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# INFLUENCE OF FOOD PLOTS ON NORTHERN BOBWHITE MOVEMENTS, HABITAT USE, AND HOME RANGE

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## ABSTRACT

Natural resource managers at the Fort Riley Military Reservation in Kansas have established plantings to provide winter food for northern bobwhites (*Colinus virginianus*) since 1959. These food plots have the potential for reducing movements and home range sizes of bobwhites during winter because birds should apparently need to forage over less area to obtain sufficient food. To determine if this was occurring, we conducted a 3-year radio telemetry study of bobwhites on Fort Riley. We equipped 511 bobwhites with radio transmitters and followed their movements and habitat use from October through March, beginning in 1994.

Daily movements of bobwhites near food plots varied by field season and study site, but generally did not differ significantly between food plot and non-food plot areas. Home ranges of bobwhites did not differ significantly between food plot and non-food plot areas, study site, or field season. Prairie habitat always was used significantly less than its proportional availability by bobwhites. Food plots were used significantly more than their proportional availability during 2 of 3 field seasons. Habitat use by bobwhites on the 2 study sites differed between food plot and non-food plot areas.

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## INTRODUCTION

The availability of food has been demonstrated to influence the movement and home ranges of many wildlife species. For example, the presence of food patches reduced daily movements of ring-necked pheasant (*Phasianus colchicus*) in Wisconsin during the fall and winter (Gatti et al. 1989). Supplemental food reduced home range sizes relative to individuals without access to supplemental food among red squirrels (*Tamiasciurus hudsonicus*) and deer mice (*Peromyscus maniculatus*) in British Columbia (Sullivan 1990 and Taitt 1981, respectively), and chipmunks (*Tamias striatus*) in Pennsylvania (Mares et al. 1976). Wildlife using food plots may also reduce their predation risk by decreasing exposure when foraging (Martin 1992).

Natural resource managers at the Fort Riley Military Reservation, Kansas, began establishing food plots to supplement winter food supplies for bobwhites in 1959 (Joselyn 1965). These food plots were effective at improving body condition of bobwhites during winter (Robel et al. 1974) and increasing their overwinter survival (Robel and Kemp 1997). Natural resource managers at Fort Riley have also observed that hunters concentrate their efforts near food plots. Intense hunting pressure is known to affect the movements of bobwhites. Rosene (1969) observed that bobwhites disturbed repeatedly by hunters moved to different locations to avoid such hunting activity. When regularly disturbed, bobwhites are known to become more elusive (Kellogg et al. 1982) and shift their home range or increase their movements to avoid the disturbance (Dimmick and Yoho 1972).

The effect of food plots on bobwhite movement patterns and home ranges during winter is unknown. We initiated this study to examine the influence of food plots on the daily movements, home ranges, and habitat use of bobwhites on the Fort Riley Military Reservation. We also examined whether hunting activity affected bobwhite movements relative to food plots.

## STUDY AREA

The Fort Riley Military Reservation is a 40,740 hectare area approximately 22 kilometers west of Manhattan, Kansas. It is located within the Flint Hills region of Kansas, which is a rolling landscape dominated by tall-grass prairie (Kuchler 1974). Natural resource managers at Fort Riley currently manage 160 food plots across the military reservation. These food plots vary in size from 1–5 hectares, are generally lo-

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cated adjacent to woody cover, and are planted with grain sorghum (*Sorghum bicolor*) or soybeans (*Glycine max*).

We selected a study site in the western area of Fort Riley and another in the eastern area of Fort Riley to conduct this study. These 2 study sites were separated by 10–15 kilometers, and their habitat composition significantly differed ($P \leq 0.001$); the eastern study site was 44% forested and 40% prairie, whereas the western site was 67% prairie and 13% forested.

We choose 6 food plot and 6 non-food plot areas within each of the 2 Fort Riley study sites to conduct trapping and radio telemetry activities. A food plot area was defined as any area ≤600 meters from a food plot and a non-food plot area as any area >900 meters from a food plot, based on Robel et al. (1974). The eastern ($P \leq 0.038$) and western ($P \leq 0.006$) study sites differed between food plot and non-food plot sites in habitat composition. In eastern Fort Riley, food plot sites were 32% prairie and 63% wooded cover, whereas non-food plot sites were 48% prairie and 52% wooded cover. Food plot sites were 52% prairie and 45% wooded cover in western Fort Riley, whereas non-food plot sites were 74% prairie and 26% wooded cover. This was an artifact of the method used by the natural resource managers at Fort Riley when they selected locations for establishing food plots. They selected areas where the food plots would border large stands of wooded cover.

## METHODS

Bobwhites were captured from October through December during 1994, 1995, and 1996 at each study site. We attempted to capture all birds prior to the beginning of the hunting season (second weekend in November). Walk-in funnel-traps baited with grain sorghum were used to capture all bobwhites.

Captured bobwhites were sexed and aged. All adult bobwhites and juveniles ≥ 58 days of age (based on primary feather replacement) (Larson and Taber 1980) were fitted with a necklace radio transmitter, banded, and released. The radio transmitter weighed 7.5–8.0 g and contained a mortality switch.

Bobwhites were tracked using radio telemetry 4–5 days per week from October through March, depending on the intensity of military activities. The location of radio-marked bobwhites was determined by triangulating their position from as close as possible (50–200 meters), while attempting to minimize disturbance to the covey. Bobwhite locations were categorized into 4 habitat types: forested, woody thicket, prairie, and food plots.

Daily movement was estimated by determining the distance between locations on consecutive days based on the Universal Transverse Mercator (UTM) coordinate system. The effect of hunting on daily movements of bobwhites was estimated by dividing each field season into 3 periods: pre-hunting (prior to the second weekend in November), hunting, and post-hunting (after 31 January). Home range was estimated using the adaptive kernel method (Worton 1989) with a 90% confidence interval. Habitat preferences and avoidance were estimated using a $\chi^2$ analysis with a Bonferonni z-test (Neu et al. 1974). Differences in habitat use between food plot and non-food plot areas were determined using $\chi^2$ analysis (Christensen 1990). Analysis of variance was used to test for differences and interactions in daily distance moved and home range size (Steele and Torrie 1980). A least significance difference mean comparison test was used to delineate differences between main effects. These data were analyzed as a split-plot design with repeated measures (Milliken and Johnson 1992) at an $\alpha = 0.10$. Means are presented ± 1 standard error.

## RESULTS

We captured 551 bobwhites and fitted them with radio-transmitters during this study; 140 during the 1994–1995 field season, 211 during 1995–1996, and 200 in 1996–1997. Overall, we monitored 26 coveys near food plots and 26 coveys in non-food plot areas. We recorded 2,454 telemetry locations across study sites and field seasons, of which 1,260 locations were collected on consecutive days.

### Daily Movements

Daily movement of bobwhites varied according to study site and field season ($P \leq 0.001$). Daily movements of bobwhites in the western study sites averaged 227 ± 9 meters per day, which was greater ($P \leq 0.101$) than those in the eastern study site (218 ± 8 meters per day). Daily movements were also greater ($P \leq 0.059$) in the 1995–1996 field season (242 ± 13 meters per day) and 1996–1997 field season (221 ± 7 meters per day) than in the 1994–1995 field season (195 ± 11 meters per day). During the 1995–1996 field season in western Fort Riley, movements near food plots were significantly greater than bobwhite movements in non-food plot areas (Table 1). Across all other field seasons and study sites, there were no differences between the daily movement of bobwhites near food plots and those in non-food plot areas. The maximum daily movement observed in the eastern study site across field seasons was 1.1 kilometers in a food plot area and 1.2 kilometers in a non-food plot area. In the western study site, the maximum movement was 1.3 kilometers in a food plot area and 1.0 kilometer in a non-food plot area.

There were sufficient data only in the pre-hunting, hunting, and post-hunting periods of the 1996–1997 field season to test for hunting effects. The majority of bobwhites were captured after the start of the hunting season in the 1994–1995 field season and most bobwhites had died by the post-hunting period in the 1995–1996 field season. During the 1996–1997 field season, there was a significant difference in daily movements between each period ($P \leq 0.003$), but it did not differ between food plot and non-food plot areas ($P \leq 0.733$) or study sites ($P \leq 0.511$). Bobwhites moved an average of 271 ± 17 meters per day

Table 1. Average daily movement (meters per day) and standard error (S.E.) of bobwhites between food plot and non-food plot areas in eastern and western Fort Riley, Kansas, study sites by field season.

| Field season | Study site | Food plot | | | Non-food plot | | |
|---|---|---|---|---|---|---|---|
| | | *n* | $\bar{x}$ | S.E. | *n* | $\bar{x}$ | S.E. |
| 1994–1995 | | | | | | | |
| | Eastern Ft. Riley | 22 | 257 a[1] | 44 | 34 | 220 a | 27 |
| | Western Ft. Riley | 73 | 181 a | 18 | 87 | 181 a | 17 |
| 1995–1996 | | | | | | | |
| | Eastern Ft. Riley | 102 | 194 a | 16 | 108 | 205 a | 24 |
| | Western Ft. Riley | 84 | 320 a | 28 | 57 | 250 b | 30 |
| 1996–1997 | | | | | | | |
| | Eastern Ft. Riley | 254 | 235 a | 12 | 135 | 209 a | 14 |
| | Western Ft. Riley | 187 | 204 a | 14 | 111 | 233 a | 19 |

[1] Rows with the same letters are statistically similar at $\alpha = 0.10$.

during the pre-hunting period, which was significantly greater than the daily movement within both the hunting (212 ± 9 meters per day) and post-hunting (181 ± 14 meters per day) periods.

## Home Range

There was no difference ($P \leq 0.769$) between home range sizes of bobwhites near food plots (40.6 ± 5.0 hectares) and those in non-food plot areas (42.7 ± 4.7 hectares). Home ranges of bobwhites near food plots ranged from 10 to 126 hectares; home ranges of bobwhites far from food plots was 7 to 117 hectares. Home ranges of bobwhites did not vary with field season ($P \leq 0.829$) or study site ($P \leq 0.758$), nor was there an interaction between field season and study site ($P \leq 0.223$). Bobwhite home ranges also did not differ significantly between food plot and non-food plot areas within each field season ($P \leq 0.216$), study site ($P \leq 0.131$), or field season and study site ($P \leq 0.134$).

## Habitat Use

There was a difference in the habitat use by bobwhites between field seasons ($P \leq 0.001$) and study site ($P \leq 0.001$). Therefore, habitat use by bobwhites in food plot and non-food plot areas was analyzed within field season by study site.

Tall grass prairie was always used by bobwhites less than its proportional availability across field seasons, study sites, and food plot and non-food plot areas (Tables 2 and 3). Food plots were always used by bobwhites greater than their proportional availability among food plot areas across field seasons and study sites. However, during the 1994–1995 field season, the preference for food plots was not statistically significant in either the eastern or western study sites (likely due to low sample size).

The use of thickets and forests by bobwhites relative to availability varied between field seasons and food plot and non-food plot areas in the eastern study site (Table 2). During the 1994–1995 field season, bobwhites in both food plot and non-food plot areas used thickets and forests greater than their proportional availability. Thickets were used less than their proportional availability in both food plot and non-food plot areas in the 1995–1996 field season. Forests were used greater than their proportional availability by bobwhites in non-food plot areas, but equal to their proportion in food plot areas. During the 1996–1997 field season, bobwhites near food plots used thickets equal

Table 2. Percentage of bobwhite locations habitat composition, and habitat use in proportion to availability by habitat type, within food plot and non-food plot areas, by field season, in eastern Fort Riley, Kansas.

| Field season | Habitat type | Food plot | | | | Non-food plot | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | *n* | Locations % | Composition % | Used | *n* | Locations % | Composition % | Used |
| 1994–1995 | | | | | | | | | |
| | Food plot | 12 | 11.1 | 5.0 | =[1] | | Not applicable | | |
| | Prairie | 11 | 10.2 | 33.6 | < | 19 | 22.3 | 71.0 | < |
| | Thicket | 19 | 17.6 | 20.5 | > | 33 | 37.9 | 8.5 | > |
| | Forest | 66 | 61.1 | 40.9 | > | 32 | 36.8 | 20.5 | > |
| 1995–1996 | | | | | | | | | |
| | Food plot | 46 | 24.3 | 5.3 | > | | Not applicable | | |
| | Prairie | 12 | 6.4 | 26.4 | < | 30 | 14.8 | 48.2 | < |
| | Thicket | 19 | 10.1 | 16.0 | < | 12 | 5.9 | 10.1 | < |
| | Forest | 112 | 59.3 | 52.4 | = | 161 | 79.3 | 41.7 | > |
| 1996–1997 | | | | | | | | | |
| | Food plot | 67 | 18.3 | 4.6 | > | | Not applicable | | |
| | Prairie | 90 | 24.5 | 31.2 | < | 42 | 21.7 | 36.9 | < |
| | Thicket | 83 | 22.6 | 21.5 | = | 53 | 27.3 | 10.3 | > |
| | Forest | 127 | 34.6 | 42.7 | < | 99 | 51.0 | 52.8 | 0 |

[1] A ">" indicates the habitat was used in a greater proportion than available; a "<" indicates the habitat was used in a lesser proportion than available; and a "=" indicates the habitat was used in the same proportion as available.

Table 3. Percentage of bobwhite locations habitat composition, and habitat use in proportion to availability within food plot and non-food plot areas, by field season, in western Fort Riley, Kansas.

| Field season | Habitat type | Food plot | | | | Non-food plot | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | *n* | Locations % | Composition % | Used | *n* | Locations % | Composition % | Used |
| 1994–1995 | | | | | | | | | |
| | Food plot | 16 | 9.5 | 4.8 | =[1] | | Not applicable | | |
| | Prairie | 24 | 14.3 | 54.4 | < | 78 | 35.1 | 72.8 | < |
| | Thicket | 58 | 34.5 | 11.2 | > | 101 | 45.5 | 23.4 | > |
| | Forest | 70 | 41.7 | 29.5 | > | 43 | 19.4 | 3.8 | > |
| 1995–1996 | | | | | | | | | |
| | Food plot | 35 | 15.2 | 5.1 | > | | Not applicable | | |
| | Prairie | 48 | 20.9 | 60.4 | < | 33 | 22.3 | 66.5 | < |
| | Thicket | 109 | 47.4 | 15.3 | > | 90 | 60.8 | 28.6 | > |
| | Forest | 38 | 16.5 | 19.2 | = | 23 | 15.5 | 4.9 | > |
| 1996–1997 | | | | | | | | | |
| | Food plot | 59 | 17.6 | 5.1 | > | | Not applicable | | |
| | Prairie | 47 | 14.0 | 56.7 | < | 22 | 10.8 | 76.5 | < |
| | Thicket | 114 | 34.0 | 14.9 | > | 156 | 76.9 | 20.4 | > |
| | Forest | 115 | 34.3 | 23.0 | > | 25 | 12.3 | 3.1 | > |

[1] A ">" indicates the habitat was used in a greater proportion than available; a "<" indicates the habitat was used in a lesser proportion than available; and an "=" indicates the habitat was used in the same proportion as available.

to, and forests less than, their proportional availability. Bobwhites in non-food plot areas used thickets more often than forests.

Habitat use by bobwhites in the western study site did not vary as greatly as it did in the eastern study site. Thickets were always used greater than proportionally available in both food plot and non-food plot areas across field seasons (Table 3). Forests were used by bobwhites in non-food plot areas greater than their proportional availability across field seasons. Bobwhites in food plot areas also used forests greater than their proportional availability, except during the 1995–1996 field season.

## DISCUSSION

Researchers in Missouri observed that bobwhites moved no more than 410 to 810 meters during the entire winter (Lewis 1954, Murphy and Basket 1952). We recorded occasional daily movements > 1 kilometer. Williams (1996) observed that daily movements of bobwhites during winter in Kansas ranged from a mean of 81.9 to 271.3 meters per day, and total mean movement was 1,216 meters. Bobwhites in our study area had mean daily movements of 180 to 320 meters per day, which was generally greater than most movements reported by other researchers.

The home range sizes we observed near (40.6 ± 5.0 hectares) and far from (42.7 ± 4.7 hectares) food plot areas on Fort Riley were also generally greater than home ranges observed by researchers elsewhere (4.4 hectares, Wiseman and Lewis 1981; 9.6 hectares, Roseberry 1964; 12.6 hectares, Hunt 1991; 16.7 hectares, Dimmick and Yoho 1972; 4.2 to 33.0 hectares, Dixon et al. 1996). Williams (1996) observed home ranges of bobwhites in central Kansas averaged 19.5 hectares, half that observed for bobwhites on Fort Riley. Bell et al. (1985) did observe home range sizes similar to those on Ft. Riley. They observed home range sizes of 18.4 to 58.4 hectares in Louisiana pinelands. They postulated that the marginal habitat quality of pinelands for bobwhites caused the large home range sizes. There is evidence that home range sizes and daily movements may be linked to habitat quality, where movements and home range sizes are generally greater in areas with poorer quality habitat (Brennan 1999). For example, Lee (1994) observed home range sizes for bobwhites as large as 282 hectares in an area in Mississippi where habitat had deteriorated.

The presence of food plots on Fort Riley did not significantly influence the daily movements of bobwhites or their use of habitat types. Daily movements and home range sizes of bobwhites generally were similar between food plot and non-food plot areas across field seasons and study sites. The only exception was that during the 1995–1996 field season in the western study site, daily movement of bobwhites near food plots was greater than bobwhites in non-food plot areas. Bobwhites near food plots in this study site tended to have a bimodal home range, in that more than one central area was utilized. Several coveys interchanged between the food plot and an alternate area that was > 500 meters from the food plot on successive days. The reason for these shifts in their location was unknown. Dimmick and Yoho (1972) observed shifts in bobwhite home ranges due to human disturbance, but we observed no specific disturbance that could be linked to the shifts in home ranges during our study.

The presence of supplemental food has been documented to reduce the movements or home ranges of several wildlife species. Robel and Kemp (1997) observed that bobwhites near food plots spent less time foraging and bobwhites in non-food plot areas had longer foraging movements. Several factors may have led to our observation of no differences in daily movements and home ranges between food plot and non-food plot areas. Robel and Kemp (1997) determined that food plots had their greatest impact on overwinter survival during severe winters (10–12 consecutive

days of temperatures ≤ 5° C in January). During the 3 field seasons of this study, no winter had > 5 consecutive days of ≤ 5° C temperatures in January. Therefore, winter weather during our study may not have been severe enough to impact the behavior of bobwhites near food plots. The daily movements of bobwhites near and far from food plots may be similar during mild winters, but during more severe winters, bobwhite movements may decrease near food plots.

Predators may also be affecting the daily movements of bobwhites near food plots. Predator density is known to be greater in areas where the prey base is high (Clark 1972, Robinson and Bolen 1984). Foraging time of many avian species has been documented to increase when predation risk is elevated (Grub and Greenwald 1982, Lima 1986). We did not measure predator or prey densities in this study, but if predators are concentrated near food plots, their presence may influence bobwhite foraging time (movements and home ranges) near food plots.

We observed that hunting did not affect the daily movements of bobwhites between food plot and non-food plot areas. Daily movements were greatest prior to the beginning of hunting season and progressively decreased through the winter. Williams (1996) observed a slight increase in daily movements of bobwhites in Kansas during November and December, which he attributed to the onset of hunting season. Smith et al. (1982) concluded that the impacts of hunting on bobwhite movements in Florida were insignificant. Dimmick and Yoho (1972) determined that when coveys were repeatedly disturbed during field trials in Tennessee, they tended to shift their home range. However, coveys receiving only moderate disturbance did not exhibit changes in their home range. During the opening weekend of the 1996–1997 hunting season on Fort Riley, hunter numbers averaged 0.53 hunters per 100 hectares and decreased to 0.08 hunters per 100 hectares one month after the start of hunting season. These numbers of hunters probably did not constitute heavy enough hunting pressure to alter bobwhite movement patterns for extended periods of time.

Habitat use by bobwhites near and far from food plots was similar, particularly in the western study site of Fort Riley. Prairie always was used less than proportionally available. Wiseman and Lewis (1981) and Williams (1996) observed that pastures were used less than proportionally available by bobwhites during winter. Grasslands are an integral component of bobwhite habitat (Casey 1965), but open grasslands are avoided. Food plots always were used greater than their proportional availability within food plot areas substantiating Robel (1969), i.e., a majority of bobwhites < 300 meters from food plots fed in those plots. Bobwhites on Fort Riley also used woody cover. Such habitat provides protection and escape cover for bobwhites across their North American range (Schroeder 1985, Wiseman and Lewis 1981).

In summary, we found few differences between the daily movements, home ranges, and habitat use between food plot and non-food plot areas during our study. Food plots were utilized by bobwhites, but daily movements and home ranges of bobwhites were not reduced near food plots, as we had expected. Mild winter weather and potential influences of predators near food plots may have limited the influence of food plots on bobwhite movements and home ranges.

Future research on the influence of food plots on the daily movements, home ranges, and habitat use by bobwhites should focus on assessing the impact of habitat quality and predator populations. Habitat quality, rather than the presence or absence of food plots, may better explain fluctuations in home range sizes and movement patterns. This would likely involve sampling bobwhite densities near and far from food plots, which is known to reflect habitat quality. In addition, the densities of both avian and mammalian predators could be estimated to determine if predators appear to be congregating near food plots. Experimental manipulations of the predator populations could further determine the impact of their presence on the movements, home ranges, and habitat use of bobwhites.

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