Cover Selection by Northern Bobwhites and Hunters on a Public-hunting Area

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Abstract: Strength of the correlation between cover selection indices for hunters and quarry may provide information for improving hunter satisfaction and managing hunting pressure. Using radiotelemetry, we studied northern bobwhite (*Colinus virginianus*) cover selection on the Packsaddle Wildlife Management Area in western Oklahoma, during Oct-Feb periods beginning in 1991–92 and extending through 2001–02. Hunter locations were recorded by Global Position System (GPS) units for the 2004–05 and 2005–06 hunting seasons to determine hunter cover selection. Avoidance, neutral use, or selection of cover types by bobwhites was relatively consistent among years because 27 of 32 cover types had annual indices similar ($P > 0.05$) to the 11-year mean in ≥9 years. This yearly consistency provided support for our comparison of bobwhite to hunter selection indices recorded in separate years. The 11-year mean of cover selection indices for bobwhites was positively correlated with cover selection indices of hunters ($r = 0.45$, $P = 0.01$, $n = 32$ cover types). Hunters avoided shinnery oak (*Quercus havardii*)-little bluestem (*Schizachyrium scoparium*) on gradients ≥3% at distances of 500–1,500 m from roads whereas bobwhites strongly selected for this type. Hunter success on our study area may be increased by improving access to bobwhite-selected cover types, reducing access to bobwhite-avoided types, and educating hunters on the nature and location of bobwhite-selected types.

Key words: Colinus virginianus, cover selection, hunting, hunter satisfaction, northern bobwhite, Oklahoma

Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 62:46–50

We hypothesized that cover selection indices for bobwhites and human hunters are highly correlated, leading hunters to select and avoid cover types in the same manner as bobwhites. However, hunters vary in experience, age, physical abilities, and knowledge of bobwhite habitat. Many hunters use bird dogs that vary in experience, age, olfactory ability, field behavior, and stamina (Gutzwiller 1990). Environmental conditions, such as humidity, temperature, and wind speed, also may affect efficiency of dogs (Syrotuck 1972). Therefore discrepancies between cover selection indices of bobwhites and hunters may occur.

Our objective was to estimate the potential correlation between cover selection by bobwhites and hunters on a public-hunting area in western Oklahoma. These data have potential for increasing hunter satisfaction and managing harvest.

Study Area and Methods

We conducted this study on the Packsaddle Wildlife Management Area (WMA) in Ellis County, Oklahoma. Little bluestem (*Schizachyrium scoparium*), shinnery oak (*Quercus havardii*), sand sagebrush (*Artemisia filifolia*), switchgrass (*Panicum virgatum*), and western ragweed (*Ambrosia psilostachya*) characterized the vegetation on this large (6,475 ha), non-fragmented area. Elevation ranged from 569 to 762 m above sea level and soils consisted primarily of fine sands and loamy fine sands (Cole et al. 1966). The area receives average annual precipitation of 53 cm. DeMaso et al. (1997) and Townsend et al. (2001) provided details on climate, soils, and vegetation of the area.

During 1991–92 – 2001–02, quail hunting on Packsaddle WMA was available to the public through a controlled hunt drawing. Starting in 2003 quail hunting was open to the public, with no limit on the number of hunters. Because of personnel changes on the WMA we were unable to obtain quail hunter numbers and harvest for the area.

Cover Types

We defined a cover type as a unique combination of vegetation association, distance from roads publicly accessible by motor vehicles, and slope. Vegetation classification was based on Hoagland (2000). We verified vegetation classifications on site by inspection and consultation with local authorities. Distance classes were arbitrarily set at <500 m, 500–<1,500 m, 1,500–<2,500 m, and ≥2,500 m from publicly accessible roads. Slopes were considered level

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(≤3% grade) or steep (>3% grade). We pooled cover types with areas <1% of the study area into 1 class (rare types).

We created cover type maps using ArcView 3.3 and ArcDesktop GIS (Environmental Systems Research Institute, Redlands, California). Color ortho-quarter-quad images from the 2003 National Agriculture Imagery Program were the basis for delineation and categorization of vegetation associations.

Bobwhite Cover Selection

Radio location data for bobwhites came from an 11-year study (1991–2002) on the Packsaddle Area (Cox et al. 2004). Biologists monitored radioed birds ≥6 times/week and determined locations by homing (White and Garrott 1990), which involved approaching birds on foot until signal strength indicated a distance of about 20 m from the subject. Sampling locations were considered random and independent from one another. Biologists then circled the subject to estimate the precise location. During 1991–1996, technicians recorded bobwhite locations on U.S. Geologic Survey topographic maps (1:24,000). Thereafter, they used a Garmin GPS III accurate within ±15 m (Garmin International, Olathe, Kansas). We censored locations occurring outside the boundary of the Packsaddle Area.

We selected radio locations during the hunting season (Oct–Feb) from each year's telemetry data, determined annual selection, and estimated mean selection for the 11-year period. An annual selection ratio for northern bobwhites was w_i, where $w_i = o_i/\pi_i$ (o_i = proportional use of cover type i and π_i = proportional availability of cover type i; Manly et al. 1993). Mean values of w_i indicated avoidance if the upper 95% CL was <1, neutral use if 95% CLs bracketed 1 (the lower CL is <1 and the upper CL is >1), and selection if the lower 95% CL was >1. We estimated consistency in selection values by determining the number of years that annual values were similar ($P > 0.05$) to the overall mean based on overlapping 95% CLs.

Hunter Cover Selection

We obtained spatial data on hunting parties that volunteered to participate in the study using a Foretrex 201 GPS unit (Garmin International, Olathe, Kansas). The units recorded the hunter's location (<15-m accuracy) every 7 seconds. After the hunters returned, we downloaded data from each GPS unit into text files. We censored data points recorded while hunters were at their vehicles before leaving to hunt or after returning and erroneous points due to GPS error or signal loss. We identified these points by plotting the recorded path and examining for aberrant locations. Locations were considered aberrant if they were not consistent with the movement of the hunting party. This usually occurred when the satellite lost the GPS signal, then regained the signal at a later time. A total of six locations were considered aberrant and removed during the study. If a hunting party carried >1 GPS units, we used data from the unit that best maintained satellite connection and had the fewest number of locations censored. Database files were imported into ArcView 3.3 and used for analysis of cover selection.

We defined proportional use (o_h) of cover types by an individual hunting party (h) as the ratio of hunting-path length within a cover type to total path length during a hunt instead of using point data or time in cover type. This approach reduced the effect of variable velocities (rest, move). For each hunt, we had a hunter selection index w_h, where $w_h = o_h/\pi_h$ ($\pi_h = \pi_i$; proportional availability of cover type was the same for bobwhites and hunters). We computed the mean and variance of w_h over the population of hunters pooled over years. Cover types were considered avoided by hunters if the upper 95% CL was <1, used neutrally if 95% CLs bracketed 1 (the lower CL is <1 and the upper CL is >1), and selected if the lower 95% CL was >1.

Vehicle Access Influence

We determined the degree to which roads disproportionately sampled available cover types to understand the possible influence of road access to cover types on cover selection by hunters,. Selection-avoidance was determined by the proportional length of roads in cover type i (use) divided by the proportion of that cover type on the study area (π_i). Distance from road was not a cover type classification factor in this analysis. Statistical testing was unnecessary because we had complete information (census) of the study area for roads and cover types. Hunter and bobwhite selection indices for cover types <500 m from roads provided data for comparison of bobwhite, hunter, and road selection indices.

Results

This study accumulated >100,000 radio locations on >3,000 bobwhites. Selection indices were based on between 1,026 and 3,940 radio locations per season. The number of radioed bobwhites averaged 74 per season (SE = 7.5; min = 43, max = 115). Bobwhites selected the sand sagebrush-little bluestem association wherever it occurred regardless of slope and distance from road (Table 1). They also selected the shinnery oak-little bluestem association at slopes >3% and distances of 500–<1,500 m from roads. Bobwhites preference for the shinnery oak-little bluestem association was neutral or negative, for all other slope and distance categories. Bobwhites uniformly avoided the little bluestem-switchgrass association, sideoats grama (*Bouteloua curtipendula*) prairie, wetlands, and rare cover types. Bobwhites occurred in all cover

Table 1. Mean northern bobwhite (w_i) and hunter (w_h) selection indices for cover types on the Packsaddle Wildlife Management Area, Ellis County, Oklahoma. Bobwhite indices[a] are means for Oct–Feb periods beginning 1991–92 through 2001–02 (11 years); consistency is the number of years the annual selection index was similar ($P > 0.05$) to the mean. Hunters provided data during the 2004–05 and 2005–06 hunting seasons.

Slope (%), distance (m) to road Hoagland classification	Bobwhites				Hunters		
	w_i[b]	SE	Use[c]	Consistency	w_h[d]	SE	Use[c]
≤3, <500							
Agriculture and oil field	1.2	0.40	o	7	1.5	0.44	o
Little bluestem and switchgrass	<0.1	0.01	–	11	1.0	0.32	o
Shinnery oak and little bluestem	0.8	0.14	o	7	1.1	0.23	o
Sand sagebrush and little bluestem	3.5	0.33	+	11	2.0	0.36	+
Rare vegetation	<0.1	0.04	–	11	0.7	0.19	o
≤3, 500–<1,500							
Agriculture and oil field	0.2	0.05	–	11	0.2	0.09	–
Little bluestem and switchgrass	<0.10	<0.01	–	11	0.4	0.21	–
Sideoats grama prairie	0.1	0.05	–	11	1.4	0.29	o
Shinnery oak and little bluestem	0.9	0.09	o	7	0.8	0.24	o
Sand sagebrush and little bluestem	3.1	0.34	+	9	1.5	0.23	+
Wetland	<0.1	<0.01	–	11	0.3	0.23	–
Rare vegetation	0.2	0.15	–	10	1.5	0.71	o
≤3, 1,500–<2,500							
Sideoats grama prairie	0.2	0.09	–	11	1.0	0.35	o
Shinnery oak and little bluestem	0.5	0.16	–	6	<0.1	0.04	–
Wetland	<0.1	0.03	–	11	0.2	0.11	–
Rare vegetation	<0.1	0.06	–	11	1.2	0.45	o
≤3, ≥2,500							
Wetland	<0.1	<0.01	–	11	0.2	0.16	–
Rare vegetation	<0.1	0.06	–	11	0.4	0.33	–
>3, <500							
Little bluestem and switchgrass	<0.1	0.03	–	11	1.7	0.86	o
Sideoats grama prairie	<0.1	0.02	–	11	1.6	0.42	o
Shinnery oak and little bluestem	<0.1	0.13	–	5	1.0	0.25	o
Sand sagebrush and little bluestem	1.9	0.15	+	10	1.8	0.34	+
Rare vegetation	0.3	0.12	–	9	0.5	0.18	–
>3, 500–<1,500							
Sideoats grama prairie	0.14	0.04	–	11	1.2	0.23	o
Shinnery oak and little bluestem	2.7	0.26	+	10	0.5	0.15	–
Sand sagebrush and little bluestem	3.2	0.21	+	11	1.5	0.25	+
Rare vegetation	<0.1	0.01	–	11	0.8	0.24	o
>3, 1,500–<2,500							
Sideoats grama prairie	0.2	0.11	–	10	0.9	0.22	o
Shinnery oak and little bluestem	0.3	0.15	–	9	<0.1	0.03	–
Rare vegetation	0.3	0.16	–	10	1.5	0.41	o
>3, ≥2,500							
Sideoats grama prairie	0.0	0.0	–	11	<0.1	0.02	–
Rare vegetation	0.0	0.0	–	11	0.2	0.14	–

a. Based on selected radio locations during the hunting season (Oct–Feb) from each year's telemetry data, determined annual selection, and estimated mean selection for the 11-year period.

b. $w_i = o/\pi_i$ (o_i = proportional use of cover type i and π_i = proportional availability of cover type i).

c. implies avoidance, o implies neutral use, and + implies selection based on CI of selection indices for bobwhites or hunters.

d. $w_h = o_h/\pi_h$ (o_h = proportional use of cover types by an individual hunting party (h) as the ratio of hunting-path length within a cover type to total path length during a hunt and $\pi_h = \pi_i$; proportional availability of cover type was the same for bobwhites and hunters).

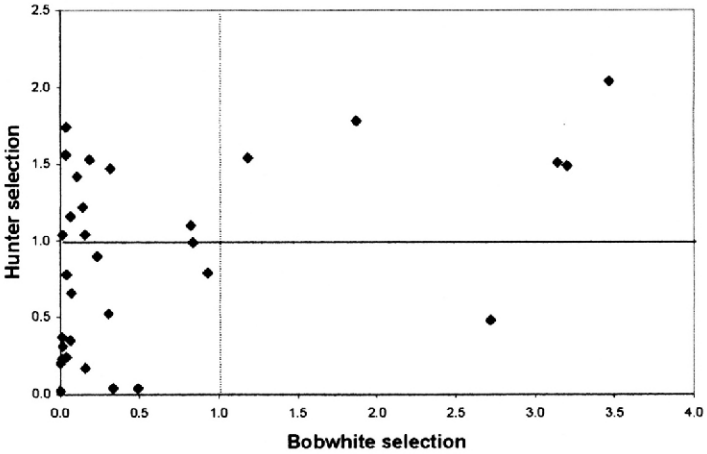

Figure 1. Comparative cover selection indices (32 cover types) for northern bobwhites (1991–2002) and hunters (2004–05 and 2005–06 hunting seasons) on the Packsaddle Wildlife Management Area, Ellis County, Oklahoma. The horizontal line denotes neutral use by hunters and the vertical line denotes neutral use by bobwhites.

types except sideoats grama and rare vegetation at slopes >3% and distances ≥2,500 m from roads. Cover type use by bobwhites was relatively consistent among years because 27 of 32 cover types had annual indices similar ($P > 0.05$) to the 11-year mean in ≥9 years (Table 1). The most inconsistent cover type was shinnery oak-little bluestem.

We obtained data for 28 hunts (55,262 usable 7-second periods) during the 2004–05 season and 42 hunts (65,219 usable periods) during 2005–06. Like bobwhites, hunters selected the sand sagebrush-little bluestem association wherever it occurred. Hunters were neutral about the use of the shinnery oak-little bluestem association, little bluestem-switchgrass, sideoats grama prairie, and certain configurations (distance, slope) of rare cover types. They avoided wetlands and sideoats grama prairie ≥2,500 from roads. Hunters occurred in all cover types.

Of the 32 cover types considered, bobwhites and hunters simultaneously selected the same 4 cover types that included sand sagebrush and little bluestem regardless of slope or distance from roads. Bobwhites selected shinnery oak-little bluestem at slopes >3% and distances of 500–<1,500 m from roads, whereas hunters avoided this type. The correlation between bobwhite and hunter selection indices was $r = 0.45$ ($P = 0.01$, $n = 32$), indicating a somewhat weak relationship (Figure 1).

We obtained eight data points for comparing disproportionate occurrence of roads within cover types and bobwhite and hunter selection within 500 m of roads (Table 2). (We will ascribe "selection" and "avoidance" to roads for simplicity of presentation.) Three patterns recurred in these data: 1) approximately neutral selection by all subjects for the agriculture-oil field association

Table 2. Comparative cover selection indices for northern bobwhites, hunters, and access roads on the Packsaddle Wildlife Management Area, Ellis County, Oklahoma, during the 2004–05 and 2005–06 hunting seasons. Data for bobwhites and hunters are for areas <500 m from roads.

Slope / Cover type	Northern bobwhite		Hunters		Road index[a]
	Index	SE	Index	SE	
≤3%					
Agriculture-oldfield	1.2	0.40	1.5	0.44	1.3
Little bluestem-switchgrass	<0.1	<0.01	1.0	0.32	2.8
Shinnery oak-little bluestem	0.8	0.14	1.1	0.23	2.0
Sand sagebrush-little bluestem	3.5	0.33	2.0	0.36	1.8
>3%					
Little bluestem-switchgrass	<0.1	0.03	1.7	0.86	2.2
Sideoats grama prairie	<0.1	0.02	1.6	0.42	<0.1
Shinnery oak-little bluestem	<0.1	0.13	1.0	0.25	0.6
Sand sagebrush-little bluestem	1.9	0.15	1.8	0.34	1.1

a. The road index represents a census so there is no uncertainty.

at slopes ≤3% and the shinnery oak-little bluestem association at slopes ≥3%; 2) apparent selection by all subjects for the sand sagebrush-little bluestem association at both slopes; and 3) strong avoidance by bobwhites, neutral use by hunters, and strong selection by roads for the little bluestem-switchgrass association at both slopes.

Discussion

"Understanding habitat use of both hunters and prey is essential to understanding hunter success" (Stedman et al. 2004:765). Stedman et al. (2004) studied habitat use by white-tailed deer (*Odocoileus virginianus*) hunters in Pennsylvania; they reported negative associations between the probability of hunter presence and distance from road, slope, and slope × distance interaction. To our knowledge, only one other paper has compared cover selection by bobwhites and hunters. Michener et al. (2000) found that bobwhites and hunters tended to co-occur at food plots and agriculture fields in Georgia.

A potential criticism is that data on bobwhite use of cover types predated our measurement of hunter behavior. The semiarid Packsaddle Area, is subject to large annual variation in precipitation. This variation would invoke substantial variation in annual plant communities. However, we would expect slopes and soil types to remain constant over the long term, and this would promote stability in vegetation associations. Excepting the shinnery oak-little bluestem type, there was strong consistency in interannual selection behavior towards specific cover types by bobwhite.

Bobwhites and hunters simultaneously selected the same four cover types that included sand sagebrush and little bluestem regardless of slope or distance from roads. Sand sagebrush associations are an important cover type for bobwhites. Hiller et al. (2007) found that grass upland and sand sagebrush associations occurred in ≥86% of bobwhite home ranges in the Texas Panhandle. Bobwhites will use sand sagebrush as nesting cover (S. G. Smith, Oklahoma State University, unpublished data). Guthery et al. (2005b) reported that bobwhites avoided sand sagebrush during winter, but it did provided roosting cover (Hiller 2004). Puckett (2002) found that sand sagebrush provided angles of obstruction (68˚ ± 5%); angles ≥45˚ indicated selected points in habitat space, whereas angles <45˚ indicate avoided points. Hunters may have selected sand sagebrush associations because that is where they had previously encountered bobwhites and/or that cover type was more readily available to hunt.

The correlation between bobwhite and hunter selection was not as high as expected possibly because of our method of quantifying hunter selection, the influence of hunter skill on selection, hunter success not related to bobwhite cover needs, skill of bird dogs, and/or road access to hunting areas. We quantified hunter selection based on the proportion of total path length in a cover type. If speed of hunter movements was affected by quail cover selection (e.g., hunters moving rapidly across cover types avoided by quail and slowly in cover types selected by quail), the proportion of total time in cover types might have yielded a stronger correlation between bobwhites and hunters. However, walking bobwhite hunters tend to move at a fairly stable average velocity of 0.73–0.80 m/sec (Richardson 2006, Mecozzi 2007).

Guthery et al. (2005a) found that in Oklahoma the skill of the average hunter declined as the statewide bobwhite population increased. Our study of hunters took place during years with strong regional bobwhite population based on roadside surveys conducted by the Oklahoma Department of Wildlife Conservation. This would imply a lowering of average hunter skill based on Guthery et al.'s (2005a) findings. However, the average hunter in our sample claimed 25 years of bobwhite hunting experience (Richardson 2006). Therefore hunter experience would be expected to facilitate use of areas selected by bobwhites in our study.

Hunters may be successful in cover types that bobwhites used randomly or less than expected by chance. Neutrally used and apparently avoided cover types may be important to bobwhites based on the frequency of use and their magnitude of contribution to usable space (Hiller et al. 2007). Hunters might be exercising good judgment by hunting habitats at the appropriate times even though these areas are not highly selected by quail overall. However, this behavior could reduce the correlation between bobwhite and hunter selection indices. A bird dog hunts for bobwhites by scent rather than cover recognition. It seems plausible that hunters who follow bird dogs may find themselves in cover types generally avoided by quail, but used intermittently.

The location of public access roads may have affected the cover

types accessible to hunters. On the Packsaddle Area, primary access was a road on the northern boundary with 3 laterals into the area (Richardson 2006). We observed a disproportionately high occurrence of roads in the little bluestem-switchgrass association, while bobwhites strongly avoided this cover type (Table 1). Hunters, on the other hand, exhibited neutral use of the little bluestem-switchgrass association, which might be explained by disproportionately high access to this cover type.

Management Implications

Richardson (2006) found that seeing several coveys was an important component of hunter satisfaction on the Packsaddle area, yet the cover selection indices of bobwhites and hunters were weakly correlated, with both bobwhites and hunters selecting the same four cover types that included sand sagebrush and little bluestem regardless of slope or distance from roads. The correlation could be increased by increasing access (roads) to bobwhite-selected cover types, reducing access to bobwhite-avoided types, and educating hunters on the nature and location of types selected and avoided by bobwhites.

Acknowledgments

We thank S. Cox and M. White, Oklahoma Department of Wildlife Conservation, for providing assistance during the field study. F. Hernandez, R. D. Elmore, and D. Rollins critiqued a draft of this paper. Support for this study was provided by the Oklahoma Department of Wildlife Conservation through Federal Aid, the Pittman-Robertson Wildlife Restoration Act under project W-149-R of the Oklahoma Department of Wildlife Conservation and Oklahoma State University. The Oklahoma Cooperative Fish and Wildlife Research Unit (Oklahoma Department of Wildlife Conservation, Oklahoma State University, U.S. Geological Survey Biological Resources Division, and Wildlife Management Institute cooperating) provided logistical support. Additional support came from the Department of Natural Resource Ecology and Management, Oklahoma Agricultural Experiment Station, Grand National Quail Foundation, Mixon Foundation, Game Bird Research Fund, Bollenbach Endowment, and an anonymous donor through Frank Merrick Foundation Management, Inc. The Oklahoma Agricultural Experiment Station approved publication of this paper.

Literature Cited

Cole, E. L., A. J. Conradi, and C. E. Rhoads. 1966. Soil survey of Ellis County, Oklahoma. U.S. Soil Conservation Service, Washington, D.C.

Cox, S. A., A. D. Peoples, S. J. DeMaso, J. J. Lusk, and F. S. Guthery. 2004. Survival and cause-specific mortality of northern bobwhites in western Oklahoma. Journal of Wildlife Management 68:663–671.

DeMaso, S. J., A. D. Peoples, S. A. Cox, and E. S. Parry. 1997. Survival of northern bobwhite chicks in western Oklahoma. Journal of Wildlife Management 61:846–853.

Guthery, F. S., A. Crews, J. J. Lusk, R. N. Chapman, and M. Sams. 2005a. Effects of bag limits on bobwhite hunters and harvest. Journal of Wildlife Management 68:1095–1103.

———, A. R. Rybak, W. R. Walsh, S. D. Fuhlendorf, and T. L. Hiller. 2005b. Quantifying usable space for wildlife with use-availability data. Journal of Wildlife Management 69:655–663.

Gutzwiller, K. J. 1990. Minimizing dog-induced biases in game bird research. Wildlife Society Bulleting 18:351–356.

Hiller, T. L. 2004. Nocturnal ecology of northern bobwhites: habitat, energetic, predation risk. Thesis, Oklahoma State University, Stillwater.

———, F. S. Guthery, A. R. Rybak, S. D. Fuhlendorf, S. G. Smith, W. H. Puckett, Jr., and R. A. Baker. 2007. Management implications of cover selection data: northern bobwhite example. Journal of Wildlife Management 71:195–201.

Hoagland, B. 2000. The vegetation of Oklahoma: a classification for landscape mapping and conservation planning. Southwestern Naturalist 45:385–420.

Manly, B. F. J., L. L. McDonald, and D L. Thomas. 1993. Resource selection by animals. Chapman and Hall, London, United Kingdom.

Mecozzi, G. E. 2007. Northern bobwhite hunting: behavior of hunters and dogs. Thesis, Oklahoma State University, Stillwater.

Michener, W. K., J. B. Atkinson, D. G. Edwards, J. W. Hollister, P. F. Houhoulis, P. M. Johnson, and R. N. Smith. 2000. Habitat characteristics of northern bobwhite quail-hunting party encounters: a landscape perspective. Proceedings of the National Quail Symposium 4:173–182.

Puckett, W. H., Jr. 2002. Habitat and space use by northern bobwhites in north Texas. Thesis, Oklahoma State University, Stillwater.

Richardson, J. L. 2006. Comparison of cover selection by northern bobwhites and hunters in western Oklahoma. Thesis, Oklahoma State University, Stillwater.

Stedman, R., D. R. Diefenbach, C. B. Swope, J. C. Finley, A. E. Luloff, H. C. Zinn, G. J. San Julian, and G. A. Wang. 2004. Integrating wildlife and human-dimensions research methods to study hunters. Journal of Wildlife Management 68:762–773.

Syrotuck, W. G. 1972. Scent and the scenting dog. Arner Publishing, Rome, New York.

Townsend, D. E., R. E. Masters, R. L. Lochmiller, D. M. Leslie, Jr., S. J. DeMaso, and A. D. Peoples. 2001. Characteristics of nest sites of northern bobwhites in western Oklahoma. Journal of Range Management 54:260–264.

White, G. C. and R. A. Garrott. 1990. Analysis of wildlife radio-tracking data. Academic Press, New York.