

RING-NECKED PHEASANT: EVALUATION OF WINTER SURVIVAL, HABITAT
USE, AND CURRENT RESEARCH METHODS OF NEST SEARCHING

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Ring-necked pheasant: Evaluation of winter survival, habitat use, and
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ABSTRACT

Radio telemetry was used to monitor a population of male and female ring-necked pheasant (*Phasianus colchicus*; hereafter pheasant) in southwestern North Dakota to examine pheasant habitat selection. Study objectives were to: 1) determine preferred pheasant winter cover habitat; 2) develop management recommendations to increase pheasant abundance; 3) identify habitat use, survival, and dispersion differences between male and female pheasants; and 4) compare nest-searching techniques to determine most efficient research technique for finding pheasant nests. We captured 191 pheasants, assessed weekly survival using known-fate models in Program MARK and determined home ranges and habitat selection and preference using ArcGIS. We assessed three common methods of nest searching: intense ground searching, chain dragging, and telemetry. Averaging >2000 hectares, our home ranges estimates. Pheasant showed selection toward farmsteads with livestock, large wetlands, and CRP-type grasslands. Pheasant survival estimates for the winters of 2011 and 2012 were 91 and 84 percent, respectively.

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CHAPTER 1. GENERAL INTRODUCTION

Ring-necked pheasants (*Phasianus colchicus*), originally native to Asia, have been introduced throughout the world as a renowned game bird and is possibly the most studied species of Galliform in the world (Johnson and Knue 1989, Giudice and Ratti 2001). Hunters and wildlife viewers alike are attracted to this species due to the spectacular multicolored plumage of the males, resistance to human encroachment, and its overall visibility to the inexperienced birder. The pheasant has become one of the iconic symbols throughout the highly cultivated Midwest landscapes. The male pheasant has proven to be an excellent quarry for sportsmen with its swift running ability and explosive flight characteristics (Johnson and Knue 1989, Giudice and Ratti 2001).

The first viable population of pheasants in North America was introduced into the Willamette Valley, Oregon in 1881 (Johnson and Knue 1989). The initial 100 pairs imported from China provided a growing population that allowed managers to capture and transport wild birds to other parts of the country and increase the chance of successful establishment into new areas. Oregon-reared pheasants were released as early as 1891 in South Dakota, with over two million pheasants killed annually in the state by 1927 (Johnson and Knue 1989). Introduced to North Dakota by 1910 with the first open hunting season in 1931, pheasants have flourished, making both North and South Dakota known internationally for great pheasant hunting opportunities (Johnson and Knue 1989). Since these early stocking efforts, managers have accomplished pheasant establishment across much of the nation. Pheasants have flourished in a variety of farmland habitats when adequate quantities of grain crops and uncultivated grass and shelter areas were present to

provide suitable habitat. The pheasant has become one of United States' favorite game birds and has thrived throughout the Great Plains.

Since the pheasant is continuously in high demand as a game bird, it has received large amounts of funding for habitat improvements to increase the population success and survivorship. Like most wildlife species, food, predation, and necessary cover from severe weather are important influences on pheasant demographics. Management of pheasants in North America has evolved around two main focuses: 1) enhancing winter survival by establishing woody or herbaceous cover and providing food plots and 2) enhancing reproduction by increasing grasslands (Leif 2005). There has been a limited amount of research done on pheasants in North Dakota's primary pheasant range. This study will give land managers in North Dakota's prime pheasant habitat information regarding pheasant habitat selection during both reproduction and winter phases of the population's life cycle. Understanding pheasant biology in an area that receives substantial amounts of income from recreational hunting is important to the local communities and for the retention of high pheasant populations while record-high commodity prices are driving the loss of permanent cover across the landscape. The most serious limitation in most regions of pheasant habitat is the change in agriculture industry from small, multi-crop farms to large mono-crop farms with little idle cover or diversity on the landscape (Giudice and Ratti 2001).

The goal of this project was to provide landowners and managers with information to better manage ring-necked pheasants on private and public lands. This project identified different variables of scale associated with ring-necked pheasant selection of winter habitat to allow managers to adjust their strategies to include the necessary aspects of winter

habitat in their management plans. We also determined the most effective nest searching techniques for use in other pheasant nesting studies.

The economic value of pheasants in North Dakota rationalizes the cost associated with this study. Landowners have potential economic gains from increased pheasant production on their properties through increased recreational activities. This research provides landowners and managers data showing the ecological value of winter habitat and nesting cover on the landscape to reduce pheasant losses and encourage pheasant population growth for potential, subsequent increases in recreational demand throughout North Dakota.

An Explanation of Thesis Organization

This thesis follows the format required for submission into the Journal of Wildlife Management. The literature review is contained within Chapter 2, while Chapters 3, 4, and 5 represent separate submissions for journal publication.

I used the pronoun “we” to give credit to my co-authors who provided their professional experience to help comprise different aspects of Chapters 3, 4, 5, and 6. Chapters 3, 4, and 5 are denoted with a footnote marker that explains the co-authors’ contributions to the proposed publication.

CHAPTER 2. LITERATURE REVIEW

Species Description

There are four main groups of pheasant in North America: 1) the ring-necked pheasant, common to Europe, Asia, and North America, 2) the white-winged pheasant from Afghanistan, 3) the green pheasant from Japan, and 4) the European pheasant from Eastern Europe (Sibley 2003). Females from each of these species are all similar in appearance with a drab, sandy-brown color, a long, pointed tail, and barred flight feathers (Sibley 2003). Males of each species are denoted by specific characteristics. The ring-necked pheasant is known for the white ring around their neck, white-winged pheasant have white secondary and primary feathers along their wings; green pheasants have many green iridescent feathers along their breast and sides. The European pheasant lacks the white ring of feathers around the neck that the ring-necked pheasant has, but is otherwise similar with red plumage around cheeks and iridescent brown, green, red, olive, gray, orange, and black feathers covering the body that make the male pheasants unmistakable when combined with their long, pointed, perpendicularly striated tail (Johnson and Knue 1989, Sibley 2003). Ring-necked pheasants range in size, but are typically about 53 cm long and have a wing span of about 79 cm (Sibley 2003). Trautman (1982) recorded weights from 13,124 male and 2,071 female pheasants in South Dakota with average masses of 1,263 and 917 g, respectively.

Distribution and Abundance

Ring-necked pheasants are found throughout much of the world. In the United States, sustained populations have occurred throughout much of the nation with the

exception of the southeastern states (Sibley 2003). The data on true distribution of viable pheasant populations is obscure due to widespread release efforts across the country, especially in areas where the local population is not self-sustaining (Giudice and Ratti 2001). Pheasants are located throughout North Dakota with the greatest densities in southwestern North Dakota in the Missouri Slope Region (Martison and Grondhal 1966). There are relatively stable populations throughout the state, but demographics vary depending upon annual winter intensity (Johnson and Knue 1989). In southwestern North Dakota, pheasants are commonly in larger flocks of 15 to 1000 during fall and winter; respectively, but tend to be more solitary during spring and summer. However, they will concentrate, to a lesser degree, on areas of adequate nesting cover and appropriate thermal cover for roosting during spring and summer months (Johnson and Knue 1989).

Diet

Pheasant are opportunistic and a very adaptive bird in the aspect of forage behavior. Although there are subtle differences in forage selection seasonally, the basic food sources remain constant throughout the year. Pheasants primarily consume seeds, grasses, roots, insects, and wild fruits and nuts, but in proportions based on location and seasonality of food availability (Trautman 1952, Olsen 1977, Hill and Robertson 1988, Johnsgard 1999). Waste grain is a common food for pheasants throughout much of their range, but access can be limited by snow depth during winter months (Olsen 1977, Trautman 1982, Giudice and Ratti 2001). Pheasants have also been recorded by Gates and Hale (1974) acquiring waste grain from livestock manure, which is commonly available around farmsteads even in deep snow conditions. Many land managers provide food plots for pheasants to offset

potential energy losses during extreme winter conditions to increase survival and subsequent populations for hunter harvest.

Habitat

Pheasant habitat is generally associated with agricultural lands primarily used for small grains, interspersed with permanent grass cover (Snyder 1985, Johnson and Knue 1989, Giudice and Ratti 2001, Geaumont 2009). Self-sustaining pheasant populations require portions of the landscape to be in a form of permanent grass cover for reproduction. Many populations also require additional cover types for protection from severe weather conditions. Populations of pheasants in northern latitudes, like North and South Dakota, often require some form of woody cover to provide thermal relief from severe weather conditions (Perkins et al. 1997, Homan et al. 2000, Leif 2005).

Winter Habitat

Extended snow cover and minimum temperatures affect pheasant survival (Leptich 1992, Perkins et al. 1997, Gabbert et al. 1999, Homan et al. 2000, Leif 2005). Due to severe North Dakota weather, winter cover is often the limiting factor on pheasant survival (Martison and Grondhal 1966, Johnson and Knue 1989). Primary pheasant range in North Dakota is south and west of the Missouri River (Martison and Grondhal 1966). The ecoregion associated with the highest densities of pheasants is the Slope Region of the Missouri Plateau including but not limited to Adams, Bowman, Grant, Hettinger, and Stark counties. Agricultural land in southwestern North Dakota is primarily used for small grain, sunflower, canola, corn, pea, grazing, and hay production (Martison and Grondhal 1966).

Tree growth is slow and most often requires multiple plantings and watering to establish viable tree-rows. Since woody cover is hard to establish, the few available wetlands can provide valuable winter cover for pheasants in the region.

Since areas of North and South Dakota lack adequate winter cover for pheasants in the form of shelterbelts, cattail (*Typha sp.*) wetlands are commonly the best available thermal cover (Gabbert et al. 1999, Homan et al. 2000). Gabbert et al. (1999) studied pheasant utilization of cattail wetlands (more than 50% emergent vegetation) and open wetlands (less than 50% emergent vegetation) in South Dakota. They found that during most winter conditions pheasants showed preference to tall grass, food plots, and cattail wetlands. Their study showed that pheasants preferred wetlands that had greater than 50% emergent vegetation such as cattails. If managers are interested in encouraging pheasant populations in areas that lack available thermal cover, removal of *Typha* and other dense wetland vegetation was not recommended.

During periods of heavy snow and blizzards, pheasants showed strong preference to shelterbelts. Linear arrangements of shrubs and trees (shelterbelts) have been planted throughout the nation to reduce climatic effects on rural housing, farmsteads, livestock, and crops (Gabbert et al. 1999). Severe weather concentrated pheasants and predators in the same habitat type, increasing pheasant mortality (Perkins et al. 1997, Gabbert et al. 1999). This was especially true in areas with widely-spaced patches of winter cover. Gatti et al. (1989) noted that corn fields, retired croplands, and marshes were used more in the fall than winter by female pheasants in Wisconsin; while thick, woody brush was used more in the winter than fall. Pheasant habitat selection in southeastern North Dakota followed a use sequence from idle uplands, to large Class IV wetlands, to shelterbelts as weather

conditions became increasingly worse (Homan et al. 2000). This trend is common in other states including Wisconsin, Iowa, and South Dakota (Homan et al. 2000). Therefore, pheasant managers are encouraged to develop thick shelterbelts adjacent to cattail wetlands when possible to aid pheasant survival during the harshest winter conditions.

Pheasants can show high preference to cattail wetland habitats during portions of harsh winters (Gatti et al. 1989, Leptich 1992, Gabbert et al. 1999, Homan et al. 2000). Researchers have found that wetlands overgrown with monotypic stands of cattail have lower biodiversity and an altered ecological function (Homan et al. 2000). Current wetland managers are interpreting ways to reduce the encroachment of cattail into wetland areas to encourage native species and natural function of wetlands throughout the Prairie Pothole Region. This management practice is beneficial to waterfowl and other native avian species; however, if pheasants are the targeted management species, sediment and cattail removal from wetlands is not the best management option (Gabbert et al. 1999, Homan et al. 2000).

Although pheasants often inhabit the same cover-type throughout the winter, pheasants form a stronger bond with upland breeding sites than lowland wintering areas (Homan et al. 2000). Pheasants will remain in the vicinity of their breeding sites until forced to leave due to lack of cover. Homan et al. (2000) reported that once pheasants left their upland areas due to snow depths reaching 30 cm they moved into large Class IV wetlands that were a minimum of 10 hectares in size. In other studies, it has been noted that snow depths greater than 38 cm are a threshold that drives pheasants away from the preferred cattail wetlands to emergency woody-cover habitats (Gatti et al. 1989, Gabbert et al. 1999).

Pheasant winter-related casualties and the need for more suitable winter cover are common in the western states. In southern Idaho, Leptich (1992) found winter cover as the limiting factor on pheasant populations. Idaho vegetation of bunchgrasses and big sagebrush (*Artemisia tridentata*) do not provide effective thermal cover; however, sagebrush can be very important to pheasants for loafing and escape cover. Leptich (1992) suggests that current managers of roadsides, irrigation ditch banks, and odd farm corners should stop mowing, spraying, and burning these herbaceous areas and allow them to persist as herbaceous cover for pheasant use. Old, overgrown farmsteads are known in southern Idaho for their pheasant holding capacity. The tall, erect herbaceous cover and cluttered landscape of abandoned farmsteads provide great microclimates for pheasants, especially during the winter as they avoid snow and search for food. In all, pheasants often seek areas of dense cover as previously discussed, but the importance of woody cover depends greatly on winter severity (Gates and Hale 1974, Hill and Robertson 1988, Leptich 1992, Gabbert et al. 1999, Homan et al. 2000, Geaumont 2009).

Spring Dispersal

Winter mortality is significant in many parts of the country, but the highest mortality can occur during spring dispersion in some cases. Snyder (1985) found the lowest hen survival occurred during dispersal, pre-laying, and laying periods in northeastern Colorado. The lowest survival was in April associated with the annual spring influx of avian predators and lack of vegetation with appropriate height-density for hen concealment. Once new growth wheat reached a 1 dm. height, hen survival increased, followed by nest initiation and brood rearing.

Seasonal movements of pheasants generally range in distance from 0.8 to 3.2 km from wintering areas to summer home ranges (Olsen 1977). Male pheasants leave wintering grounds up to a month before hens because they reach mating condition earlier and establish territories before hens begin searching for nesting sites (Gates and Hale 1974). Male pheasants are polygamous and claim their territories by crowing at the boundaries (Leif 2005). Gates and Hale (1974) noted that roosters tended to have established breeding territories and finish dispersing by early April, while most hens were still dispersing from wintering areas by early May in Wisconsin. Male pheasants tend to concentrate in areas interspersed with heavy or thick cover and an open, relatively flat area so they are close enough to nesting cover for hens and open enough so they can show their impressive mating plumage to be seen by the hens (Hill and Robertson 1988). Non-territorial males are often found in small bachelor groups during the breeding season, farther from potential breeding cover than other males (Hill and Robertson 1988).

Warner et al. (2000) reported that survival of pheasants, independent of sex and age class, is usually lowest during the winter months; however, the greatest proportion of deaths during the growing season was related to older hens during the incubation period. Both male and female pheasants showed high return rates to past breeding sites with no difference between distances traveled in Wisconsin. Juvenile hens showed the lowest levels of natal site fidelity at 26 percent followed by juvenile roosters at 52 percent (Gates and Hale 1974). Pheasant exhibit different use patterns in response to local habitat conditions wherever found (Leptich 1992). Cover, cultivation, and the distribution of both in relation to each other are important to provide food, safety from predators, and protection against harsh environmental conditions for pheasants.

Several research projects have reported differences in body condition, movement, and habitat use between adult and juvenile pheasants (Gates and Hale 1974, Snyder 1985, Gatti et al. 1989, Homan et al. 2000, Warner et al. 2000). Survival for juveniles is typically less than that of adults due to lower body weights and increased movement. Homan et al. (2000) found that juveniles made considerably longer linear movements than those made by adults, averaging 299 m and 183 m, respectively. Gatti et al. (1989) found home range size, interval, and net moves were all greater for juveniles than adults, supporting other such findings from past studies. Warner et al. (2000) found that home ranges for adults were about twice that of adolescents in Illinois; however, there was no difference of survival between age classes in their study. Increased movement tends to be strongly correlated to increased mortality of ring-necked pheasants, but varies by region.

Reproduction

Behavior

Male pheasants display agnostic behavior and establish breeding territories after spring dispersal. This is the time of the most aggressive encounters between pheasants. Fighting among pheasants usually entail physical interaction of males fluttering up together, pecking, spurring, and beating each other with their wings until one bird is established as the dominant male and remains in his territory as the loser retreats (Cramp and Simmons 1980). Territories are maintained by crowing, boastful displays, and physically chasing of intruding males. Seasoned adult males usually reestablish previous territories, whereas young males breeding for the first time tend to fill vacancies (Grahn et al. 1993). Territories are not strictly defined, and may overlap (Gates and Hale 1974).

After leaving wintering sites, females form harems (groups) that move into male territories and create a mating system called harem-defense polygyny where males fend off other males from their group of females (Oring 1982, Hill and Robertson 1988). Males defend and guard their harems as they defend and guard their territories to reduce the chances of forced copulation from outside males (Hill and Robertson 1988). As males guard, and watch for predators and intruding males into their territories, females are able to increase food intake from the decreased need of vigilance since the male is watching over the entire harem (Hill and Robertson 1988). Because harems have individual females leaving and entering the group throughout the breeding season, breeding readiness of females tends to be asynchronous (Oring 1982) thus one male in a wild population can sufficiently cover fertility needs of 10 females (Dale 1956). Females within a harem have a seasonal monogamous bond to the territorial male (Cramp and Simmons 1980), and females in England have been recorded remaining loyal to their previous territorial male in successive years (Hill and Robertson 1988). Territories and agnostic behavior of males begins to diminish as the last hens leave to initiate nests and open female presence within their territories decreases.

Nesting

Due to its high popularity as a game bird, much research has been conducted regarding pheasant ecology (Warner 1981, Trautman 1982, Whiteside and Guthery 1983, Snyder 1984, Johnson and Knue 1989, Robertson 1996, Geaumont 2009). Perhaps the most investigated aspect of ring-necked pheasant biology is the species reproductive behavior (Linder et al. 1960, Jarvis and Simpson 1978, Dumke and Pils 1979, Leif 1994). Leif

(1996) recorded hens forming breeding harems as early as April to meet with males on the landscape. Initial nesting of pheasant hens after spring dispersal typically falls within land uses with residual, herbaceous cover to provide visual obstruction from predators and thermal cover for the sitting hen (Hill and Robertson 1988, Camp and Best 1994). Areas with large expanses of permanent nesting cover are often preferred when available, but any areas providing residual, herbaceous cover can be used by nesting pheasants, including but not limited to: road ditches, cool-season grain crops, fence lines, right-of-ways, waste areas, or wetlands (Snyder 1984, Camp and Best 1994, Guidice and Ratti 2001, Geaumont 2009).

Pheasants are persistent renesters, initiating as many as five nests or until a clutch is successfully hatched, leading to diverse laying and hatching dates within the same year (Wagner et al. 1965, Penrod et al. 1986, Guidice and Ratti 2001). If the first nest attempt is not successful and an additional nest is needed for a successful hatch, pheasants commonly use areas that previously lacked residual cover during the first nesting attempt, such as hay land, due to the increase of new herbaceous cover available to conceal a nest from the current year's growth (Gates and Ostrom 1966, Dumke and Pils 1979, Guidice and Ratti 2001, Geaumont 2009). CRP has provided much of the Northern Great Plain's pheasant nesting cover since the late 1980's, but as contracts expire and crop prices increase, pheasants will likely be displaced from these large expanses of permanent cover and forced to find other potential nest sites (Ryan et al. 1998, Geaumont 2009).

Egg-laying typically begins around the same time every year, but the first few eggs are commonly dropped at random or in dump-nests (nests with eggs from more than one female) (Dale 1956). Dump nests are more common in areas of high pheasant densities,

and although they are most often abandoned and never incubated (Dale 1956), there is some evidence that females may adopt abandoned dump nests (Dumke and Pils 1979). If a nest is incubated, incubation begins after the last egg has been laid and will continue for approximately 23 days, but may be longer with increased levels of disturbance to incubating hen (Dale 1956, Cramp and Simmons 1980, Johnsgard 1999).

Brood Rearing

Clutch sizes range from 2 to >23, but if there are more than 18 eggs, it is almost always by 2 females (Cramp and Simmons 1980). Gates and Hale (1975) found the average clutch size in Wisconsin to be about 11 eggs, estimated from a total of 574 nests. Similarly, Trautman (1982) obtained an average clutch size of 10.6 eggs based on a sample of 4,940 nests found in New Zealand and North America (Guidice and Ratti 2001). Clutch size can vary year to year, and most often decreases as the nesting season progresses (Gates and Hale 1975, Trautman 1982, Clark and Bogenschutz 1999, Johnsgard 1999). Clark and Bogenschutz (1999) recorded clutch size in Iowa declining 0.08 egg/day as a function of nest initiation date. If incubation is successful, 89 to 95 percent of the eggs will hatch (Dale 1956, Johnsgard 1999) into precocial chicks that are highly susceptible to predation due to the inability to fly during the first 2 weeks of life (Riley et al. 1998). Prejuvenile molt begins on about day 10 and chicks are reliant upon the adult for an additional 60 to 70 days (Johnsgard 1999). Some pheasant broods will remain with the hen late into the fall and follow her to wintering areas (Gates and Hale 1974).

Habitat that is desirable for nesting cover can also be used for brood rearing (Riley et al. 1998). Food availability is a driving force for habitat use of pheasant broods 1 to 4

weeks of age, and they tend to select habitats with large amounts of arthropods (Hill and Robertson 1988). Nelson et al. (1990) reported that cool-season grass mixtures of legumes and grasses provide better arthropod habitat than dense, monotypic fields of grasses with no forb component. Riley et al. (1998) found that landscapes with 25% grass and legume cover resulted in earlier hatching dates, heavier chicks, and higher survival than areas with 10% cover.

In Illinois, pheasant broods were recorded using hay and grass cover for feeding and roosting during the morning and roosting periods; respectively, but used row crops such as soybeans (*Glycine max*) and corn (*Zea mays*) during the afternoon (Warner 1979). As broods mature and increase in mobility, they exhibit increased movements and use greater diversity of cover types (Warner 1979). At 4 to 6 weeks of age, pheasant chicks tend to alter their diet from primarily arthropods to include more plant matter and grain (Olsen 1977, Johnsgard 1999). Food and habitat diversity are essential for broods as they mature and their food preferences change. For all pheasant age groups, localized food and cover are key aspects to attain high densities of pheasants on the landscape.

Predation

Predation is the primary cause of mortality in wild pheasant populations (Trautman 1960, Leif 1996, Riley et al. 1998, Hill and Robertson 1988). Most wild pheasant populations incur 4 main types of predation: 1) nest and brood loss, 2) hunter harvest, 3) winter related predation, and 4) predation during spring dispersal (Snyder 1985, Leif 1996, Gabbert et al. 1999, Guidice and Ratti 2001). Common predators to pheasants include

raptors, corvids, snakes, sciurids, mustelids, felids, canids, procyonids, and humans (Wagner et al. 1965, Hill and Robertson 1988, Riley et al. 1998, Geaumont 2009).

There have been many studies that have attempted to quantify effects of predation on pheasant populations through predator removal (Chesness et al. 1968, Riley et al. 1998, Clark and Bogenschutz 1999, Riley and Schulz 2001, Frey et al. 2003). Results from predator removal studies vary and the overall long-term effect of predator removal on pheasant populations is likely low. Frey et al. (2003) assessed the effects of predator removal in Utah over a four year study. In their study they had mixed results from predator trapping, with increased survival related to increased size of removal areas. Chesness et al. (1968) found that predator removal increased nest success slightly; however, they and others (Frey et al. 2003) reported that soon after trapping, predator populations returned to pre-trapping levels.

Many predators are successful at finding pheasant nests and broods. Often when a brood is found, a predator will kill >1 chick at a time (Riley et al. 1998). Clark and Bogenschutz (1999) reported that the majority of nest losses were attributed to predation. Nest success rates have been shown to increase with predator removal (Riley and Schulz 2001), but the logistics of predator removal most often prove too time consuming and costly for most managers.

Riley and Schulz (2001) suggest that the creation and maintenance of permanent grasslands across the landscape would prove more beneficial than predator removal efforts (Geaumont 2009). This suggestion is supported by Clark et al. (1999) who found higher nest success and lower predation rates in large undisturbed grasslands in Iowa, but did not hold true in Illinois where chick survival remained low despite conversion of millions of

row crop hectares to CRP (Warner et al. 1999). Riley (1995) reported a positive association between percentage of lands enrolled in CRP and pheasant numbers. Riley (1995) suggested that the increasing nesting habitat and winter cover provided by CRP was responsible for the increased population. His finding was supported by King and Savidge (1995) where they too reported increased numbers of pheasants in areas with approximately 20% of the landscape enrolled in CRP.

The CRP not only increased nest and brood success due to a decrease in predation levels, but also protected pheasant nests and broods from human disturbances related to agricultural production (e.g. haying and crop harvest). Humans are likely the greatest predator to adult male pheasants in any hunted population; however, mortality related to agriculture is likely more significant to these populations (Guidice and Ratti 2001). Haying practices likely cause one of the largest habitat traps for nesting and brooding pheasants. Female pheasants are attracted to hay fields for nesting habitat and hay cutting often occurs during peak nesting periods, destroying both nests of incubating pheasants and many pheasant broods. Dumke and Pils (1979) reported lower success in hay land than idle ground and the majority of re-nesting attempts on hay lands were destroyed by haying practices. Warner and Etter (1989) estimated that 65 percent of sitting hens were struck by haying equipment and of the hens struck, only 14 percent survived, totaling 44 percent hen survival in areas that were hayed. Similarly, Leedy and Hicks (1945) concluded that nearly 33 percent of hens nesting in hay fields were killed by mowers. One reason human influences of hunting may be less than that of agricultural practices is regulated by the “law of diminishing returns”, when population levels are down and hunter success is low, there will be less hunting pressure. However, no matter what the pheasant population, livestock

still need feed and grasslands still must be mowed for hay production. Human influences on land management have proven to have high impacts on pheasant populations.

Human activity undoubtedly has negative effects on pheasant populations; however, pheasants tend to occur in areas of high human disturbance (i.e. agriculture practices). Pheasants have established viable populations throughout the world due to their demand as a game bird species, and humans continue to make sacrifices in agriculture production to provide pheasant habitat. The amount of lands set aside from agricultural production is closely tied to commodity prices, for the higher the commodity prices the higher the opportunity cost to exclude those lands from production. Therefore, when commodity prices are high, lands set aside for wildlife habitat often diminishes and when priced are low, hectares set aside for wildlife habitat tend to increase. Pheasant survival varies from region to region and year to year; however, survival tends to increase when lands of permanent cover are set aside for all life stages of pheasant reproduction and survival. Although individual populations of pheasants may decrease in viability and disappear without population supplementation, the overall pheasant population of North America appears to be stable and the pheasant will remain a popular game bird for future American generations.

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CHAPTER 3. EVALUATION OF THREE NEST SEARCHING METHODS FOR RING-NECKED PHEASANT¹

Abstract

Management of ring-necked pheasants (*Phasianus colchicus*) is enhanced by knowledge of the relationship between habitat nest selection and habitat composition. Numerous models have been created to estimate nesting densities and preferred cover types for pheasant nests. These models require the initial location of nests on the landscape and appropriate nest searching methods must be chosen to locate pheasant nests. We utilized and compared 3 different nest searching methods in the summer of 2011. We assessed chain dragging, intensive ground searching, and radio telemetry to locate pheasant nests in herbaceous cover. We located 63 pheasant nests on our research sites and were able to develop detection rates for each method (nests/man-hour spent searching). Chain dragging had a nest detection rate of 0.14, intensive ground searching of 0.19, and telemetry of 1.11. Overall, telemetry was the most efficient method for finding pheasant nests. Timing of capture and subsequent collaring of pheasants for telemetry greatly influences rate of capture and return to research sites. Understanding the goals, research design, and resources available is necessary to determine the most efficient nest searching method for any research project.

¹ This chapter is co-authored by Jeffery Stackhouse, Kevin Sedivec, and Benjamin Geaumont. Jeffery Stackhouse (graduate student) was the main co-author responsible for collecting data, statistical analysis, interpreting statistical outputs, and comprising the information presented in this chapter. Benjamin Geaumont provided insight on study design and helped with overall organization and writing of the chapter. Both Benjamin Geaumont and Kevin Sedivec helped with editing the chapter and added professional insight into the discussion and management suggestion sections.

Introduction

Introduced to North America in 1881, ring-necked pheasant are a highly sought after gamebird and as such much research has been conducted regarding their ecology (Warner 1981, Trautman 1982, Whiteside and Guthery 1983, Snyder 1984, Johnson and Knue 1989, Robertson 1996). Perhaps the most investigated aspect of pheasant biology is the species reproductive behavior (Linder et al. 1960, Jarvis and Simpson 1978, Dumke and Pils 1979, Leif 1994). Many studies evaluating the reproduction of pheasant have focused on nesting habitat (Baskett 1947, Clark et al. 1999) and results from previous research have acknowledged the difficulty associated with locating pheasant nests in their preferred cover types (Evrard 2000). Many investigations into pheasant nesting ecology have been based on the research team's ability to locate nests (Schottler et al. 2008) and as such, a variety of methods have been employed for locating nests (Whiteside and Guthery 1983, Berthelsen et al. 1990, Evrard 2000). Methods used for locating pheasant nests include, but are not limited to: a cable chain device as described by Higgins et al. (1969) used by Evrard (2000), a rope drag technique as described by Duebbert and Kantrud (1974), radio telemetry (Dumke and Pils 1979, Whiteside and Guthery 1983), intensive ground searches (Stokes 1954, Labisky 1957), and spring prescribed burning to find legacy pheasant nests (Schottler et al. 2008). The use of numerous methods for locating pheasant nests suggests that one method that is useful across all research efforts has not been established.

Each method has its advantages and disadvantages. The utility of each technique depends upon factors including: objectives of the study, area in which the study occurs, and the available budget. Radio telemetry is a valuable tool for many nesting studies, but may

have limitations when used in a study where the primary objective is to determine nest density and success on specific treatments applied to a limited portion of the landscape. Radio tagged hens may not initiate nests within research plots. Therefore, useful data regarding treatment effect is not provided. In these instances, searching for nests in areas in which treatments have been applied may be more useful. However, if researchers are interested in pheasant habitat selection and use on a landscape scale without the limitations of nests located within given treatments, telemetry-based nest searching methods may be the most efficient method to acquire such data. Limiting search efforts to selected plots on a landscape scale would likely lead to missed areas that provided potential habitat for nesting pheasants, and therefore a subsequent bias in the data collected.

The cable chain device was established to facilitate the location of duck nests on a variety of upland habitats (Higgins et al. 1969). The device is hooked to two jeeps and dragged across herbaceous cover in attempt to find upland nesting waterfowl. When a bird is flushed, observers leave the vehicles to search for a potential nest. The cable chain device is dependent upon the hen being present and flushing from the nest during nest searching efforts. This method has been used extensively in waterfowl studies and to a lesser degree in pheasant trials (Higgins et al. 1969, Barker et al. 1990, Evrard 2000, Fondell and Ball 2004). One potential explanation for why the cable chain device has not been used in more pheasant studies is that unlike ducks, pheasants have potential to vacate their nests prior to being flushed by the chain, resulting in lower nest location rates (Evrard 2000). Also, in contrast to ducks, pheasants spend the majority of their lives on upland sites. This adds potential for flushing hens that are not nesting, resulting in time spent nest searching areas where a nest may not be present. However, the cable chain device provides

an efficient tool for searching large areas of land in studies examining expansive treatment areas.

Intensive ground searching has been used extensively for locating pheasant nests (Evans and Wolfe 1967, Gates and Hale 1974, George et al. 1979, Berthelsen et al. 1990). This technique requires several searchers who space themselves out at a distance based on where one observer's field of vision ends and where the next searcher's begins. Generally, searchers are spaced approximately 1.5 to 2.0 meters apart and use sticks to part the vegetation as they walk back and forth across plots. Unlike the cable chain device or use of telemetry, the intensive ground searching method does not require the hen to be present during nest searching efforts. It is assumed that the nest will be found regardless of hen presence or absence. Intensive ground searches are typically done on subplots within whole treatments due to the time required to adequately search an area. This method requires more laborers than telemetry or chain dragging, but does not require the initial investment into a chain and vehicles or radio transmitters and telemetry equipment. Given the multitude of techniques available for locating pheasant nests, researchers planning to evaluate nesting ecology of pheasant need to choose the method most suitable for their environment, research objectives, and budget.

We began a research trial in southwest North Dakota with the goal of evaluating pheasant production on post-contract Conservation Reserve Program (CRP) lands that were being managed for both wildlife and agricultural outputs in 2006. Given the objectives of our study, the geographical location in which the study was conducted, and our available budget, we choose to locate nests within our treatments utilizing the chain drag technique. However, over time we became interested in evaluating the ability of the chain drag

method to locate nests on our research plots. Therefore, in 2011 we developed a field trial aimed at evaluating three common techniques often employed during pheasant nesting studies. The purpose of this paper is to report and discuss our findings regarding a comparison among the chain drag technique, radio telemetry, and the intensive ground searching technique for finding pheasant nests.

Study Area

The study was conducted on privately owned lands near Hettinger, North Dakota in Adams County. The study occurred on two parcels of land, 193 ha each. Prior to the beginning of our research, each parcel of land was enrolled in CRP for approximately 10 years. At the onset of the CRP contract, each parcel of land was established with cool season grasses and legumes that included intermediate wheatgrass (*Elymus hispidus* (P. Opiz) Melderis), crested wheatgrass (*Agropyron cristatum* (L.) Gaertn), alfalfa (*Medicago sativa* L.), and yellow sweetclover (*Melilotus officinalis* (L.) Lam.) (Geaumont et al. 2010). The 2 study sites are composed of different management treatments using a randomized block design: 1) season long grazing, 2) hay land, and 3) unmanipulated CRP. The 2 sites total 64 ha of hay land, 64 ha of idle CRP land, and 258 ha of season long pasture (Geaumont et al. 2010). The season long treatment includes a 129 ha pasture for each study site and grazed with Angus cattle from June to December with a targeted 50 percent degree of disappearance. For a complete description of the original study design refer to Geaumont (2009).

The study area receives approximately 40.6 cm of precipitation annually, with 87 percent occurring from April through October (NDAWN 2012). The 20-year average

winter temperature (January through March) is approximately -9°C and average summer temperature (June through August) approximately 19°C (NDAWN 2012).

Methods

The three nest searching techniques tested were: chain dragging, intensive ground searching, and radio telemetry. For the purpose of this study, we defined a nest as any depression containing egg remnants or ≥ 1 intact egg. Our study was designed to coincide with the peak nesting period of pheasants in the region. To do so, we chose to evaluate nest searching methods from 26 May 2011 to 22 June 2011 (Geaumont 2009). We assessed the human resources needed to locate nests per unit time using each method and compared known nest locations among search methods to assess the ability of each searching techniques to locate nests that otherwise would not have been found. This was a blind study; searchers partaking in each technique were not aware of nests located during other nest searching efforts.

Chain Dragging Surveys

We conducted chain dragging surveys over the entirety of our research plots 2 times during the peak pheasant nesting period. The first chain dragging event occurred from 31 May to 2 June and the second effort from 13 June to 18 June 2012. Nests were located using a modified chain dragging technique, similar to Higgins et al. (1969), to cover areas of permanent vegetation on our sites. The modifications include the use of all-terrain vehicles (ATVs) versus jeeps, a single chain versus a double chain, and pulling the chain 8 to 10 km per hour versus 5 to 8 km per hour. We used two ATVs approximately 20 m apart

to pull a 30 m chain (0.80 cm diameter) horizontally across the vegetation until the entirety of our research plots with permanent cover had been explored (Geaumont 2009). The chain was drug at slightly faster speeds compared to those used by Higgins et al. (1969) due to previous observations of pheasants running prior to being flushed by the chain (Evrard 2000). A single chain was used since the ATV's had limited horse-power to pull the chain through the vegetation at a consistent speed. When a hen flushed, the operator of each ATV stopped and actively searched for a nest. Search efforts following the flushing of a hen were limited to 10 minutes. If a nest was located, its location was marked on a Global Positioning System (GPS). We limited chain dragging efforts to 0700 to 1300 hours. Areas that were covered with the chain were excluded from other search methods for ≥ 24 hours.

Intensive Ground Search Surveys

We searched 96 randomly located 0.4 ha plots (comprising approximately 10 percent of the total permanent cover) using the intensive search method. Each sub-plot was searched once in its entirety. The plots were selected and searched randomly from 31 May to 22 June. Teams of 2 to 5 individuals actively searched the random plots. Individuals were spaced out at approximately 1.5 meter intervals and walked back and forth parting herbaceous vegetation until the entire subplot was searched. When a nest was located it was marked on a hand-held GPS and additional details recorded. Nest searching efforts were conducted primarily from 0800 to 1600 hours. Telemetry and ground searching crews typically alternated days at each of the two research sites to avoid possible bias in nest locations between the two methods.

Radio Telemetry

For the duration of both the chain dragging and intensive nest searching efforts, we monitored breeding hens equipped with 12.5-g necklace-type radio transmitters (Riley and Fistler 1992, Perkins et al. 1997) on our research sites. Pheasants were captured during 3 time intervals, using 2 different techniques. Capture techniques employed were nightlighting and winter bait-trapping, both previously shown to successfully capture adult pheasants (Labisky 1968, Gates 1971, Dumke and Pils 1979, Perkins et al. 1997). In the fall of 2010 and spring 2011, we captured pheasants using nightlighting techniques similar to those described in Labisky (1968) on our research sites. During the winter of 2011, we captured pheasants at winter bait sites (Gates 1971, Perkins et al. 1997). Winter bait sites were areas known to have large flocks of wintering pheasants located within 2.4 kilometers of our research sites. Following capture, we located collared hens at least once every 5 days during the identified 4 week period of peak pheasant nesting. Prior to the initiation of this study, we knew at least a portion of each monitored hen's home range fell within the bounds of our study sites. Knowing the relative home range of these individuals prior to the study eliminated the need to spend unnecessary time searching for individuals that were unlikely to nest on the research sites. When a hen was found on a nest it was recorded in a GPS and checked approximately every 10 days in order to monitor nest status and to ensure that the hen had not initiated a new nest. Telemetry locations were recorded primarily from 0500 to 1800 hours on research sites that had not experienced chain dragging or ground searching efforts within 24 hours.

We evaluated the efficiency of each method for locating nests by calculating detection rates, specifically raw detection rates (i.e., the number of instances when a nest

was detected by a single survey method) and unique detection rates (i.e., the number of instances detection by a given method represented the only detection of the nest) (Campbell 2004, Long et al. 2006). We compiled a detection history based on 11 days of chain dragging (95 hrs.), 96 intensive search plots (172 hrs.), and data from tracking 26 on-site, radio-collared hens (24 hrs.). Detection rates of pheasant nests associated with each nest searching method were calculated using the following equation: $(r) = \text{number of hours spent searching for each method} / \text{total number of nests found via each method}$. We determined the total search time per pheasant nest found within each searching technique to assess the efficiency of each method.

Results

Pheasants captured and radio collared that did not nest within our treatments provided little data to answer our overall study questions. Therefore, we were interested in what method of capture provided the greatest number of returning birds to our sites. We captured a total of 128 pheasants to be fitted with telemetry units or leg bands. Of the birds captured, we fitted 39 adult pheasants on our research sites during 15 hours of nightlighting in the fall of 2010. We quantified the efficiency of each trapping method by calculating a capture rate. The capture rate for fall night lighting was 0.38 hours per captured bird (Table 3.1). In the winter of 2011, we captured 69 pheasants in 50 hours, resulting in a capture rate of 0.43 hours per captured bird (Table 3.1). In the spring of 2011, we spent 45 hours to capture 20 pheasants, resulting in a spring night lighting capture rate of 2.25 hours per captured pheasant (Table 3.1).

Table 3.1. Number of ring-necked pheasants captured, person-hours to capture pheasants, hours per captured bird, and percent of birds returning to study sites in southwestern, North Dakota, USA, September 2010 – May 2011.

Capture Method	Effort (person-hrs)	Hrs/captured bird	Percent return to site ^a
Fall Nightlighting	15	0.38	15%
Winter Bait-Trapping	30	0.43	4%
Spring Nightlighting	45	2.25	83%
<i>Totals:</i>	68		

^aPercentage of radio-collared pheasants that returned to our specified research sites.

Sixty-two pheasant nests were located from May – June, 2011. Raw detection rates varied among the three methods (Table 3.2). The use of the chain dragging method resulted in a raw detection rate of 0.14 nests per person-hour (13 nests/ 95.25 search hours; Table 2). During our intensive searching we surveyed 96 sub-plots (0.4 ea.) resulting in a raw detection rate of 0.19 nests per hour (32 nests/172.45 search hours; Table 3.2). We tracked 26 radio collared hens, known to have portions of their home ranges on our research sites. Considering only the time spent monitoring pheasants, radio telemetry resulted in a raw detection rate of 0.95 nests per hour (23 nests/ 24.2 search hours; Table 3.2). There were 6 nests found by more than 1 search method; 1 nest by telemetry and chain dragging, 1 by intensive ground search and telemetry, 4 nests by intensive ground search and chain dragging, each of which were not included in the unique detection totals in Table 3.2. Although the intensive ground search method resulted in the greatest number of raw and unique nest detections, the use of radio-telemetry proved to be ≥ 5 times more efficient at finding nests than either of the other methods (Table 3.2).

Table 3.2. Number of raw detections, raw detection rates, unique detections, and unique detection rates for ring-necked pheasant nests in southwestern, North Dakota, USA. We conducted surveys May-June 2011.

Search Method	Raw detections ^a	Raw detection rate ^b	Unique detections ^c	Unique detection rate ^d
Intensive Ground Search	32	0.19	27	0.16
Telemetry	23	0.95	21	0.87
Chain-drag	13	0.14	8	0.08
<i>Totals:</i>	68		56	

^aSum of nests detected with each nest searching method.

^bRaw detection rates calculated as the total number of nests detected by each survey method divided by person-hours.

^cSum of nests found by each nest searching method that were not found by another method.

^dUnique detection rates calculated by total number nests detected by a single method and only by that method divided by person-hours.

Although the telemetry method was 5 times more efficient at locating pheasant nests than the other nest searching techniques, we did not originally consider time and effort spent trapping pheasants. When the total trapping time is added from all three trapping occasions (68 hours) to the time we spent searching for telemetry-related nests, the raw detection rate of telemetry nests is decreased to 0.25, still making it the most time-efficient method of locating nesting female pheasants when compared to intensive nest searching and chain-dragging methods at 0.19 and 0.14, respectively (Table 3.2).

Since our initial research was assessing pheasant response to different treatments, having telemetry birds return to our specified research sites was of particular interest. To assess differences in dispersal post-capture we followed and monitored pheasants from each trapping group to assess percentage return to the research site from fall nightlighting, winter bait-trapping, and spring nightlighting. We found that 15, 4, and 83 percent of birds

returned to the research sites, respectively (Table 3.1). Bird death and possible radio failures were included in the proportion of birds that did not return to the site.

Discussion

Each survey method was successfully used in locating nests of pheasants. In general, a greater number of nests were located using the intensive ground searching method than were located using the chain drag or telemetry techniques. Of the 32 nests located using the intensive ground searching method, 11 were previously predated and 1 hatched prior to being located. Additionally, 10 of the unpredated nests found during the intensive ground searching contained eggs that were cold and/or sun bleached. These characteristics suggest that the nest was a “dump” nest, previously abandoned by the hen, or that the hen was still in the egg-laying stage (Baskett 1947, Evans and Wolfe 1967, Martin and Geupel 1993). Hens in the egg-laying stage generally spend less time at the nest than during incubation and the eggs could have felt cold as a result (Martin and Geupel 1993). The benefit of the intensive ground searching method is the assumption that all nests are found, regardless of hen presence or absence. Both the telemetry and chain dragging methods require the hen to be present to find the nest. This method allows researchers to more accurately estimate nest densities. Only finding those nests where the hen is present during searching could potentially lead to underestimation of nest densities.

The least productive of our 3 nest searching methods was the chain dragging method. We located 13 active nests using the chain dragging method, with the lowest detection rates per hour of the methods assessed (Table 3.2). On several occasions we observed hens running and flushing before the chain, similar to what Evrard (2000)

experienced, but were able to locate a nest regardless. The occurrence of hens running and flushing prior to coming into contact with the chain appeared to decrease as hens moved from clutch development to incubation. In general, incubating hens were more reluctant to leave their nests than hens in the egg laying process. We noted that locating pheasant nests after flushing a hen required more time and effort than finding duck nests using the same technique.

The time required to search one hectare of land for nests of pheasant varied greatly between the intensive ground searching and chain dragging methods. During chain dragging we covered approximately 4.05 ha per person-hour, while intensive nest searches on similar habitats only covered 0.22 ha per hour of labor. The chain dragging method was the most efficient way to cover large expanses of land, but research planners must take into consideration the lower nest detection probabilities associated with this method.

We found the most efficient nest searching method in our study to be radio telemetry. This method had the highest detection rates per unit time, and resulted in locating 23 active nests (Table 3.2). The telemetry method was approximately 5 times more efficient than either the intensive ground searching method or the chain dragging method per unit of labor time. The disadvantage of both the telemetry and chain dragging methods is that the hen must be present to locate a nest; therefore, a proportion of pheasant nests will go undetected on any given research plot. The benefit of finding nests where the hen is present, however, is that researchers know that the nest is active and then have the ability to monitor the nest for more accurate estimates of nest success without the potential of unknowingly using dump nests or previously abandoned nests in success or predation estimates.

Management Implications

Research scientists interested in the nesting ecology of pheasants on specific research sites should consider using radio-collared hens captured in the spring due to the high retention of hens on capture locations despite the low capture rate. However, if the goals of the project were to analyze landscape-scale use of available nesting cover, we found winter bait-trapping was the most efficient way to capture pheasants and likely the best way to assess a population's nesting ecology at the landscape scale.

Each nest searching method has its advantages and disadvantages. For the purposes of a site-specific study assessing nesting ecology of pheasants, the use of telemetry from spring-captured nightlighted birds is the most beneficial and least disruptive way to monitor female pheasants. For a landscape-scale study, using telemetry with winter bait-trapped pheasants is the most efficient way to collect data. If researchers are interested in surveying small areas to assess the density of pheasant nests to extrapolate to the entirety of a larger area, we found the intense ground searching method as the best fit. Lastly, if researchers are interested in studying pheasants over areas of land that are too expansive to cover via intense nest searches, and/or are interested in assessing upland nesting ducks as well, then the chain drag method is the best candidate. When designing a nesting ecology study on pheasant, survey objectives, availability of personnel, and the wintering and nesting ecology of pheasants in the region are factors that will help to determine which nest searching method is most appropriate for a particular study.

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CHAPTER 4. USE OF HOME RANGE ESTIMATORS FOR EVALUATING RING-NECKED PHEASANT (*PHASIANUS COLCHICUS*) HABITAT USE AT MULTIPLE SCALES²

Abstract

Habitat use and home range size of ring-necked pheasant (*Phasianus colchicus*) were analyzed using telemetry and GIS mapping techniques in southwestern North Dakota. Movement and habitat use of 191 pheasant was monitored via telemetry. Pheasant movements and GPS (Global Positioning System) locations were recorded weekly from July 2010 to April 2012. For birds that had ≥ 20 GPS locations (n= 89), we determined home range using two different estimators: minimum convex polygon (MCP) and kernel density estimation (KDE). We then compared proportions of each habitat type within the polygons determined by each of the home range estimators against each other and the habitat availability within the study area. Habitat types were delineated from 2010 NAIP (National Agriculture Imagery Program) imagery and broken into 7 categories: croplands (Crop), farmable herbaceous cover or Conservation Reserve Program (CRP) cover (CRPcov), rangeland cover (RngCov), farmsteads with livestock (FarmStd), wetlands (WetCov), shelterbelts (WoodCov), and other areas that did not fall within these previously stated categories, including urban areas (Other). Upon delineation, areas where the ground cover was unknown were ground truthed by visiting the areas in question. We also analyzed proportions of edge within each home range polygon. The average home range

² This chapter is co-authored by Jeffery Stackhouse, Kevin Sedivec, Arthur Stackhouse, and Benjamin Geaumont. Jeffery Stackhouse (graduate student) was the main co-author responsible for collecting data, data processing, statistical analysis, interpretation of statistical outputs, and incorporating those data into the information presented in this chapter. Arthur Stackhouse provided assistance with technical data processing and analysis. Benjamin Geaumont provided insight on study design and helped with data collection and statistical analyses. Both Benjamin Geaumont and Kevin Sedivec helped with editing and added professional insight throughout the chapter.

size of individuals in our population using the MCP and KDE estimates was 2583 and 2368 hectares, respectively. Within each home range type, the average number of hectares needed to produce 1 kilometer of edge for MCP and KDE estimates was 209 and 200; respectively, as compared to the 287 ha/km that was considered available in our study area MCP. These estimates of animal space use and annual home range size is beneficial for managers attempting to improve pheasant habitat on the landscape.

Introduction

Introduced to the United States late in the 19th century, pheasants have grown to become one of America's favorite game birds (Johnson and Knue 1989). Due to their popularity, ring-necked pheasants (*Phasianus colchicus*; hereafter, pheasant) are one of the most studied species in North America, and as such, there have been many studies conducted on their habitat preference and space use (Guidice and Ratti 2001). Home range is one of the most commonly used techniques to analyze habitat selection for wildlife species. Many different methods and techniques within those methods have been developed to assist in the creation of home range polygons in space use studies. Data on space use by wildlife typically consists of a series of discrete observations over time (Litchi and Swihart 2010). Since direct observation of the home range is usually impossible, home ranges are usually modeled from discrete observations (Horne et al. 2007). Home ranges often model polygons described as utilization distributions, or estimates of the probability that an animal will fall within a particular area during a specific time (Worton 1995, Horne and Garton 2006). Estimating the probability of an animal occurring in a given area can be very useful for biologists assessing multiple aspects of habitat for an individual simultaneously.

Unlike a single point, usually with 1 habitat variable, a polygon can contain many different habitat types and describe necessary landscape-scale attributes required for a species' existence.

Numerous methods for estimating home range have been developed (Horne and Garton 2006). With each method comes discussion of associated pros and cons of available estimate strategies, use, correction factors, and available computer programs associated for deriving each estimate. Currently, the most commonly used estimate is a variation of the kernel density estimator (KDE). This has been suggested as the best-available non-mechanistic home range estimator (Kerohan et al. 2001, Horne and Garton 2006, Lichti and Swihart 2010). Kernel density estimation is a statistical technique for estimating an underlying probability density function from the data input where a kernel is placed over each observation and the probability density values are created by summing the neighboring values of that point (Horne and Garton 2006). The width of each kernel placed over the observed locations is called the smoothing parameter, which is chosen by the scientists, and therefore must be reported as a factor in establishing KDE estimates (Horne and Garton 2006). There are numerous smoothing parameters (i.e, bandwidths) that can be chosen within the KDE estimate, causing variation in data output. Likelihood Cross-Validation (i.e., smoothed cross validation) bandwidth was used in our study because it generally performs better than the other methods and was found to be especially beneficial for small sample sizes (Horne and Garton 2006). There are numerous types of KDE models. We chose to use the Gaussian bivariate normal estimate because it was found to be least affected by both observation bias and unequal observation rates (Horne et al. 2007). This estimate was the recommended default of the Geospatial Modeling Environment

(GME) program that we used to create our initial KDE rasters (Beyer 2012). Kernel techniques are useful for estimating intensity of home range use and therefore the degree of habitat use within an animal's home range.

Historically, the minimum convex polygon (MCP) (Mohr 1947) was the preferred home range estimator and is still commonly used today. A MCP, also known as a minimum convex hull, is a planar polygon that contains all line segments connecting any pair of points (Mohr 1947). The benefit of the MCP estimator is that it is nonparametric and is conceptually easy to understand and create for analysis (Mohr 1947). The MCP creates a boundary around the furthest-most dispersed points of an individual's observed locations, therefore including every known location in analysis. Unfortunately, the MCP is sensitive to outliers, sample size, and ignores boundaries that exclude animal movement within the home range polygon such as waterways, urbanization, or other uninhabitable landscapes. We chose to model both the KDE and MCP home range estimators so our results were comparable with current and historical studies of ring-necked pheasants.

Study Area

The study was conducted on a heterogeneous landscape near Hettinger, North Dakota in Adams County (Figure 4.1). Overall, the study area included about 23,500 ha of privately and publicly owned lands in both North and South Dakota. Trapping sites consisted of 4 privately owned tracts of land in North Dakota. Prior to the beginning of our research, land parcels used for nightlighting were enrolled in CRP for approximately 10 years. At the onset of the CRP contract, each parcel of land was established with cool season grasses and legumes that included intermediate wheatgrass (*Elymus hispidus* (P.

Opiz) Melderis), crested wheatgrass (*Agropyron cristatum* (L.) Gaertn), alfalfa (*Medicago sativa* L.), and yellow sweetclover (*Melilotus officinalis* (L.) Lam.) (Geaumont et al. 2010). The 2 winter trapping sites were privately owned areas that held high densities of pheasants during the harsh winter of 2011.

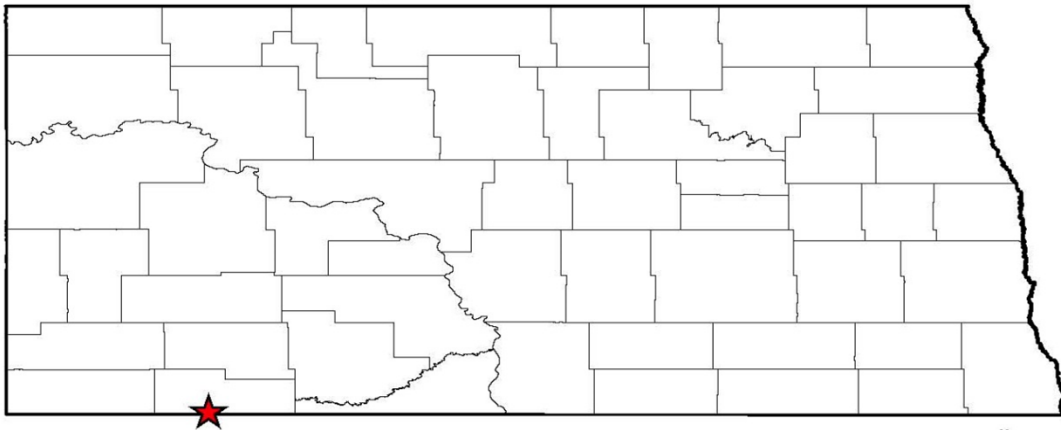


Figure 4.1. Map of North Dakota with the relative location of the research site. The red star indicates the center of the pheasant population’s minimum convex polygon.

The study area receives approximately 41 cm of precipitation annually, with 87 percent occurring from April through October (NDAWN 2012). The 20-year average winter temperature (January through March) is approximately -9°C and average summer temperature (June through August) approximately 19°C (NDAWN 2012). Fifty-six year averages and annual fluctuations in monthly precipitation and temperatures are shown in Figures 4.2 and 4.3, respectively. Data included in these figures was collected daily at the Hettinger Research Extension Center.

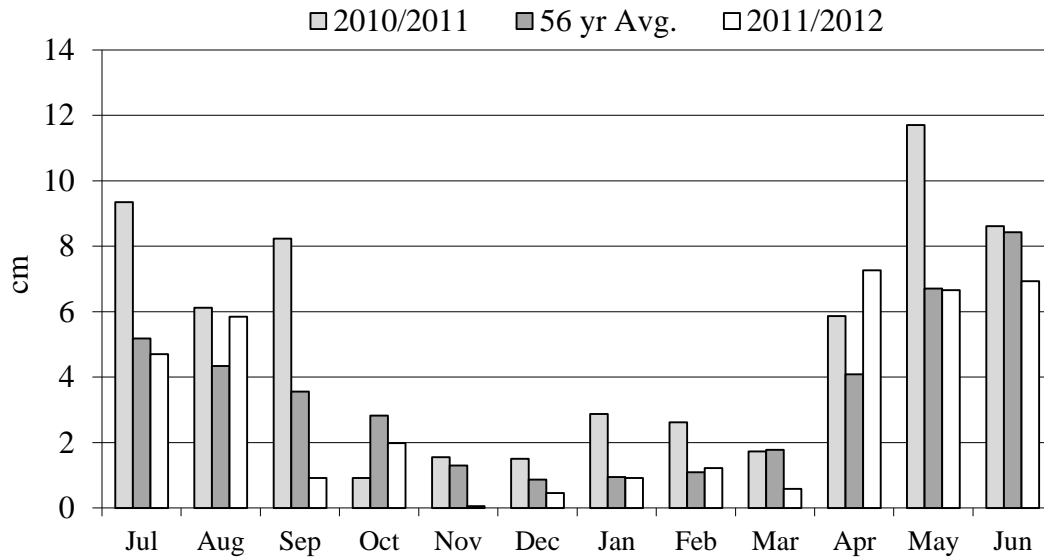


Figure 4.2. Average monthly precipitation (cm) in Hettinger, ND for 2010/2011, 2011/2012, and the 56 year average. Data provided from the Hettinger Research Extension Center climate station.

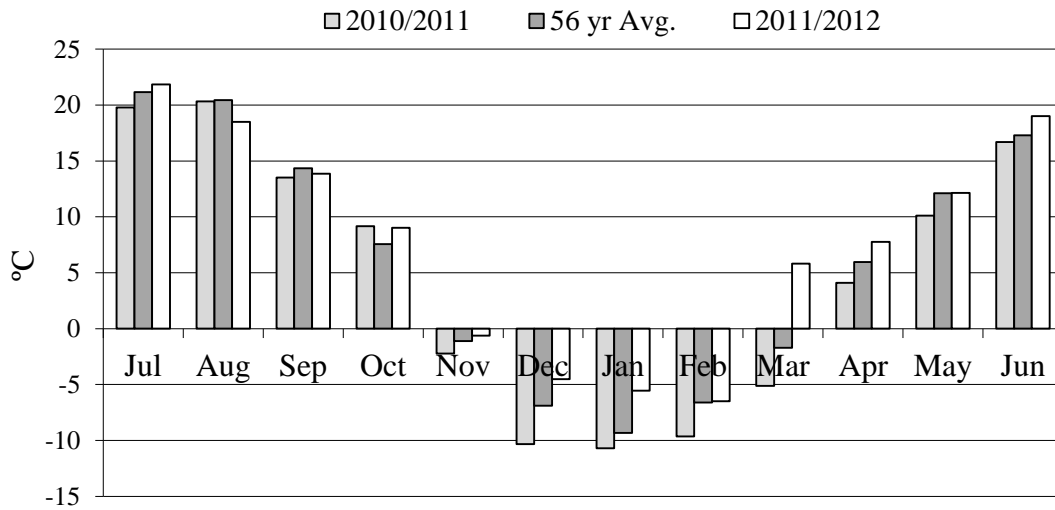


Figure 4.3. Average monthly temperature (°C) in Hettinger, ND for years: 2010/2011, 2011/2012, and the 56 year average. Data provided from the Hettinger Research Extension Center climate station.

Methods

Data Collection

For the duration of our study, we monitored pheasants equipped with 12.5-g necklace-type radio transmitters similar to Riley and Fistler (1992) and Perkins et al. (1997) purchased from Advanced Telemetry Systems; Insanti, Minnesota. Radio collared pheasants were monitored 1 to 3 times a week using handheld three element Yagi antennas and model R2000 receivers (Advanced Telemetry Systems; Isanti, Minnesota). Pheasants were captured during 1 of 5 occasions, using 2 different techniques. Capture techniques employed were nightlighting and winter bait-trapping, both previously shown to successfully capture adult pheasants (Labisky 1968, Gates 1971, Dumke and Phils 1979, Perkins et al. 1997, Gabbert et al. 1999). In the summer and fall of 2010 and spring and fall of 2011, we captured pheasants using the nightlighting techniques similar to those described in Labisky (1968). During the winter of 2011, we captured pheasants at winter bait stations (Gates 1971, Perkins et al. 1997). Upon capture, pheasants were sexed and equipped with radio collars, as previously described, and their movements monitored starting 1 week post-capture to allow for the individuals to get accustomed to the radio collars.

The radio collars were not thought to affect survival or movements of pheasants, therefore were assumed to have no effect on the results. We used trapping and handling techniques that were approved by The North Dakota State University Institutional Animal Care and Use committee (Protocol #A11034).

Pheasant trapping began in May 2010 and pheasant movements were monitored until April 2012. We tracked pheasant movements and recorded locations at least once a

week from May – December, and twice a week from January – April for the duration of the study. Pheasant locations were found either by homing pheasants or by using triangulation techniques. Resulting coordinates were derived using handheld GPS units. Pheasants that had not been located for ≥ 10 months were removed from the active telemetry search list. If an individual bird died or was considered lost prior to 20 relocations the individual was removed from the home range analysis (Leif 2005). Similarly, active birds with less than 20 observed point locations were not used in calculating individual home range estimates. Individuals with ≤ 20 observations were added to the general population's observed locations to create the study area boundary but were not used in any individual analyses.

Data Processing and Analysis

To create our home range polygons and tables required to run statistical analyses on those home ranges, we chose to use the Economic and Social Research Institute's (ESRI's) ArcInfo products: ArcMap 10 and ArcCatalog 10. The original dataset was created from a Microsoft Excel file with fields for: landowner, date, coordinates, descriptive habitat type, and notes. Each Excel spreadsheet was converted to comma-separated-values (csv) before use in ESRI's ArcMap or ArcCatalog.

We used the Python scripting language to convert our raw data files into the required format. To assist in the creation of the Python script, the program software WingIDE 4.0 (Wingware Python IDE, Version 4.0.2-1) was utilized to write and run the code that would analyze each of the 191 Excel spreadsheets in our dataset. This Python script converted each spreadsheet into a csv file for use in ESRI products and removed birds with data that spanned < 1 week. Birds that lived < 1 week were considered to have

potential research-related mortality and were removed from all analyses. Converted files were used as input into ESRI products to begin the home range analysis.

The purpose creating these programs was to use Chi squared analysis with SAS (Statistical Analysis Software) to assess selection of observed home range habitat proportions versus the available proportion of habitat types on the landscape scale for both MCP and KDE home range estimators. Habitat preference is defined as the disproportionate use of some resources over others (Hall et al. 1997, Gabbert et al. 1999) and is the reflection of the likelihood of a particular resource being chosen if offered on an equal basis as others (Johnson 1980). Habitat preference was analyzed by habitat type in our study using seven categories: CRP (Conservation Reserve Program) Cover, Range Cover, Shelterbelts, Wetlands, Croplands, Farmsteads, and Other. Typical crops for southwestern North Dakota include but are not limited to canola, sunflowers, corn, and small grains. CRP cover consisted of all areas of CRP-type grasses that were hayed, grazed, or left as idle grasslands. Range areas were those grasslands that consisted of primarily native grasses that were either left as idle or grazed.

We defined the study area by mapping the 3909 locations from 184 pheasants that provided one or more GPS locations, creating a MCP, and then clipping the MCP to the 2010 NAIP (National Agriculture Imagery Program) imagery for Adams County, ND (Sawyer et al. 2006). We used NAIP imagery to designate cover types and delineated each cover type in ArcMap 10, similar to Gabbert et al. (1999). Once the NAIP imagery was delineated into seven habitat categories the areas in question were then ground truthed and adjusted accordingly as to match the correct habitat type on the landscape. We then created

MCPs for individuals with ≥ 20 points and intersected the MCPs on the digitized maps. Once overlain on the maps, proportions of habitat types within the MCPs were calculated.

To assess each individual's home range habitat proportions, size, and overall abundance of edge we used ArcCatalog 10. ArcCatalog used csv files to create MCP polygons and provided tools necessary to quantify all other datasets. In ArcCatalog; however, we were not able to create the KDE polygons that we wanted with the specified types and techniques discussed earlier in this chapter. Therefore, we used the program Geospatial Modeling Environment provided by spatialecology.com as a free data processing program (Beyer 2012). This program enabled us to create KDE estimates that use the Gaussian bivariate normal kernel type using smoothed cross validation smoothing parameters and a 10x10 m kernel size.

We chose the 10 m grid size through trial and error and tried KDE estimates that were both larger and smaller. The 10 m cell size was the largest usable size without causing noticeable problems with pixelated edges as suggested by Beyer (2012). Using the Geospatial Modeling Environment program, we were able to create floating, grid-based rasters that represented each bird's KDE that could then be imported into ArcCatalog for further analysis. Once imported into ArcCatalog, the floating rasters were multiplied by 100 to make all grid values > 1 (Figure A1), converted to integer rasters (Figure A2), and then converted to polygons (Figure A3). The top 95 percent of the KDE were selected in the model represented by Figure A4 and transformed the values back to the original scale by dividing by 100 before importation to the general GIS (Global Information System) point/polygon processing sequence that eventually created required Excel spreadsheets for statistical analysis.

GIS Modeling

Within ArcCatalog 63 models, with numerous steps per model, were used to create usable output tables. After running our Python script in WingIDE, we created a model that made a frequency table for each GPS location recorded during our study (Model 5, Figure A5). We then created a model that made individual bird feature classes from the initial population's feature class (Model 6, Figure A6). In model 7, we iterated through each feature class created by model 6, added a field for the sum of all observed points for that individual and calculated the individual's total point count (Figure A7). Model 8, shown in Figure A8, created individual bird MCPs by iterating through each bird's data, applying the points to the map, and creating a minimum bounding polygon. Model 9 took the MCPs that were calculated for each individual (and the total population) and created the same number of random points within each MCP that were found for the total point count in model 7 (Figure A9). Upon the creation of random points in model 9, we intersected the MCPs with the cover types that were derived from delineating the NAIP image discussed earlier in this chapter, using model 10 (Figure A10). Model 11, Figure A11, created an empty append for a MCP cover intersect feature class to be created in model 12. Model 12 iterated through each individual bird's feature class, collected the values, and then appended those values to the MCP attribute table (Figure A12). Model 13 was used to discard the 95 individual pheasants that did not have ≥ 20 observed locations (Figure A13). Model 14, Figure A14, generated MCP habitat frequencies to be added to the frequency tables.

Model 15 iterated through the observed locations for each bird and intersected the observed points with their associated cover (Figure A15). Models 16 and 17 iterated through the random points generated for each bird, added fields for the random points, and

filled the fields by intersecting the random points with the cover map (Figures A16 and A17). Model 18 organized a datasheet that could be exported to Excel that summarized all point data (both observed and random) in a format that was compatible with SAS, called “AllBirdPoints” (Figure A18). Model 19 filled the datasheet by appending the point intersects into the “AllBirdPoints” table (Figure A19).

After creating the “AllBirdPoints” to be entered into SAS as the point data, the next step in our analysis was to analyze the home range polygons to a greater extent. Model 20, Figure A20, created an empty table called “BirdData” for outputs from the next series of models. Models 21 – 38 analyzed the MCP polygons for each individual bird and for the population. The goal of this series was to develop proportions of each habitat type, a total count of points, and total home range area for each individual bird and send those data to the “BirdData” table. Figures A21- A32 show the steps of each corresponding model: 21) fixed the random, intersected points and gave them a total count field in the table, 22) calculated the frequencies of the observed points and their associated habitat types, 23) calculated the frequencies of the random points and their associated habitat types, 24) created empty columns for observed data in the frequency table, 25) iterated through each bird’s table and appended all observed data points, with their associated cover, to columns in the table, 26) viewed the number of observations in a table and appended values that were greater than 19, 27) created empty columns for random data in the frequency table, 28) iterated through each bird’s table and appended all random data points, with their associated cover, to columns in the table, 29) viewed the number of random points in the table and appended values that were greater than 19, 30) created empty columns for all (the population’s) MCP data in the frequency table, 31) appended all of the random and

observed data points generated for each bird (within each individual's MCP) and the observed and random points generated for the population and the extent of the study area. These data (collected in a table by model 31) were then summarized in a frequency table by model 32.

Model 33, Figure A33, took the frequency table from model 32 and appended it with "BirdData" to create one frequency table for this series of models. Models 34 and 35 populated point values for the "BirdData" table, as shown in their related Figures A34 and A35, respectively. Model 36 generated the total MCP area for each bird and the population, and model 37 added fields for habitat proportions that were then populated in model 38 (Figures A36, A37, A38). This series of models finished the MCP analysis for our study.

The next step of our proportions-based data processing was to create similar summary tables for the KDE polygons that we created from models 1 – 4 described earlier. Models 1 – 4 created polygons from rasters. However, some of those polygons had lines within the outer bounds of the polygon. After matching each KDE with its associated bird identification in model 39, we dissolved the inner lines of the polygon using model 40 and added total point count values with model 41 (Figures A39, A40, and A41). We then used model 42 to intersect the dissolved KDE polygon with the cover map and created empty feature classes to be appended with models 43 and 44, respectively (Figures A42, A43, and A44). Model 45 took these tables and generated habitat frequencies while model 46 calculated the total KDE areas for each polygon, model 47 added KDE fields to the "BirdData" frequency table, and model 48 populated those fields with the appropriate habitat proportions for each bird's 95% KDE home range polygon (Figures A45, A46, A47, and A48).

The last datasheet created in ArcCatalog and exported to Excel for further analysis was called “BirdTotals”. Models 49 – 63 were created to build this datasheet. Model 49 was used to build the table by adding the appropriate fields that contained data for each bird and the population, including: total number of observed points, MCP and KDE total areas, and MCP and KDE total amount of habitat edge (Figure A49). Models 50 and 51 were used to take data that was collected in the “BirdData” tables and append it to the “BirdTotals” table (Figures A50 and A51). Models 52 – 57 were constructed to calculate the total amount of habitat edge within a bird’s MCP and place a total edge measurement (km) into the “BirdTotals” frequency table. Model 52 was created to iterate through each bird’s MCP and generate habitat lines (edge) while model 53 was built to select only the inner lines of each polygon and model 54 calculated the length and the frequencies of each line that were then added to each bird’s frequency table by model 55 (Figures A52, A53, A54, and A55). Model 56 took the inner line frequencies and collected them into one frequency table. This table was then joined and populated by model 57, finishing the edge calculations for the MCPs (Figures A56 and A57).

Similar edge analyses were conducted for the KDE polygons by models 58 – 63 for the “BirdTotals” frequency table. Similar to models 52 and 53, model 58, shown in Figure A58, was created to generate KDE inner line values while model 59 was created to select only the inner lines of each polygon, representing habitat edge (Figures A58 and A59). Model 60 was created to calculate the frequency of each set of inner lines for each bird and model 61 and 62 combined those lines into one frequency table (Figures A60 and A61). Lastly, model 63 populated the KDE edge estimates into the “BirdTotals” table to complete our data analysis goals in ArcCatalog (Figure A63). Upon completion of model 63,

“BirdTotals”, “BirdData”, and “AllBirdPoints” were converted to dbase files to be exported to Excel for further manipulation and statistical analyses.

Data Analysis

In total, 89 MCPs and 89 KDEs were created from the initial 191 individual pheasant datasheets (See example: Figure 4.4): one for each individual pheasant with ≥ 20 observed points and one for the population were created for comparison of each individual’s home range habitat proportions to available habitat as a measure of habitat selection. The tables that were created in ArcCatalog were refined and formatted in Excel and the outliers removed. Outliers included $\sim 5\%$ of the home range dataset for both the MCP and KDE estimated areas and were removed from the dataset. Once the data was formatted in Excel, we compared individual pheasant home range sizes and the proportion of habitat types within the home ranges against their availability on the landscape in both the KDE and MCP estimates. We then used 95% confidence intervals to determine relative significance of reported habitat preferences within each cover type.

Pheasant 980A Home Range Estimates

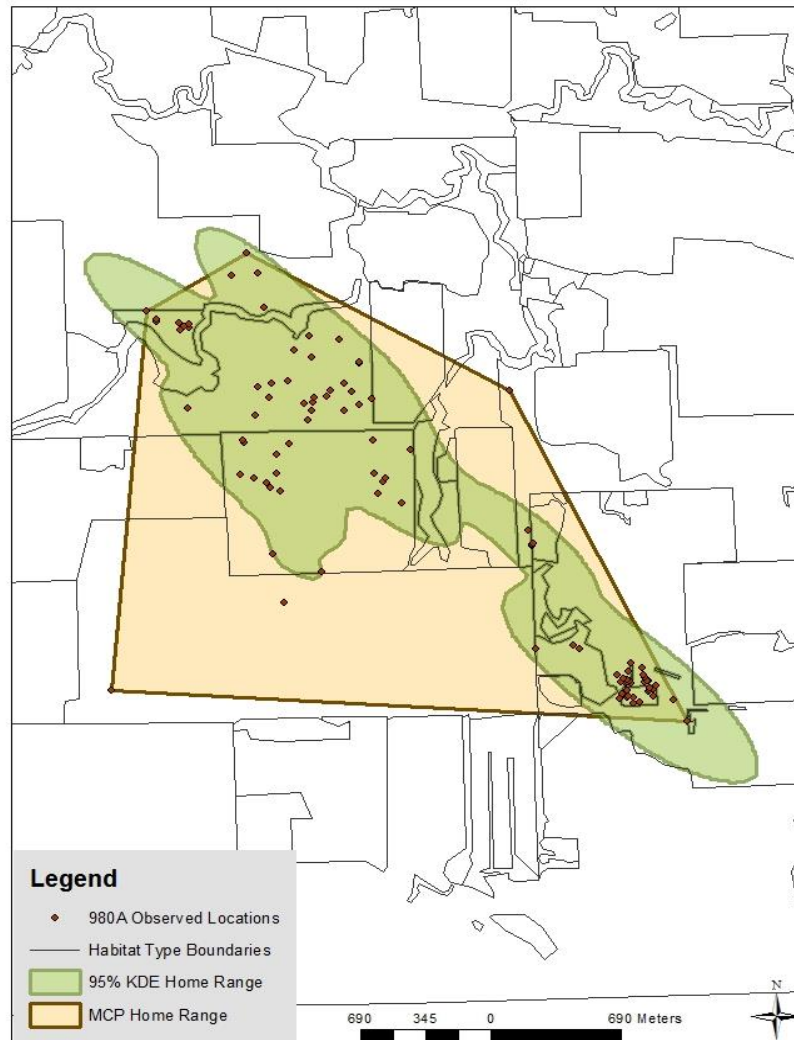


Figure 4.4. Visual representation of a pheasant hen’s (980A) minimum convex polygon (MCP), 95% kernel density estimation polygon (KDE), and all observed points (n=100) overlain on the habitat type map for our study area in southwestern North Dakota, October 2010 – March 2012.

Results

The average number of points used to derive 89 annual home range estimations was 39, and ranged from 20 to 100. Of the 89 pheasants that contained ≥ 20 locations, 31 were roosters and 58 hens. The total number of observations (points) in the study used to create the compiled population MCP estimates (i.e., study area) was 3908. The areas of high

observed point density is the driving factor for why the population KDE estimate was much smaller than the population's MCP estimate (Table 4.1). Since the population KDE appeared to be biased toward trapping areas, for all comparisons we used the population MCP as an estimate of available habitat proportions. We used confidence intervals to test the population MCP against both the MCP and KDE averages compiled from the individual estimates.

Table 4.1. Summary of annual home range values estimated using minimum convex polygon (MCP) and kernel density estimation (KDE) techniques for a population of ring-necked pheasant in southwestern North Dakota, July 2010 – March 2012.

	MCP Area (ha)	KDE Area (ha)	MCP Edge (m/ha)	KDE Edge (m/ha)
Individual Bird Average ^a	2583	2368	4.76	4.93
Median of Individual Bird Values ^b	2195	1705	4.56	5.06
Compiled Population Estimates ^c	235183	13113	3.49	5.48

^aAverage of all individual bird home range estimates after removing the outliers (n= 81).

^bMedian of all individual bird home range estimates after removing the outliers (n=81).

^cValues calculated for the entire population's home range estimates, derived by including every observed point during the study from a total of 191 collared pheasants.

The average number of points used while calculating home ranges was 41 and 38 for roosters and hens, respectively. Hens tended to have larger home range estimates in areas of less edge proportion than males within the same study area (Table 4.2). From all sites, pheasants were able to move freely and we observed several individuals disperse over 7.5 kilometers.

Table 4.2. Summary of male and female annual home range values estimated using minimum convex polygon (MCP) and kernel density estimation (KDE) techniques for a population ring-necked pheasant in southwestern North Dakota, July 2010 – March 2012. (SE= Standard Error)

	MCP Area		KDE Area		MCP Edge		KDE Edge	
	(ha)	SE	(ha)	SE	(m/ha)	SE	(m/ha)	SE
Male ^a	2092	305	1875	244	5.00	0.71	5.58	0.75
Female ^b	2881	285	2694	323	4.70	0.49	4.91	0.56

^aAverage of male home range and edge density estimates (n= 25).

^bAverage of female home range and edge density estimates (n=56).

After estimating average size of pheasant home ranges, we were interested in assessing proportions of habitat within the average individual’s home range in comparison to what was available on the landscape. Habitats were considered to be selected if they were present within the home ranges at greater proportions than on the study area (Johnson 1980, Perkins et al. 1997, Gabbert et al. 1999, Schmitz and Clark 1999). To make this comparison, we used the population MCP’s habitat composition as the available habitat proportions for pheasants to select from and used the average proportions from the same 81 individual MCPs that were used to create the average and median estimates in Table 4.1. The proportions of used habitats for the MCP and KDE estimates are shown in Tables 4.3 and 4.4, respectively. Table 4.3 represents the average MCP proportions for the 81 individuals against the available proportions of all areas used by pheasants in our study. Table 4.4 made the same comparison of proportions with the estimated KDE polygon proportions for the 81 individuals to the MCP of the population. Both tables have a “Used - Available” value that represents the difference between what was used (i.e., proportions of habitats within the individual’s home range estimates) and what was available (i.e., proportions of habitats within the population’s MCP) to represent trends of habitat selection.

Table 4.3. Summary proportions of annual home range habitat composition estimated using minimum convex polygon (MCP) techniques for a population ring-necked pheasant in southwestern North Dakota, July 2010 – March 2012.

Habitat	Crop	CRPCov	FarmStd	Other/City	RngCov	WetCov	WoodCov
Ind. Mean MCP	0.27	0.44	0.10	0.02	0.10	0.04	0.02
Pop MCP	0.30	0.32	0.01	0.01	0.34	0.02	0.01
Used - Available	-0.03	0.12	0.09	0.01	-0.24	0.03	0.01

Table 4.4. Summary proportions of annual home range habitat composition estimated using 95% kernel density estimation (KDE) techniques for a population ring-necked pheasant in southwestern North Dakota, July 2010 – March 2012.

Habitat	Crop	CRPCov	FarmStd	Other/City	RngCov	WetCov	WoodCov
Ind. Mean KDE	0.29	0.43	0.11	0.04	0.07	0.04	0.02
Pop MCP	0.30	0.32	0.01	0.01	0.34	0.02	0.01
Used - Available	-0.01	0.11	0.10	0.02	-0.27	0.03	0.02

MCP home range estimate areas were typically larger in size than the KDE home range estimates with averages of 2583 and 2368 hectares, and associated standard errors of 211 and 222, respectively (Table 4.1). The average edge densities were greater in the KDE home range estimates than the MCP estimates with 4.93 and 4.76 meters of edge per hectare, and standard errors of 1.03 and 1.01, respectively (Table 4.1). Although the average size of the MCP and KDE home range sizes varied slightly and had rather large

standard errors, the proportions of used versus available habitat types were fairly consistent between the two methods (Tables 4.3 and 4.4).

Crop and RngCov were negatively selected in proportion to their availability. Negative preference for the Crop habitat type was relatively low in both polygons. RngCov; however, showed much greater negative selection in the used versus available proportions in both estimations compared to its availability (Table 4.3). The average individual's home range KDE contained 27% less RngCov and 1% less Crop than the study area while the MCP contained 24% less RngCov and 3% less Crop than the study area's estimated 30% crop and 34% RngCov estimates (Table 4.3 and 4.4).

CRPcov, FarmStd, Other, WetCov, and WoodCov types all showed positive habitat preference when comparing average individual habitat proportions to the study area. CRPcov showed positive selection for both the KDE and MCP estimates with 11 and 12% increases of overall home range habitat proportions from the study area's estimated 32% CRPcov. Although FarmStd only showed a 9 and 10% increase in preference from the study area's habitat proportion, FarmStd only constituted 1% of the study area. Both the MCP and the KDE showed strong selection for FarmStd that had livestock. The Other cover type category showed positive selection compared to the study area availability. The Other classification had little variance between the three polygons.

WetCov estimates were similar for both the KDE and MCP home range polygons. The available WetCov on the landscape was less than 2% while the percent contained within the average home range polygons was greater than 4%. Shelterbelts, or WoodCov, was similar to WetCov in that its proportions contained within the individual's home ranges was almost 2 times that contained in the study area. For both the KDE and the MCP

methods, the rounded proportions of WetCov were 2% of the home range polygons while the proportion of WoodCov on the landscape was less than 1% of the total area.

To express the significance of these differences, we created Table 4.5 that shows the 95% confidence intervals and the differences in used versus available habitat proportions on the landscape. This simple statistical analysis showed that there were highly significant differences in proportions of habitat within the average individual's home range compared to the habitat proportions found within our study area for: CRPcov (positive), FarmStd (positive), and RngCov (negative) as shown in Table 4.5. WetCov also fell outside of the confidence interval, for both MCP and KDE estimates, suggesting that pheasants are selecting for WetCov within their home ranges in greater proportion than what is available on the landscape. Crop, Other and WoodCov habitat types each had overall differences that did not consistently fall outside of the 95% confidence interval, suggesting that preference toward those cover types were neither positively or negatively significant (Table 4.5).

Table 4.5. Summary of the difference in habitat proportions of average annual home range compositions of individual pheasants estimated using 95% kernel density estimation (KDE) and minimum convex polygon (MCP) techniques compared to the proportions of habitat on the landscape. Confidence intervals were created using the data for all individual home range estimates for a population ring-necked pheasant in southwestern North Dakota, July 2010 – March 2012.

Habitat	Crop	CRP Cov	Farm Std	Other /City	Rng Cov	Wet Cov	Wood Cov
MCP – Available	-0.03	0.12	0.09	0.01	-0.24	0.03	0.01
95% CI (MCP) ^a	0.03	0.04	0.04	0.01	0.03	0.01	0.01
KDE - Available	-0.01	0.11	0.10	0.02	-0.27	0.03	0.02
95% CI (KDE) ^b	0.03	0.04	0.03	0.02	0.02	0.01	0.01

^a(+/- 95%) Confidence intervals for all MCP habitat proportions.

^b(+/- 95%) Confidence intervals for all KDE habitat proportions.

Discussion

Compared to previous studies, our MCP and KDE estimated pheasant home ranges were large. Our average home range estimates were 2583 ha for the MCP method and 2368 ha for the 95% KDE method. Most other studies that have analyzed pheasant home range have been interested in seasonal home range size, either summer reproduction areas or winter survival and associated habitats. It has been reported that home range size is generally smaller in the winter than in the spring for most pheasant species (Gatti et al. 1989, Perkins et al. 1997, Gabbert et al. 1999, Xu et al. 2009). It was reported by Gabbert et al. (1999) and Perkins et al. (1997) that severe weather likely concentrates pheasants in few, widely-spaced patches of thermal cover. As a result, other studies reported home range sizes of: 36 ha (Hanson and Progulske 1973), 24 ha (Gatti et al. 1989), 35 – 145 ha (Perkins et al. 1997), 37 - 48 ha (Schmitz and Clark 1999), 55 - 73 ha (Homan et al. 2000), 137 - 278 ha (Warner et al. 2000), and 25 ha (Gabbert et al. 2001). All these values are

much smaller than our estimated home range values of > 2000 hectares. Whiteside and Gunthery (1983) conducted research on a population of pheasants in Texas where they split home ranges by season and found home range size varied by season from 14 to 7 ha depending on the season and the sex. Combining these seasonal home ranges as we did, combines each seasonal home range and all annual movements, therefore creating the potential for greatly increased home range estimations as previously discussed.

The proportions of our home range habitats were similar to other studies, despite their size. Homan et al. (2000) reported similar negative selection for croplands in their study of pheasant habitat use in southeastern North Dakota. Also, similar to previous studies, we found that pheasants were selecting for areas that had greater proportions of wetland cover and CRP-type grass than was available on the landscape (Gates and Hale 1974, Gatti et al. 1989, Leptich 1992, and Gabbert et al. 1999, Homan et al. 2000). Our study also concluded that farmsteads with livestock were positively selected. We suspect that was due to decreased food availability during the winter months in correlation with increased snow depths, especially during the 2010/2011 winter. These farmsteads commonly had shelterbelts in close proximity that were used in correlation to the areas that contained livestock. The shelterbelts that contained pheasants during deep snow typically contained multiple rows of coniferous trees with dense underbrush, but were not quantified during our study (Gabbert et al. 1999).

Similar to Homan et al. (2000), we found pheasants tended to show plasticity in their selection of habitats. As snow depth increased they moved from idle grasslands to large wetlands and finally to farmsteads with dense shelterbelts and livestock. This observation is also similar to reports by Gatti et al. (1989), Perkins et al. (1997), and

Gabbert et al. (1999). Comparison of winter 2010/2011 to 2011/2012 made this especially evident. The first winter was much colder with greater snowfall and accumulation than the average year while the second year was dryer and warmer than average (Figures 4.2 and 4.3). We noted that individuals moved greater distances and concentrated in greater numbers during the cold, wet 2010/2011 winter than they did during the mild 2011/2012 winter.

We expect that during cold, wet winters, pheasants in the vast southwestern North Dakota landscape are forced to travel distances of up to 8 km to reach farmsteads that contain livestock and shelterbelts to provide adequate areas of winter food and cover. Pheasant movements were more restricted hence producing smaller home range sizes during the winter of 2011/2012. Since most individuals had relatively low observation rates (≤ 100) we did not attempt to split our dataset into seasons or year. We were able to make seasonal and yearly separations using habitats correlated to single point locations, discussed in greater detail in Chapter 5.

Our measurement of edge within home range polygons compared to the study area showed similar results as previous studies. Pheasants were selecting for areas of greater proportions of edge than what was available (Schmitz and Clark 1999). The average edge density within the study area was 3.5 meters of edge per hectare, while the observed pheasant edge densities averaged 4.8 m/ha for MCP estimates and 4.9 m/ha for KDE estimates. This suggests that pheasants select for areas with greater proportions of habitat edge in our study area.

Management Implications

The results presented in this chapter suggest that pheasants in southwestern North Dakota have much larger home ranges than other populations in the Midwest when using either MCP or KDE estimation techniques. The magnitude of these movements is likely caused by winter severity where pheasants are forced to travel greater distances in severe climatic conditions to find suitable thermal cover in close proximity to food.

Since southwestern North Dakota has few, widely spaced farmsteads with adequate food sources and shelterbelts for thermal winter cover, pheasants are forced to move up to 8 km in this area. In our study region, managers wishing to have viable pheasant populations on management areas smaller than 2000 ha should consider altering their landscape to contain ample amounts of CRP-type cover, large wetlands with cattails, and dense, coniferous shelterbelts in close proximity to livestock to provide pheasants with the necessary cover for their annual habitat requirements.

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CHAPTER 5. RING-NECKED PHEASANT (*PHASIANUS COLCHICUS*) WINTER SURVIVORSHIP AND HABITAT SELECTION³

Abstract

Goals in management of ring-necked pheasants (*Phasianus colchicus*) are commonly directed toward increasing the survivorship of wild populations. Managers often attempt to alter survivorship by enhancing habitat and limiting hunting pressures. Knowing the survivorship of a population over time allows biologists to assess the impacts that their management techniques have upon the population of interest through differing time intervals and environmental variables. This is especially useful in understanding fluctuations, trends and driving factors behind those changes within a population. As managers begin to better understand those factors effecting survival within a population and what kind of habitats individual are selecting for, they can better analyze ways to alter the availability of those environmental components to benefit the population. We used Program MARK to assess the survivorship of pheasants in southwestern North Dakota from January to April for 2011 and 2012. We assessed our data from 184 pheasant equipped with mortality-sensing necklace-style radio transmitters. These 184 individuals were categorized by sex for both time intervals. We trapped each pheasant during one of 5 trapping occasions to equip each individual with a radio collar. Upon completion of testing each reduced parameter model from the full, we found the full time-dependent model including sex, time, and sex*time interactions to be the best fit for the winter 2011 dataset

³ This chapter is co-authored by Jeffery Stackhouse, Kevin Sedivec, Arthur Stackhouse, and Benjamin Geaumont. Jeffery Stackhouse (graduate student) was the main co- author responsible for collecting data, statistical analysis, interpreting statistical outputs, and comprising the information presented in this chapter. Arthur Stackhouse provided assistance with data processing and analysis. Benjamin Geaumont provided insight on study design and assisted with statistical analyses. Both Benjamin Geaumont and Kevin Sedivec helped with editing and added professional insight throughout the chapter.

and the model including time only to be the best fit model for the 2012 winter. Overall winter survival was 0.91 in 2011 and 0.85 in 2012. We used the same telemetry dataset to overlay GPS (Global Positioning System) points on a digitized map in ESRI's (Economic and Social Research Institute) product ArcMap 10 to assess habitat selection of ring-necked pheasant. We categorized the habitat types into 7 categories. For each observed point, we generated one random point on the digitized map using ArcCatalog 10 which were used to define habitat availability. We then took the habitat types from an overlay of both random and observed points to create a spreadsheet to be used for logistic regression analysis in SAS (Statistical Analysis Software). Our habitat use analysis indicated a positive correlation for pheasant selection toward woody habitat types and farmsteads with livestock during the disparate winter of 2011 and during the mild winter of 2012; however, analysis of winter of 2012 also suggested pheasant selection toward wetland and Conservation Reserve Program (CRP) type grass cover. Habitat use during spring, summer, and fall, showed positive correlations to CRP-type grasses, wetland cover, and wood cover. All analyses supported negative selection of pheasants toward habitats classified as range-type grassland cover.

Introduction

Introduced to North America in 1881, ring-necked pheasant (*Phasianus colchicus*) are a highly sought after game bird and as such much research has been conducted regarding their ecology (Warner 1981, Trautman 1982, Whiteside and Guthery 1983, Snyder 1984, Johnson and Knue 1989, Robertson 1996). Although it is likely that the most investigated aspect of pheasant biology is the species reproductive behavior, survivorship

and habitat selection are commonly assessed for populations throughout the world (Linder et al. 1960, Jarvis and Simpson 1978, Dumke and Pils 1979, Leif 1994). Radio telemetry studies, in particular, have allowed scientists to capture more precise documentation of mortality and related cause of death in pheasant studies in addition to providing a more accurate assessment of habitat use (Dumke and Pils 1973, Snyder 1985).

Due to high winter mortality, most survival studies on galliformes have focused on winter survival and its relationship to cover and food plot habitat types (Dumke and Pils 1973, Gates and Hale 1974, Hill and Robertson 1988a, Perkins et al. 1997, Gabbert et al 1999). However, other studies have focused on spring dispersal and loss of pheasants from the time they disperse the wintering grounds until the end of the nesting season. Some of these studies have shown greater losses during this time period than occurred as a result of winter (Snyder 1985, Riley et al. 1994, Schmitz and Clark 1999). Low winter temperatures, availability of thermal winter cover, herbaceous reproductive cover, dispersal rates and distances, home range size, percent edge within home range, hunting pressure, population demographics, and fall population density have all been noted to affect pheasant survivorship (Dumke and Pils 1973, Snyder 1985, Hill and Robertson 1988b, Riley et al. 1994, Gabbert et al. 1999, Perkins et al. 1999, Shmitz and Clark 1999, Homan et al. 2000, Warner et al. 2000, Grove et al. 2001).

The objective of this study was to assess winter pheasant habitat use, survival, and movements in southwestern North Dakota. We were also interested in the differences in habitat use throughout the year when pheasants are not constrained by the needs of thermal cover. The usage of a resource is defined as the quantity of the resource that is utilized (Manly et al. 2002). It is assumed that species will select resources that are best able to

satisfy its life requirements, therefore increasing the populations' viability (Manly et al. 2002). This research was conducted to examine annual differences in habitat use and survival of radio collared pheasant to provide insight to managers attempting to alter their lands to increase pheasant numbers for recreational opportunities.

Study Area

The study was conducted on privately owned lands near Hettinger, North Dakota in Adams County (Figure 5.1). The study occurred on approximately 23,500 ha of privately and publicly owned lands in both North and South Dakota. Our trapping sites consisted of 4 privately owned parcels of land in North Dakota. Prior to the beginning of our research, the land parcels used for nightlighting were enrolled in the Conservation Reserve Program (CRP) for approximately 10 years. At the onset of the CRP contract, each parcel of land was established with cool season grasses and legumes that included intermediate wheatgrass (*Elymus hispidus* (P. Opiz) Melderis), crested wheatgrass (*Agropyron cristatum* (L.) Gaertn), alfalfa (*Medicago sativa* L.), and yellow sweetclover (*Melilotus officinalis* (L.) Lam.) (Geaumont et al. 2010). The 2 winter trapping sites were privately owned areas that held high densities of pheasants during the disparate winter of 2011. From these sites, pheasants were able to disperse, and we had numerous birds move over 7.5 kilometers.

The study area receives approximately 41 cm of precipitation annually, with 87 percent occurring from April through October (NDAWN 2012). The 20-year average winter temperature (January through March) is approximately -9°C and average summer temperature (June through August) approximately 19°C (NDAWN 2012). Fifty-six year, long-term averages and annual fluctuations in monthly precipitation and temperatures are

shown below (Figures 5.2 and 5.3 respectively). Data included in these figures was collected at the Hettinger research Extension Center weather station daily.

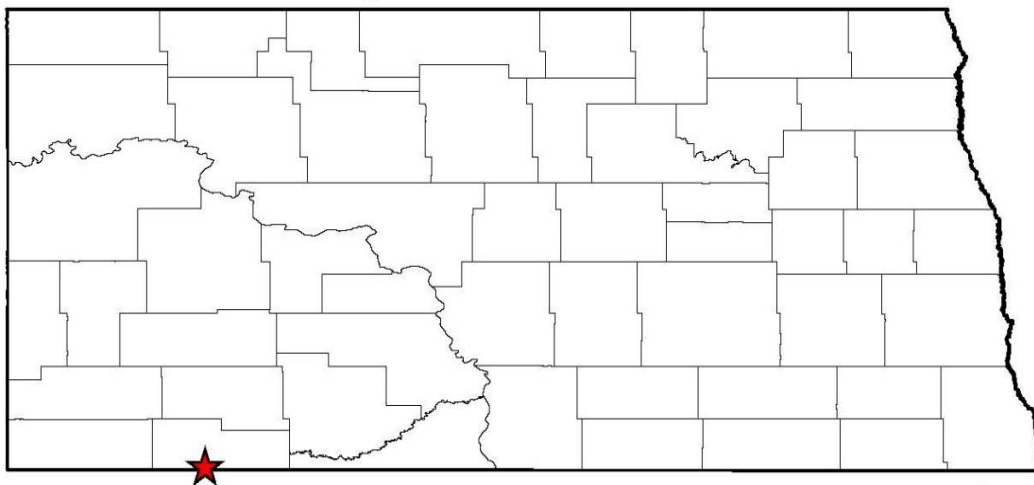


Figure 5.1. Map of North Dakota with the relative location of the research site. The red star indicates the center of the pheasant population's minimum convex polygon.

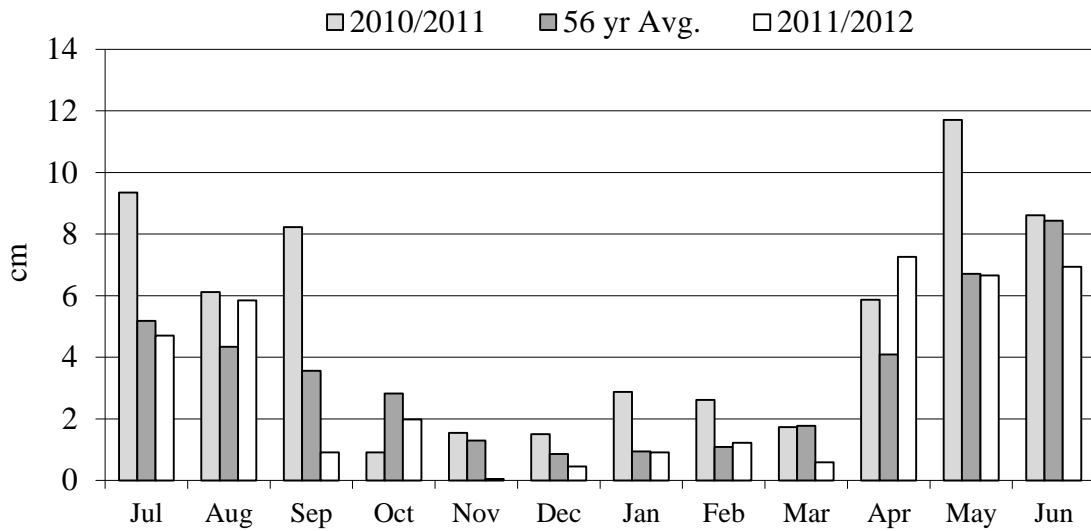


Figure 5.2. Average monthly precipitation in Hettinger, ND for 2010/2011, 2011/2012, and the 56 year average. Data provided from the Hettinger Research Extension Center climate station.

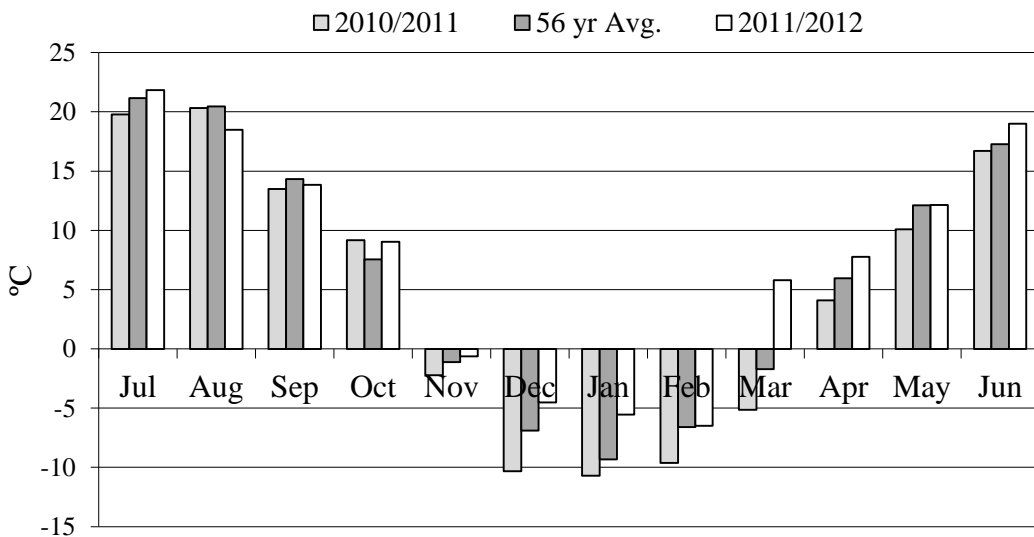


Figure 5.3. Average monthly temperature (°C) in Hettinger, ND for years: 2010/2011, 2011/2012, and the 56 year average. Data provided from the Hettinger Research Extension Center climate station.

Methods

Data Collection

For the duration of our study, we monitored both male and female pheasants equipped with 12.5-g necklace-type radio transmitters (Riley and Fistler 1992, Perkins et al. 1997). Radio collared pheasants were monitored 1 to 3 times per week using handheld three element Yagi antennas and model R2000 receivers (Advanced Telemetry Systems; Isanti, Minnesota). Pheasants were captured during 1 of 5 occasions, using 2 different techniques. Capture techniques employed were nightlighting and winter bait-trapping, both previously shown to successfully capture adult pheasants (Labisky 1968, Gates 1971, Dumke and Phils 1979, Perkins et al. 1997). In the summer and fall of 2010 and spring and fall 2011, we captured pheasants using the nightlighting techniques similar to those described in Labisky (1968) on our research sites. During the winter of 2011, we captured pheasants using bait and wire funnel traps (Gates 1971, Perkins et al. 1997). Upon capture, pheasants were sexed and equipped with either radio collars, as previously described, or banded with butt-end aluminum leg bands for identification purposes.

Neither the radio collars nor the leg bands were thought to significantly reduce survival of individuals used in our research as compared to others in the general population. We used trapping and handling techniques that were approved by The North Dakota State University Institutional Animal Care and Use Committee (Protocol #A11034).

We began trapping pheasants in May 2010 and monitored survival since the first capture. We monitored pheasant survival at least once a week from May - December each year, and 3 times a week from January – April. Pheasant locations were located either by

homing or by using triangulation techniques and resulting coordinates were derived via handheld GPS units. Data used in our statistical analysis was constricted to data collected from July 2010 – April 2012.

Statistical Analyses

Survival estimates were derived using Program MARK known fate analysis. We trapped and collared birds during 5 different trapping occasions; therefore, we attempted to use the Pollock's Kaplan-Meier Staggered Entry Design (Pollock et al. 1989, Riley et al. 1994, Perkins et al. 1997, Cooch and White 2012). However, perhaps as a result of over-abundant censorship our models and subsequent survival estimates were poor. As a result, we assessed our data using the original Kaplan-Meier study design and focused solely on survival of pheasants during the winter months (1 January – 1 April). The focus of known fate models is to estimate the survival probability during a specified interval(s). Known fate analyses assumes that the presence of a radio-collar does not affect the animal's survival and that each sampling probability is assumed to be 1 since radio collars allow for "recaptures" regardless of the animal's actions (Pollock et al. 1989, Cooch and White 2012). Additionally, these methods assume that survival times are independent between animals, that newly tagged animals have the same survival as previously tagged animals, and that the censoring method is random (Pollock et al. 1989, Riley et al. 1994, Cooch and White 2012). It is also assumed that the status (dead or alive) is known for all collared animals at the end of each interval. This analysis is a product of simple binomial likelihoods and the precision of these types of datasets is quite high in comparison to other mark-recapture type studies (Cooch and White 2012).

The original dataset created from the raw-field datasheets was an Excel file that had fields for: landowner, date, coordinates, descriptive habitat type, and notes. Program MARK requires text files as input, with specified encounter histories for each individual pheasant. In total, we had 184 pheasants that lived > 1 week after initial capture, making them eligible for our habitat selection and survivorship analyses. For each interval (week) of our study, each pheasant gets 1 of 3 possible entries: 10, 11, or 00 (Cooch and White 2012). The input “10” implies that the animal survived the interval given that it was alive at the beginning of the interval. Input “11” implies that the animal died during the given interval, given it was alive at the beginning of that interval. Input “00” implies that the animal was censored (omitted) for that interval (Cooch and White 2012). Since the entirety of our study encompassed 90 weeks, or 89 intervals, this resulted in 178 1’s and 0’s required for each of the 184 pheasants before they could be analyzed in Program MARK. Additionally, each Excel sheet needed to be converted to comma-separated-values (csv) before they could be used in ESRI’s ArcMap or ArcCatalog.

In order to accomplish this task we used the program software WingIDE 4.0 (Wingware Python IDE, Version 4.0.2-1) to assist in writing Python scripts that would analyze each of the 191 Excel spreadsheets in our dataset, one for each pheasant ever equipped with a radio collar. This Python script needed to be able to convert each spreadsheet into a csv file to be imported into ESRI products, and remove any bird that did not have data that spanned more than 1 week for data entry into ArcMap and ArcCatalog. Additionally, this program needed to have logic to group each pheasant into 7 categories: sex, age, cohort 1, cohort 2, cohort 3, cohort 4, cohort 5. For each pheasant captured, there were records of the sex and age of the individual, and of the date captured. The program

needed to have logic that placed each pheasant into the correct cohort based on when it was initially captured. Also, the program needed to censor each bird for all weeks preceding initial capture. In addition to placement into these 7 groups, the program had logic that gave each bird the appropriate code: 10, 11, or 00 depending on either the data being present suggesting that the bird was either alive or dead (10 or 11) or the lack of data suggesting that the bird needed to be censored (00) for each weekly interval. The created model is able to convert our field datasheets from Excel into text files which are compatible with Program Mark and ESRI.

Upon computation of habitat utilization for each bird, we combined the data for each bird using summary statistics in ArcCatalog and created an equivalent random point, within the study area's minimum convex polygon, for each observed point in our dataset. These random points were considered the available habitat for pheasants and were intersected with the habitat feature class created in ArcCatalog. The outputs were placed on a frequency table with the observed values to be exported to Excel where they were then prepared for entry into SAS (Statistical Analysis Software). In total, over 3900 observed points (used) were collected during our study and an equivalent number of random points were generated. Each random point was also intersected with the habitat feature class map and recorded in a table within ArcCatalog. All processes included in the creation of the point habitat tables for preparation of analysis are discussed in greater detail in the GIS Analysis portion of the Methods section in Chapter 4 and shown in Appendices 4.4 – 4.18.

Habitat preference is defined as the disproportionate use of some resources over others (Hall et al. 1997, Gabbert et al. 1999) while habitat selection is the act of the animal choosing a particular resource (Johnson 1980). Habitat usage, as defined by Johnson

(1980), is the quantity of a habitat resource being utilized during a specified period of time. We chose to analyze habitat selection by assessing usage of habitat types in our study. Habitat selection was estimated using logistic regression analysis in SAS. Once habitat selection rates were estimated, we used a resource selection function (RSF) to estimate the relative probability of each habitat type being used to estimate habitat preference (McDonald et al. 2005).

Habitat type was broken into seven categories: CRP Cover, Range Cover, Shelterbelts, Wetlands, Croplands, Farmsteads, and Other (i.e., primarily urban areas). CRP Cover was considered any area that has potential to be re-submitted to enrollment into CRP, including but not limited to hay land, grazed pastures, and idle ground composed of primarily introduced grass species. Range lands were areas composed by primarily native grasses and experiencing idled or grazed pasture uses. Shelterbelts were those areas of trees that were greater than 2 meters in height. Wetlands were areas along waterways that had potential for aquatic vegetative growth. Farmsteads were areas that over-wintered livestock including feedlots and homesteads. Croplands primarily consisted of corn, sunflower, canola, and small grain fields in commercial agricultural production.

We designated the population's available habitat and general study area by creating a minimum convex polygon around the total selection of GPS points that were gathered throughout the study as depicted in Figure 5.4 (Sawyer et al. 2006). Within this polygon, 2010 NAIP (National Agriculture Imagery Program) imagery was used to designate cover types and delineated each cover type in ArcMap 10. Areas where habitat type identification was questionable were ground truthed for accurate habitat classification. The observed data points (used habitat) were then overlain on the digitized map and intersected with the map,

quantifying observed habitat use for each bird in the population using ArcCatalog (Figure 5.4).

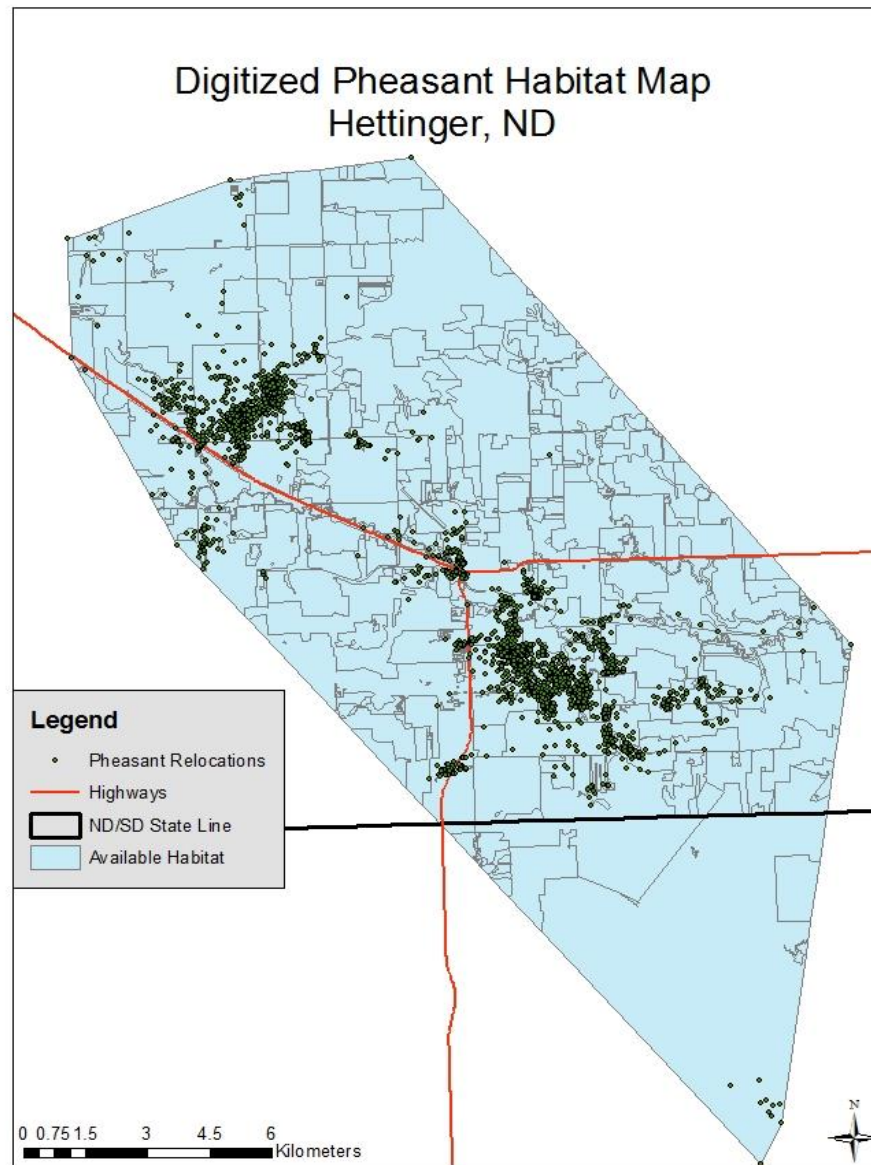


Figure 5.4. Pictorial representation of the minimum convex polygon of a population of pheasant near Hettinger, North Dakota signifying the available habitat (in blue) and the observed pheasant locations (green points). Data was included from July 2010 to April 2012.

Habitat resources selection was described using 3907 observed locations of pheasants in our study. The complete set of these units will be referred to as the population

of available resource units (Manly et al. 2002). We used logistic regression for analysis of our single categorical habitat variable (McDonald et al. 2005, Aldredge and Griswood 2006). Since the sampling unit is a point in this analysis, scaling our logistic regression for our resource selection analysis was not possible since there are an infinite number of possible points in our study area (Boyce and McDonald 1999, Boyce et al. 2002). Since scaling is not possible, we followed the guidelines in McDonald et al. (2005) and ignored the constant β_0 from the logistic regression function equation for our RSF equation:

Logistic Regression Function Equation:

$$\frac{\exp(\beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \beta_3 X_{i3})}{[1 + \exp(\beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \beta_3 X_{i3})]}$$

Resource Selection Function Equation:

$$w(x_i) = \exp(\beta_1 X_{i1} + \beta_2 X_{i2} + \beta_3 X_{i3})$$

We collected data on pheasants over a 90 week period, from July 2010 to April 2012. We split habitat use into seasonal categories of winter (January-March) and non-winter (April-December) for the duration of the study. These seasonal categories were then separated by year to allow pheasant habitat use and environmental characteristics, especially crop, to change through time (Sawyer et al. 2006).

Second-Order Resource Selection

Second-order resource selection pertains to the usage of various habitat components within the home range of a social group (Johnson 1980). Similar to Mace et al. (1996), we compared characteristics of telemetry coordinates of individuals to random coordinates within the composite MCP for the entirety of the study. Once the logistic regression equation was fitted to our dataset, the estimated coefficients were placed in the RSF

equation and numerical selection values were estimated (McDonald et al. 2005). Each data point was assigned to one of 7 habitat types and was coded as observed (1) and random (0). For the winters (January – March) of 2011 and 2012 the habitat type “Other” was set as the standard variable used to get estimates for the 6 remaining habitat types. For the other seasons (April – December), the cropland habitat types was used as the standard variable since there were no observed locations in the “Other” habitat type category.

Third-Order Resource Selection

Third-order selection is typically assessed on an individual basis (Mace et al. 1996); however, we were unable to model our individuals in this manner due to the limited number of observations per habitat type. Therefore, we compiled the observations and locations of each bird with ≥ 20 observations and analyzed their data together to assess third-order selection within home range polygons (Johnson 1980). The difference between this data and the second-order selection is we only used birds with 20 or more observations, and the random points we compared the observed points with were derived from each individual’s MCP. Our third-order selection analysis included 89 pheasants.

We used logistic regression to assess winter habitat for both second and third-order selection (1 December – 1 April), and non-winter habitat selection (1 April – 1 November) of ring-necked pheasants for 2010 through 2012. We choose to analyze each year separately to allow for annual variations in climate and annual differences in crop species planted within crop fields that may influence habitat use.

After assessing differences in habitat selection for the winters of 2011 and 2012, we became interested in habitat use of pheasants during the remaining seasons. To assess the

use of pheasants for the remainder of the year, we again used logistic regression to assess the habitat type categorical variables for used against random (available) points. During the non-winter months, the habitat type “Other” did not contain observed locations so it was omitted from the analysis and “Crop” was used as the standard variable during analysis.

It was reported by Gabbert et al. (1999) and Perkins et al. (1997) that severe weather likely concentrates predators and pheasants in the same areas, particularly in areas with few widely-spaced patches of cover. To evaluate if the presence of snow in depths of greater than 12.7 cm influenced habitat selection, we used logistic regression and all known bird locations ($N > 3900$) regardless of year. We modeled those habitat locations which occurred when greater than 12.7 cm of snow were present against those used locations that occurred when less than 12.7 cm of snow blanketed the landscape. We suspected that snow depth was a leading factor driving pheasants to select for woody cover during winter months and speculated that 12.7 cm or more of snow cover was enough to drive pheasants from their typical, herbaceous cover to taller, lignified, thermal cover.

Similar to the analysis for second-order selection, the habitat category “Other” was used as the standard variable for estimating the intercept value and a RSF was used to estimate habitat preference during times of snow cover. Unlike the analysis used in both the second and third-order selection, both the used (1) and available (0) were derived from observed pheasant locations, not points generated randomly by ArcCatalog.

Results

Survival

We monitored 36 and 45 birds for the winter survival estimates in 2011 and 2012, respectively. Surprisingly, the wet, cold winter of 2011 had higher survival estimates than the mild winter of 2012, as shown in Table 5.1.

Table 5.1. Weighted-average winter survival estimates derived from the best-fit models in Program MARK for pheasants equipped with radio collars during the winters of 2011 and 2012 in southwestern North Dakota, January 1 to April 1.

	Male Survival Probability	Male Survival Standard Error	Female Survival Probability	Female Survival Standard Error
Winter 2011 ^a	0.913	0.047	0.916	0.079
Winter 2012 ^b	0.852	0.056	0.836	0.079

^aWinter 2011- Males (n=12); Females (n=24)

^bWinter 2012- Males (n=16); Females (n=29)

The best models used for the weighted-average survival estimates, shown in Table 5.2, included different variables from winter 2011 to 2012, suggesting differences between the two years. The 3 models that best fit the data for winter 2011 were the full model, the reduced model without the sex*time interaction, and the constant model (Table 5.2). The three best models describing the data for the winter of 2012 were the reduced model excluding the sex and sex*time interaction, the reduced model excluding the sex*time interaction, and the full model (Table 5.2). The Phi model, or full candidate set consisted of sex, time, and sex*time interactions in program MARK (Table 5.2).

Table 5.2. Program MARK output tables for pheasants equipped with radio collars during the winters of 2011 and 2012 in southwestern North Dakota, January 1 to April 1.

Model	AIC_c	ΔAIC_c	AIC_c Weight	Model Likelihood
<u>Winter 2011^a</u>				
Phi(Full)	44.01	0.00	0.574	1.00
Phi-(Sex*Time)	45.79	1.78	0.235	0.41
Phi(Constant)	46.21	2.21	0.191	0.33
<u>Winter 2012^b</u>				
Phi-(Sex;Sex*Time)	67.40	0.00	0.588	1.00
Phi-(Sex*Time)	69.35	1.95	0.222	0.38
Phi(Full)	69.67	2.26	0.190	0.32

^aWinter 2011- Males (n=12); Females (n=24)

^bWinter 2012- Males (n=16); Females (n=29)

Although the AIC values differ between the two years, the Delta AIC and the AIC weights are similar between the two years. For both winters, the best model is approximately 2.5 times as well supported as the next best model, indicated by the AIC weights. The general “rule of thumb” for Delta AIC interpretation is that differences in AIC values that are < 2 do not support a difference between two models, while AIC differences that are $2 < \text{AIC} < 7$ show considerable support for real differences between models (Cooch and White 2012). Since our second and third best models in both years have a difference of approximately 2, their survival estimates were weighted appropriately and included in the averages reported in Table 5.1.

Habitat Selection

Second-Order Resource Selection

Table 5.3 shows the coefficients for the various habitat categories which were generated using logistic regression for the winters of 2011 and 2012. During the comparatively harsh winter of 2011, pheasants showed strong selection for farmsteads and shelterbelts and avoidance toward CRP, crop, and range cover types compared to the

“other” habitat category (Table 5.3). The mild winter of 2012 revealed pheasant selection toward CRP, crop, farmsteads, wetlands, and shelterbelts when compared to the “other” category (Table 5.3).

Table 5.3. Logistic regression output for second order selection for a population of pheasants equipped with radio collars during the winters of 2011 and 2012 in southwestern North Dakota, January 1 to April 1.

Parameter	Coefficient	Standard Error	Chi-Squared	Prob. > X²
<u>Winter 2011^a</u>				
β_0 -				
Intercept	0.86	0.319	7.23	0.0072
CRP	-0.79	0.325	5.92	0.0150
Crop	-1.47	0.332	19.54	<0.0001
Farmstead	2.91	0.441	43.35	<0.0001
Range	-3.84	0.352	119.05	<0.0001
Wetland	0.09	0.383	0.06	0.8129
Shelterbelt	2.41	0.395	37.10	<0.0001
<u>Winter 2012^b</u>				
β_0 -				
Intercept	-2.05	0.475	18.70	<0.0001
CRP	2.45	0.481	26.05	<0.0001
Crop	1.22	0.483	6.41	0.0114
Farmstead	3.58	0.554	41.78	<0.0001
Range	0.65	0.551	1.40	0.2364
Wetland	3.49	0.520	45.21	<0.0001
Shelterbelt	3.12	0.600	27.01	<0.0001

^aWinter 2011- Observed (n=1863); Random (n=1863)

^bWinter 2012- Observed (n=882); Random (n=882)

Logistic regression coefficients were positive for CRP and Shelterbelts and negative for Range cover during the non-winter months of 2010 (Table 5.4). Logistic regression coefficients were positive for CRP, wetland and shelterbelts and negative for range cover during the non-winter of 2011 (Table 5.4).

Table 5.4. Logistic regression output for second order selection of a population of pheasants equipped with radio collars during the non-winter months of 2011 and 2012 in southwestern North Dakota.

Parameter	Coefficient	Standard Error	Chi-Squared	Prob. > X²
<u>Non-Winter 2010^a</u>				
β_0 -				
Intercept	0.01	0.138	0.00	0.9451
CRP	0.43	0.179	5.70	0.0170
Farmstead	-0.70	0.565	1.55	0.2135
Range	-3.88	0.728	28.45	<0.0001
Wetland	15.19	577.7	0.00	0.9790
Shelterbelt	1.47	0.514	8.20	0.0042
<u>Non-Winter 2011^b</u>				
β_0 -				
Intercept	-0.33	0.095	11.71	0.0006
CRP	0.68	0.119	32.59	<0.0001
Farmstead	16.53	486.4	0.00	0.9729
Range	-1.23	0.188	42.99	<0.0001
Wetland	4.02	1.017	15.59	<0.0001
Shelterbelt	1.75	0.465	14.25	0.0002

^aNon-Winter 2010- Observed (n=342); Random (n=342): (July 18 – December 31)

^bNon-Winter 2011- Observed (n=819); Random (n=819): (April 1 – December 31)

The results from the second-order resource selection (Tables 5.3 and 5.4) are summarized in Table 5.5 using the RSF equation presented above. The RSF demonstrates a way to convert simple selection ratios (Tables 5.3 and 5.4) into relative probability (odds) of selection among habitat types that are considered (McDonald et al. 2005). Table 5.5 presents the relative probability of selection for each habitat type, for each time period, based on observed pheasant locations in our study.

Table 5.5. Estimated values for the Resource Selection Function presenting estimated relative probability of selection among each habitat type used (P-value < 0.05) from a population of pheasants equipped with radio collars in southwestern North Dakota (ns-refers to “not significant” at 95% confidence level).

Habitat Type	$w(x_i)$	$w(x_i)/\sum w(x_i)$	$w(x_i)$	$w(x_i)/\sum w(x_i)$
	<u>Winter 2011^a</u>		<u>Winter 2012^b</u>	
Other	1.00	0.032	1.00	0.009
CRP	0.45	0.015	11.59	0.108
Crop	0.23	0.007	3.39	0.032
Farmstead	18.36	0.588	35.87	0.334
Range	0.02	0.001	ns	ns
Wetland	ns	ns	32.79	0.306
Shelterbelt	11.13	0.357	22.65	0.211
Totals	31.20	1.000	107.28	1.000
	<u>Non-Winter 2010^c</u>		<u>Non-Winter 2011^d</u>	
Crop	1.00	0.145	1.00	0.015
CRP	1.54	0.223	1.97	0.030
Farmstead	ns	ns	ns	ns
Range	0.02	0.003	0.29	0.005
Wetland	ns	ns	55.70	0.861
Shelterbelt	4.35	0.630	5.75	0.089
Totals	6.91	1.000	64.72	1.000

^aWinter 2011- Observed (n=1863); Random (n=1863); (January 1 – March 31)

^bWinter 2012- Observed (n=882); Random (n=882); (January 1 – March 31)

^cNon-Winter 2010- Observed (n=342); Random (n=342): (July 18 – December 31)

^dNon-Winter 2011- Observed (n=819); Random (n=819): (April 1 – December 31)

When observing pheasant movements during our research, we assumed that snow depth was a contributing factor driving pheasants to select for woody cover during winter months. Logistic regression coefficients based on habitat use and the presence of snow in depths greater than 12.7 cm were positive for shelterbelts and negative for CRP, crop, range, and wetland cover in comparison to the standard, “other” category (Table 5.6).

Table 5.6. Logistic Regression for days of ≥ 12.7 cm of snow from a population of pheasants equipped with radio collars during combined winters of 2011 and 2012 in southwestern North Dakota, January 1 to April 1.

Parameter	Coefficient	Standard Error	Chi-Squared	Prob. > X^2
<u>Winters 2011/2012^a</u>				
β_0 - Intercept	0.15	0.321	0.23	0.6313
CRP	-1.36	0.326	17.28	<0.0001
Crop	-1.62	0.336	23.09	<0.0001
Farmstead	0.27	0.332	0.66	0.4168
Range	-1.51	0.397	14.39	0.0001
Wetland	-1.57	0.359	19.07	<0.0001
Shelterbelt	1.15	0.337	11.55	0.0007

^aWinters 2011/2012- Snow (n=1415); No Snow (n=2492)

Once the selection ratios were calculated in SAS, shown in Table 5.6, we were able to use the RSF equation to estimate the relative probability of selection for habitat types during times of ≥ 12.7 cm of snow. Table 5.7 shows the calculated odds of use, indicating that shelterbelts were expected to be used approximately 63% of the time during periods of snow accumulation of 12.7 cm or more.

Table 5.7 Estimated values for the Resource Selection Function representing estimated relative probability of selection among each habitat type used (P-value < 0.05) from a population of pheasants equipped with radio collars in southwestern North Dakota during times of ≥ 12.7 cm of snow depth (ns- refers to “not significant” at 95% confidence level).

Habitat Type	$w(x_i)$	$w(x_i)/\sum w(x_i)$
<u>Winters 2011/2012^a</u>		
Other	1.00	0.198
CRP	0.26	0.051
Crop	0.20	0.039
Farmstead	ns	ns
Range	0.22	0.044
Wetland	0.21	0.041
Shelterbelt	3.16	0.626
Totals	5.04	1.000

^aWinters 2011/2012- Snow (n=1415); No Snow (n=2492)

Third-Order Resource Selection

All random points for these analyses were generated within the individual bird MCPs. Based on logistic regression analysis, coefficients for categorical habitat classes

were positive for farmstead, wetland, and shelterbelts and negative for crop, compared to the other, standard category during the 2011 winter (Table 5.8). During the winter of 2012, logistic regression coefficients were positive for shelterbelts (Table 5.8).

Table 5.8. SAS output tables representing third-order logistic regression selection ratios from a population of pheasants equipped with radio collars during the winter and non-winter seasons from July 2010 to April 2012 in southwestern North Dakota.

Parameter	Coefficient	Standard Error	Chi-Squared	Prob. > X²
<u>Winter 2011^a</u>				
β_0 - Intercept	-0.44	0.223	3.80	0.0514
CRP	0.12	0.230	0.28	0.5994
Crop	-0.55	0.240	5.31	0.0211
Farmstead	1.41	0.240	34.72	<0.0001
Range	-1.30	0.273	22.82	<0.0001
Wetland	0.49	0.275	3.13	0.0767
Shelterbelt	2.72	0.267	103.46	<0.0001
<u>Winter 2012^b</u>				
β_0 - Intercept	-0.34	0.586	0.33	0.5655
CRP	0.36	89	0.38	0.5376
Crop	0.02	0.594	0.00	0.9758
Farmstead	0.46	0.611	0.57	0.4521
Range	0.55	0.657	0.71	0.3983
Wetland	0.91	0.606	2.23	0.1354
Shelterbelt	1.76	0.721	5.94	0.0148
<u>Non-Winter 2010^c</u>				
β_0 - Intercept	0.08	0.142	0.32	0.5698
CRP	-0.08	0.175	0.19	0.6651
Farmstead	-0.77	0.629	1.52	0.2183
Range	-2.33	0.757	9.49	0.0021
Wetland	0.10	0.451	0.05	0.8221
Shelterbelt	0.53	0.386	1.85	0.1736
<u>Non-Winter 2011^d</u>				
β_0 - Intercept	-0.19	0.098	3.60	0.0577
CRP	0.41	0.120	11.45	0.0007
Farmstead	-0.18	0.214	0.74	0.3898
Range	-0.28	0.212	1.69	0.1933
Wetland	0.09	0.239	0.14	0.7054
Shelterbelt	0.70	0.341	4.17	0.0410

^aWinter 2011- Observed (n=1870); Random (n=1870)

^bWinter 2012- Observed (n=861); Random (n=861)

^cNon-Winter 2010- Observed (n=337); Random (n=337): (July 18 – December 31)

^dNon-Winter 2011- Observed (n=821); Random (n=821): (April 1 – December 31)

For the non-winter period in 2010, logistic regression coefficients were negative for range cover (Table 5.8). Logistic regression coefficients were positive for CRP and shelterbelts for the non-winter period of 2011 (Table 5.8). The logistic regression models for the third-order selection were not as strong as our second-order models when assessing P-values. Using RSF analysis, shelterbelts were selected 68% of the time during 2011, but the same analysis was not possible for the winter of 2012 due to the lack of significance within the analysis. We believe the differences between the second and third-order selection logistic regression models originated from where the random points (available habitat) were generated. In the second-order analysis, random points were generated on the entirety of the study area, while the third-order random points were generated in the individual's home range polygon. Points generated randomly within individual home range polygons are likely too similar to the observed locations to be consistently successful at estimating habitat selection.

The dataset with the most significance in estimating third-order analysis was the winter of 2011. We assumed the 2011 winter worked best because pheasants were concentrated to shelterbelts and farmsteads with animals due to low temperatures and greater than average snow accumulation. Pheasants had limited access to the entirety of their home ranges during the winter of 2011, which created subsequent, significant differences between observed and random locations during that timeframe.

Discussion

Choices related to time and scale should be strongly considered when analyzing large datasets relating to animal survival and space use. Thomas and Taylor (2006), in their

paper on study design and tests of resource use, suggest that pooling unequal number of locations per animal results in some individuals influencing selection inferences greater than others. In this portion of our study, each individual point is the experimental unit (Manley et al. 2002). Although it is true that individuals with more points have greater influences on the outcomes of selection, those individuals lived proportionately longer by selecting the habitats they had. Therefore, we decided that having disproportionate influences derived from longer-lived individuals was acceptable in our study design. Our goal in this research was to analyze ways for managers to increase survival of pheasants by altering habitats. Using selection data from long-lived individuals seems acceptable with these goals in mind.

Survival

When estimating survival, it is equally as important to decide the intervals and duration of the times being estimated. We chose to estimate survival for the winters (January 1 to April 1) for 2011 and 2012. These times were chosen to coincide with our winter resource selection analyses discussed previously. Our survival estimates for males were not greater than that of females for either winter of our study. The average survival estimate for both sexes was approximately 0.91 for 2011 and 0.84 for 2012 during the 13-week winter intervals from January 1 to April 1 each year. Although these estimates were higher than expected, survival of pheasants in southwestern North Dakota should be best following growing seasons with adequate rainfall (Martinson and Grondahl 1966).

Pheasant winter survival estimates tend to vary greatly within publications from different region of North America. Although it is difficult to compare survival estimates

between studies due to different survival intervals, study durations, and season of estimates, our survival estimates seemed to be on the upper end of most pheasant studies. Snyder (1985) estimated survival for pheasants in Colorado to be 0.651 for the spring season (March-May). The most comparable study to ours in both number of pheasants, and duration of the interval was that by Riley et al. (1994) where they estimated survival from January-March during three years, 1978-1980. Their estimates were 0.80, 0.52, and 0.69 for female pheasants in Iowa; they noted that survival was less during the spring months than the winter, supporting our assumptions of spring survival in our study. Perkins et al. (1997) estimated survival over 5 years from November 27 – April 1 in Iowa. Their survival estimates were highly variable among years, estimates ranged from 0.964 to 0.228 between 2 sites over the 5-year period (Perkins et al. 1997). Gabbert et al. (1999), observed survival rates that ranged from 0.65 to 0.16 during two disparate winters in South Dakota. Homan et al. (2000) observed average winter survival of 0.41 over three winter seasons ranging from 0.86 to 0.04 during a study in southeastern North Dakota. It is evident that survival is highly variable among pheasant populations between years. Research described in these publications suggests that our observations may have fallen within two favorable winters for our pheasant population.

We should note that the later storms in mid-April of 2011 caused numerous deaths within our population, since most individuals had already dispersed from their wintering grounds prior to these storm events. Since the data was not available for comparison of April 2012 at the time of these analyses, the data associated with this storm event was not included in this analysis. It is suspected that survival would have more-closely matched our

hypotheses of winter 2012 having increased survival over the winter of 2011 if this data were included.

Another factor that may have contributed to our high survival rates was the availability of food plots on the landscape. Gabbert et al. (2001) estimated winter survival for 2 separate pheasant populations in South Dakota, 1 with access to food plots and 1 without. In their study, survival estimates were from December 15 to March 15, 1994-1996 for hen pheasants. Hen pheasant's average survival in areas with food plots was 0.93 and survival for hens that had home ranges without food plots had average survival estimates of 0.60. Many individuals within our study had food plots contained within their home range estimates. The study area contained 2 large, 80 ha, standing corn food plots that were grazed by cattle, supplying ample food resources to a large number of pheasants in our study. These large food plots could have contributing to the high survival estimates in our study, but has not been quantified.

Habitat Selection

Within our logistic regression analyses we modeled habitat selection based on 7 habitat types for both second and third-order selection. Second-order selection models were more significant, hence are the estimates we chose to compare to previous research. After the RSF analysis was completed (Table 5.5), it was evident that there were selection differences between the harsh winter of 2011 and the mild winter of 2012. Our research (RSF results) suggests that during harsher winters, pheasants spend 95% of their time in shelterbelts and/or on farmsteads that are in close proximity to livestock. Although we observed pheasants in shelterbelts and farmsteads in 2012, the odds of their presence in

these habitat types decreased to 55%, while wetlands and CRP increased in relative probability of being selected, 11% and 30% respectively. We observed greater variability in our non-winter habitat use, which may be due to seasonality and differences in duration of data collection between 2010 and 2011. The most notable observation, however, was that our “Range” habitat type was negatively selected for during all time-frames of our analysis.

Past pheasant research has reported similar results using varying habitat selection analysis techniques. Hanson and Progulské (1973) analyzed movements and habitat use of 13 female pheasants in South Dakota from June-October 1969 and 1970, where they observed 85% of all pheasant observations occurring in four habitat types: corn (33%), small grain (23%), alfalfa (15%), and residual cover (14%). Gates and Hale (1974) assessed winter habitat use by surveying pre-defined transects for signs of use (i.e., tracks, roosts, sightings). Through these methods, they were able to generalize population trends in winter cover types and concluded that wetland shrub-carr was the most essential winter cover type in their area of Wisconsin (Gates and Hale 1974). Gatti et al. (1989) monitored 56 hen pheasant and observed marsh habitats as the most widely used habitat type in their study from October-April. Their research also indicated that habitat use was a function of season and the interaction of season. Corn fields, retired croplands, and marshes were used more in the fall while brush was used more in the winter than in the fall (Gatti et al. 1989).

During a study on hen pheasant in southern Idaho, Leptich (1992) observed that ungrazed sagebrush, wetlands, and herbaceous areas were generally preferred by pheasants, while grazed sagebrush and corn fields were used in proportion to their availability. Perkins et al. (1997) observed Iowa pheasants selecting for areas with more grass cover and less

crop stubble than was available on the landscape. Gabbert et al. (1999) monitored pheasants in south Dakota where they modeled pheasant habitat preference and found cattail wetlands, tall grass, and food plot areas ranking higher than all other habitat types, while open wetlands, row crops, pasture-hay, and roadway habitats ranked the lowest. Both second and third-order selection were analyzed by Homan et al. (2000) in their study in southeastern North Dakota. Their second-order results indicated selection for class 4 wetlands during both years of their study and for uplands during the milder year of their study. Third-order habitat selection modeling showed positive selection for wetland boundaries during both winters, but selection for the central part of the wetlands only during the more severe of the two winters (Homan et al. 2000). Our results support findings that pheasants show plasticity in their selection of habitats that varies with increased weather severity and snow depth. Habitat selection of North American ring-necked pheasants tends to follow a sequence that went from CRP-type grasslands, to cattail wetlands, to dense shelterbelts in close proximity to farmsteads with livestock (Gates and Hale 1974, Gabbert et al. 1999, Homan et al. 2000). The results described in this chapter support general trends noted in past pheasant research.

Management Implications

For areas of pheasant habitat in southwestern North Dakota, dense shelterbelts in close proximity to livestock or another food source is the limiting habitat-type on the landscape with respect to winter habitat needs of ring-necked pheasant. This combination of food and shelter is necessary for pheasant survival during harsh winters like the one in 2011. Unlike much of the Midwest where trees and farmsteads are plentiful and there are

many outlets for pheasants to escape from harsh weather conditions, western North Dakota does not have volunteer trees and farmsteads are more wide spread than elsewhere within ring-necked pheasant distribution in North America.

Managers interested in increasing pheasant populations should consider increasing available CRP-type cover, large wetlands, and shelterbelts in close proximity to farmsteads with livestock. The CRP cover is essential for nesting, brood rearing, and winter cover during years of low snow accumulation. Large wetlands and dense shelterbelts in close proximity to farmsteads with livestock are used during the winters with more harsh weather conditions. This combination of habitat types will allow for pheasant use and inhabitation during the full-range of climatic conditions that North Dakota has to offer.

Acknowledgements

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CHAPTER 6. GENERAL CONCLUSIONS

Over the course of this study, we successfully captured and collared 191 ring-necked pheasant in Adams County, North Dakota. We monitored these individuals weekly for up to 90 weeks (July 18, 2010 to April 1, 2012) before the dataset was prepared for analysis. During this research project we were able to analyze the best nest searching techniques, estimate home range size and relative proportions of habitats compared to what was available on the landscape, analyze second and third-order resource selection and habitat preference, and estimate winter survival for male and female pheasants in southwestern North Dakota.

During our nest searching study, we found that telemetry-based nest searching techniques were the most efficient, especially from hens captured during the spring. Additionally, telemetry-based nest searching was the least disruptive to nesting birds and allowed pheasants to be followed to whatever habitat-type they chose, hence was not limited to areas searched using other methods.

Our home range estimations were the largest estimates that we were able to find in published literature, averaging over 2000 ha in size for both the MCP and KDE estimation methods. The proportions of habitats used within the home range estimates, did, however, follow closely to findings from past pheasant research. We assume that our proportionately large home range sizes were attributed to our attempt to analyze annual home ranges while most studies chose a specific season, and that the landscape in southwestern North Dakota has few areas of dense shelterbelts that are in close proximity to food sources for pheasant during the cold, North Dakota winters forcing birds to travel greater distances to find winter habitat.

Our survival estimates were on the upper end of the published literature's estimates, however, they seem to follow the trends that are associated with high average rainfall that we were fortunate to experience during this 2 year study. Our resource selection function analysis, based from logistic-regression statistics from our observed pheasant locations were very similar to past pheasant research. Our winter resource selection function gave relative probabilities that favored shelterbelts, farmsteads with livestock, wetland cover, and CRP-type cover. All habitat selection analyses showed negative selection towards the range-type cover for pheasants in our area.

Landowners wanting to increase pheasant populations should focus on providing different habitat types in close proximity to each other to decrease the distance required for pheasants to travel from one cover type to the next. Pheasants are strongly associated with wetlands for thermal cover throughout winter months and to dense shelterbelts during the harshest winter storms. The perfect thermal cover for pheasants during the full range of North Dakota winter weather is composed of substantial buffers of stout, residual vegetation planted around cattail wetlands or idle grasslands in close proximity to food plots or livestock operations. This cover combination allows pheasants to loaf and feed near their winter roosting sites in wetland basins and prevents an abundance of snow from drifting into those basins. If managers are interested in increasing reproduction of pheasant populations, resources in North Dakota should be focused towards increasing winter cover and Conservation Reserve Program (CRP) type grasslands for pheasants.

Managers interested in increasing pheasant abundance on their property should consider: 1) providing ample CRP-type cover to supply adequate nesting and non-winter cover, 2) create large wetlands with dense cattail stands, 3) provide dense shelterbelts with

mixed conifer and deciduous trees, and 3) provide food plots or house livestock with ample feed near the dense shelterbelts to provide nutritional resources for pheasants during periods of deep snow cover.

APPENDIX

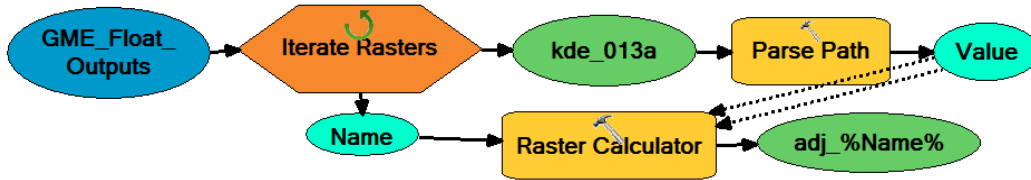


Figure A1. Multiply KDE floating raster values by 100.

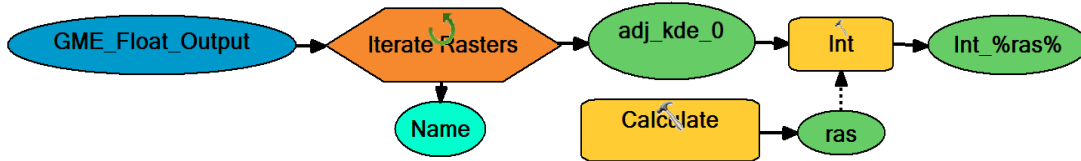


Figure A2. Convert KDE floating raster to integer raster.

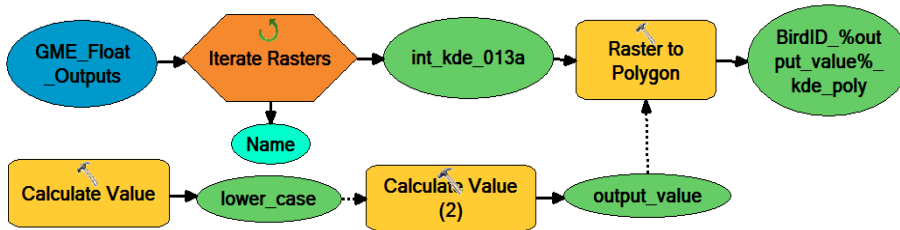


Figure A3. Convert KDE integer raster to polygon.

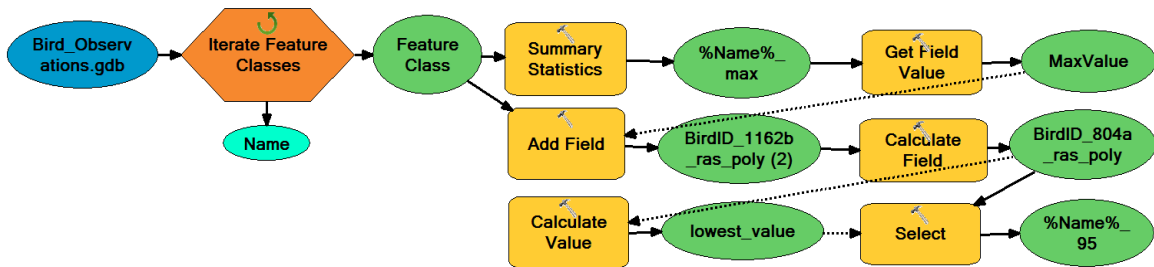


Figure A4. Select top 95 percent probability of occurrence of KDE.

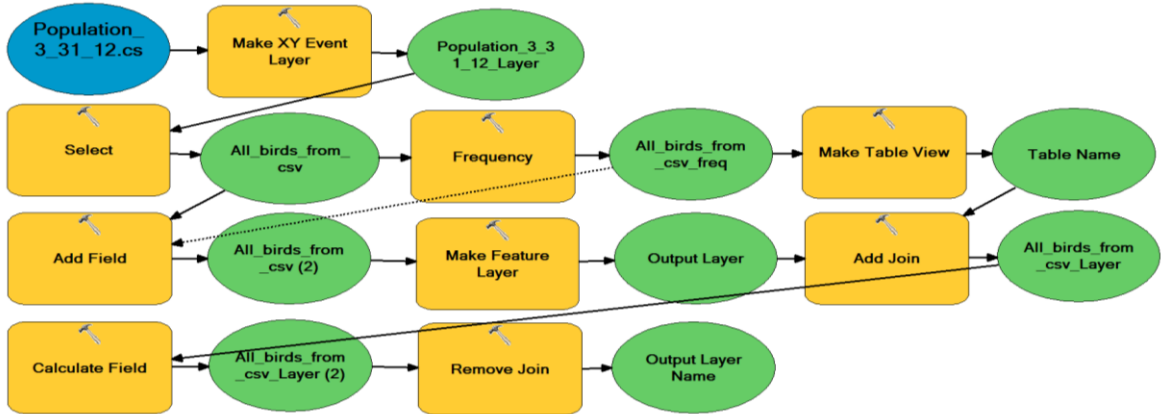


Figure A5. Created all birds and frequency table from python csv output spreadsheet.

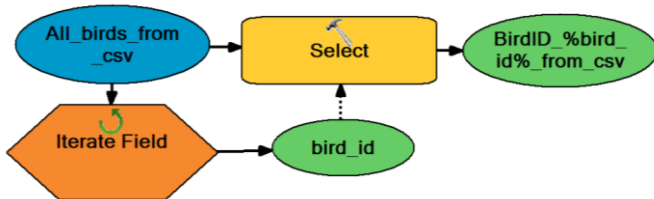


Figure A6. Make individual bird feature classes.

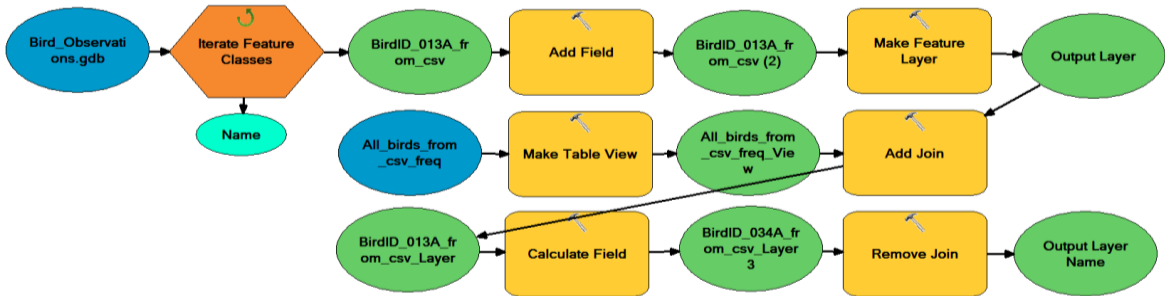


Figure A7. Calculate individual bird total count values for observed locations.

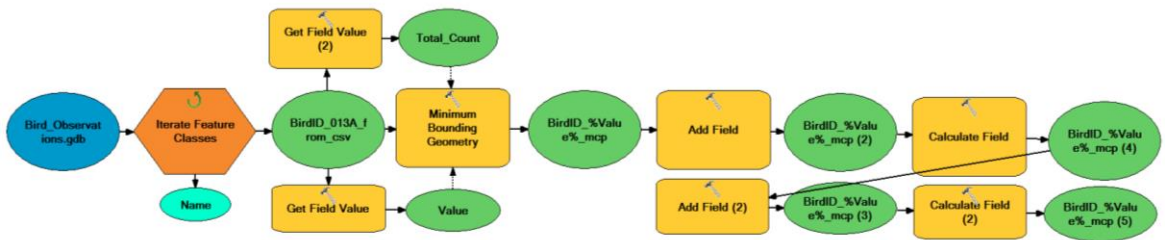


Figure A8. Generated MCPs.

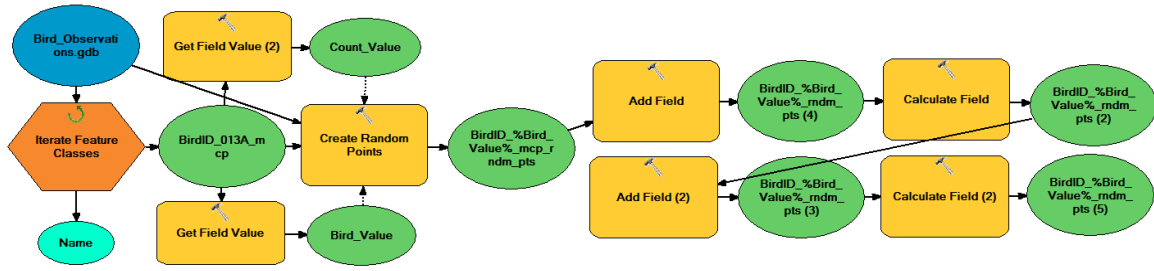


Figure A9. Create MCP random points.

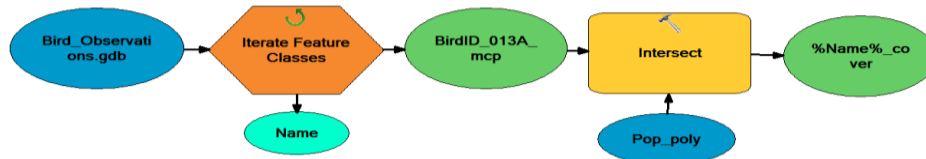


Figure A10. Intersect each MCP with habitat map.

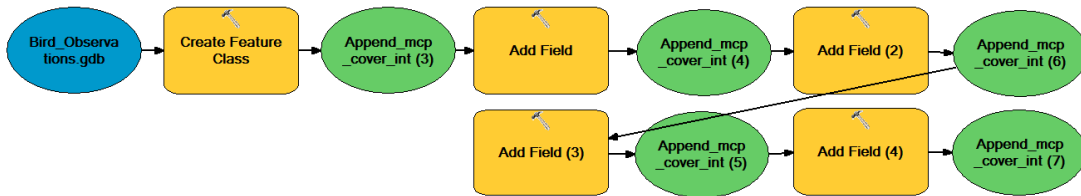


Figure A11. Create empty append MCP cover intersect feature class.

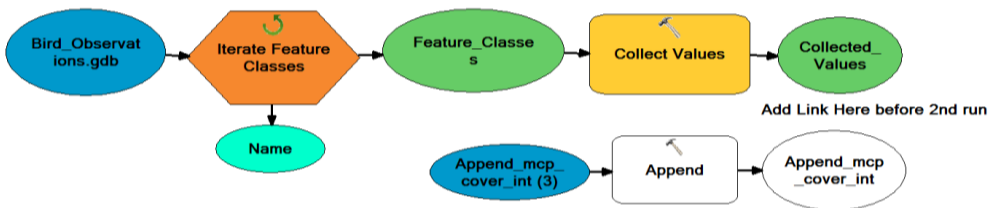


Figure A12. Append MCP cover feature classes.

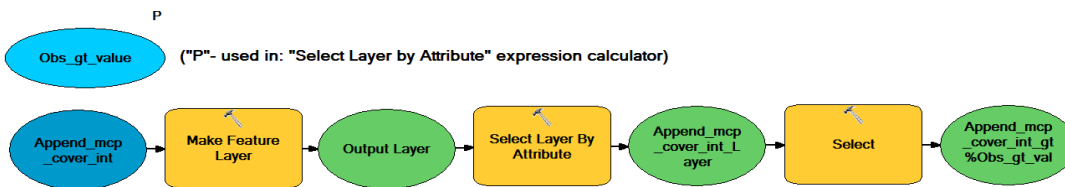


Figure A13. Select birds with greater than 19 observed locations.

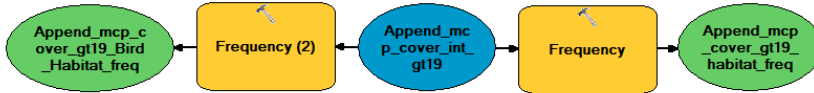


Figure A14. Generated MCP habitat frequencies.

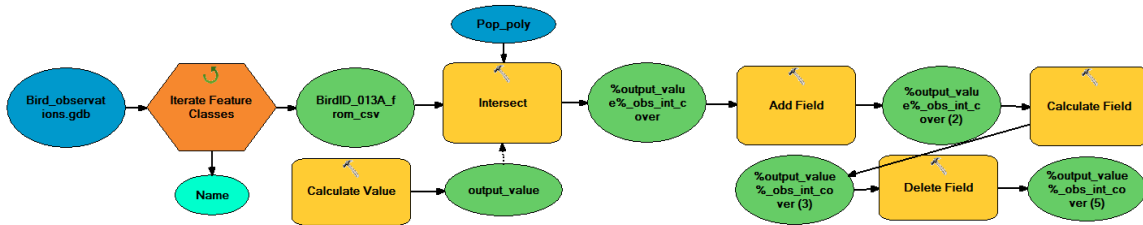


Figure A15. Intersect observed points with habitat map.

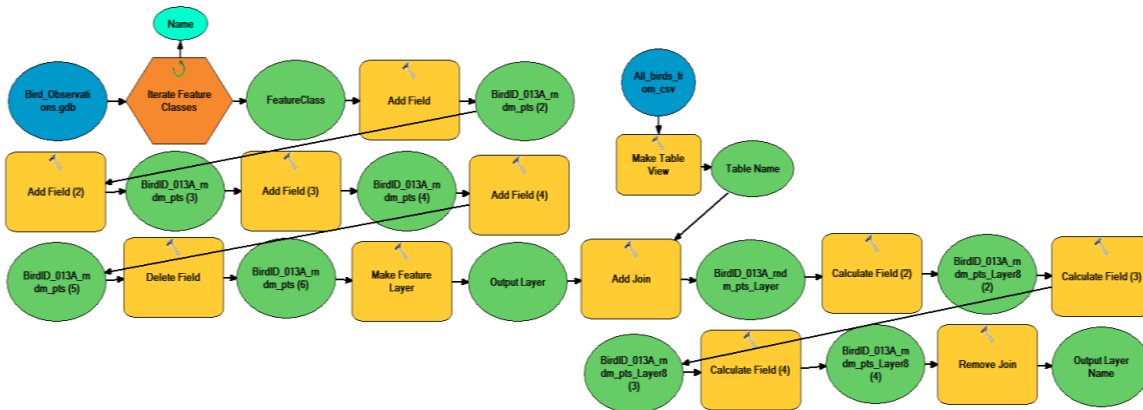


Figure A16. Add fields to random point values in table.

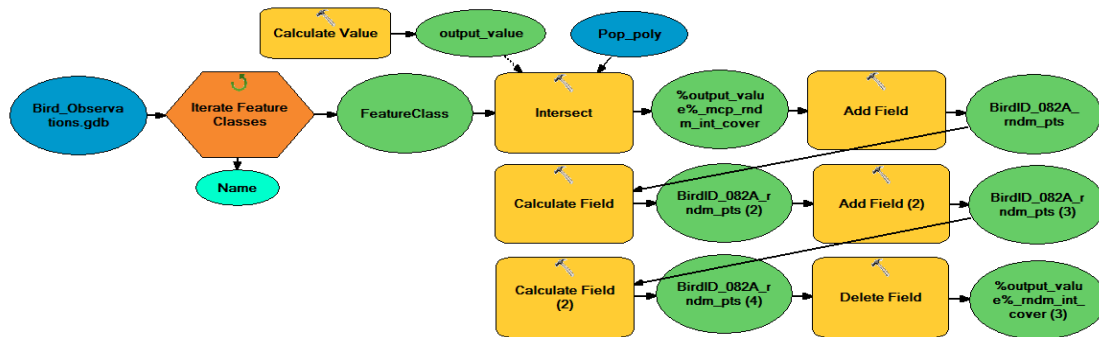


Figure A17. Intersect random points with habitat map.

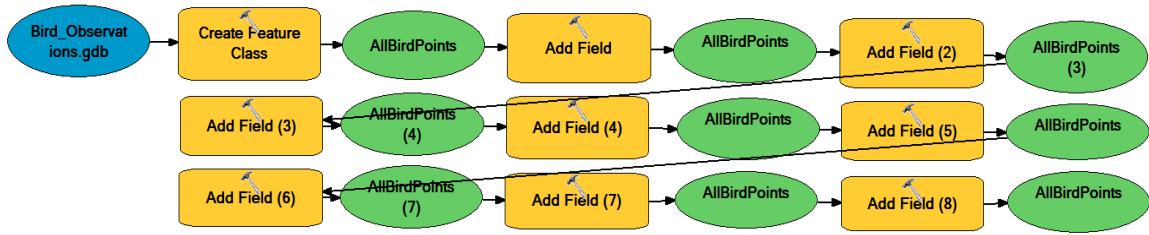


Figure A18. Create “AllBirdPoints” feature class.

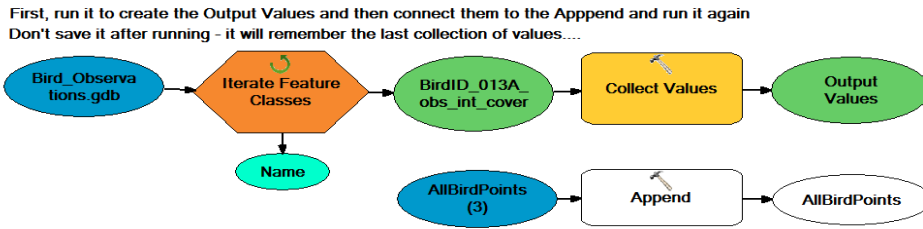


Figure A19. Append intersect feature classes into “AllBirdPoints”.

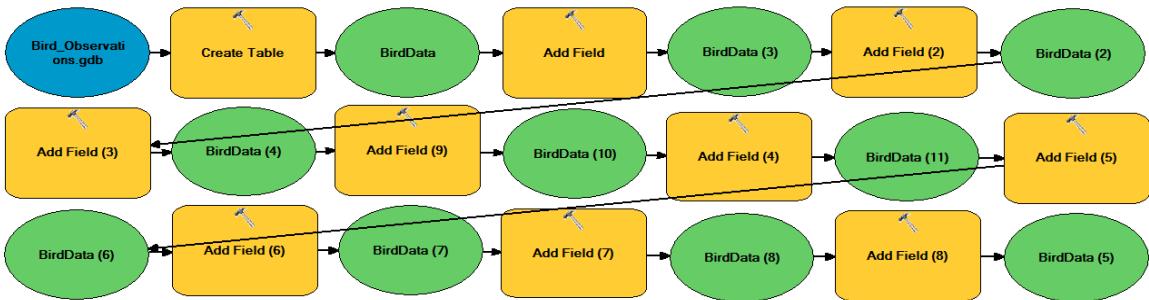


Figure A20. Create “BirdData” table.

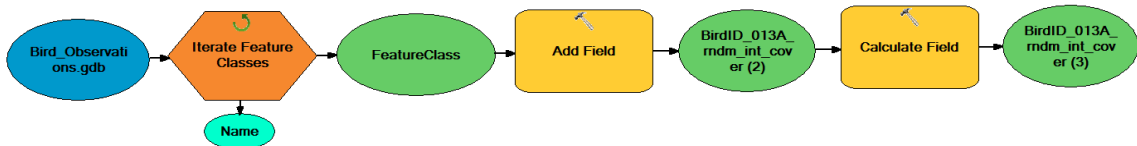


Figure A21. Fix random point total count field.

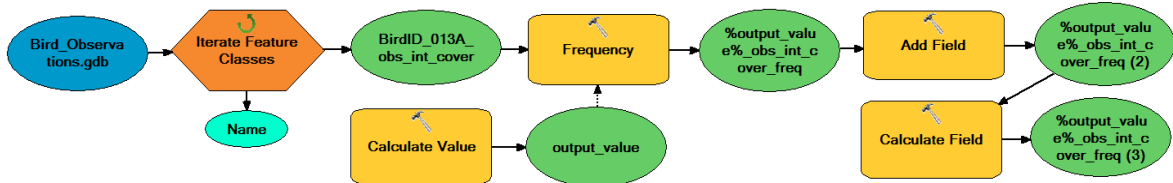


Figure A22. Calculate frequency of observed point cover feature classes.

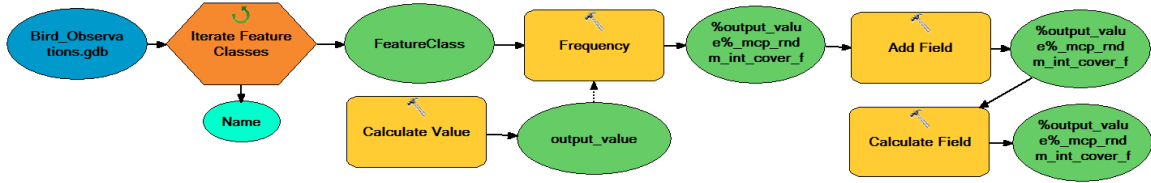


Figure A23. Calculate frequency of observed cover feature classes.

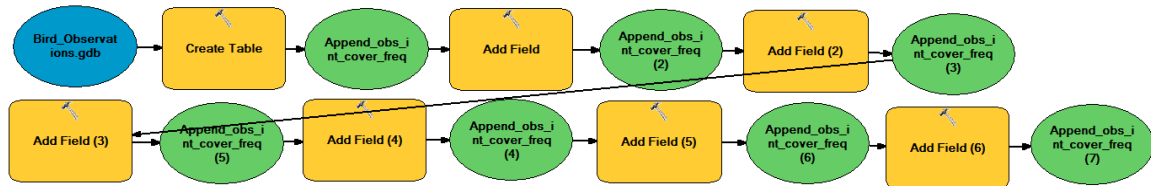


Figure A24. Create empty append for observed cover feature class.

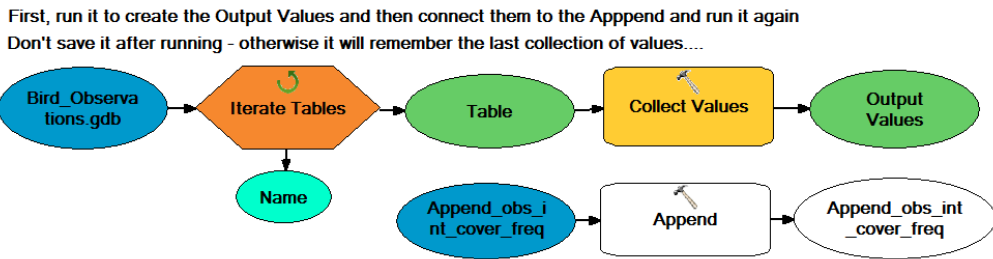


Figure A25. Append observed cover frequencies together.

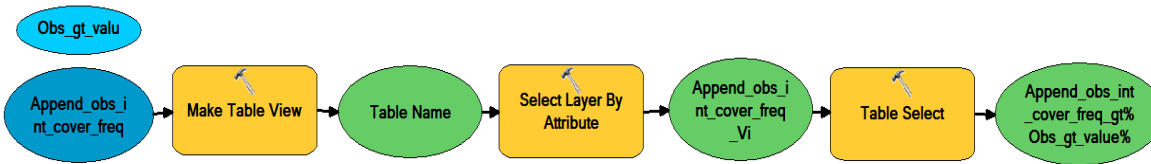


Figure A26. Select number of observations greater than 19.

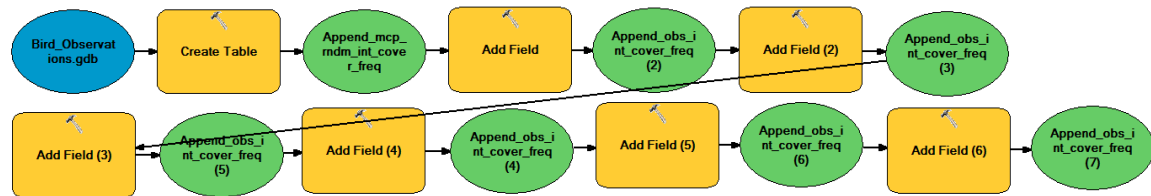


Figure A27. Create empty append for random cover feature classes.

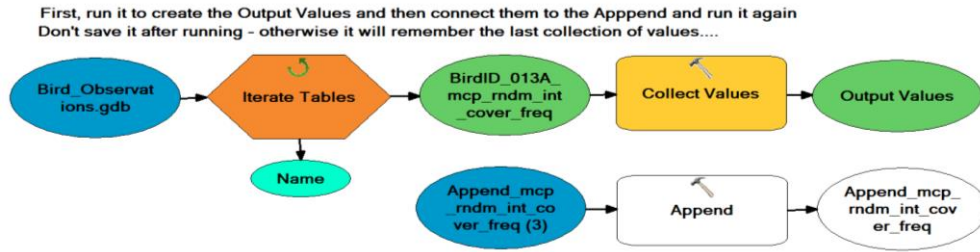


Figure A28. Append random cover frequencies together.

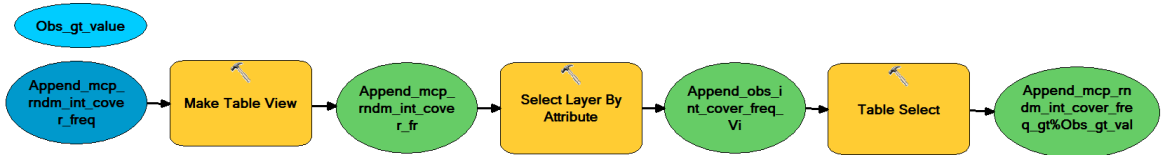


Figure A29. Select number of random points greater than 19.

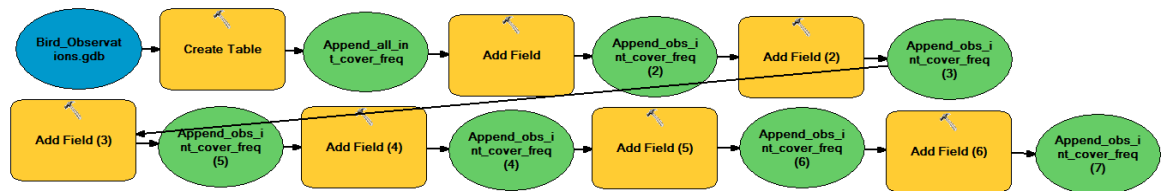


Figure A30. Create empty append for all observed and random habitat values.

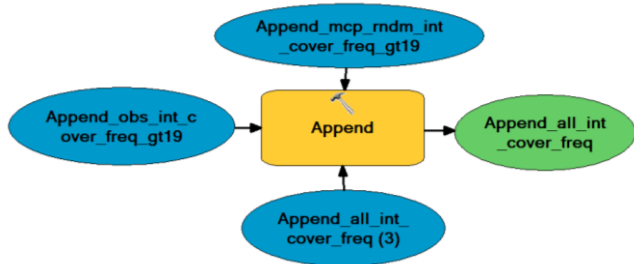


Figure A31. Combine observed and random cover values into one table.



Figure A32. Calculate frequency values of the combined table.

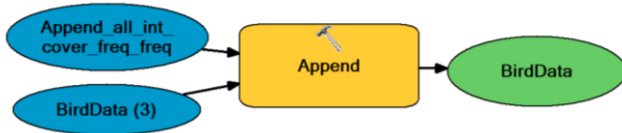


Figure A33. Append the combined table values into “BirdData”.

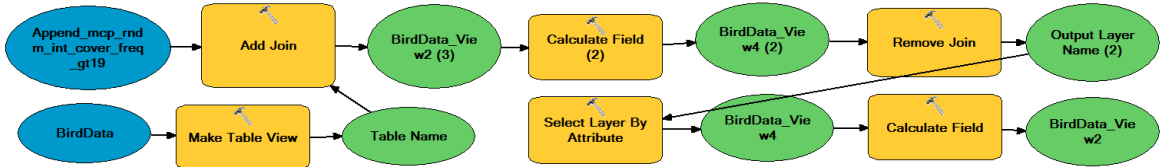


Figure A34. Populate random point count in “BirdData”.

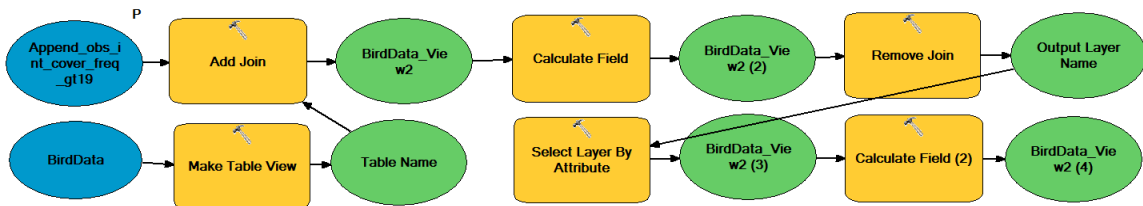


Figure A35. Populate observed point count in “BirdData”.

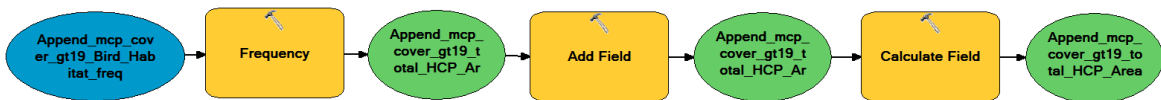


Figure A36. Generate total MCP area values.

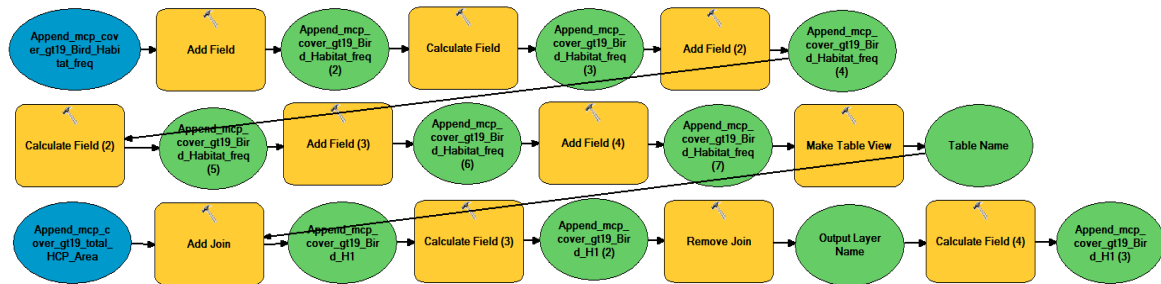


Figure A37. Add fields in table for bird habitat proportions.

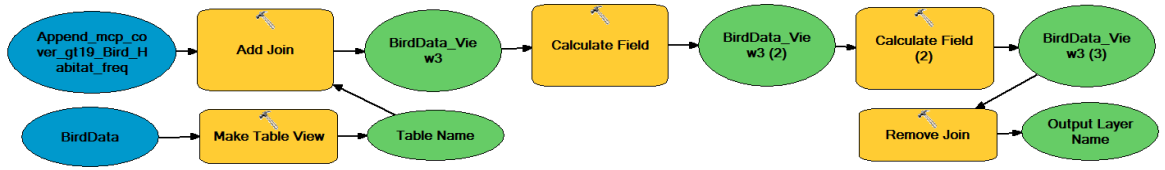


Figure A38. Populate MCP area proportions in “BirdData”.

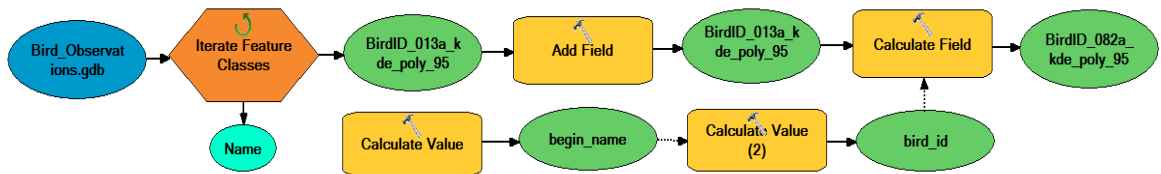


Figure A39. Add bird identification column to KDE 95% tables.

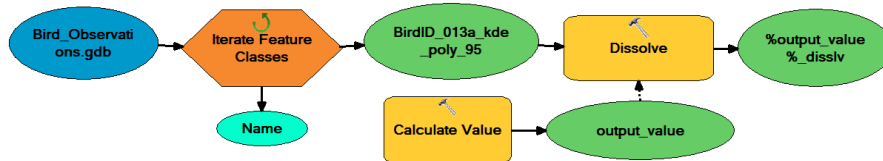


Figure A40. Dissolve inner lines from raster to polygon conversion in KDE polygons.

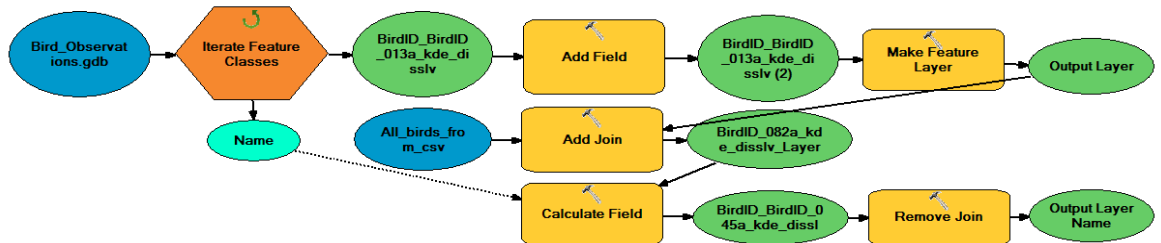


Figure A41. Add total count values to dissolved KDE tables.

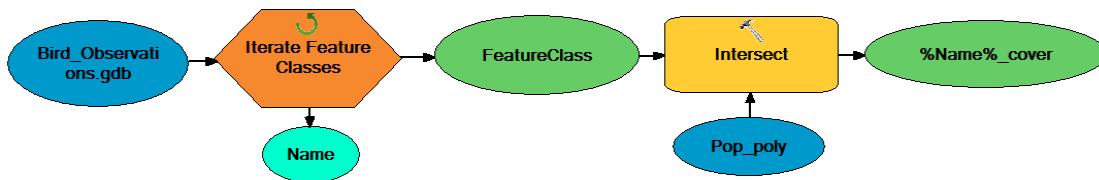


Figure A42. Intersect KDE polygons with habitat cover type map.

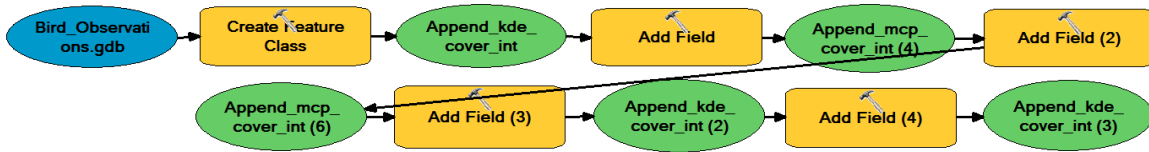


Figure A43. Create empty append for KDE cover values.

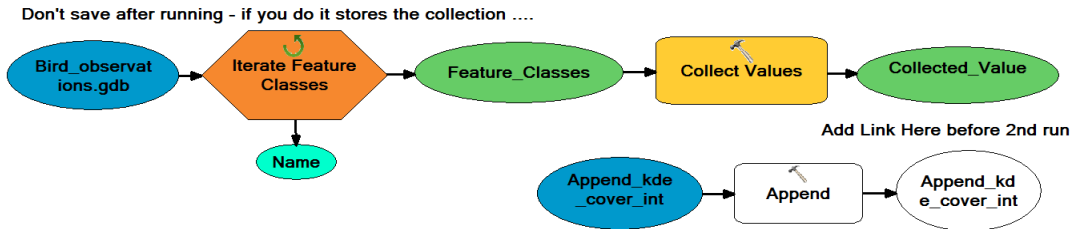


Figure A44. Append KDE cover feature classes.

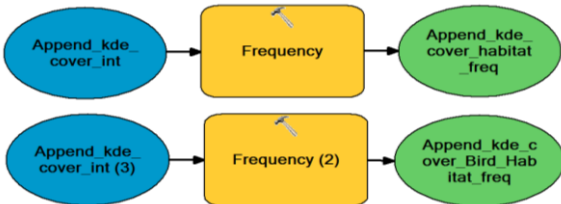


Figure A45. Generate KDE habitat frequencies.



Figure A46. Generate total KDE area values.

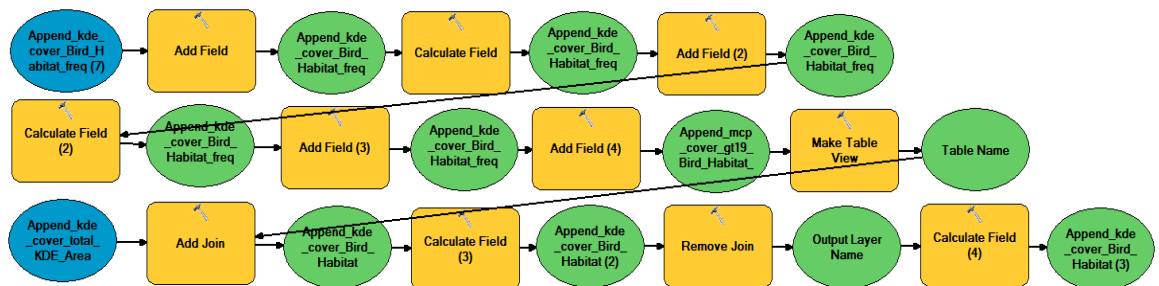


Figure A47. Add fields to KDE tables for habitat proportions.

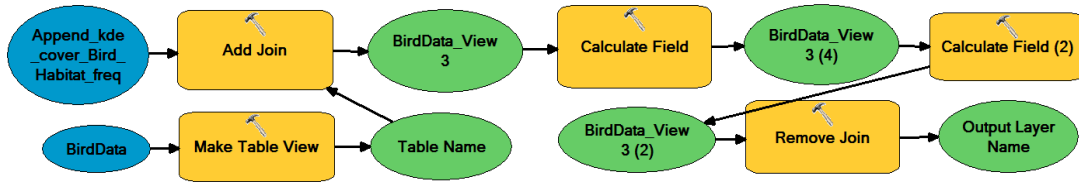


Figure A48. Populate KDE area habitat proportion values.

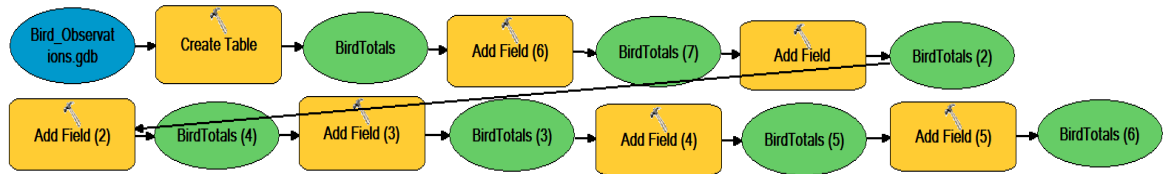


Figure A49. Create "BirdTotals" table.

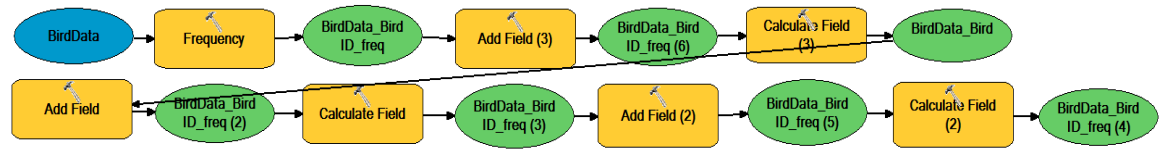


Figure A50. Run frequency on "BirdData" for "BirdTotals" input.

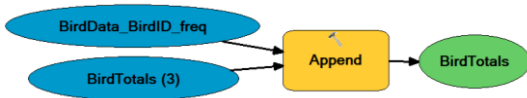


Figure A51. Append "BirdData" frequencies into "BirdTotals" table.

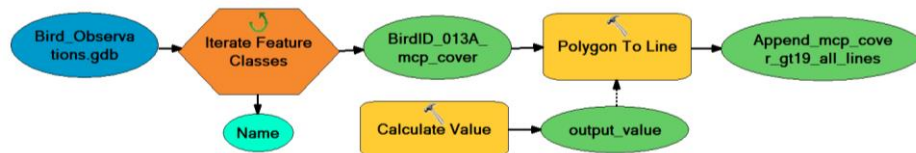


Figure A52. Generate MCP habitat lines for edge calculations.

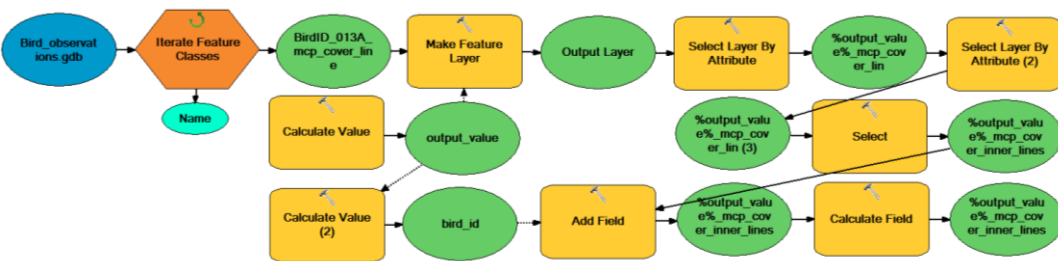


Figure A53. Select MCP habitat inner lines.

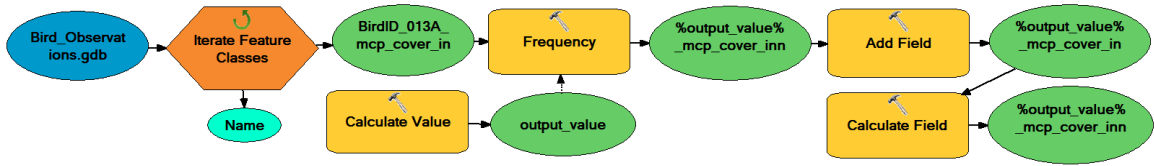


Figure A54. Run frequency on MCP habitat inner lines.

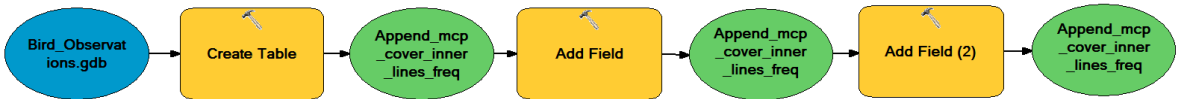


Figure A55. Create empty append MCP inner line frequency table.

First, run it to create the Output Values and then connect them to the Append and run it again
Don't save it after running - otherwise it will remember the last collection of values....

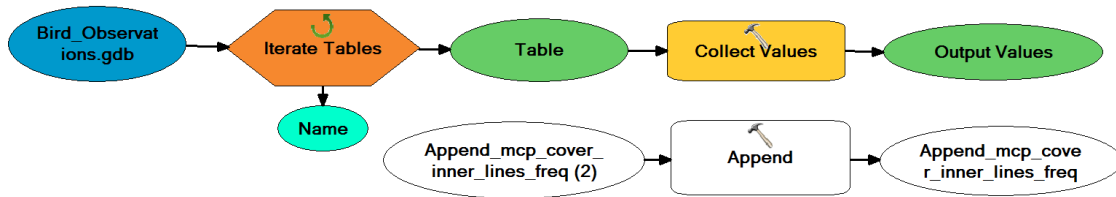


Figure A56. Append all MCP inner line frequencies together.

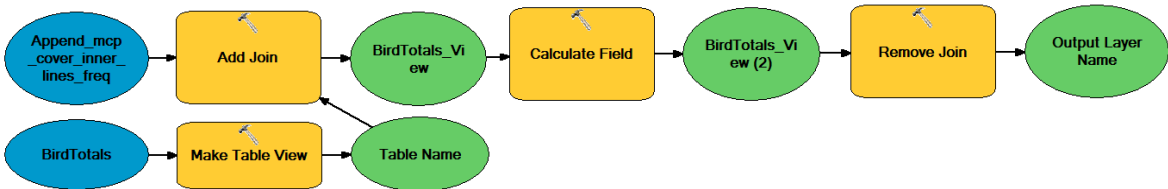


Figure A57. Populate MCP edge values in "BirdTotals" table.

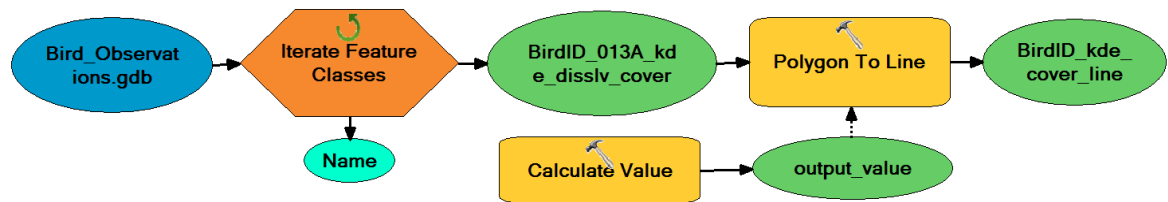


Figure A58. KDE lines for habitat edge measurements.

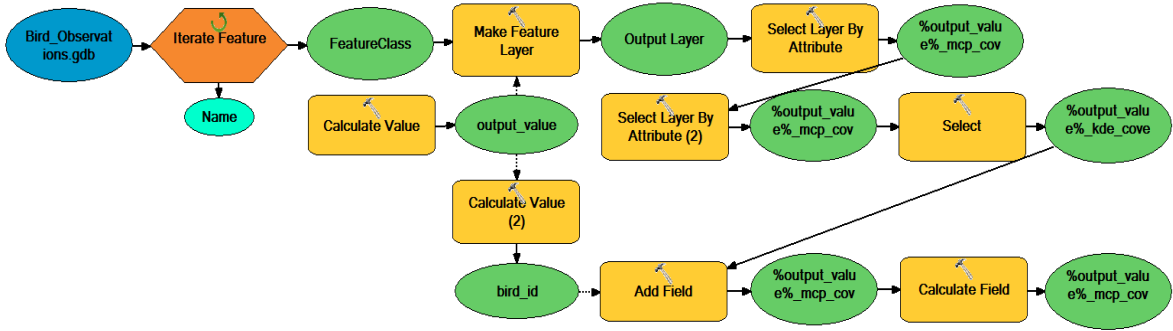


Figure A59. Select KDE habitat inner lines.

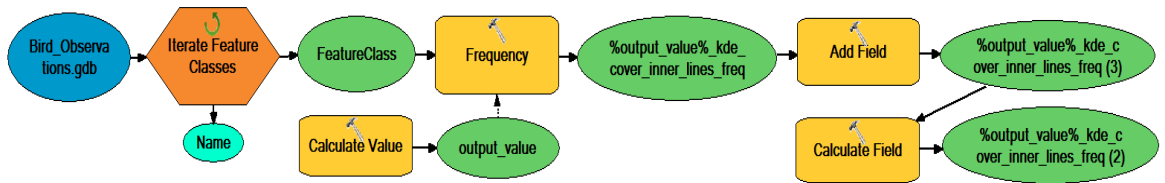


Figure A60. Run frequency on KDE habitat inner line measurements.



Figure A61. Create empty append KDE inner line frequency table.

First, run it to create the Output Values and then connect them to the Append and run it again
 Don't save it after running - otherwise it will remember the last collection of values...

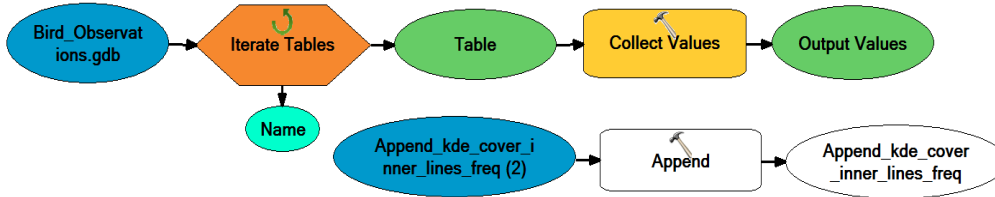


Figure A62. Append KDE inner line frequencies together.

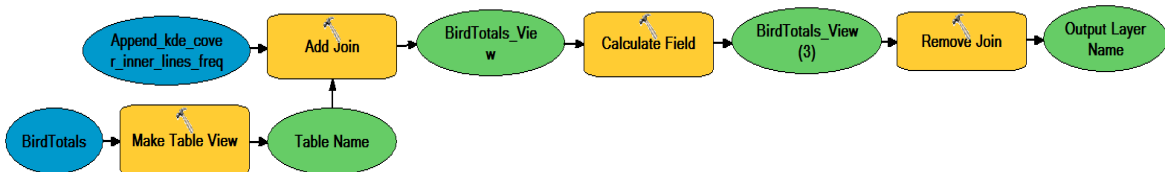


Figure A63. Populate KDE edge values into “BirdTotals” table.