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# NORTHERN BOBWHITE SURVIVAL, NEST SUCCESS, AND HABITAT USE IN KENTUCKY DURING THE BREEDING SEASON

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## ABSTRACT

Northern bobwhite (*Colinus virginianus*) populations have experienced protracted declines over much of their range. There has been an annual decrease of 2.61% since the 1960s in Kentucky, an area representative of the Mid-South where there is a lack of data on basic population parameters. Much of the decline is attributed to prevailing land-use practices and associated habitat loss. We monitored northern bobwhite on a 515-ha farm in Oldham County, Kentucky to assess survival rates, nest success rates, and habitat use in the Mid-South. The farm consisted of row crops, cool-season pastures and hay (primarily tall fescue), fallow native warm-season grass fields, and woods. We captured birds using baited funnel traps and fitted them with harness radio transmitters and monitored them daily during April–August, 2009 and 2010. We radiomarked 88 birds (40 females, 48 males) and monitored 24 nests, 9 (37.5%) of which were successful, over the 2 years. Survival rates were 25.3 and 27.9% for 2009 and 2010, respectively, based on estimates from Program MARK. Home range size (54.0, range = 38.0–55.9 ha) did not differ by sex, age, or year ($P > 0.05$). Quail favored food plots in both years and avoided developed areas.

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***Key words:*** *Colinus virginianus,* habitat use, home range, Kentucky, nest success, northern bobwhite, radiotelemetry; survival rate

## INTRODUCTION

Northern bobwhite populations have declined across their range (Sauer et al. 2008) due to habitat alteration and loss resulting from agriculture (Brennan 1991, Burger et al. 1995a), silviculture (Brennan 1991, White et al. 2005), and urbanization (Veech 2006). This decline within Kentucky has occurred at an annual rate of 2.61% since the mid-1960s (Sauer et al. 2008).

Considerable work has been done to document bobwhite population parameters and habitat use in other parts of the species' range (Cox et al. 2004, Terhune et al. 2006, Lohr et al. 2011), but data are lacking in the Mid-South, an area largely congruous with the Central Hardwood Bird Conservation Region (CHBCR). There are several older studies in the region that provide data from the 1960s (e.g., Klimstra and Roseberry 1975, Roseberry et al. 1979), but advances in field research technologies (i.e., radiotelemetry) and analytical tools (i.e., Program MARK), and changes in land-use practices dictate these issues be addressed with new research. This research must be conducted in the appropriate context, representative of the region's prevailing land use practices and landscape configuration.

Landscapes of the Mid-South are dominated by deciduous forests and exotic grass pastures and currently have low bobwhite populations (Applegate et al. 2011). However, certain land management practices have been deemed helpful in maintaining and increasing local northern bobwhite populations. These include planting native grasses, fallow rotations, and planting annual food plots. These practices have not been widely implemented, but many individual landowners have used these techniques. The impacts of these practices at scales appropriate to contemporary conservation paradigms (i.e., National Bobwhite Conservation Initiative; NBTC 2011) are also currently unexamined within the Mid-South. An appropriate framework for research would include both ownership scales and practices that are contextually appropriate to the region.

We conducted research on a site that was representative of the diversified landscapes of the region and, to the extent possible, appropriate to landownership scales and conservation practices likely to be implemented by regional landowners. Our objectives were to use radiotelemetry to examine home range size, adult and nest survival, nest success, nest site attributes, brood habitat,

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and adult habitat use of northern bobwhite during the breeding season on a representative Mid-South site.

## STUDY AREA

We conducted our research on a 515-ha farm in Oldham County, Kentucky (38° 26′ 56” N, 85° 27′ 07” W). The farm was within the CHBCR and was within 10 km of the Ohio River. The area was a part of the Outer Bluegrass Physiographic Province with elevations ranging from 190 to 240 m asl. Soils were classified within the Crider-Nicholson Association along ridges and the Beasley-Caneyville Association on lower slope positions; both associations were formed over limestone parent materials (Whitaker 2011). Land use included 4.5 ha (1%) of fields dominated by annual weeds, 40 ha (8%) of annual food plots, 62 ha (12%) of native warm-season grasses (NWSG) that were not being used for forage (grazing or hay production), 77 ha (15%) of rotational corn and soybeans, 76 ha (15%) of cool-season pastures, and 18 ha (3%) of hay fields dominated by tall fescue (*Festuca arundinacea*), 228 ha (44%) of deciduous woodlands, and 10 ha (2%) of developed areas including houses, barns, equipment sheds, and associated curtilage. The scale of our site, while larger than most land holdings in the region (e.g., 60–70 ha), was the smallest scale on which we could work and develop meaningful sample sizes. It was also representative of the scale that may be a realistic goal for landowner cooperatives focused on bobwhite conservation. The other deviation from regional norms at our study site was the presence of considerable area devoted to conservation practices including annual weed fields, food plots, and NWSG plantings. The presence of these habitat features gave us the opportunity to evaluate possible impacts to northern bobwhites and may have been responsible for the greater density of birds on the study site compared to the surrounding landscape (5–10 vs. 1–2 known coveys), making research on this site feasible.

## METHODS

We trapped bobwhites using bait and Stoddard funnel traps (Burger et al. 1995a) at known covey locations during March–April 2009 and February–April 2010. We raked each trap site to bare soil and baited it with grain sorghum, corn, millet, or a mixture of the grains. Traps were hidden with freshly cut eastern red cedar (*Juniperus virginiana*) limbs to minimize stress of trapped birds. Traps were checked every evening. We recorded sex, age (adult or juvenile), mass to the nearest gram, and condition for each captured bobwhite, and attached a uniquely numbered, size-4 leg band. We initially fit both males and females with harness-type transmitters (American Wildlife Enterprises, Monticello, FL, USA) weighing 6 g to ensure an adequate sample size. We did not place transmitters on birds with mass $<$130 g. Transmitters had a signal of 38 pulses/min or, after 12 hrs without movement, a mortality signal of 70 pulses/min. We recovered transmitters from dead birds and tried to classify cause of death (e.g., avian or mammalian). Bobwhites were released at the trap site following processing. All trapping and handling of animals for this project was approved by the University of Tennessee Animal Use and Care Committee, protocol # 561.

We obtained locations for radio-marked birds by approaching to within 25 m and recording the bird’s location on a 1:5,765 scale map; locations were later transferred into an ArcGIS data layer. We located all radio-marked birds every other day until covey break-up in spring ($\sim$ late Apr in both years), and then daily to document nest initiation. We marked nests by placing flagging 5 m distant and in four directions, centered on the nest site. We waited until the bird had initiated incubation and was off the nest to count eggs to ascertain clutch size. We also recorded plant species at the nest site and overall habitat type in which it was located. We tracked broods twice daily to document movements and habitat use.

We sampled vegetation at each nest and a randomly-located point (10–50 m from the nest) paired with that nest. We established two perpendicular 20-m lines (centered over the nest) to sample herbaceous species, litter depth, average vegetation height, and cover density. We recorded plant species at 1-m intervals; plants were identified to species whenever possible. More than one plant may have been recorded at each point due to layering of vegetation. We recorded average vegetation height (cm) at 5-m intervals, starting at the 0-m mark, for a total of five measurements per transect. Litter depth (cm) was measured at the first location where litter was present, starting from both ends of the 20-m transect moving toward the center and from the center moving out in each direction for a total of four per transect. We measured cover density using a Robel pole (Robel et al. 1970) placed at the center of each transect. We analyzed means for vegetation variables under a randomized block model using one-way analysis of variance (ANOVA).

We calculated home ranges with a 95% Kernel method for birds having $>$20 known locations after 1 April using the animal movement extension in ArcView 3.2 (Hooge and Eichenlaub 1997). We compared mean home range sizes among adult males, adult females, juvenile males, and juvenile females using ANOVA with year, sex, and age as main effects and home range size as the dependent variable. We used a known fates model within Program MARK (White and Burnham 1999) to estimate adult and juvenile survival for the season from our radiotelemetry data. We used the Mayfield method (Mayfield 1975) to estimate daily nest survival rates because of our small sample size of nests, We raised daily nest survival to the 23rd power (nest incubation period of northern bobwhite) to calculate nest success. We used 1:12,000 aerial photography (2008; USDA Farm Service Agency) and ground examination to classify the study area into 8 cover types: annual forbs, food plot, NWSG, row crop, cool-season pasture, cool-season hay, woods, and developed. We evaluated habitat use by first clipping the vegetation layer for each useable (i.e., $>$20 locations) home range and calculated the proportion of each range allocated to the 8 cover types. We used Chi-square tests to examine nest success by substrate and nest selection by

Table 1. Number of northern bobwhite captured in north-central Kentucky, 2009–2010.

| | Year | |
|---|---|---|
| | 2009 | 2010 |
| Total captured | 52 | 44 |
| Adult males | 10* | 10 |
| Adult females | 6 | 2 |
| Juvenile males | 19* | 17 |
| Juvenile females | 17 | 15 |
| Total radiomarked | 44 | 44 |

*Only 21 males (7 adults and 14 juveniles) were radiomarked in 2009.

habitat. Expected values for nest success by substrate were taken by multiplying total number of nests per substrate by nest success (averaged between both years), and nest selection by habitat by multiplying percent of each habitat by the total number of nests. We used a Chesson Habitat Index (Chesson 1978) to examine habitat use. This approach compares available habitat to what an animal actually used. Use of any cover type for which the lower limit of the 95% confidence interval for that type exceeded proportional use (i.e., 1/8 or 0.125) was considered selected for, and was considered to be selected against where proportional use (1/8 or 0.125) was below that interval.

## RESULTS

We had 1,689 trap nights in 2009 and 2,442 in 2010. Fifty-two bobwhites were captured in 2009 and 44 in 2010 for a trap success rate of 3.1 and 1.8%, respectively. We radiomarked 44 birds each year; 8 males captured in 2009 were not instrumented to save transmitters for use on females (Table 1). We calculated home range sizes for 31 birds in 2009 and 24 in 2010 (Table 2). Home range size did not differ by year ($F = 1.59$, $P = 0.21$), sex ($F = 0.51$, $P = 0.48$), or age ($F = 1.01$, $P = 0.32$). Mean (± SE) survival during the 2009 and 2010 breeding seasons and across all sex and age classes was 25.3 ± 9.3% and 27.9 ± 6.9%, respectively; small sample sizes precluded analyses by sex or age class. We recorded 4 avian, 14 mammalian, and 8 unknown mortalities during 2009 and 11 avian, 10 mammalian, and 4 unknown mortalities for 2010.

Sixteen active nests were located in 2009 and 8 in 2010 with 5 (31.3%) and 4 (50.0%) of those being successful, respectively. Nest survival estimates using the Mayfield method were 24.2% for 2009 and 42.0% for 2010. Average clutch size was 13.1 eggs per successful nest and 12.0 eggs per unsuccessful nest, and mean date for nest initiation was 8 June and 10 June for 2009 and 2010, respectively. The species most commonly used by bobwhites for constructing their nests was Indiangrass (*Sorghastrum nutans*) followed by tall fescue (Table 3); nest success did not differ by nest substrate ($X^2 = 5.44$, $P > 0.05$). We did not detect differences ($P > 0.05$) between nest and random sites for nest vegetation measures (Table 4). Fifteen of 24 nests were either in NWSG or on a NWSG edge with another type (Table 3); NWSG was used more than expected and woods less than expected ($X^2 = 96.13$, $P < 0.001$). Radio-marked birds favored food plots both years, NWSG in 2009 and row crops in 2010 (Table 5). Developed areas were avoided both years and cool-season pastures and hay fields were avoided in 2010. We were not able to analyze brood home range sizes, survival, or habitat use because of the small sample size for broods ($n = 2$ for each year). Size (and number of days tracked post-hatching) of these 4 brood ranges were 9.5 (17 days), 4.2 (19 days), 1.7 (19 days), and 1.7 ha (10 days) each (mean = 4.3 ha). Field observation of diurnal habitat use indicated 2 of the 4 broods primarily used areas with prominent shrubby cover (2–3 m tall saplings), while one stayed in and around an annual weed field, and the fourth split its time between a shrubby area and a cool-season pasture.

## DISCUSSION

Our data, despite modest sample sizes, present much needed insight into the basic biology of northern bobwhite on a contemporary Mid-South landscape, a region that has been largely understudied with respect to this species. Klimstra and Roseberry (1975) and Roseberry et al. (1979) investigated northern bobwhite populations during the 1950s and 1960s on a landscape somewhat similar to ours and, in broad terms, in the same region of the U. S. (350 km from our study area). However, there have been numerous changes in land use, and agricultural and forestry practices since that time. Better information is clearly needed to inform conservation strategies for this species within the region.

Mean home range size in our study exceeded breeding season estimates of those in New Jersey (38.7 ha; Lohr et al. 2011), but were similar to those in the Flint Hills in Kansas (54–75 ha; Taylor et al. 1999). Terhune et al. (2006), working in high quality habitat managed intensively for bobwhites, reported mean home range sizes (16.8 ha) much smaller than ours. All three studies were conducted in landscape contexts quite different from

Table 2. Mean (± SE) home range size (ha) for northern bobwhite during April–August, 2009–2010 in north-central Kentucky.

| | Male | | | | Female | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Adult | *n* | Juvenile | *n* | Adult | *n* | Juvenile | *n* | Pooled |
| 2009 | 55.9 ± 11.4 | 6 | 77.0 ± 17.0 | 9 | 43.7 ± 30.8 | 6 | 58.2 ± 23.0 | 10 | 61.0 ± 10.4 |
| 2010 | 38.0 ± 12.5 | 5 | 56.9 ± 7.8 | 11 | n/a | 0 | 32.6 ± 10.7 | 8 | 44.9 ± 5.9 |
| Pooled | 47.8 ± 8.5 | | 66.5 ± 9.1 | | 43.7 ± 30.8 | | 46.1 ± 13.2 | | 54.0 ± 6.5 |

Table 3. Vegetation substrate and cover type associations at 24 northern bobwhite nests during 2009–2010 in north-central Kentucky. Values represent number of nests within a given substrate or cover type.

| Nest vegetation substrate | | Nest cover type | Single type | Edges: Pasture | Edges: Woods | Totals |
|---|---|---|---|---|---|---|
| Indiangrass (*Sorghastrum nutans*) | 10 | NWSG | 10 | 1 | 4 | 15 |
| *Bromus* spp. | 2 | Woods | 3 | | | 3 |
| Goldenrod (*Solidago* spp.) | 3 | Pasture | 2 | | 1 | 3 |
| Tall fescue (*Festuca arundinacea*) | 8 | Annual weeds | 2 | | 1 | 3 |
| Thistle (*Carduus* spp.) | 1 | | | | | |
| Totals | 24 | | 17 | 1 | 6 | 24 |

ours; however, we are not aware of any work in areas more similar to ours.

Klimstra and Roseberry (1975) did not investigate survival in their nesting season research in southern Illinois. Roseberry et al. (1979), working in Jackson County, Illinois, reported a seasonal (16 Mar–9 Nov) survival rate of 58.9% over a 5-year period based on periodic field censuses using bird dogs. The first study using radiotelemetry in a region and landscape somewhat comparable to ours was in northern Missouri ($\sim$ 50% row crop and 10% wooded in Missouri vs. 15% row crop and 44% wooded in Kentucky) during the early 1990s (Burger et al. 1995a). They reported summer survival rates of 33.2% over the 3 years of their study ($n = 406$, pooled across years); those rates did not differ by sex or age. These rates are higher than those we observed during our 2-year study (25.3 and 27.9%, respectively). Sandercock et al (2008) summarized 76 studies of bobwhites conducted within the U. S. that reported estimates of summer survival of which 13 were <20%, 8 were between 20 and 30%, and 51 were >30%. These studies used a variety of techniques and had a wide range of sample sizes and durations, but it is clear survival rates on our study area were well below that in most other investigations.

Nest success in the region has been reported at 33.7% by Klimstra and Roseberry (1975) during their 15-year study and at 46% over a 4-year period by Roseberry et al. (1979). Burger et al. (1995b) reported nest success for females (40.2%) and males (13.5%) over their 3-year study; we did not evaluate success by males and females in our study. Our success rates (31.3 and 50.0% for 2009 and 2010, respectively) appear to be comparable to those reported by others working in the region. Nest initiation dates on our site appear to have been later than reported by others (Klimstra and Roseberry 1975, Burger et al. 1995b) and may have been indicative of second nesting attempts (Burger et al. 1995b). The only other published estimate of nest survival of which we are aware from this region is that of Burger et al. (1995b). Their estimated nest survival, 43.7% for 159 nests using the same method (Mayfield), was higher than ours (24.2 and 42.0%, 33.1% averaged across both years). Fifty-five of 68 nest survival studies evaluated by Sandercock et al. (2008), reported rates >30%, further indication that nest survival on our site was below average.

Table 4. Mean ($\pm$ SE) vegetation metrics for nests and random locations for northern bobwhites in north-central Kentucky, April–August, 2009–2010. Means were compared with an ANOVA model.

| Variable | Nest | Random | *P* |
|---|---|---|---|
| Height (cm) | 69.8 ± 4.8 | 71.8 ± 4.8 | 0.597 |
| Litter depth (cm) | 5.3 ± 0.7 | 5.7 ± 0.7 | 0.456 |
| Vertical density (dm) | 7.3 ± 0.6 | 7.5 ± 0.6 | 0.779 |
| Cover (%) | | | |
| NWSG | 53.3 ± 12.4 | 42.1 ± 12.4 | 0.010 |
| Cool-season grass | 82.5 ± 11.6 | 96.2 ± 11.6 | 0.083 |
| Forbs | 112.8 ± 14.2 | 114.6 ± 14.2 | 0.840 |
| Woody | 20.5 ± 5.3 | 19.1 ± 5.3 | 0.692 |
| Legumes | 21.1 ± 4.2 | 23.8 ± 4.2 | 0.616 |
| Other warm-season grass | 2.4 ± 0.1 | 2.6 ± 0.1 | 0.312 |

Bobwhites on our study area had a strong affinity for 2 key species for nesting substrate: Indiangrass (42%) and tall fescue (33%). Indiangrass was the most common species in the planted NWSG areas and tall fescue comprised the overwhelming majority of the pastures and hayfields in the study area. The much greater amount of tall fescue available than Indiangrass (94 vs. 62 ha) coupled with greater use of the latter species suggests preferential selection for Indiangrass for nesting. The apparent selection is further reinforced by placement of a high proportion of nests in habitat patches or edges associated with NWSG. Broomsedge (*Andropogon virginicus*), perhaps the species in which bobwhites most commonly nest (Rosene 1969, Klimstra and Roseberry 1975), was present on the study area, but did not dominate any cover type and only occurred in scattered clumps. Indiangrass may have served as the primary replacement for broomsedge for nest sites in our study area.

Avoidance of fescue-dominated pastures and hay fields by bobwhites in our study during 2010 was not surprising (Barnes et al. 1995, Washburn et al. 2000). However, we did not expect these cover types to be used in proportion to availability during 2009. We expected use of NWSG in 2009, but not the proportional use observed in 2010. This pattern may have been a result of patterns in use of prescribed fire by the landowner for stand maintenance. The NWSG on this site were dense with few forbs present and probably could have been improved for bobwhite habitat (Millenbah et al. 1996, Kopp et al.

Table 5. Mean proportion of available habitats within home ranges of radio-marked northern bobwhites in north-central Kentucky, April–August, 2009–2010. Bold numbers for confidence intervals indicate a preference while italic numbers indicate avoidance based on the Chesson Habitat Index.

| | 2009 | | | | 2010 | | | |
|---|---|---|---|---|---|---|---|---|
| | Proportion of home range mean | SE | 95% Confidence interval | | Proportion of home range (mean) | SE | 95% Confidence interval | |
| Annual weeds | 0.099 | 0.039 | 0.022 | 0.175 | 0.176 | 0.063 | 0.053 | 0.300 |
| Food plot | 0.186 | 0.029 | **0.130** | **0.243** | 0.213 | 0.035 | **0.146** | **0.281** |
| NWSG | 0.282 | 0.038 | **0.207** | **0.357** | 0.170 | 0.032 | 0.106 | 0.233 |
| Row crop | 0.111 | 0.023 | 0.067 | 0.155 | 0.240 | 0.042 | **0.158** | **0.322** |
| C-S Pasture | 0.078 | 0.033 | 0.013 | 0.144 | 0.027 | 0.011 | *0.006* | *0.047* |
| C-S Hay | 0.092 | 0.026 | 0.041 | 0.143 | 0.027 | 0.018 | *−0.009* | *0.063* |
| Woods | 0.121 | 0.016 | 0.090 | 0.151 | 0.118 | 0.015 | 0.088 | 0.148 |
| Developed | 0.031 | 0.009 | *0.013* | *0.048* | 0.029 | 0.012 | *0.006* | *0.052* |

1998, Greenfield et al. 2003) through some additional disturbance such as pyric herbivory (Fuhlendorf et al 2009, Doxon et al. 2011). Use of row crop areas in 2010 may have been a result of extensive planting of no-till corn within this cover type. The height of corn and associated understory weeds and litter, and its earlier planting date, may have provided adequate cover at a time important to breeding bobwhites. However, only limited brooding activity was documented in row crop areas; brood use was primarily associated with fallow fields and areas with moderate brushy components. Woods were not avoided as expected (Veech 2006, Lohr et al. 2011), possibly because our delineation of woods included edges where much of the shrub habitat on the study area occurred. Use of food plot areas in both years was expected given the open nature of the ground layer on most plots, combined with substantial overhead cover (Greenfield et al. 2003).

Our findings of low adult and nest survival, late nest initiation dates, and larger than typical home range sizes support our assumptions about the declining, low-density populations typical of the region. The high proportion of forest and non-native grasslands in our study area likely contributed to marginal habitat quality (Roseberry and Sudkamp 1998, Veech 2006, Seckinger et al. 2008), a problem that apparently was not overcome by substantial annual food plot and NWSG plantings. However, both of these habitat features appeared to be important to bobwhites on this site and the population may have fared worse had these features not been present. Additional changes in land use practices, likely in terms of scale and intensity, will be necessary in typical CHBCR landscapes to improve survival and productivity of northern bobwhite populations.

## MANAGEMENT IMPLICATIONS

Annual food plots and NWSG plantings should be encouraged wherever bobwhite management is a goal. Food plots may be more important for providing early successional cover where soil has been exposed, litter reduced, and annual plants encouraged, than for increasing available food. Native grasses managed for wildlife habitat enhancement (as opposed to forage production) should be more diverse and receive more regular disturbances. One alternative is to use managed grazing or pyric herbivory to optimize wildlife benefits in dense, production-type stands. Exotic, sod-forming grasses in production systems (e.g., tall fescue) should be replaced whenever feasible with NWSG as a preferred forage option. Commercial forest thinning coupled with judicious use of prescribed fire, even around forest edges, could help alleviate some problems associated with extensive forest cover. Efforts that foster use of these practices at a large scale will be important for advancing bobwhite conservation within this region.

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