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DISTANCE–BASED HABITAT ASSOCIATIONS OF NORTHERN BOBWHITES IN A FESCUE-DOMINATED LANDSCAPE IN KANSAS

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ABSTRACT

Northern bobwhites (*Colinus virginianus*) have a wide distribution across North America which influences its' associations with habitats in a variety of landscapes. We used radio-marked bobwhites and Euclidean distance to characterize land cover associations of bobwhites at generalized level 1 and specific level 2 land cover classifications during the reproductive (15 Apr-14 Oct) and covey (15 Oct-14 Apr) periods in southeastern Kansas from 2003 to 2005. Habitat associations occurred during the reproductive (Wilkes' $\lambda = 0.04$, $F_{6,36} = 143.682$, $P < 0.001$) and covey (Wilkes' $\lambda = 0.056$, $F_{6, 29} = 81.99$, $P < 0.001$) periods. Ranking of the reproductive period habitats indicated bobwhites preferred locations in close proximity to fescue (*Festuca* spp.) over all other habitats. Coveys preferred locations in close proximity to woody cover. Bobwhites were found to associate with specific habitats at the level 2 land cover classification during the reproductive (Wilkes' $\lambda = 0.006$, $F_{16, 26} = 284.483$, $P < 0.001$) and covey (Wilkes' $\lambda = 0.004$, $F_{16, 19} = 276.037$, $P < 0.001$) periods. Bobwhites preferred locations in close proximity to fescue pastures and roads equally over all other habitats during the reproductive period. Coveys preferred locations in close proximity to roads and Conservation Reserve Program lands during the covey period. Fescue pastures may be avoided by bobwhites during the covey period, provided adequate cover is not provided, but bobwhites are strongly associated with them during the reproductive period because they meet nesting and brooding needs not met by other habitats.

INTRODUCTION

The decline of bobwhite populations has often been attributed to changes in land use, particularly changes in farming practices (Brennan 1991, Church and Taylor 1992, Brady et al. 1993, Peterson et al. 2002). The widespread shift to clean farming and removal of fencerows and idle land has made agricultural landscapes less favorable to bobwhites through fragmentation and loss of habitat (Brennan 1991, Roseberry 1993). Veech (2006) found that declining, and locally extinct bobwhite populations occur in landscapes that are different from those of increasing populations. He found that declining populations tend to occur in landscapes having more closed canopy woodland or forest than increasing populations.

The widespread use of cool-season grasses such as tall fescue (*Festuca arundinacea*) has been suggested as a factor in the decline of bobwhites. Little research has been conducted on the effects of exotic grasses on habitat use during the life cycle of bobwhites. Much of the limited research was in undisturbed areas (Burger et al. 1990, Barnes et al 1995). One of the reasons that fescue has been viewed as poor habitat for bobwhites is its limited diversity and lack of bare ground in stands that have not

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been mowed or grazed (Barnes et al. 1995). However, recent work by Labrum (2007) suggests fescue, while not providing optimum habitat for bobwhites, may supply structure and insects not available elsewhere in a landscape. Kuvlesky et al. (2002) indicated more research was needed to quantify the specific effects of fescue and other exotic grasses on bobwhites throughout their range.

The 'edge', ecotone, or transition where different plant communities blend together has been hypothesized to be an important habitat component for bobwhites (Stoddard 1931, Rosene 1984). Edge can take several forms. It can be a hard and distinct boundary (inherent edge) between habitat types, such as envisioned by Leopold (1933) or it can be a true ecological transition zone (induced edge) where two successional stages blend together such as described by Smith and Smith (2009). However, little information is available on the preference of bobwhites for different edge types or what constitutes an acceptable edge type and the scale of edge use (field vs. landscape). Roseberry and Sudkamp (1998) reported bobwhite in Illinois were associated with patchy landscapes that contained moderate amounts of row crops, grassland, and abundant woody edge, but we do not know the scale of patch use in their study.

Our objectives were to examine: (1) the effects of landscape configuration in a fescue- dominated agricultural system on bobwhite locations during the year using Euclidean distances, and (2) the effect of specific land cover types on bobwhite locations.

STUDY AREA

The 64.8-km^2 study area was in southwestern Bourbon County, Kansas, 3.2 km south of Uniontown (37° 46′ 58″ N, 94° 58′ 43″ W) (Fig. 1). This was also a demonstration area for the Southeastern Kansas Quail Initiative sponsored by the Kansas Department of Wildlife and Parks, and other partners. The vegetation was dominated by fescue pastures and hayfields intermixed with native prairie pastures and hayfields. Large tracts of cropland were within the floodplains of streams. Smaller tracts of cropland were scattered throughout the upland. There were narrow riparian forests interconnected with small woodlots and linear fencerows throughout the area. Many of the fencerows consisted of mature Osage orange (*Maclura pomifera*). Conservation Reserve Program (CRP) lands were scattered in the uplands and in small patches in the floodplains of streams. CRP consisted of a mix of native warm-season grasses including big bluestem (*Andropogon gerardii*), Indiangrass (*Sorghastrum nutans*), and switchgrass (*Panicum virgatum*).

The land cover of the study area consisted of a patchy landscape (Fig. 1). Fescue hayfields comprised 5.8%, fescue pasture 36.3%, fescue waterways 0.9%, farm ponds 0.5%, farmsteads 1.0%, idle land 1.2%, native prairie hayfields 1.6%, native prairie pasture 4.3%, native grass waterways 0.1%, roads 0.9%, woodlands 20.6%, and woody fencerows 1.6% of the study area. Most changes occurred in CRP and cropland (Table 1). Woodland patch size varied from 0.4 to 332.2 ha.

Cropland patch size varied from 0.1 to 83.5 ha while fescue patch size varied from 0.3 to 282.2 ha. Native prairie patch size varied from 0.1 to 128.9 ha. The CRP tracts in the study area were isolated with patch sizes from 0.5 to 58 ha.

METHODS

Field Procedures

We trapped bobwhites from January through March 2003 through 2005 and October through December 2003 and 2004 using baited funnel traps on 8 0.64-km^2 areas. We classified captured birds to age and sex, and all were weighed. Individuals within each covey weighing > 150 g were fitted with a necklace radio transmitter (AVM Instrument Company Ltd., Colfax, CA, USA) weighing < 5 g. We released bobwhites immediately after processing at the capture location. We located bobwhites 3 to 7 times/week until mortality, loss of contact (radio failure or long distance movement), or end of study.

We located bobwhites with radio transmitters using a combination of hand-held 3-element yagi antennas and a 4-element null peak antenna mounted on a vehicle. We conducted homing with hand-held antennas. The null peak antenna was used to relocate bobwhites that moved long distances.

Locations of bobwhite were recorded on Universal Transverse Mercator (UTM) grids on aerial photographs. We used a global positioning system (GPS) to record the location where bobwhites were flushed. Vehicle telemetry consisted of 2 to 3 bearings taken rapidly within 10 min to triangulate the radio-marked bobwhite's location. Triangulation was used to locate bobwhites during the reproductive period. We used GPS to record the base stations for vehicle triangulation. Program LOAS (Ecological Software Solutions, Urnsach, Switzerland) was used to estimate locations of radio-marked bobwhite based on triangulation data.

We used on-screen digitizing in ArcView 3.3 (Environmental Systems Research Institute Inc., Redlands, CA, USA) to classify land cover based on digital images. We used 2002 Digital Orthophoto Quarter Quads (DOQQ) as well as 2003, 2004, and 2005 National Agricultural Inventory Program (NAIP) digital color aerial photographs as base maps for land cover analysis. We obtained DOQQs and NAIP digital color aerial photos from Kansas Data Access and Support Center (http://www.kansasgis.org/). Land cover was classified for 2003, 2004, and 2005. We classified land cover into a level 2 classification of farmsteads, roads, farm ponds, fescue hayfields, fescue pasture, fescue waterways, idle land, native prairie hayfields, native prairie rangeland, native prairie waterways, new CRP, burned CRP, and established CRP. New CRP was general sign-up and continuous sign-up < 2 years of age. Burned CRP was those areas burned by landowners during March and April through the first growing season and up until mid-April of the following year. Established CRP had been established for a minimum of 3 years. The differentiation between CRP and native prairie was due to differences in
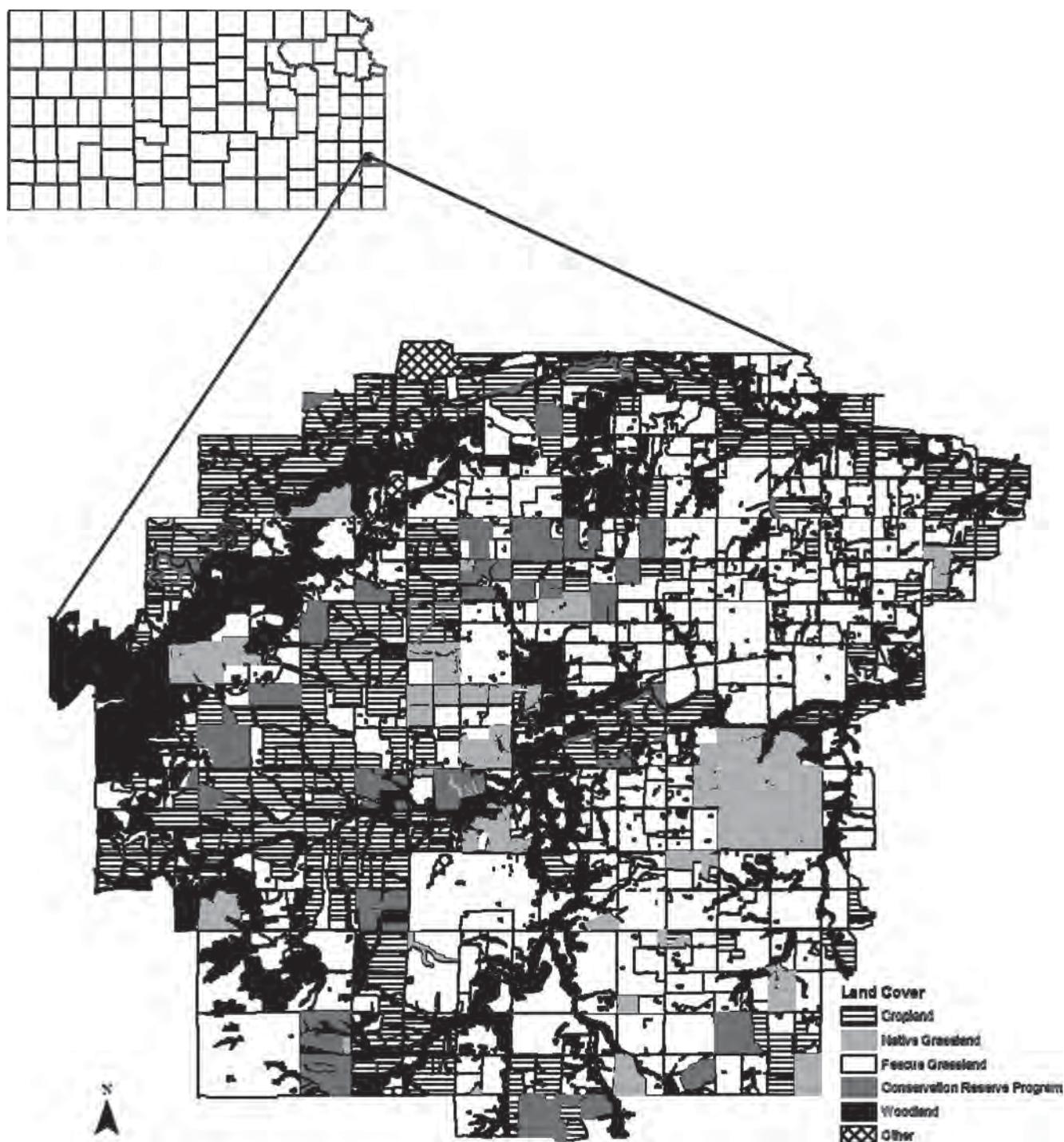
Fig. 1.   Study area in Bourbon County, Kansas, USA with general land cover class distribution, 2003–2005.

management of those areas along with higher plant diversity that often occurred in prairie areas versus CRP. We analyzed habitat association of bobwhites and grouped land cover into level 1 generalized classification of other (farmsteads, urban, roads, and farm ponds), fescue grassland (fescue hayfield, fescue pasture, fescue waterway, and idle land), native prairie (native prairie hayfield, native prairie rangeland, and native prairie waterway), woodland (fencerows and woodlots), and

CRP (new, burned, and established general sign-up CRP). We ground-truthed all areas each year to obtain an accurate map.

Habitat Association Analysis

We used Euclidean distance (Conner and Plowman 2001, Conner et al. 2003) to analyze habitat use by bobwhites during covey (15 Oct-14 Apr) and reproductive

(15 Apr-14 Oct) periods because of its advantages over other methods. Conner et al. (2003) found Euclidean distance identified edges as important habitat features and was not affected by location error. Bingham and Brennan (2004) reported this method did not inflate Type I error. Our Euclidean distance analysis was based on ratios of use versus expected distance to habitat. The observed-random ratio should equal 1.0 for each habitat type if use was nonrandom. The ratio suggested which habitat was associated more or less with bobwhite locations if the habitat was associated disproportionately. The observed-random ratio was < 1.0 if bobwhites were associated more with the habitat than expected. The observed-random ratio was > 1.0 if bobwhites were associated less with the habitat than expected.

We conducted home range analyses separately for covey and reproductive periods. We used the Animal Movement Extension (Hooge and Eichenlaub 2001) to calculate the 95% fixed-kernel home range for each covey (covey period) and individual (reproductive period). We used ArcView 3.3 to buffer each home range at 1,000 m. The 1,000-m buffer was used to generate a comparison of potential use to landscape availability around bobwhite home ranges. A 1,000-m buffer was used because bobwhites seldom moved > 1,000 m beyond their home ranges during their lives. We used the Animal Movement Extension to generate 30 uniformly random points within each buffer for each home range. We separated habitats for 2003, 2004, and 2005 into different layers, and used the ArcView Nearest Neighbor extension (Weigel 2004) to estimate the distance for each random and bobwhite location for each habitat type and year. The Nearest Neighbor analysis was conducted at the initial general and detailed land-cover classes.

We calculated r_j which was the average distance for random locations for each bobwhite or covey to each land cover type (Conner and Plowman 2001) and u_i which was the average distance to each habitat for each bobwhite or covey (Conner and Plowman 2001). We created d_i which was a vector of ratios for each bobwhite or covey by dividing u_i by r_j (Conner and Plowman 2001). The expected value of each element in d_i is 1.0 under the null hypothesis of no selection (Conner and Plowman 2001). We used MANOVA to test for significance of d_i for sex and year. We used the mean of the d_i which was ρ and MANOVA to examine if ρ differed from a vector of ones (Conner and Plowman 2001).

We used the Wilkes' λ test statistic to indicate non-random resource selection (Conner and Plowman 2001). We tested each element of ρ for each habitat type against 1 using a paired t-test to examine which habitat types were used disproportionately (Conner and Plowman 2001). Bobwhites were associated less with the habitat if a statistically significant element of ρ was > 1 (Conner and Plowman 2001). Bobwhites were associated more with the habitat if a statistically significant element of ρ was < 1 (Conner and Plowman 2001). We also tested whether a particular habitat type was used more than other habitat types using a paired t-test. The pair-wise test provided a habitat ranking matrix similar to the compositional analysis approach of Aebischer et al.

Table 1. Percent land cover class that changed in study area in southeastern, Kansas, USA, 2003–2005.

	2003	2004	2005
Burned CRP[a]	0.6	0.1	2.5
CRP[a]	3.2	3.8	1.4
Cropland	21.1	19.9	19.9
New CRP[a]	0.3	1.4	1.4

[a] Conservation Reserve Program lands.

(1993). We conducted analyses at both levels 1 and 2 land cover classifications. We conducted statistical analyses with SPSS 12.0 (SPSS Inc., Chicago, IL, USA).

RESULTS

We captured and radiomarked 275 northern bobwhites representing 42 coveys. We used 179 radio-marked bobwhites representing 35 coveys for analysis. Sample size was reduced because 7 coveys did not survive past the 14-day acclimation period. Ninety-four of the 179 remaining radio-marked bobwhites during the covey period were males and 85 were females. Forty-two radio-marked individuals were used for analysis during the reproductive period of which 25 were males and 17 were females.

There was no difference in habitat association by sex during the reproductive period (Wilkes' $\lambda = 0.885$, $F_{6,35} = 0.756$, $P = 0.609$). There was no detectable difference in habitat association between years for covey period (Wilkes' $\lambda = 0.523$, $F_{12,54} = 1.724$, $P = 0.087$). There was a difference in habitat association between years for the reproductive period (Wilkes' $\lambda = 0.516$, $F_{12,68} = 2.219$, $P = 0.02$). Covey period data were pooled by sex and year, and also for the reproductive period due to small sample sizes during individual years.

Analysis of habitat associations using Euclidean distance for the reproductive period at the generalized land cover classification indicated habitat selection occurred (Wilkes' $\lambda = 0.04$, $F_{6,36} = 143.682$, $P < 0.001$). Bobwhites were closer than expected during the reproductive period to woody cover ($t_{41} = -4.065$, $P < 0.001$), other ($t_{41} = -6.336$, $P < 0.001$), fescue grassland ($t_{41} = -8.872$, $P < 0.001$), and CRP ($t_{41} = -8.872$, $P < 0.001$). There was no detectable preference or avoidance of bobwhite locations in relation to native prairie ($t_{41} = -0.707$, $P = 0.483$) or cropland ($t_{41} = 0.848$, $P = 0.401$). Bobwhites had a greater preference for fescue during the reproductive period than other habitats (Table 2).

Habitat selection occurred for the covey period based on Euclidean distance (Wilkes' $\lambda = 0.056$, $F_{6,29} = 81.99$, $P < 0.001$). Coveys were closer than expected to woody cover ($t_{34} = -11.563$, $P < 0.001$), other ($t_{34} = -3.630$, $P = 0.001$), native prairie ($t_{34} = -2.658$, $P = 0.012$), CRP ($t_{34} = -5.642$, $P < 0.001$), and cropland ($t_{34} = -2.915$, $P = 0.006$). Coveys did not show a detectable proximity to fescue grassland ($t_{34} = -1.002$, $P = 0.323$) during the covey period. Coveys had an overall preference for locations closer to woody cover than other habitats during

Table 2. Pair-wise comparisons (*t*- and *p*-values and final land cover ranking; the higher the rank, the more preference for that land cover type) of distance/random ratios for habitats during the reproductive period with initial generalized land cover classifications (level 1) for bobwhites in southeastern Kansas, USA, 2003–2005.

	Cropland		CRP[a]		Fescue		Native prairie[b]		Other		Woodland		
	t	*P*	*t*	*P*	*t*	*P*	*t*	*P*	*t*	*P*	*t*	*P*	Rank
Cropland			−3.507	0.001	−5.709	0.001	−1.155	0.255	−3.931	0.001	−3.01	0.004	1
CRP[a]	3.507	0.001			−2.511	0.016	2.857	0.007	−0.91	0.368	−0.1	0.921	3
Fescue	5.709	0.001	2.511	0.016			6.088	0.001	2.567	0.014	2.462	0.018	6
Native prairie[b]	1.155	0.255	−2.857	0.007	−6.088	0.001			−4.219	0.001	−2.54	0.015	2
Other	3.931	0.001	0.91	0.368	−2.567	0.014	4.219	0.001			0.589	0.559	5
Woodland	3.01	0.004	0.1	0.921	−2.462	0.018	2.54	0.015	−0.589	0.559			4

[a] Conservation Reserve Program land.
[b] Mix of native grasses and forbs not established under CRP.

the covey period based on the pair-wise comparisons (Table 3).

Bobwhites exhibited habitat selection during the reproductive period (Wilkes' $\lambda = 0.006$, $F_{16,26} = 284.483$, $P < 0.001$). They were closer than expected to burned CRP ($t_{41} = -4.878$, $P < 0.001$), CRP ($t_{41} = -3.119$, $P = 0.003$), woody fencerows ($t_{41} = -2.910$, $P = 0.006$), fescue pasture ($t_{41} = -4.091$, $P < 0.001$), fescue waterways ($t_{41} = -2.224$, $P = 0.32$), native prairie hayfield ($t_{41} = -2.121$, $P = 0.40$), native prairie waterways ($t_{41} = -3.441$, $P = 0.001$), new CRP ($t_{41} = -3.526$, $P = 0.001$), ponds ($t_{41} = -3.667$, $P = 0.001$), and roads ($t_{41} = -4.772$, $P < 0.001$). Bobwhites did not show a detectable preference or avoidance for locations close to woodlots ($t_{41} = -1.884$, $P = 0.067$), cropland ($t_{41} = 0.803$, $P = 0.427$), farmsteads ($t_{41} = -0.424$, $P = 0.674$), fescue hayfield ($t_{41} = -0.377$, $P = 0.708$), idle land ($t_{41} = 0.449$, $P = 0.656$), and native prairie pasture ($t_{41} = -0.684$, $P = 0.498$). Bobwhites preferred locations during the reproductive period closer to fescue pastures and roads more than other habitats (Table 4).

Coveys exhibited habitat selection during the covey period at the level 2 land cover classification (Wilkes' $\lambda = 0.004$, $F_{16,19} = 276.037$, $P < 0.001$). Coveys were closer to woodlots ($t_{34} = -2.813$, $P = 0.008$), burned CRP ($t_{34} = -2.588$, $P = 0.14$), cropland ($t_{34} = -2.602$, $P = 0.014$), CRP ($t_{34} = -3.438$, $P = 0.002$), woody fencerows ($t_{34} = -2.322$, $P = 0.26$), idle land ($t_{34} = -3.031$, $P = 0.005$), native prairie pasture ($t_{34} = -2.309$, $P = 0.27$), native prairie waterways ($t_{34} = -3.346$, $P = 0.002$), new CRP ($t_{34} = -3.431$, $P = 0.002$), and roads ($t_{34} = -5.067$, $P < 0.001$). Coveys were farther from fescue pastures than expected ($t_{34} = 2.491$, $P = 0.018$). Coveys did not show a detectable preference or avoidance to farmsteads ($t_{34} = 0.348$, $P = 0.730$), fescue hayland ($t_{34} = -0.111$, $P = 0.912$), fescue waterway ($t_{34} = -1.284$, $P = 0.208$), native prairie hayland ($t_{34} = -1.351$, $P = 0.186$), or ponds ($t_{34} = -1.772$, $P = 0.085$). Coveys preferred locations that were in close proximity to roads and CRP (Table 5).

DISCUSSION

Bobwhite populations in Kansas have been relatively stable after declining from their highest recorded levels in the early 1970s (Applegate and Williams 1998). Bobwhite whistle-count data indicate populations in southeastern Kansas were relatively stable from 1998 through 2006 (Pitman 2006) but have since declined slightly due to weather conditions (Dahlgren 2011). This suggests current habitat conditions in the area are able to sustain populations although weather influences may periodically intervene. Understanding the influence of landscape configuration on bobwhite locations can greatly assist in managing bobwhite populations in other landscapes.

We used Euclidean distance to examine how bobwhite locations were influenced by their proximity to other land cover types or habitats within the landscape. Bingham et al. (2010) believed landscape configuration

Table 3. Pair-wise comparisons (*t*- and *p*-values for each pair-wise comparison along with final ranking); the higher the rank, the more preference for that land cover type of distance random ratios for habitats during the covey period with initial generalized land cover classifications (level 1) for bobwhites in southeastern Kansas, USA, 2003–2005.

	Cropland		CRP[a]		Fescue		Native prairie[b]		Other		Woodland		
	t	*P*	*t*	*P*	*t*	*P*	*t*	*P*	*t*	*P*	*t*	*P*	Rank
Cropland			−0.13	0.897	2.236	0.032	0.891	0.379	−0.13	0.897	−2.825	0.008	3
CRP[a]	1.121	0.270			3.98	0.001	1.97	0.057	1.341	0.189	−1.354	0.185	5
Fescue	−2.236	0.032	−3.98	0.001			−1.917	0.064	−3.308	0.002	−5.667	0.001	1
Native prairie[b]	−0.891	0.379	−1.97	0.057	1.917	0.064			−0.949	0.349	−4.485	0.001	2
Other	0.13	0.897	−1.341	0.189	3.308	0.002	0.949	0.349			−3.011	0.005	4
Woodland	2.825	0.008	1.354	0.185	5.667	0.001	4.485	0.001	3.011	0.005			6

[a] Conservation Reserve Program land.
[b] Mix of native grasses and forbs not established under CRP.

and juxtaposition of habitat patches would influence which habitats would be preferred and would vary depending on the landscape context. They recommended Euclidean distance not be used in resource selection until these problems could be corrected. We did not use Euclidean distance for resource selection such as compositional analysis, but used it to show the influence of landscapes on bobwhite locations.

Habitat associations of bobwhites in Bourbon County varied between the reproductive and covey periods, most likely due to changes in biological needs of bobwhites throughout their life cycle. Bobwhites tend to prefer areas of primarily dead vegetation that is denser than surrounding habitat for nesting (Rosene 1984, Taylor et al. 1999a). Bobwhites also tend to select vegetation that is an average of 50 cm in height in Illinois (Klimstra and Roseberry (1975) to 52 cm in Kansas (Taylor et al. 1999a) for nesting. Bobwhites during the brood-rearing period tend to select areas with relatively abundant bare ground and forb cover for brooding (Taylor and Guthery 1994, Taylor et al. 1999a). Labrum (2007) suggested bobwhites during the reproductive period may be selecting for habitats having a higher insect diversity. Winter roost sites during the covey period were in vegetation that had a mean height of 59 cm in Illinois (Klimstra and Ziccardi 1963), 68 cm in Oklahoma (Wiseman and Lewis 1981), and 91 to 106 cm in Missouri (Chamberlain et al. 2002). Habitat selection appears to be for habitat patches which allow predator avoidance, increased accessibility to food, and increased nesting and brood rearing success (Roseberry and Klimstra 1984, Rosene 1984).

Conner et al.'s (2003) distance analysis of bobwhite habitat association indicated greater use of edge or ecotone than expected. However, use of edge was only associated with some habitats. Our results indicated bobwhites preferred edges between woody cover, other (farmsteads and ponds), fescue, and CRP during the reproductive period. Bobwhites preferred edges between woody cover, other, native grassland, CRP, and cropland during the covey period.

There was a distinct shift in proximity of bobwhite locations between seasons. Bobwhites avoided fescue during the covey period, but associated strongly with it during the reproductive period. Avoidance of fescue during the covey period and its use during the reproductive period was probably due to changes in vegetation characteristics between the 2 periods as well as changes in the biological needs of bobwhites. Continuous grazing of fescue and changes in plant growth during the covey period resulted in extremely short vegetation. The change in vegetation height became most pronounced from December through early April. The short stature of the vegetation during this time period probably would not provide adequate thermal cover or protection from predators.

Reduction of vegetation height also can have a significant effect on habitat connectivity between suitable habitat patches by not providing sufficient cover during the covey period. Large areas of short fescue, mowed native grass, bare crop fields, or other short vegetation reduce movement of bobwhites between habitats and potentially reduce overall survival of individuals. It can also result in isolation of bobwhites into small patches where taller vegetation occurs. This results in small coveys being unable to increase to an optimum group size. Williams et al. (2003) reported bobwhites had an optimal group size of 10–11 individuals. Thus, as group size increased, survival decreased for individuals, movement increased, and individual body mass decreased. Small groups of 1 to 7 individuals also had lower group persistence, individual survival, and increased movement (Williams et al. 2003). Isolation of coveys in our study due to habitat fragmentation may have prevented small coveys from recruiting new members reducing overall fitness of these coveys.

Fescue pastures in the study area were typically grazed by cattle rotated among fields in spring which resulted in a mix of short grass and tall thick patches during the summer with a variety of intermixed short annual forbs. The strong association of bobwhites with fescue on our study area was probably because it was the only habitat that met bobwhite needs. Labrum (2007) also believed that although fescue pastures were not ideal habitat for bobwhites, they provided structure and insect diversity not available in other habitats. Osborne et al. (2012) reported fescue CRP fields which were disturbed had more bobwhite use during the reproductive period than fields that were not disturbed. The positive associations that we found with fescue differ from previous reports. Barnes et al. (1995) concluded that undisturbed tall fescue was not good bobwhite habitat because it lacked proper vegetation structure, floristic composition, and sufficient food. Sole (1995) reported bobwhites did not use fescue fields but used a field converted from fescue to native warm-season grasses. Klimstra and Roseberry (1975) indicated bobwhites used fescue pastures little during the breeding season, and used unimproved pastures more. Unimproved pastures were those that contained a mix of naturally occurring forbs, grasses, shrubs, and briars (*Rubus* spp.) (Klimstra and Roseberry 1975), a habitat commonly referred to as old field.

Woody cover generally was more preferred in the covey than the reproductive period, but woody fencerows were preferred during spring over other woody cover. Woody fencerows were linear areas throughout the study area composed of mature trees and/or a mix of shrubs, grasses, and forbs. Other woodlands were along riparian areas and as large patches of trees in cool-season grass pastures. This spatial distribution of woody vegetation over the landscape allowed bobwhites to feed and be close to woody cover for escape and thermal protection.

Williams et al. (2000) reported woody cover (tree-lines and wooded drainage ways) was the primary escape cover for bobwhites during the winter in east-central Kansas. Wiseman and Lewis (1981) indicated woody cover (tall shrubs, short shrubs, and woodland) was an important habitat throughout the year for bobwhites in tallgrass prairie of Oklahoma. Woody cover provided feeding, resting, and escape cover for quail throughout the year. Taylor and Burger (2000) reported bobwhites during the breeding season in Mississippi preferred woody areas

Table 4. Simplified ranking matrices based on pair-wise comparisons of distance/random ratios for each land cover class during the reproductive period using a detailed land cover classification (level 2) for bobwhites in southeastern Kansas, USA, 2003–2005. Each element in the matrix was replaced by its sign; a triple sign represents difference at $P < 0.05$ (+ = a positive association and − = a negative association). The higher the rank, the more preference for that land cover type.

	BCRP[a]	Cropland	CRP[b]	Farm[c]	Fence[d]	FH[e]	FP[f]	FW[g]	Idle	NPH[h]	NPP[i]	NPW[j]	New CRP	Pond	Road	Woodlot	Rank
BCRP[a]		+++	+	+++	+	+++	−	+	+++	+++	+++	+++	+++	+	−	+	13
Cropland	−−−		−−−	−	−−−	−	−−−	−−−	−	−	−	−	−−−	−−−	−−−	−	1
CRP[b]	−	+++		+	−	+	−	+	+++	+	+	+	+	−	−	−	9
Farm[c]	−−−	+	−		−	−	−	−	+	−	−	−	−−−	−−−	−−−	−	3
Fence[d]	−	+++	+	+		+	−	+	+	+	+++	+	+	+	−	+	12
FH[e]	−−−	+	−	+	−		−−−	−	+	−	−	−	−−−	−−−	−−−	−	3
FP[f]	+	+++	+	+	+	+++		+++	+	+	+++	+	+	+++	+	+	14
FW[g]	−	+++	−	+	−	+	−−−		+	+	+	+++	−	−	−	−	7
Idle	−−−	+	−−−	−	−	−	−	−		−	−	−	−	−	−	−	2
NPH[h]	−−−	+	−	+	−	+	−	−	+		+	+	−	−−−	−−−	−	6
NPP[i]	−−−	+	−	+	−−−	+	−−−	−	+	−		−	−−−	−−−	−−−	−	4
NPW[j]	−−−	+	−	+	−	+	−	−−−	+	−	+		−−−	−−−	−−−	−	5
New CRP	−−−	+++	−	+++	−	+++	−	+	+	+	+++	+++		−	−−−	−	8
Pond	−	+++	+	+++	−	+++	−−−	+	+	+++	+++	+++	+		−	+	11
Road	+	+++	+	+++	+	+++	−	+	+	+++	+++	+++	+++	+		+	14
Woodlot	−	+	+	+	−	+	−	+	+	+	+	+	+	−	−		10

[a] Burned Conservation Reserve Program land.
[b] Conservation Reserve Program land.
[c] Farmstead.
[d] Woody fencerow.
[e] Fescue hayland.
[f] Fescue pasture.
[g] Fescue grass waterway.
[h] Native prairie hayland.
[i] Native prairie pasture.
[j] Native prairie waterway.

Table 5. Simplified ranking matrices based on pair-wise comparisons of distance/random ratios for each land cover class during the covey period using a detailed land cover classification (level 2) for bobwhite in southeastern Kansas, USA, 2003–2005. Each element in the matrix was replaced by its sign; a triple sign represents difference at $P < 0.05$ ($+$ = a positive association and $-$ = a negative association). The higher the rank, the more preference for that land cover type.

	BCRP[a]	Cropland	CRP[b]	Farm[c]	Fence[d]	FH[e]	FP[f]	FW[g]	Idle	NPH[h]	NPP[i]	NPW[j]	New CRP	Pond	Road	Woodlot	Rank
BCRP[a]		−	−	+	−	−	+++	−	−	+	+	+	−	+	−−−	−	9
Cropland	+		−	+	+	+++	+++	−	+	+	+	+	+	+	−	−	13
CRP[b]	+	+		+	+	+++	+++	−	+	+	+	+	+	+	−	+++	15
Farm[c]	−	−	−−−		−−	−	+++	−	−−−	−	−	−	−	−−	−−	−	2
Fence[d]	+	−	−−−	−−		+	+++	−	−	+	+	+	+	+	−	−	11
FH[e]	−	−−−	−−−	−	−		+++	−	−	−	−−−	−	−	−−	−−	−	3
FP[f]	−−−	−−−	−−−	−−−	−−−	−−−		−−−	−−−	−−−	−−−	−	−	−−−	−−−	−−−	1
FW[g]	−	−	−	+	+	+	+++		−	+	−	+	−	+	−−	−	6
Idle	+	−	−	+++	−	+	+++	−		+	+	−	+	+	−	−	12
NPH[h]	−	−	−	+	−	+	+++	+	−		−	+	−	−	−−	−	4
NPP[i]	−	−	−	+	−	+	+++	−	−	+		−	−	+	−−	−	8
NPW[j]	−	−	−	+	−	+	+	+	−	+	−		−	+	−−	−	7
New CRP	+	−	−	+++	−	+++	+	+	−	+	+	+		+	−−	−	10
Pond	−	−	+	+	−	+	+++	+	−	+	−	+++	−		−−	−	5
Road	+++	+	+	+++	+	+++	+++	+++	+	+++	+++	+++	+++	+		+	16
Woodlot	−	−	−	+++	+	+++	+++	+	+	+	+	+	+	+	−		14

a Burned Conservation Reserve Program land.
b Conservation Reserve Program land.
c Farmstead.
d Woody fencerow.
e Fescue hayland.
f Fescue pasture.
g Fescue waterway.
h Native prairie hayland.
i Native prairie pasture.
j Native prairie waterway.

and old fields that were burned and disked. Sandercock et al. (2008) indicated winter survival was vital to population growth and increasing the availability of woody cover provided more protection from predators during this period.

Woody fencerows were often along boundaries of fescue pastures. Many fencerows associated with fescue were grazed and had reduced shrub cover and forbs compared to fencerows associated with road edges and CRP that were not grazed. Preference of bobwhites for locations in close proximity to woodlands during the covey period was probably due to the association of woodlands and CRP fields in our study area.

Bobwhites had a higher preference for CRP edge during the covey period than during the reproductive period. Williams et al. (2000) reported bobwhites preferred idle land which included CRP, grass waterways, and roadsides during the winter. Taylor et al. (1999b) also reported idle land, of which 62% consisted of CRP, was preferred habitat in Kansas during the breeding season in both cropland and rangeland areas.

Little other information on use of CRP by bobwhite is available. This lack of research has resulted in limited changes to CRP that might be beneficial to bobwhites. CRP edge was preferred over new or burned CRP during the covey period. CRP fields were areas that had at least 1 growing season since the last disturbance. New CRP was preferred to burned CRP as it contained minimal grass cover and was often covered with annual weeds. However, burned CRP edge was preferred over unburned or new CRP during the reproductive period. This difference may have been due to increased diversity of CRP, 1 year after disturbance. Burned CRP may have been preferred in the breeding season due to increased bare ground and shorter vegetation which made the areas more favorable for movement and feeding by broods.

Bobwhites favored locations near roads during the reproductive and covey periods over all other land cover classes. Association of bobwhites with roads during the reproductive period may also be due to proximity to fescue pastures. Roads may serve as dusting and foraging areas. Roadsides contained fencerows or scattered trees in many instances that could provide escape cover for bobwhites throughout the year.

MANAGEMENT IMPLICATIONS

Agricultural landscapes provide challenges for managing early-successional (i.e., old field) wildlife species including northern bobwhites. Continued disturbance of many areas can reduce cover and wildlife value. For example, grazing, haying, and dormancy of fescue reduces plant height and can result in isolated patches of winter cover, but grazing fescue during late spring and early summer may provide a mix of plant structure that can support bobwhites. Managers in a fescue-dominated landscape need to focus on increasing habitat connectivity and winter cover needed by coveys for survival. Connectivity can be increased by adding and protecting woody cover within the landscape. Increasing the width of

existing fencerows could enhance their value to bobwhites during the covey period. Converting portions of fescue pastures along fencerows to native warm season grasses and shrub buffers may allow for increased connectivity and provide more areas for coveys to survive during the winter as well as providing secure nesting cover.

Management of CRP can also have an impact on bobwhite habitat association. Lack of habitat disturbance can result in reduced value for bobwhites (Burger et al. 1990). Disturbance of CRP can affect its use by bobwhites by potentially altering its structure and reducing its value. Ryan et al. (1998) suggested that applying rotational disturbances to enhance the value of early and mid-successional plant communities on CRP might allow these habitats to meet seasonal needs of bobwhite. One method that might provide a good mix of early and mid-successional habitat is patch burning which has been proposed by Fuhlendorf and Engle (2001) for rangelands. They recommended patch burning as a way to create more heterogeneous native grasslands as opposed to the current management which creates a more homogeneous vegetation structure. This same technique could be used to manage CRP to create more heterogeneous patches to improve its value to bobwhites and other wildlife. Bobwhites are grassland/woodland transitional species that need a diversity of forbs, grasses, and woody cover to survive. More emphasis should be placed on creating and managing woody cover in and around CRP to mimic an early-successional old field community.

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