



NESTING AND BROOD-REARING HABITAT SELECTION AND SURVIVAL RATES OF RING-NECKED PHEASANTS IN PRAIRIE RECONSTRUCTIONS IN SOUTHWEST MINNESOTA

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SUMMARY OF FINDINGS

Ring-necked pheasant (*Phasianus colchicus*) responses to the amount of grassland on the landscape have been well documented but we lack current information on the individual components of reproductive success (e.g., nest success, brood success, chick survival) that are driving pheasant population dynamics in Minnesota. From early spring 2015 through summer 2018, we radiocollared 164 hens on 2 study sites in southwest Minnesota and monitored them during nesting and brood-rearing each year. We collected vegetation data on nest site selection and survival data on hens, nests, broods, and individual chicks each year. In 2016 and 2017, we also collected data on brood-rearing habitat selection. Video cameras were used to document nest predation events in 2015 and 2016. Preliminary descriptive findings are described within this report and final results are pending. Ultimately, our results will be used to better understand the factors that limit reproductive success of pheasants so that natural resource managers can prioritize their grassland management and land acquisition strategies.

INTRODUCTION

Ring-necked pheasant population dynamics are driven largely by variation in survival rates. Although adverse weather can impact survival rates in some years, predation is the primary cause of mortality for hens and their young (Peterson et al. 1988, Riley et al. 1998). Predator control efforts can help improve reproductive output over short time periods, but such efforts are economically and ecologically inappropriate over the long-term and at the landscape scale (Chesness et al. 1968, Riley and Schulz 2001). Management aimed at increasing pheasant populations has instead focused primarily on providing abundant nesting cover to minimize the effects of predation and maximize reproductive success. As acres enrolled in the Conservation Reserve Program (CRP) and similar cropland retirement programs decline in Minnesota, providing suitable habitat on public lands to sustain populations will become more critical for mediating the effects of predation and weather on pheasant population dynamics. However, the interaction between habitat and predation will no doubt remain. Thus, gaining new insights into the relationship between pheasant habitat selection and subsequent survival rates will be important for improving wildlife management strategies on publicly-owned lands.

Predation during the nesting season is a major factor affecting pheasant population dynamics. Nest predation is the leading cause of nest failure for many grassland-nesting birds, including pheasants (Chesness et al. 1968, Clark et al. 1999), and can limit productivity. Additionally, hens take only short recesses from incubating, which puts them at greater risk to predation during nesting (Giudice and Ratti 2001, Riley and Schulz 2001). Management efforts aimed at increasing patch size and reducing edge effects are assumed to alleviate rates of predation on birds and their nests (e.g., Johnson and Temple 1990, Sample and Mossman 1997, Winter et al. 2000); however, the composition of the landscape surrounding a patch (Clark et al. 1999,

Heske et al. 2001) and the vegetation within a patch (Klug et al. 2009, Lyons 2013, Fogarty et al. 2017) also play important roles in determining susceptibility to nest predation.

Recent advances in video camera technology have allowed better monitoring of bird nests and provided evidence that nest predator communities are more complex than previously thought (Pietz et al. 2012). In particular, the predators associated with nest depredation events can vary with the structure and diversity of nesting cover (e.g., percent cover of litter, forbs, or cool-season grasses; Klug et al. 2009, Lyons 2013). Thus, management actions attempting to mitigate the impact of predators may not necessarily reduce rates of nest predation but rather create a spatial or temporal shift in the nest predator community and susceptibility to nest predation (Benson et al. 2010, Thompson and Ribic 2012). Nest predator communities also vary across regions and habitats and results from studies of other species or in other states may not be entirely applicable to Minnesota's pheasant population (Thompson and Ribic 2012, Benson et al. 2013). Understanding how management at the site level (e.g., vegetation structure, composition, and diversity) impacts the dynamics of nest predation is an important but as of yet unintegrated step in our ability to manage habitat for increased productivity of pheasants and other grassland birds (Jiménez and Conover 2001).

Chick survival is also a vital component of pheasant population dynamics but it remains poorly understood (Riley et al. 1998, Giudice and Ratti 2001). Assessing the causes of pheasant chick mortality has been difficult because many previous studies have relied on estimates of brood survival (e.g., the proportion of broods in which ≥ 1 chick survived to a certain age) rather than survival of individual chicks within a brood (e.g., Meyers et al. 1988, Matthews et al. 2012; but see Riley et al. 1998). Using brood survival estimates is likely unreliable because brood mixing can occur (Meyers et al. 1988; N. Davros, unpublished data). Further, lack of data on individual chicks (e.g., body condition, cause of death) prevents us from understanding the role of different factors (e.g., exposure, food limitation, predation) that leads to variation in recruitment. Evidence that predation is the leading cause of chick mortality for grassland gamebirds in North America is well established (e.g., Riley et al. 1998, Schole et al. 2011). Food availability has been implicated as an important factor explaining chick survival for many gamebird species in Europe (Green 1984, Hill 1985, Potts 2012); however, strong evidence that food is a major limiting factor for survival of chicks in North America is still lacking. Moreover, food availability and rates of predation likely interact in relation to vegetation structure and composition and confound conclusions from chick survival and food resource studies (Hill 1985). Finally, death from exposure has been shown to decrease chick survival rates, especially after periods with increased precipitation when chicks are still very young and unable to fully thermoregulate (Riley et al. 1998, Schole et al. 2011). Risk of exposure and starvation may interact to decrease chick survival, but few studies have been able to directly address this question (but see Riley et al. 1998). Therefore, additional data are needed to understand the interplay between these potential limiting factors on brood habitat selection and chick survival in different grassland habitat types within Minnesota's pheasant range.

Minnesota Department of Natural Resources (MNDNR) wildlife managers in the farmland region have indicated a need for more information on pheasant nesting, brood habitat suitability, and chick survival in relation to management activities. Indeed, better understanding the factors that limit brood production and chick survival will help natural resource agencies prioritize their management strategies at both the local (e.g., forb interseeding or other grassland reconstruction activities) and landscape (e.g., acquisition priorities) levels in the face of reduced CRP acreages. Additionally, obtaining data on individual components of pheasant population dynamics will aid in future assessment of MNDNR management activities [e.g., Prairie Plan implementation (Minnesota Prairie Plan Working Group 2011), conservation grazing] and

agricultural land use practices (e.g., cover crops, pesticide use) on Minnesota's pheasant population.

OBJECTIVES

Our overall objective is to evaluate the relative importance of within-patch diversity (e.g., sites dominated by cool-season grasses, warm-season grasses, and high diversity grass-forb mixtures) within Wildlife Management Area (WMA) project areas on pheasant productivity. Specifically, we will:

1. Evaluate pheasant nest site selection and nest, brood, chick, and adult hen (hereafter, hen) survival in relation to vegetation cover and composition.
2. Evaluate pheasant brood-rearing habitat selection in relation to vegetation cover and composition.
3. Evaluate the relative importance of different factors (e.g., vegetation, predation, weather) on nest, brood, chick, and hen survival.

Results from a pilot study during the 2015 breeding season allowed us to refine methods and protocols for the study's expansion during 2016-2018. Data collection, analysis, and interpretation are still underway. Therefore, we present preliminary results here.

STUDY AREA

Our study is being conducted in the southwest region of Minnesota, a core region of the state's pheasant range. Topography ranges from flat to gently rolling. This region is intensively farmed, and corn and soybeans combined account for approximately 75% of the landscape (U.S. Department of Agriculture 2013a, U.S. Department of Agriculture 2013b). Grassland habitats, including those on private land [CRP, Reinvest in Minnesota (RIM), Conservation Reserve Enhancement Program (CREP), and Wetlands Reserve Program (WRP)] and public land [MNDNR Wildlife Management Areas (WMA) and U.S. Fish & Wildlife Service (USFWS) Waterfowl Production Areas (WPA)] account for 6.3% of the landscape in this region (Davros 2016).

For our study sites, we selected 2 WMA project areas representing the grassland/wetland habitat complexes that are a goal of the Prairie Plan (Minnesota Prairie Plan Working Group 2011) and the Pheasant Summit Action Plan (MNDNR 2015). Each study site is about 9 mi² in size and contains extensive amounts of permanently protected grassland habitat. The Lamberton WMA study site (Redwood County) is a large, nearly contiguous WMA complex with >1,100 acres of permanently protected upland and wetland habitats. The Worthington Wells study site (Nobles County) has >1,500 acres of permanently protected habitat that spans multiple WMAs, the Okabena-Ocheda Watershed District, and USFWS lands.

METHODS

Data Collection

We captured hen pheasants in each study site during 6 time periods: 2 February – 15 April 2015, 7 October – 11 November 2015, 11 January – 29 April 2016, 26 September – 15 November 2016, 18 March – 14 April 2017, and 18 September – 11 October 2017 (hereafter referred to as spring 2015, fall 2015, spring 2016, fall 2016, spring 2017, and fall 2017, respectively). We used 2 capture techniques: baited walk-in traps and netting via nighttime spotlighting from a 6-wheel utility-task vehicle (UTV). Each hen was weighed to the nearest 5.0 g, measured on the right tarsus to the nearest 0.5 mm, banded with a uniquely numbered aluminum leg band, fitted with a 16.0-g necklace-style VHF radiotransmitter with integrated

mortality switch (Advanced Telemetry Systems (ATS), Isanti, MN), and released at the site of capture.

We began radiotracking hens 3-5 times per week in late April each year to determine the onset of incubation. We assumed incubation had begun when a hen's radio signal was projected from the same location for several consecutive days. We flushed each hen from her nest once between incubation day 5-20 to determine clutch size and floated 3-5 eggs to estimate hatch date (Westerskov 1950, Carroll 1988). We marked the location of nests using a global positioning system (GPS) receiver. We also placed flagging ≤ 5 m from nests to aid relocation efforts. If a hen began making large daily movements prior to being flushed, we assumed nest failure and waited for the hen to resettle and begin incubating again before attempting another flush. We used the homing technique on radiocollars emitting a mortality signal to retrieve the collars and determine a fate. We used the presence and condition of any bodily remains and the condition of the radiocollar (e.g., teeth marks, feathers plucked, body intact but frozen, frayed collar, missing crimp) and nearby evidence (e.g., predator scat, den site) to determine survival status (e.g., mortality vs. unknown) and assign a potential cause of death (e.g., predation, human/machinery, weather), if applicable.

During 2015 and 2016 only, we placed miniature color video cameras (GE 45231 MicroCam Wired Color Camera, Louisville, KY) at a random subset of nests in an attempt to document nest predation events (Cox et al. 2012). Cameras were placed at nests at the same time that hens were flushed to float eggs, and our total time near the nest was ≤ 20 min. We placed cameras 1-5 m away from the nest bowl at a height of approximately 0.3 m. Cameras had infrared light-emitting diodes (LEDs) to allow recording at night and were connected via a >20 m cable to digital video recorders (DVRs; Model MDVR14H, Super Circuits, Austin, TX) with SD memory cards for video storage and deep-cycle marine batteries for remote power. The DVRs and battery equipment were housed in waterproof containers located >20 m from nests. Video footage was reviewed and relevant video clips were archived.

Near the estimated hatch date of known nests, we monitored hen activity 2-3 times daily to pinpoint a hatching event. We assumed hatching was occurring when a hen's signal fluctuated in intensity (Riley et al. 1998). We captured 1-3 chicks by hand between day 0-2 (day 0 = hatch day) once the hen and her brood had moved away from the nest. We used 2 techniques to capture chicks. The first technique involved flushing the hen from her brood and using a decoy and playback to call chicks to us while we hid in the grass. The second technique involved flushing the hen from her brood just before sunrise during brooding and capturing chicks by hand as they scattered. We never captured more than 50% of the brood at one time. We also never kept the hen away from her remaining brood for >30 minutes to minimize risk of hypothermia for the uncaptured chicks. We discontinued chick capture attempts for a particular brood if we were unsuccessful at capturing any chicks by the end of day 2.

We transported captured chicks in a small cooler or waist belt heated with hand-warmers to a nearby field truck for processing. We determined the mass of each chick to the nearest 0.1 g and we measured tarsus length to the nearest 0.5 mm before suturing a 0.65-g backpack-style VHF radiotransmitter without mortality switch (ATS, Isanti, MN) to the chick's back (Burkpile et al. 2002, Dahlgren et al. 2010). Handling time lasted <5 min per chick and all captured chicks were returned to the hen within 30-60 min of capture. We followed the methods of Riley et al (1998) to return chicks to the hen.

We triangulated hens and their broods 2-3 times daily ≥ 3 times per week. Each bearing-coordinate pair was taken ≥ 100 m from target hens and their broods to reduce disturbance. We used specialized computer software (LOAS, Ecological Software Solutions LLC) to generate estimated locations from bearing-coordinate pairings. We monitored hens and their broods via

triangulation through the first 4 weeks post-hatching. On day 14 and day 30, we flushed the hen just before sunrise to determine brood status and size.

To estimate individual chick survival, we listened for the signal of each radiomarked chick every 1-3 days in conjunction with monitoring the hen. We relied primarily on fluctuation in the chick's signal to determine survival status, as backpack transmitters were too small to accommodate a mortality sensor. If the signal indicated that the chick was not moving, we used the homing technique to locate the transmitter and we searched the area for a carcass and any evidence for a cause of death.

We collected vegetation data at the nest site within 7 d of hatching for successful nests. For nests that failed, we also collected vegetation data at the nest site ≤ 7 d after the estimated hatch date. At each nest site, we visually estimated percent cover (Daubenmire 1959) of the upper canopy [i.e., grasses, forbs, woody vegetation, and other (e.g., logs, rocks)] using a 0.5 m² sampling quadrat. We estimated percent cover using 8 classes: 0%, 1-10%, 11-25%, 26-50%, 51-75%, 76-90%, 91-99%, and 100%. We separately estimated the cover of the ground layer (i.e., litter and bare ground) using the same 8 classes. We estimated litter depth to the nearest cm and we counted the number of grass and forb species to determine species richness within the quadrat. We also recorded visual obstruction readings from 4 m away at a height of 1 m (VOR; Robel et al. 1970) in each of the 4 cardinal directions to determine the vertical density of vegetation to the nearest 0.5 dm around the nest. Finally, we recorded the maximum height of live and standing dead vegetation within 0.5 m of the Robel pole. We repeated these sampling efforts at 2 random locations within 15 m of the nest site.

To evaluate brood habitat selection, we collected vegetation data at 5 brood locations estimated via triangulation and 10 random points outside but within 100 m of each brood's biweekly home range. Biweekly home ranges were generated twice for each brood: one home-range for the first 2 weeks of age and a second home-range for age 3-4 wk. For broods not surviving a 2-wk observation window, home ranges were generated and vegetation sampled if the brood survived for the first 7 d of the observation window. We used a Geographic Information System (GIS; ArcMap 10.2, ESRI, Redlands, CA) to estimate each biweekly home range using the minimum convex polygon tool. We generated a 100-m buffer around each home range polygon and generated random points within that buffer to identify the 10 random points for sampling. We restricted the selection of random points so that they were within the same habitat type (e.g., grassland). Any estimated brood locations or generated random points falling in habitat types other than grassland (e.g., row crop, wetlands, woodlots) were not sampled. Road right-of-ways were considered as available grassland habitat and included in sampling efforts. We collected vegetation data within 7 d of the end of each biweekly interval. At each estimated brood point, we sampled 1 center point and 3 equidistant points 10 m to the north, southwest, and southeast to capture the spatial variation associated with a brood location (i.e., hens and their broods are mobile and thus distributed around a point). We estimated percent canopy cover, litter depth, species richness, VOR, and maximum height of live and dead vegetation using the same methods described above for nest site selection. We repeated this sampling scheme at each of the 10 random points associated with each brood's biweekly home range. If a hen and her brood spent more than 50% of their time in habitat other than grassland (as defined above), we did not sample vegetation for that home range and associated random points. If a hen with a similar-aged brood had a home range that overlapped with another hen, we only sampled 5 additional random points associated with that second brood's home range.

Data Analyses

To date, we have conducted preliminary analyses on hen and nest survival. We also calculated basic descriptive statistics for nest site selection. Preliminary and final data analyses were

ongoing at the time of this report; thus, not all analyses have been included here and not all research objectives are addressed below.

We conducted a preliminary survival analysis to evaluate hen survival during the nesting and brood-rearing phases (15 April – 15 October; hereafter, breeding season) only. For hens captured between spring 2015 and spring 2017, we estimated cumulative survival using a Kaplan-Meier analysis approach in R v3.3.2 (R Core Team, 2016). The Kaplan-Meier approach assumes a known fate for each individual. As such, 36 individuals were censored at various intervals during the analysis period because they were reported missing and not relocated or their fate was otherwise unknown (e.g., slipped or failed radiocollar). We also excluded 35 individuals with capture and mortality or censor events occurring outside of the analysis period from this particular analysis.

Using 2015-2017 data, we conducted a preliminary nest survival analysis using the logistic-exposure method (Shaffer 2004) to estimate daily survival rate (DSR) of nests. We used a constant survival model (PROC GENMOD; SAS v9.3; SAS Institute, Cary, NC) which assumes that survival is constant across time and does not include any nest-specific explanatory variables.

RESULTS and DISCUSSION

We radiocollared 164 hen pheasants during the 6 trapping periods across our 2 study sites from spring 2015 through fall 2017. The baited walk-in traps were not a productive capture technique. We speculate that pheasants were not motivated to use bait due to mild winter conditions with above-average food availability each year. Only 3 hens were captured using the walk-in traps (2% of total hen captures) whereas 161 hens (98%) were captured by spotlighting. We ended spotlighting capture efforts at the onset of the nesting season, which limited our ability to increase sample sizes. In the future, we would consider using baited walk-in traps in late winter if weather conditions were severe enough to warrant this method. Winter conditions are considered severe for pheasants when snow is ≥ 6 inches deep and temperatures reach $\leq 0^\circ$ F.

From 2015-2017, cumulative survival for hens during the breeding season (183-day period pooled across years) across study areas was 0.72 ($n = 94$; CI: 0.64-0.82; Figure 1). During the 3 breeding seasons, 55% of marked individuals ($n = 51$) suffered a known mortality event. Of these mortality events, 94% were attributed to predation events, 6% to human causes (specifically, vehicle collision and agricultural equipment), and $<1\%$ to research-related marking. Although the Kaplan-Meier survival method provides a quick estimate of hen survival, the strict assumptions of this model may be inappropriate given our dataset. Because nearly 28% of individuals were censored during this analysis due to unknown fates (in particular, slipped radiocollars), our subsequent survival analyses will use methods that include expert knowledge to incorporate uncertainty in fate to refine survival estimates (Walsh et al. 2018).

We monitored 99 potential nesting attempts during the 2015-2017 seasons. We excluded 12 nests from analysis due to various reasons (e.g., hen abandoned after initial flushing event, nest area flooded prior to researcher's visit and actual nest bowl was never found). The remaining 87 nests provided 657 observation intervals and 1,244 exposure days for analysis (Shaffer 2004). Overall, DSR was 0.9777 ± 0.20 (range: 0.9674-0.9848) which results in a 59.5% overall nest success rate when extrapolated to a 23-day incubation cycle. Our nest success rate is comparable to the rate found by Clark et al. (2008) in their study of a large, contiguous grassland landscape of northern Iowa. Although the relationship between landscape fragmentation and nest success cannot be automatically inferred across study areas or regions (Benson et al. 2013), our results lend further support to the idea that landscapes with large amounts of grassland cover can benefit pheasant nest productivity in the upper Midwest. We used a constant survival model for our initial analyses; however, future analyses will examine

the role of vegetation, spatial (e.g., distance to edge), and temporal (e.g. nest age, ordinal date, year) covariates on nest DSRs. In particular, time-specific patterns of nest survival have been documented in several duck and passerine species (Grant et al. 2005, Grant and Shaffer 2012) and such analyses are likely more appropriate for pheasants given their long nesting cycle and extended breeding seasons.

During 2015 and 2016 only, we placed video cameras on approximately 40% of nests each year. Most hens were tolerant of cameras but a few hens did abandon their nests. However, these hens may have abandoned due to our other research activities (specifically, being flushed to float eggs too early in incubation) rather than the presence of the camera itself. We potentially captured 2 predation events on camera in 2016 but the video qualities were low due to obstruction from vegetation and windy conditions, which greatly reduced our ability to clearly view activity at the nests. One notable observation included a rooster visiting a hen at her nest almost daily during late incubation. Although all nests were visible when cameras were first placed, the rapid growth of vegetation during the nesting cycle quickly impacted our ability to view nest contents or activities in the immediate area. Windy conditions often compounded our inability to review camera footage by causing vegetation to blow in front of the camera. In the future, we would consider using cameras to document nest predation events but we would alter our camera set-up (e.g., distance to nest, height of camera) to reduce the impact of vegetation and wind on the quality of the footage.

We captured and radiomarked 84 chicks between day 0-2 during the 2015-2017 breeding seasons. During the 2016 and 2017 field seasons only, we recaptured 3 chicks between day 12-15 and replaced their 0.65 g transmitters with sutured 1.1-g backpack-style transmitters (ATS, Isanti, MN). Recapturing radiomarked chicks at this age was relatively easy and may be a viable option to replace lighter transmitters with heavier ones that have a longer battery life, thereby allowing monitoring of chicks beyond 4 wk of age in future work. We attributed known fates ($n = 38$) as follows: 32% died due to predation, 26% died from exposure, 24% of chicks died due to unknown causes, 11% died due to human-induced causes (specifically, agricultural operations, vehicle collisions, and researcher activities), and 8% survived beyond 30 days. Similar to our hen survival analyses, our future chick survival analyses will use methods that incorporate expert knowledge about uncertain fates to refine estimates (Walsh et al. 2018).

During 2015-2017, we collected vegetation data from 90 nest sites. We calculated means and standard errors (SE) for 2 groups of comparisons: nest sites versus random points (Table 1), and successful versus depredated nests (Table 2). We included all nests regardless of nest fate (e.g., successful, depredated, abandoned, other failure) for the comparison of nest sites versus random points. Percent cover of forbs was similar between nest sites and random points ($\bar{X} \pm SE = 16.4 \pm 2.10\%$ vs. $20.8 \pm 2.40\%$, respectively; Table 1, Figure 2a); however, successful nests had more than twice as much forb cover compared to depredated nests ($18.8 \pm 3.01\%$ vs. $8.3 \pm 2.97\%$, respectively; Table 2, Figure 2b). The percent cover of standing dead vegetation was greater at nest sites compared to random points nearby ($15.0 \pm 1.36\%$ vs. $9.9 \pm 1.06\%$, respectively) but hatched nests and depredated nests had similar amounts of standing dead cover ($15.1 \pm 1.54\%$ and $13.2 \pm 4.20\%$, respectively). Vertical density of the vegetation, as measured by VOR, was similar between nest sites and random points (5.2 ± 0.21 dm vs. 5.3 ± 0.22 dm, respectively; Figure 3a) yet successful nests had greater vertical density compared to depredated nests (5.4 ± 0.26 dm vs. 4.5 ± 0.60 dm, respectively; Figure 3b). Although preliminary, these findings have practical implications for wildlife management activities. For example, previous MNDNR research found that neither burning nor mowing were successful management techniques for increasing forb diversity in warm-season grass-dominated stands (Davros et al. 2014), yet our results show that forb cover is positively associated with pheasant nest success. Therefore, managers should consider other options for increasing forb cover in

prairie reconstructions to benefit pheasants. Additionally, we found that hens selected nest sites with more standing dead canopy cover, which is especially important for visual concealment early in the nesting season, and they were more successful when nests had greater vertical density, which is also assumed to provide visual concealment. However, recent studies suggest that increased structural heterogeneity of the vegetation may better conceal nests from olfactory-based nest predators (Fogarty et al. 2017, Fogarty et al. 2018). Management actions that create vegetation that provides both visual and olfactory concealment may be key to creating more productive nesting habitat.

We monitored 55 broods for survival during the 3 years of our study. During 2016-2017 only, we collected vegetation related to brood habitat selection for 40 broods. We continued to monitor each brood until 4 wk of age or until complete brood loss, whichever came first. We documented at least one hen who re-nested after losing her brood between 1-2 wk of age. Although rare, other researchers have also documented second brood attempts after early losses of first broods (Dumke and Pils 1979; A. Annis and T.J. Fontaine, personal communication; T. Bogenschutz, personal communication; T. Lyons, personal communication).

The final results from this study will relate pheasant survival rates to nesting and brood-rearing habitat selection. Ultimately, the information gained will help managers better understand factors that may limit pheasant productivity so that they can prioritize their management activities in an era of reduced grassland habitat on the landscape.

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Table 1. Descriptive statistics for vegetation surveys at sites used for nesting by ring-necked pheasant hens and nearby random points (≤ 15 m away) as a comparison in southwest Minnesota during the 2015-2017 breeding seasons.

	Nest sites ($n = 90$)		Random points ($n = 90$)	
	Mean	SE	Mean	SE
% Canopy cover				
Grasses	40.3	2.80	42.9	2.49
Forbs	16.4	2.10	20.8	2.40
Standing dead	15.0	1.36	9.9	1.06
Species richness				
Total	4.0	0.27	4.5	0.28
Grasses	1.8	0.10	1.9	0.09
Forbs	2.2	0.23	2.5	0.23
Maximum height (cm)				
Live vegetation	53.1	4.74	57.2	5.21
Dead vegetation	56.9	6.64	44.8	4.60
Litter depth (cm)	2.9	0.31	4.2	0.29
Vertical density (dm) ^a	5.2	0.21	5.3	0.22

^aVertical density is the average visual obstruction reading (VOR) as determined by using a Robel pole.

Table 2. Descriptive statistics for vegetation surveys at successful versus depredated nest sites of ring-necked pheasants in southwest Minnesota during the 2015-2017 breeding seasons.

	Successful nests (<i>n</i> = 52)		Depredated nests (<i>n</i> = 17)	
	Mean	SE	Mean	SE
% Canopy cover				
Grasses	41.1	3.42	43.0	8.35
Forbs	18.8	3.01	8.3	2.97
Standing dead	15.1	1.54	13.2	4.20
Species richness				
Total	4.3	0.37	3.8	0.63
Grasses	1.9	0.13	1.8	0.22
Forbs	2.4	0.30	1.9	0.62
Maximum height (cm)				
Live vegetation	53.1	6.56	63.7	7.73
Dead vegetation	55.2	8.42	50.2	12.80
Litter depth (cm)	2.5	0.28	3.0	0.47
Vertical density (dm) ^a	5.4	0.26	4.5	0.60

^aVertical density is the average visual obstruction reading (VOR) as determined by using a Robel pole.

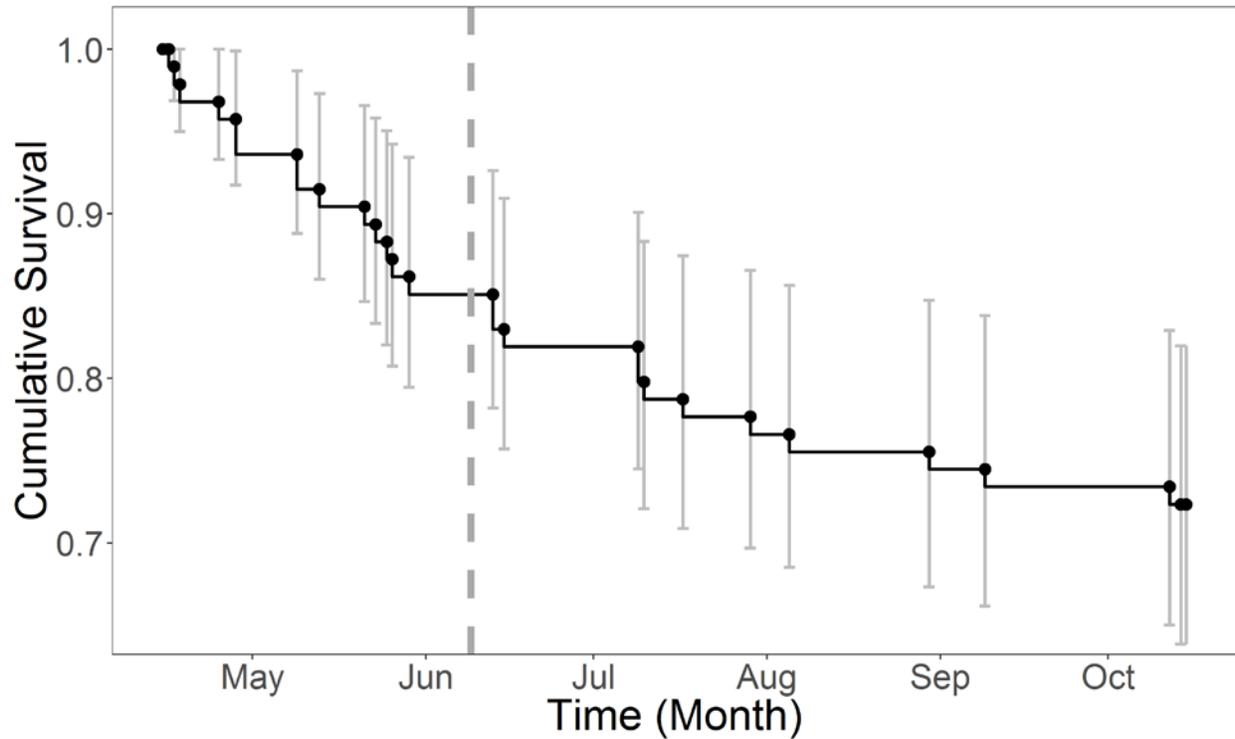


Figure 1. Cumulative survival of radiocollared ring-necked pheasant hens during the 2015-2017 breeding seasons (15 April – 15 October) in southwest Minnesota. Points represent survival estimates at intervals where mortality events took place. Error bars (vertical gray lines extending from each point) represent the upper and lower 95% confidence interval for each survival estimate. The 10-year average (2007-2016) for peak hatch of pheasant nests in Minnesota, as estimated by MNDNR's annual August roadside count surveys, is 12 June and is shown with the vertical gray dashed line.

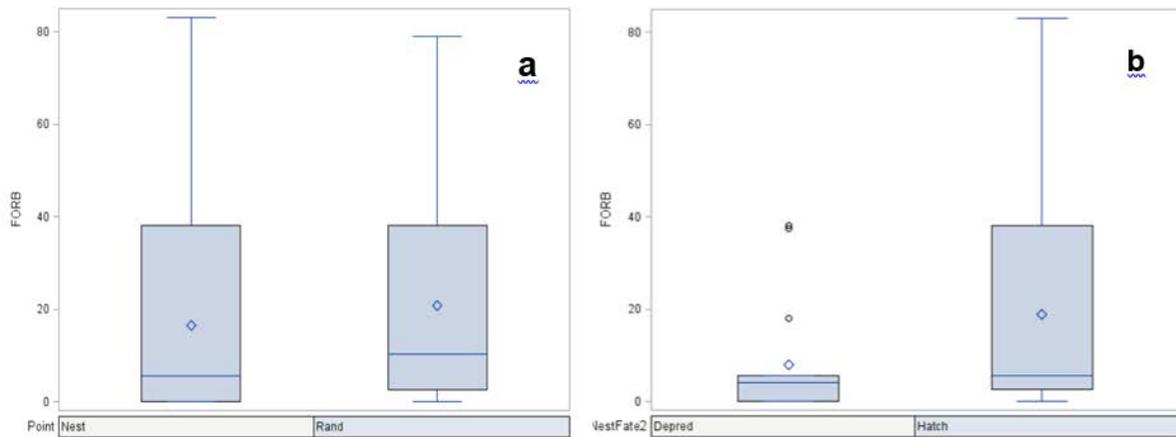


Figure 2. Box plot comparisons of the estimated percent cover of forbs at (a) nest sites versus nearby random points (<15 m away) and (b) depredated versus successfully hatched nests of ring-necked pheasants in southwest Minnesota during 2015-2017.

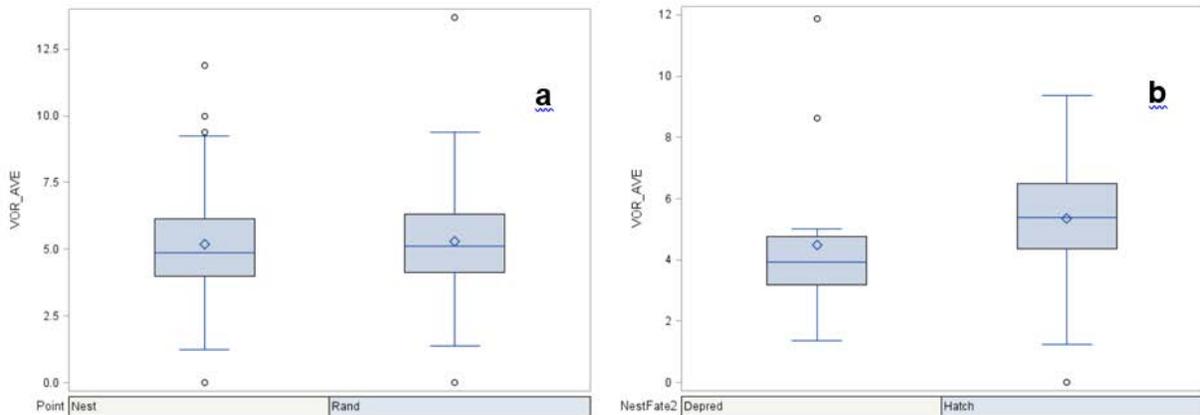


Figure 3. Box plot comparisons of vegetation vertical density, as measured by a visual obstruction reading (VOR) using a Robel pole, at (a) nest sites versus nearby random points (<15 m away) and (b) depredated versus hatched nests of ring-necked pheasants in southwest Minnesota during 2015-2017.