Habitat Preferences of Relocated and Resident Northern Bobwhite in Eastern Texas

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Abstract: During 1990–1992, 291 northern bobwhite (*Colinus virginianus*) were captured, radio-tagged, and relocated from southern and eastern Texas to an intensively managed 563-ha eastern Texas study area; 139 resident birds were also captured, radio-tagged, and released at the point of capture. We examined macro- and micro-habitat selection by relocated and resident birds. At the macro-habitat level, all 3 groups of bobwhite were associated with food plots ($P < 0.05$), preferred stands of pure pines > 30 years old, and avoided stands of pure pines 6–15 years old, hardwoods > 30 years old, and mixed pine-hardwoods > 30 years. At the micro-level, bird locations had more dead grass and bare ground but less live grass than random locations ($P < 0.05$). Bobwhite were not associated with edges ($P > 0.05$).

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Throughout the southern United States, the northern bobwhite is an important game species. In Texas, it ranks behind only mourning dove (*Zenaida macroura*) and white-tailed deer (*Odocoileus virginianus*) in terms of hunter participation (Boydston 1983). However, studies have indicated that bobwhite populations are declining throughout the south, including eastern Texas (Robbins et al. 1986, Brennan 1991, Church et al. 1993).

Since the 1930s, many approaches have been taken to rehabilitate bobwhite populations. State agencies began to respond to declining populations with a variety of unproven techniques, such as reduced seasons and bag limits, restocking with pen-

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raised and Mexican and native wild-trapped birds, and predator control. None of these approaches proved successful (Coggins 1986). Research has shown that the best way to rehabilitate bobwhite populations is to recreate suitable habitat conditions (Klimstra 1972).

In the late 1980s, Temple-Inland Forest Products Corporation committed to intensively manage approximately 563 ha for northern bobwhite in eastern Texas. The general goal was to rebuild the bobwhite population in the area through habitat improvement and bobwhite relocation; one objective of a broad-based associated research project was to evaluate bobwhite habitat preferences in the study area.

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Methods

The study area was in the central portion of South Boggy Slough Hunting and Fishing Club in southeastern Trinity County, approximately 17 km southwest of Lufkin, Texas. Trinity County is in the Pineywood Ecological Region of eastern Texas; climate of the region is hot and humid with precipitation ranging from 90 to 150 cm (Gould 1975). Forests of the study area were mainly composed of 50- to 60-year-old pine and mixed pine-hardwood stands with some mixed hardwood-pine stands along drainages. The dominant pines were loblolly (*Pinus taeda*) and shortleaf (*P. echinata*); there also were several small concentrations of longleaf pine (*P. palustris*). Hardwoods included sweetgum (*Liquidambar styraciflua*), southern red oak (*Quercus falcata*), white oak (*Q. alba*), post oak (*Q. stellata*), black hickory (*Carya texana*), and bitternut hickory (*C. cordiformis*). Rayburn (1983) described the forests of adjacent North Boggy Slough Hunting Club in some detail. The forests of South Boggy Slough were similar. Two 10-ha pine plantations, each 5 years old, and a 40-ha marsh which remained flooded most of the year were on the study area. Approximately 10 km of pipeline rights-of-way and 40 km of roads traversed through the study area.

Habitat modifications were initiated during February 1989 and most had been completed by January 1990. Habitat modifications involved basal area reduction, food plot establishment, bobwhite cover establishment, and the use of prescribed fire. Throughout the study area, basal area was reduced from 21–28 m^2/ha to 9–14 m^2/ha using crown and/or low thinnings. Generally, suppressed, intermediate, and some codominant trees were removed. A tornado damaged the timber on a 101-ha area in the southeastern portion of the study area in spring 1989. Timber on that area was salvaged and the area site-prepared and planted to pine seedlings. Approximately 20% of the study area was converted into warm-season and cool-season food plots. A variety of native and agricultural species were planted in the plots (Parsons 1994).

Throughout the study area, naturally-occurring cover blocks were designated; additional blocks were created by planting shrub lespedeza (*Lespedeza thunbergii*) and autumn olive (*Eleagnus fruitilandii*), usually along the edges of food plots. When the 2 plantations and the tornado damaged area are included, cover blocks comprised approximately 30% of the study area. The study area was initially burned with a prescribed fire in 1989 and was burned again during both 1991 and 1992. Cover blocks, food plots, and young pine plantations were protected during the prescribed burns.

Bobwhite from southern and eastern Texas were relocated to the study area during January–March 1990–1992. South Texas bobwhite (*C. v. texanus*) were captured in Kleberg and Kenedy counties in the South Texas Ecological Region, which is characterized by rangelands dominated by grasses, shrubs, and low-growing trees. The climate is hot and dry with precipitation ranging from 40 to 150 cm per year (Gould 1975). Most relocated eastern Texas bobwhite (*C. v. mexicanus*) were captured in the forests of North Boggy Slough Hunting Club, which is approximately 15 km north of the study area. During the 3-year period, 291 bobwhite were relocated to the study area, 155 from southern Texas and 136 from eastern Texas (Liu 1995). Each bird was aged, sexed, checked for injuries, fitted with a numbered aluminum leg band and a frequency-specific transmitter, and released on the study area in a covey of ≥4 birds.

A drive count in February 1989 indicated that there were no bobwhite on the study area. However, 2 small coveys of approximately 10 birds each were known to be on or adjacent to it in January 1990. Thirteen of these birds were captured, banded, radio-tagged, and released at the point of capture. During 1991 and 1992, 126 resident birds (i.e., raised on or around the study area) were captured, radio-tagged, and released at the point of capture (Parsons 1994, Liu 1995).

Beginning immediately after release, radio-tagged birds were tracked at least 5 days weekly using a receiver and a hand-held yagi antenna; during the deer hunting season, tracking was reduced to 2–3 days weekly. Bird locations were plotted on aerial photos and 100 × 100 m gridded maps. Radio-tagged birds were tracked for as long as they were alive or until the project ended. Throughout the study period, radio-tagged birds were recaptured and transmitters replaced as necessary.

Error testing was done by placing transmitters at 36 random locations in the study area and radio-locating and plotting these transmitters as if they were birds. The distances between estimated locations and the actual locations were then measured with a GIS (Environ. Systems Res. Inst. 1994) and an analysis of variance was performed on these data to compare accuracy of radiotrackers.

Habitat relationships were examined at the macro- and the micro-levels. At the macro-level, habitat components evaluated were proximity to food plots and forest type (Table 1). In order to analyze bobwhite association with food plots, an area of influence was created around each food plot. All bobwhite locations in the food plots and within the influence areas were considered to be associated with the food plots. To determine the width of the influence areas, a coverage of random points was created and overlaid with the food plot coverage using the GIS. Distance of each random point to the nearest food plot was measured with the system and the average

Table 1. Macro- and micro-habitat components and categories for the northern bobwhite study on the South Boggy Slough Hunting Club study area in Trinity County, Texas, 1990–1992.

Habitat component	Category
Macro-habitat	
Food plots	Food plots and their 40-m influence zones
	Non-food plot areas (areas >40 m from food plots)
Forest type	(1) Pure pine plantations ≤6 years old, (2) Pure pine stands 6–15 years old, (3) Pure pine stands 16–30 years old, (4) Pure pine stands >30 years old, (5) Pure hardwood stands >30 years old, (6) Mixed pine-hardwood stands >30 years old
Micro-habitat	
General habitat characteristics	Forest type (opening, young pine plantation, pine, hardwoods, mixed pine-hardwoods)
	Type of ground vegetation at sampling point (hardwood, herbaceous, grass, young pine, logging debris, windrow, other)
	Edge (presence/absence of edge within 150 m)
	Proximity to edge (distance from edge, in 5-m increments)
	Type of edge (food plot/forest, food plot/young pine plantation, food plot/opening, young pine plantation/forest, opening/forest, other)
Ground cover	Grass species (frequency)
	Herbaceous species (frequency)
	Woody species (frequency)
	Dead grass (frequency)
	Height of ground cover (cm)
Surrounding cover	Overstory (woody species >3 m tall) crown closure (%)
	Understory (woody species <3 m tall) crown closure (%)
	Bare ground (exposed soil, %)

was calculated. The average random-point-to-nearest-food-plot distance was 44 m; thus, we assumed that a location <44 m from a food plot was not due to a chance. To be conservative in making inferences that the birds in the influence areas were associated with food plots, the width of the areas was set to 40 m.

Over 15,000 bobwhite radio locations were obtained during the 1990–1992 study period. However, only locations within the study area were used for evaluating macro-habitat utilization. The number of radio locations in each habitat category was used as the measurement of habitat utilization by the birds. Expected numbers of radio locations based on availability were derived by multiplying total number of locations by the relative area of each category. Chi-square goodness-of-fit tests were performed between the expected and observed numbers of locations for each habitat component. The null hypothesis was that there was no difference between the observed and the expected numbers; i.e., the birds would exhibit no habitat preference. Because of heavy mortalities, our sample sizes decreased rapidly after the breeding season. Therefore, the data were used to analyze annual macro-habitat selection and no seasonal comparisons were performed.

When chi-square tests showed significant differences between observed and expected numbers of locations, either Bonferroni confidence interval or simultaneous confidence interval procedures (Neu et al. 1974, Byers et al. 1984), as appropriate, were applied to the data to further identify categories preferred or avoided by the birds. When the tests showed that the birds were consistent in utilizing a habitat category among all 3 years, the data on utilization of that category were pooled and analyzed as a whole. If utilization of a category was not consistent among years, no additional analyses were made.

At the micro-level, general habitat characteristics, ground cover, and surrounding cover were evaluated at and around bobwhite-centered and random points (Table 1). General habitat characteristics included overstory and ground vegetation types at and around the point and characteristics of edge in the vicinity of the point. General cover was classified at each point as living herbaceous, grass, or woody plants, or dead grass. Surrounding cover was categorized as overstory and understory crown closure and ground cover conditions within 25 m of the point.

A bird was selected, radio-located, and approached to establish a bobwhite-centered point. The location of the bird before it flushed or began moving away from the observer became the bobwhite-centered point. Random points were established using computer-generated coordinates; these were plotted on the gridded map and located in the field by compass and pacing from land marks.

General habitat conditions were evaluated and recorded upon locating a point. Data on ground cover were collected using a 10-pin-frame sampling procedure (Heady and Rader 1958, Conrad 1969, Parsons 1994, Liu 1995) at 5 subpoints on or around the center point (Fig. 1). Two lines which crossed at the bobwhite-centered or random point were established after the pin-frame measurements were completed and a line-point sampling procedure (Fig. 1) was used to evaluate surrounding cover (Whiting and Fleet 1987).

Micro-habitat variable measurements took place from early July to the end of October during 1991 and 1992. During both years, 2 samples were taken for each radio-tagged bird that had an active transmitter during the sampling period. For each bird, 1 sample was taken early and the other late on different days. Some birds were lost between the first and second sample, so for every other bird, the first sample was taken late in the day. Totals of 57 random and 29 bobwhite-centered points were sampled in 1990, and 100 random and 75 bobwhite-centered points were sampled in 1992.

Multivariate analysis of variance and chi-square test of homogeneity were applied to micro-habitat data to identify variables that differentiated the habitat selected by bobwhite from the overall habitat of the study area. Due to poor survival, it was necessary to pool habitat data of all 3 groups, thus generalizing the differences between habitat selected by bobwhite and average habitat available. Statistical tests were performed using SAS (SAS Inst. 1988), and the alpha levels for all tests were set *a priori* at 0.05.

Results and Discussion

Distances from the radio-trackers (N = 4) to the test transmitters ranged from 150 to 300 m, within which most bobwhite radio locations were also taken. The

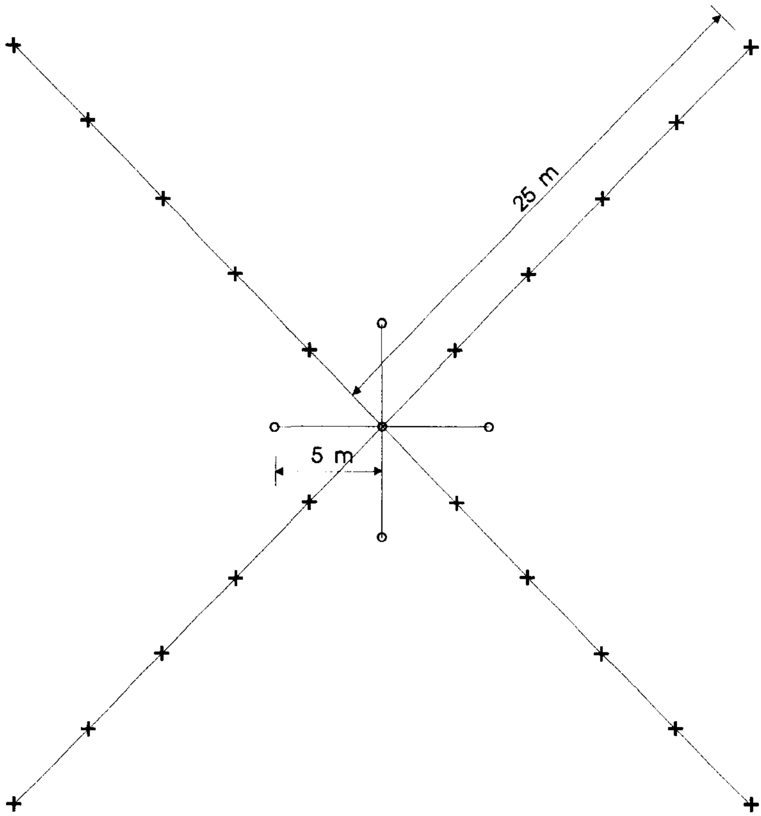

Figure 1. Layout of micro-habitat sampling points on the South Boggy Slough northern bobwhite study area, Trinity County, Texas, 1990–1992. Each 'o' denotes a pin-frame sampling subpoint, and each 'x' a line-point sampling subpoint (after Whiting and Fleet 1987).

average deviation of estimated locations from true locations of the test transmitters ranged from 27.6 to 42.0 m for radio-trackers, but did not vary among individuals ($P = 0.09$). Mean deviation was 33.9 m.

Macro-habitat

Radio locations during the 3-year period indicated that bobwhite were not evenly distributed throughout the study area. Bobwhite from all 3 groups were consistently associated with food plots ($P < 0.05$). Likewise, all 3 groups showed preferences in their use of different forest types (Table 2). The forest type preferred by all groups were pure pines > 30 years old. Stands avoided were pure pines 6–15 years, hardwoods >30 years, and mixed pine-hardwoods >30 years old. Both South Boggy residents and South Texas relocated bobwhite showed preference for pure pines <6 years old, while the use of this type by East Texas birds was inconsistent during the 3 years. Preference/avoidance of pure pines 16–30 years by South Boggy residents were not

Table 2. Observed and expected numbers of bobwhite radio locations in different forest types on the South Boggy Slough study area, Trinity County, Texas, 1990–1992. Chi-square goodness-of-fit tests on pooled data are significant for each subpopulation ($P < 0.01$). Bonferroni simultaneous confidence interval tests on forest types are also significant for each subpopulation ($P < 0.05$).

	1990*		1991		1992		Pooled		
Forest type	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.	Use
South Boggy residents									
Pines <6 years	3	26	144	76	227	152	371	228	prefer
Pines 6–15 years	3	6	5	18	6	37	11	56	avoid
Pines 16–30 years	1	11	57	31	25	61	83	103	**
Pines >30 years	0	18	230	51	285	103	515	155	prefer
Hdwds >30 years	0	5	0	14	0	28	0	42	avoid
Pine-hdwds >30 years	378	319	671	917	1,674	1,836	2,345	2,761	avoid
Total	385	385	1,107	1,107	2,217	2,217	3,242	3,242	—
East Texas relocated									
Pines <6 years	88	110	142	83	135	168	365	361	**
Pines 6–15 years	9	27	0	20	16	41	25	88	avoid
Pines 16–30 years	101	44	71	33	38	67	210	144	prefer
Pines >30 years	201	74	71	56	116	113	388	243	prefer
Hdwds >30 years	0	21	4	16	0	32	4	69	avoid
Pine-hdwds >30 years	1,206	1,329	924	1,004	2,143	2,027	4,273	4,356	avoid
Total	1,605	1,605	1,212	1,212	2,448	2,448	4,900	4,904	—
South Texas relocated									
Pines <6 years	127	119	155	55	221	128	503	302	prefer
Pines 6–15 years	4	29	9	13	9	31	22	73	avoid
Pines 16–30 years	145	48	34	22	174	52	353	122	prefer
Pines >30 years	142	81	83	37	86	87	311	205	prefer
Hdwds >30 years	0	23	0	11	0	24	0	58	avoid
Pine-hdwds >30 years	1,326	1,444	523	666	1,381	1,549	3,230	3,659	avoid
Total	1,744	1,744	804	804	1,871	1,871	4,419	4,419	—

*Data on 1990 resident birds deemed biased due to small sample size (13 birds); thus, were excluded from statistical tests.

**Preference or avoidance was inconsistent among the 3 years.

consistent during the study period, whereas East and South Texas relocated bobwhite consistently avoided this type (Table 2).

The 2 most important factors affecting bobwhite distribution are food and cover. Therefore, the principal objectives of recreating suitable habitat in which to relocate bobwhite are to provide adequate food sources and cover. As a major or a supplementary food source, food plots can play an important role in bobwhite relocation and management. Food plots created for this study consisted of food-producing plant species within the plots and cover-producing species around the edge, thus the plots provided food as well as cover. The significant association of the birds with food plots suggests that these areas better met the species' daily requirements than did the non-food plot areas.

The apparent avoidance of 6- to 15-year-old pure pine, mixed pine-hardwood, and pure hardwood stands by all 3 groups is an indication that these areas possessed some characteristics which negatively affected the distribution of the birds. The 6- to 15-year-old pure pine stands were the densest in the study area. The high degree of crown closure prevented the development of ground cover and as a result, the stands probably did not provide adequate food and cover for bobwhite.

Although the mixed pine-hardwood and pure hardwood stands composed the largest portion of the study area, both types were at relatively low elevations. The relatively high moisture content of the soils associated with the lower elevations could have indirectly affected the birds' distribution through its effects on species composition of the ground cover. Likewise, prescribed fires were cooler at lower elevations. This resulted in relatively dense ground cover and litter at lower elevations. Also, heterogeneity of the mixed-species stands may have attracted avian predators that would have negative effects on bobwhite.

Preferences for pure pine stands <6 years old and those >30 years old (Table 2) were probably a result of ground cover conditions. Subjectively, the <6-year-old pure pine stands provided the most open ground conditions on the study area. Likewise, the >30-year-old pure pine stands appeared to be the most open of the mature stands.

Micro-habitat

During 1991 and 1992, bobwhite-centered points were associated with areas that had higher percentages of bare ground, higher frequencies of dead grass, and lower frequencies of living grass than did random points. In 1991, the average ground cover height at bobwhite points was higher than at random points; in 1992, the relationship was reverted. In 1992 only, overstory crown closure and understory crown closure measurements were higher at bobwhite-centered points than at random points (Table 3).

The types of ground vegetation at bobwhite sampling points were different from those at random points ($P < 0.01$). Compared with random points, more bobwhite points were associated with grass and fewer were associated with either woody or herbaceous species. No differences were found between bobwhite locations and random locations in forest type ($P = 0.92$), presence/absence of edge ($P = 0.80$), or type of edge ($P = 0.80$).

Table 3. Numerical micro-habitat characteristics of bobwhite-centered and random points on the South Boggy Slough study area, Trinity County, Texas, 1991–1992. Results of multivariate analysis of variance are also shown.

	1991					1992				
	Bobwhite points ($N = 29$)		Random points ($N = 57$)			Bobwhite points ($N = 75$)		Random points ($N = 100$)		
Habitat component	Mean	SE	Mean	SE	*P*	Mean	SE	Mean	SE	*P*
Ground cover ht. (cm)	98.3	30.0	72.7	31.3	<0.01	28.5	16.1	37.4	22.8	<0.01
Bare ground (%)	11.4	20.1	2.1	7.2	<0.01	7.4	10.6	2.2	8.6	<0.01
Dead grass (hits/10 pins)	9.7	15.1	3.6	7.0	0.01	2.2	3.7	0.9	2.3	<0.01
Living grass (hits/10 pins)	32.2	23.1	48.2	33.5	0.02	33.1	21.2	62.5	43.7	<0.01
Herbaceous (hits/10 pins)	13.2	10.5	10.5	10.5	0.26	17.7	20.4	19.5	30.7	0.65
Dist. from edge (m)	45.9	56.6	54.0	50.4	0.50	34.9	42.8	34.9	36.6	0.99
Overstory closure (%)	45.0	28.9	43.4	27.2	0.80	21.4	12.2	16.8	12.4	0.02
Understory closure (%)	26.7	19.6	25.9	23.4	0.87	14.2	30.0	5.6	8.8	0.01
Woody species (hits/10 pins)	7.8	9.7	7.6	9.5	0.94	17.7	22.8	9.5	35.0	0.70

Bobwhite select habitats with certain features due to requirements for food, escape cover, and nesting cover (Roseberry and Klimstra 1984). The bobwhite's requirement for bare ground has been well documented (Rosene 1969, Schroeder 1985). Bare ground or light litter allows the birds access to seeds (Schroeder 1985) and dusting areas (Rosene 1969). Although the percentages of bare ground on bobwhite-centered plots were lower in this study than those in other studies (Schroeder 1985, Cline 1988, Lee 1994), they were higher than those found on the random plots (Table 3). Apparently, as in other studies, the bobwhite selected areas with high proportions of bare ground.

Dead grass is most important to bobwhite during the nesting period. Birds not only choose places with dead grass as nest sites (Rosene 1969), but also use it as nest-building material (Rosene 1969, Roseberry and Klimstra 1984). Much of our data were collected after the breeding season. The fact that bobwhite were in areas with relatively high frequencies of dead grass (Table 3) suggests that it affects selection of micro-habitat after the breeding season also.

Bobwhite avoided areas with high living-grass density. This result is consistent with the findings by Cline (1988), in which bobwhite showed preference for areas with relatively low grass density. Cline (1988) speculated that this was attributable to the birds' preference for herbaceous diversity. In our study, the avoidance of areas with high living-grass density was probably caused by grass interference with bird movement. While grass provided seeds and protective cover, in some parts of the study area it was dense enough to restrict movements. As both food and protective cover were widely available throughout most of the study area, the birds were able to avoid areas with high densities of living grass.

Bobwhite is considered an edge species (Rosene 1969). Cline et al. (1991) found that the abundance of suitable edges was a significant factor for predicting relative number of bobwhite. Lee (1994) concluded that distances between bobwhite-used plots and edges were less than those between random plots and edges. However, DeVos and Mueller (1993) compared distances between brood-centered plots and edges to those between random plots and edges and found no difference. Lee (1994) attributed this to the homogeneity and high quality of the habitats they examined.

The number and types of edges are an indicator of habitat diversity or spatial heterogeneity. When a species tends to be associated with edges, it suggests that these areas better meet the species' requirements for food, cover, young-rearing conditions, etc., during various stages of its life. Bobwhite occur in a variety of habitats. In homogeneously developed habitats, such as cropland, edges are crucial to the species. However, if a habitat possesses the characteristics of high heterogeneity, an 'edge species' may not necessarily need to be associated with edges.

The South Boggy Slough study area was specifically modified to meet bobwhite habitat requirements. The forest was thinned, escape covers were protected during burning, and large numbers of food plots of various sizes were created throughout the study area. As noted earlier, the average distance from a random point to the nearest food plot was only 44 m. Had natural openings and other edges been included, the distance would have been even shorter. In such a heterogeneous habitat, it comes as no surprise that the birds showed no association with edges, even though the species is classified as an edge species.

Management Implications

Because of the decline of bobwhite throughout its range, relocation of wild birds may be an important means of rehabilitating populations. Habitat improvement before relocating bobwhite will be necessary in areas void of the species or having low densities. The study area used for this research was intensively managed for bobwhite. The necessary habitat improvements were costly and may negatively affect other management goals. Therefore, cost effectiveness and compatibility with other land management goals need to be a consideration when attempting to relocate bobwhite.

The association of northern bobwhite with edges is merely a result of the fulfillment of their life requirements. Highly diversified habitats satisfy these requirements and allow birds the flexibility of selecting areas that improve their survival and reproduction. Therefore, diversification should be incorporated into habitat improvement, with special considerations given to the establishment of food plots with cover producing species.

Bobwhite are mainly affected by conditions of understory vegetation and ground cover. In forested areas, these conditions are directly influenced by overstory species composition, density, crown closure, etc. Therefore, among other factors, overstory conditions should be considered in bobwhite relocation, and in eastern Texas, 6- to 15-year-old pure pine and >30-year-old pure hardwood and mixed pine-hardwood stands should be avoided.

Areas with high percentages of bare ground, relatively high frequencies of dead grass, and moderate densities of living grass are preferred by bobwhite in eastern Texas. These micro-habitat conditions may be improved by changing overstory conditions or manipulated directly using measures such as prescribed burning, discing, and grazing.

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