Farmland Wildlife Populations and Research Group
35365 800th Avenue
Madelia, Minnesota 56062-9744
(507) 642-8478 Ext. 221

EVALUATION OF LOCALIZED DEER MANAGEMENT FOR REDUCING AGRICULTURAL DAMAGE CAUSED BY WHITE-TAILED DEER IN MINNESOTA

Gino D'Angelo

SUMMARY OF FINDINGS

Minimizing damage caused by white-tailed deer (*Odocoileus virginianus*) is an important consideration for managing deer densities in Minnesota. I am conducting an ongoing study, which began in April 2014 in southeast Minnesota to assess the effectiveness of localized management of deer (i.e., targeted removal of deer in a limited area) to reduce damage to agricultural crops. The objective of this study is to evaluate the effectiveness of localized management for reducing fine-scale deer abundance and to examine whether damage caused by deer to agricultural crops is reduced on properties where deer densities are lowered. One field season of the study was completed during 2014 in southeast Minnesota. Baited infrared camera surveys were used to estimate deer abundance on focal properties, and spotlight surveys were used to estimate deer abundance in the local area surrounding focal properties. Yields of corn in fenced and unfenced plots were evaluated to estimate the impacts of browsing by deer. Corn yield loss was seemingly low on most properties, and there was no difference in corn damage between properties where localized management was utilized versus normal sport-hunting. Corn damage could not be explained solely by deer abundance at the property level or deer abundance in the area surrounding focal properties. However, extra deer harvest opportunities were utilized when requested. Deer management was >2 times as intensive on properties where integrated management was used versus normal sport-hunting. A second field season is being conducted in 2015. The results of this study will provide a basis for improving the framework for future application of localized management in agricultural regions.

INTRODUCTION

Damage caused by white-tailed deer can be severe in the United States with ≥$100 million lost annually by agricultural producers (Conover 1997). Results from previous studies have demonstrated only through anecdotal evidence that population reduction of deer can reduce damage to agriculture (McShea et al. 1993, Frost et al. 1997, Conover 2001). In some situations, localized management has effectively reduced the abundance of deer to maintain lowered deer densities over time (McNulty et al. 1997). As a result, damage to resources targeted for protection should be reduced because fewer deer are available to cause damage. However, conditions including high deer densities in surrounding areas (Miller et al. 2010), seasonal migratory behavior of deer (Vercauteren and Hygnstrom 1998), and colonization by deer from adjacent populations (Comer et al. 2007) may inhibit the creation of sufficient temporal periods of low deer densities to provide resource protection. Studies of the effectiveness of localized management to reduce damage to specific properties in agricultural settings are lacking.

Minimizing damage caused by deer is an important consideration in managing their populations in Minnesota. In many deer permit areas in Minnesota, deer are managed at or near population goals annually. However, complaints of deer damage from agricultural producers are common. During years 2003-2012, wildlife managers fielded an average of 130 complaints annually about damage caused by deer. Complaints of depredation by deer in Minnesota include consumption of forage stored for livestock, damage to specialty crops (e.g., produce, Christmas trees, nursery stock), row crops (corn [*Zea mays*] and soybeans [*Glycine max*]), alfalfa (*Medicago sativa*), and forest stands. Deer damage is reported throughout Minnesota, but a distinct cluster of complaints occurs in the Southeast region of the state (Nelson and Engel 2013).

In Southeast Minnesota the majority of complaints involve standing row crops and alfalfa in the field. Farmers who enter into a Cooperative Damage Management Agreement with MNDNR are eligible for cost-sharing to install exclusion fencing. However, funds for deer damage assistance are limited and fencing is only practical for protecting areas that are relatively small (i.e., stored forage and specialty crops). Sound and visual deterrents and taste and smell repellents have proven ineffective for reducing deer damage in agricultural fields (Belant et al. 1996, Belant et al. 1998, Gilsdorf et al. 2004). Therefore, most attempts to reduce damage to standing crops in Southeast Minnesota involve the use of localized deer damage management techniques such as shooting permits and depredation permits (herein, localized management).

MNDNR Regional Offices have issued shooting permits to agricultural producers experiencing extreme damage caused by deer for use outside of hunting seasons. Shooting permits allow landowners to shoot deer at any time of day or night and with a high-powered rifle. For years 2004 through 2012, an average of 95 shooting permits for nuisance deer were issued annually for use during summer and winter (Nelson and Engel 2013). In Southeast Minnesota, landowners with support from local legislators requested shooting permits to be issued during the regular hunting seasons to reduce depredation to standing row crops. As an alternative to their request, a pilot program using depredation permits allocated to specific properties was instituted in 2012 in Southeast Minnesota (Luedtke 2013). Depredation permits were to be used by private sport-hunters during regular hunting seasons. Additionally, a temporary DNR position, the Landowner Assistance Specialist, was created to administer the program in Fillmore, Goodhue, Houston, Olmsted, Wabasha and Winona counties.

Depredation permits allowed up to 15 hunters per property to harvest up to five antlerless deer in addition to established bag limits during regular hunting seasons–75 deer could be harvested on an individual property using depredation permits. To be eligible, applicants had to demonstrate: 1) a history of deer damage documented through complaints to the DNR Area Wildlife Office, 2) crop losses, 3) enrollment in a Cooperative Damage Management Agreement with MNDNR including a plan for deer hunting management, and 4) hunting was allowed on the property during the previous hunting season.

Localized management in Southeast Minnesota increased deer harvest on individual properties from previous years and anecdotally landowners and hunters involved in the program were satisfied (Luedtke 2013). However, the effect of localized management on agricultural damage caused by deer is unknown. Also, logistical limitations and eligibility guidelines restrict the number of properties where depredation permits may be issued annually. Given the onerous nature of administering localized management from an agency perspective, it is important to establish whether such management aids in reducing agricultural damage as intended.

The purpose of this study is to evaluate whether localized management of deer reduces agricultural damage and to provide a basis for improving the framework for future application of localized management in Minnesota. No previous studies have examined the effectiveness of localized management for reducing damage to agricultural crops. Other research has suggested that using recreational hunting to institute localized management of overabundant deer and effectively reduce damage may be difficult (Simard et al. 2013). If localized management can be used to minimize damage, these techniques should be utilized wherever feasible in Minnesota. Otherwise, alternative strategies for balancing local deer populations with social carrying capacity should be explored.

OBJECTIVES

1. To evaluate the effects of localized white-tailed deer management techniques– Including shooting permits, and depredation permits–on localized deer densities in Southeast Minnesota.

2. To quantify the amount of damage caused by white-tailed deer to agricultural crops relative to localized management in Southeast Minnesota.

STUDY AREA

This study was conducted in the Minnesota counties of Fillmore, Houston, and Winona. Southeast Minnesota is characterized by a mosaic of rolling limestone uplands dominated by agriculture (Mossler 1999). Typical crops include corn, soybeans, alfalfa, and small grains. Steep ravines cut by narrow streams are interspersed throughout the uplands. Ravines are rocky and primarily forested by mature hardwoods (Omernik and Gallant 1988).

Pre-fawn deer densities in these Southeast Minnesota averaged 5 deer per km^2 (Grund 2013), which represents the highest deer densities found in the farmland zone of Minnesota. An average of 1.5 deer per km^2 was harvested in these Southeast Minnesota during 2012, which was nearly twice the statewide average (McInenly 2013).

METHODS

Experimental Design

My objective was to evaluate the effectiveness of localized management for reducing fine-scale deer abundance and to examine whether damage caused by deer to agricultural crops is reduced on properties with higher management intensity. Therefore, I examined deer depredation to crops and deer abundance on individual focal properties in Southeast Minnesota. On properties used as treatments, localized management strategies were utilized in addition to regular sport-hunting. On control properties, normal sport-hunting was allowed by the landowner. I included 7 focal properties in the study, including 4 treatments and 3 controls.

Data Collection

Corn Evaluations–Within each field, I delineated 8 plots, which were stratified into interior (>10 m from the field edge) and edge (0-5 m from the field edge). Each plot included two paired 5-m X 5-m subplots (~6/1000th acre) separated by 5 m and within the same rows of corn. One subplot of each pair was fenced to exclude deer and the other subplot was an unfenced control. Within each pair, the treatment and control were assigned randomly. Square exclosures were constructed with 2-m high heavy-duty plastic mesh attached to four 2.4-m u-posts. Exclosures surrounding subplots were approximately 6 m X 6 m to reduce the effect of fencing on plants within the subplot. Exclosures were installed immediately following planting and herbicide treatment or initial cultivation. When necessary, exclosures were removed for ≤24 hours to allow farmers to conduct additional field treatments. I evaluated corn crops near the estimated date of plant maturity before senescence. Within each subplot I recorded the number of rows, number of plants, and for 30 randomly selected plants, I measured plant height, level of herbivory per plant, and classified the quality of each ear of corn relative to damage caused by deer. I estimated grain yield (total seeds produced per 30 plants) for fenced and unfenced subplots, and calculated the proportional loss of corn for each fenced and unfenced plot as: ((total seeds in fenced plot minus total seeds in unfenced plot) divided by total seeds in the fenced plot. I consulted with the agricultural producer to determine the variety of corn planted in each field.

Deer Abundance Estimates on Focal Properties–To aid in estimating deer abundance and management intensity (i.e., deer harvested per deer available for harvest) on focal properties, I used baited infrared camera surveys to obtain estimates of the abundance of deer at a fine scale in the area of crop fields designated for evaluation. This method of survey was conducted according to previous research by Jacobson et al. (1997) and a pilot study I conducted in Southeast Minnesota during 2013 (G. D'Angelo, unpublished data). The abundance of deer in an area can be determined using baited surveys, where bucks can be uniquely identified by antler characteristics and their number used to infer the number of does and fawns visiting repeatedly a bait site. Cameras were placed at a density of one camera per 65 hectares in wooded or brushy habitat immediately adjacent to crop fields. This relatively high density of cameras was intended to reduce bias associated with capturing adult bucks at a higher rate at lower camera densities because males have larger home ranges (Jacobson et al. 1997). A bait site was established at each camera location during a 7-day pre-baiting period. During pre-baiting, whole kernel corn and trace mineral salts were placed at each bait site in a quantity sufficient to maintain consistent access by deer 24 hours per day. Following this acclimatization period, an infrared camera was set to record still photographs of deer 24 hours a day at 10-minute intervals during a 14-day survey period. As in the pre-baiting period, bait was provided ad libitum. I generated deer abundance estimates using data pooled from all cameras on a property. Deer abundance estimates were conducted during August. This timing increased the likelihood that: 1) fawns were mobile with their dams and available for survey, 2) antler growth of bucks was sufficient to uniquely identify individuals, 3) deer photographed near crop fields were those that caused damage during the growing season and were available for harvest in the same area, and 4) harvest mortality and disturbance of deer by hunting activities was minimized since the survey preceded deer hunting seasons.

Deer Abundance Estimates in 5-km Area including Focal Properties–I bounded focal properties with a 5-km square quadrat and established transects totaling 5.5 km in length along roads to conduct spotlight surveys. Surveys were conducted in early November after leaf senescence of most deciduous trees, after most corn was harvested, and before firearms deer season. Surveys were conducted between 1 hour after sunset and 1 hour before sunrise. Two replicate surveys were conducted for each focal property. Two observers in the cab of an MNDNR vehicle scanned for deer in the landscape along survey routes using handheld 12-volt spotlight (1000 m at 1 Lux of illumination, Lightforce, Orofino, ID). A real-time, moving-map software program (DNRSurvey; Wright et al. 2011), coupled to a global positioning system receiver and a convertible tablet computer, was used to guide transect navigation and record deer locations directly to ArcGIS (Environmental Systems Research Institute, Redlands, CA) shapefiles. Observers recorded the number of deer per group and estimated the distance of deer groups from the transect using a laser rangefinder (Leupold and Stevens, Beaverton, OR). I estimated the deer density for individual surveys using Distance software (Thomas et al. 2010) and averaged the two estimates for each focal property.

Management Intensity–I asked agricultural producers to report deer harvested on their properties by season. I quantified management intensity as: number of deer harvested divided by the total number of deer estimated to be on the property via infrared camera surveys. I also classified properties under two management strategies: hunting (herein HUNT, i.e., hunting conducted by sport-hunters during the regular season framework, or integrated management (herein INT, i.e., in addition to hunting, deer were harvested using depredation and shooting permits outside of the regular season framework).

RESULTS AND DISCUSSION

The portion of the study described in this summary occurred during April 2014-December 2014, and field work is ongoing during 2015. HUNT was used to manage deer on three properties and INT was used on four properties. I sampled 112 subplots in corn fields including 56 unfenced subplots and 56 fenced subplots. I excluded 2 pairs of fenced and unfenced subplots (i.e., 4 subplots total) on one property from analysis because the growth of corn plants was severely affected by soil erosion.

Deer abundance via infrared camera surveys was similar on HUNT and INT properties (Table 1, t = 0.139, df = 5, P = 0.896). Likewise, deer abundance was similar in the area surrounding HUNT and INT properties as determined via spotlight surveys (t = 0.120, df = 5, P = 0.910). Agricultural producers on INT properties utilized extra deer harvest opportunities, and management intensity on INT properties was more than double the management intensity on HUNT properties (HUNT = 0.19, INT = 0.44, t = -2.393, df = 5, P = 0.097). Despite increased harvest pressure on INT properties, deer damage to corn was similar on all properties regardless of the deer management strategy employed (HUNT = 7% mean proportional corn loss, INT = 8% mean proportional corn loss, t = -0.121, df = 5, P = 0.908). There was no difference in proportional loss of corn between edge and interior plots (t = 0.529, df = 12, P = 0.606).

The primary objective of this study was to evaluate the effectiveness of localized management for reducing fine-scale deer abundance and to examine whether damage caused by deer to agricultural crops is reduced on properties where deer densities are lowered. The true effects of integrated deer management conducted during 2014 and 2015 on deer abundance will not be evident until the field season is completed in 2015. During 2014, corn yield loss was seemingly low on most properties. There was no difference in corn damage between properties where localized management was utilized versus normal sport-hunting, and the level of corn damage could not be explained by deer abundance at the property level or in the surrounding area. However, extra deer harvest opportunities were utilized by landowners when requested. Management was more intensive on INT properties versus HUNT properties. Also, deer were harvested earlier and more continuously throughout the growing season, corn drydown period, and crop harvest seasons on INT properties. Increased deer harvest pressure on INT properties may have prevented corn damage from being worse had additional deer not been harvested. Therefore, extra opportunities to harvest deer should be afforded on properties where landowners consult with MNDNR staff about their concerns for potential deer damage. These concerns are likely legitimate and landowners are basing their concerns on prior experiences and current conditions.

A second field season is being conducted in 2015. I will also examine landscape characteristics associated with levels of deer damage to corn, deer damage to alfalfa over winter and during the growing season, and the human dimensions associated with application of localized deer management strategies. The results of this study will provide a basis for improving the framework for future application of localized management in agricultural regions.

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Table 1. Estimates of the abundance of white-tailed deer, management intensity of deer, and corn damage caused by deer on 7 privately owned properties in Southeast Minnesota, 2014.

Property	Deer management strategy[1]	Estimated deer abundance (deer per camera)[2]	Local deer density (deer per km^2)[3]	Management intensity[4]	Mean proportional corn loss[5]
A	HUNT	26	17	0.16	0.07
B	HUNT	22	10	0.21	-0.01
C	HUNT	13	14	0.21	0.14
D	INT	26	28	0.35	0.24
E	INT	21	13	0.39	-0.06
F	INT	22	2	0.28	0.00
G	INT	11	9	0.74	0.12

[1]On properties with HUNT management deer harvest was conducted by sport-hunters during the regular season framework. On properties with INT management deer harvest was through integrated methods including by sport-hunters during the regular season framework and using depredation and shooting permits outside of the regular season framework.
[2]Deer abundance estimated from infrared camera surveys indexed as deer per camera with camera densities of 1 camera per 65 ha on each focal property.
[3]Deer density estimated from spotlight surveys in 5-km quadrat encompassing each focal property.
[4]Proportion of the number of deer estimated to be using a property that were harvested.
[5]Negative values indicate higher average yield estimates in unfenced subplots versus subplots fenced to exclude deer.

MNDNR

PILOT STUDY TO ASSESS HARVEST MORTALITY RATES OF GRAY AND FOX SQUIRRELS ON PUBLIC LAND IN MINNESOTA

Rachel Curtis and Nicole Davros

SUMMARY OF FINDINGS

Small game hunting is a popular recreational activity in Minnesota but the number of squirrel hunters and the squirrel harvest has declined since 1985. In addition, metropolitan hunters have indicated that they have limited access to private land and heavy hunting pressure exists on publicly owned land. We intend to study the contribution of harvest mortality to overall gray and fox squirrel mortality rates on public hunting lands; but first we conducted a small pilot study to evaluate trapping, handling, and tracking methods. During September-October 2014 we set traps using different trap placement arrays and baits in Minneopa State Park. We captured 20 squirrels and tested 2 styles of radio-transmitting collars. We tracked the collared squirrels from October 2014 through May 2015. In the expanded study we will use baits and trap placement grids that were effective in this study. We will use the collar style that contained a mortality sensor and took the longest time for the squirrels to remove. We will also only assess survival status and sources of mortality instead of determining locations for collared squirrels.

INTRODUCTION

Small game hunting is a popular recreational activity in Minnesota, but since 1985 the number of squirrel hunters has declined by almost 25% and the squirrel harvest has declined by about 40% (Dexter 1997, Dexter 2013). The DNR conducted a survey of squirrel hunters to assess squirrel hunter perceptions and opinions (Dunbar 2009). More hunters in the Twin Cities metropolitan area (hereafter, metro) responded that they believed squirrel populations were declining (51%) than their statewide counterparts (19%) and more metro hunters hunt exclusively on public land. Metro hunters indicated that there was limited access to private land and heavy hunting pressure existed on publicly-owned land (Dunbar 2009). Previous research has shown that hunting pressure can be considerably higher on forests open to the public than on privately-owned property (Nixon et al. 1974) so this perception of hunters could be a real management issue for squirrel populations around the metro area.

The DNR Section of Wildlife has considered changes to the squirrel season structure in the metro area based on these survey results. However, many factors cause squirrel populations to fluctuate naturally (see Barkalow et al. 1970, Nixon et al. 1975, Healy and Welsh 1992, Descamps et al. 2009, Vander Haegen et al. 2013) and limited population-level data exists for Minnesota's squirrel populations. Therefore, it is unclear whether the squirrel harvest is declining due to overexploitation on high-use wildlife management areas or if the decline is due to reduced hunter participation. We have proposed a study to assess the contribution of harvest mortality to overall mortality rates of gray and fox squirrels (*Sciurus carolinensis* and *S. niger*, respectively) on public hunting lands. Prior to initiating this large research project, we initiated a pilot study to evaluate squirrel trapping, handling, and tracking methods.

OBJECTIVES

This project was a pilot study to evaluate trapping, handling, and tracking methods for gray and fox squirrels as part of a larger study that will evaluate squirrel mortality rates on public lands (beginning July 2015). Our pilot study objectives included the following:

1) Determine the number of traps that can be monitored each day.
2) Determine the spacing of traps for effective capture rates.
3) Assess handling methods to determine if improvements could be made to further reduce stress and handling time of squirrels while maintaining safety for handlers.
4) Deploy 15-20 collars on gray and fox squirrels (combined total).
5) Track collared squirrels once per week to evaluate logistics such as collar battery life, signal strength, and staff time required for monitoring efforts.

METHODS

Study Area

We conducted our study at Minneopa State Park because the park had abundant gray and fox squirrels to meet our target sample size and good forest habitat to test and refine radio-tracking methods for squirrels. Additionally, the park was within easy commuting distance from our research station and from the locations of our student volunteers [Mankato (Minnesota State University) and St. Peter (Gustavus-Adolphus College)]. We conducted our trapping efforts in the deciduous forest in and around the campground (Figure 1). This area had a large number of squirrels and road access in all seasons.

Trapping

During September-October 2014, we trapped gray and fox squirrels using wire box traps (48 x 15 x 15 cm; 2.5 x 1 cm mesh) baited with dried corn, sunflower seeds, peanut butter, pecans, and/or hickory nuts. We used two different trap placement methods (Figure 2). The first method involved placing ≤25 traps at known squirrel-use sites within the campground. We set and removed traps each day to reduce interference with park visitors. We set traps when the last camping group left in the morning, typically from 1000 to 1100 h, and removed them when guests began arriving in the evening, typically from 1500 to 1600 h. The campground continued to have visitors during the day; therefore, we checked these traps and released trapped animals every 1.5 h to reduce stress. Our second trapping method involved setting 30 traps in the forest interior. Using GIS, we placed a 30 m buffer around all trails and roads. We created a grid of points 30 m apart in the area outside the buffer and placed baited traps at these points. Peak squirrel activity is in the morning and evening; therefore, we checked traps three times per day (late morning, afternoon, and night) to reduce the amount of time squirrels remained in the traps. We closed the traps each night to prevent animals from staying in the traps overnight, and opened them again the following morning. We closed the traps during inclement weather and removed them over the weekend.

We weighed squirrels in the trap using a digital hanging scale. We restrained captured squirrels using a modified handling cone which allowed us to handle and radio-collar without sedation (Koprowski 2002). Handling cones were constructed of denim with Velcro© straps to secure the squirrel and a zipper to allow access to the head and neck during collar attachment (Figures 3 & 4). We placed a removable plastic funnel around the squirrel's neck to protect handlers from bites during collaring (McCleery et al. 2007; Figure 5). We released a squirrel back into the trap if it was not oriented correctly or became twisted in the cone. We intended to release un-collared any squirrel that could not be collared after being placed in the cone twice to avoid stress mortality. However, all squirrels were properly aligned in the cone by the first or second try and none needed to be released un-collared. We deployed two different VHF necklace-style radio-collars: 13.0 g collars with integrated mortality sensors and 5.0 g collars without integrated mortality sensors. Mortality sensors change the pulse rate of the signal if an animal has not moved for 8 h. All squirrels were immediately released after handling was complete (Figure 6). We counted handling time as the time from when we approached the trap to when we released the collared squirrel. We immediately released any non-target animals.

Tracking

We tracked the collared squirrels biweekly from October 2014 through January 2015 and monthly from February through May 2015. For squirrels carrying a 13.0 g collar, we determined the location of squirrels using triangulation techniques, and determined survival status by listening for the mortality signal. This technique provided the least amount of disturbance to the animal. When a 13.0 g collar transmitted a mortality signal, we attempted to retrieve the transmitter. For squirrels carrying a 5.0 g collar without mortality sensor, we used a homing radio-tracking technique in an attempt to locate the animal to determine survival status and location. Survival status could not always be determined when squirrels with a 5.0 g collar were inside of a tree cavity that prevented visual inspection.

RESULTS AND DISCUSSION

We trapped and collared 20 squirrels (Table 1). Total handling time per squirrel ranged from 5-11 min ($\bar{x}$ = 7 min). Our handling times were faster with ≥2 handlers. Handling times were slower when squirrels were collared by one person or when a squirrel had to be re-aligned in the cone. Overall, our handling cone and funnel method provided a safe, effective way to handle squirrels for researchers and animals alike.

We collared 8 squirrels in the campground and 12 squirrels from the forested grid (Figure 7). In the campground, the percentage of traps containing a gray or fox squirrel heavy enough to collar was 9.4% per day (85 trap days), and 2.4% per trap check (333 trap checks). In the forested grid, the percentage of traps containing a gray or fox squirrel heavy enough to collar was 7.7% per day (155 trap days), and 3.2% per trap check (372 trap checks). The slightly higher trapping success at the campground may be due to higher squirrel densities, trap placement in known-use locations, preferred baits, habituated animals, and/or shorter times between checks. Although the targeted trapping method had a higher per day success rate, it is likely unreliable for the contiguous forest habitats on wildlife management areas, and we will use the grid system to trap squirrels in our expanded study. We determined that 40-50 traps will be a reasonable number for each handler to monitor each day, and that 25-30 m spacing between traps efficiently covers an area of forest.

We collared 19 gray squirrels and 1 fox squirrel. Our trapping sites, particularly in the forest grid, were primarily gray squirrel habitat and contained little of the open, savannah-type habitat preferred by fox squirrels. We collared 6 female and 14 male squirrels. Squirrel weights ranged from 440-660 g ($\bar{x}$ = 550g). We were unable to definitively determine age because most juveniles had reached adult size and reproductive status was difficult to determine in October.

Two study animals are still collared. Of the 18 losses, 2 were possible mortalities, 3 were likely transmitter failures, 2 batteries have failed, and 11 squirrels were able to remove their collars either by slipping them over their heads or chewing through the plastic collar. We will not use the 5.0 g collars for our expanded study. All 3 transmitter failures were this type, the thin zip-tie collar attachment style is easy for the squirrels to chew through, and without the mortality sensor it is very time consuming to determine survival status. Of the 11 slipped collars, 6 were 13 g collars, and 5 were 5 g collars; however, the squirrels removed the 5 g collars soon after collaring while the 13 g collars began to slip after several months. The large number of slipped collars is likely due to attaching collars too loosely. Additionally, we collared animals in fall during the peak in their body weight. As winter progressed and squirrels became slimmer, squirrels began to lose their collars.

In the expanded study, we will only use radio-collars with integrated mortality sensors as this will allow us to more easily determine survival status of collared squirrels. We will not triangulate squirrel locations because it is too time intensive. However, we will use the homing technique to locate collars emitting a mortality signal and determine cause of death, if possible. Survival status can be determined remotely ≤0.5 km from the collared squirrel, depending on transmitter battery strength and topography. Scanning collar frequencies to listen for mortality signals takes only a few minutes but it will take 30-60 min to recover a collar and determine cause of death. Additionally, it will take more time to assess survival status in the expanded study because squirrels will be dispersed throughout the site and some transmitter signals may not be audible from the nearest road.

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Table 1. Squirrels collared at Minneopa State Park, September and October 2014.

Collar Frequency	Date Trapped	Handling Time	Location	Species	Sex	Weight (g)	Collar Size	Current Status
164.715	9/30/2014	6:00	Forest	Gray	Female	660	13 g	Collar off, unrecovered
164.443	10/7/2014	9:00	Forest	Gray	Female	550	5 g	Missing, likely transmitter failure
164.304	10/7/2014	9:00	Forest	Gray	Male	550	5 g	Slipped collar
164.633	10/8/2014	5:00	Forest	Fox	Male	610	13 g	Collar off, unrecovered, likely mortality
164.614	10/8/2014	6:00	Forest	Gray	Female	610	13 g	Slipped collar
164.043	10/8/2014	9:00	Campground	Gray	Male	440	5 g	Missing, likely transmitter failure
164.091	10/8/2014	10:00	Campground	Gray	Female	620	5 g	Collar off, unrecovered
164.061	10/9/2014	6:00	Campground	Gray	Male	520	5 g	Collar off, unrecovered
164.073	10/9/2014	6:00	Campground	Gray	Male	520	5 g	Alive
164.512	10/9/2014	7:00	Campground	Gray	Male	480	5 g	Collar off, unrecovered
164.625	10/9/2014	8:00	Campground	Gray	Male	550	13 g	Collar off, unrecovered, likely mortality
164.323	10/9/2014	6:00	Forest	Gray	Male	490	5 g	Alive
164.654	10/9/2014	7:00	Forest	Gray	Female	560	13 g	Chewed through collar
164.546	10/9/2014	6:00	Campground	Gray	Male	660	13 g	Slipped collar
164.432	10/9/2014	11:00	Forest	Gray	Male	510	5 g	Missing, likely transmitter failure
164.733	10/10/2014	5:00	Forest	Gray	Male	620	13 g	Slipped collar
164.053	10/10/2014	5:00	Forest	Gray	Male	490	5 g	Chewed through collar
164.585	10/10/2014	6:00	Forest	Gray	Female	500	13 g	Missing, possible battery failure
164.703	10/10/2014	7:00	Forest	Gray	Male	630	13 g	Missing, possible battery failure
165.105	10/14/2014	9:00	Campground	Gray	Male	500	13 g	Slipped collar

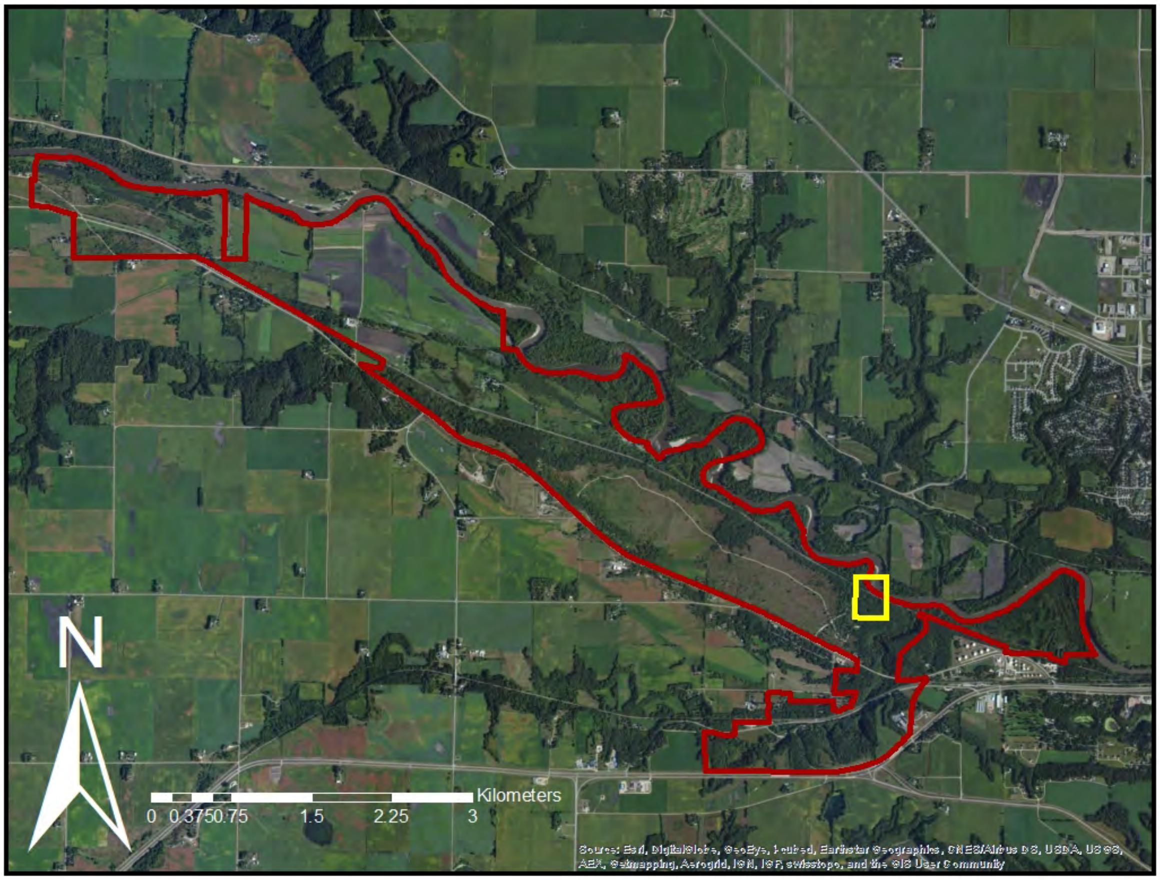

Figure 1. Our pilot study was conducted in the area surrounding Minneopa State Park's campground (trapping area shown in yellow). The red border defines the park boundary.

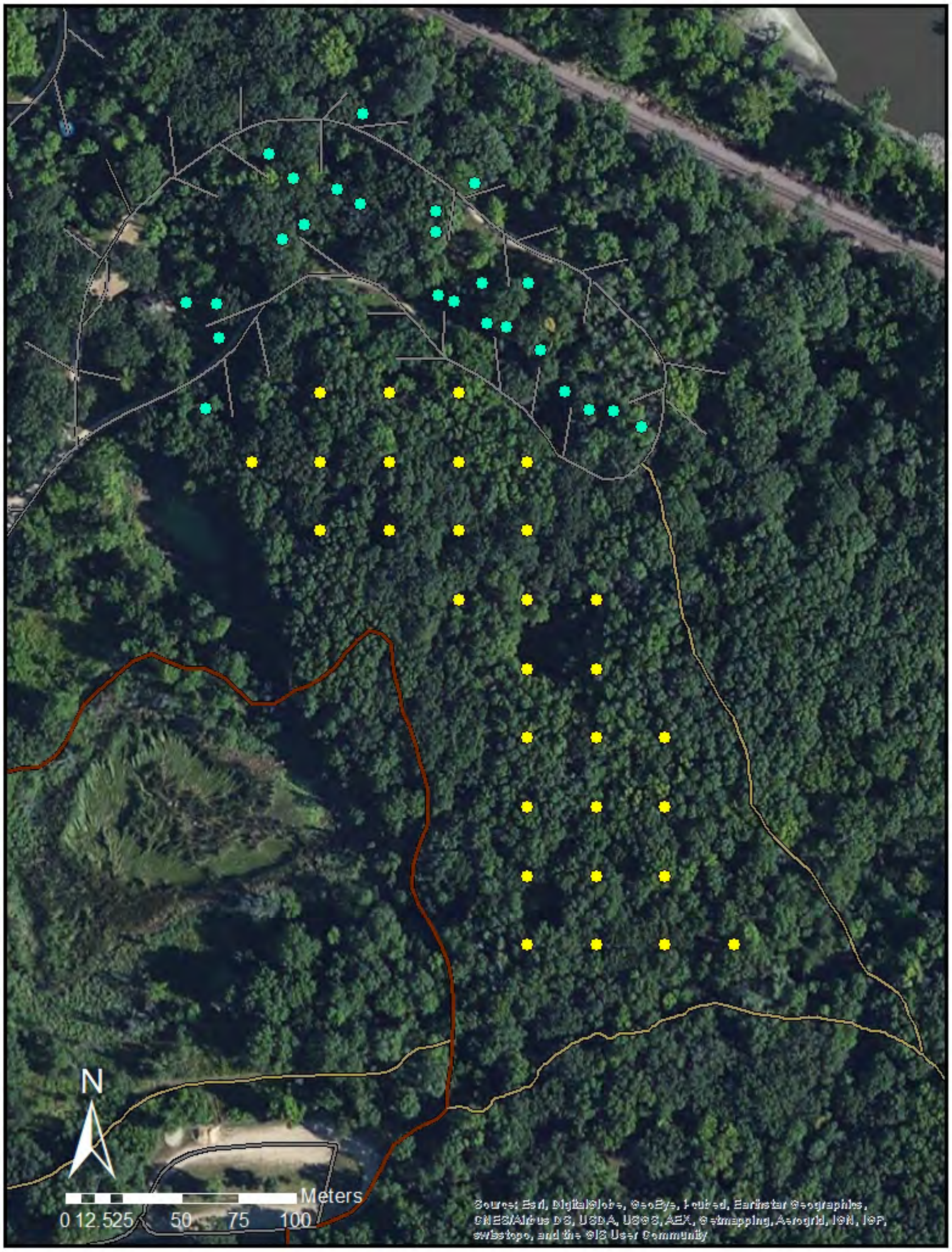

Figure 2. Trap distribution near the campground. Green dots represent known squirrel-use campground sites. Yellow dots mark the forested grid trap sites.

Figure 3. Placing the wide end of the handling cone over the trap door allowed us to release the squirrel directly into the cone. The squirrel exited the trap and became caught in the constricted end of the cone. Velcro© straps secured the trapped squirrel.

Figure 4. By partially unzipping the handling cone, we were able to expose the squirrel's head and then secure a plastic funnel around its neck.

Figure 5. With the squirrel secured, we were able to safely attach radio-transmitters.

Figure 6. We removed the plastic funnel, loosened the straps, and unzipped the cone to release the squirrel.

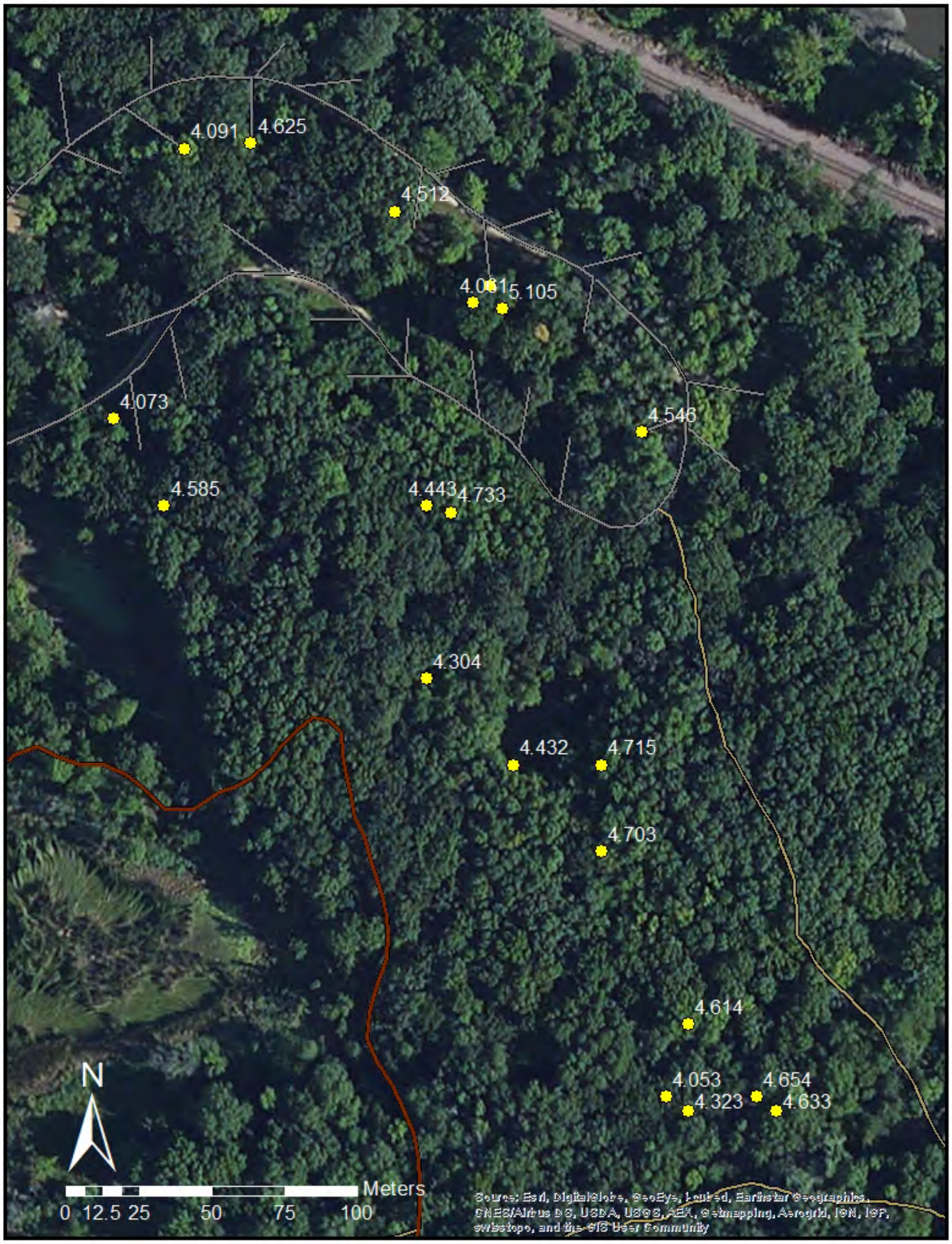

Figure 7. Location of initial squirrel captures. A total of 20 squirrels were collared.

MNDNR

AN EVALUATION OF NESTING AND BROOD-REARING HABITAT SELECTION AND SURVIVAL RATES OF RING-NECKED PHEASANTS IN RELATION TO VEGETATION STRUCTURE AND COMPOSITION

Nicole Davros and Rachel Curtis

SUMMARY OF FINDINGS

Ring-necked pheasant (*Phasianus colchicus*) responses to the amount of grassland acres in 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. Better understanding the factors that limit reproductive success can help natural resource agencies prioritize their management and acquisition strategies. We radiocollared 20 hen pheasants across two study areas in southwestern Minnesota during spring 2015 to monitor them during nesting and brood-rearing. We are currently capturing and radiotagging chicks to estimate juvenile survival rates and collecting vegetation data to evaluate nest-site and brood habitat selection. The results from our 2015 field season will provide the basis for a broader study aimed at assessing the influence of vegetation structure and composition on pheasant hen nest-site selection, nest success, brood success, brood habitat selection, and chick survival.

INTRODUCTION

Ring-necked pheasant population dynamics are largely driven by variation in survival rates, and 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 at the landscape scale (Chesness et al. 1968, Riley and Schulz 2001). Management of pheasant populations has instead focused mainly on providing abundant nesting cover to minimize the effects of predation and maximize reproductive success to increase populations. As acres enrolled in 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 on pheasant population dynamics. However, the interaction between habitat and predation will no doubt remain, and gaining new insights into old problems will be important for improving 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) 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) and landscape context (Benson et al. 2010). 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). Understanding how management at both the site level (e.g., vegetation structure, composition, and diversity) and the landscape level (e.g., tree removal, wetland restoration) 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). 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 lead 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, better data are needed to understand the interplay between these potential limiting factors on brood habitat selection and chick survival in different habitats and landscapes within Minnesota's pheasant range.

Minnesota DNR 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 and agricultural land use practices. 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 level (e.g., forb interseeding) and landscape level (e.g., acquisition priorities) in this new era of reduced CRP acreages. Additionally, obtaining data on individual components of pheasant population dynamics will aid in future assessment of DNR management activities [e.g., Prairie Plan implementation (Minnesota Prairie Plan Working Group 2011), conservation grazing] and agricultural land use practices (e.g., pesticide use) on Minnesota's pheasant population.

OBJECTIVES

Our long-term research objective is to evaluate the relative importance of potential limiting factors (e.g., vegetation cover type, food, predation, weather) on pheasant productivity. We will evaluate hen nest site selection, nesting and brood-rearing success, brood habitat selection, and hen and chick survival in Wildlife Management Area (WMA) project areas with varying amounts of site-level diversity [e.g., sites dominated by smooth brome (*Bromus inermis*), warm-season grasses, and high diversity grass-forb mixtures]. Specific objectives include:

1) Evaluate nest site selection, nesting success, and survival of ring-necked pheasant hens in relation vegetation cover and composition.
2) Evaluate pheasant brood-rearing habitat selection, brood success, and chick survival rates in relation to vegetation cover and composition.
3) Evaluate the relative importance of different factors (e.g., predation, food limitation, weather) on pheasant nesting success, brood success, and hen and chick survival to help guide management priorities.

STUDY AREA

Our study is being conducted in the southwest region of Minnesota (Figure 1). 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 [Conservation Reserve Program (CRP), Reinvest in Minnesota (RIM), Conservation Reserve Enhancement Program (CREP), and Wetlands Reserve Program (WRP)] and public land [MN DNR Wildlife Management Areas (WMA) and U.S. Fish and Wildlife Service Waterfowl Production Areas (WPA)] account for 5.7% of the landscape in this region (Davros and Curtis 2014). The southwest region lies within the core of Minnesota's pheasant range, and MN DNR's 2014 August roadside counts indicated 50.7 pheasants/100 mi (Davros and Curtis 2014).

We focused our efforts at two project areas for the 2015 field season. Each project area is about 9 m^2 in size and has extensive amounts of permanently protected habitat. The Lamberton WMA project area (Redwood County) is a large, nearly contiguous WMA complex with >1,100 acres of permanently protected upland and wetland habitats. The Worthington Wells project area (Nobles County) has >1,500 acres of permanently protected habitat that spans multiple WMAs, the Okabena-Ocheda Watershed District, and U.S. Fish & Wildlife Service (USFWS) lands.

METHODS

We captured hen pheasants from 2 February – 15 April 2015 using baited walk-in traps and nighttime spotlighting via 6-wheel utility-task vehicle (UTV). We also opportunistically captured roosters during our efforts. We weighed each hen to the nearest 5.0 g, measured the right tarsus to the nearest 0.5 mm, banded her with a unique combination of leg bands (1 numbered aluminum band and 3 colored plastic bands), and fitted her with a 16.0 g necklace-style VHF radiotransmitter with integrated mortality switch before release. Roosters were weighed, measured, and banded with a unique leg band combination before being released.

We began radiotracking hens 3-5 times per week in late April to determine the onset of incubation. We assume that incubation has begun when the radio signal is projected from the same location for several consecutive days. Once incubation is initiated, we flush hens from their nest to determine clutch size and float a subset of eggs to estimate hatch dates (Westerskov 1950, Carroll 1988). We mark the location of nests using a global positioning system (GPS) receiver. We also place flagging within 5-8 m of nests to aid relocation efforts. If a hen begins making large daily movements prior to us flushing her to locate a nest, we assume her nest has failed and we wait for her to re-localize and begin incubating her next nest before we flush her. We use the homing technique on radiocollars emitting a mortality signal to retrieve the collar and determine a cause of death when possible.

We place miniature color video cameras at a random subset of nests to document nesting behavior, hatching, and nest predation events (Cox et al. 2012). Cameras have infrared light-emitting diodes (LEDs) to allow recording at night and are connected to digital video recorders (DVRs) with SD cards and deep-cycle marine batteries housed in waterproof containers >20 m away from nests. We use a portable monitor to adjust camera settings and check video feeds and we switch batteries and SD cards every 4-7 days. Video footage is reviewed in the office weekly and relevant video clips are archived.

Near the estimated hatch date, we monitor hen activity 2-3 times daily to determine if hatching is occurring. We assume hatching is occurring when the hen's signal fluctuates in intensity (Riley et al. 1998). We also occasionally flush hens on the estimated hatch date to determine if hatching is occurring. We capture chicks on day 0 (hatch day) or day 1 (i.e., 1-day post-hatching) while they are still on the nest by flushing the hen off early in the morning. If the hen and her brood have already moved from the nest, we flush the hen from the brood and immediately play a recording of a hen's brood-gathering call or a hen turkey call until 1-5 chicks are captured by hand. We never capture more than 50% of the brood at one time. If the chicks do not respond to either playback within 30 min, we leave the area to allow the hen to gather her brood and try to capture them again the next day. We discontinue chick capture attempts for a particular brood if we are unsuccessful at capturing any chicks by the end of day 2.

We transport captured chicks in a small box cooler heated with hand-warmers to a nearby field truck for processing. We determine the mass of each chick to the nearest 0.1 g and we measure tarsus length to the nearest 0.5 mm. We surgically suture a 0.65 g backpack-style VHF radio-transmitter to the backs of 1-3 chicks/brood (Burkepile et al. 2002, Dahlgren et al. 2010). If more than 3 chicks are captured, we subcutaneously implant a passive integrated transponder (PIT) tag on the back between the scapula and neck (Nicolaus et al. 2008) on each of the additional captured chicks to allow for identification of individuals during future recapture efforts. Handling time lasts <5 min per chick and chicks are returned to the hen within 30-60 min of capture. We follow the methods of Riley et al (1998) to return chicks to the hen.

We monitor hens and their broods 2-3 times daily at least 3 times per week to determine their locations and estimate brood and chick survival. First, we triangulate a hen to estimate her location and we take each bearing from approximately 100-200 m away. We then flush the hen and note the presence of any chicks by sight or sound. We make conservative estimates of the number of chicks detected each time. We also make note of the hen's behavior after flushing (e.g., approximate distance flown when flushed, returned immediately to the area or stayed away, gave a brood-gathering call) to aid in determining whether she has any surviving chicks if the chicks themselves are not detected. We triangulate the location of chicks that are radiotagged from that brood during this same sampling period. If a chick is detected >50 m from a hen or doesn't appear to be moving (as determined by signal fluctuation), we use the homing technique to locate the chick and determine survival status. When a chick is found dead, we examine the carcass and surrounding area to assign a cause of death, if possible. Following Riley et al (1998), we classify mortality as due to "predation" if we find puncture marks from teeth, hemorrhaging, or parts of the body consumed and when there are predator tracks, fur/feathers, scat, or a den present. We classify mortality as due to "exposure" when evidence of predation is lacking and death was associated with recent rain and/or cold temperatures. We classify mortality as "other" when other circumstances are obvious (e.g., killed by machinery in a mowed patch of grass). We classify mortality as "unknown" when the transmitter has fallen off the back with no obvious signs of tampering or suture failure.

We collect vegetation data at the nest site within 7 days after a nest has hatched, failed, or been abandoned. We estimate litter depth and the percent canopy cover (Daubenmire 1959) of grasses, forbs, litter, bare ground, woody vegetation, and other (e.g., logs, rocks) using a 0.5 m^2 sampling quadrat. We estimate percent cover on an overlapping basis using 7 classes: 0%, 0.1-5%, 5-25%, 25-50%, 50-75%, 75-95%, and 95-100%. We count the number of grass and forb species to determine species richness within the quadrat. We also record visual obstruction readings (VOR; Robel et al. 1970) in the 4 cardinal directions to determine vegetation vertical density around the nest and we record the maximum height of live and standing dead vegetation within 0.5 m of the Robel pole. Finally, we repeat these sampling efforts at two random points within 15 m of the nest site.

RESULTS AND DISCUSSION

Data collection is ongoing at the time of this report; therefore, we provide only a summary overview of the data collected and note adjustments to field methods that we have made thus far.

We captured and collared 10 hens at Lamberton and 10 hens at Worthington Wells. Two roosters were opportunistically captured and banded at Lamberton. The baited walk-in traps were not a productive capture technique. Tracks in the intermittent snow cover showed that birds walked near the traps but were unwilling to enter them. We speculate that this result is due to a mild winter with above-average food availability for pheasants. Only 2 hens were captured using the walk-in traps (10%) whereas 18 hens (90%) and 2 roosters (100%) were captured by spotlighting/UTV. The onset of the breeding season limited our spotlighting/UTV capture efforts in the spring. In the future, we plan on also conducting spotlighting/UTV capture efforts in the fall and early winter to help increase our sample sizes. We will also use the baited walk-in traps if winter conditions are conducive to this capture method.

To date, 3 collar crimps have failed (15%) which led to the hens' collars falling off. Extreme cold temperatures during the collaring process likely led us to incorrectly install the crimps, resulting in the failures. Two hens (10%) died due to predation during the early nesting season (late April – early May). Prior to losing their collars or being depredated, two hens made short movements (<800 m) to initiate nesting on privately-owned grasslands enrolled in CRP. Fifteen hens (75%) are currently being monitored via radiotelemetry. Neither marked rooster has been re-sighted yet.

Fourteen of the 15 remaining hens (93%) have stayed within 400-800 m of their initial capture location for their nesting attempts whereas one hen (7%) has made a >4 mi movement to nest in a roadside outside of the Worthington Wells project area. To date, 6 hens (40%) have successfully hatched a nest. One additional nest has been located during our field efforts and has since hatched. Therefore, 7 out of 16 monitored nests have been successful (43.7% apparent nest success) to date. At least 2 nests failed due to cold, wet weather in mid-May and 2 nests have failed due to predation thus far. Three nests were abandoned in the laying stage in early May due to our monitoring efforts. In all three cases, the hen was sitting on her nest extensively while laying and our telemetry efforts therefore seemed to indicate that each hen had begun incubating. We have modified our protocol for flushing hens to locate nests and determine clutch size to allow hens to incubate for longer (>5 days) before we disturb them. Two hens began moving again after telemetry indicated that they had begun incubation but before we could locate their nests; therefore we do not know their clutch sizes or the cause of nest failure for these nesting attempts. We have begun to mark the general nest location by placing flagging 10-15 m to the north and south of the nest during laying and early incubation so that we can avoid losing these data in the future if nests fail before we flush the hen.

Cameras have been deployed on 7 nests to date. No predation events have been captured on video yet. Notable observations include a rooster visiting a hen at her nest (Figure 2) and a chick appearing on video (Figure 3) within 2 h of the hen leading the brood away from the nest site. We initially set cameras to record video continuously at 6 frames per second (fps) but later changed to 12 fps to increase the quality of video. Hens have been extremely tolerant of the cameras and we have been able to place the cameras within 1 m of the nest bowl.

We are currently monitoring 6 broods. We believe 3 of these broods hatched between 27 May and 1 June and the other broods hatched between 11 June and 16 June. We have captured and radio-tagged 4 chicks from 2 broods. In all cases thus far, hens have flown <200 m when flushed from their broods and have returned to within 5-50 m of the brood almost immediately, regardless of our presence. One transmitter has fallen off of a chick for unknown reasons; the remaining 3 chicks are currently alive and being monitored. Future efforts will be aimed at capturing and radiotagging chicks between 3-4 weeks old to allow tracking beyond the first 30 days post-hatch. We expect these efforts will be difficult because chicks will be capable of flying at this age. We will suture 3.4 g backpack-style VHF radiotransmitters onto the backs of these older chicks. These heavier transmitters are expected to last approximately 90 days and will allow us to estimate juvenile survival to the beginning of October. The PIT tags implanted into hatchlings will allow us to identify older individuals during this second round of chick captures and help refine our survival analyses.

Vegetation data is currently being collected around nest sites. Vegetation data related to brood habitat selection will be collected over the remainder of the field season.

This first field season has aided in the refinement of field techniques necessary for assessing survival and habitat selection of pheasants. Furthermore, the data that is being collected will be used to plan the expansion of the study in 2016.

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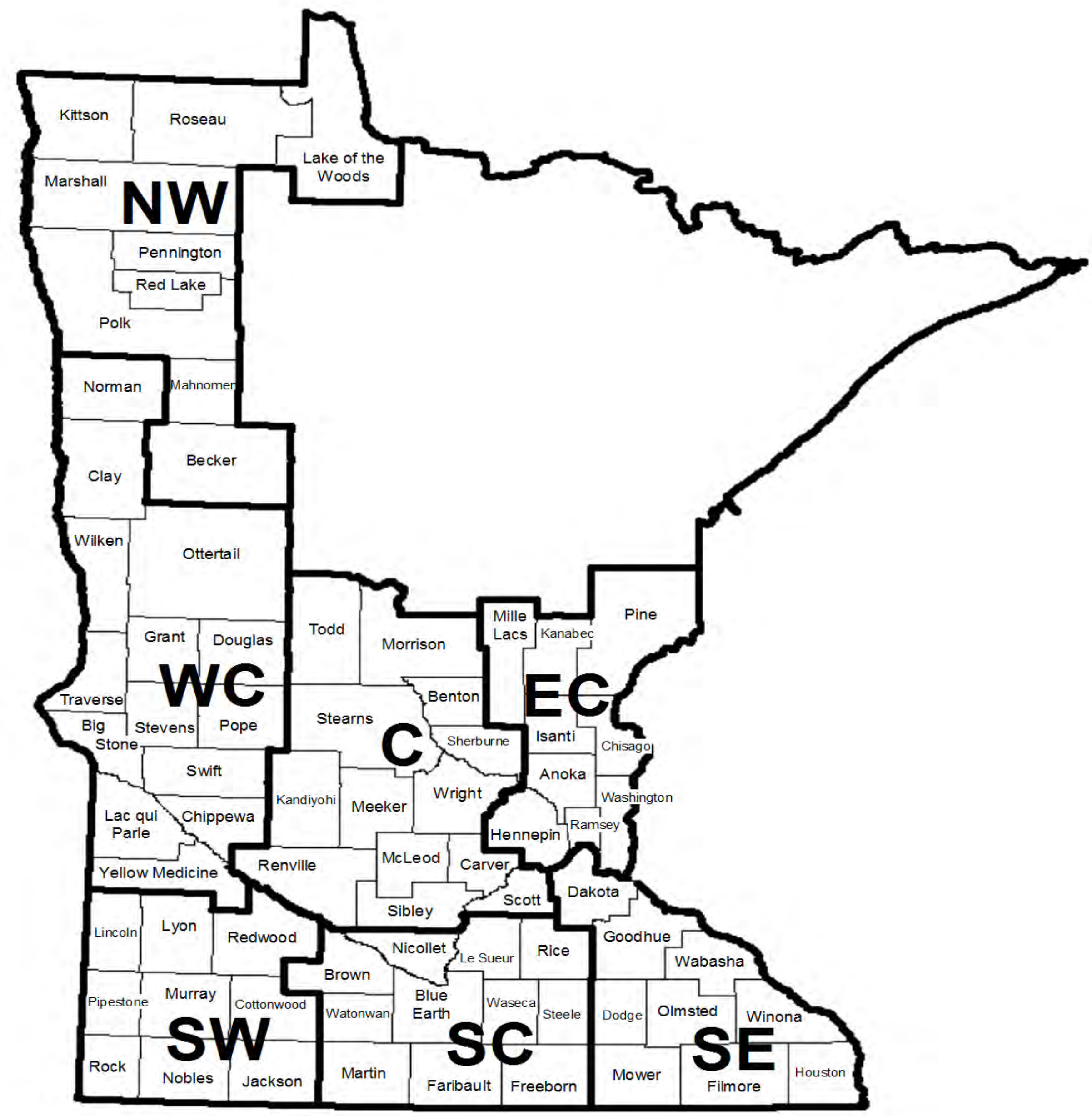

Figure 1. This study is being conducted in Redwood and Nobles Counties in southwestern Minnesota, which lies within the core of Minnesota's pheasant range.

Figure 2. A rooster visits a hen at her nest during incubation.

Figure 3. A chick appears <1 m from a nest within hours of hatching. About 2 h later, the video showed the hen leaving the nest with her brood.

QUANTITATIVE ASSESSMENT OF BULLET FRAGMENTS IN VISCERA OF SHEEP CARCASSES AS SURROGATES FOR WHITE-TAILED DEER[1]

Luis Cruz-Martinez, Marrett D. Grund, and Patrick T. Redig

ABSTRACT

Research indicates that avian scavengers, such as bald eagles (*Haliaeetus leucocephalus*), can be exposed to lead through the consumption of spent lead from ammunition in carcasses of animals shot with lead-based projectiles. Few studies have examined the degree of bullet fragmentation in viscera (offal) of game mammals. Our objective was to quantify the number of bullet fragments deposited in sheep carcasses shot with different types of lead and nonlead, high-velocity centerfire rifle bullets and with lead projectiles fired from shotguns and muzzleloader rifles marketed for hunting white-tailed deer (*Odocoileus virginianus*). We hypothesized that after controlling for velocity, angle of entry, distance from target, and shot placement (thoracic region), most of the bullet fragments would be deposited in the impact zone (heart and lungs). After examining all viscera from each carcass, we detected metal fragments in 96% of the viscera and found that metal fragments were deposited in greater quantities in the abdominal viscera (organs caudal to the diaphragm) compared to the thoracic viscera (heart and lungs). Additionally, bullets fired from the centerfire rifle fragmented more than the projectiles fired from the shotgun and muzzleloader rifle. Rapid-expansion lead bullets fragmented more than controlled-expansion lead bullets and lead-free bullets. However, 1 type of controlled-expansion bullet that is comprised almost entirely of lead and advertised to retain >90% of its weight, fragmented similarly to the rapid expansion lead bullets. We observed lead fragments produced by centerfire rifle bullets and shotgun and muzzleloader projectiles present in sheep carcasses and conclude that lead is made available to scavengers from the distribution of lead fragments lodged in the carcasses of game through viscera left in the field by hunters.To eliminate this type of lead exposure, shooters must employ the use of nonlead projectiles or completely remove the remains of shot animals from the field.

VALUATING COMPETING PREFERENCES OF HUNTERS AND LANDOWNERS FOR MANAGEMENT OF DEER POPULATIONS[1]

Gino J. D'Angelo and Marrett D. Grund

ABSTRACT

Most state wildlife agencies consider public input in the management of white-tailed deer (*Odocoileus virginianus*) populations. In 2013, we surveyed deer hunters (n = 3,600) and landowners (n = 4,604) in southwest Minnesota to gauge their preferences for managing deer. We sought to identify whether a priori assumptions about these main stakeholder groups in a primarily rural, agricultural region of the Midwest U.S. aligned with their perceptions of the impacts of deer. We hypothesized that irrespective of their perceived impacts of deer, hunters would prefer deer populations to be increased and landowners would prefer deer populations to be decreased. Our findings suggest that defining stakeholder groups according to primary associations with deer (i.e., farming and/or hunting) accurately categorized differences in tolerance levels for deer populations in our study area. Deer damage was considered relatively minor by landowners, yet 51% of landowners wanted deer densities reduced. Although 59% of hunters were satisfied with the number of deer, 62% of hunters still wanted deer densities increased in the future. Almost two-thirds of hunters were not satisfied with the number or quality of bucks where they hunted, and an antler point restriction was the only potential regulation supported by hunters to reduce harvest mortality rates of bucks. To enable managers to monitor trends in public satisfaction relative to the fundamental objectives of deer management in an area, we recommend conducting frequent surveys of primary stakeholders.