Ring-necked pheasant survival, nest habitat use, and predator occupancy in Kansas spring cover crops

by

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Abstract

The ring-necked pheasant (*Phasianus colchicus*) is a popular and economically important upland gamebird in Kansas. Population declines have stakeholders seeking methods to manage populations on agricultural lands. Cover crops planted during the breeding period may provide important resources pheasants require for survival and successful reproduction. I evaluated three cover crop mixes; a custom mix, commercial mix, a wildlife mix, and a chemical fallow control in three counties in western Kansas, during 2017 and 2018 to determine their potential as a management practice for increasing pheasant habitat. I tested the relative effects of spring cover crops on female pheasant survival, nest survival, nest-site selection, and mesocarnivore occupancy. Females pheasants (73) were captured via nightlighting during February – April and fitted with 15-g very-high-frequency radio collars and monitored them by telemetry. I placed 58 camera traps on field edges and within cover crop treatments from April to September. Vegetation data were collected at nests and random points to assess nest-site selection and weekly random vegetation points were sampled within treatments. I used known fate and nest survival models in the package RMark interface in R to investigate adult and nest survival (R Core Team 2018). Adult breeding season survival was 0.57 (SE < 0.0001, CI = 0.5739 – 0.5740). Percent spring cover crop positively influenced adult survival (AIC_c w_i = 0.450). Nest survival was 0.361 (SE < 0.001, CI = 0.3614 - 0.3614). Daily nest survival followed a pattern of high survival that gradually declined over the breeding season. Resource selection functions suggest female ring-necked pheasants selected vegetation between 5-7 dm at 50% VOR for nest sites (AIC_c w_i = 0.97). Chi-square analyses suggest females selected Conservation Reserve Program (CRP) patches for nest sites more than expected during both years (2017 χ^2_4 = 26.49, P < 0.001; 2018 χ^2_4 = 9.80, P = 0.04). CRP supported 57% of nests and 56% of successful nests relative to other cover types. All three of the monitored nests in cover crops were depredated. Ring-necked pheasant occupancy was greatest on edges of treatments (ψ = 0.97, SE = 0.081) and influenced by proportion of the Chick Magnet seed mix (AIC_c w_i = 0.68). Mesocarnivore occupancy was greatest on treatment edges with a constant occupancy of 0.99 (SE = 0.47, AIC_c w_i = 0.66). Spring cover crops provide cover and foraging resources when the majority of agricultural practices are fallow. Spring cover crops do not provide sufficient vertical cover for nesting until

after peak nesting occurs, especially during cooler than average winter and spring conditions such as 2018. However, there are tangible benefits of spring cover crops to other biological periods, such as adult female survival, and brood resources if placement of cover crops is targeted near quality nest habitat. My results indicates wheat is an ecological trap for nesting due to increased predation and destruction during harvest. Providing quality nest structure will reduce females nesting in wheat. Incorporation of spring cover crops is a beneficial wildlife management tool that can increase ring-necked pheasant habitat on the landscape.

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Chapter 1 - Influence of Spring Cover Crops on Survival of Ring-necked Pheasant Adults and Nests

Introduction

Survival of an organism is influenced by a variety of factors that occur at different spatial and temporal scales. Factors influencing survival may include resource availability, competition, weather, and stochastic events. The main factors affecting survival of a species is of particular interest to wildlife managers and stakeholders attempting to stabilize or increase wildlife populations. Individuals with the greatest reproductive ability are targeted for conservation efforts to increase populations through annual recruitment. Such is the case with ring-necked pheasants (*Phasianus colchicus*), a non-native upland gamebird from East Asia with naturalized populations throughout the state of Kansas. Pheasants are an economically important revenue source for Kanas with pheasant hunters contributing >$50 million annually to state and local economies (Midwest Pheasant Study Group 2013). However, declining populations in response to agricultural change have stakeholders seeking information on specific causes of the population decline and specifically how it relates to survival of individuals within regional populations (Snyder 1985, Warner et al. 1987, Riley et al. 1994, Rodgers 1999, Schmitz and Clark 1999).

Managers typically focus on those biological periods that have the greatest influence on recruitment of individuals into a population. Breeding is considered the biological period of greatest risk for adult female ring-necked pheasants due to the exposure during breeding, investment of nutrient reserves in forming and laying eggs, selecting a nest site, incubating nests, and raising broods (Snyder 1985, Hill and Robertson 1988, Riley et al. 1994). Ring-necked pheasants require different resources during different biological stages for survival and successful reproduction (Baxter and Wolfe 1973, Hill and Robertson 1988). Nesting females require >15 ha large patches of undisturbed dense residual vegetation to avoid predation of individuals and associated nests (Snyder 1984, Clark and Borgenshutz 1999, Matthews et al 2012*a*). Broods require herbaceous vegetation to efficiently forage for insects with overhead cover for protection from predators, but reduced basal cover and stem density of vegetation to facilitate chick movement. Nest and brood habitats needs to be adjacent or within close proximity to be accessible to chicks (Hill and Robertson 1988, Matthews et al. 2012*b*).

Sensitivity analyses suggest survival during the first year may have the greatest influence on population demography for ring-necked pheasants (Clark et al. 2008). Furthermore, adult survival of female ring-necked pheasants varies over their life cycle, with typical survival of individuals declining during the breeding, nesting and brooding (i.e., raising chicks) periods (Baxter and Wolfe 1973, Snyder 1985, Hill and Robertson 1988, Riley et al. 1994). Finally, nest success is a primary metric for determining population recruitment and persistence. Annual and period (seasonal/monthly) survival for female ring-necked pheasants within the Midwestern United States ranges between 20-92% for adult females, with a range of 10-69% for nest survival (Tables 1.1, 1.2). A variety of methods have been implemented to improve survival of females, with the focus in the Midwest to provide high quality vegetation cover for nesting and brooding periods. This has primarily occurred through the use of the federal Farm Bill's Conservation Reserve Program (CRP), which pays landowners to plant perennial grass cover on agricultural land for 10-15 year contracts. Originally intended to provide environmental benefits, such as decreased water and wind erosion of cropland, CRP also provides habitat for grassland obligate species that currently have the greatest population declines (Best et al. 1997). However, limits on CRP enrollment, and expiring contracts over the next decade may have negative influences on pheasant populations as quality habitat is removed from the landscape. In Kansas alone, >722 thousand hectares will expire between 2018 and 2030, with anticipated decreased annual enrollment likely unable to compensate for expiring CRP acres (USDA 2017). With the current outlook of CRP, managers need to focus on additional land cover types that can provide quality habitat to ensure survival of reproducing females and regional population persistence.

Stakeholders are currently seeking additional management strategies to increase female survival and nest success to bolster regional populations with a focus on conservation within working agricultural lands. The majority of agricultural crops can potentially provide ring-necked pheasants with resources for survival depending on the biological period within their life cycle (Baxter and Wolfe 1973). However, to increase survival of breeding females, high quality vegetation resources need to be available during the April through September breeding season. Small-grain crops, such as winter wheat, can provide high quality substrate for breeding females, particularly when fields are fallow and weedy growth is produced (Snyder 1985; Rodgers 1999, 2002). However, winter wheat is now generally planted in agricultural rotations between corn and or grain sorghum, eliminating the weedy fallow period. The number of acres for each crop on the landscape is varies annually dependent on market commodity prices. Agricultural fields between primary crop rotation are typically maintained as chemically treated fallow in Kansas using herbicides to reduce plant growth and presence of noxious weeds and other noncrop herbaceous vegetation. These chemically fallow fields provide few resources for wildlife, including ring-necked pheasants during important biological periods, which may decrease survival of nests if substantial area of the landscape surrounding high quality vegetative cover is chemically fallow fields (Simonsen and Fontaine 2016). Chemically fallow agricultural fields between primary crop rotations, particularly those leading into the fall planting of winter wheat, may provide an opportunity for ring-necked pheasant habitat management.

One potential strategy to provide females with additional vegetation structure to increase survival during biologically important periods may be to incorporate spring cover crops during primary crop rotations instead of chemically fallow fields. Cover crop is a term applied to any noncash multi or single species mix that provides agricultural services, including reducing soil and water erosion, increasing predatory insect abundance, nitrogen reduction and/or fixation for primary crops and noxious weed control (Delgado et al. 2007, De Baets et al. 2011, Blesh and Drinkwater 2013, Smith et al. 2015). Spring cover crops are typically planted in March and April, as part of the fallow phase within a winter wheat-grain crop rotation. The vertical and horizontal structure of cover crops remains on the landscape even after chemical termination in June or July, providing a vegetation cover for ring-necked pheasants during the breeding season.

My objectives were to 1) determine if spring cover crops influence adult ring-necked pheasant survival, and 2) if spring cover crops influence nest survival during the nesting period. I predicted that spring cover crops will positively influence adult and nest survival of adult pheasants.

Study Area

My study area included 10 sites in Graham, Norton and Russell counties, Kansas, during February to September 2017 and 2018 (Figs. 1.1, 1.2a-h). Two sites were located in Graham County in 2017 with a total area of 6,623 ha. The project expanded to four sites in Graham County during 2018 with a total area of 4,333 ha. Russell County had two sites in 2018 with a total area of 5,860 ha. Finally, Norton County had two sites in 2018 with a total area of 5,688 ha.

Graham and Norton counties were transitional between the north-central Smoky Hills and western High Plains ecoregions of Kansas. Russell County occurred within the north-central Smoky Hill ecoregion. Common land cover surrounding the seven study sites in Graham County included native pasture, row-crop and dryland agricultural fields, properties enrolled in CRP, forested draws, rivers, man-made objects, stock ponds created by damming draws, and weedy waste areas (Fig. 1.2a-e). Norton and Russell counties had similar land cover as Graham County, with the addition of state wildlife management areas near a reservoir. The Norton Wildlife Management area encompassed a total area of 3,157 ha (Fig. 1.2f-g). The Wilson Wildlife Management Area was comparable in size to the Norton Wildlife Management area with a total area of 3,237 ha (Fig. 1.2h, Table 1.3).

All study sites occurred within the mixed-grass prairie region and species within native pastures included sideoats grama (*Bouteloua curtipendula*), little bluestem (*Schizachyrium scoparium*), tall dropseed (*Sporobolus compositus*), western wheatgrass (*Pascopyrum smithii*), buffalo grass (*Bouteloua dactyloides*), blue grama (*Bouteloua gracilis*), hairy grama (*Bouteloua hirsuta*), Virginia ground cherry (*Physalis virginiana*), windmill grass (*Chloris verticillata*), common ragweed (*Ambrosia artemisiifolia*), western ragweed (*Ambrosia psilostachya*), silky prairie-clover (*Dalea villosa*), field mint (*Mentha arvensis*), common milkweed (*Asclepias syriaca*), wavy-leaf thistle (*Cirsium undulatum*), buffalo bur (*Solanum rostratum*), and blue vervain (*Verbena stricta*). Row-crop agricultural fields primarily contained monocultures of dryland wheat (*Triticum aestivum*), corn (*Zea mays*), milo (*Sorghum bicolor*), or soybeans (*Glycine max*); few corn and soybean fields were irrigated. Fields between crop rotations contained crop stubble and were maintained in the chemical-fallow state using herbicide applications.

Properties enrolled in CRP had planted native species mixtures containing Indian grass (*Sorghastrum nutans*), big bluestem (*Andropogon gerardii*), little bluestem, switchgrass (*Panicum virgatum*), sideoats grama, western wheatgrass, yellow sweet clover (*Melilotus officinalis*), purple prairie-clover, common ragweed, common milkweed , western ironweed (*Vernonia baldwinii*), pale dock (*Rumex altissumus*), wavy-leaf thistle, Maximillian sunflower (*Helianthus maximiliani*), and common sunflower (*Helianthus annuus*). Forested draws consisted of buckbrush (*Symphoricarpos oribiculatus*), Missouri gooseberry (*Ribes missouriense*), yucca (*Yucca filamentosa*), wild plum (*Prunus americana*), and sumac (*Rhus spp.) thickets with the occasional black cherry (*Prunus serotina*), eastern cottonwood (*Populus deltoides*), and eastern red cedar (*Juniperus virginiana*). Common species within riparian areas and wooded slopes included eastern cottonwood ,eastern red cedar ,box elder (*Acer negundo*), sumac, black cherry, hack berry (*Celtis occidentalis*), wild plum , Missouri gooseberry, buckbrush, stinging nettle (*Urtica doica*), western wheatgrass, smooth brome (*Bromus inermis*), cheat grass (*Bromus tectorum*), timothy (*Phleum pratense*), giant ragweed (*Ambrosia trifida*), poison ivy (*Toxicodendron radicans*), dandelion (*Taraxacum officinale*), pale dock, prairie cordgrass (*Spartina pectinata*), broad-leaf cattail (*Typha latifolia*), and prairie bulrush (*Schoenoplectus maritimus*).

Man-made objects included oil infrastructure, buildings, dirt roads, buildings, distribution and transmission powerlines, and communication towers. Native, noxious and naturalized species occur throughout the weedy waste area surrounding fields and man-made objects. These species include cheat grass, smooth brome, caucasian bluestem (*Bothriocholoa bladhii*), marestail (*Hippuris vulgaris*), kochia (*Bassia scoparia*), western wheatgrass, Russian thistle (*Salsolsa kali*), common sunflower, field bindweed (*Convolvulus arvensis*), poison ivy, green foxtail (*Setaria viridis*), pale dock, Palmer's pigweed (*Amaranthus palmeri*), sandbur (*Cencrhus longispinus*), carpetweed (*Mollugo verticillata*), and grey-green wood sorrel (*Oxalis dillenii*). Taxonomic references were obtained from the Kansas wildflowers and grasses webpage (www.kswildflower.org) and the Kansas Native Plant Society webpage (www.kansasnativeplantsociety).

Breeding Season Weather

Long-term average (1981-2010) April through August precipitation and temperature was 44.2 cm and 20.3° C in Graham County, 49.8 cm and 19.6° C in Norton County and 48.9 cm and 21° C in Russell County (National Centers for Environmental Information). Norton had lower precipitation at 21 cm 2018 than 28 cm in 2017, whereas Russell County had similar precipitation between years at 42 cm in 2017 and 46 in 2018 and Graham County had greater precipitation in 2018 with 63 cm verses 39 cm in 2017. (Fig. 1.3). During 2018, temperatures were cooler than in 2017, with 19-22 more days below 0° C, particularly in February through April, and only 5-14 days above 37° C compared to 11-21 in 2017 (Fig. 1.4). Weather conditions during the 2018 study period were colder in February through April (53-57 days below 0° C) than the long-term average (47 days below 0° C). Furthermore, May through August were also cooler during the 2018 study period (41-62 days above 32.2 ° C) compared to the long-term average (67 days above 32.2° C).

Cover Crop and Chemical Fallow Description

Spring-summer cover crops contained legume and non-legume single species or multiple species mixes (Table 1.4). Cover crops were planted during March 2017 into fields of harvested grain sorghum. Planting occurred in early April of 2018 and cover crops were seeded into fields of harvested corn and grain sorghum. Each cover crop treatment was terminated in mid to late-June or early July using chemical herbicide or mechanical methods such as tillage. The commercial cover crop seed mixes and a custom wildlife cover crop seed mix were obtained from Star Seed Company, Osborne, Kansas. There were a total of three cover crop mixes (GreenSpring, Chick Magnet and a custom mix), and a chemically fallow treatment was included as a control.

GreenSpring was a cool-season mix typically planted during early spring for a hay crop or livestock grazing prior to termination for fall primary crops such as wheat. The mix was intended to produce greater yields than single species mixes. This mix included oats (*Avena sativa*) and peas (*Pisum sativum*) with a seeding rate of 73 kg/ha.

Chick Magnet was a warm-season grass and forb cover-crop blend designed to increase brood survival by providing adequate substrate for protection from weather and avian predators, and substantial soft-bodied insects for foraging. The mix contained hybrid brassicas Winfred (*Brassica napus*) and Pasja (*Brassica rapa*), yellow sweetclover (*Melilotus officinalis*), peas, sunflower (*Helianthus annuus*), and buckwheat (*Fagopyrum esculentum*) with a seeding rate of 26 kg/ha.

Custom Mix was a seed mix created by Star Seed Company based on input from wildlife professionals and producers that incorporated the herbaceous and structural component of the two commercial mixes. This mix included turnips (*Brassica rapa*), oats, cowpeas (*Vigna unguiculata*), radish (*Raphanus raphanistrum*), yellow sweetclover, (*Melilotus officinalis*), peas, sunflower, safflower (*Carthamus tinctorius*), chickling vetch (*Lathyrus sativus*), and rapeseed (*Brassica napus*) with a seeding rate of 40 kg/ha.

Methods

Study Design

Study sites within each county consisted of 8-16 fields, which were 12-20 ha in size and were adjacent or within 1 kilometer to one another. The design incorporated replicates of four fields (block) with four treatments applied per block. Each block had three different cover crop mixes and a chemically fallow control. Each field was randomly assigned a specific treatment. In 2017, there were three treatment replicates in Graham County; in 2018, there were four treatment replicates in Graham County, four in Norton County, and two in Russell County. Cover crop treatments were terminated in mid to late June, based on needs of the individual producer and restrictions of compliance with crop insurance regulations, prior to the sowing of wheat in September.

Capture

Nightlighting Techniques

To capture ring-necked pheasants using night-lighting, I refitted the front bumper of a Chevy Silverado half-ton pickup with a metal bar to hold two tractor chairs with welded metal frames and pins were used to keep the chairs in place. I installed a light bar above the windshield to locate moving vegetation from pheasant movement. To avoid searching the same area during a capture event, I used a Garmin car GPS (Nuvi 50LM) to map search areas. Previous night-lighting techniques employed sound to cover noise from the vehicle and field personnel. I incorporated a wireless Bluetooth speaker, which was taped to the hood of the vehicle and controlled by cell phone using downloaded Spotify fast-paced soundtracks.

Netters on the chairs carried hoop nets to chase and capture pheasants. Spotlighters stood in the back of the vehicle and once moving vegetation was seen, pheasants were spotlighted to aid detection by netters. Slightly shaking spotlights (Stanley Black and Decker Inc, New Britain, Connecticut, model FATMAX SL10LEDS) aided in disorienting the pheasant and decreasing likelihood of flight. Netters avoided running between spotlights and pheasants as the absence of light appeared to spook the pheasants into flight.

I outfitted each captured female ring-necked pheasant with a 15-g very-high-frequency (VHF) necklace radio transmitter (Model #A3960, Advanced Telemetry Systems, Inc., Isanti, MN, USA). All VHF transmitters were programmed with a switch to indicate mortality after eight hours of no movement. I measured mass by placing pheasants in a bag and using a 2,500-g spring scale (Pesola AG, Switzerland, model 42500). The left tarsus was measured using digital calipers (Neiko Co, China, model 01407A), which were accurate to 0.01 mm. I measured wing chord (flattened) to mm using a wing chord ruler board. A leg band was secured on each pheasant for identification of individuals during recapture events (FAO 2007). Procedures followed guidelines for handling wild animals required by the Kansas State University Institutional Animal Car and Use Committee (IACUC #3831) and State of Kansas Scientific Wildlife Permits SC-018-2017 and SC-024-2018.

Monitoring

Adult

Radio-collared ring-necked pheasants were located every one to three days during main foraging and loafing periods using hand-held 3-element antennas (Baxter and Wolfe 1973). Foraging periods occurred from sunrise to two hours after sunrise, and two hours before sunset to sunset (Baxter and Wolfe 1973). Loafing periods occurred between the two foraging periods. A minimum of three azimuths with corresponding Universal Transverse Mercator (UTM) coordinates were recorded within a 20-min period to reduce movement bias (Kenward 2001). Store onboard computers with Location of a Signal (LOAS) software were used to estimate the animals location and calculate error polygons (Ecological Software Solutions, LLC, Hegymagas, Hungary, Version 4.0). Additional azimuths were collected when initial error polygons exceeded 2,000 m^2. I located all suspected mortalities using handheld telemetry units and homing techniques to investigate cause-specific mortality (Dumke and Pils 1973, Bumann and Stauffer 2002).

Nest Locations

From April-August, females with stationary locations for ≥2 detections indicated initiation of nest incubation. I visually confirmed nest location by locating the female on the nest using a receiver (R-1000, Communications Specialists, CA, USA). I attempted to avoid flushing the female from the nest as disturbance may increase predation or abandonment (Evans and Wolfe Jr. 1967, Giuliano and Daves 2002). Flags were positioned five m north and south of the nest to provide observers with the nest location for subsequent visits (Matthews et al. 2012*a*). Each location was recorded using a Global Positioning System (GPS) handheld unit (GPSMAP 64, Garmin International Inc., Olathe, KS, USA).

Nests were visited when the female was absent, or after estimated day 14 of incubation to minimize potential abandonment, to record clutch size, egg volume (length and width in mm) using digital calipers, and incubation stage by floating the eggs (Westerskov 1950). I monitored nest viability daily remotely using telemetry. I determined nest fate when the attending female's activity indicated she had permanently left the nest (≥2 locations away from nest site) or a mortality signal occurred (Matthews et al. 2012*a*). Nests with broken or cracked eggshells with membranes attached, or disappearance of the clutch were considered failed. Nests with ≥1 egg having detached membranes or when females were observed with broods indicated that a nest was successful (Klett et al. 1986).

Vegetation Surveys

Nest

I measured vegetation composition and structure at nests and associated random points. Associated random points were randomly generated between 20 and 150 m from each nest and at 0° to 260°, occurred in the same patch type (a contiguous area of specific vegetation characteristics such a CRP property or cover-crop mix), and represented available vegetation composition and structure with the patch type. Vegetation composition and structure at the nest and an associated random point were measured during the initial nest visit (i.e., early incubation).

I conducted vegetation surveys at each nest and random point and 4 m in each cardinal direction to determine factors influencing nest survival at the point scales. Percent cover of bare ground, litter, forbs, warm-season grasses, cool-season grasses, woody species greater and less than 1.5 m, crop, and other were measured using a modified 60 x 60-cm Daubenmire horizontal frame (Daubenmire 1959). I recorded visual obstruction using a modified Robel pole using 5-cm bands at a distance of 4 m four meter and height of 1 m (VOR; Robel et al. 1970). Ocular readings were estimated for 100%, 75%, 50%, 25%, and 0% obstructed cover in 4 cardinal directions. I measured litter depth (cm) in the northwest corner of the Daubenmire horizontal frame.

Land-Cover Map Analysis

GIS Layers

I created a buffer boundary of 2 km surrounding capture sites to encompass female ring-necked pheasant seasonal movements from wintering grounds to breeding sites (Gates and Hines 1974). In 2017, I created 2-km buffer zones surrounding three study sites including capture sites and cover crop fields in Graham County. Capture sites and project cover crop acres increased to three counties including Graham, Norton, and Russell counties in 2018 when four buffer zones were created in Graham County, four in Norton County, and three in Russell County. I obtained aerial imagery from the USGS National Map database and digitized patch boundaries using ArcMap (ESRI, Redlands, CA, version 10.5). Roads and counties layers were retrieved from the Kansas Data Access and Support Center. I delineated the digitized land cover patches through ground-truthing in summer 2017 and 2018 using driving surveys and walking surveys when land features obstructed view of targeted property. Land-cover categories included Cover Crop treatment (project cover crop and other cover crop), Crop Stubble (agricultural land between primary crop rotations and kept chemically fallow or weedy fallow), Conservation Reserve Program (CRP), and Native Grasses (grazed and ungrazed pastures, expired CRP, warm-season grass hay fields, and weedy waste areas), Primary Growing Crop (primary cash crop such as wheat, milo, or corn), Open Water (rivers, streams and man-made ponds), Roads (county roads, highways, oil-field roads), and Man-made Objects (houses, barns, agricultural buildings). Land-use categories were used to determine potential influences on adult survival and nest survival of breeding females during 2017 and 2018.

Home Ranges

Seasonal home range sizes of females were calculated using the kernel density method in package adhabitatHR and R (R Core Team 2018). I estimated 95% kernel densities with a minimum of 30 triangulated points on individuals. Mortalities prior to reaching the 30-point limit were assigned an average home range, calculated from other individuals within the same county.

Survival Analysis

Adult

I estimated weekly survival rates using known-fate models in Program MARK through the RMark package in R during the mid-April-August breeding season (White and Burnham 1999, R Core Team 2018). I selected the mid-April through August period as this corresponded to the primary breeding period for females, and allowed me to incorporate individuals captured in early April that survived past the initial two-week censor period. To combine both years of data, I concluded the survival period in mid-August due to a cease in weekly monitoring of females during the 2017 study period. I developed four *a priori* model suites to determine factors influencing adult survival based on pheasant behavior and ecology. Model covariates included mean weekly precipitation, maximum and minimum temperature, percent of locations in cover crops, and home-range size. Weather data were collected from the nearest National Oceanic and Atmospheric Administration weather stations in Hill City, Norton and Russell, Kansas (NOAA 2018). No correlated variables ($|r| > 0.5$) were included in the same model. Model ranking and fit were determined using Akaike's Information Criterion (AIC_c) for small sample sizes, ΔAIC_c values, and Akaike weights (w_i; Hurvich and Tsai 1995, Burnhamand Anderson 2002, Wagenmakers and Farrell 2004, Arnold 2010).

Nest

I developed five *a priori* model suites to determine factors influencing daily nest survival based on ring-necked pheasant behavior and ecology. Model suites included visual obstruction readings, percent composition, proportion of land use type within home ranges, average incubation period temperatures and precipitation, and a final model suite containing the top models from the previous suite, a time trend (nest survival follows a trend through time), and nest age covariate. I estimated daily nest survival using the nest survival model in Program MARK through package RMark interface in R (R Core Team 2018). Nest survival was estimated for the entire nesting period, which included the laying and incubation periods. I extrapolated daily nest survival to overall nest success by raising the number of days of nesting to 35 days, which included 12 days for egg laying and 23 days for incubation (Dumke and Pils 1979). I used the delta method to determine period-specific standard errors (Powell 2007).

Model covariates included weekly mean precipitation, maximum and minimum temperature during the nesting period, nest visual obstruction reading, percent cover composition, proportion of land-cover type within the female's home range, time trend, quadratic influence of time, year and nest age. I included the year, nest age and weather covariates as these factors have been found to influence gallinaceous species nest success (Hill and Robertson 1988, Davis et al. 2015). Proportion of land cover surrounding nests, particularly CRP, crop and chemical fallow crop stubble have been found to influence pheasant nest survival in Iowa and Nebraska (Clark et al. 1999, Simonsen and Fontaine 2016). In addition, the substrate type surrounding nests and density of the vegetation may influence survival of ground-nesting species (Giuliano and Daves 2002). No correlated variables were included in the same model ($|r| > 0.5$). Model ranking and fit were determined by using AIC_c, ΔAIC_c values, and Akaike weights (w_i; Hurvich and Tsai 1995, Burnham and Anderson 2002, Wagenmakers and Farrell 2004, Arnold 2010).

Results

I captured 73 females during 2017 and 2018; 10 were captured in Norton County in 2018, 14 in Russell County and 49 in Graham county (2017 n = 34, 2018 n = 14, 1 recapture). Spring capture accounted for the most collared individuals (67), with one individual captured on a nest in summer 2017, and five individuals captured in November of 2017. In 2017, average mass was 982 g (SE = 21.0), average flattened wing chord was 21.2 cm (SE = 0.10), and average left tarsus was 66.83 mm (SE = 0.50). Females in 2018 declined in body mass with an average mass of 912 g (SE = 14.74), flattened wing chord 21.3 cm (SE = 0.10), and left tarsus 78.21 mm (SE = 0.43). In 2017, 11 mortalities occurred including three in April, seven in May, and one in July.

Eighteen females survived from 2017 to be monitored starting in February 2018. Mortality of females increased in 2018 for a total of 46 mortalities; five deaths in February, three in March, nine in April, 14 in May, 11 in June and one in July (Fig. 1.5). Mean home ranges of breeding females in 2017 was 126 ha (SE = 20.2) and 92 ha in 2018 (SE = 0.25.7).

Weekly survival was estimated for 58 females (2017 = 27, 2018 = 31) during the breeding season from April 22 to August 13, with an estimated weekly survival rate of 0.9679 (SE = 0.006, 95% CI 0.9523 - 0.9784) and period survival of 0.5739 (SE < 0.001, CI = 0.5739-0.5740). The final model suite included a null model, the percentage of cover crop within female home ranges, body condition (mass/tarsus), home-range size of the female, average maximum temperature during the week of 25 June, average minimum temperature during the week of 30 April, and the average precipitation during the week of 30 July (Table 1.5). The percent of cover crop locations within a female's home ranges had a positive influence on survival and was the top-ranked model (AIC_c w_i = 0.45; Fig. 1.6, Table 1.6).

I confirmed 82 nests during the study. In 2017, there were 38 confirmed nests from 23 collared and 2 uncollared females with an average clutch size of nine and range of 1-16 eggs; six females nested once, 13 nested twice, and two individuals nested three times. Nests were located in a variety of vegetative types, 27 were located in CRP (71%), 4 in green wheat, 3 in ungrazed pastures, 2 in cover crop (GreenSpring), and one in a cool-season grass road ditch. Of the 38 nests, eight were abandoned, 22 failed due to predation, and eight hatched (21%). In 2018, I confirmed 44 nests from 38 collared and six uncollared females and average clutch size increased to 11, with a range of five to 19 eggs. I documented 12 females who nested once, nine nested twice, one nested three times, and one individual nested four times. Females nested in several land-use types including 20 nests located in CRP (45%), 12 nests in wheat, three in warm-season grassland, two in an alternative cover crop mix (radishes, spring peas, sunflowers, spring peas, oats), two in chemical fallow wheat stubble, one in soybeans, one in ungrazed warm-season grass pasture, one in the Chick Magnet cover crop mix, one in a warm-season hayfield, and one in a smooth brome water drainage strip. Of the 44 nests, 20 failed due to predation, nine were abandoned, two failed due to extreme weather (hail), one failed due to a tractor, one was a dump nest, one nest's fate was unknown, and ten were successful (23%). Average initiation of first nest attempts was May 22 in 2017 and May 14 in 2018 (Fig. 1.7).

Nest data were combined for both years for analyses. Twenty-eight nests were included in nest survival analyses (21 failed, 7 successful) from 2017 and 35 nests (25 failed, 10 successful) were included from 2018. Model suites were created *a priori* and the top model from each suite was selected for use in the final composite model set. The final model suite included a null model, nest age, time trend, and year. Nest age was the top-ranked model for nest survival (AIC_c w_i = 0.999; Table 1.7), the overall period survival was 0.361 (SE < 0.001, 95% CI = 0.361 – 0.361; Fig. 1.8).

Discussion

Understanding factors influencing survival of adult females and their nests is critical to ring-necked pheasant management and population persistence. My results suggest survival of adult females can be positively influenced by the percent of cover crop locations within home ranges during the mid-April through August breeding season. Survival can vary drastically among years for adult females, with the greatest mortality occurring between mid-April through May, which corresponds to the main breeding and initial laying period for females. The best predictor for nest survival was the nest age model for both years of the study, where survival was high during the beginning of the season and declined during the remainder. Female ring-necked pheasants predominately used CRP fields for nesting with 55% of nests and 56% successful nests located on active and retired CRP properties, contributing the most to annual recruitment of any land cover type. Green and recently harvested stubble fields of wheat had 20% of the nests across years; however, only 18% percent of those nests were successful.

Nest survival of ring-necked pheasants varies across states and different landscape features, ranging from 10% in north-central South Dakota to almost 70% in parts of Iowa and Nebraska (Baxter and Wolfe 1973, Olson and Flake 1975, George et al. 1979, Snyder 1984, Clark et al. 1999, Berman 2007, Matthews et al. 2012*a*). In northeastern Colorado 78% of nests were located in growing wheat or stubble, and period nest survival ranged between 57-94% (Snyder 1895). Destruction of nests within wheat ranged from 0-25% depending on harvest dates. In Nebraska, pheasants nesting in CRP that had undergone mid-contact management had a greater incubation period survival at 69% than 31% for nests in unmanaged grasslands and CRP (Matthews et. al. 2012*a*). Providing sufficient tall residual cover, potentially in the form of CRP or a fall cover crop, during the initial nesting period of late April through May should reduce use of winter wheat for females. Nest survival was not influenced by the percent of cover crop surrounding nests, or the proportion of cover crops within breeding female home ranges. In addition, spring cover crops do not provide high quality substrate for nesting females, as only 6% of nests were located in this land cover type and 100% of monitored nests failed from depredation events. While spring cover crops and wheat in Kansas do not provide benefits for pheasant nest survival, it is possible they provide important resources during different biological periods, such as breeding and brooding.

Survival can be influenced by a variety of factors, including the presence of spring cover crops on the landscape in western Kansas. There are currently no known research studies that have directly researched ring-necked pheasant survival within cover crops. A study of mortality on bobwhite quail (*Colinus virginianu*s) coveys in Kansas reported mortality of 24%-46%, when individuals had access to a mix of corn, sorghum, wheat, and multiflora rose (*Rosa multiflora*), compared to 24%-82% for coveys without access to food plots (Robel and Kemp 1997). While my results suggest there may be a benefit of cover crops for survival of upland gamebirds during the breeding season, Robel and Kemp (1997) evaluated winter survival in relation to food availability. Additional factors, such as severe winter and spring weather may also influence survival of females (Gates et al 1974, Riley et al 1994).

My estimates of adult survival fall within the range found within the literature (Warner and Etter 1983, Snyder 1985, Riley et al. 1994, Schmitz and Clark 1999, Messinger 2015, Pauly 2018). Female survival in Colorado was lowest in April (78%), and increased as winter wheat reached adequate height for concealment (Snyder 1985). Survival between March and August was 56% in Colorado, which is similar to my estimates. Pheasants in Iowa had the greatest mortality during the spring season, with 77% due to predation (Riley et al. 1994, Schmitz and Clark 1999). Female survival between April and September was 39% in Iowa; however, a low of 25% was documented during the study (Riley et al. 1994).

Depending on severity, stochastic spring and summer events, such as spring blizzards or hail storms have been found to negatively affect survival (Allen 1956). Reduced survival of females has been documented following severe cold winters in Iowa and Wisconsin, with direct mortality attributed to predation events (Gates 1971, Riley et al 1994). In Iowa, average temperatures were 10-11° C below the normal of 15° in January and February, which reduced spring and summer survival from 56% to just 25% (Riley et al. 1994). Severe, cold weather in 2018 may be the principal factor driving increased mortality of females from predation during 2018. During 2018, extreme cold weather occurred in February through April, with 19-22 more days below 0° C in all three counties than in 2017. Females were on average 70 g less at capture in 2018 (912 g) than in 2017 (982 g), suggesting weather conditions during winter negatively influenced body condition, which was reflected in overall body condition entering the breeding season.

Lowered body condition in 2018 for female ring-necked pheasants may have required individuals to expend more time foraging to increase condition before entering the breeding season. The reduced mortality risk during the initial breeding and nesting period in 2017 may have been a result of high quality vegetation structure on the landscape and mild weather during winter and early spring. Movement from wheat stubble to high herbaceous cover was linked to increased hen survival in Colorado, with delays in wheat growth due to extreme snow levels leading to decreased survival at 54% compared to 78% during normal wheat growth the prior year (Snyder 1985). High quality cover for foraging females was not available during early nesting in 2018, as cold temperatures and late planting of winter wheat and spring cover crops significantly stunted vegetation growth during the spring and summer months compared to 2017. Differences between years for 50% visual obstruction were most extreme for wheat, where the average 50% obstruction during the week of May 21 was 8 dm in 2017, but only 4.6 dm in 2018, which is less than optimal for nesting ring-necked pheasants (Chapter II). Growth of cover crops was also reduced in 2018, with 50% visual obstruction at 1 dm or below compared to 2 dm to 3.5 dm during the week of May 21 in 2017. Spring cover crops in 2017 may have reached high visual obstruction readings that provided high quality foraging and loafing vegetation during peak nest incubation, which may have reduced predation events.

Adult survival can be positively influenced by spring cover crops; however, the proportion of cover crops within home ranges, and percentage of spring cover crops surrounding nests did not appear to influence nest survival. This is potentially due to the small number of nests located within spring cover crops and low proportion of spring cover crops within the female home ranges during the study. Variation in regional landscape configuration has been found to influence pheasant nest survival (Warner et al. 1987, Clark et al. 1999). Females placed the majority of nests in properties enrolled in CRP, which was similar to contemporary studies in Iowa, Nebraska, and South Dakota (Clark et al. 1999, Matthews et al. 2012*a*, Pauly et al. 2018). In Kansas, 57% of nests were located in CRP, and 56% of all successful nests occurred within this land cover type, whereas winter wheat had 20% of nests with a low apparent nest survival of just 18%. Nest success in South Dakota was similar across land-cover types at 51%; however, females were more likely to select CRP fields over winter wheat 66% of the time (Pauly et al. 2018). Wheat harvest in South Dakota also caused nest failure, albeit at a lower rate than in my study as harvest occurs later in the season potentially following the peak nesting period (Pauly et al 2018). Wheat harvest in Kansas overlaps with the peak nesting period of pheasants, which negatively influenced nest survival during my study.

Period nest survival of ring-necked pheasants in western Kansas was 36%, which is within the range of nest survival estimates reported across the Midwest. Nest survival is influenced by a variety of factors including patch size of the nesting substrate (Clark et al. 1999). Moderate patch sizes of 60 ha of undisturbed grassland produced the greatest nest success in Iowa; however, small tracks of isolated (1 ha) patches also had high nest success (Clark et al. 1999). Over a 10-year period in Illinois, nest success within hayfields was 25%, versus 29% in managed road ditches (Warner et al. 1987). Roadside nest sites were located near additional breeding habitat, suggesting females place nests within close proximity to potential brood habitat (Warner et al. 1987). Providing tall herbaceous brood vegetation adjacent to quality nest substrate will likely increase both nest and brood survival of pheasants. However, other factors which cannot be manipulated, such as time of season, also play an important role in nest success (Pauly et al 2018).

My results suggest that nest age had the greatest influence on pheasant nest survival in western Kansas, which has been documented for ring-necked pheasants in South Dakota (Pauly et al. 2018). While it is not possible to directly manage nest age to influence populations, my results indicate that targeting habitat management to provide quality residual substrate during late April to early June should be the priority to increase survival of first and second nest attempts. Quality residual structure can be obtained through the management of CRP tracts, either through disking, patch burning, or managed grazing. Properly managed native grass pastures, with residual cover between 25-30 cm, have been found provide adequate nesting cover (George et al. 1979). Female pheasants appear to select warm-season grass pastures with large amounts of residual litter when compared to cool season pastures (George et al. 1979). Residual cover required for nest selection by females may be created through the planting of a late summer or fall cover crop that remains on the landscape until after peak breeding the following year. Idle farmland seeded with cover crops in fields that contained cool season grasses and legumes produced 4.8 ducklings/ha versus 0.8 ducklings/ha in active agricultural fields (Dubbert and Kantrud 1974). However, this trend was not apparent in my results as the area planted to spring cover crops may not have been sufficient to influence nest survival. Low visual obstruction within the spring cover crop treatments during peak breeding periods during both years influenced female selection for nesting (Chapter II). Furthermore, none of the nests monitored in spring cover crops ($n = 3$) were successful. Therefore, although the presence of spring cover crops can influence survival of adult female ring-necked pheasants, presence of spring cover crops at the level of land cover densities that I tested does not provide quality nest substrate for selection or nest survival, even in years of ample precipitation and warm temperatures during the initial April growing period, such as the conditions were in 2017. Besides nest success, survival during other biological stages can have profound influences on population growth and decline (Clark and Borgenshutz 2008).

Sensitivity analyses from Illinois suggest survival during the brood period through the first winter may have the largest effect on ring-necked pheasant populations (Clark and Borgenshutz 2008). The National Pheasant Conservation Plan estimated that for Kansas to maintain an annual harvest of 700,000 ring-necked pheasants, the state would need an increase of 23% in winter wheat acres, or an increase of 182% in CRP acres, or a combination of both to meet habitat requirements and harvest goals (Midwest Pheasant Study Group 2013). However, winter wheat in western Kansas should only be considered for its benefits to adult and brood survival, as we documented low nest success due to predation or destruction and abandonment from harvest equipment. Therefore, management efforts should focus on providing high quality resources for adults and broods, potentially through the use of cover crops adjacent to nesting substrate, in patches greater than 15 ha to promote long-term population persistence (Robertson 1996; Clark et al. 1999, 2008). If managers aim to utilize cover crops to provide nesting structure for females, residual structure during the peak period of first nest attempts is necessary. Spring cover crops may play an important role in adult pheasant and brood survival, and could potentially be implemented into a statewide pheasant management plan.

Management Implications

Spring cover crops can have beneficial influences on survival of female ring-necked pheasants during the breeding season. Spring cover crop mixes that provide sufficient vertical cover in the form of a cool-season crop such as oats will provide the concealment females need for survival by reducing predation during high mortality risk periods in late April through May. Properties enrolled in CRP that contain residual cover provide the greatest benefit to annual recruitment; therefore, efforts should be made to maintain this land cover in western Kansas to stabilize or increase pheasant populations. Winter wheat may provide additional survival benefits for adults and broods; however, growing and fallow wheat fields create an ecological trap for nesting females in Kansas due to early harvest and high predation rates. If managers aim to provide females with high quality nest substrate through the use of cover crops, a late summer and early fall planting of dense vegetation that creates residual cover through mid-June and July is necessary.

Literature Cited

Allen, D. L. 1956. Pheasants in North America. The Stackpole Company. Harrisburg, Pennsylvania.

Arnold, T. W. 2010. Uninformative parameters and model selection using Akaike's information criterion. Journal of Wildlife Management 74:1175-1178.

Basore, N. S., L. B. Best, and J. B. Wooley, Jr. 1986. Bird nesting in Iowa no-tillage and tilled cropland. Journal of Wildlife Management 50:19-28.

Baxter, W. L., and C.W. Wolfe. 1973. Life history and ecology of the ring-necked pheasant in Nebraska. Nebraska Game and Parks Commission, Lincoln.

Berman, G. 2007. Nesting success of grassland birds in fragmented and unfragmented landscapes of north central South Dakota. M.S Thesis. South Dakota State University, Brookings.

Best, L. B., H. Campa, III, K. E. Kemp, R. J. Robel, M. R. Ryan, J. A. Savidge, H. P. Weeks, Jr., and S. R. Winterstein. 1997. Bird abundance and nesting in CRP fields and cropland in the Midwest: a regional approach. Wildlife Society Bulletin 25:864-877.

Blesh, J., and L.E. Drinkwater. 2013. The impact of nitrogen source and crop rotation on nitrogen mass balances in the Mississippi River Basin. Ecological Applications 23:1017-1035.

Burnham, K. P., and D. R. Anderson. 2002. Model selection and multimodel inference – a practical information-theoretic approach. 2nd edition. Springer-Verlag New York Inc. New York, New York.

Camp, M., and L. B. Best. 1994. Nest density and nesting success of birds in roadsides adjacent to rowcrop fields. American Midland Naturalist 131:347-358.

Chesness, R. A., M. M. Nelon, and W. H. Longley. 1968. The effects of predator removal on pheasant reproductive success. Journal of Wildlife Management 32:683-697.

Clark, W. R., and T. R. Borgenshutz. 1999. Grassland habitat and reproductive success of ring-necked pheasants in northern Iowa. Journal of Field Ornithology 70:380-392.

Clark, W. R., R. A. Schmitz, and T. R. Borgenshutz. 1999. Site selection and nest success of pheasants as a function of location in Iowa landscapes. Journal of Wildlife Management 63:976-989.

Clark, W. R., T. R. Borgenshutz, and D. H. Tessin. 2008. Sensitivity analyses of a population projection model of ring-necked pheasants. Journal of Wildlife Management 72:1605-1613.

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

Davis, A. J., M. L. Phillips, and P. F. Doherty Jr. 2015. Nest success of Gunnison sage grouse in Colorado, USA. PLoS ONE DOI:10.1371/journal.pone.0136310

De Baets, S., J. Poesen, J. Meersmans, and L. Serlet. 2011. Cover crops and their erosion-reducing effects during concentrated flow erosion. Catena 85:237-244.

Delgado, J. A., M. A. Dillon, R. T. Sparks, and S. Y. C. Essah. 2007. A decade of advances in cover crops. Soil and Water Conservation 62:110A-117A.

Dubbert, H. F., and H. A. Kantrud. 1974. Upland duck nesting related to land use and predator reduction. Journal of Wildlife Management 38:257-265.

Dumke, R. T., and C. M. Pils. 1979. Renesting and dynamics of nest site selection by Wisconsin pheasants. Journal of Wildlife Management 43:705-716.

Evans, R. D., and C. W. Wolfe, Jr. 1967. Effects of nest searching on fates of pheasant nests. Journal of Wildlife Management 31:754-759.

FAO. 2007. Wild Birds and Avian Influenza: an introduction to applied field research and disease sampling techniques. Edited by D. Whitworth, S.H. Newman, T. Mundkur and P. Harris. FAO Animal Production and Health Manual, No. 5. Rome, Italy.

Gates, J. M., and J. B. Hine. 1974. Seasonal movement, winter habitat use, and population distribution of east central Wisconsin pheasant population. Edited by L. Ruth. Technical Bulletin No. 76, Wisconsin Department of Natural Resources, Madison.

George, R. R., A. L. Farris, C. C. Schwartz, D. D. Humburg, and J. C. Coffey. 1979. Native prairie grass pastures as nest cover for upland birds. Wildlife Society Bulletin 7:4-9.

Giuliano, W. M., and S. E. Daves. 2002. Avian response to warm-season use in pasture and hayfield management. Biological Conservation 106:1-9.

Hill, D., and P. Robertson. 1988. The pheasant: ecology, management and conservation. BSP Professional Books. Nebraska Game and Parks Commission. Lincoln.

Hurvich, C. M., and C. Tsai. Model selection for extended quasi-likelihood models in small samples. Biometrics 51:1077-1084.

Kenward, R.F. 2001. A manual for wildlife radio tagging, 2nd edition. Academic Press. San Diego, California.

Klett, A. T., H. F. Duebbert, C. A. Faanes, and K. F. Higgins. 1986. Techniques for studying nest success of ducks in upland habitats in the prairie pothole region. U. S Fish and Wildlife Service Resource Publication 158, Washington D.C.

Leif, A. P. 1994. Survival and reproduction of wild and pen-reared ring-necked pheasant hens. Journal of Wildlife Management 58:501-506.

Matthews, T. W., J. S. Taylor, and L. A. Powell. 2012a. Mid-contract management of Conservation Reserve Program grasslands provides benefits for ring-necked pheasant nest and brood survival. Journal of Wildlife Management 76:1643-1652.

Matthews, T. W., J. S. Taylor, and L. A. Powell. 2012b. Ring-necked pheasant females select managed Conservation Reserve Program grasslands for nesting and brood-rearing. Journal of Wildlife Management 76:1653-1660.

Messinger, L. 2015. Habitat and site selection of pheasants and their hunters during the hunting season. M.S. Thesis. University of Nebraska, Lincoln.

Midwest Pheasant Study Group. 2013. National wild pheasant conservation plan. N.B. Veverka (ed.). Association of Fish and Wildlife Agencies. 111 pp.

National Oceanic and Atmospheric Administration (NOAA). 2018. National Climate Data Center. Climate 1981-2010 Climate and Daily Normals. https://www.ncdc.noaa.gov/data-access/quick-links#loc-clim Accessed 16 November 2018.

Olson, R. A., and L. D. Flake. 1975. Nesting of ring-necked pheasants in eastern South Dakota. Proceedings South Dakota Academy of Science 54:126-126.

Pauly, B. J., T. J. Runia, A. J. Solem, C. D. Dieter, and K. C. Jensen. 2018. Ring-necked pheasant nest success and habitat selection in central South Dakota. Great Plains Research 28:39-50.

Powell, L. A. 2007. Approximating variance of demographic parameters using the delta method: a reference for avian biologists. Condor 109:949-954.

Purvis, J. R., A. R. Gabbert, and L. D. Flake. 1999. Nest site characteristics of ring-necked pheasants in eastern South Dakota. Prairie Naturalist 31:1-7.

R Core Team. 2018. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. www.R-progrject.org.

Riley, T. Z., J. B. Wooley, and W. B Rybarczyk. 1994. Survival of ring-necked pheasants in Iowa. Prairie Naturalist 26:143-148.

Robel, R. J., and K. E. Kemp. 1997. Winter mortality of northern bobwhites: effects of food plots and weather. Southwestern Naturalist 42:59-67.

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

Robertson, P. A. 1996. Does nesting cover limit abundance of ring-necked pheasants in North American? Wildlife Society Bulletin 24:98-106.

Rodgers, R. D. 1999. Why haven't pheasant populations in western Kansas increased with CRP? Wildlife Society Bulletin 27:654-665.

Rodgers, R. D. 2002. Effects of wheat-stubble and weed control on winter pheasant abundance. Wildlife Society Bulletin 30:1099-1112.

Schmitz R. A., and W. R. Clark. 1999. Survival of ring-necked females during spring in relation to landscape features. Journal of Wildlife Management 63:147-154.

Simonsen, V. L., and J. J. Fontaine. 2016. Landscape context influences nest survival in Midwest grassland. Journal of Wildlife Management 80:877-883.

Smith, R. G., L. W. Atwood, F. W. Pollnac, and N. D. Warren. 2015. Cover-crop species as distinct biotic filters in weed community assembly. Weed Science 63:282-295.

Snyder, W. D. 1984. Ring-necked pheasant nesting ecology and wheat farming on the High Plains. Journal of Wildlife Management 48:878-888.

Snyder, W. D. 1985. Survival of radio-marked female ring-necked pheasants in Colorado. Journal of Wildlife Management 49:1044-1050.

USDA Conservation Reserve Program Statistics. 2017. CRP contract expirations by state, 2016-2030. Accessed 11-06-2018. www.fsa.usda.gov/programs-and-services/conservation-programs/reports-and-statistics/conservation-reserve-program-statistics/index.

Wagenmakers, E., and S. Farrell. 2004. AIC model selection using Akaike weights. Psychonomic Bulletin & Review 11:192-196.

Warner, R. E and S. L. Etter. 1983. Reproduction and survival of radio-marked female ring-necked pheasants in Illinois. Journal of Wildlife Management 47:369-375.

Warner, R. E., G. B. Joselyn, and S. L. Etter. 1987. Factors affecting roadside nesting by pheasants in Illinois. Wildlife Society Bulletin 15:221-228.

Warner, R. R and S. L. Etter. 1989. Hay cutting and the survival of pheasants: a long-term perspective. Journal of Wildlife Management 53:455-461

Westerskov, K. 1950. Methods for determining the age of game bird eggs. Journal of Wildlife Management 14:56-67.

White, G. C., and K. P. Burnham. 1999. Program MARK: survival estimation from populations of marked animals. Bird Study 46:120-139.

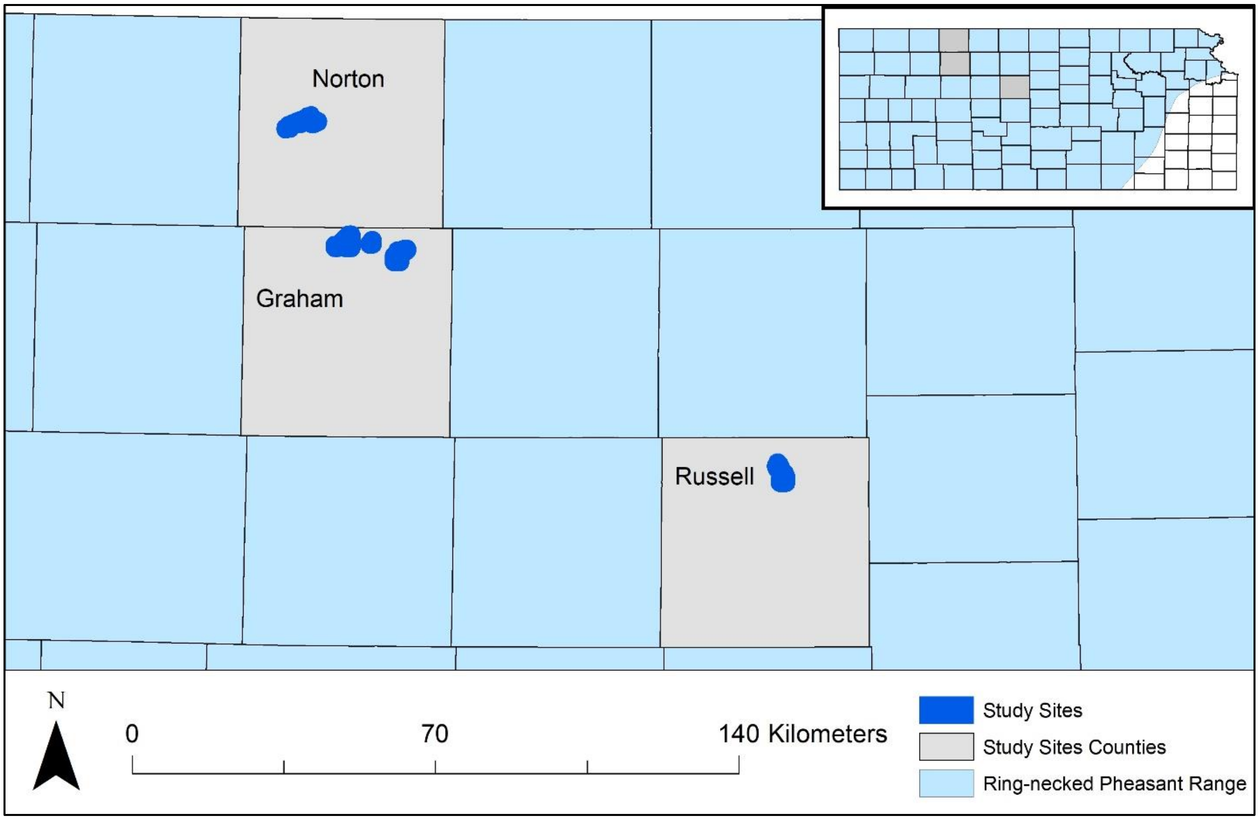


Figure 1.1 Location of ring-necked pheasant and spring cover crop study sites; six study sites were located in Graham County, two in Russell County, and two in Norton County during 2017 and 2018 in western Kansas.

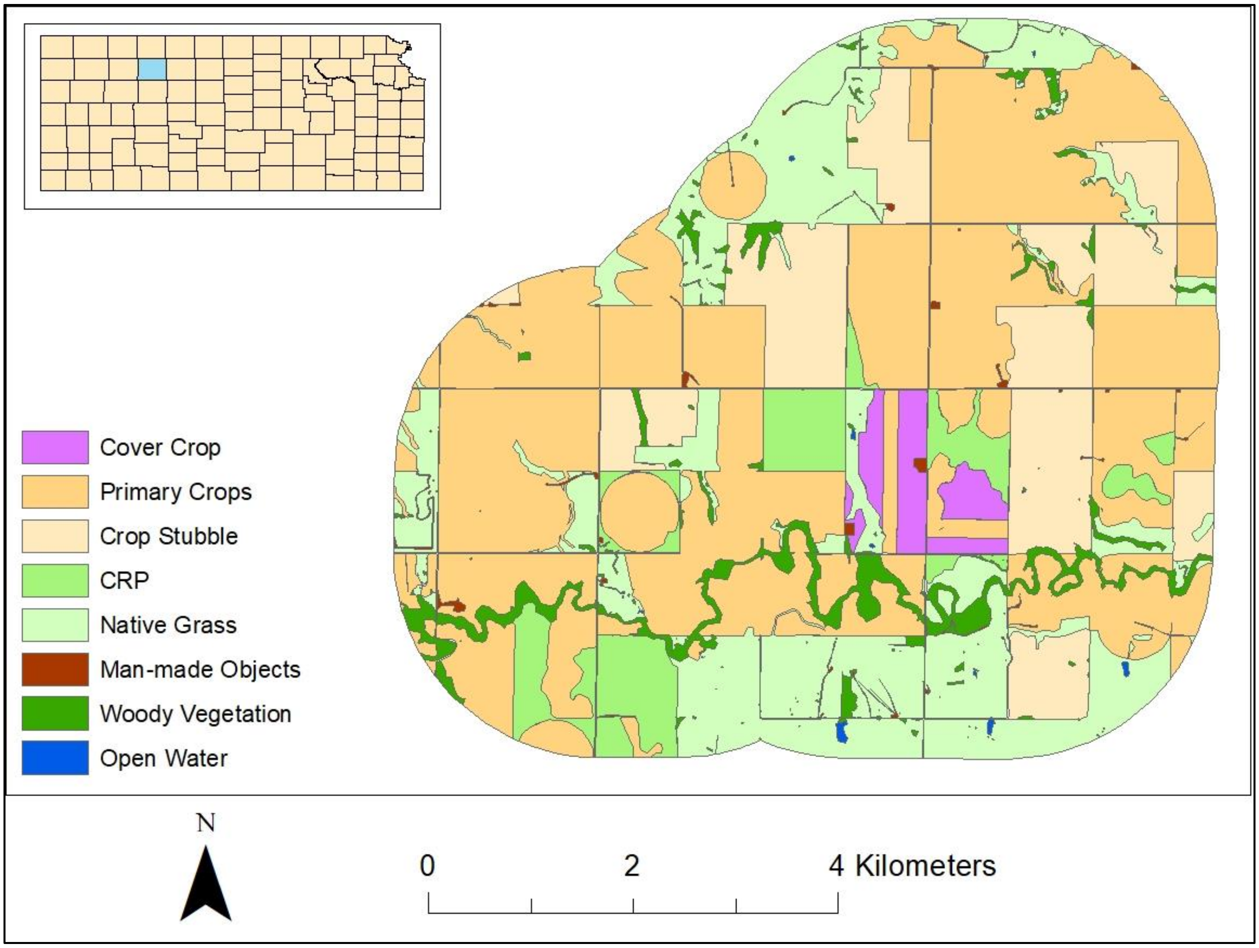


Figure 1.2 Land cover for each study site including (a) the 2017 study site and associated land-use classes located 19 km north of Hill City and 3 km west of Highway 283 in Graham County, Kansas, (b) the 2017 study site and associated land-use classes 17 km north of Hill City and 10 km east of Highway 283 in Graham County, Kansas, (c) the 2018 study site and associated land-use classes located 19 km north of Hill City and 3 km west of Highway 283 in Graham County, Kansas, (d) the 2018 study site and associated land-use classes located 19 km north of Hill City and 1.5 km east of Highway 283 in Graham County, Kansas, (e) the 2018 study site and associated land-use classes located 14 km north of Hill City and 7 km west of Highway 283 in Graham County, Kansas, (f) the 2018 study sites and associated land-use classes located 9 km west of Norton and 3 km south of Highway 36 in Norton County, Kansas, (g) the 2018 study site and associated land-use classes located 4 km south of Luray and 3 km west of 194th street in Russell County, Kansas, and (h) the 2018 study sites and associated land-use classes located 6 km south and 1 km west of Luray and 1 km south of 194th street in Russell County, Kansas.

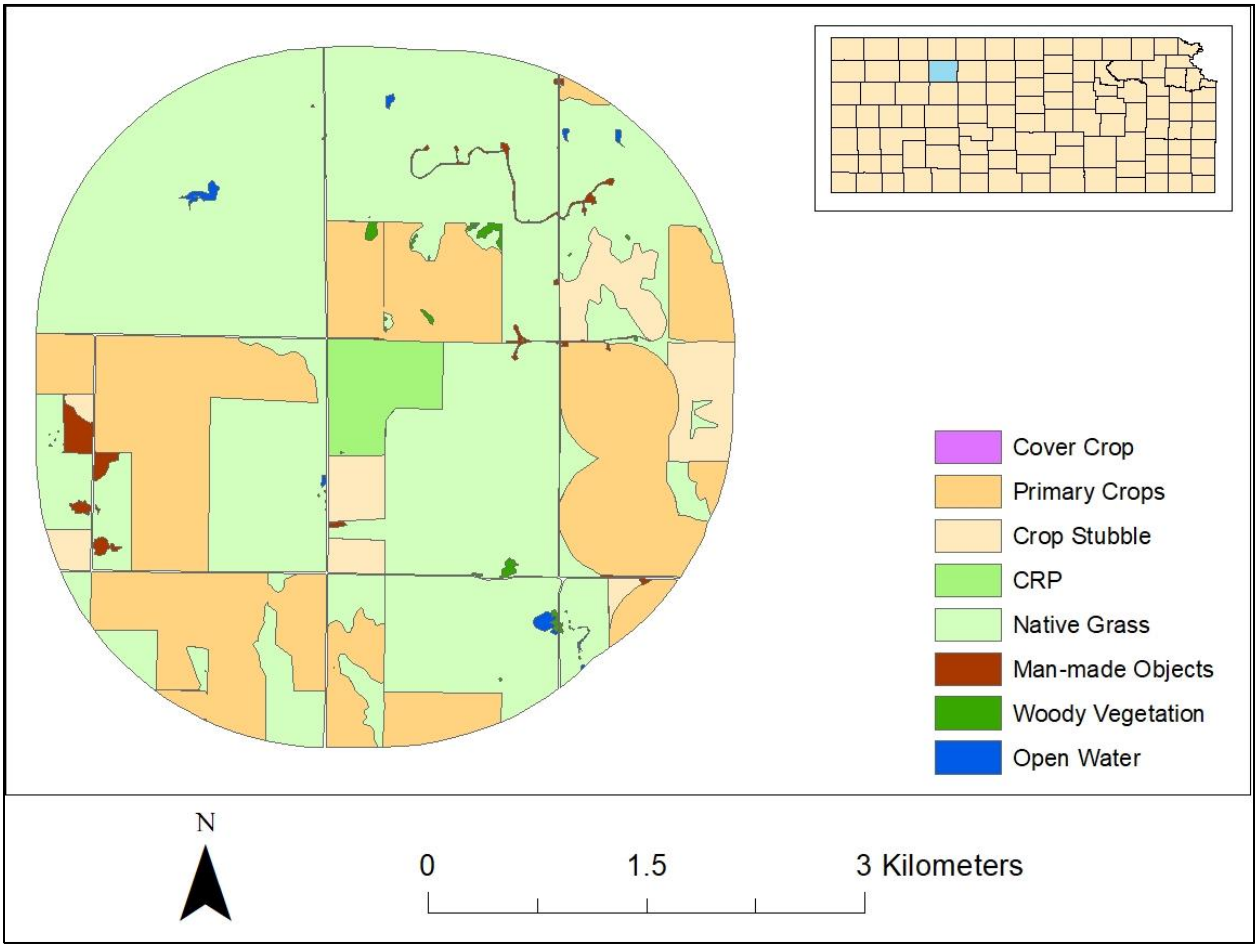

Cover Crop
Primary Crops
Crop Stubble
CRP
Native Grass
Man-made Objects
Woody Vegetation
Open Water
N
0
1.5
3 Kilometers

Figure 1.2b

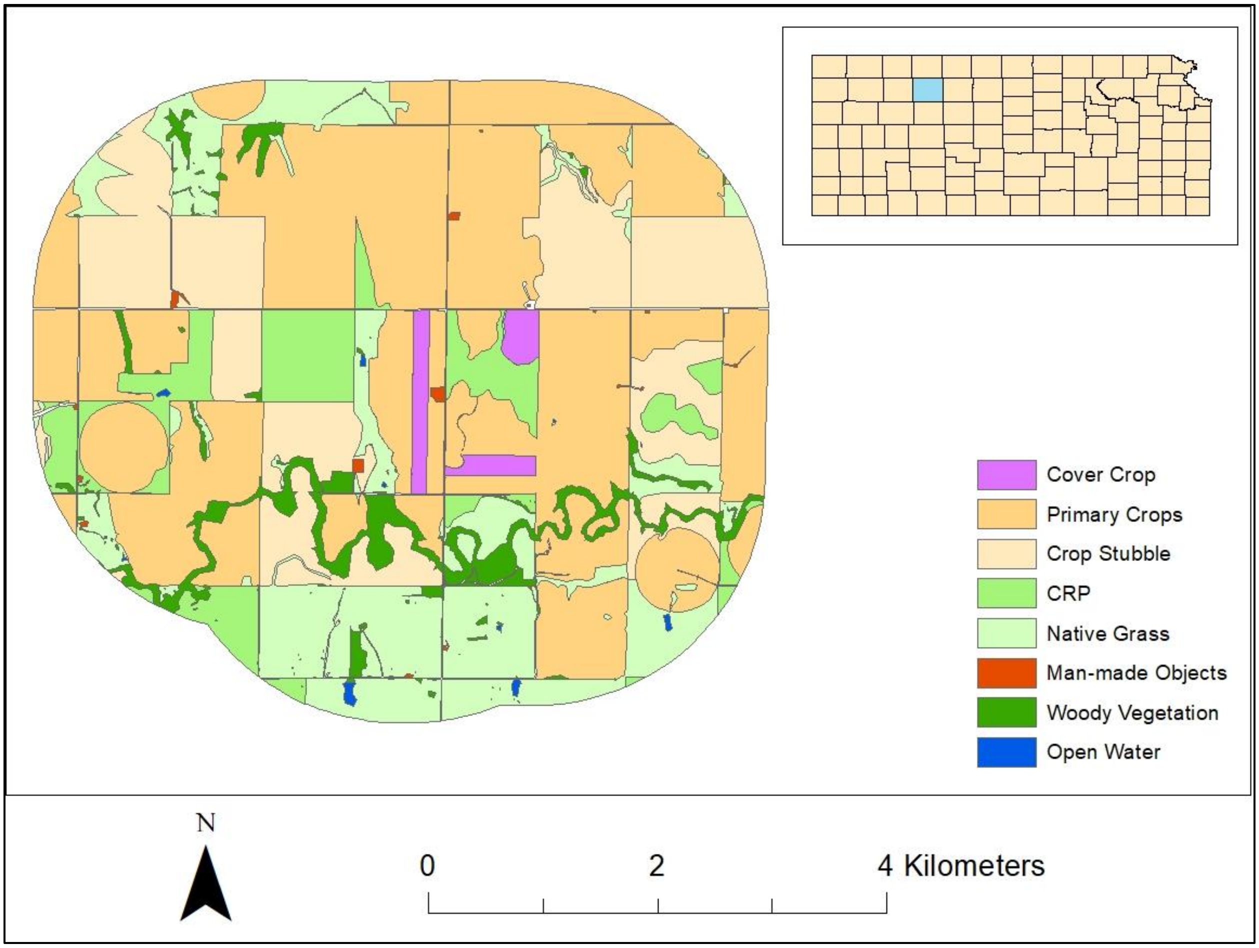

Cover Crop
Primary Crops
Crop Stubble
CRP
Native Grass
Man-made Objects
Woody Vegetation
Open Water
N
0
2
4 Kilometers

Figure 1.2c

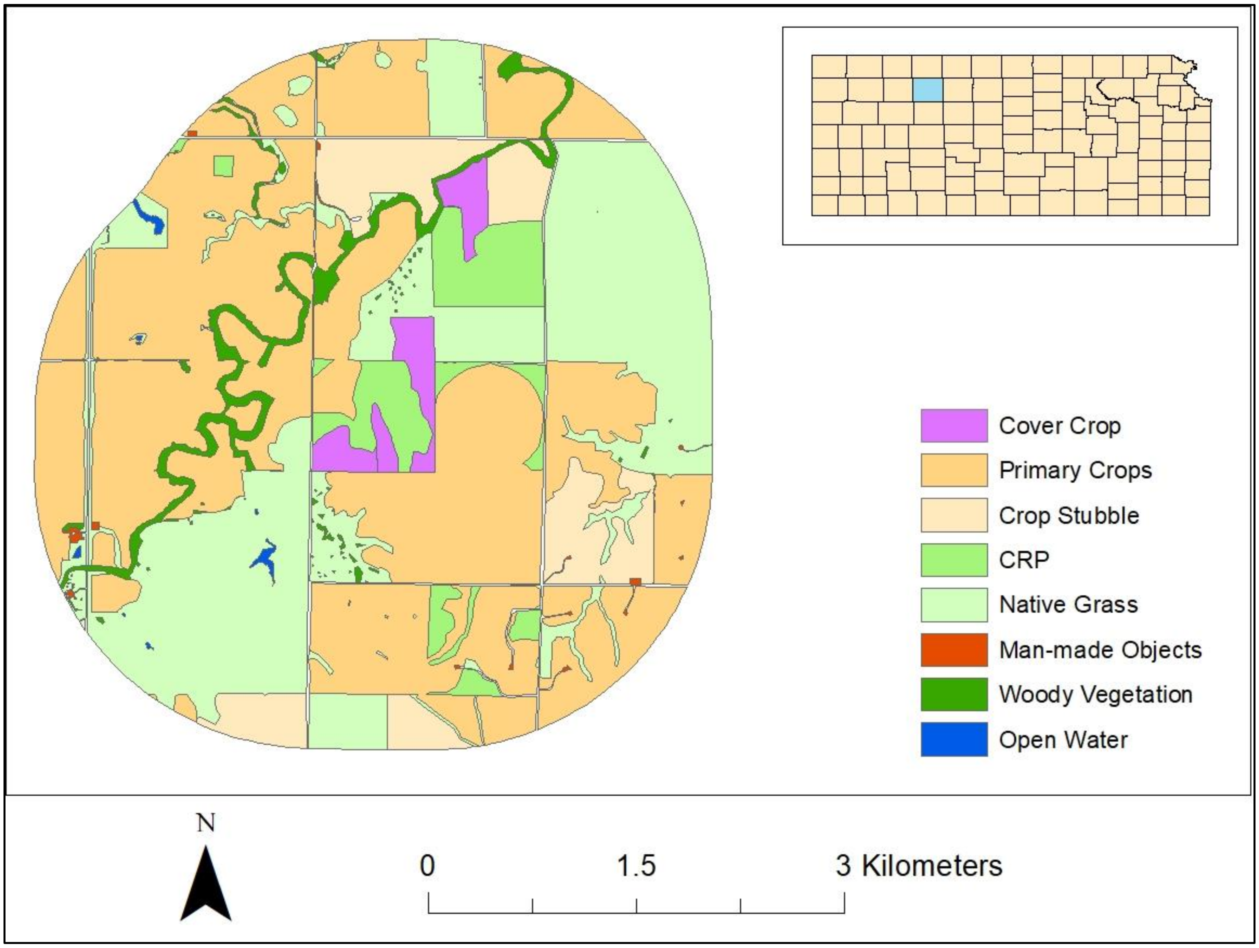

Cover Crop
Primary Crops
Crop Stubble
CRP
Native Grass
Man-made Objects
Woody Vegetation
Open Water
N
0
1.5
3 Kilometers

Figure 1.2d

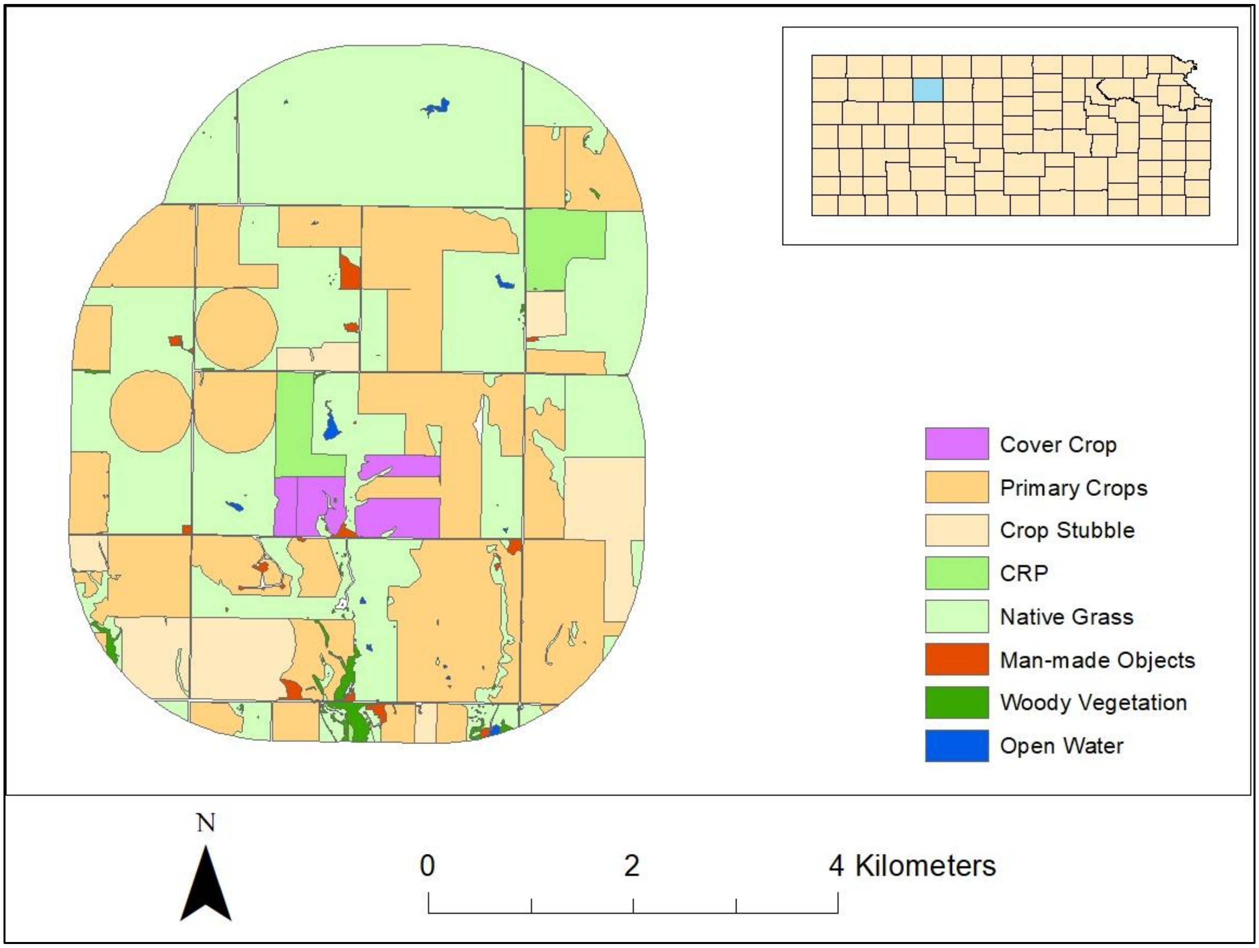

Cover Crop
Primary Crops
Crop Stubble
CRP
Native Grass
Man-made Objects
Woody Vegetation
Open Water
N
0
2
4 Kilometers

Figure 2.1e

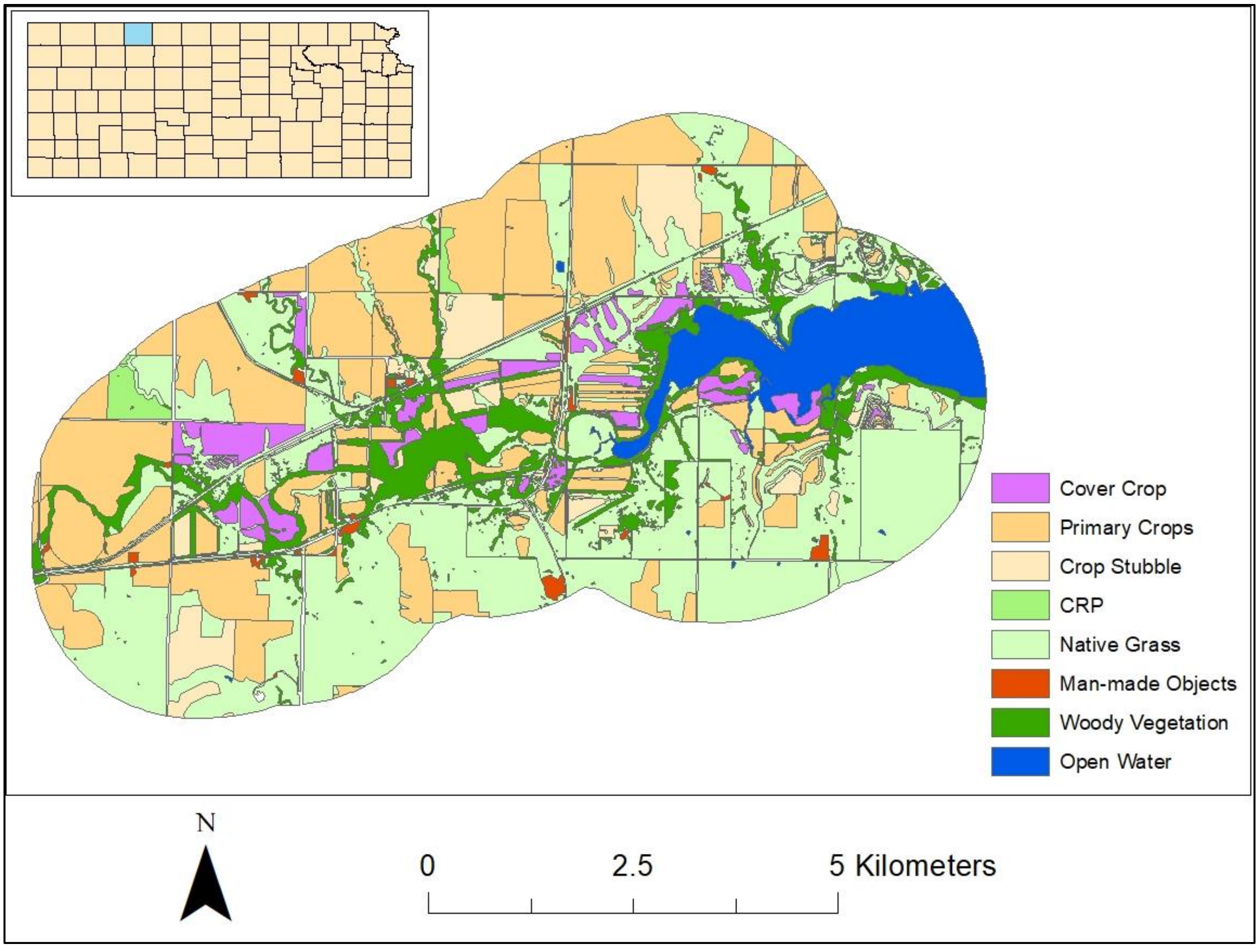

Cover Crop
Primary Crops
Crop Stubble
CRP
Native Grass
Man-made Objects
Woody Vegetation
Open Water
N
0
2.5
5 Kilometers

Figure 1.2f-g

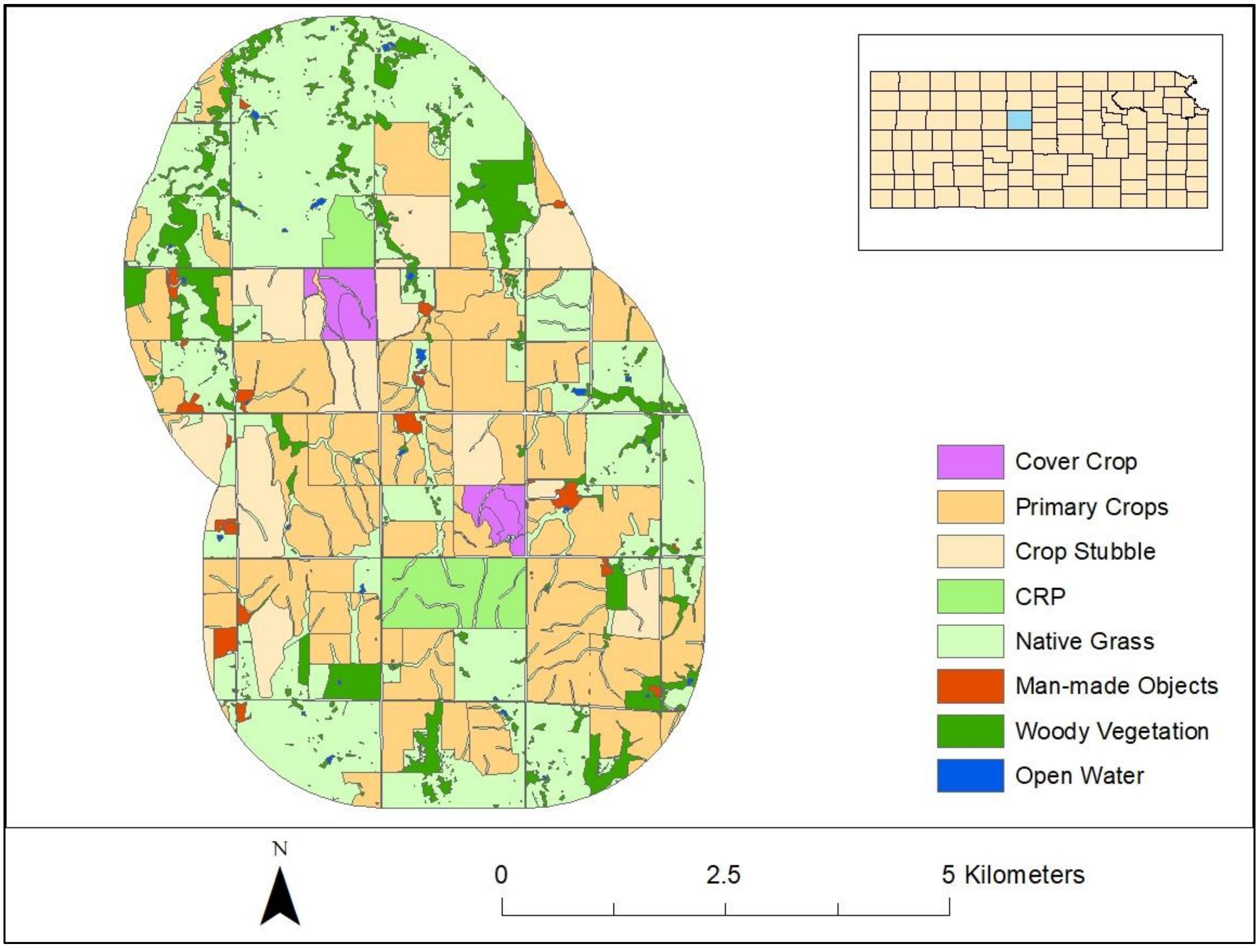

Cover Crop
Primary Crops
Crop Stubble
CRP
Native Grass
Man-made Objects
Woody Vegetation
Open Water
N
0
2.5
5 Kilometers

Figure 1.2h

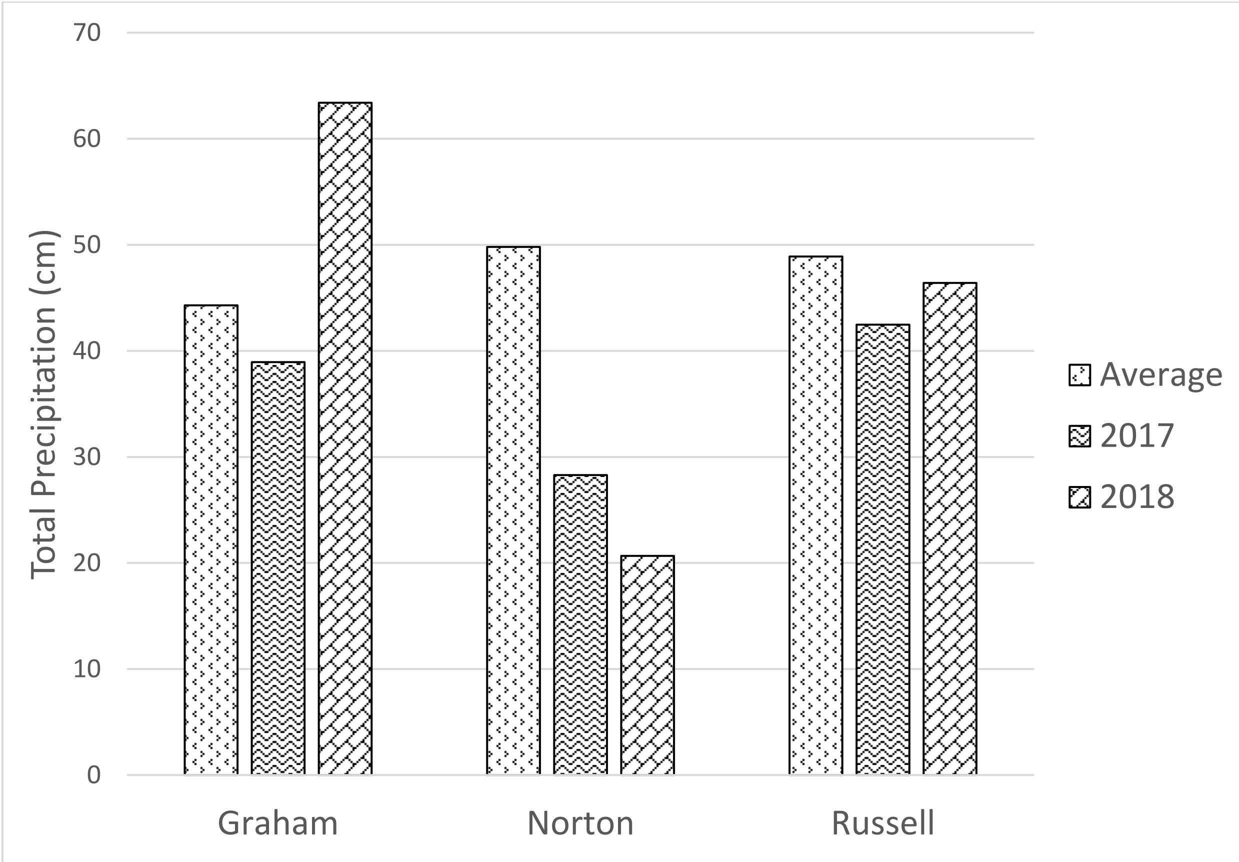


Figure 1.3 Total precipitation from February through August for Graham, Norton and Russell counties, Kansas, for 2017 and 2018 compared with the long-term average since 1981.

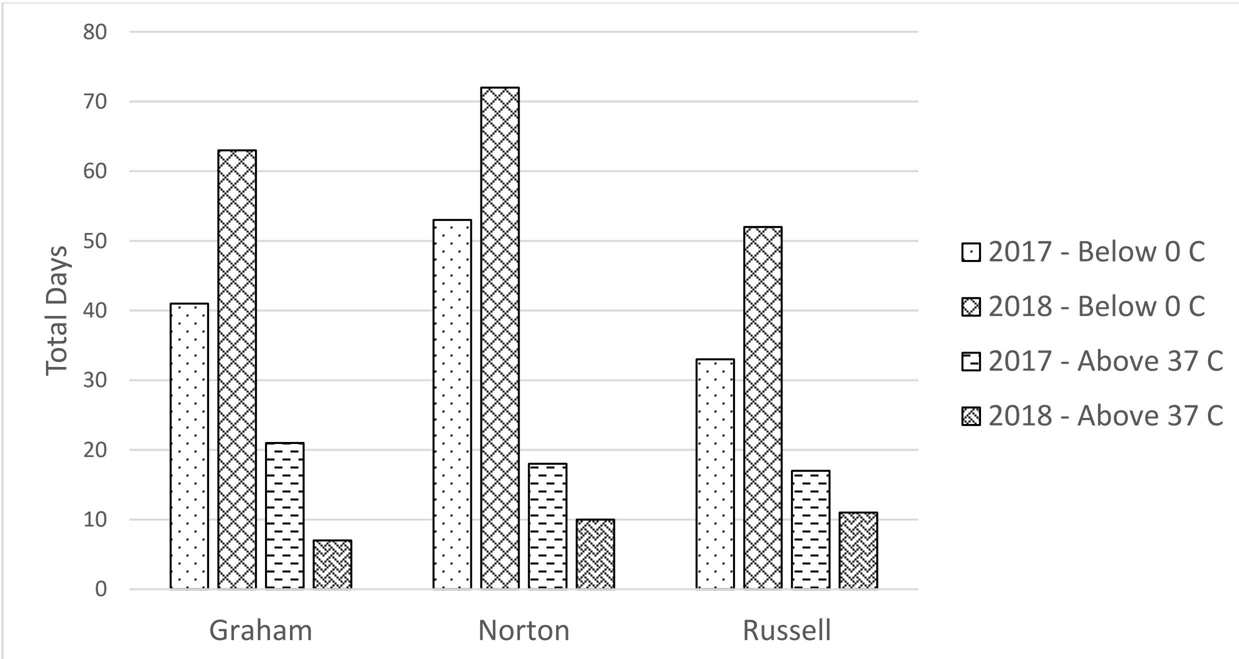


Figure 1.4 Total number of days between February and August below 0° C and above 37° C in Graham, Norton and Russell counties, Kansas in 2017 and 2018.

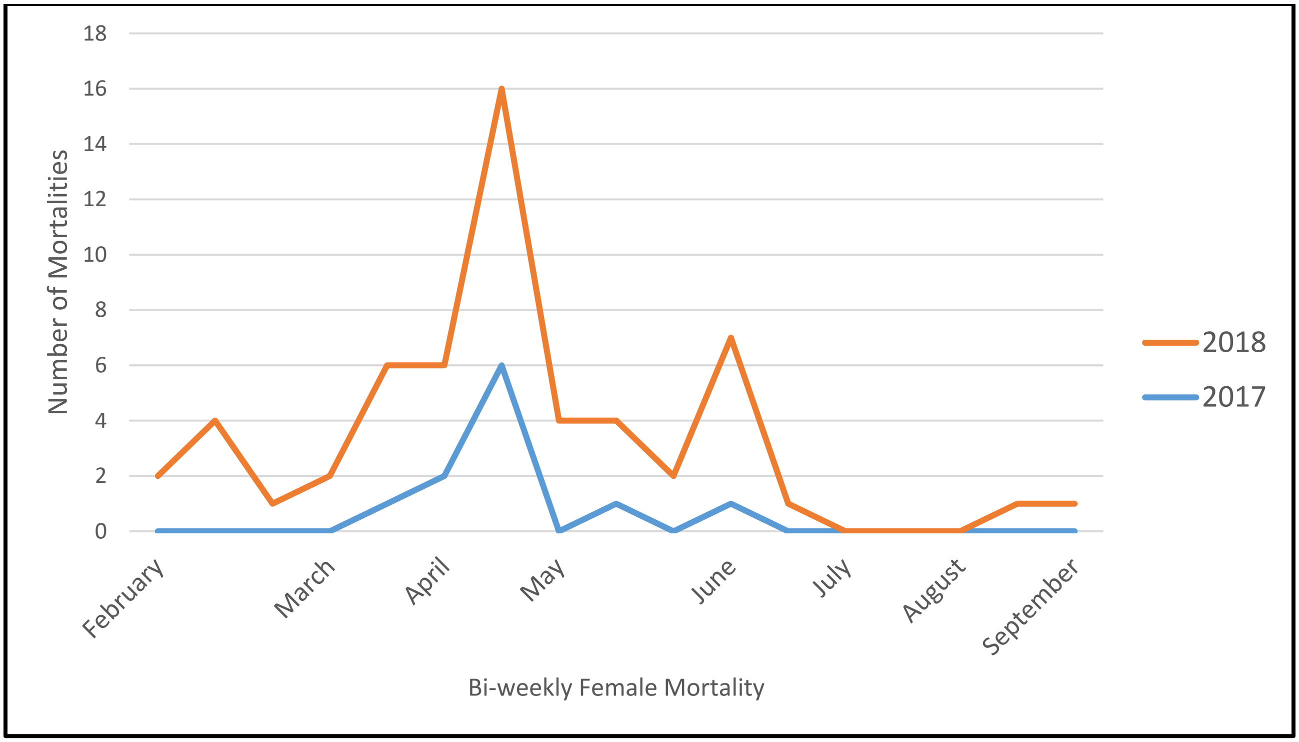


Figure 1.5 Monthly temporal distribution of ring-necked pheasant mortalities during 2017 (*n* = 11) in Graham County, Kansas and 2018 (*n* = 46) in Graham, Russell, and Norton counties, Kansas.

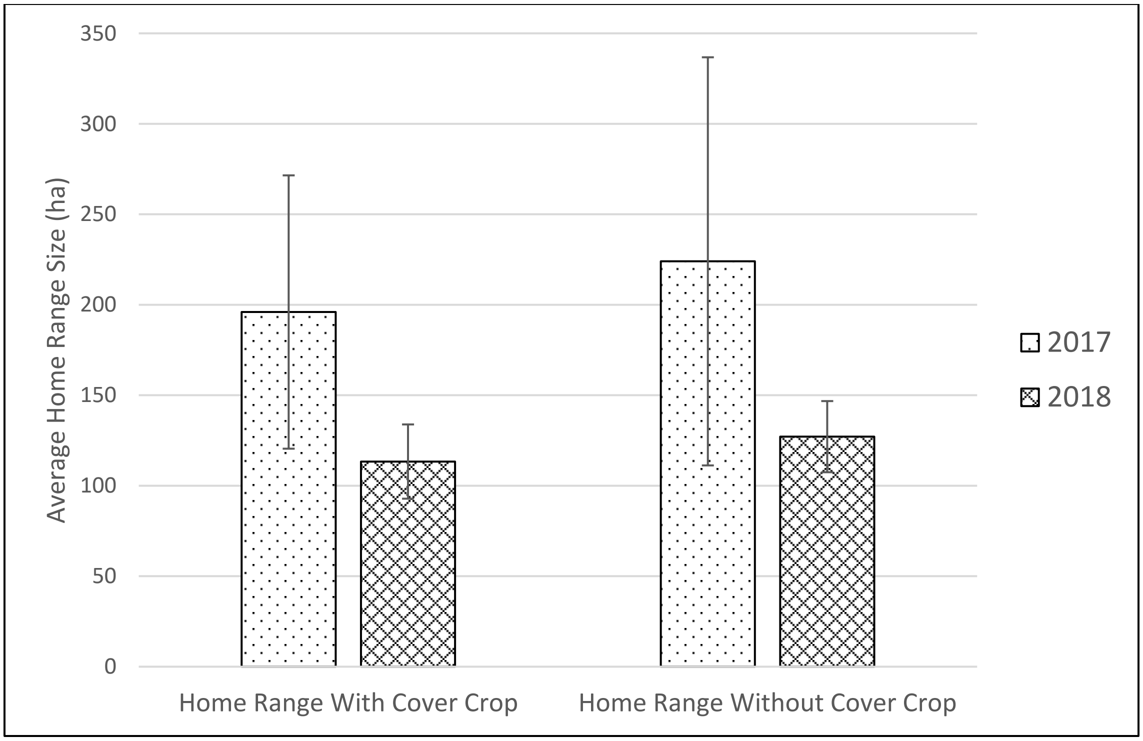


Figure 1.6 Average home range sizes (ha) for ring-necked pheasants with and without spring cover crops in their home range during 2017 (*n* = 14, *n* = 13) and 2018 (*n*=14, *n* = 17) in Graham County, Kansas.

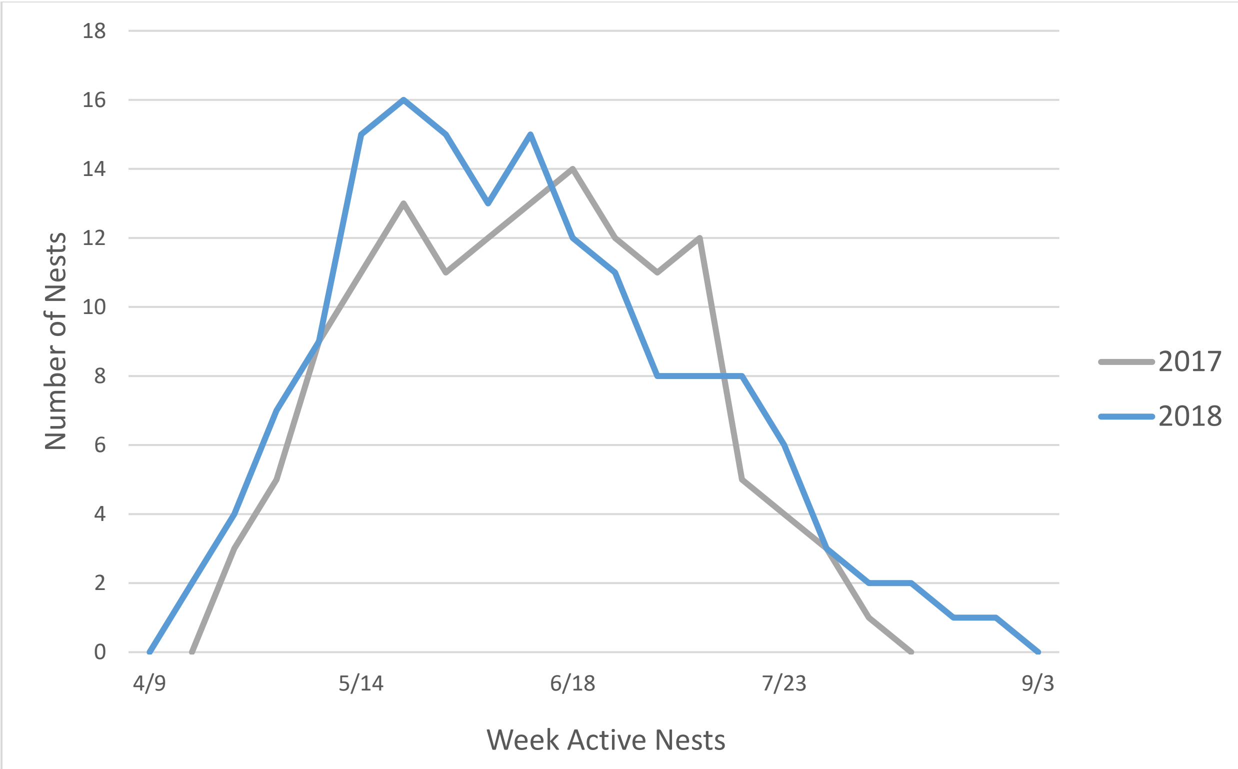


Figure 1.7 Temporal distribution of active nests of ring-necked pheasants during 2017 (*n* = 30) in Graham County, Kansas and 2018 (*n* = 35) in Graham, Russell and Norton counties, Kansas.

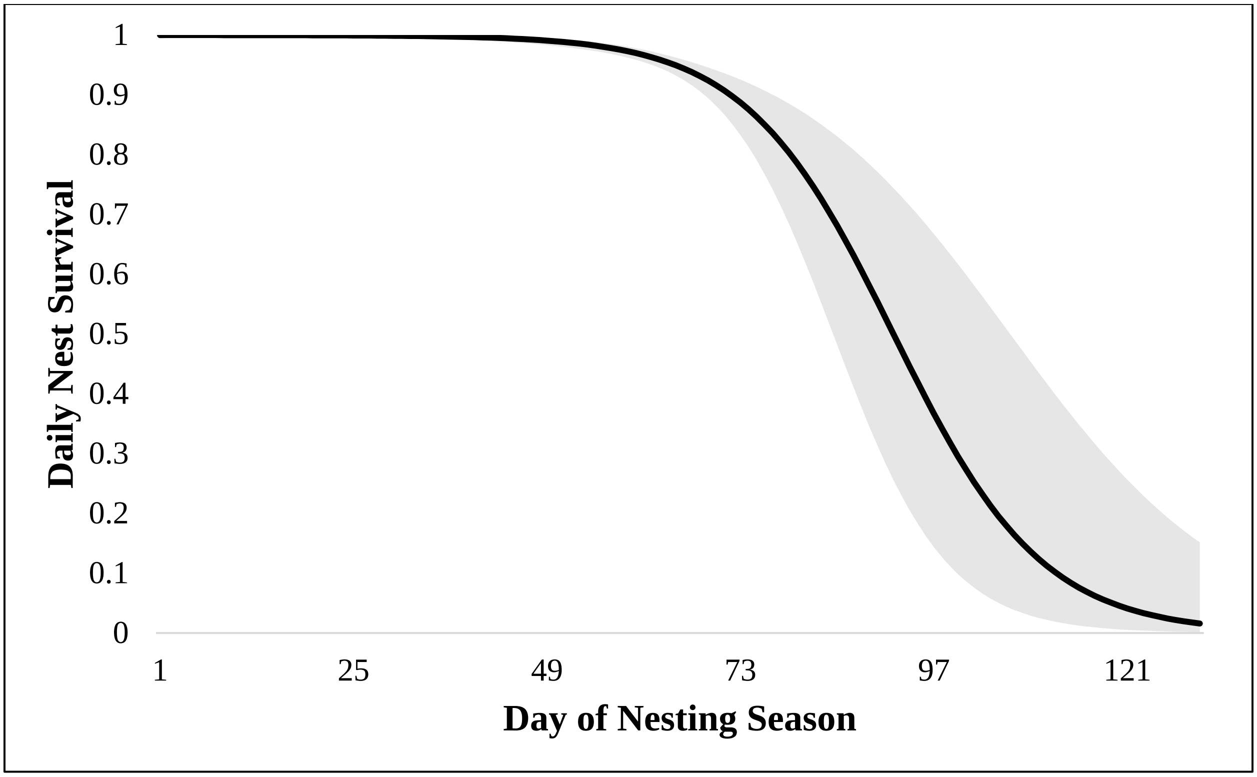


Figure 1.8 Daily nest survival and day of nesting season with associated confidence intervals for ring-necked pheasant nests monitored from late April until August in 2017 and 2018 in Graham, Kansas.

Table 1.1 Survival estimates of female ring-necked pheasants from states within the Great Plains

State	Survival Estimate Period	Survival Estimate (%)
Colorado (Snyder 1985)	Annual, Seasonal, & Monthly	51.7%, 68%, 56%-93%.
Illinois (Warner and Etter 1983)	Annual	20%
Iowa (Riley et al. 1994, Schmitz and Clark 1999)	Annual, Seasonal, & Monthly	57%, 81%, 44%-92%
Nebraska (Messinger 2015)	Seasonal (September-December)	61%

Table 1.2 Nest survival estimates of ring-necked pheasants from states located with the Great Plains region.

State	Nest Success
Nebraska (Evans and Wolfe Jr. 1967, Baxter and Wolfe 1973, Matthews et al. 2012*a*)	31.4-69.6%
Colorado (Snyder 1984)	50.5%
Iowa (George et al. 1979, Basore et al. 1986, Camp and Best 1994, Clark et al. 1999, Clark and Borgenshutz 1999)	22-70%
South Dakota (Olson and Flake 1975, Leif 1994, Purvis et al. 1999, Berman 2007, Pauly et al. 2018)	10%-51%
Wisconsin (Dumke and Pils 1979)	31%
Illinois (Warner et al. 1987, Warner and Etter 1989)	13%-35%
Minnesota (Chesness et al. 1968)	16%-36%

Table 1.3 The proportion of eight land-use categories in the 2017 and 2018 ring-necked pheasant and western Kansas spring cover crop study sites within the 2 kilometer boundary of capture locations in Graham (Jordan and Terry 2017; Fost, Ted, and Terry West 2018), Norton, and Russell counties, Kansas.

Land-use Category	Study Sites 2017		Study Sites 2018				
	Jordan	Terry	Fost	Ted	Terry West	Norton	Russell
Cover Crop	0.000	0.024	0.025	0.024	0.016	0.039	0.020
Crop Stubble	0.061	0.484	0.081	0.080	0.196	0.046	0.103
Primary Crops	0.291	0.165	0.387	0.495	0.469	0.291	0.334
CRP	0.026	0.063	0.029	0.055	0.083	0.008	0.036
Native Grass	0.609	0.216	0.448	0.299	0.176	0.422	0.390
Manmade Objects	0.008	0.005	0.020	0.016	0.011	0.031	0.030
Woody Vegetation	0.003	0.043	0.007	0.031	0.047	0.098	0.084
Open Water	0.002	0.001	0.002	0.002	0.001	0.064	0.003

Table 1.4. Plant species within the GreenSpring, Chick Magnet and Custom Mix cover crop treatments planted to determine ring-necked pheasant adult and nest survival between 2017 and 2018 in Graham, Norton and Russell counties, Kansas.

GreenSpring	Chick Magnet	Custom Mix
Oats	Hybrid Brassicas	Oats
Peas	Peas	Peas
	Yellow Sweet Clover	Yellow Sweet Clover
	Sunflower	Sunflower
	Buckwheat	Radish
		Rapeseed
		Cowpea
		Chickling Vetch
		Safflower

Table 1.5 The final model suite of *a priori* models, the number of parameters (K), AIC_c (Akaike's Information Criterion AIC corrected for small sample sizes), ΔAIC_c the difference between the top model, AIC_c weights (w_i), and deviance for models determining factors influencing adult ring-necked pheasant survival in Graham County, Kansas, during 2017 and 2018.

Model	K	AIC_c	ΔAIC_c	w_i	Deviance
Percent Cover Crop	2	208.631	0.000	0.450	204.615
Average Precipitation Week 7/30	2	210.934	2.302	0.142	206.918
Average Maximum Temperature Week 6/25	2	211.135	2.504	0.129	207.119
Average Minimum Temperature Week 4/30	2	211.330	2.699	0.117	207.314
Year	2	212.018	3.387	0.083	208.002
Body Condition	2	213.518	4.886	0.039	209.502
Null	1	214.250	5.619	0.027	29.719
Home Range	2	215.518	6.887	0.014	211.502

Table 1.6 Intercept, beta estimate, standard error, and lower and upper 95% confidence interval for the top-ranked model (percent cover crop) of adult survival for female ring-necked pheasants in Graham, Norton, and Russell counties, Kansas during 2017 and 2018.

	Estimate	Standard Error	Lower CI	Upper CI
Intercept	3.078	0.228	2.630	3.525
Beta Estimate	0.137	0.076	-0.013	0.287

Table 1.7 The composite model output containing the number of parameters (K), AIC_c (Akaike's Information Criterion AIC corrected for small sample sizes), ΔAIC_c the difference between the top model, AIC_c weights (w_i), and deviance for nest survival of ring-necked pheasants in Graham County, Kansas, during 2017 and 2018.

Model	K	AIC_c	ΔAIC_c	w_i	Deviance
Nest Age	2	321.521	0.000	0.999	317.514
Time Trend	2	354.955	33.433	0.000	350.947
Null	1	359.037	37.515	0.000	357.034
Year	2	361.029	39.508	0.000	357.021

Chapter 2 - Effect of Spring Cover Crops on Nest-Site Selection by Ring-necked Pheasants

Introduction

Resource selection is characterized by species selecting resources from an available matrix of landscape patches that vary in quality to complete important life history events. Species utilize resources at multiple scales, which has implications for management actions related to habitat quality. Research focused on resource selection provides insights into processes or cues necessary for individuals to utilize quality resources critical for survival and reproduction (i.e., fitness). Of particular interest in wildlife management is what drives selection of a specific resource required for increased reproductive output of individuals. This is especially true for the ring-necked pheasant (*Phasianus colchicus*), an economically important upland gamebird with naturalized populations within the conterminous United States. Declines of ring-necked pheasants within the Midwest region of the United States have largely been attributed to changes in agricultural practices. Ring-necked pheasants require different resources to complete their life cycle; specifically vegetation with high visual obstruction for winter and nesting substrate and herbaceous vegetation with an open understory to support brood foraging and cover from predators and weather (Baxter and Wolfe 1973, Hill and Robertson 1988). Declines of populations in western Kansas have been attributed to the loss of the weedy-wheat fallow system, which decreased on the landscape due to increased use of herbicide in no-till agricultural practices (Rodgers 1999, 2001). Conservation of ring-necked pheasants currently focuses on reproductive periods for population recruitment, specifically attributes selected by females for nest and brood sites to satisfy habitat requirements and inform management efforts to ensure high quality habitat on remaining available habitat.

The ring-necked pheasant is a large gallinaceous upland gamebird native to east Asia introduced to the United States for recreational hunting during latter decades of the 19th century (Hill and Robertson 1988). Populations in the Midwest region peaked during the 1950s when common practices in row-crop agricultural operations emphasized rotational weedy-fallow fields and small-grain crop production (Baxter and Wolfe 1973, Rodgers 1999). Steady population declines since the 1960s are attributed to increased field size, changes in land-use and agricultural rotations, and, of primary importance in Kansas, loss of the weedy-wheat (*Triticum aestivum*) fallow rotation (Rodgers 1999). The major landscape-scale change that has improved quality and quantity of upland gamebird and native species habitats in the Midwest is the implementation and continued funding of the Conservation Reserve Program (CRP), which was initiated in the 1985 Farm Bill (Rodgers 1999). This program retires targeted agricultural land to perennial grass cover for 10-15 year contract periods. Kansas had over two million acres enrolled in CRP contracts in 2017. However, pheasant populations didn't increase as CRP fields failed to adequately replace the loss of quality habitat provided by fallow weedy-wheat habitat (Rodgers 1999). Caps on enrollment, expiring contracts, and recent high prices of crop commodities will negatively affect pheasant populations if CRP acreage declines on the landscape (USDA 2017). As agricultural intensification increases, stakeholders are looking for ways to provide critical habitats, potentially through the use of cover crops, to bolster declining regional ring-necked pheasant populations (Midwest Pheasant Study Group 2013).

Cover crop is a general term applied to any variety or combination of short-term crops that provide soil services, such as decreased wind and water erosion of fine particles, nitrogen scavenging, increasing organic matter, and weed suppression (Delgado et al. 2007, De Baets et al. 2011, Blesh and Drinkwater 2013, Smith et al. 2015). Spring cover crops are planted between March and May, and then terminated in June or July prior to the planting of a primary crop, such as winter wheat (planted in September or October). Termination of the cover crop during mid-summer is required to be eligible for crop insurance for the subsequent wheat crop. Other primary crops, such as corn (*Zea mays*) and sorghum (*Sorghum bicolor*), are not planted until after May; therefore, spring cover crops may provide critical nesting and brood-rearing habitats when other cropping rotations are fallow.

Spring cover crops could provide essential nesting habitat in agricultural systems, this strategy differ from previous management, whose focus that emphasized the use of perennial native grasses to provide high vertical cover necessary for selection by females. Native grass plantings if seeded to switch grass (*Panicum virgatum*), big bluestem (*Andropogon gerardii*), and Indian grass (*Sorghastrum nutans*), have been shown to provide adequate nesting cover (George et al. 1979). To increase the quality of these plantings for wildlife within CRP mid-contract management has been adopted including disking and interseeding, burning, and grazing. Mid-contract management in the form of disking and interseeding of CRP has been shown to increase diversity and heterogeneous visual obstruction (Matthews et al. 2012). Previous nest studies have focused almost exclusively on perennial grass as nesting habitat; however, few studies have incorporated vegetative manipulations, especially of agricultural species, to determine what attributes females select for nest-sites. The scale at which selection is occurring, or to be studied must be addressed, as nest selection occurs at different spatial scales. The advantage of using a spring cover crop to potentially provide nesting substrate is the ability to customize mixes and the planting rate to potentially meet the vegetation qualities pheasants require for selection. However, the scale at which cover crops are implemented may play an important role in selection by females.

Nest selection by ring-necked pheasants occurs at multiple scales starting at the point-scale within selected patches, which incorporates vegetative qualities including vegetation vertical cover, vegetation groups such forbs, warm-season grasses, and the presence of bare ground and litter (Matthews et al. 2012). Patch-scale selection (contiguous area of specific vegetation characteristics or land cover and land use) occurs either through placement of a home range or differential use of vegetation patches within an established home range. However, selection at the patch scale is directly related to the ability of the individual to access different patch types within the extent of their home range. Few studies have manipulated features on the landscape to measure response or selection by females during reproductive periods to establishment of novel, temporary land cover or vegetation types (e.g., cover crops). In Nebraska, Matthews et al. (2012) incorporated a multi-species mix into unmanaged CRP fields and recorded an increase of nest-site selection within and nearby the managed area. This led to managers incorporating mid-management requirements into the CRP program. However, while the CRP program may provide adequate nest habitat with regularly management, the program is federally funded and has undergone a significant reduction in allotted acreage since the early 2000s. Continued reduction in CRP area and increased intensification of row-crop agriculture are expected, requiring wildlife managers to develop conservation strategies for ring-necked pheasants that focus on development and implementation of other land-use types, such as fallow between primary crop rotation, which may provide high quality nest and brood resources.

Agricultural rotations between primary crops, specifically entering into a wheat rotation are typically retained as chemically fallow from February to early September. These fallow periods offer few resources for ring-necked pheasants during the critically important breeding period when recruitment necessary to sustain populations occurs. Fallow periods provide an opportunity to implement spring cover crops during the breeding season to determine if spring cover crops are an effective management strategy that provide females with alternative structure for nesting in agricultural systems.

Therefore, my objectives were to 1) identify factors influencing nest-site selection of female ring-necked pheasants in western Kansas agricultural landscapes that include spring cover crops, 2) determine the relative influence of spatial scale, such as patch or point scale, on nest selection, and 3) evaluate the capacity of spring cover crops to provide the necessary vegetation structure and composition for nest-site selection. I predicted that female ring-necked pheasants require specific vegetation structure to cue for nest-site selection. Therefore, I hypothesized female ring-necked pheasants require dense vegetation structure with a litter component for nest-site selection. Scale can influence resource selection by individuals and I hypothesized that female ring-necked pheasants would select nest sites at the broader patch scale than point scale.

Study Area

My study area included 10 sites in Graham, Norton and Russell counties, Kansas, during February to September 2017 and 2018 (Figs. 2.1, 2.2a-h). Two sites were located in Graham County in 2017 with a total area of 6,623 ha. The project expanded to four sites in Graham County during 2018 with a total area of 4,333 ha. Russell County had two sites in 2018 with a total area of 5,860 ha. Finally, Norton County in 2018 had two sites with a total area of 5,688 ha. Graham and Norton counties were transitional between the north-central Smoky Hills and western High Plains ecoregion. Russell County occurred with the north-central Smoky Hill ecoregion. Common land cover surrounding the seven study sites in Graham County included native pasture, row-crop and dryland agricultural fields, properties enrolled in CRP, forested draws, rivers, man-made objects, stock ponds created by damming draws, and weedy waste areas. Norton and Russell counties had similar land cover as Graham County, with the addition of state wildlife management areas near reservoirs. The Norton Wildlife Management area encompassed a total area of 3,157 ha. The Wilson Wildlife Management Area was comparable in size to the Norton Wildlife Management area with a total area of 3,237 ha (Table 2.1).

All study sites occurred within the mixed-grass prairie region and species within native pastures included sideoats grama (*Bouteloua curtipendula*), little bluestem (*Schizachyrium scoparium*), tall dropseed (*Sporobolus compositus*), western wheatgrass (*Pascopyrum smithii*), buffalo grass (*Bouteloua dactyloides*), blue grama (*Bouteloua gracilis*), hairy grama (*Bouteloua hirsuta*), Virginia ground cherry (*Physalis virginiana*), windmill grass (*Chloris verticillata*), common ragweed (*Ambrosia artemisiifolia*), western ragweed (*Ambrosia psilostachya*), silky prairie-clover (*Dalea villosa*), field mint (*Mentha arvensis*), common milkweed (*Asclepias syriaca*), wavy-leaf thistle (*Cirsium undulatum*), buffalo bur (*Solanum rostratum*), and blue vervain (*Verbena stricta*). Row-crop agricultural fields primarily contained monocultures of dryland wheat (*Triticum aestivum*), corn (*Zea mays*), milo (*Sorghum bicolor*), or soybeans (*Glycine max*); few corn and soybean fields were irrigated. Fields between crop rotations contained crop stubble and were maintained in the chemical-fallow state using herbicide applications.

Properties enrolled in CRP had planted native species mixtures containing Indian grass, big bluestem, little bluestem, switchgrass, sideoats grama, western wheatgrass, yellow sweet clover (*Melilotus officinalis*), purple prairie-clover, common ragweed, common milkweed, western ironweed (*Vernonia baldwinii*), pale dock (*Rumex altissumus*), wavy-leaf thistle, Maximillian sunflower (*Helianthus maximiliani*), and common sunflower (*Helianthus annuus*). Forested draws consist of buckbrush (*Symphoricarpos oribiculatus*), Missouri gooseberry (*Ribes missouriense*), yucca (*Yucca filamentosa*), wild plum (*Prunus americana*), and sumac (*Rhus spp.*) thickets with the occasional black cherry (*Prunus serotina*), eastern cottonwood (*Populus deltoides*), and eastern red cedar (*Juniperus virginiana*). Common species within riparian areas and wooded slopes included eastern cottonwood ,eastern red cedar ,box elder (*Acer negundo*), sumac, black cherry, hack berry (*Celtis occidentalis*), wild plum , Missouri gooseberry, buckbrush, stinging nettle (*Urtica doica*), western wheatgrass, smooth brome (*Bromus inermis*), cheat grass (*Bromus tectorum*), timothy (*Phleum pratense*), giant ragweed (*Ambrosia trifida*), poison ivy (*Toxicodendron radicans*), dandelion (*Taraxacum officinale*), pale dock, prairie cordgrass (*Spartina pectinata*), broad-leaf cattail (*Typha latifolia*), and prairie bulrush (*Schoenoplectus maritimus*).

Man-made objects included oil infrastructure, buildings, dirt roads, buildings, oil wells, distribution and transmission power lines, and communication towers. Native, noxious and naturalized species occur throughout the weedy waste area surrounding fields and man-made objects. These species include cheat grass, smooth brome, Caucasian bluestem (*Bothriocholoa bladhii*), marestail (*Hippuris vulgaris*), kochia (*Bassia scoparia*), western wheatgrass, Russian thistle (*Salsolsa kali*), common sunflower, field bindweed (Convolvulus arvensis), poison ivy, green foxtail *(Setaria viridis*), pale dock, Palmer's pigweed (*Amaranthus palmeri*), sandbur (*Cencrhus longispinus*), carpetweed (*Mollugo verticillata*), and grey-green wood sorrel (*Oxalis dillenii*). Taxonomic references were obtained from the Kansas wildflowers and grasses webpage (www.kswildflower.org) and the Kansas Native Plant Society webpage (www.kansasnativeplantsociety).

Breeding Season Weather

Long-term average (1981-2010) April through August total precipitation and temperature was 44.2 cm and 20.3° C in Graham County, 49.8 cm and 19.6° C in Norton County and 48.9 cm and 21° C in Russell County (NOAA 2018). Norton had lower precipitation at 21 cm 2018 than 28 cm in 2017, whereas Russell County had similar precipitation between years at 42 cm in 2017 and 46 in 2018 and Graham County had greater precipitation in 2018 with 63 cm verses 39 cm in 2017 (Fig. 2.3). During 2018 temperatures were cooler than in 2017, with 19-22 more days below 0° C, particularly in February through April, and only 5-14 days above 37° C compared to 11-21 in 2017 (Fig. 2.4). Weather conditions during the study period were cooler in February through April (53-57 days below 0° C) than the long-term average (47 days below 0° C). May through August were also cooler during the study period (41-62 days above 32.2° C) compared to the long-term average (67 days above 32.2° C).

Cover Crop and Chemical Fallow Description

Spring-summer cover crops contained legume and non-legume single species or multiple species mixes (Table 2.2). Cover crops were planted during March 2017 into fields of harvested grain sorghum. Planting occurred in early April of 2018 and cover crops were seeded into fields of harvested corn and grain sorghum. Each cover crop treatment was terminated in mid to late-June or early July using chemical herbicide or mechanical methods. The commercial cover crop seed mixes and a custom wildlife cover crop seed mix were obtained from Star Seed Company, Osborne, Kansas. There were a total of three cover crop mixes (GreenSpring, Chick Magnet, and a Custom Mix), and a fallow treatment was included as a control.

GreenSpring was a cool-season mix typically planted during early spring for a hay crop or livestock grazing prior to termination for fall primary crops such as wheat. The mix was intended to produce greater yields than single species mixes. This mix included oats (*Avena sativa*) and peas (*Pisum sativum*) with a seeding rate of 73 kg/ha.

Chick Magnet was a warm-season grass and forb cover-crop blend designed to increase brood survival by providing adequate substrate for protection from weather and avian predators, and substantial soft-bodied insects for foraging. The mix contained hybrid brassicas Winfred (*Brassica napus*) and Pasja (*Brassica rapa*), yellow sweetclover, peas, sunflower, and buckwheat (*Fagopyrum esculentum*) with a seeding rate of 26 kg/ha.

Custom Mix was a seed mix created by Star Seed Company based on input from wildlife professionals and producers that incorporated the herbaceous and structural component of the two commercial mixes. This mix included turnips (*Brassica rapa*), oats, cowpeas (*Vigna unguiculata*), radish (*Raphanus raphanistrum*), yellow sweetclover, peas, sunflower, safflower (*Carthamus tinctorius*), chickling vetch (*Lathyrus sativus*), and rapeseed (*Brassica napus*) with a seeding rate of 40 kg/ha.

Methods

Study Design

Study sites within each county consisted of 8-16 fields, which were 12-20 ha in size and within close proximity to one another. The design incorporated replicates of four fields (block) with four treatments applied per block. Each block had three different cover crop mixes and a chemical fallow crop control. Each field was randomly assigned a specific treatment. In 2017, there were three treatment replicates in Graham County; in 2018, there were four treatment replicates in Graham County, four in Norton County, and two in Russell County. Cover crop treatments were terminated in mid to late June, based on needs of the individual producer and restrictions of compliance with crop insurance regulations, prior to the sowing of wheat in September.

Capture

Nightlighting Techniques

To capture ring-necked pheasants using night-lighting, I refitted the front bumper of a Chevy Silverado half-ton pickup with a metal bar to hold two tractor chairs with welded metal frames and pins were used to keep the chairs in place. I installed a light bar above the windshield to locate moving vegetation from pheasant movement. To avoid searching the same area during a capture event, I used a Garmin car GPS (Nuvi 50LM) to map search areas. Previous night-lighting techniques employed sound to cover noise from the vehicle and field personnel. I incorporated a wireless Bluetooth speaker, which was taped to the hood of the vehicle and controlled by cell phone using downloaded Spotify fast-paced soundtracks.

Netters on the chairs carried hoop nets to chase and capture pheasants. Spotlighters stood in the back of the vehicle and once moving vegetation was seen, pheasants were spotlighted to aid detection by netters. Slightly shaking spotlights (Stanley Black and Decker Inc, New Britain, Connecticut, model FATMAX SL10LEDS) aided in disorienting the pheasant and decreasing likelihood of flight. Netters avoided running between spotlights and pheasants as the absence of light appeared to spook the pheasants into flight.

I outfitted each captured female ring-necked pheasant with a 15-g very-high-frequency (VHF) necklace radio transmitter (Model #A3960, Advanced Telemetry Systems, Inc., Isanti, MN, USA). All VHF transmitters were programmed with a mortality switch to indicate mortality after eight hours of no movement. I measured mass by placing pheasants in a bird bag and using a 2,500-g spring scale (Pesola AG, Switzerland, model 42500). The left tarsus was measured using digital calipers (Neiko Co, China, model 01407A), which were accurate to 0.01 mm. I measured wing chord (flattened) to mm using a wing chord ruler board. A leg band was secured on each pheasant for identification of individuals during recapture events (FAO 2007). Procedures followed guidelines for handling wild animals required by the Kansas State University Institutional Animal Car and Use Committee (IACUC #3831) and State of Kansas Scientific Wildlife Permits SC-018-2017 and SC-024-2018.

Monitoring

Adult

I located radio-collared ring-necked pheasants every one to three days during main foraging and loafing periods using hand-held 3-element antennas (Baxter and Wolfe 1973). Foraging periods occurred from sunrise to two hours after sunrise, and two hours before sunset to sunset (Baxter and Wolfe 1973). Loafing periods occurred between the two foraging periods. A minimum of three bearings with corresponding Universal Transverse Mercator (UTM) coordinates were recorded within a 20-min period to reduce movement bias (Kenward 2001). Store onboard computers with Location of a Signal (LOAS) software were used to calculate error polygons (Ecological Software Solutions, LLC, Hegymagas, Hungary, Version 4.0). Additional bearings were collected when initial error polygons exceeded 2,000 m^2. I located all suspected mortalities using handheld telemetry units to investigate cause-specific mortality (Dumke and Pils 1973, Bumann and Stauffer 2002).

Nest Locations

From April-August, females with stationary locations for ≥2 detections indicated initiation of nest incubation. I visually confirmed nest location by locating the female on the nest using a receiver (R-1000, Communications Specialists, CA, USA). I attempted to avoid flushing the female from the nest as disturbance may increase predation or abandonment (Evans and Wolfe Jr. 1967, Giuliano and Daves 2002). Flags were positioned 5 m north and south of the nest to provide observers with the nest location for subsequent visits (Matthews et al. 2012*a*). Each location was recorded using a Global Positioning System (GPS) handheld unit (GPSMAP 64, Garmin International Inc., Olathe, KS, USA).

Nests were visited when the female was absent, or after estimated day 14 of incubation to minimize potential abandonment, to record clutch size, egg volume (length and width in mm) using digital calipers, and incubation stage by floating the eggs (Westerskov 1950). I monitored nest viability daily remotely using telemetry. I determined nest fate when the attending female's activity indicated she had permanently left the nest (≥2 locations away from nest site) or a mortality signal occurred (Matthews et al. 2012*a*). Nests with broken or cracked eggshells with membranes attached, or disappearance of the clutch were considered failed. Nests with ≥1 egg having detached membranes or when females were observed with broods indicated that a nest was successful (Klett et al. 1986).

Vegetation Surveys

Nest

I measured vegetation composition and structure at nests and associated random points. Associated random points were randomly generated between 20 and 150 m from each nest and zero to 260^{o}, occurred in the same patch type (a contiguous area of specific vegetation characteristics such a CRP property or cover-crop mix), and represented available vegetation composition and structure with the patch type. Vegetation composition and structure at the nest and an associated random point were measured during the initial nest visit (i.e., early incubation).

I conducted vegetation surveys at each nest and random point and 4 m in each cardinal direction to determine selection at patch and point scales. Percent cover of bare ground, litter, forbs, warm-season grasses, cool-season grasses, woody species greater and less than 1.5 m, crop, and other were measured using a modified 60 x 60-cm Daubenmire horizontal frame (Daubenmire 1959). I recorded visual obstruction using a modified Robel pole using 5-cm bands at a distance of 4 m and height of 1 m (VOR; Robel et al. 1970). Ocular readings were estimated for 100%, 75%, 50%, 25%, and 0% obstructed cover in 4 cardinal directions. I measured litter depth (cm) in the northwest corner of the Daubenmire horizontal frame.

Home Ranges

Home range sizes of females were calculated using the kernel density method in package adhabitatHR and R (R Core Team 2018). I estimated 95% kernel densities with a minimum of 30 triangulated points on individuals. Mortalities prior to reaching the 30-point limit were assigned an average home range, calculated from other individuals within the same county.

Land-Cover Map Analysis

GIS Layers

I created a buffer boundary of 2 km surrounding capture sites to encompass female ring-necked pheasant seasonal movements from wintering grounds to breeding sites (Gates and Hines 1974). In 2017, I created 2-km buffer zones surrounding three study sites including capture sites and cover crop fields in Graham County. Capture sites and project cover crop acres increased to three counties including Graham, Norton, and Russell counties in 2018 when four buffer zones were created in Graham County, four in Norton County, and three in Russell County. I obtained aerial imagery from the USGS National Map database and digitized patch boundaries using ArcMap (ESRI, Redlands, CA, version 10.5). Roads and counties layers were retrieved from the Kansas Data Access and Support Center. I delineated digitized land cover patches through ground-truthing in summer 2017 and 2018 using driving surveys and walking surveys when land features obstructed view of targeted property. Land-cover categories included Cover Crop treatment (project cover crop and other cover crop), Crop Stubble (agricultural land between primary crop rotations and kept chemically fallow or weedy fallow), Conservation Reserve Program (CRP), and Native Grasses (grazed and ungrazed pastures, expired CRP, warm season grass hay fields, and weedy waste areas), Primary Growing Crop (primary cash crop such as wheat, milo, or corn), Open Water (rivers, streams and man-made ponds), Roads (county roads, highways, oil-field roads), and Man-made Objects (houses, barns, agricultural buildings). Land-use categories were used to determine nest-site selection of breeding females at the 3rd order of selection for land-use-scale during 2017 and 2018.

Nest-Site Selection Analysis

I used 4th order of resource selection in the form of used versus random to determine selection of vegetation characteristics surrounding nests. Variables included mean measures of visual obstruction, percent composition, and litter depth. Initially, I used the multivariate Hotelling's T^2

test and univariate Students *t*-test to compare vegetation characteristics between nests and associated random points. If the Hotelling's T^2 test was significant ($P < 0.05$), then I used univariate Student's paired *t*-test to determine which vegetation variable differed between nests and random points. I set $\alpha = 0.05$ for all multivariate and univariate statistical tests.

To determine if females select vegetation that differs from available in the cover crop treatments, I used 4th order selection in the form of a Hotelling's T^2 test. If the Hotelling's T^2 test was significant ($P < 0.05$), then I used univariate Student's paired *t*-test to determine which vegetation variable differed between nests and random points, including visual obstruction readings (0%, 25%, 50%, 75%, 100%), percent cover composition, and litter depth.

I used a resource selection functions to assess the relative influence of vegetation measurements on nest-site selection. Analysis was conducted using a logistic regression framework of resource selection functions using packages AICcmodavg and Rcpp in R (R Core Team 2018). Four *a priori* model suites were created from visual obstruction (0%, 25%, 50%, 75%, 100%), percent cover composition, and litter depth measurements surrounding the nest site. Model comparison and ranking were determined using Akaike Information Criterion for small samples (AIC_c) using package AICcmodavg (Hurvich and Tsai 1995, Wagenmakers and Farrell 2004).

To evaluate female nest selection at the patch scale relative to land cover, I used 3rd order selection and the proportion of available land cover categories within breeding female home ranges. The proportion of available land cover categories was considered a method for estimating the number of expected nests in each category if nest placement was random. I compared the number of expected nests to the observed number of nests within land cover and substrate categories using the Pearsons χ^2 test of Goodness of Fit (Neu et al. 1974, Johnson 1980). Analysis was conducted using packages rcompanion and the fisheries assessment package in R (R Core Team 2018). Confidence intervals were calculated using the Bonferroni method to determine if observed nest locations were selected or avoided within patch land-cover types (Neu et al. 1974). Selection of land-cover types was considered significant if calculated confidence intervals did not overlap with the associated expected proportion. (Byers et al. 1984).

To determine if distance to edge of patch type influenced nest-site selection, I randomly generated points within the 2-km pheasant land-use boundary, and calculated distance to edges for random points and nests using Generate Near Table and Create Random Points tools in ArcMap (ArcGIS, version 10.6.1). I used Welch's two-sample *t*-test for unequal variances to compare the mean distance of nests to land cover edges to the mean distance of randomly generated points within average breeding home ranges.

Results

I captured 73 females during 2017 and 2018; ten were captured in Norton County in 2018, 14 in Russell County, and 49 in Graham County (2017 n = 34, 2018 n = 14, one recapture). I confirmed a total of 82 nests during the study. In 2017, there were 38 confirmed nests from 23 collared and 2 uncollared females with an average clutch size of nine and range of 1-16 eggs; six females nested once, 13 nested twice, and two individuals nested three times. Nests were located in a variety of vegetative types, 27 were located in CRP (71%), four in green wheat, three in ungrazed pastures, two in cover crop (GreenSpring), and one in a cool-season grass road ditch. Of the 38 nests, eight were abandoned, 22 failed due to predation, and eight hatched (21%). In 2018, I confirmed 44 nests from 38 collared and six uncollared females and average clutch size increased to 11, with a range of five to 19 eggs. I documented 12 females who nested once, nine nested twice, one nested three times, and one individual nested four times. Mean home ranges of breeding females in 2017 was 126 ha (SE = 20.2) and 92 ha in 2018 (SE = 0.25.7).

Females nested in several land-use types during 2018 including 20 nests located in CRP (45%), 12 nests in growing and fallow wheat, three in warm-season grassland, two in an alternative cover crop mix (radishes, spring peas, sunflowers, spring peas, oats), two in chemical fallow wheat stubble, one in soybeans, one in ungrazed warm-season grass pasture, one in the Chick Magnet cover crop mix, one in a warm-season hayfield, and one in a smooth brome water drainage strip. Of the 44 nests, 20 failed due to predation, nine were abandoned, two failed due to extreme weather (hail), one failed due to a tractor, one was a dump nest, one nest's fate was unknown, and ten were successful (23%). Average initiation of first nest attempts was May 22 in 2017 and May 14 in 2018 (Fig. 2.5).

Point selection of nest and associated random vegetation characteristics was determined using the Hotelling's T^2 test and Students *t*-test for 36 nests in 2017 and 41 nests in 2018. Data were combined for both years and there was no difference between used and random points for visual obstruction readings ($F_{5, 148}$ = 1.1, P = 0.39), percent composition ($F_{11, 142}$ = 0.5, P = 0.91), and litter depth (t_{147} = -0.5, P = 0.65).

I separated 2017 and 2018 for the nest vegetation and random spring cover crop points, as cover crop growth was retarded in 2018 due to late planting and cold growing temperatures in April. In 2017, there was a difference in vegetation characteristics between cover crop treatments and nest sites for visual obstruction reading, percent composition, and litter depth measurements ($F_{5, 405}$ = 48.1; $F_{5, 403}$ = 257.6, $t_{37.3}$ = 4.3, P < 0.001). In univariate analyses, visual obstruction at the 0%, 25%, 50%, 75%, and 100% reading, percent composition of crop stubble, litter, bare ground, warm-season grass, cool-season grass, and litter depth differed between cover crops and nest sites during 2017 (Table 2.3). Differences in the mean visual obstruction between nest locations and cover crops ranged from 1.78 dm at the 100% reading to 4.60 dm at the 0% reading, with nest locations having greater mean values. The percent cover composition had pronounced differences between nest locations and spring cover crop points, most notably in the percent composition of warm-season grasses, which nest sites had 49.9% greater mean values than spring cover crop points. Crop stubble had smallest difference in means for percent cover composition, with a difference in means of 4.23%, with spring cover crops having a greater mean value than nest locations. The difference in litter depth was 0.82 cm, with nests having a higher mean value. There was not a difference between cover crops and nest sites for percent crop ($t_{35.0}$ = 2.1, P = 0.59) and percent forb ($t_{45.1}$ = -1.2, P = 1.00).

In 2018, there were differences for visual obstruction reading ($F_{5, 1326}$ = 36.3, P < 0.001), percent composition ($F_{7, 1324}$= 170.7, P < 0.002), but not litter depth ($t_{43.3}$ = 2.45, P = 0.104) between nest and randomly sampled cover crop vegetation data. In univariate comparisons, there were differences between nest and randomly sampled cover crop vegetation for all measurements except percent crop ($t_{42.1}$ = 2.4, P = 0.02), percent crop stubble ($t_{42.3}$ = 0.1, P = 1.00), percent bare ground ($t_{44.6}$ = -2.3, P = 0.33), percent cool-season grass ($t_{42.7}$ =-0.5, P = 1.00), and litter depth ($t_{43.4}$ = 2.4, P = 0.24; Table 2.3). Differences in means between the visual obstruction readings between nests and cover crop fields was greatest at the 0 reading at 4.16 dm, and lowest at the 50 reading at 1.93 dm. Similar to 2017, percent cover composition of warm season grasses had the greatest difference in means between nests and cover crop fields, with nest locations having a 34.57% greater percentage of this vegetation type. The lowest significant difference for percent cover composition was for forbs at 10.56 cm, with spring cover crops having a greater mean than nest locations.

Resource selection functions contained nests for both years with a total of 77 nests used in analyses (2017 n = 36, and 2018 n = 41). With data combined across years the top model for the visual obstruction reading suite was the quadratic 50% visual obstruction model (AIC_c w_i = 0.40). Percent forb cover was the top model for the percent cover composition (AIC_c w_i = 0.23); the null model had the most support in the litter depth model suite (AIC_c w_i = 0.38). The final model suite included visual obstruction at the 50% reading, the quadratic percent cover composition of forb, and a null model. Females selected nest sites at the point scale based on the 50% visual obstruction reading, and selection of vertical cover occurring between 5-7 dm (AIC_c w_i = 0.97, Fig. 2.5, Table 2.4).

Females selected land-use categories for nesting more than expected in 2017 (χ^2_4 = 26.49, P < 0.001) and 2018 (χ^2_4 = 9.80, P = 0.04; Table 2.5). In 2017, 35 nests were observed in four land-use types including of cover crop, primary crop, CRP properties, and native grass. Females selected CRP for nesting more than expected by chance in 2017 (expected proportion = 0.477, observed proportion 95% CI = 0.523-0.905), and no land-use types were avoided. In 2018, 44 nests were observed in the same four categories as 2017 with the addition of crop stubble for a total of five land-use categories. Similar to 2017, females selected CRP more than expected in 2018 (expected proportion = 0.149, observed proportion 95% CI = 0.262-0.648), in addition primary crop was used less than expected (expected proportion = 0.477, CI = 0.118 – 0.472). Additional land-use information in 2018 allowed for analysis of land-use substrate categories, which included CRP properties, wheat, grassland, pasture, warm-season hayfields, soybeans, chemical fallow crop stubble, an alternative cover crop mix, and Chick Magnet cover crop mix. Females once again selected CRP more than expected by chance (expected proportion = 0.208, observed proportion 95% CI = 0.247 – 0.662), and used pasture less than expected (expected proportion = 0.118, observed proportion 95% CI = 0.00 – 0.85);

Years were separated due to potential changes in patch edges between years. There was no difference between distance to edge of nests and randomly generated points in 2017 ($t_{95.8}$ = -1.1, P = 0.31), with the mean distance of nests at 64.4 m (SE = 9.1) from an edge, and the mean distance of random points was 80.9 m (SE = 9.8) from edges. In addition, there was no difference between mean distance of nest and randomly generated points in 2018 ($t_{79.2}$ = 0.697, P = 0.48), with mean distances of nests from edges at 83.8 m (SE = 13.0), and mean random points 94.3 m (SE = 9.4) from edges.

Discussion

Ring-necked pheasant nest-site selection can occur at multiple scales, which has important implications for management of nesting structure (Clark et al. 1999). In western Kansas, female ring-necked pheasants selected vegetation with high visual obstruction for nesting at the point scale, primarily located in landscape patches enrolled in the federal Farm Bill CRP for native grasses. Resource selection functions suggest females selected nest sites between 5-7 dm at 50% VOR for nest-site selection. This coincides with previous research from southwestern Kansas, where females selected nest-sites close to 5 dm (Hagen et al 2007). Additional factors influencing selection, such as distance to edge, have been suggested to influence nest placement (Baxter and Wolfe 19730; however, there was no indication in my research that females were selecting nests closer to edges. During both years of the study, nesting females selected CRP at a greater proportion than was available in average breeding female home ranges. In addition, the use of crop and pasture for nesting in 2018 was less than expected. These land use types are available to females, but potentially do not provide vegetation structure females require for nest-site selection. In 2017, females nested primarily in CRP; however, use of CRP declined slightly in 2018, and nest placement in green wheat and recently harvested stubble increased proportional to availability within female home ranges. Weather conditions during February-April may have influenced growth of wheat to the range within females select nests at the point scale-selection occurred.

Weather variables such as temperature and rainfall influence growth of cool season vegetation, including cool and warm season grasses during the ring-necked pheasant breeding season. In 2017, there was a stochastic snow event on May 1 where 10 cm of snow fell overnight, when females were selecting nest sites or laying eggs, which significantly delayed nesting in 2017 compared to 2018. Average nest initiation of confirmed first nest attempts in 2017 was May 22, which was eight days later than that of 2018 when average first nest attempts occurred on May

14. Severe weather conditions have been found to delay nest initiation of females in Nebraska with springs characterized as wet and cold delaying initiation (Baxter and Wolfe 1973). During the 2018 breeding season winter wheat growth was stunted to within the range of female selection due to extreme cold weather in February to April. It is possible that I failed to detect the initial first nest attempt in 2017 as females likely abandoned those nests due to the extreme weather event resulting in a week-delayed nesting attempt.

Use of CRP by nesting ring-necked pheasants has increased in importance in locations where agricultural production has intensified, leaving road ditches and CRP as the last remaining tracts of native grasses (Camp and Best 1994). Females in areas of high intensity agricultural production selected strips of native grass at densities 14 times greater and had greater nest success rates than in adjacent no-tillage sod, suggesting the importance of undisturbed native grasses for population persistence in high intensity agricultural landscapes (Basore et al. 1986). Failure of CRP to provide quality pheasant structure for nesting is attributed to the lack of disturbance during the 10-year contract period (Matthews et al 2012). During my study period, CRP was the dominant nesting land cover. Other studies have found wheat to be the main nesting substrate; green wheat accounted for over 80% of the available nest substrate surrounding nests in Colorado (Snyder 1984). However, females selected this land-use type potentially as it was the only cover available for nesting birds. The proportion of wheat surrounding nests in my study was greatest in 2018; however, even with an increase in availability of wheat females consistently selected CRP in 2018.

Between years in Graham County, vegetation structure of CRP was similar, suggesting it can be a substrate females can rely on for nest-site selection. For CRP fields to remain quality nesting substrate for ring-necked pheasants, active management in the form of disking, interseeding, prescribed fire, or grazing is necessary to maintain heterogeneous structure for nesting and brood rearing (Basore et al. 1986, Matthews et al. 2012). A study in Nebraska found that females selected portions of the field that had improved species diversity through mid-contact management by interseeding herbaceous species (Matthews et al. 2012). CRP is the primary nest substrate, where available, for ring-necked pheasants in Kansas; however, native pastures, when managed appropriately, can provide necessary vertical cover for nest-site selection. Pheasants were reported to nest in native warm-season grass pastures in Iowa, with management recommendations to minimize grazing height to 20-25 cm (2-3 dm) to allow sufficient height for pheasant nest-selection (George et al. 1979). While these numbers are lower than selected by western Kansas females, it is possible that regional effects may be influencing nest-site selection at these lower vertical cover heights. Managed CRP and native warm-season pastures provide high quality nest substrate for ring-necked pheasants. Alternative strategies, such as spring cover crops in agricultural fields, are limited in the time frame the primary crop is fallow, and may not provide sufficient structure for selection during the short fallow period.

Of the spring cover crop mixes planted in March 2017, only two reached densities required for nest-site selection at the point scale prior to termination (Fig 2.7). GreenSpring reached average vertical cover of 5 dm at the 50% VOR during the 1st week of June and Custom Mix at the 2nd week of June. Chick Magnet never reached densities >2.5 dm at the 50% VOR reading prior to termination. Visual obstruction of vegetation within the GreenSpring and Custom Mix may be attributed to high spring temperatures in 2017, which promoted growth of the oats within the mixes. For spring cover crops planted in April of 2018, no mix reached vertical cover heights past 4.5 dm at the 50% VOR prior to termination in June because of delayed planting and cool weather during April retarding vegetation growth. In some years, cover crops may provide adequate structure for nest-site selection when termination occurs in July; however, delaying termination past mid-June is not a common practice as senescence of the cover crops, such as oats, may use nutrients that were targeted for the primary crop. In addition, cover crop seed may remain viable if termination occurred after seed development, which could cause issue during harvest of the primary crop, particularly green wheat.

During both years of the study, spring cover crops yielded low numbers of nesting individuals (2017 n = 2, 2018 n = 3), which coincides with my findings that these mixes did not meet selection requirements of females at the point scale. This is likely due to the low VOR of spring cover crop during the ring-necked pheasant breeding period. While selection was similar to the expected proportion for both years, all nests in cover crops were initiated after June when vegetation grew to the 5-7 dm 50% VOR required for point-scale selection. None of the four monitored nests located in cover crops were successful (3 fail, 1 abandon), which may be due to the low nest survival of late season nests, or potentially the row structure and lower vegetation densities of cover crops increases the search efficiency of olfactory nest predators. Initiation of nests in central Nebraska occurred earliest in land use containing sufficient residual cover, such as roadside ditches (Baxter and Wolfe 1973). Peak nesting occurred between mid-May to late-June in 2017 and 2018, indicating that spring cover crops may be only of use to individuals for re-nest attempts during years of adequate visual obstruction. Chemical fallow treatments did not provide habitat for nesting birds during initial nesting periods or re-nesting attempts as no nests were located in this treatment during 2017 or 2018. Previous research has found pheasants will utilize agricultural fields with sufficient sod cover; however, nesting visual obstruction was low, and potentially contributed to the low nest success, which suggests this land use type was not a viable management option in comparison to native warm-season grass strips (Basore et al. 1986).

My research indicates nest survival declines with age during the breeding season (Chapter I); therefore, to increase early season nesting for enhanced nest survival (and selection by females), residual cover during early breeding period is required. Ring-necked pheasants select nest sites at multiple scales. In my study, selection occurred first at the patch level, and then within the patch (primarily native grasses in the form of CRP), at the point scale (Clark et al 1999). To target use of nest substrate by breeding females, both of these scale requirements must be met. Although the proportion of crop within average female home ranges was relatively high, this substrate, and that of pasture, was used less than expected. These land-use types make up a large portion of the total land-use within western Kansas, placing even more emphasis on the need for land cover types containing quality residual cover for females during breeding, such as CRP, to ensure nest selection and success to maintain populations. My results suggest females do not select spring cover crops for nesting cover, as they do not reach VOR height required for selection during peak pheasant breeding periods. However, the presence of cover crops may benefit other important periods, such as the brooding, in comparison to the alternative chemical fallow option, which offer few resources for pheasants and other wildlife species.

Management Implications

To target cover crops for nest-selection during first nest attempts, cover crops should be planted in late summer or early fall and left on the landscape until the following summer to ensure densities are available during initial and peak nesting periods. Landscape patches enrolled in CRP were consistently selected by females for nesting, especially during years when other substrates, such as green wheat and spring cover crops exceed or do not reach required vertical cover. Managers should focus on providing a form of nest substrate through the use of CRP enrollment or native pasture to ensure nesting substrate is available. Spring cover crops may provide quality habitat requirements during other important life stages, such as brooding, which may be a limiting resource in western Kansas.

Literature Cited

Basore, N. S., L. B. Best and J. B. Wooley, Jr. 1986. Bird nesting in Iowa no-tillage and tilled cropland. Journal of Wildlife Management 50:19-28.

Blesh, J., and L.E. Drinkwater. 2013. The impact of nitrogen source and crop rotation on nitrogen mass balances in the Mississippi River Basin. Ecological Applications 23:1017-1035.

Byers, R., R. K. Steinhorst and P. R. Krausman. 1984. Clarification of a technique for analysis of utilization-availability data. Journal of Wildlife Management 48:1050-1053.

Camp, M., and L. B. Best. 1994. Nest density and nesting success of birds in roadsides adjacent to rowcrop fields. American Midland Naturalist 131:347-358.

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

De Baets, S., J. Poesen, J. Meersmans, and L. Serlet. 2011. Cover crops and their erosion-reducing effects during concentrated flow erosion. Catena 85:237-244.

Delgado, J. A., M. A. Dillon, R. T. Sparks, and S. Y. C. Essah. 2007. A decade of advances in cover crops. Soil and Water Conservation 62:110A-117A.

Evans, R. D., and C. W. Wolfe Jr. 1967. Effects of nest searching on fates of pheasant nests. Journal of Wildlife Management 31:754-759.

FAO. 2007. Wild Birds and Avian Influenza: an introduction to applied field research and disease sampling techniques. Edited by D. Whitworth, S.H. Newman, T. Mundkur and P. Harris. FAO Animal Production and Health Manual, No. 5. Rome.

Gates, J. M., and J. B. Hine. 1974. Seasonal movement, winter habitat use, and population distribution of east central Wisconsin pheasant population. Edited by L. Ruth. Technical Bulletin, Wisconsin Department of Natural Resources No. 76, 55 pages. Madison, Wisconsin.

George, R. R., A. L. Farris, C. C. Schwartz, D. D. Humburg, and J. C. Coffey. 1979. Native prairie grass pastures as nest cover for upland birds. Wildlife Society Bulletin 7:4-9.

Giuliano, W. M., and S. E. Daves. 2002. Avian response to warm-season use in pasture and hayfield management. Biological Conservation 106:1-9.

Hagen, C.A., J. C. Pitman, R. J. Robel, T. M Loughin, and R. D. Applegate. 2007: Niche partitioning by lesser prairie-chicken Tympanuchus pallidicinctus and ring-necked pheasants Phasianus colchicus in southwestern Kansas. Wildlife Biology 13:34-41.

Hurvich, C. M., and C. Tsai. 1995. Model selection for extended quasi-likelihood models in small samples. Biometrics 51:1077-1084.

Johnson, D. H. 1980. The comparison of usage and availability measurements for evaluating resource preference. Ecology 61:65-71.

Kenward, R.F. 2001. A manual for wildlife radio tagging, 2nd edition. Academic Press. San Diego, California.

Klett, A. T., H. F. Duebbert, C. A. Faanes, and K. F. Higgins. 1986. Techniques for studying nest success of ducks in upland habitats in the prairie pothole region. U. S Fish and Wildlife Service Resource Publication 158.

Matthews, T. W., J. S. Taylor, and L. A. Powell. 2012. Ring-necked pheasant females select managed Conservation Reserve Program grasslands for nesting and brood-rearing. Journal of Wildlife Management 76:1653-1660.

Midwest Pheasant Study Group. 2013. National wild pheasant conservation plan. N.B. Veverka (ed.). Association of Fish and Wildlife Agencies. 111 pp.

National Oceanic and Atmospheric Administration (NOAA). 2018. National Climate Data Center. Climate 1981-2010 Climate and Daily Normals. https://www.ncdc.noaa.gov/data-access/quick-links#loc-clim Accessed 16 November 2018.

Neu, C. W., C. R. Byers, and J. M. Peek. 1974. A technique for analysis of utilization-availability data. Journal of Wildlife Management 38:541-545.

R Core Team. 2018. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. www.R-progrject.org.

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

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

Smith, R. G., L. W. Atwood, F. W. Pollnac, and N. D. Warren. 2015. Cover-crop species as distinct biotic filters in weed community assembly. Weed Science 63:282-295.

Snyder, W. D. 1984. Ring-necked pheasant nesting ecology and wheat farming on the High Plains. Journal of Wildlife Management 48:878-888.

USDA Conservation Reserve Program Statistics. 2017. CRP Years Enrolled by State. Accessed 11-19-2018. www.fsa.usda.gov/programs-and-services/conservation-programs/reports-and-statistics/conservation-reserve-program-statistics/index.

Wagenmakers, E., and S. Farrell. 2004. AIC model selection using Akaike weights. Psychonomic Bulletin & Review 11:192-196.

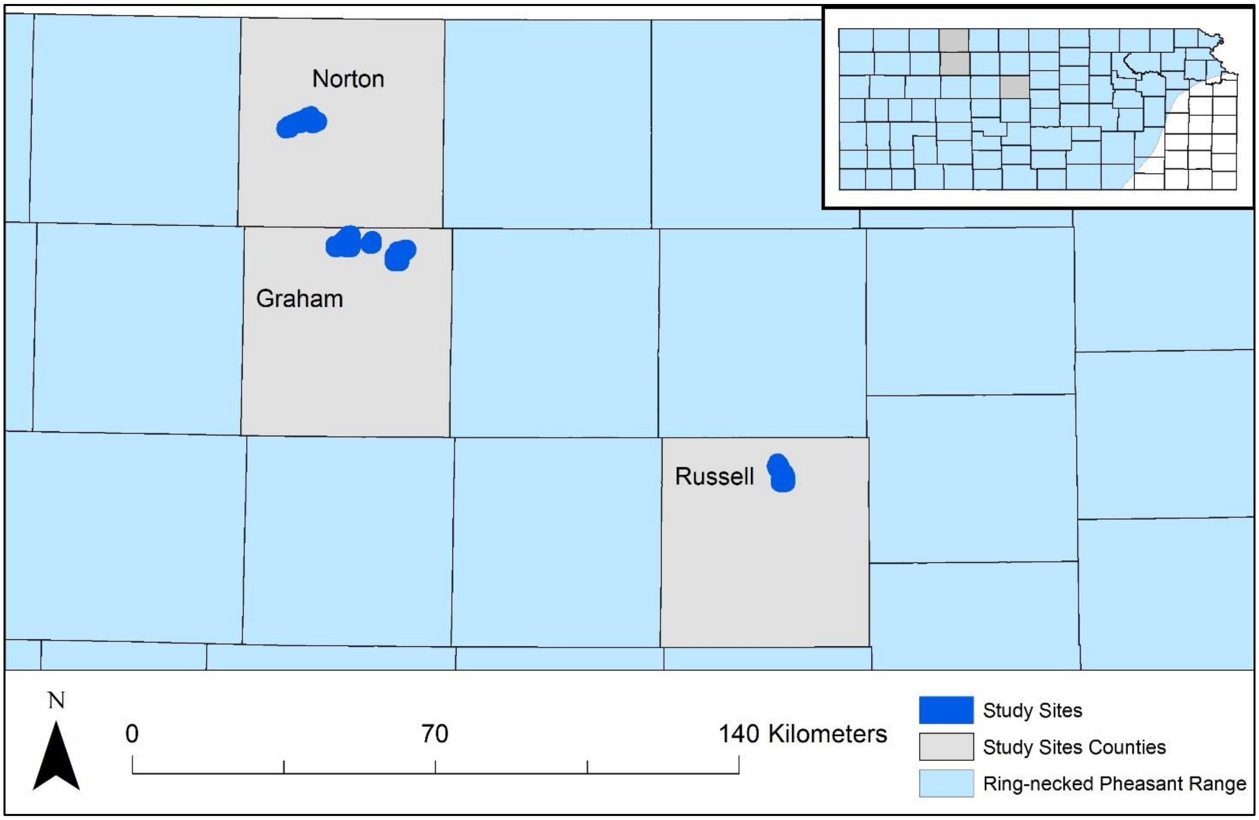


Figure 2.1 Location of ring-necked pheasant and spring cover crop study sites; six study sites were located in Graham County, two in Russell County, and two in Norton County during 2017 and 2018 in western Kansas.

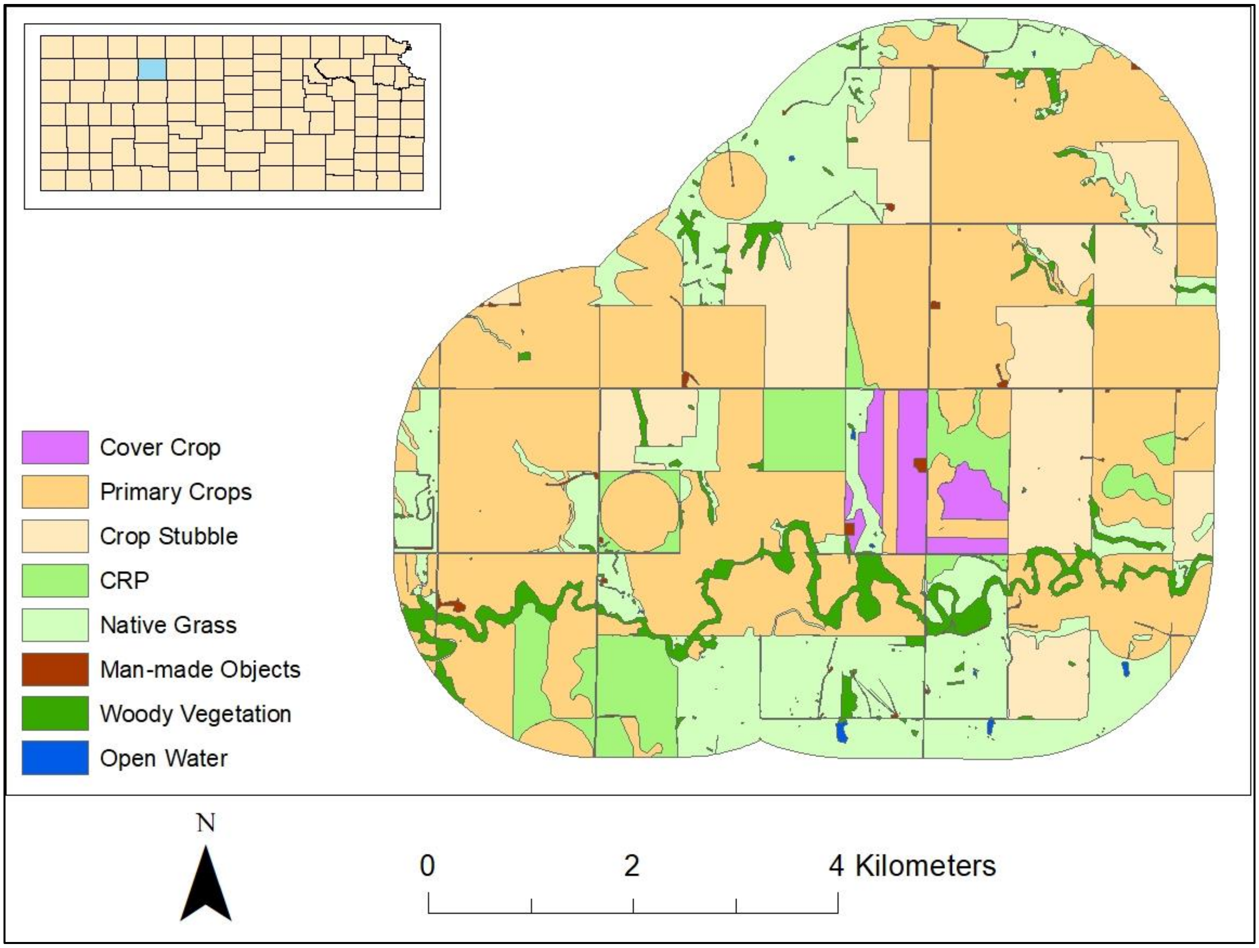


Figure 2.2 Land cover for each study site including (a) the 2017 study site and associated land-use classes located 19 km north of Hill City and 3 km west of Highway 283 in Graham County, Kansas, (b) the 2017 study site and associated land-use classes 17 km north of Hill City and 10 km east of Highway 283 in Graham County, Kansas, (c) the 2018 study site and associated land-use classes located 19 km north of Hill City and 3 km west of Highway 283 in Graham County, Kansas, (d) the 2018 study site and associated land-use classes located 19 km north of Hill City and 1.5 km east of Highway 283 in Graham County, Kansas, (e) the 2018 study site and associated land-use classes located 14 km north of Hill City and 7 km west of Highway 283 in Graham County, Kansas, (f) the 2018 study sites and associated land-use classes located 9 km west of Norton and 3 km south of Highway 36 in Norton County, Kansas, (g) the 2018 study site and associated land-use classes located 4 km south of Luray and 3 km west of 194th street in Russell County, Kansas, and (h) the 2018 study sites and associated land-use classes located 6 km south and 1 km west of Luray and 1 km south of 194th street in Russell County, Kansas.

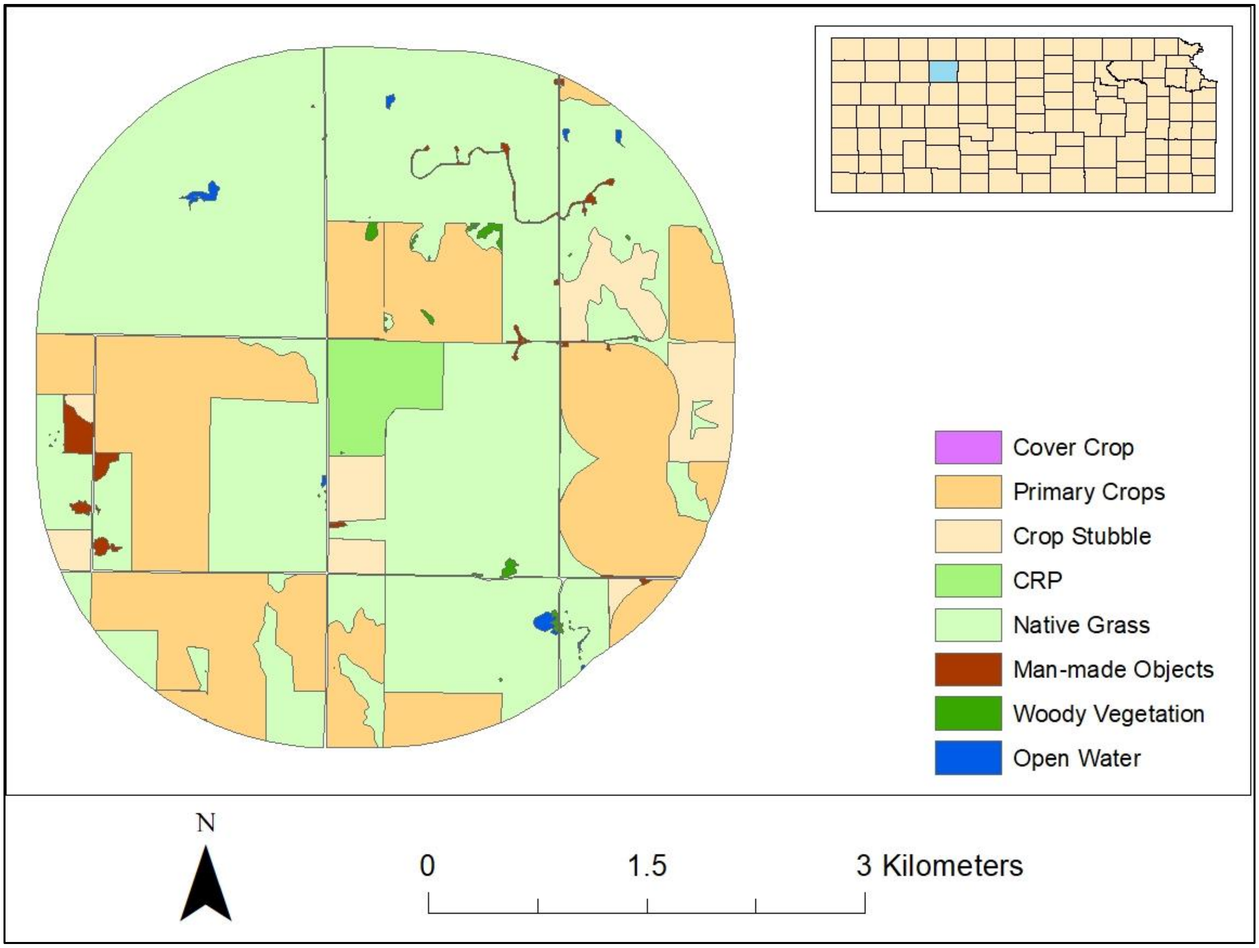

Cover Crop
Primary Crops
Crop Stubble
CRP
Native Grass
Man-made Objects
Woody Vegetation
Open Water
N
0
1.5
3 Kilometers

Figure 2.2b

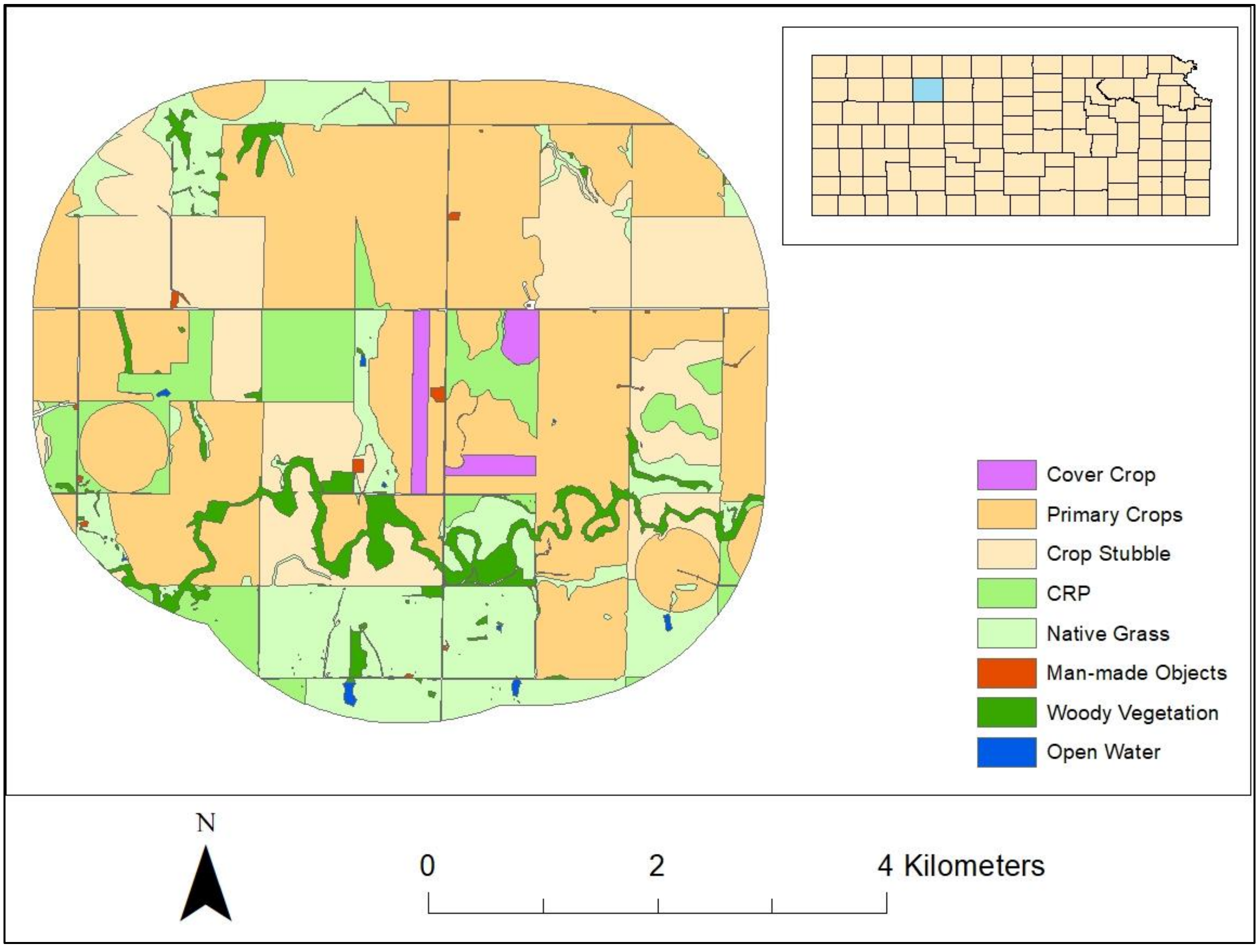

Cover Crop
Primary Crops
Crop Stubble
CRP
Native Grass
Man-made Objects
Woody Vegetation
Open Water
N
0
2
4 Kilometers

Figure 2.2c

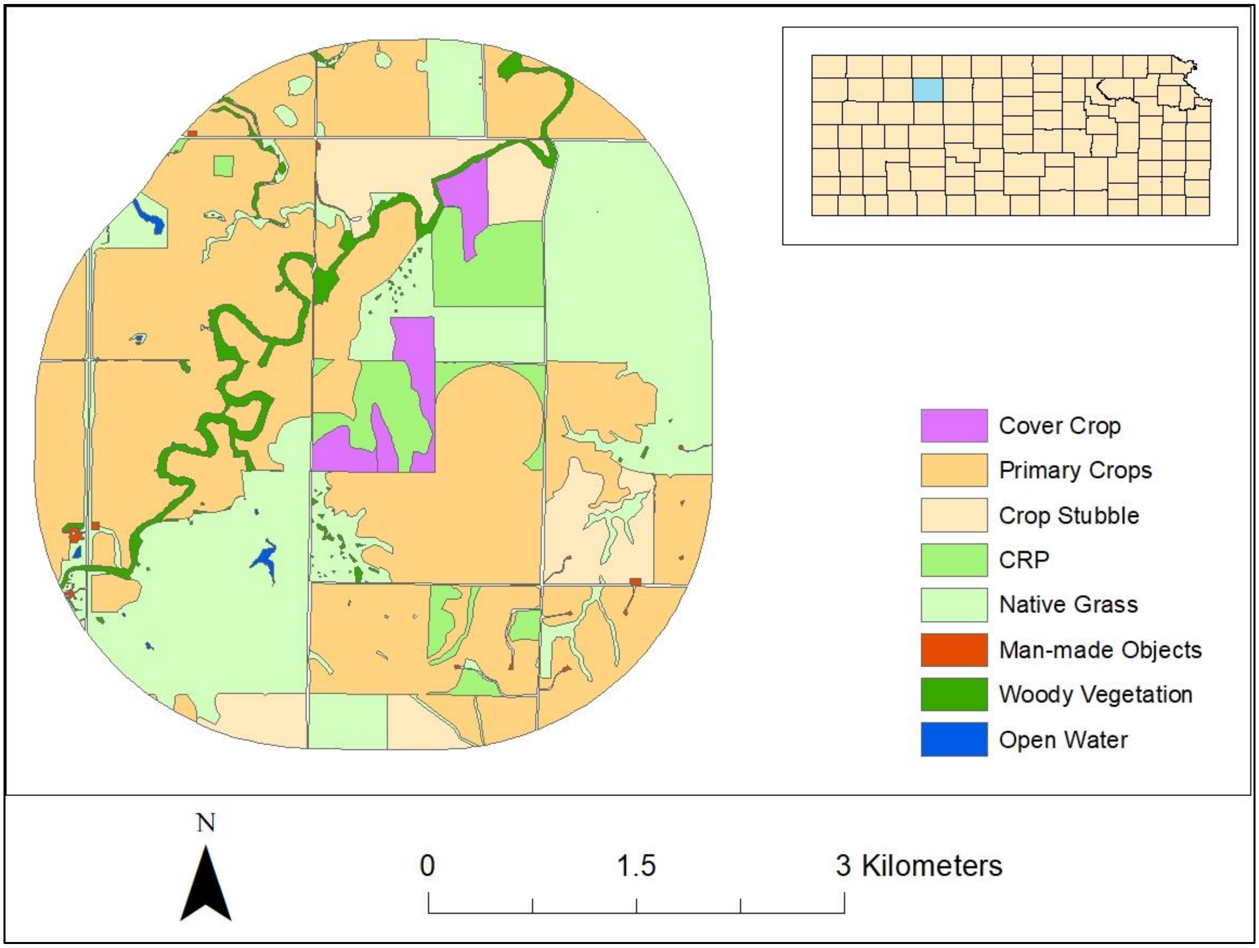

Cover Crop
Primary Crops
Crop Stubble
CRP
Native Grass
Man-made Objects
Woody Vegetation
Open Water
N
0
1.5
3 Kilometers

Figure 2.2d

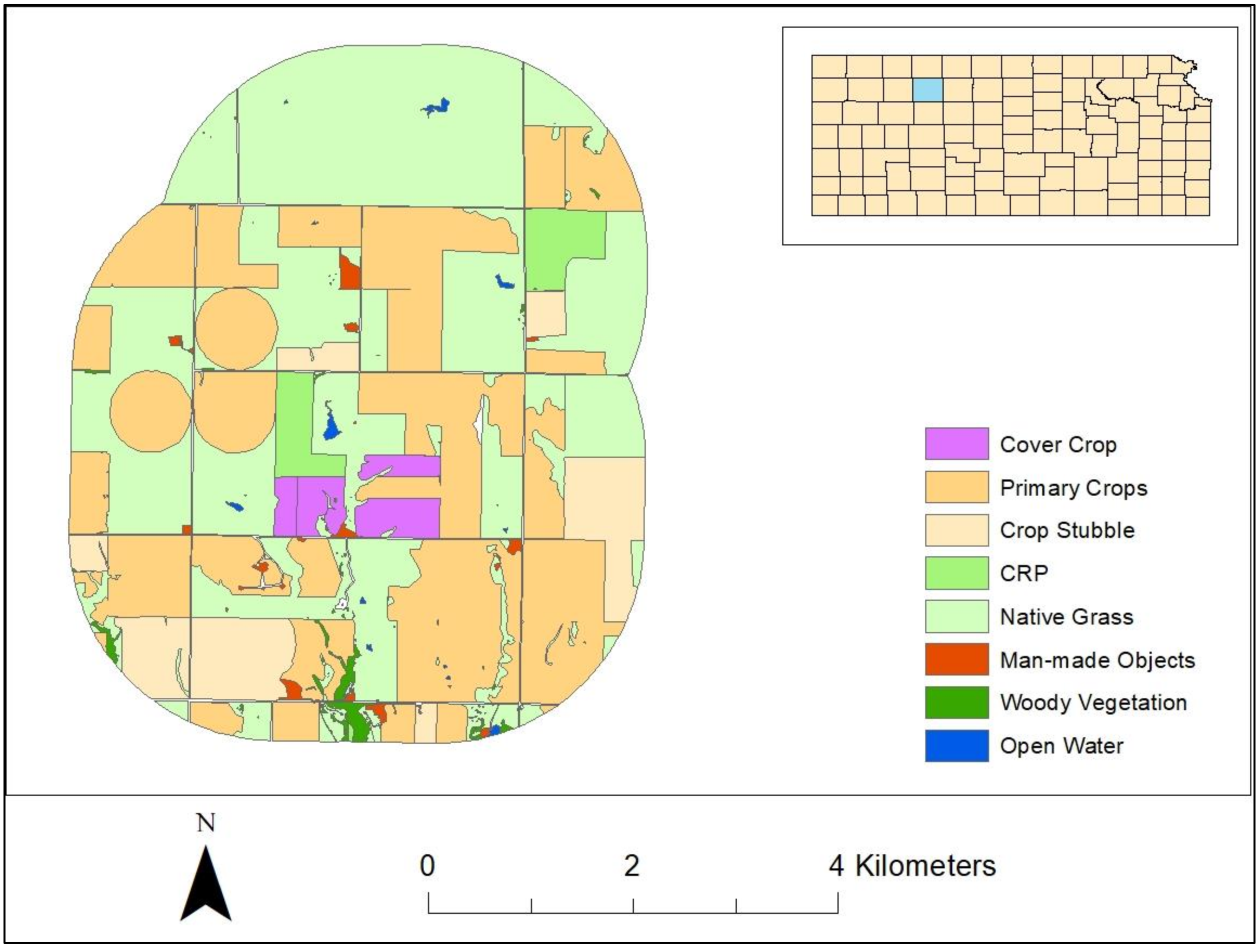

Cover Crop
Primary Crops
Crop Stubble
CRP
Native Grass
Man-made Objects
Woody Vegetation
Open Water
N
0
2
4 Kilometers

Figure 2.1e

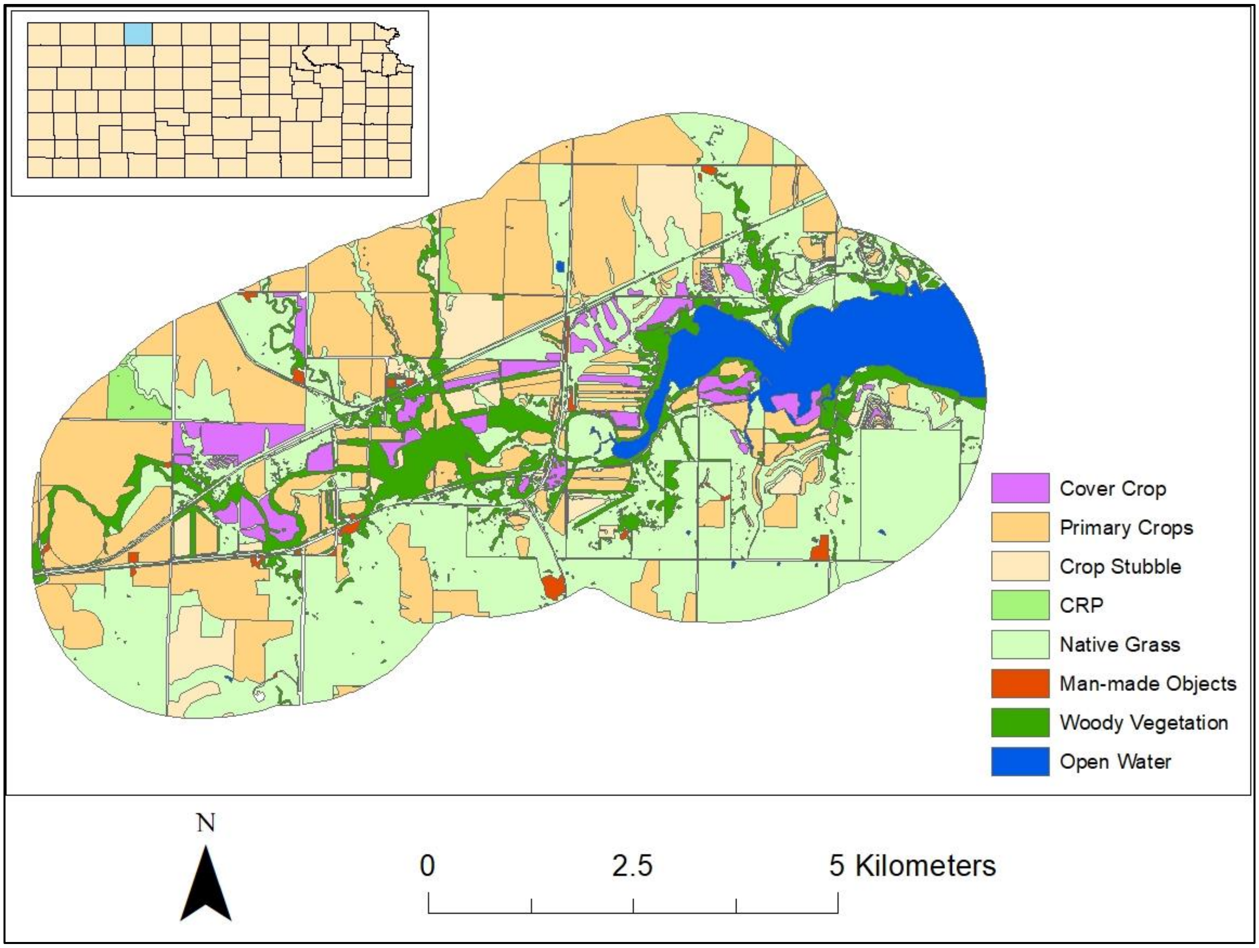

Cover Crop
Primary Crops
Crop Stubble
CRP
Native Grass
Man-made Objects
Woody Vegetation
Open Water
N
0
2.5
5 Kilometers

Figure 2.2f-g

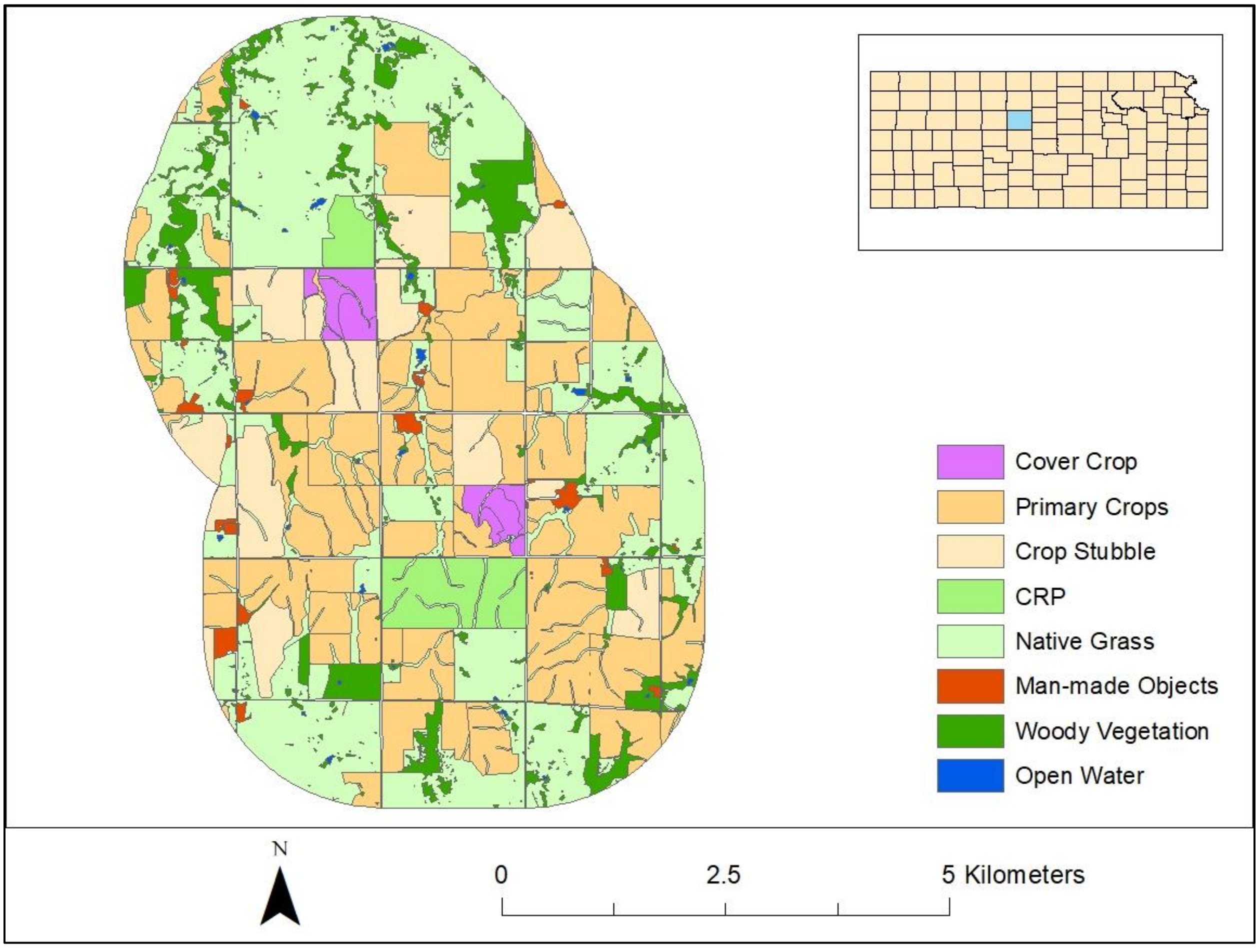

Cover Crop
Primary Crops
Crop Stubble
CRP
Native Grass
Man-made Objects
Woody Vegetation
Open Water
N
0
2.5
5 Kilometers

Figure 2.2h

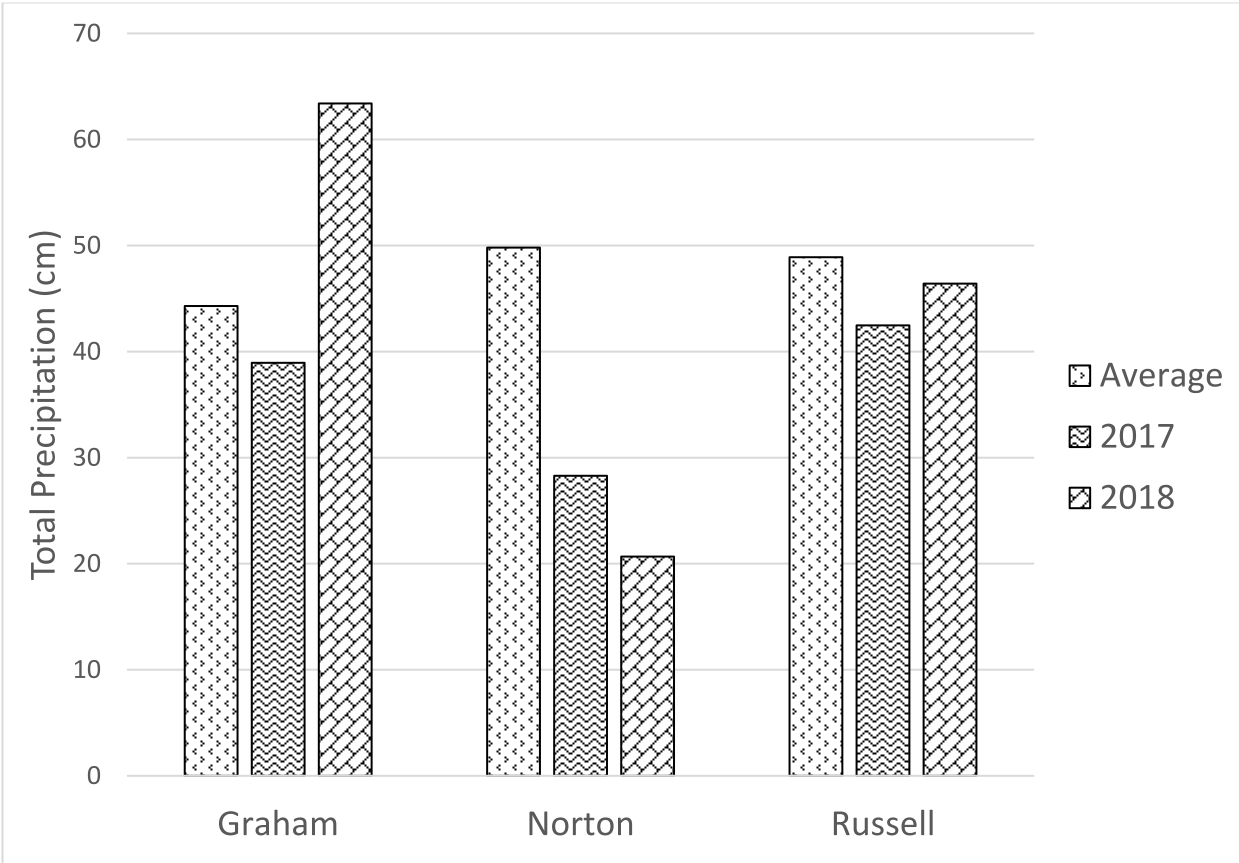


Figure 2.3 Total precipitation from February through August for Graham, Norton and Russell counties, Kansas, for 2017 and 2018 compared with the long-term average since 1981.

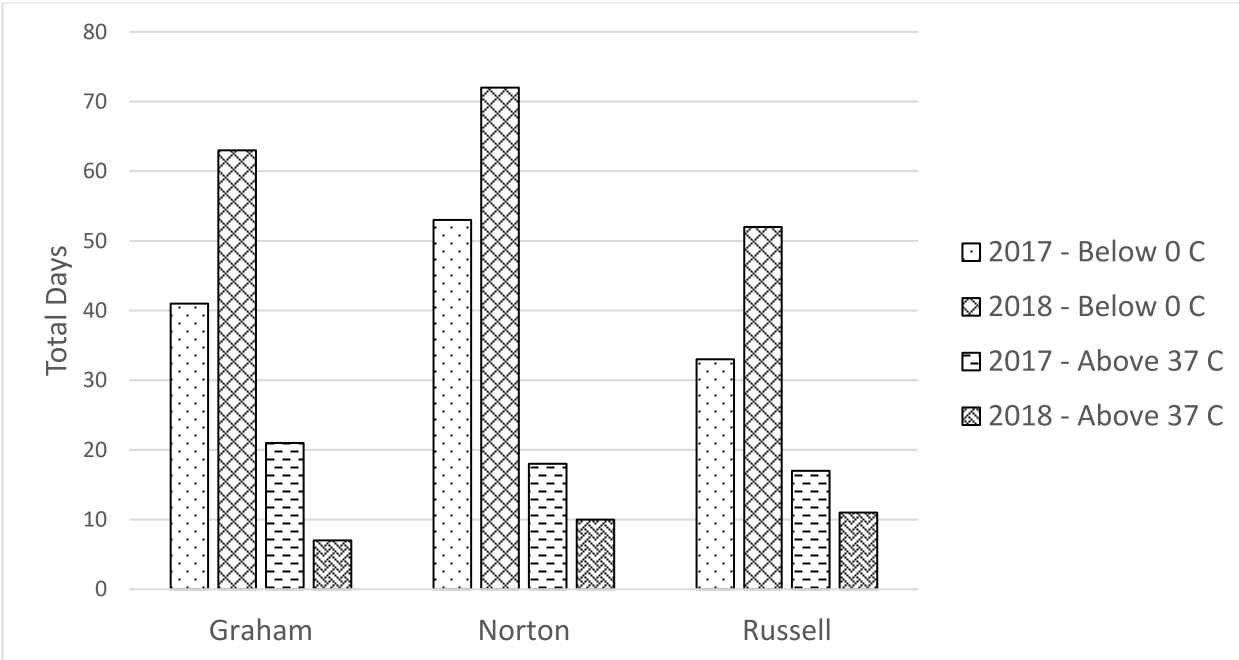


Figure 2.4 Total number of days between February and August below 0° C and above 37° C in Graham, Norton and Russell counties, Kansas in 2017 and 2018.

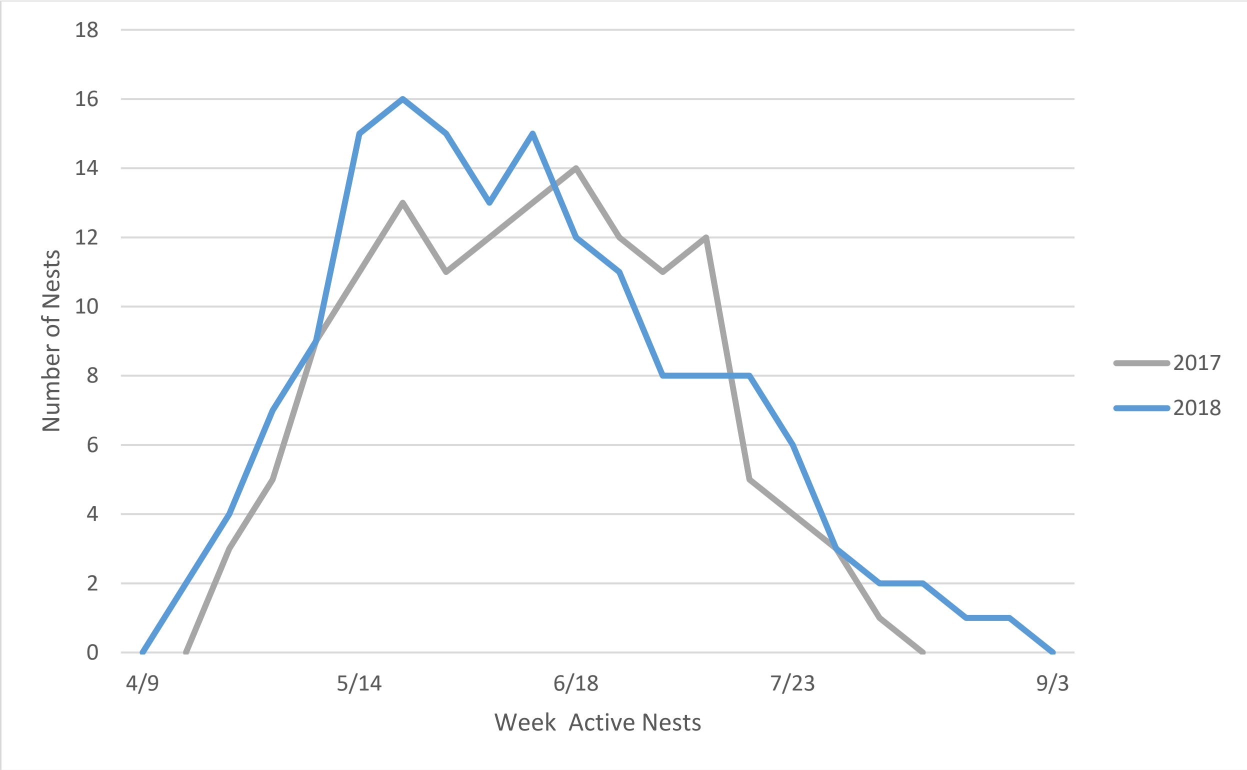


Figure 2.5 Week temporal distribution of active nests of ring-necked pheasants during 2017 (*n* = 30) in Graham County, Kansas and 2018 (*n* = 35) in Graham, Russell and Norton counties, Kansas.

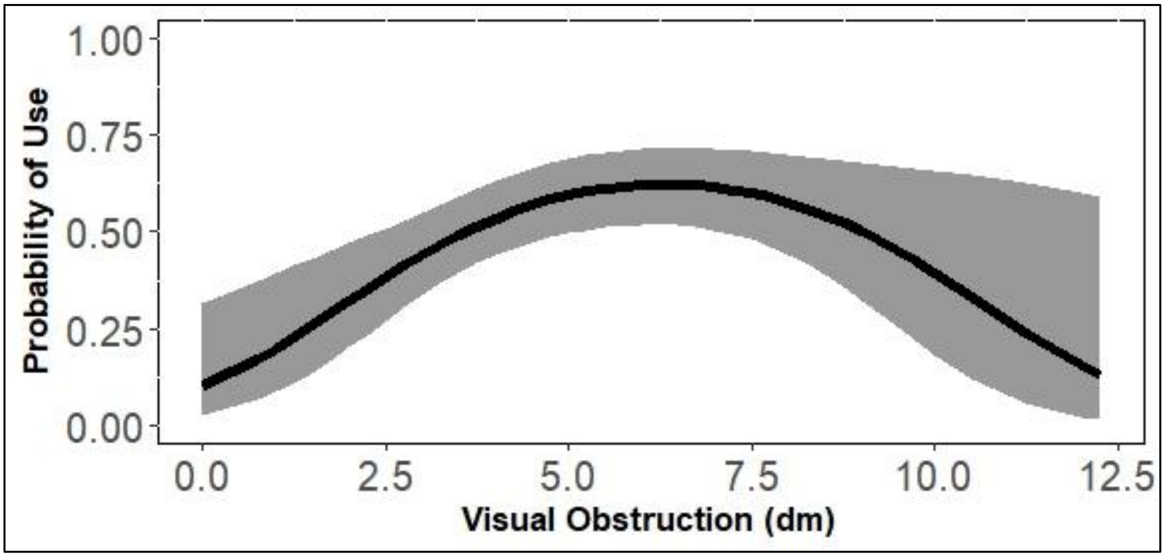


Figure 2.6 Nest-site selection by female ring-necked pheasants in 2017 and 2018 based on the probability of use at the 50% visual obstruction reading in Graham, Norton and Russell counties, Kansas.

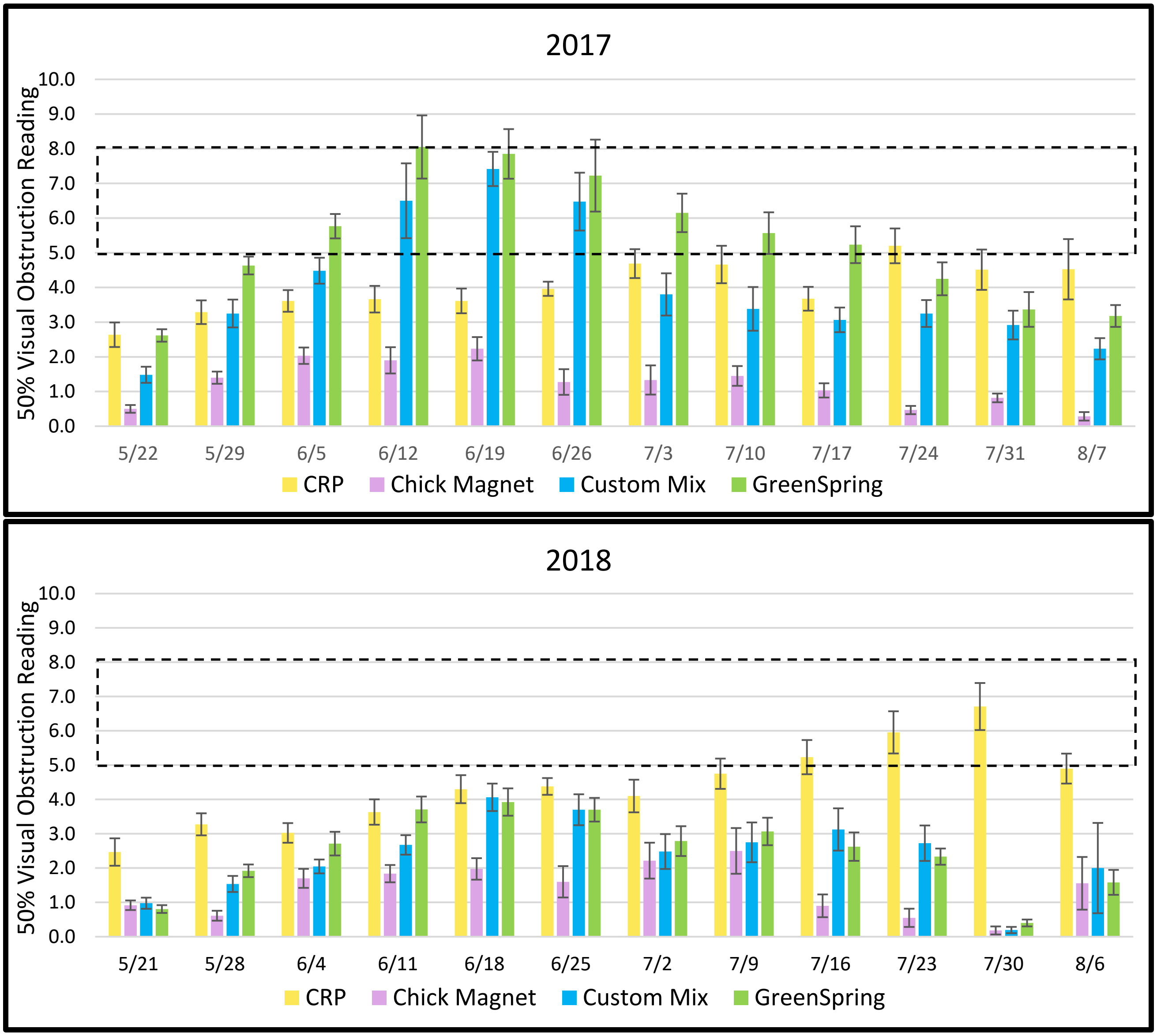


Figure 2.7 Average weekly 50% visual obstruction readings in Conservation Reserve Program fields, and the spring cover crop mixes Chick Magnet, Custom Mix, and GreenSpring from May through August during 2017 and 2018 in Graham (2017, 2018), Norton (2018) and Russell (2018) counties, Kansas. The black dashed box indicates the optimal selection range (5-7 dm) of Kansas females.

Table 2.1. The proportion of eight land-use categories in the 2017 and 2018 ring-necked pheasant and western Kansas spring cover crop study sites within the 2 kilometer boundary of capture locations in Graham (Jordan and Terry 2017; Fost, Ted, and Terry West 2018), Norton, and Russell counties, Kansas.

Land-use Category	Study Sites 2017		Study Sites 2018				
	Jordan	Terry	Fost	Ted	Terry West	Norton	Russell
Cover Crop	0.000	0.024	0.025	0.024	0.016	0.039	0.020
Crop Stubble	0.061	0.484	0.081	0.080	0.196	0.046	0.103
Primary Crops	0.291	0.165	0.387	0.495	0.469	0.291	0.334
CRP	0.026	0.063	0.029	0.055	0.083	0.008	0.036
Native Grass	0.609	0.216	0.448	0.299	0.176	0.422	0.390
Manmade Objects	0.008	0.005	0.020	0.016	0.011	0.031	0.030
Woody Vegetation	0.003	0.043	0.007	0.031	0.047	0.098	0.084
Open Water	0.002	0.001	0.002	0.002	0.001	0.064	0.003

Table 2.2. Plant species within the GreenSpring, Chick Magnet and Custom Mix cover crop treatments planted to determine ring-necked pheasant habitat use and selection between 2017 and 2018 in Graham, Norton and Russell counties, Kansas.

GreenSpring	Chick Magnet	Custom Mix
Oats	Hybrid Brassicas	Oats
Peas	Peas	Peas
	Yellow Sweet Clover	Yellow Sweet Clover
	Sunflower	Sunflower
	Buckwheat	Radish
		Rapeseed
		Cowpea
		Chickling Vetch
		Safflower

Table 2.3 Results of Welch's two-sample *t*-test for unequal variances comparing mean ring-necked pheasant nest (*n* = 37) and randomly generated cover crop locations (*n* = 376) for vegetation visual obstruction readings (dm), percent composition (%), and litter measurements (cm). Cover Crop treatments including GreenSpring, Chick Magnet and a custom wildlife mix planted to determine selection by ring-necked pheasants. Vegetation sampling occurred in Graham County, Kansas during 2017.

	Nest	Nest SE	Cover Crop	Cover Crop SE	t-test	Bonferroni P-value
2017						
Visual Obstruction 100	4.30	0.30	2.60	0.40	5.30	0.0000
Visual Obstruction 75	5.30	0.30	3.50	0.50	5.00	0.0000
Visual Obstruction 50	5.90	0.30	3.90	0.50	5.40	0.0000
Visual Obstruction 25	6.50	0.40	4.50	0.50	5.10	0.0000
Visual Obstruction 0	10.50	0.50	5.90	0.50	8.60	0.0000
Percent Crop	7.20	3.40	0.00	0.10	2.10	0.5941
Percent Crop Stubble	0.10	0.10	4.30	0.50	-20.90	0.0000
Percent Litter	15.30	1.80	40.90	2.60	-13.60	0.0000
Percent Bare ground	3.40	1.40	18.00	1.90	-9.40	0.0000
Percent Warm-season	50.30	5.40	0.40	0.40	8.90	0.0000
Percent Cool-season	9.80	3.00	19.90	2.90	-3.10	0.0468
Percent Forb	12.40	2.20	15.10	2.60	-1.20	1.0000
Litter Depth	2.20	0.20	1.30	0.10	4.30	0.0013
2018						
Visual Obstruction 100	3.33	0.27	1.32	0.30	7.25	0.0000
Visual Obstruction 75	4.56	0.31	2.31	0.40	7.16	0.0000
Visual Obstruction 50	5.02	0.32	3.10	1.92	4.08	0.0013
Visual Obstruction 25	5.65	0.32	3.31	0.45	7.16	0.0000
Visual Obstruction 0	8.60	0.47	4.44	0.49	8.75	0.0000
Percent Crop	8.13	2.86	1.01	0.51	2.45	0.2405
Percent Crop Stubble	4.28	1.68	4.15	0.62	0.14	1.0000
Percent Litter	24.42	1.95	46.84	3.07	-11.65	0.0000
Percent Bare ground	11.67	2.78	18.45	2.56	-2.32	0.3276
Percent Warm-season	36.28	4.72	1.80	0.93	7.11	0.0000
Percent Cool-season	7.05	2.82	9.26	1.66	-0.47	1.0000
Percent Forb	6.67	1.43	17.23	2.78	-7.18	0.0000
Litter Depth	2.47	0.24	1.88	0.16	2.45	0.2392

Table 2.4 Model rankings of the Resource Selection Function final composite model suite for nest-site selection of breeding females at the point-scale with used and available data. Nest data were collected during 2017 and 2018 to determine female selection of vegetation characteristics within Graham, Norton and Russel counties, Kansas. AICc is Akaike's information criterion for small sample sizes, K is the number of model parameters, ΔAIC_c is the difference between the top model, AICc w_i is the model weight.

Model	K	AIC_c	ΔAIC_c	w_i
Visual Obstruction 50%	3	211.94	0.00	0.97
Percent Composition Forb	3	220.10	8.16	0.02
Null	1	221.06	9.12	0.01

Table 2.5 The 2017 (*n* = 35) and 2018 (*n* = 44) land-use categories with the observed and expected proportion of ring-necked pheasant nests at the land-use and substrate (2018) scale. Expected proportions were calculated as equal to the proportion of land-use types within average female homeranges, which were buffered to nest locations. Nest data was collected to determine female selection of land-use types within Graham (2017, 2018), Norton (2018) and Russell County (2018), Kansas. AICc is Akaike's Information Criterion for small sample sizes, ΔAIC_{c} is the difference between the top model, and AIC_c w_i model weights.

	Observed Proportions	Expected Proportions	Lower CI	Upper CI
2017 Land-use Type				
Spring Cover Crop	0.06	0.13	0.00	0.16
Primary Crops	0.14	0.49	0.00	0.29
CRP	0.71	0.15	0.00	0.91
Native Grass	0.09	0.23	0.00	0.20
2018 Land-use Type				
Spring Cover Crop	0.07	0.10	0.00	0.17
CRP	0.46	0.15	0.26	0.65
Crop Stubble	0.05	0.09	0.00	0.13
Primary Crops	0.30	0.48	0.12	0.47
Native Grass	0.14	0.19	0.00	0.27
2018 Substrate Type				
Chemical Fallow	0.05	0.04	0.00	0.13
Chick Magnet	0.02	0.03	0.00	0.08
CRP	0.45	0.21	0.25	0.66
Native Grass	0.09	0.13	0.00	0.21
Pasture	0.02	0.12	0.00	0.08
Other Cover Crop	0.05	0.04	0.00	0.13
Soybeans	0.02	0.06	0.00	0.08
Warm Season Hay Field	0.02	0.01	0.00	0.08
Wheat	0.27	0.36	0.09	0.46

Chapter 3 - Ring-necked Pheasant and Mesocarnivore Occupancy within Western Kansas Spring Cover Crops

Introduction

Habitat management for the benefit of a single species can have both positive and negative effects on nontarget species (Gallo and Liba Pejchar 2016). For instance, managing for nest substrate increases quality nesting habitat for a single species, but can also provide resources for other grassland obligates. Of conservation interest are management efforts that influence predator communities, which in turn may negatively influence the occupancy of the targeted species through direct mortality and trait-mediated effects (Preisser et al. 2005). This is potentially the case with ring-necked pheasants (*Phasianus colchicus*) that utilize a variety of land-cover types in western Kansas. The ring-necked pheasant is a naturalized upland gamebird that provides Kansas with >$50 million annually from hunters. Declines in populations due to land-use change, agricultural intensification, and loss of the weedy wheat fallow system have stakeholders seeking additional ways to provide habitat for ring-necked pheasants to maintain and increase regional populations (Rodgers 1999). Current efforts are focused on providing vegetation resources for individuals, specifically during the spring and summer breeding season.

Management practices aim to provide ring-necked pheasants with additional resources to increase recruitment; however, habitat management that focuses on pheasants may positively influence occurrence of their predatory species. One potential method to provide pheasants with additional habitat is to incorporate spring cover crops into primary crop rotations during fallow periods. Spring cover crops are a multiple or single species mix of noncash crops that provide agricultural services such as nitrogen absorption and fixation, weed suppression, wind and water erosion, and increased predatory insect abundance (Dabney et al. 2001, DeBaets 2011). Spring cover crops are planted between March and April typically following corn or grain sorghum harvest the previous fall and remain on the landscape until wheat planting in September or October, with chemical termination occurring between June and July for insurance purposes. Incorporating spring cover crops into agricultural rotations can potentially increase wildlife populations by providing resources during important biological and breeding periods in locations generally devoid of resources such as fallow fields (Rodgers 2002). Chemical fallow is still a very common practice, especially in conjunction with no-till farming. However, use of cover crops has increased steadily in the past decade as stakeholders are realizing the benefit of maintaining active soils that can benefit primary crop production. The USDA Cover Crop survey, which began in 2012, has seen an increase of the average area of cover crop used per farm from 88 to 162 ha in 2017. This dramatic increase in areas of high agricultural intensity can unintentionally provide benefits for local and migratory wildlife, depending on the active time frame of the cover crop.

The majority of cover crop mixes and usage are targeted to improve or provide specific farm services, similarly cover crops created specifically to benefit wildlife focus on an array of functions to increase resources. Cover crops targeted for wildlife have been used to increase game species occurrence, promote native pollinators, increase abundance of beneficial insects, and expand habitat quantity and quality for waterfowl, upland gamebirds and nongame species (Dubbert and Kandtrud 1974, Nicholls et al. 2000, Edwards et al. 2004, Tillman et al. 2004). Cover crop mixes created to target upland gamebirds focus on providing tall vegetation structure to decrease avian predation risk, nest habitat, brood habitat, and brood foraging opportunities through the increase in soft-bodied arthropods. These resources, in turn, may also benefit nontarget wildlife of conservation concern and potentially predators.

Mesocarnivore is a term applied to species less than 17 kg with diets consisting of 50%-70% meat and the remainder other nonanimal foods such as fungi, fruit, and vegetation. Common mesocarnivores that depredate ring-necked pheasant nests and broods, such as raccoons (*Procyon lotor*) and badgers (*Taxidea taxus*), may also utilize spring cover crops and could negatively influence occupancy by ring-necked pheasants. Raccoons are generalists with a diverse diet that can include eggs and may utilize forage resources within spring cover crops during primary breeding periods (Greenwood 1982). Mesocarnivores occur in multiple land-use types and focus on edges that act as travel corridors denning sites (Bixler and Gittleman 2000). Land cover and vegetation variables can influence occupancy mesocarnivores (Covet et al. 2012, Winters et al. 2000), Urbanization positively influenced occupancy of smaller mesocarnivores, as they are better adapted to exploit resources in disturbed environments created by humans (Covet et al. 2012).

Understanding local mammalian predator occupancy in different agriculture environments is critical for assessing predation for ring-necked pheasants among landscapes and management strategies (With and King 2001, Giuliano and Daves 2002). Therefore, my study objectives were to 1) estimate the probability of occupancy of ring-necked pheasants and their broods within spring cover crops and 2) determine probability of occupancy of their mesocarnivore predators. I predicted that probability of occupancy of pheasants will be influenced by treatment, and probability of occupancy will be greater along edges. For mesocarnivore probability of occupancy, I predicted that treatment type and edge habitats between cover crop and the type of edge (hard vs soft) will influence occupancy.

Study Area

My study area included 8 sites in Graham and Russell counties, Kansas, during April to September 2017 and 2018 (Fig. 3.2, 3.2a, 3.2b, 3.2c, 3.2e). Two sites were located in Graham County in 2017 with a total area of 6,623 ha. The project expanded to four sites in Graham County during 2018 with a total area of 4,333 ha (3.2f, 3.2h). Russell County had two sites in 2018 with a total area of 5,860 ha (Table 3.1). Graham was transitional between the north-central Smoky Hills and western High Plains ecoregions. Russell County occurred with the north-central Smoky Hill ecoregion. Common land cover surrounding the seven study sites in Graham County included native pasture, row-crop and dryland agricultural fields, properties enrolled in the federal Farm Bill Conservation Reserve Program (CRP), forested canyons, rivers, man-made objects, stock ponds created by damning canyons, and weedy waste areas. Russell County had similar land cover to Graham County, with the addition of state wildlife management areas near a reservoir.

All study sites occurred within the mixed-grass prairie region and species within native pastures included sideoats grama (*Bouteloua curtipendula*), little bluestem (*Schizachyrium scoparium*), tall dropseed (*Sporobolus compositus*), western wheatgrass (*Pascopyrum smithii*), buffalo grass (*Bouteloua dactyloides*), blue grama (*Bouteloua gracilis*), hairy grama (*Bouteloua hirsuta*), Virginia ground cherry (*Physalis virginiana*), windmill grass (*Chloris verticillata*), common ragweed (*Ambrosia artemisiifolia*), western ragweed (*Ambrosia psilostachya*), silky prairie-clover (*Dalea villosa*), field mint (*Mentha arvensis*), common milkweed (*Asclepias syriaca*), wavy-leaf thistle (*Cirsium undulatum*), buffalo bur (*Solanum rostratum*), and blue vervain (*Verbena stricta*). Row-crop agricultural fields primarily contained monocultures of dryland wheat (*Triticum aestivum*), corn (*Zea mays*), milo (*Sorghum bicolor*), or soybeans (*Glycine max*); few corn and soybean fields were irrigated. Fields between crop rotations contained crop stubble and were maintained in the chemical-fallow state using herbicide applications.

Properties enrolled in CRP had planted native species mixtures containing Indian grass (*Sorghastrum nutans*), big bluestem (*Andropogon gerardii*), little bluestem, switchgrass (*Panicum virgatum*), sideoats grama, western wheatgrass, yellow sweet clover (*Melilotus officinalis*), purple prairie-clover, common ragweed, common milkweed , western ironweed (*Vernonia baldwinii*), pale dock (*Rumex altissumus*), wavy-leaf thistle, Maximillian sunflower (*Helianthus maximiliani*), and common sunflower (*Helianthus annuus*). Forested canyons consist of buckbrush (*Symphoricarpos oribiculatus*), Missouri gooseberry (*Ribes missouriense*), yucca (*Yucca filamentosa*), wild plum (*Prunus americana*), and sumac (*Rhus* spp.) thickets with the occasional black cherry (*Prunus serotina*), eastern cottonwood (*Populus deltoides*), and eastern red cedar (*Juniperus virginiana*). Common species within riparian areas and wooded slopes included eastern cottonwood, eastern red cedar, box elder (*Acer negundo*), sumac, black cherry, hack berry (*Celtis occidentalis*), wild plum, Missouri gooseberry, buckbrush, stinging nettle (*Urtica doica*), western wheatgrass, smooth brome (*Bromus inermis*), cheat grass (*Bromus tectorum*), timothy (*Phleum pratense*), giant ragweed (*Ambrosia trifida*), poison ivy (*Toxicodendron radicans*), dandelion (*Taraxacum officinale*), pale dock, prairie cordgrass (*Spartina pectinata*), broad-leaf cattail (*Typha latifolia*), and prairie bulrush (*Schoenoplectus maritimus*).

Man-made objects included oil infrastructure, buildings, dirt roads, buildings, oil wells, distribution and transmission powerlines, and communication towers. Native, noxious, and naturalized species occurred throughout the weedy waste area surrounding fields and man-made objects. These species include cheat grass, smooth brome, caucasian bluestem (*Bothriocholoa bladhii*), marestail (*Hippuris vulgaris*), kochia (*Bassia scoparia*), western wheatgrass, Russian thistle (*Salsolsa kali*), common sunflower, field bindweed (*Convolvulus arvensis*), poison ivy, green foxtail (*Setaria viridis*), pale dock, Palmer’s pigweed (*Amaranthus palmeri*), sandbur

(*Cencrhus longispinus*), carpetweed (*Mollugo verticillata*), and grey-green wood sorrel (*Oxalis dillenii*).

Breeding Season Weather

Long-term average (1981-2010) total precipitation and average temperatures from April through August were 44.3 cm and 20.3° C in Graham County and 49.8 cm and 21° C in Russell County (NOAA 2018). During the course of the project, Russell County had similar precipitation between years at 42 cm in 2017 and 46 in 2018, Graham County had greater precipitation in 2018 (63 cm) than in 2017 (39 cm), which was above and below the long-term average, respectively (Fig. 3.3). Russell County experienced similar precipitation in 2018 as the long-term average of 49 cm. During 2018, temperatures were cooler than in 2017, with 19-22 more days below 0° C, particularly in February and April, and fewer days above 37° C than in 2017 (Fig. 3.4).

Cover Crop and Chemical Fallow Description

Spring-summer cover crops contained legume and non-legume single species or multiple species mixes (Table 1.2). Cover crops were planted during March 2017 and April 2018 into fields of harvested grain sorghum and corn. Each cover crop treatment was terminated in mid to late-June or early July using chemical herbicide or mechanical methods, such as tillage. The commercial cover crop seed mixes and a custom wildlife cover crop seed mix were obtained from Star Seed Company, Osborne, Kansas.

GreenSpring was a cool season mix typically planted during early spring for a hay crop or pasture prior to termination for fall primary crops such as wheat. The mix was intended to produce greater yields than single species mixes. This mix included oats (*Avena sativa*) and peas (*Pisum sativum*) with a seeding rate of 73 kg/ha.

Chick Magnet was a warm-season grass and forb cover crop blend designed to increase brood survival by providing adequate substrate for protection from weather and avian predators, and substantial soft-bodied insects for foraging. The mix contained hybrid brassicas Winfred (*Brassica napus*) and Pasja (*Brassica rapa*), yellow sweetclover (*Melilotus officinalis*), peas

(*Pisum sativum*), sunflower (*Helianthus annuus*), and buckwheat (*Fagopyrum esculentum*) with a seeding rate of 26 kg/ha.

Custom Mix was a seed mix created by Star Seed Company based on input from wildlife professionals and producers that incorporated the herbaceous and structural component of the two commercial mixes. This mix included turnips (*Brassica rapa*), oats (*Avena stativa*), cowpeas (*Vigna unguiculata*), radish (*Raphanus raphanistrum*), yellow sweetclover, (*Melilotus officinalis*), peas (*Pisum sativum*), sunflower (*Helianthus annuus*), safflower (*Carthamus tinctorius*), chickling vetch (*Lathyrus sativus*), and rapeseed (*Brassica napus*) with a seeding rate of 40 kg/ha.

Methods

Study Design

Study sites within each county consisted of 8-16 fields, which were 12-20 ha in size and within close proximity to one another. The design incorporated replicates of four fields (block) with four treatments applied per block. Each block had three different cover crop mixes and a chemical fallow crop control. Each field was randomly assigned a specific treatment. In 2017, there were three treatment replicates in Graham County; in 2018, there were four treatment replicates in Graham County and two in Russell County. Cover crop treatments were terminated in mid to late June, based on needs of the individual producer and restrictions of compliance with crop insurance regulations, prior to the sowing of wheat in September.

Camera Placement and Programing

I used camera traps (Bushnell Trophy Cam, Bushnell Outdoor Products, Overland Park, KS) to estimate ring-necked pheasant and predator occupancy within spring cover crop and chemical fallow treatments. The cameras used passive infrared sensors and were motion sensitive with a trigger speed of 0.6 sec with a motion activation up to 15 m. During 2017, I deployed 24 cameras in three treatment repetitions within Graham County. I increased my camera trap effort to 42 in 2018 across four treatment repetitions (28 cameras) in Graham County, and two treatment repetitions (14 cameras) in Russell County. Cameras were active for the 24-hr period and a photo strip was also enabled to determine time, temperature, and photo number during a capture event.

Camera settings were in widescreen, low sensitivity, and medium night shutter to increase detection and minimize false trigger events. No lures or bait were used to capture photos of mesocarnivores to reduce attracting mesocarnivores not utilizing cover crop resources. A single camera per treatment was placed on either the west field boundary facing east, or on the south field boundary facing north to determine occupancy of mesocarnivores on the edges of treatments. An additional camera was placed 35 m either north or east into each cover crop treatment facing the same direction as the edge camera to determine occupancy of mesocarnivores within the cover crop treatments. Cameras were placed at 30 cm in height on wooden stakes pounded into the ground or on fencepost. To ensure moving mesocarnivores were detected, cameras were programmed to take 3 pictures instantaneously, with 1 min between photo bursts. Vegetation was cleared in 1 by 2-m sections directly in front of the camera to reduce false triggers by moving vegetation within the treatment fields.

Monitoring

I gave each camera a unique number identifier to determine location within treatment and associate photos. Cameras were active from mid-April through September 1, 2017 and 2018 in the cover crop and chemical fallow treatments. Batteries were changed every 15-30 days in 2017, and every 14-17 days in 2018 days and secure digital (SD) cards replaced to avoid loss of data. In 2018, to reduce the loss of information from camera date malfunction, a white board was placed in front of the camera during each check with written information about the camera ID, treatment type, camera placement (edge/interior) time of visit, and date. Approximately 90% of the batteries were AmazonBasics batteries (AA Performance Alkaline Batteries, AA High Capacity Rechargeable, Amazon, Seattle, WA), with Tenergy (Tenergy AA Rechargeable NIMH Battery, Tenergy, Fremont, CA) comprising the remaining ~10% used. Cameras with malfunctioning exposure were replaced to maintain similar detection probabilities as the other cameras within the trapping grid.

Photo Sorting and Species Identification

Photos were individually viewed and sorted to determine presence of wildlife species within the photo frame using the Colorado Parks and Wildlife Photo Warehouse Software (Version 4.0). The program creates an ACCESS database for photo and record storage. A simple to use interface creates records of study site and camera location. Species-specific information, including scientific name, short ID, short-cut keys, and the option to include the species within a predefined group, such as mammalian predators, were entered. Observers examined the photos and determined presence of wildlife within the frame, species were categorized using the pre-specified species options.

Independent detection events were placed at a 60-min limit. All events that occurred within an hour were viewed to determine independence of all detections. If an independent detection occurred within the hour censor period, such as two separate detections of a male and brooding female, the second detection was assigned a new independent detection event. Ring-necked pheasant and mesocarnivore detections received additional information during the independent detection sorting phase, including age (Adult/Juvenile), sex (Male/Female), and number of individuals. However, due to the limitations and quality of photos, the majority of mesocarnivores could only be sorted down to age. Once compiled, the program produced EXCEL format output depending on specific queries, such as “mammalian predators” or more specific “badger” for use in occupancy modeling methods.

Land-Cover Map Analysis

GIS Layers

I created a 100-m buffer surrounding camera sites to determine if occupancy of mesocarnivores and ring-necked pheasants was influenced by surrounding land-use (Cove et al. 2012). In 2017, I created buffers surrounding 16 camera locations including spring cover crop and chemical fallow treatments Graham County. The number of camera sites increased to 42 in 2018, with six study sites occurring across Graham and Russell counties; 28 camera sites were located in Graham County and 14 were located in Russell County. I obtained aerial imagery from the USGS

National Map database and digitized patch boundaries using ArcMap (ESRI, Redlands, CA, version 10.5). Roads and counties layers were retrieved from the DASC Kansas Data Access and Support Center. I delineated digitized land cover patches through ground-truthing in summer 2017 and 2018 using driving surveys and walking surveys when land features obstructed view of targeted property. Land cover categories included Cover Crop treatment (project cover crop and other cover crop), Crop Stubble (agricultural land between primary crop rotations and kept chemically fallow or weedy fallow), Conservation Reserve Program (CRP), and Native Grasses (grazed and ungrazed pastures, expired CRP, and weedy waste areas), Primary Growing Crop (primary cash crop such as wheat, milo, or corn), Open Water (rivers, streams and man-made ponds), Roads (county roads, highways, oil-field roads), and Man-made Objects (houses, barns, agricultural buildings).

Occupancy Analysis

I developed eight *a priori* models to determine predator occupancy and detection rates per sampling unit using single season species occupancy models in package Unmarked in R (MacKenzie et al. 2002, Fiske et al. 2011, R Core Team 2018). Occupancy (ψ) is estimated as the probability that site *i* is occupied; detection (*pij*) is calculated as the probability of detecting individuals or species at site *i* at time *j* if the species were present (MacKenzie et al. 2002). I separated detections into edge and interior groups and combined years to investigate the influence of camera placement on mesocarnivore and ring-necked pheasant occupancy. Site-level covariates (covariates associated with the location, do not change, and are associated with occupancy) included year, cover crop and chemical fallow treatment type, edge type (soft or hard edge transition), and proportion of land use type surrounding the camera. Observation-level covariates (covariates that vary weekly and can influence species detection probability) included weekly mean precipitation and weekly mean maximum temperature. Weather data were collected from the National Oceanic and Atmospheric Administration weather stations (NOAA 2018). No correlated variables ($|r| > 0.5$) were included in the same model. Occasion periods were set to one week intervals, for a total of 19 occasions, to meet model assumptions that no births or deaths occurred within the sampled period (MacKenzie et al. 2002). Model ranking and fit were determined using Akaike's Information Criterion (AIC_c) for small sample sizes, ΔAIC_c

values, and Akaike weights (w_i; Hurvich and Tsai 1995, Anderson and Burnham 2002, Wagenmakers and Farrell 2004, Arnold 2010).

Results

I only placed cameras within Graham county during 2017; whereas, I placed cameras in Graham (*n* = 28) and Russell (*n* = 14) counties during 2018. I placed 16 cameras in 2017 and 42 cameras in 2018 within spring cover crop treatments from April 18 until August 28, for a total of 1,969 trap nights in 2017 and 4,501 trap nights (Graham = 1,721, Russell = 1,410) in 2018. Between June 10 and June 18, the majority of cameras were temporarily removed from treatments due to cover crop termination by chemical spraying. Detections from three cameras from single site in Graham County in 2018 were omitted from analysis due to delayed termination in comparison to the other treatments. This caused the entire removal of detections for one camera after June 27 due to weekly disturbance by escaped cattle. Additional censor periods occurred due to delayed start date, malfunctioning due to extreme weather, and disturbance by cattle and wildlife. Due to low independent detections within Russell County, occupancy analysis was only conducted for Graham County data. Russell County occupancy analyses of adult pheasant and mesocarnivore analyses were not combined with Graham County analyses due to differences of rain gradient and geography.

In 2017, I recorded 317 independent detection events of eight mesocarnivore species in Graham County; including detections of 34 badger, nine bobcat (*Lynx rufus*), 28 coyote (*Canis latrans*), 54 feral cat (*Felis catus*), one long-tailed weasel (*Mustela frenata*), 12 opossum (*Didelphis virginiana*), 151 raccoon, and 28 detections of striped skunk (*Mephitis mephitis*). Detections of mesocarnivores decreased in 2018 with a total of 267 independent detections from seven mesocarnivore species; 71 badger, seven bobcat, 48 coyote, one feral cat, 13 opossum, 106 raccoon, and 21 detections of striped skunk. Based upon the sum of all mesocarnivore detections, raccoons had the greatest proportion of independent detections for both years (2017 = 0.48, 2018 =0.40). I detected 244 independent capture events of ring-necked pheasants in 2017, with the majority (78%) of independent detections captured on the edge of treatments (*n* = 191) compared to within treatments sites (22%, *n* = 53). Detections increased to 460 in 2018, of which 69% of independent detections occurred on edges (*n* = 318), and 31% occurred within treatments (*n* = 142).

During 2018, a total of six mesocarnivore species were detected in Russell County, including 24 independent detections of badger, 33 coyote, 6 opossum, 22 raccoon, and 32 detections of striped skunk. Ring-necked pheasants had 73 independent detection events, with a total of 80 adults and 47 juveniles detected. Pheasant detections within spring cover crop treatments increased from 27 independent detections to >100 after cover crop termination in mid-June. The majority (79%) of independent detections occurred at camera sites located on the edge of treatments (*n* = 58) compared to within treatments sites (*n* = 15). Brood occupancy was first detected on June 23, with 32 independent detections of broods occurring up until the end of the monitoring period on August 27.

Mesocarnivores were pooled as a group due to low sample sizes for several species in Graham County. There were 151 occasion detections of mesocarnivores on edges and 90 detections within treatments. The top-ranked model for probability of detection for mesocarnivore on edges was the null model (AIC_c w_i = 0.47). The top-ranked model for the probability of occupancy in edges was also the null model (AIC_c w_i = 0.66; Table 3.3), with an occupancy probability of 0.99 (SE = 0.47) and detection probability of 0.498 (SE = 0.29). Mesocarnivore detection within treatments was predicted by average precipitation (AIC_c w_i = 0.56), with probability of occupancy negatively influenced by proportion of wheat surrounding the camera location (AIC_c w_i = 0.80; Table 3.4) with an occupancy estimate of 1.00 (SE = 0.00) and detection probability of 0.263 (SE = 0.04; Fig. 3.5).

There were sufficient detections for independent occupancy analysis for raccoons and badgers. For raccoons, there were a total of 72 detections on the edge of treatments. The top-ranked model for probability of detection for raccoons on the edge of treatments was precipitation (AIC_c w_i = 0.66), with the probability of occupancy negatively influenced by proportion of CRP surrounding the camera site (AIC_c w_i = 0.50; Table 3.5), with a probability of occupancy estimate of 0.42 (SE = 0.38) and detection probability of 0.36 (SE = 0.042; Fig. 3.6). There were a total of 42 detections of raccoons within spring cover crop and chemical fallow treatments. Detection of raccoons within treatments was constant (AIC_c w_i = 0.49), but occupancy was influenced by year

(AIC_c w_i = 0.40; Table 3.6) with a probability of occupancy estimate of 0.31 (SE = 1.34) and detection probability of 0.19 (SE = 0.27).

Badgers were detected on 32 and 27 occasions on the edge of treatments and within treatments, respectively. Maximum average temperature was the top-ranked model for badger detection on the edge of treatments (AIC_c w_i = 0.71); probability of occupancy was negatively influenced by the proportion of the Chick Magnet cover crop treatment surrounding cameras (AIC_c w_i = 0.67; Table 3.7) with a probability of occupancy estimate of 0.995 (SE = 0.03), and detection estimate of 0.17 (SE = 0.04; Fig. 3.7). Within treatments, badger detection was best predicted by precipitation (AIC_c w_i = 0.95), with a detection probability of 0.036 (SE = 0.03); the probability of occupancy was low at 0.0000005 (SE < 0.001) and influenced by proportion of man-made objects surrounding camera sites (AIC_c w_i = 0.69; Table 3.8).

Ring-necked pheasants were detected on edges on 133 occasions and 75 occasions within treatments. Pheasant detection probability on edges was negatively influenced by precipitation (AIC_c w_i = 0.45), with a detection probability of 0.41 (SE = 0.044; Fig. 3.9). Probability of occupancy was 0.97 (SE = 0.081) and best predicted by proportion of Chick Magnet cover crop treatment surrounding camera sites (AIC_c w_i = 0.68; Table 3.9). The top-ranked model for probability of detection within treatments was average maximum temperature (AIC_c w_i = 0.98). Ring-necked pheasant occupancy within treatments was best predicted by year (AIC_c w_i = 0.64; Table 3.10), with a probability of occupancy estimate of 0.32 (SE = 0.74) and detection probability of 0.44 (SE = 0.04).

Ring-necked pheasant broods were detected on edges 69 times and 57 times within treatments (Fig. 3.9). Detection on edges was positively influenced by temperature (AIC_c w_i = 1.0), with a detection probability of 0.35 (SE = 0.55), The top-ranked model for probability of occupancy was the null model (AIC_c w_i = 0.39). Brood detection within treatments was 0.30 (SE = 0.08), and positively influenced by temperature, occupancy was best predicted by placement within the custom mix spring cover crop (AIC_c w_i = 0.46), with an estimate of 0.22 (SE =152). However, year was a completive model (AIC_c w_i = 0.19, Table 3.11).

Discussion

Commercial use of spring cover crops for farm services can increase resources on the landscape for wildlife during important life stages. Average weekly maximum temperatures and precipitation had both positive and negative influence on detection probability depending on the location, either within or edges of treatments. Increased weekly precipitation negatively influenced detection probability within treatments for mesocarnivores as a group; this trend continued for raccoons and badgers. However, precipitation positively influenced detection probability of raccoons at edges, but negatively influenced edge detection of ring-necked pheasants. Temperature also influenced detection, having a slight positive effect on detection of badgers at edges, and a positive influence within treatments for ring-necked pheasants. These results suggest that while occupancy within spring cover crops may be low (~30%), these substrates provide refuge for ring-necked pheasants during extremely hot temperatures.

The proportion of land use surrounding camera sites influenced occupancy of individual and grouped species. Camera location at the edge of treatments and within treatments also had a major influence on the probability of occupancy and detection. Occupancy of mesocarnivores as a group was negatively influenced by the proportion of wheat surrounding cover crops for occurrence within treatments. Mesocarnivore occupancy on edges of treatments was constant. It is possible that multiple edges near or within different vegetation types increases diversity of prey species, and therefore occupancy of mesocarnivores. Proportion of man-made objects negatively influenced occupancy of badgers within treatments; however, the low occupancy and detection probability makes it difficult to assess this finding. Overall, the low number of independent detections within the treatment (27) over 19 weeks suggest that edges were used most often, compared to interior of patches, and likely provide important resources for this species. Raccoon occupancy at edge cameras was influenced by the proportion of CRP within the 100-m buffer; however, the Year covariate was also a competing model. Occupancy of pheasants was greatest along edges and negatively influenced by proportion of Chick Magnet surrounding cameras. Proportion of Chick Magnet was a top model for edge treatments for both badgers and pheasants. This spring cover crop provides important resources for ring-necked pheasants and badgers until a threshold surrounding edges is reached and occupancy will decline.

Extreme weather conditions influenced detection probability of pheasants and their broods within the interior of treatments. Brood detection was also positively influenced by maximum average temperature on edges. Occupancy of pheasants and their broods was higher on edges than within treatments. This is not necessarily surprising, as ring-necked pheasants are considered edge species and may use edges for a variety of purposes including breeding display locations, access to forage resources, and travel corridors for broods. Edge type and its location between a soft edge (between two vegetation types) or the boundary of a hard edge (on the edge of a single vegetation type and chemical fallow/man-made objects), did not have any support for any of the species modeled. In tall grass prairies, abrupt edges with woody vegetation increased mesopredator activity within 30-50 m of the woody edge (Winter et al 2000). Because roads and chemical fallow treatments may not provide resources (structural cover or denning sites) for mesocarnivores compared to woody edges, these hard edges near camera sites may not influence occupancy. Landscape context influenced nest success of dummy pheasant nests in Nebraska with CRP fields surrounded by prairie and wheat having greater success than fields in close proximity to chemical fallow fields (Simonsen and Fontaine 2016). Cover crop fields potentially harbor additional prey and food resources for mesocarnivores and work to spread population densities over multiple treatments, which may explain the low occupancy, particularly within interior treatments (Simonsen and Fontaine 2016). Proportion of land-cover type surrounding my cameras influenced occupancy, suggesting even at a small scale of 100 m, that landscape context may influence mesocarnivore and pheasant occupancy based on available resources.

Broods require specific resources for survival, such as tall herbaceous vegetation for protection from weather and events and an open understory for efficient foraging (Baxter and Wolfe 1973). Our research suggests brood occupancy on edges was not influenced by proportion of land-cover type, year, or edge type. Suggesting use of these features by broods is influenced by additional factors that I did not include within my models. Occupancy of edges was greater in comparison to within treatments. Occupancy within treatments was influenced by the Custom Mix treatment, with year being a competing model. In 2017, there were six independent detections of broods in the Custom Mix compared to 25 (GreenSpring = 15, Chick Magnet = 10) in other cover crop treatments. Similarly, in 2018, six broods were detected in the Custom Mix, compared to eight (GreenSpring = 8) detections in other cover crop treatments. The Custom Mix provided resources, such as abundant invertebrates, and tall herbaceous cover, over both years for ring-necked pheasants broods, when compared to the other two mixes.

This influence of year on occupancy by broods is likely due to differences in vegetation height and location of the cover crop treatments. In 2017, warm temperatures during the early growing season and regular precipitation promoted germination and growth of vegetation, creating quality overhead and vertical cover within the spring cover crops, potentially providing the required cover and foraging resources necessary for brood survival. Contrary to 2017, delayed planting until early April, dry overwinter conditions, and extreme cold temperatures during April 2018 significantly stunted growth of the cover crop treatments, potentially reducing the quality of those treatments for brood occupancy in the GreenSpring and Chick Magnet mixes. Fields planted to GreenSpring mix were directly adjacent to high quality nesting substrate both years, unlike the Custom Mix; however, detections of broods in the Custom Mix occurred both years, indicating it as a quality resource for broods. The Custom Mix was developed to have successful growth over a variety of spring weather conditions, whereas Chick Magnet and GreenSpring mixes contains only five and two species, respectively, which may limit their growing potential in years with non-optimal spring weather conditions.

The proportion of Chick Magnet surrounding the camera site influenced occupancy estimates by ring-necked pheasants along edges, with occupancy remaining high until the proportion of the treatment grew above ~45%, at which point occupancy decreased dramatically. Badger occupancy along edges also declined after the proportion increased past the 45% threshold. The drop in occupancy after a threshold >45% is potentially due to a decrease in the number of edges with additional land use types, and because occupancy within treatments was lower than edges, decreasing the amount of edge near this resource may contribute to the decline in occupancy. Presence of "intimidating" predators can influence habitat selection by prey species, such as "fear" of increased predation within certain vegetation and land use types (Preisser et al. 2005, Ripple and Beschta 2011). However, the high probability of occupancy by both pheasants and badgers along edges proximate to Chick Magnet suggests that badgers are not influencing occupancy by ring-necked pheasants. Pheasants may not be a selected prey resource by badger, as research indicates their diets consist largely of mammalian prey and potential seasonal consumption of eggs (Errington 1937). However, the low badger detection probability (0.17), allows limited interpretation from these estimates as detection probabilities need to be above 0.3 to make useful inference on associated land use effects on occupancy (MacKenzie et al. 2002, O'Connell et al. 2016). Estimates for mesocarnivore and raccoon occupancy were above 0.3, which allowed for assessment of potential influences of land cover on occupancy within and on edges of cover crops.

Detection probabilities for raccoon suggest that edges near CRP influence occupancy however, as the proportion of CRP increased occupancy declined, suggesting edges near CRP provide resources for raccoons until a threshold in the proportion of CRP is reached, at which point, raccoons may search for more productive environments that require less search effort closer to edges (Winter et al. 2000). Year influenced occupancy of raccoons within treatments potentially because food resources were more abundant in 2017 in comparison to the shorter growing period and stunted vegetation in 2018. The proportion of ring-necked pheasant nests within CRP declined from 0.45 in 2017 to 0.40 in 2018, which may reflect the influence of year for raccoon occupancy in relation to CRP near edges. Raccoons are a generalist species and exploit food resources during periods of abundance, particularly those of nesting birds (Greenwood 1982), Nest success of ring-necked pheasants declined from 0.35 in 2017 to 0.32 in 2018, potentially due to increased predation events by mesocarnivores (Chapter I). The proportion of ring-necked pheasant nests increased in wheat during 2018, which may explain the influence of wheat on occupancy of mesocarnivores within cover crop treatments.

Wheat influenced within treatment occupancy by mesocarnivores; however, occupancy was constant on the edge of treatments. This finding is not surprising as mesocarnivores are known to use edges for a variety of purpose. The proximity of wheat to cover crop treatments may increase the amount of available resources and thereby increase mesocarnivore occupancy, however once the proportion of wheat surrounding cover crops increases past 0.45, occupancy will decline. The decline in occupancy is likely due to the reduced edge density which may increase food resources. Wheat may provide quality resources, such as food in the form of small mammals and invertebrates, for mesocarnivores and it is possible these detections within cover crop treatments were of individuals moving to and from this land cover type. The proportion of ring-necked pheasant nests increased in wheat during 2018, and nest success was low at 8%, largely due to predation and destruction by machinery. This increase in proportion of nesting pheasants within wheat likely provided mesocarnivores with additional resources and potentially a greater search to success ratio due to row-crop planting distance and alignment when compared to natural systems. Wheat can also provide resources besides nests, as raccoons have been found with wheat in their stomach contents after nightly foraging (Greenwood 1982). Other mesocarnivores had fewer detections during the course of the study. The majority of opossum detections occurred near treatment fields adjacent to woody vegetation or man-made objects. Opossums in northeastern Kansas reside in wooded areas and grasslands at similar frequencies; however, it is possible that cover crops do not provide the resources opossums require in comparison to woodland and grasslands environments (Sandidge 1953). Edges were used at a greater rate than interior patches, such as fields, by striped skunks (Bixler and Gittleman, 2000). This finding is supported by my results where 76% of independent detections occurred on edges. However, my overall low number of detections of opossum and striped skunk suggest occupancy within and on edges of cover crops is likely low. Wheat surrounding cameras only occurred in 2018, suggesting this substrate can significantly increase the probability of occupancy be mesocarnivores within spring cover crops, unless proportions of wheat are greater than 30%.

Spring cover crops implemented between primary crop rotations are occupied by mesocarnivores and ring-necked pheasants in western Kansas. Occupancy of mesocarnivores and pheasants are influenced by proportion of land-cover type and year effects on the edges and within spring cover crop treatments, even at the fine scale of 100 m. Proportion of wheat at the 100 m radius influenced mesocarnivore occupancy within spring cover crops until proportions reached 30%, suggesting decreasing placement of wheat fields adjacent or near spring cover crops will reduce mesocarnivore occupancy within treatments. However, occupancy of mesocarnivores on edges did not appear to influence ring-necked pheasants. Incorporating spring cover crops into management strategies can increase resources for pheasant adults and broods, which may increase survival during important biological stages, and promote long-term population persistence in agricultural dominated landscapes.

Management Implications

Incorporating spring cover crops on the landscape adjacent to primary nesting substrate, particularly mixes containing herbaceous qualities that provide cover and foraging resources, will increase occupancy of adult and juveniles pheasants during the summer period. Proportions of Chick Magnet between 0.1 and 0.4 adjacent or surrounding a location that included quality nesting habitat positively influenced occupancy of ring-necked pheasants. To reduce occupancy by mesocarnivores, spring cover crop treatments should not be placed adjacent to woody vegetation or green wheat fields. To provide the greatest resources for ring-necked pheasants, spring cover crops should be planted early in the spring to achieve growth sufficient enough to provide vertical and overhead cover for occupancy by pheasants prior to termination of the cover crops in June.

Literature Cited

Arnold, T. W. 2010. Uninformative parameters and model selection using Akaike's information criterion. Journal of Wildlife Management 74:1175-1178.

Cove, M. V., B. M. Jones, A.J. Bossert, D. R. Clever Jr., R. K. Dunwoody, B. C. White, and V. L. Jackson. 2012. Use of camera traps to examine the mesopredator release hypothesis in a fragmented Midwestern landscape. American Midland Naturalist 168:456-465.

Dabney, S. M., J. A Delgrado, and D. W. Reeves. 2001. Using winter cover crops to improve soil and water quality. Communications in Soil Science and Plant Analysis 32:1221-1250.

De Baets, S., J. Poesen, J. Meersmans, and L. Serlet. 2011. Cover crops and their erosion-reducing effects during concentrated flow erosion. Catena 85:237-244.

Err, A. B., and J. L. Gittleman. 2000. Variation in home range and use of habitat in the striped skunk (Mephitis mephitis). Journal of Zoology 251:525-533.

Errington, P. 1937. Summer food habitats of the badger in northwestern Iowa. Journal of Mammalogy 2:213-216.

Fiske, I. J., and R. B. Chandler. 2011. Unmarked: A R package for fitting hierarchical models of wildlife occurrence and abundance. Journal of Statistical Software 43:1-23

Gallo, T., and L. Pejchar. 2016. Improving habitat for game animals has mixed consequences for biodiversity conservation. Biological Conservation 197:47-52.

Giuliano, W. M., and S. E. Daves. 2002. Avian response to warm-season use in pasture and hayfield management. Biological Conservation 106:1-9.

Greenwood, R. J. 1982. Nocturnal Activity and Foraging of Prairie Raccoons (Procyon lotor) in North Dakota. American Midland Naturalist 107:238-243.

Hurvich, C. M., and C. Tsai. 1995. Model selection for extended quasi-likelihood models in small samples. Biometrics 51:1077-1084.

MacKenzie, D. I., J. D. Nichols, G. B. Lachman, S. Droege, J. A. Royle, and C. A. Langtimm. 2002. Estimating site occupancy rates when detection probabilities are less than one. Ecology 83:2248-2255

National Oceanic and Atmospheric Administration (NOAA). 2018. National Climate Data Center. Climate 1981-2010 Climate and Daily Normals. https://www.ncdc.noaa.gov/data-access/quick-links#loc-clim Accessed 16 November 2018.

O'Connell, A. F. Jr., N. W. Talancy, L. L. Bailey, J. R Sauer, R. Cook, and A. T. Gilbert. 2006. Estimating site occupancy and detection probability parameters for meso-and large mammas in a coastal ecosystem. Journal of Wildlife Management 70:1625-1633

Preisser, E. L., D. I. Bolnick, and M. F. Benard. 2005. Scared to death? The effects of intimidation on consumption of predator-prey interactions. Ecology 86:501-509.

R Core Team. 2018. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. www.R-progrject.org.

Ripple, W., and R. L. Beschta. 2011. Trophic cascades in Yellowstone. The first 15 years after wolf introduction. Biological Conservation 145:205-213.

Rodgers, R. D. 1999. Why haven't pheasant populations in western Kansas increased with CRP? Wildlife Society Bulletin 27:654-665.

Rodgers, R. D. 2002. Effects of wheat-stubble and weed control on winter pheasant abundance. Wildlife Society Bulletin 30:1099-1112.

Sandidge, L. 1953. Food and dens of the opossum (Didelphis virginiana) in northeastern Kansas. Transactions of the Kansas Academy of Science 56:97-106.

Simonsen, V. L., and J. J. Fontaine. 2016. Landscape context influences nest survival in Midwest grassland. Journal of Wildlife Management 80:877-883.

Snyder, W. D. 1984. Ring-necked pheasant nesting ecology and wheat farming on the High Plains. Journal of Wildlife Management 48:878-888.

Wagenmakers, E., and S. Farrell. 2004. AIC model selection using Akaike weights. Psychonomic Bulletin & Review 11:192-196.

Winter, M., D. H. Johnson, and J. Faanborg. 2000. Evidence for edge effects on multiple levels in tall-grass prairie. Condor 102:256-266.

With, K. A., and A. W. King. 2001. Analysis of landscape sources and sinks: the effect of spatial pattern on avian demography. Biological Conservation 100:75-88.

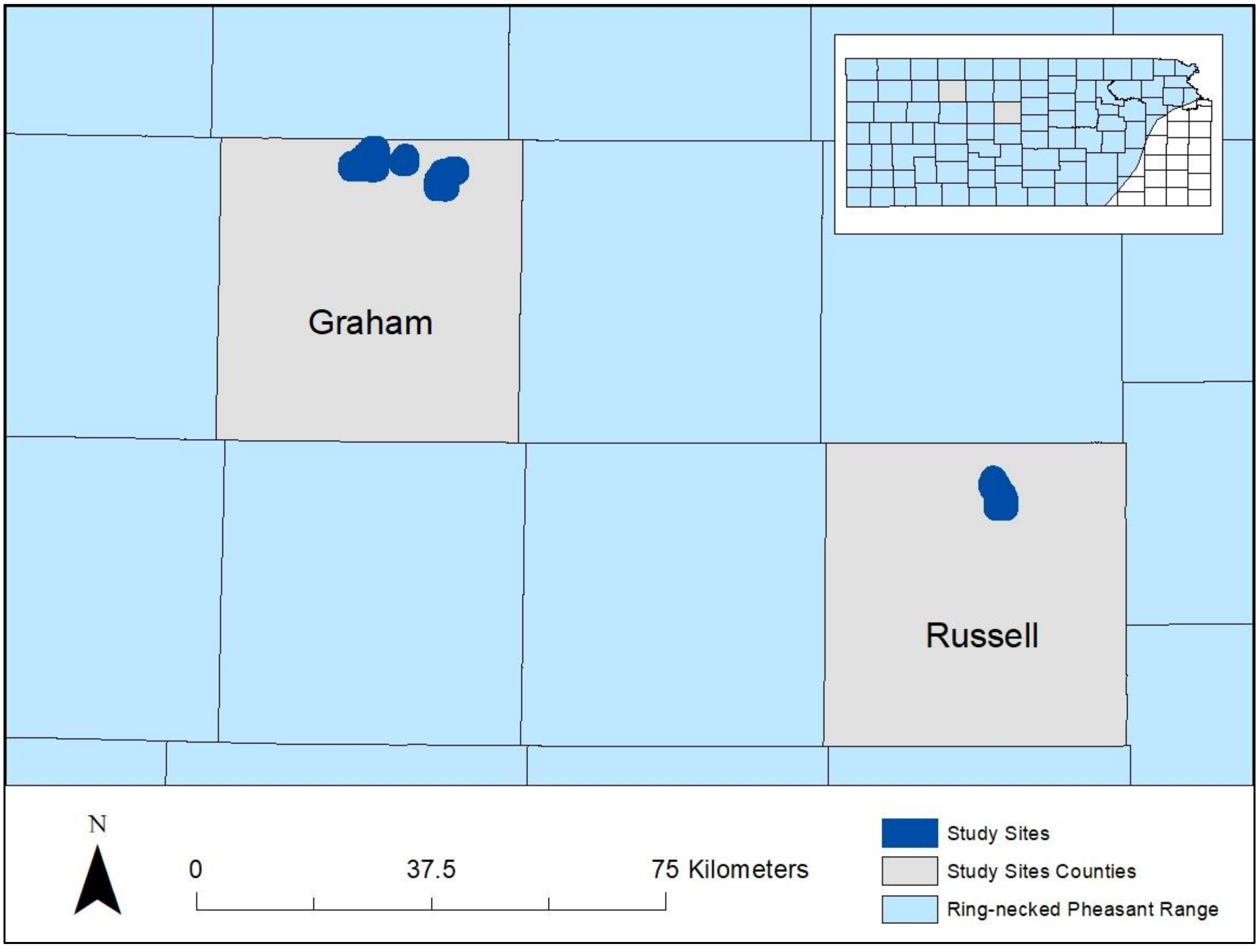


Figure 3.1 Location of ring-necked pheasant and spring cover crop study sites; six study sites were located in Graham County and two in Russell County during 2017 and 2018 in western Kansas.

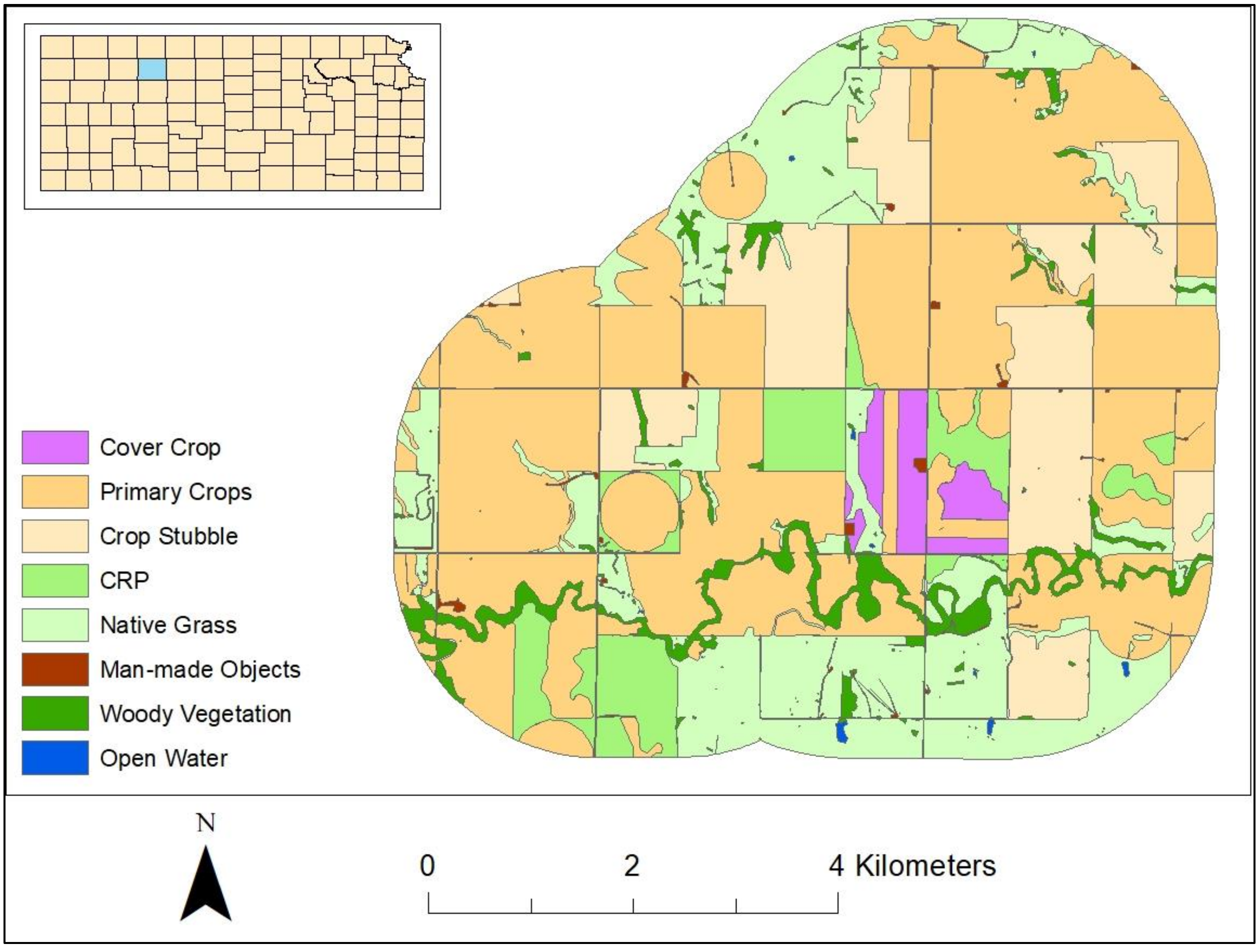
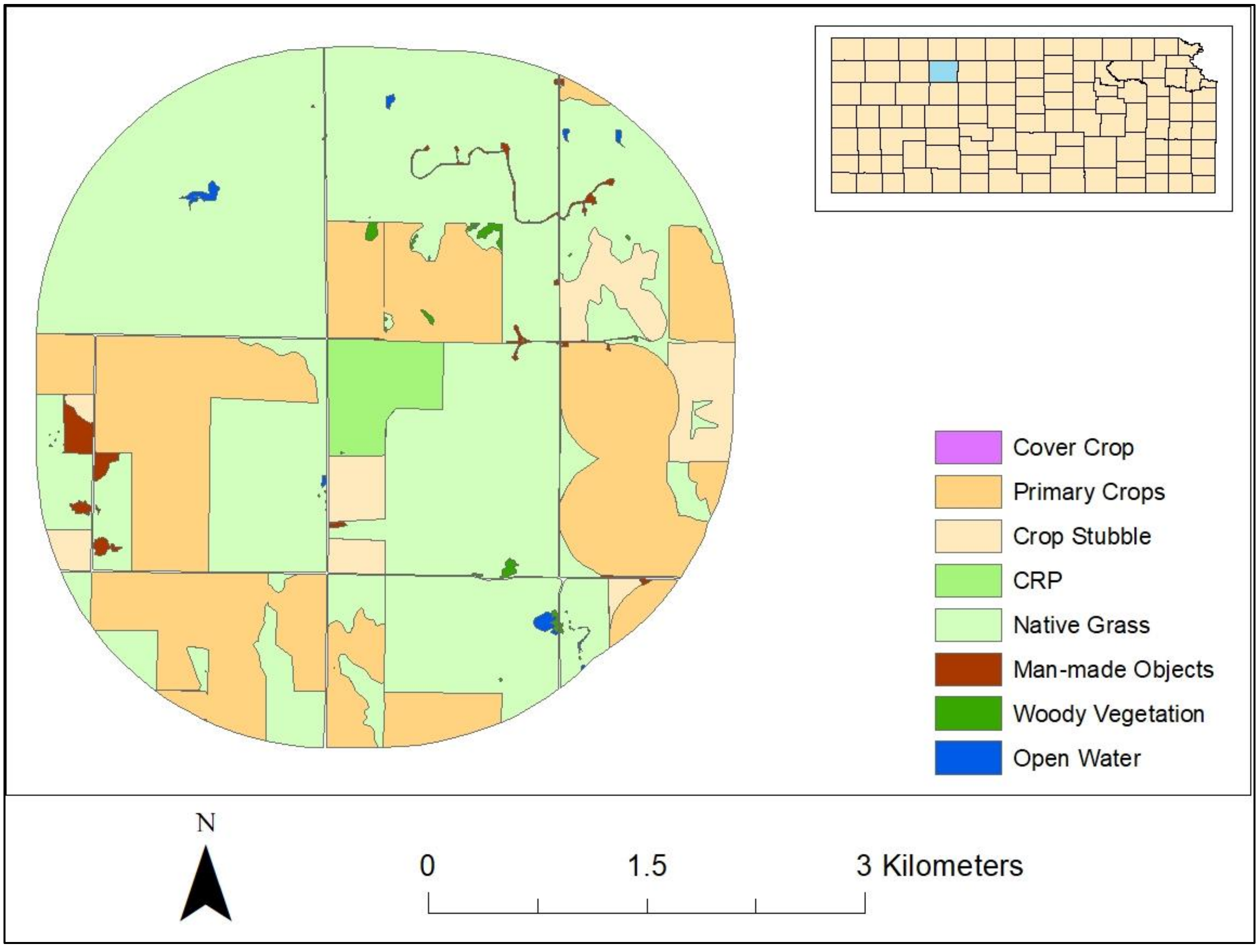


Figure 3.2 Land cover for each study site including (a) the 2017 study site and associated land-use classes located 19 km north of Hill City and 3 km west of Highway 283 in Graham County, Kansas, (b) the 2017 study site and associated land-use classes 17 km north of Hill City and 10 km east of Highway 283 in Graham County, Kansas, (c) the 2018 study site and associated land-use classes located 19 km north of Hill City and 3 km west of Highway 283 in Graham County, Kansas, (d) the 2018 study site and associated land-use classes located 19 km north of Hill City and 1.5 km east of Highway 283 in Graham County, Kansas, (e) the 2018 study site and associated land-use classes located 14 km north of Hill City and 7 km west of Highway 283 in Graham County, Kansas, (f) the 2018 study site and associated land-use classes located 4 km south of Luray and 3 km west of 194th street in Russell County, Kansas, and (h) the 2018 study sites and associated land-use classes located 6 km south and 1 km west of Luray and 1 km south of 194th street in Russell County, Kansas.



Cover Crop
Primary Crops
Crop Stubble
CRP
Native Grass
Man-made Objects
Woody Vegetation
Open Water
N
0
1.5
3 Kilometers

Figure 3.2b

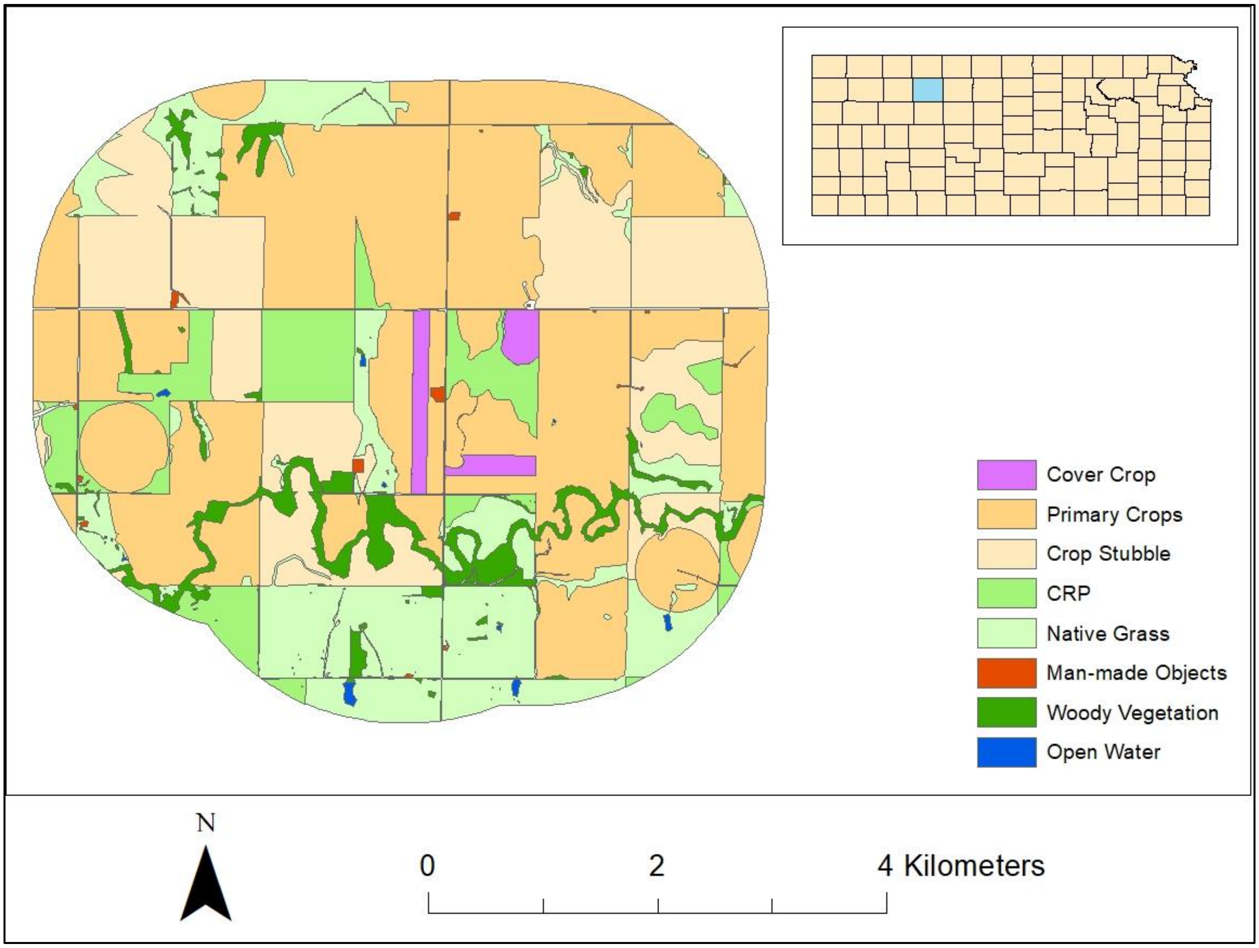

Cover Crop
Primary Crops
Crop Stubble
CRP
Native Grass
Man-made Objects
Woody Vegetation
Open Water
N
0
2
4 Kilometers

Figure 3.2c

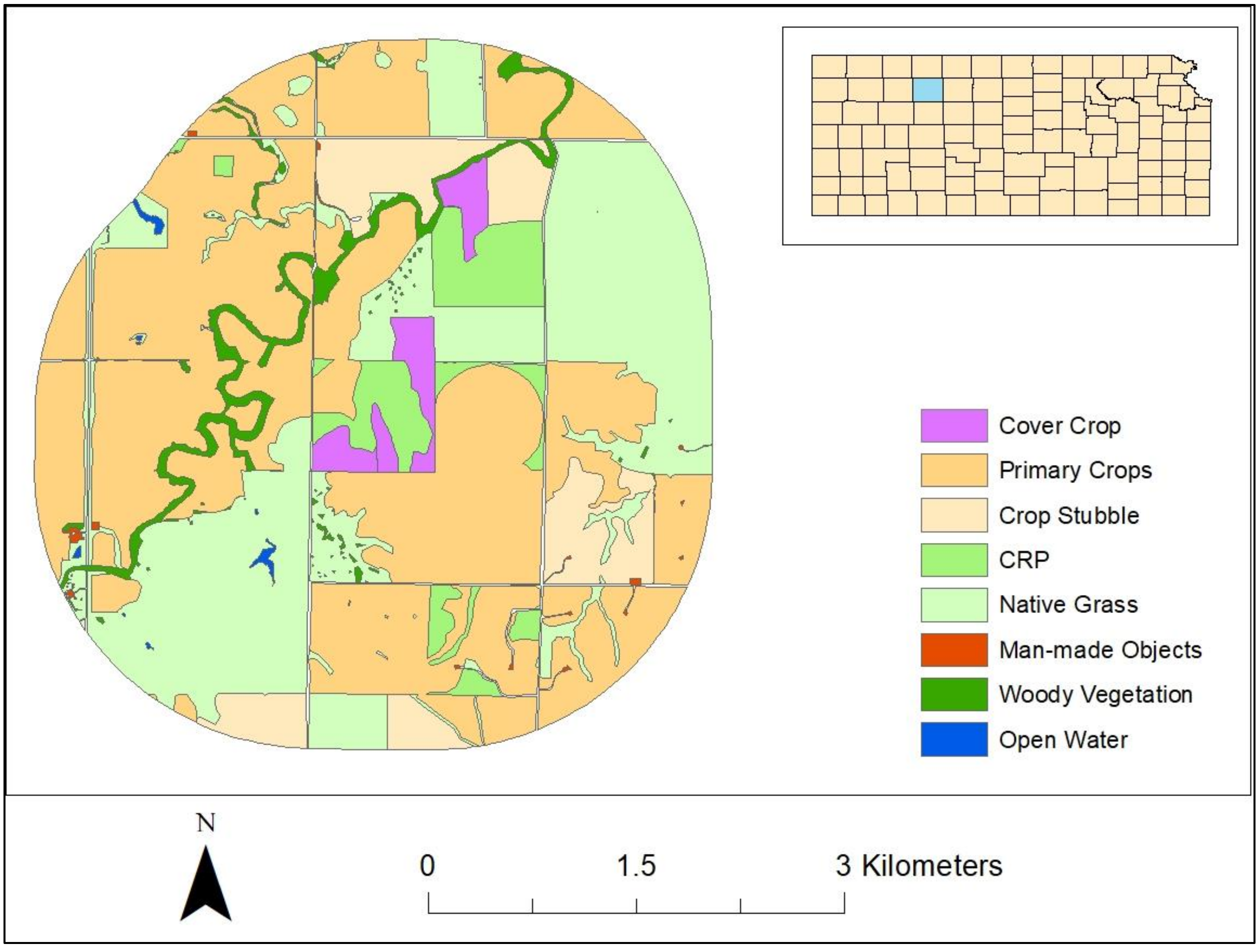

Cover Crop
Primary Crops
Crop Stubble
CRP
Native Grass
Man-made Objects
Woody Vegetation
Open Water
N
0
1.5
3 Kilometers

Figure 3.2d

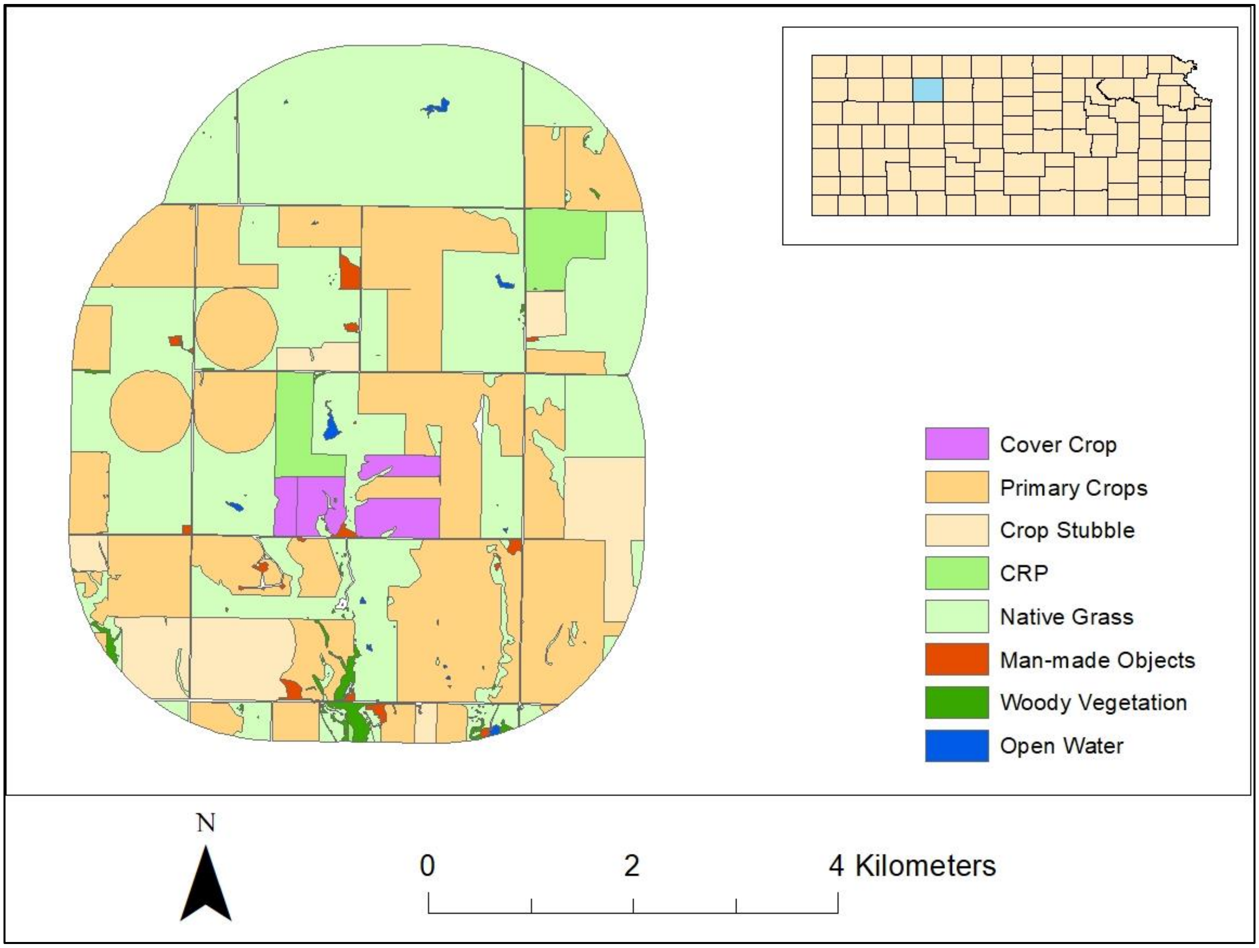

Cover Crop
Primary Crops
Crop Stubble
CRP
Native Grass
Man-made Objects
Woody Vegetation
Open Water
N
0
2
4 Kilometers

Figure 3.2e

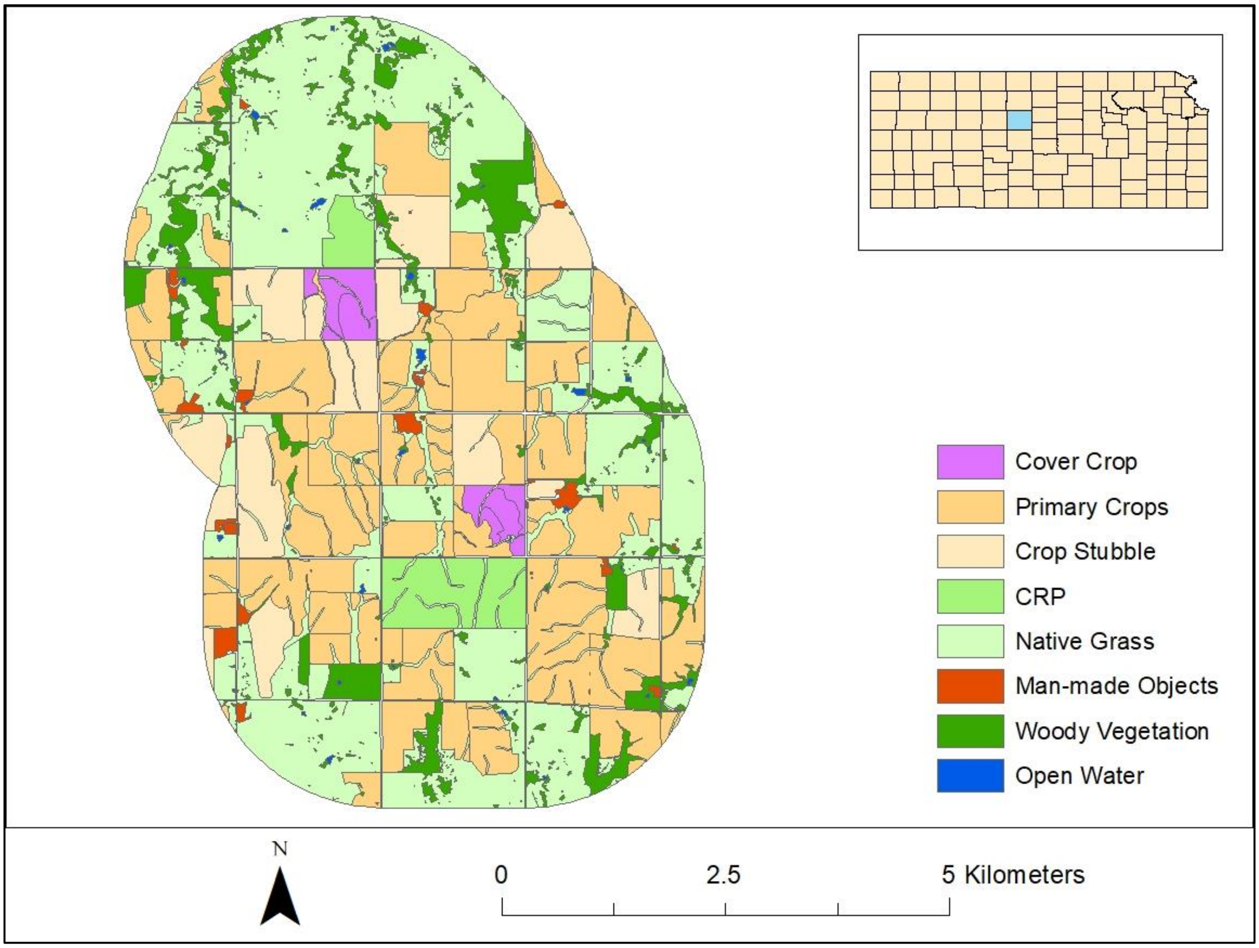

Cover Crop
Primary Crops
Crop Stubble
CRP
Native Grass
Man-made Objects
Woody Vegetation
Open Water
N
0
2.5
5 Kilometers

Figure 3.2f-h

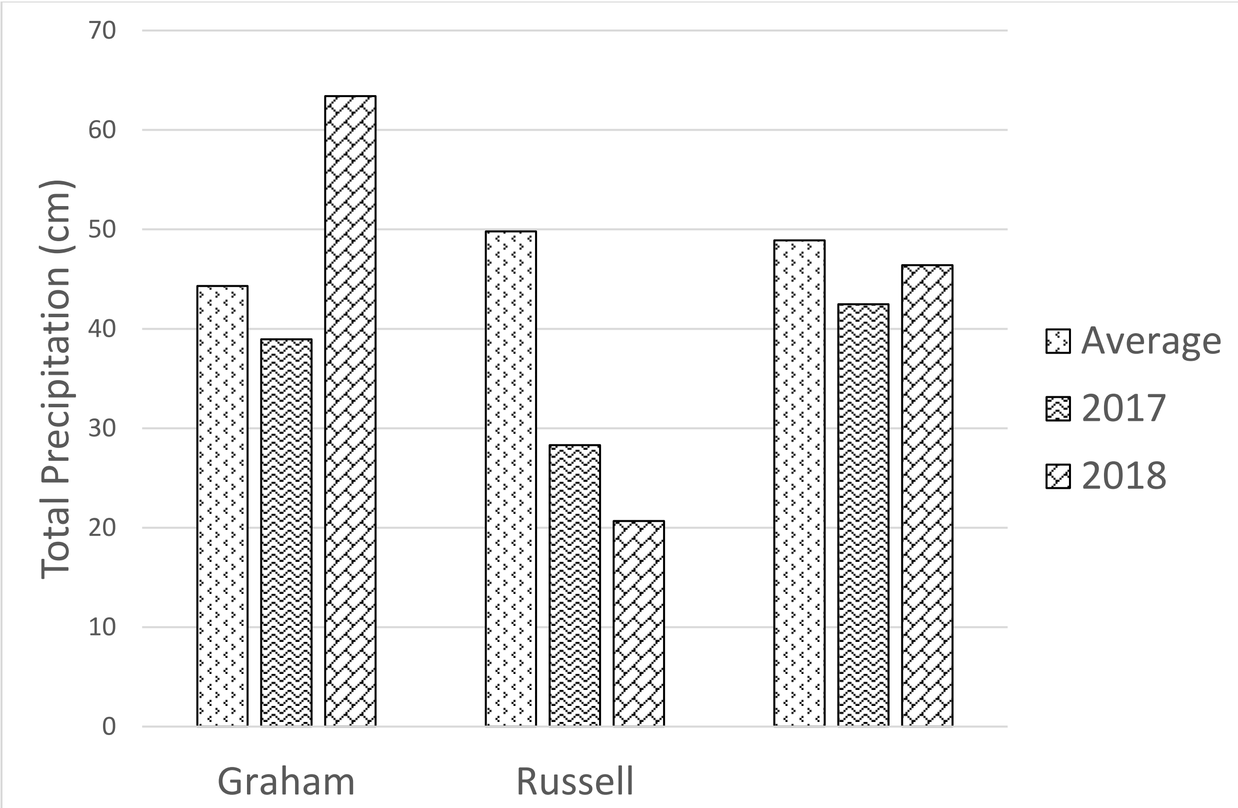


Figure 3.3 Total precipitation from February through August for Graham and Russell counties, Kansas, for 2017 and 2018 compared with the average since 1981.

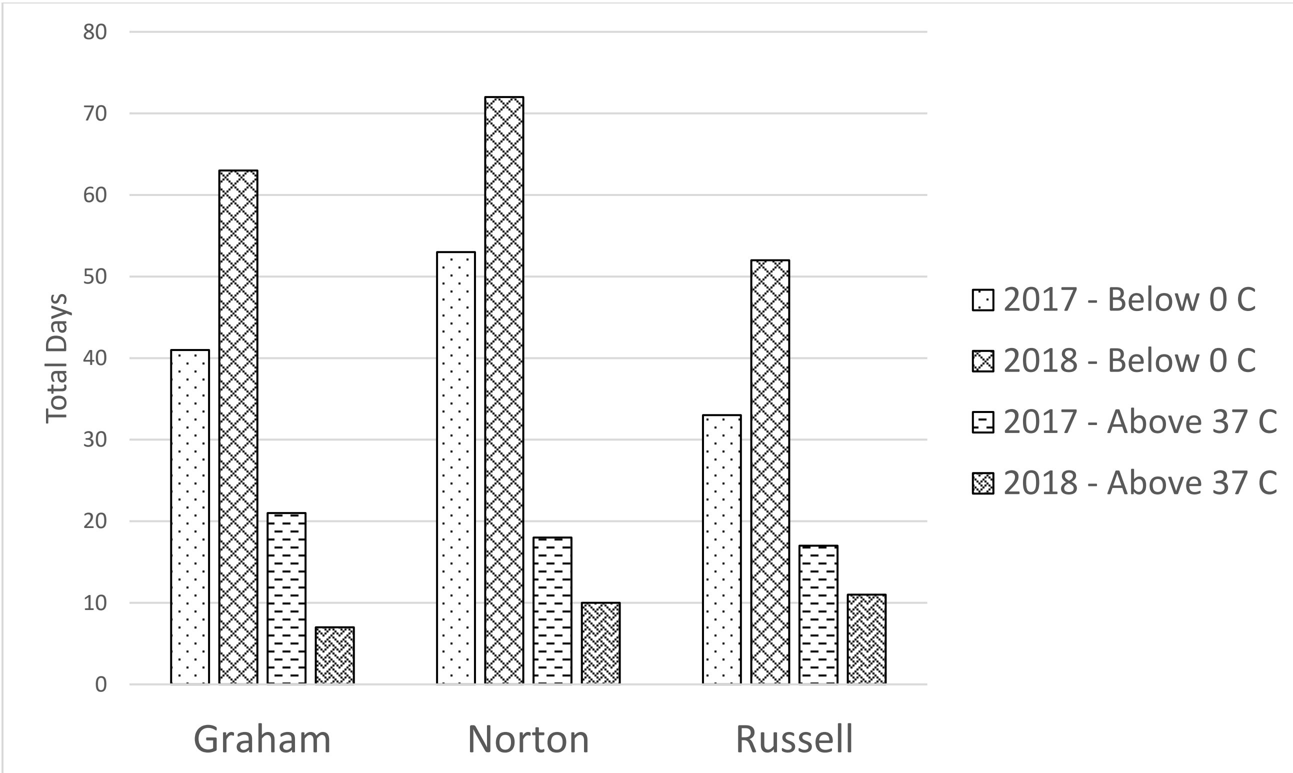


Figure 3.4 Total number of days below 0° C and above 37° C in Graham and Russell counties, Kansas, in 2017 and 2018.

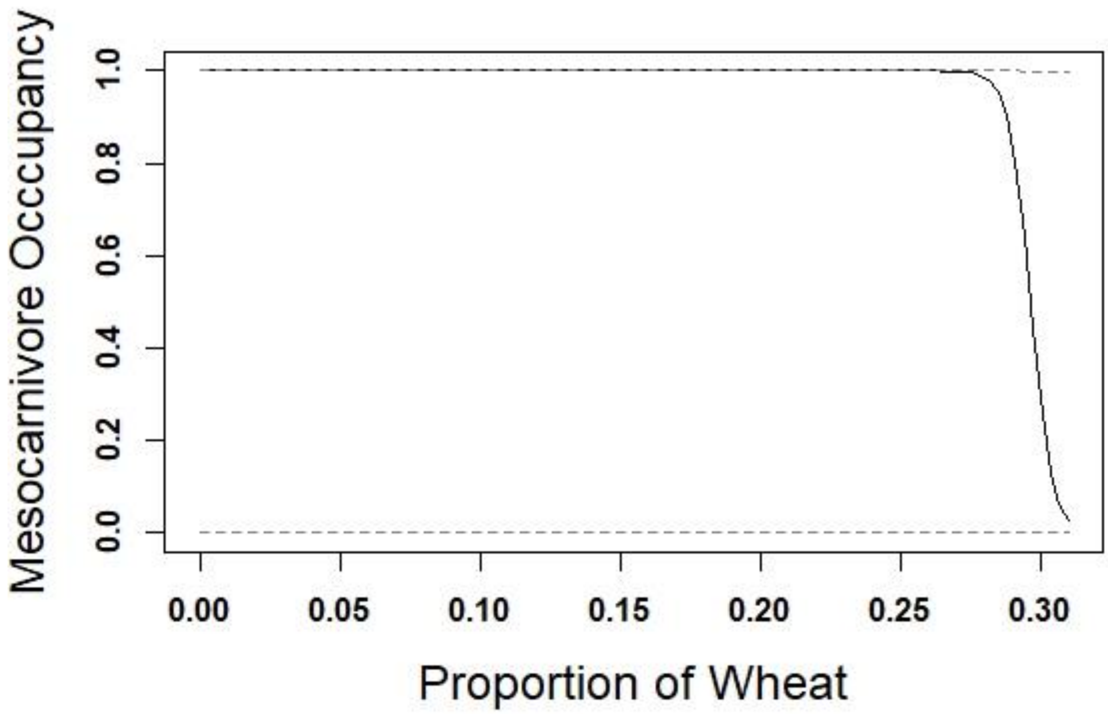


Figure 3.5 Probability of mesocarnivore occupancy (±95% CI) within cover crop and chemical fallow treatments between April and August based on the proportion of wheat surrounding camera trap sites in Graham County, Kansas, during 2017 and 2018.

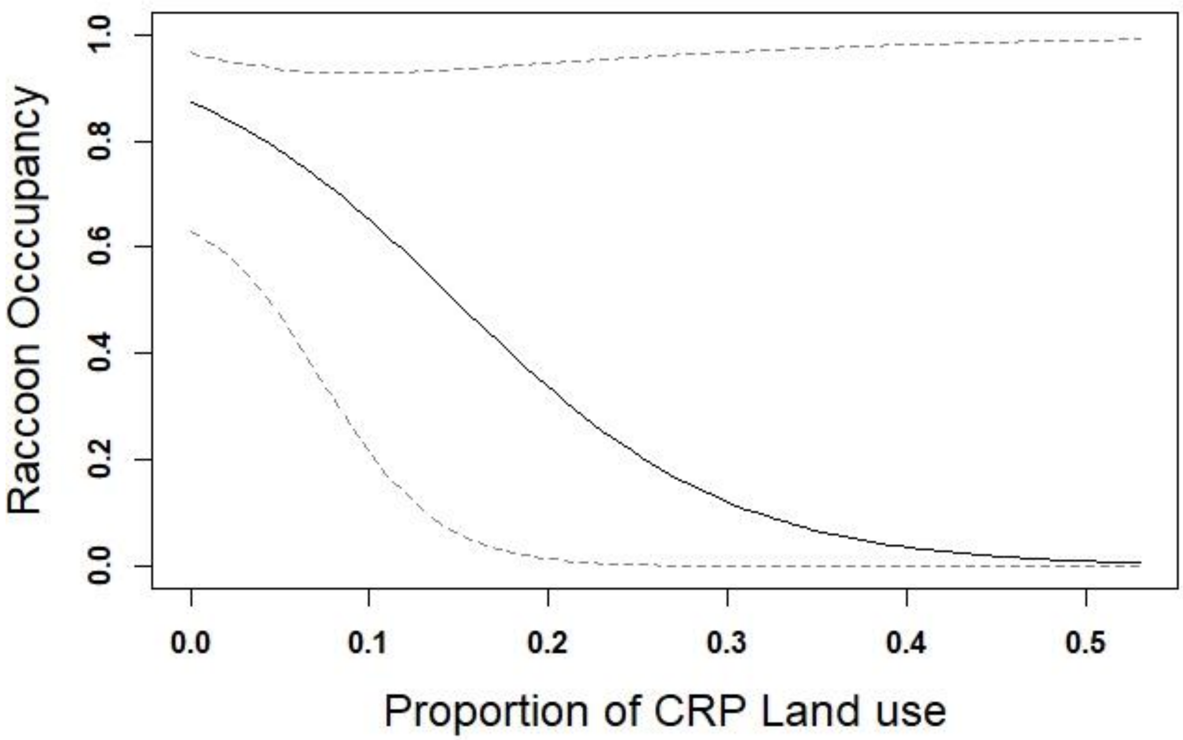


Figure 3.6 Probability of raccoon occupancy (±95% CI) on edges of cover crop and chemical fallow treatments between April and August based on the proportion of wheat surrounding camera trap sites in Graham County, Kansas, during 2017 and 2018.

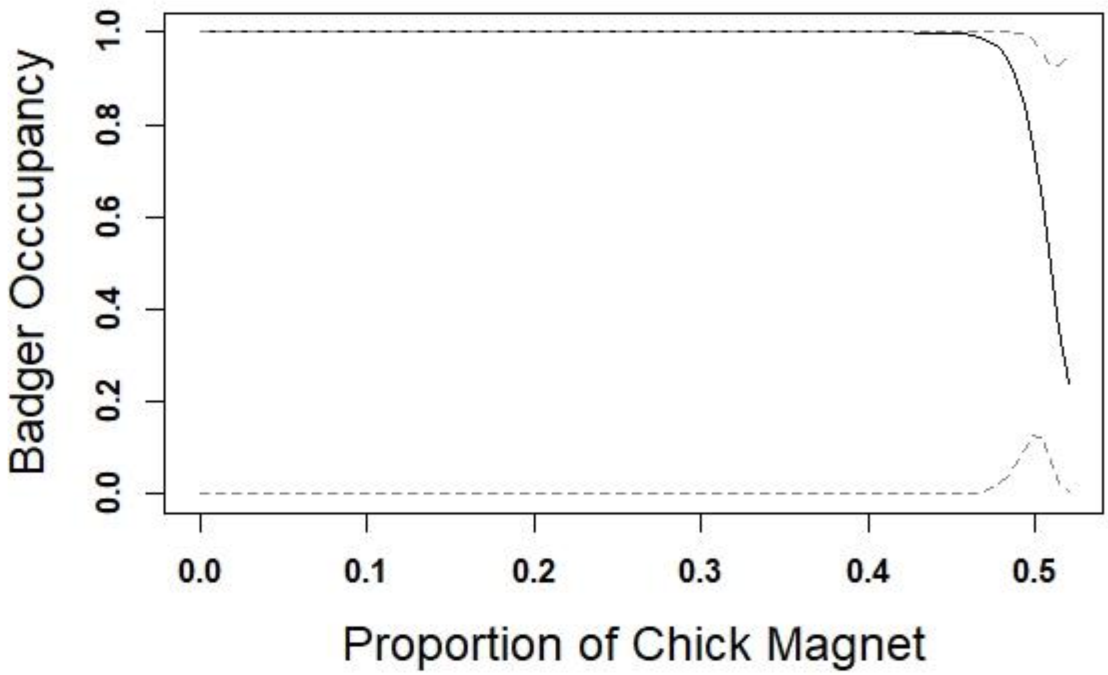


Figure 3.7 Probability of badger occupancy (±95% CI) on the edges of cover crop and chemical fallow treatments from April through August based on the proportion of chick magnet surrounding camera trap sites in Graham County, Kansas, during 2017 and 2018.

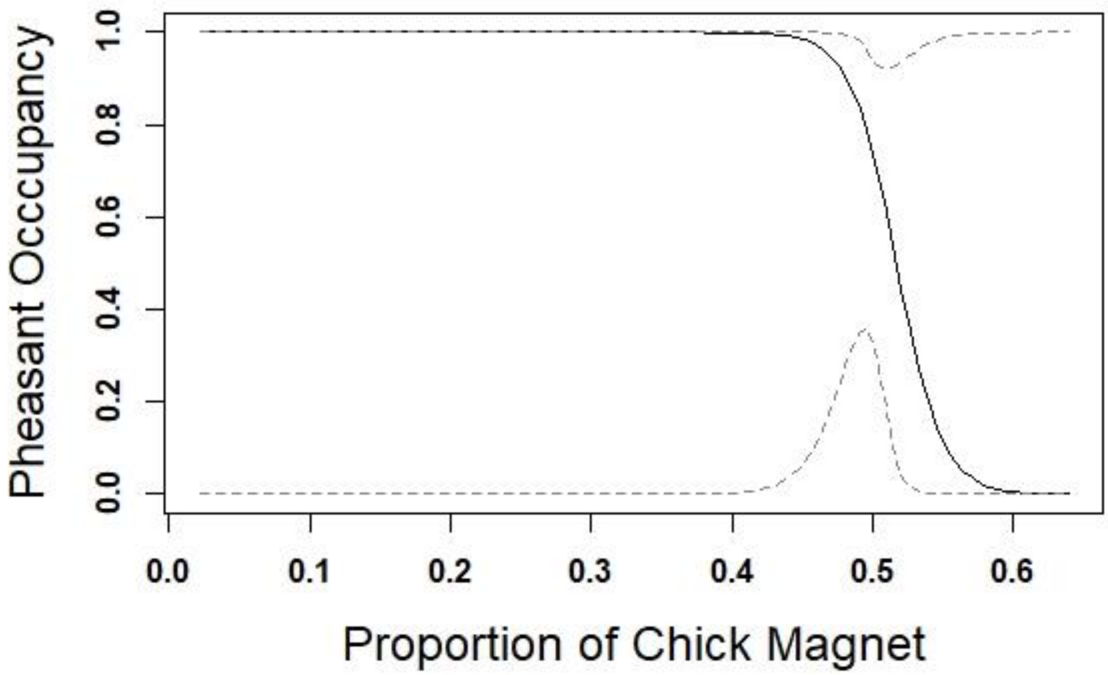


Figure 3.8 Probability of ring-necked pheasant occupancy (±95% CI) on the edges of cover crop and chemical fallow treatments from April through August based on the proportion of chick magnet surrounding camera trap sites in Graham County, Kansas, during 2017 and 2018.

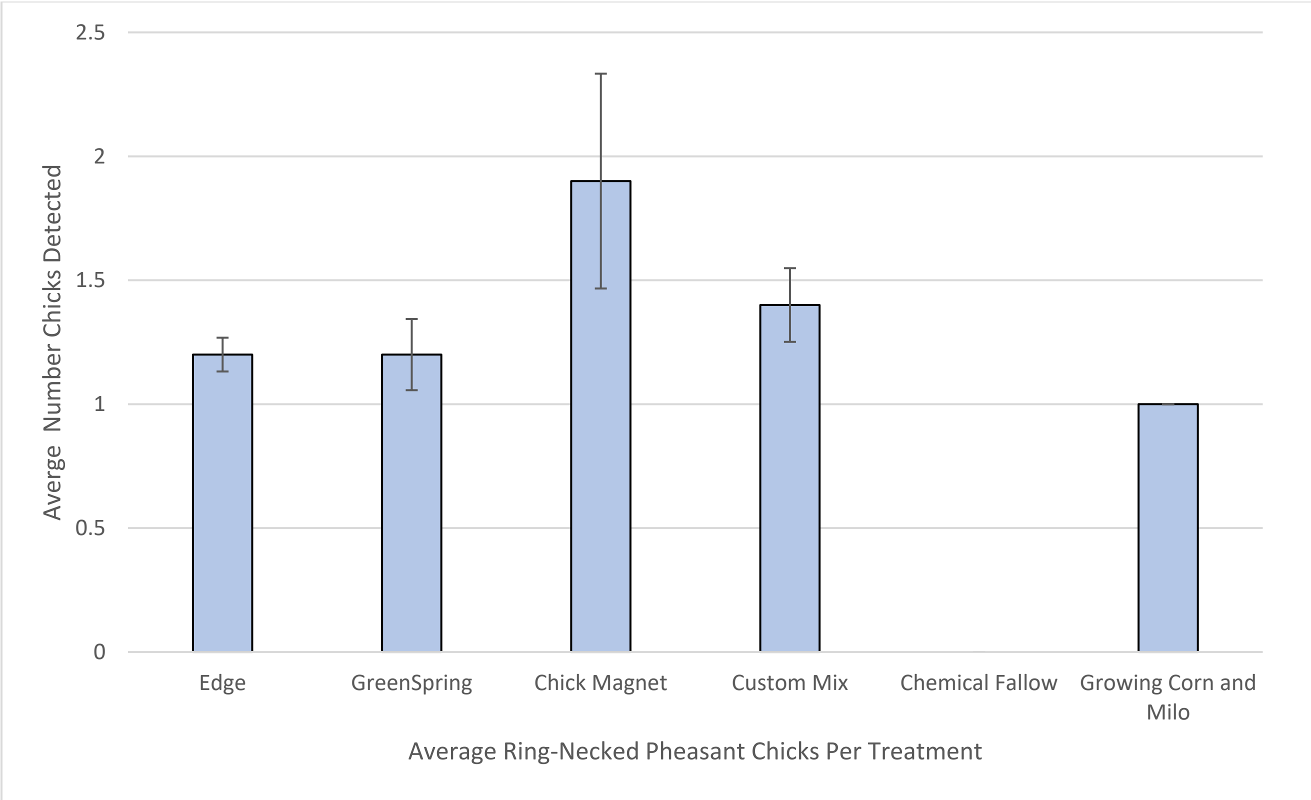


Figure 3.9 The average number of ring-necked pheasant chicks detected between late April and August within spring cover crop treatments, chemical fallow treatments and growing corn and milo within Graham and Russell Counties, Kansas, during 2017 and 2018.

Table 3.1 The proportion of eight land-use categories in the 2017 and 2018 ring-necked pheasant and western Kansas spring cover crop study sites within the 2 kilometer boundary of capture locations in Graham (Terry 2017; Fost, Ted, and Terry West 2018), and Russell counties, Kansas.

Land-use Category	Study Sites 2017 and 2018				
	Terry	**Fost**	**Ted**	**Terry West**	**Russell**
Cover Crop	0.024	0.025	0.024	0.016	0.020
Crop Stubble	0.484	0.081	0.080	0.196	0.103
Primary Crops	0.165	0.387	0.495	0.469	0.334
CRP	0.063	0.029	0.055	0.083	0.036
Native Grass	0.216	0.448	0.299	0.176	0.390
Manmade Objects	0.005	0.020	0.016	0.011	0.030
Woody Vegetation	0.043	0.007	0.031	0.047	0.084
Open Water	0.001	0.002	0.002	0.001	0.003

Table 3.2 Plant species within the GreenSpring, Chick Magnet, and Custom Mix cover crop treatments planted to determine ring-necked pheasant habitat use and selection between 2017 and 2018 in Graham and Russell counties, Kansas.

GreenSpring	Chick Magnet	Custom Mix
Oats	Hybrid Brassicas	Oats
Peas	Peas	Peas
	Yellow Sweet Clover	Yellow Sweet Clover
	Sunflower	Sunflower
	Buckwheat	Radish
		Rapeseed
		Cowpea
		Chickling Vetch
		Safflower

Table 3.3 Mesocarnivore final model suite of single season occupancy for cameras on the edges of cover crop and chemical fallow treatments from April through August in Graham County, Kansas, during 2017 and 2018. K is the number of parameters, AIC_c is Akaike's Information Criterion, ΔAIC_c is change of the AIC_c, and AIC_c w_i is the model weight.

Model	K	AIC_c	ΔAIC_c	w_i
Null	2	424.68	0.0	0.66
Edge Type	3	427.38	2.7	0.17
Year	3	427.38	2.7	0.17

Table 3.4 Mesocarnivore final model suite of single season occupancy for cameras within cover crop and chemical fallow treatments from April through August in Graham County, Kansas, during 2017 and 2018. K is the number of parameters, AIC_c is Akaike's Information Criterion, ΔAIC_c is change of the AIC_c, and AIC_c w_i is the model weight.

Model	K	AIC_c	ΔAIC_c	w_i
Proportion Wheat	4	363.43	0.00	0.80
Chick Magnet	4	368.67	5.24	0.06
Null	2	368.86	5.43	0.05
Year	4	370.40	6.97	0.02
Custom Mix	4	370.67	7.23	0.02
GreenSpring	4	370.67	7.23	0.02
Chemical Fallow	4	370.89	7.46	0.02

Table 3.5 Raccoon final model suite of single season occupancy for cameras on the edges of cover crop and chemical fallow treatments from April through August in Graham County, Kansas, during 2017 and 2018. K is the number of parameters, AIC_c is Akaike's Information Criterion, ΔAIC_c is change of the AIC_c, and AIC_c w_i is the model weight.

Model	**K**	**AIC_c**	**ΔAIC_c**	**w_i**
Proportion CRP	4	310.55	0.00	0.50
Year	4	311.32	0.77	0.34
Null	3	313.47	2.92	0.12
Edge Type	4	315.34	4.79	0.05

Table 3.6 Raccoon final model suite of single season occupancy for cameras within cover crop and chemical fallow treatments from April through August in Graham County, Kansas, during 2017 and 2018. K is the number of parameters, AIC_c is Akaike's Information Criterion, ΔAIC_c is change of the AIC_c, and AIC_c w_i is the model weight.

Model	K	AIC_c	ΔAIC_c	w_i
Year	3	238.37	0.00	0.40
Proportion Chick Magnet	3	238.42	0.05	0.39
Null	2	241.37	2.99	0.09
Chemical Fallow	3	242.76	4.39	0.04
Custom Mix	3	243.64	5.27	0.03
Chick Magnet	3	243.64	5.27	0.03
GreenSpring	3	244.01	5.64	0.02

Table 3.7 Badger final model suite of single season occupancy for cameras on the edges of cover crop and chemical fallow treatments from April through August in Graham County, Kansas, during 2017 and 2018. K is the number of parameters, AIC_c is Akaike's Information Criterion, ΔAIC_c is change of the AIC_c, and AIC_c w_i is the model weight.

Model	**K**	**AIC_c**	**ΔAIC_c**	**w_i**
Proportion Chick Magnet	4	205.23	0.00	0.67
Null	2	208.78	3.54	0.11
Year	4	208.90	3.67	0.11
Edge Type	4	208.90	3.67	0.11

Table 3.8 Badger final model suite of single season occupancy for cameras within cover crop and chemical fallow treatments from April through August in Graham County, Kansas, during 2017 and 2018. K is the number of parameters, AIC_c is Akaike's Information Criterion, ΔAIC_c is change of the AIC_c, and AIC_c w_i is the model weight.

Model	**K**	**AIC_c**	**ΔAIC_c**	**w_i**
Proportion Man-made Objects	4	171.82	0.00	0.69
Year	4	174.26	2.44	0.20
GreenSpring	4	177.77	5.95	0.04
Custom Mix	4	178.17	6.35	0.03
Chick Magnet	4	178.59	6.76	0.02
Chemical Fallow	4	178.76	6.94	0.02
Null	2	182.73	10.91	0.00

Table 3.9 Ring-necked pheasant final model suite of single season occupancy for cameras on the edges of cover crop and chemical fallow treatments from April through August in Graham County, Kansas, during 2017 and 2018. K is the number of parameters, AIC_c is Akaike's Information Criterion, ΔAIC_c is change of the AIC_c, and AIC_c w_i is the model weight.

Model	K	AIC_c	ΔAIC_c	w_i
Year	4	308.22	0.00	0.64
Proportion CRP	4	311.15	2.93	0.15
Chemical Fallow	4	312.02	3.80	0.10
Chick Magnet	4	312.78	4.55	0.07
Custom Mix	4	314.30	6.08	0.03
GreenSpring	4	314.67	6.45	0.03
Null	2	319.86	11.64	0.00

Table 3.10 Ring-necked pheasant final model suite of single season occupancy for cameras within cover crop and chemical fallow treatments from April through August in Graham County, Kansas, during 2017 and 2018. K is the number of parameters, AIC_c is Akaike's Information Criterion, ΔAIC_c is change of the AIC_c, and AIC_c w_i is the model weight.

Model	**K**	**AIC_c**	**ΔAIC_c**	**w_i**
Year	4	308.22	0.00	0.64
Proportion CRP	4	311.15	2.93	0.15
Chemical Fallow	4	312.02	3.80	0.10
Chick Magnet	4	312.78	4.55	0.07
Custom Mix	4	314.30	6.08	0.03
GreenSpring	4	314.67	6.45	0.03
Null	2	319.86	11.64	0.00

Table 3.11 Ring-necked pheasant brood final model suite of single season occupancy for cameras within cover crop and chemical fallow treatments from April through August in Graham and Russell County, Kansas, during 2017 and 2018. K is the number of parameters, AIC_c is Akaike's Information Criterion, ΔAIC_c is change of the AIC_c, and AIC_c w_i is the model weight.

Model	K	AIC_c	ΔAIC_c	w_i
Custom Mix	3	182.31	0.00	0.46
Year	3	184.04	1.73	0.19
Proportion Chick Magnet	3	185.07	2.76	0.11
Null	2	185.72	3.41	0.08
GreenSpring	3	185.79	3.48	0.08
Chemical Fallow	3	186.66	4.35	0.05
Chick Magnet	3	188.19	5.88	0.02