. However we decided that a paired analysis was inappropriate due to the difficulty to closely match treatment and control sites. Thus, beginning in 2017 we selected one control for nearby sites treated on the same day. This also provide for a more balanced sample size among the 3 treatments (control, mow, and burn).

We surveyed treatment and control sites as close as possible in time, both before and after treatment (Smith 2002, also see Morrison et al. 2001:118-130). We walked systematically spaced parallel transects with a starting point placed on the site boundary and the transect traversing the treatment capturing both edge and interior portions. The sampling rate was standardized to 10 m of transect/ac (25 m/ha), with transects at least 150 m apart, based on placement of pellet transects in other studies (Evans et al. 2007, but half as dense as Dahlgren et al. 2006, Hanser et al. 2011). We counted sharp-tailed grouse pellet piles ≤0.5 m from the transect, removing all pellets encountered (Evans et al. 2007, Schroeder and Vander Haegen 2014). At each pellet pile we recorded pellet freshness and vegetation category (i.e., grass, shrub, forb, grass-shrub mix, grass-forb mix, etc.). We also recorded all sharp-tailed grouse observed (heard, flushed, tracks seen) at the site while walking transects.

We sampled transects 4 times at each site—once before treatment, targeting measurements within 2 weeks of treatment (PRE), and 3 times after treatment; 1 week after treatment (1WK), 1 month after treatment (1MO), and 1 year after treatment (1YR). Treatment and control sites were sampled within 21 days of each other.

To adjust naïve occupancy rates for detection differences among treatment groups, vegetation categories, and other sources, we conducted pellet detection assessments. We accomplished this by surveying transects with pellets placed in known locations (but unknown to observers) and estimated detection probabilities for each vegetation and management category. Dahlgren et al. (2006) reported detectability of pellets along transects to be very high and similar in different types of vegetative cover. However, their study was conducted on sage grouse in sage brush, and sharp-tailed grouse habitats in Minnesota differ considerably in vegetative composition and structure.

We sampled vegetation within treatments using point-intercept sampling (Levy and Madden 1933, Dahlgren et al. 2006) to determine percent cover and average height of broad vegetation classes (i.e., tree, shrub, forb, and graminoid) before and after treatment. We sampled vegetation along 20-m transects placed perpendicular to the pellet transect, with the number of transects based on the size of the site. We marked the start of each vegetation transect using ground staples with numbered aluminum tags and flagging, and we used Global Positioning System (GPS) coordinates to allow re-measurement following treatment. During 2015-2016, we recorded maximum height for each vegetation class every 0.5 m for a total of 40 points per transect. After exploratory analysis of data and considering logistical tradeoffs, we reduced the amount of vegetation data collected in 2017, recording height and class every 1.0 m for a total of 20 points per transect. We used a pole with graduated measurements every dm to determine the type of vegetation intercepted (touching the pole) and the highest point at which each vegetation class touched the pole. We also recorded whether the vegetation was dead/dormant, combining those categories because it was unclear due to natural plant senescence whether vegetation was dormant or dead in late-fall surveys. Following treatment, we classified cut vegetation as dead/dormant, recorded height, and noted that the vegetation was cut. If no vegetation was present, the substrate type was recorded. For the purpose of this study, moss and lichen were considered a substrate type rather than vegetation.

Vegetation metrics were calculated for each study site. Proportion of cover in each class and mean maximum height were compared among treatment types and between sites with and without sharptail use. In our preliminary analysis, we included both live and dead vegetation, using the maximum height of either type at each point. Significant differences among survey periods were tested for using Tukey's Honest Significant Difference, and significant differences between sites occupied and unoccupied by sharptails was tested for using T-tests. For both a significance level of $P < 0.05$ was used.

RESULTS AND DISCUSSION

Sharp-tailed grouse pellets were detected on transects at 4 (19%) of the 21 treatment sites and 4 (24%) of the 17 control sites prior to treatment (Table 2). Following treatment, sharp-tailed grouse pellets were detected in ≥1 fall survey (1WK or 1MO) at 13 treatment sites (62%) and 4 control sites (24%). Sharptail observations on transects prior to treatment exhibited similar patterns, with detections at only 1 treatment site (0.05%) and no control sites (0%) in initial surveys. In later fall surveys (1WK, 1MO), however, sharptails were observed at 4 treatment sites (19%) and 2 control sites (12%, Table 3). In 1YR surveys (completed for 2015 and 2016 sites to date), we detected pellets on transects at 6 (43%) of 14 treatment sites and 3 (23%) of 13 control sites, and sharptails were observed on transects at 2 treatment sites (14%) and 1 control site (8%). Naïve occupancy of treated sites was higher 1YR later, but occupancy of control sites remained unchanged (Figure 1).

Our pellet survey results thus far suggest that our methods are capturing sharptail use of treatment and control sites. Naïve occupancy rates (i.e., site use) from data collected thus far suggest increases in sharptail use of sites following management (Figure 1). Although occupancy and detection are confounded in naïve estimates for the 1WK and 1MO surveys (due to treatment effects on screening cover), surveys conducted 1 year (1YR) following treatments should have similar detection rates to pre-treatment measurements due to regrowth of vegetation the next growing season, especially in burn sites. Thus, the PRE vs. 1YR comparison should be reasonably straightforward and informative (e.g., Figure 2), whereas results from other time comparisons are more tenuous to interpret from naïve occupancy rates. Nevertheless, demonstrating that managed sites are used after management directly addresses manager concerns.

General field observations of vegetation prior to treatment indicated that mowing might be applied to sites at a later successional stage than prescribed fire. Prior to treatment, mow sites had a lower mean proportion of grass cover, greater mean proportions of forb and shrub cover, and taller shrubs than burn sites, however these differences were not significant (Table 4). The lack of significance could be due to the low sample size and high variability among sites.

Control sites had significantly lower graminoid height in 1MO surveys than in PRE surveys, which was likely the result of vegetation senescence (Table 5). One year later, we did not detect differences in vegetation cover or height at control sites compared to pre-treatment measurements (Table 5). At sites that were mowed, graminoid, forb, and shrub cover and height were all significantly lower in 1MO surveys, but in 1YR measurements only shrub height significantly differed from PRE survey measurements. At sites that were burned, graminoid cover, forb cover, and graminoid height were significantly lower in 1MO surveys, but in 1YR surveys no differences were detected (Table 5). Sites occupied by sharp-tailed grouse did not differ in mean vegetation cover or height from unoccupied sites during PRE or 1YR surveys (Table 6).

This report includes the fall surveys for the third year of data collection (PRE, 1WK, 1MO) but not the 1YR surveys that will be conducted in fall 2018. Results presented in this report are preliminary and subject to revision. We anticipate that 5 years of data collection may be necessary to understand the complex responses of sharp-tailed grouse to fall management treatments and associated vegetation changes. Managers throughout sharptail range in Minnesota have expressed a need for this type of information to more effectively manage for sharptails. Given the current sharptail population concerns in the east-central region, information on the effectiveness of various management options would be helpful for decision-making with finite resources for management. Managers in the northwest region are also interested in this information to ensure that their management actions are as effective as possible.

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Table 1. Management activities completed for sharp-tailed grouse habitat in northwest Minnesota during fall in 2015, 2016, and 2017 and associated control sites, in order of treatment date.

Site	Work area	Treatment	Treatment date	Treatment ac (ha)	Control ac (ha)
Roseau River	Roseau River	Mow	28 Aug–16 Sep 15	31 (12.5)	28 (11.3)
Skull Lake	Karlstad	Burn	1 Sep 2015	90 (36.4)	70 (28.3)
Halma	Karlstad	Mow	16–23 Sep 2015	41 (16.6)	39 (15.8)
Red Lake Mow	Red Lake	Mow	22 Sep 2015	12 (4.9)	22 (8.9)
Spooner	Baudette	Mow	28 Sep 2015	22 (8.9)	26 (10.5)
Caribou	Karlstad	Burn	28 Sep 2015	664 (268.7)	No control
TL 2015 Burn	Thief Lake	Burn	28 Sep 2015	58 (23.5)	31 (12.5)
Red Lake Burn	Red Lake	Burn	19 Oct 2015	152 (61.5)	176 (71.2)
Prosper	Baudette	Mow	19–30 Oct 2015	63 (25.5)	201 (81.3)
TL Mow	Thief Lake	Mow	30 Oct 2015	20 (8.1)	19 (7.7)
TL 2016 burn	Thief Lake	Burn	1 Sep 2016	31 (12.5)	37 (15.0)
Noracre[a]	Roseau	Burn	14 Sep 2016	71 (28.7)	22 (8.9)
Roseau brush	Roseau	Mow	27 Sep–7 Oct 16	23 (9.3)	29 (11.7)
Espelie	Thief River Falls	Burn	3 Oct 2016	443 (179.3)	460 (186.2)
Halma 2017	Karlstad	Mow	28 Aug–8 Sep 2017	62 (25)	61 (25)
Gates	Red Lake	Burn	8 Sep 2017	388 (157)	No control
K burn	Roseau	Burn	13 Sep 2017	90 (36)	93 (38)
F burn	Roseau	Burn	13 Sep 2017	99 (40)	Same as K
Prosper 2017	Baudette	Mow	27 Sep–26 Oct 2017	70 (28)	41 (17)
O burn	Roseau	Burn	9 Oct 2017	17 (7)	100 (40)
I burn	Roseau	Burn	9 Oct 2017	48 (19)	Same as O

[a]Noracre burn was treated again (burned in spring 2017 and sprayed with herbicide in spring and summer 2017) before the 1YR survey, so it is not clear whether use in the 1YR survey was due to the burn or another treatment.

Table 2. Sharp-tailed grouse pellet detections at treatment and control sites in northwest Minnesota. Surveys were conducted before (PRE), 1 week (1WK), 1 month (1MO), and 1 year (1YR) after treatment. The number of pellet detections on transect are indicated numerically, and pellets detected off-transect are indicated with an OT, indicative of site use not captured in sampling. An asterisk indicates that snow impeded detection of pellets, and T indicates that tracks were detected in snow. Surveys with confirmed sharptail use through any source of sign are highlighted in gray. NS indicates that the 1YR survey has not yet been completed for sites managed during fall 2017.

Fecal pellets	Treatment				Control			
Site	PRE	1WK	1MO	1YR	PRE	1WK	1MO	1YR
Red Lake mow	0	0	0	2	0	0	0	1
Thief Lake mow	0	0	0*	0	0	0	0*	0
Spooner mow	0	0	2	0	0	0	0	0
Roseau 2015 mow	2 OT	1 OT	1	0	0	0	0	0
Halma mow	0	0	0	1 OT	1	1	2	0
TL 2015 burn	1 OT	0	1	1 OT	0	0	0	0
Skull Lake burn	0	1	0	1	0	0	0	0
Red Lake burn	0	0	0	0	0	0	0*	0
Prosper mow	0	1	0*	2	1	11	1T*	5 4 OT
Caribou burn	1	2	1 OT	0	-	-	-	-
TL 2016 burn	0	1	4 7 OT	7 1 OT	0	0	0	0
Noracre burn[a]	0	9 3 OT	0	3T*	0	0	0	0
Espelie burn	1	6	18 31 OT	1 3 OT	1 1 OT	1 3 OT	4 5 OT	3T* 2 OT
Roseau 2016 mow	1 OT	0	0	0	0	0	0	0
Halma 2017 mow	0	1 OT	1	NS	0	0	0	NS
Gates burn	0	3	0	NS	-	-	-	-
K burn	1 1 OT	0	7 11 OT	NS	-	-	-	-
F burn	4 1 OT	1	5 5 OT	NS	0	0	0	NS
Prosper 2017 mow	0	3T*	0	NS	0	0	0	NS
O burn	0	0	0	NS	-	-	-	-
I burn	0	0	0	NS	3 OT	1 OT	0	NS

[a]Noracre burn was treated again (burned in spring 2017 and sprayed with herbicide in spring and summer 2017) before the 1YR survey, so it is not clear whether use in the 1YR survey was due to the burn or another treatment.

Table 3. The number of sharp-tailed grouse observed at treatment and control sites in northwest Minnesota. Surveys were conducted before (PRE), 1 week (1WK), 1 month (1MO), and 1 year (1YR) after treatment. Sharp-tailed grouse observed while off-transect are indicated with OT, indicative of site use not captured in sampling. Surveys with confirmed sharptail use through observations of any birds at the site are highlighted in gray. NS indicates that the 1YR survey has not been completed for sites managed in fall 2017.

Grouse observations	Treatment				Control			
Site	PRE	1WK	1MO	1YR	PRE	1WK	1MO	1YR
Red Lake mow	0	0	0	0	0	0	0	0
Thief Lake mow	0	0	0	0	0	0	0	0
Spooner mow	0	0	11	3 OT	0	0	0	0
Roseau 2015 mow	2 OT	5 OT	2 OT	0	0	0	0	0
Halma mow	0	0	1	0	0	2	0	0
TL 2015 burn	4	0	0	0	0	0	0	0
Skull Lake burn	0	0	0	0	0	0	0	0
Red Lake burn	0	0	0	0	0	0	0	0
Prosper mow	0	0	0	1	0	0	0	12-20
Caribou burn	0	5	13	2 2 OT	-	-	-	-
TL 2016 burn	0	0	0	0	0	0	0	0
Noracre burn[a]	0	0	0	0	0	0	0	0
Espelie burn	0	1	2 OT	0	5 OT	1	7 OT	0
Roseau 2016 mow	6 OT	0	0	0	0	0	0	0
Halma 2017 mow	0	0	0	NS	0	0	0	NS
Gates burn	0	0	0	NS	-	-	-	-
K burn	0	0	0	NS	-	-	-	-
F burn	1 OT	0	0	NS	0	0	0	NS
Prosper 2017 mow	0	0	0	NS	0	0	0	NS
O burn	0	0	0	NS	-	-	-	-
I burn	0	0	0	NS	0	0	0	NS

[a]Noracre burn was treated again (burned in spring 2017 and sprayed with herbicide in spring and summer 2017) before the 1YR survey, so it is not clear whether use in the 1YR survey was due to the burn or another treatment.

Table 4. Mean pre-treatment vegetation cover and height for 4 vegetation classes at control (*n* = 17), mow (*n* = 9), and burn (*n* = 12) sites sampled for sharp-tailed grouse use in northwestern Minnesota from 2015-2017. No significant differences (P < 0.05) were observed.

	Control	Mow	Burn
Cover (proportion)			
Graminoid	0.93	0.90	0.98
Forb	0.30	0.44	0.22
Shrub	0.34	0.43	0.26
Tree	0.06	0.06	0.05
Height (m)			
Graminoid	0.52	0.53	0.54
Forb	0.33	0.37	0.28
Shrub	1.22	1.43	0.74
Tree	2.79	1.89	1.76

Table 5. Change in mean vegetation cover and height from pre-treatment to 1 month after (1MO, control *n* = 17, mow *n* = 9, and burn *n* = 12) and 1 year after (1YR, control *n* = 13, mow *n* = 7, and burn *n* = 7) at sites sampled for sharp-tailed grouse use in northwestern Minnesota from 2015-2017. Comparisons to 1YR surveys exclude sites managed in 2017. Significant differences (P < 0.05) between pre and post measurements are indicated with an asterisk.

	Control 1MO	Control 1YR	Mow 1MO	Mow 1YR	Burn 1MO	Burn 1YR
Cover (proportion)						
Graminoid	-0.03	0.00	-0.36*	-0.04	-0.43*	-0.08
Forb	-0.14	0.00	-0.36*	0.03	-0.18*	0.11
Shrub	-0.06	0.03	-0.29*	-0.12	-0.10	-0.06
Tree	-0.02	-0.01	-0.06	-0.05	-0.02	0.00
Height (m)						
Graminoid	-0.13*	-0.02	-0.39*	-0.09	-0.25*	-0.02
Forb	-0.06	0.00	-0.19*	-0.09	0.07	-0.02
Shrub	0.08	0.00	-1.20*	-0.85*	-0.03	0.03
Tree	-0.25	-0.01	-0.51	-1.29	0.19	-0.07

Table 6. Mean cover and height at sites occupied and unoccupied by sharp-tailed grouse pre-treatment (PRE, occupied *n* = 11, unoccupied *n* = 27) and one year after (1YR, occupied *n* = 13, unoccupied *n* = 14) at sites sampled for sharp-tailed grouse use in northwestern Minnesota during 2015-2017. 1YR surveys exclude sites managed in 2017. No significant differences ($P < 0.05$) between occupied and unoccupied sites were observed.

Sharptail occupancy	PRE unoccupied	PRE occupied	1YR unoccupied	1YR occupied
Cover (proportion)				
Graminoid	0.94	0.94	0.92	0.87
Forb	0.33	0.26	0.35	0.35
Shrub	0.36	0.28	0.34	0.29
Tree	0.06	0.07	0.03	0.05
Height (m)				
Graminoid	0.52	0.55	0.51	0.47
Forb	0.34	0.29	0.33	0.27
Shrub	1.15	1.03	0.99	0.87
Tree	2.03	3.32	2.27	2.27

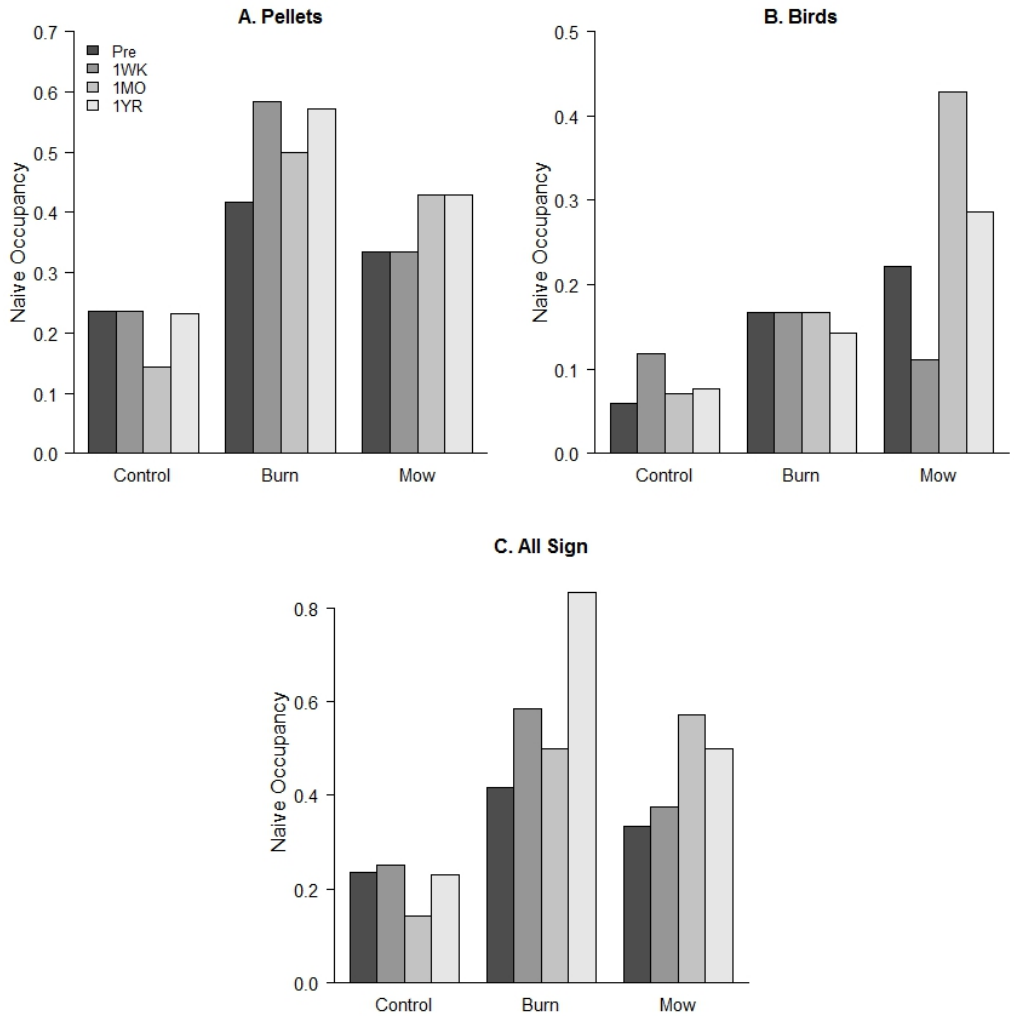

Figure 1. Naïve occupancy for sharptail pellets (A), sharptail observations (B), and all sign (includes off-transect detections, (C) during surveys conducted before (PRE), 1 week after (1WK), 1 month after (1MO), and 1 year after (1YR) treatment during 2015 and 2016 at study sites in northwest Minnesota to assess the effects of prescribed burning and mowing.

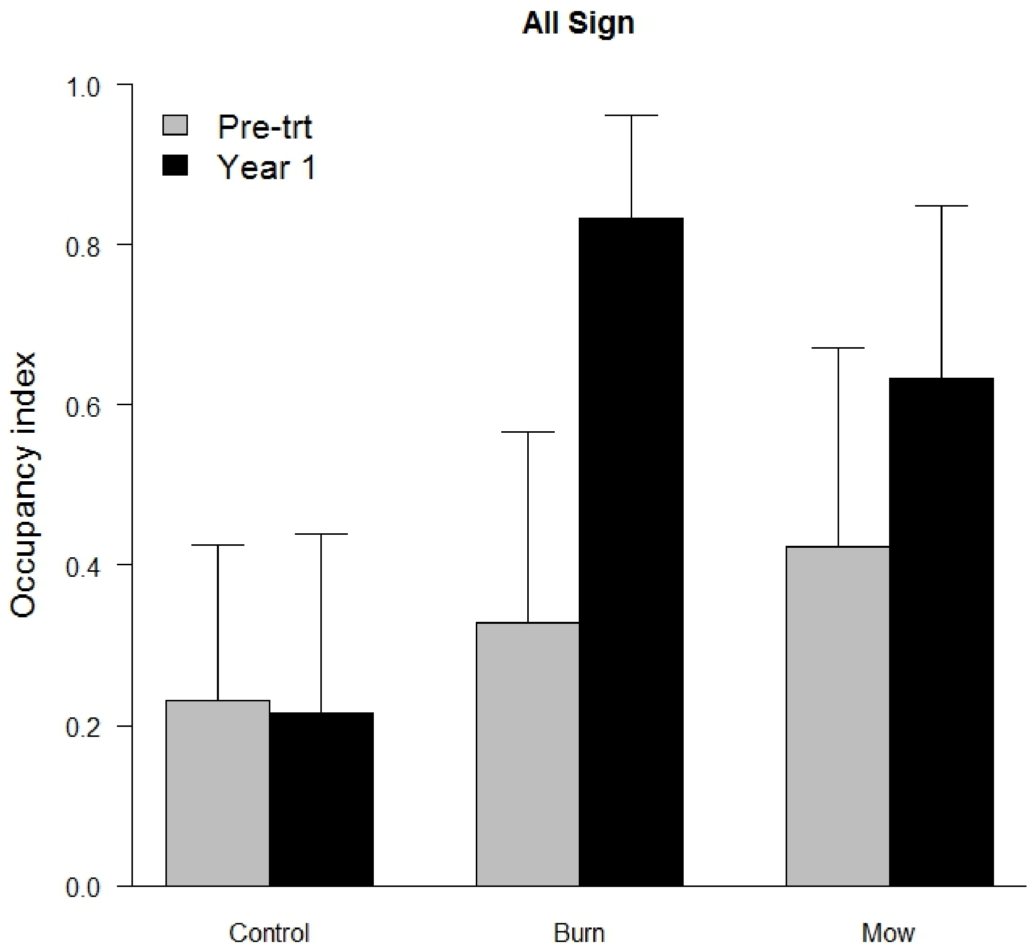

Figure 2. Mean naïve occupancy index with 85% confidence intervals at sites managed in northwestern Minnesota for sharp-tailed grouse during 2015 and 2016 based on a logistic regression model with an offset for transect length.