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SURVIVAL AND CAUSES OF MORTALITY OF RELOCATED AND RESIDENT NORTHERN BOBWHITES IN EAST TEXAS

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ABSTRACT

We estimated survival of 3 groups of northern bobwhites (*Colinus virginianus*) on a 563-ha intensively managed study area in eastern Texas. During the 3-year study, 155 bobwhites from South Texas and 136 bobwhites from East Texas were captured, radio-marked, and relocated to the study area; 139 bobwhites that were resident on the study area were also captured, radio-marked, and released at the point of capture. There were no differences ($P > 0.05$) in survival among the 3 groups of bobwhites. However, survival of bobwhites from South Texas were consistently lower than those of the other 2 groups during each year; both bobwhites from East Texas and resident bobwhites survived better than bobwhites relocated from South Texas. Avian predation claimed 57.6% of 243 known-fate birds, mammalian predation and apparent capture stress each caused 9.1% mortality, while 1.2% of the birds died of snake predation and 14.0% were lost to unidentifiable causes.

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INTRODUCTION

The northern bobwhite was present but probably not abundant throughout much of the eastern U.S. before Europeans arrived. Early farming practices favored the species, and populations boomed. In the southern U.S., numbers peaked about 1890 and remained relatively stable until about 1940. Thereafter, land use changes resulted in declining populations (Rosene 1969), with the declines continuing into the 1990's (Brennan 1991, Church et al. 1993).

In eastern Texas, bobwhite populations followed similar trends; population declines were evident by the late 1930's (Lay 1954). In eastern Texas and throughout the Southeast, many approaches have been used to restore bobwhite populations. These included reducing bag limits, season closures, predator control, and restocking both pen-reared and wild-trapped birds (Lay 1954, Coggins 1986). Most wild-trapped bobwhites relocated to the Southeast came from southern Texas and Mexico where they were relatively abundant and easy to capture; normally, local birds were not available for trapping and relocation.

None of these approaches were successful (Lay 1954), and research demonstrated that the best way to restore bobwhite populations is to recreate suitable habitat (Klimstra 1972). However, a literature search revealed no studies that investigated the combined effects of both habitat rehabilitation and restocking. Likewise, only a single study (DeVos and Mueller 1989) investigated restocking using local bobwhites. The study suggested that relocation of local birds into nearby areas apparently devoid of quail can be successful.

In 1989, Temple-Inland Forest Products Corporation initiated a project to convert a second-growth forest into an area intensively managed for northern bobwhites. The general goal was to restore the bobwhite population by improving the habitat and relocating bobwhites into the newly created habitat. One objective of an associated research project was to evaluate and compare survival rates among 3 groups of bobwhites, those relocated to the study area from South

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Texas (*C. v. texanus*), those relocated from disjunct areas of East Texas, and those assumed to have been raised on or around the study area (i.e., residents). Bobwhites in the latter 2 groups were of the *C. v. mexicanus* subspecies (Johnsgard 1973).

METHODS

The 563-ha study area was in southeastern Trinity County, which is in the Pineywood Ecological Region of eastern Texas. Climate in this region is hot and humid with annual precipitation ranging from 90 to 150 cm (Gould 1975). Forest cover was mainly 50 to 60 year-old pine and mixed pine-hardwood stands with some mixed hardwood-pine stands along drainages. Forests on and around the study area have been described in detail by Rayburn (1983), Parsons (1994), Liu (1995), and Liu et al. (1996).

The first step in habitat modifications involved thinnings which reduced basal area throughout the study area to 9 to 14 m^2 per ha (Parsons et al. *this volume*). Timber on a 101-ha tornado-damaged area was salvaged and the area site-prepared and planted to pine seedlings. A variety of native and agricultural species were planted in warm-season and cool-season food plots which comprised approximately 20% of the study area. Naturally occurring and planted cover blocks comprised approximately 30% of the study area. Food plots and escape cover are described in detail in Parsons et al. (*this volume*). The study area was initially burned with a prescribed fire in 1989 and approximately half of it was burned again each year thereafter. Food plots, cover blocks, and young pine plantations were excluded from fire.

Although a drive count in February 1989 indicated that there were no bobwhites on the study area, 2 small coveys of about 10 birds each were known to be on or adjacent to it when relocation of South Texas and East Texas bobwhites was initiated. Trapping and relocation of these birds took place during January to March of 1990, 1991, and 1992. Bobwhites residing on the study area were captured during the same periods. The South Texas birds were captured in Kleberg and Kenedy Counties in the South Texas Plains Ecological Region (Gould 1975). Most East Texas bobwhites were captured in and around young pine plantations on Temple-Inland lands in Houston County, approximately 15 km north of the study area. Each bird was aged, sexed, checked for injuries, fitted with a leg band and a frequency-specific transmitter (Parsons et al. *this volume*), and released at a previously selected site on the study area in a covey of no less than 4 birds.

Radio-marked birds were tracked at least 5 days a week except during the deer hunting season when tracking was reduced to 2 to 3 days weekly. During 1990 and 1991, birds that were deemed to have not moved for a week were flushed to determine their survival status. In 1992, the transmitters had a mortality detection circuit, so it was not necessary to flush the birds to determine survival status. Throughout the study period, radio-marked birds were recaptured and transmitters replaced as necessary.

When a bird was found dead, the cause of death was determined using a key developed at Tall Timbers Research Station, Tallahassee, Florida (B.S. Mueller, personal communication). Causes of mortality were categorized as avian, mammalian, snake, capture-related, or unknown.

When a bird was lost (i.e., could not be radio-located), efforts were made to find it and determine its fate for 3 weeks. Thereafter, the bird was considered permanently lost for purposes of survival analyses. If a bobwhite was recovered alive later, it was put back into the population as a new bird. If the bird was found dead after the 3-week period, we assumed that it died the day after the last day it was radio-located.

The Kaplan-Meier procedure as modified by Pollock et al. (1989*a*, 1989*b*) was used to estimate survival of the 3 groups of bobwhite. In the analyses, the time unit of survival was a week (i.e., only when a bird survived an entire week was it considered to be alive for that time period). For each week of the nesting season, survival distribution values were compared among subpopulations using normal tests (Pollock et al. 1989*b*). Since the capture, handling, and radio-marking might have caused subtle injuries to the birds which could have influenced survival, the survival data during the first week after release were excluded from the analyses.

Survival distributions were compared using log-rank tests, as modified by Pollock et al. (1989*b*), with the null hypothesis that there were no differences among distributions. Comparisons were made among groups within each year as well as within each group among different years. The alpha level for all tests was set *a priori* at 0.05.

RESULTS

During 1990, 1991, and 1992, 50, 50, and 55 South Texas bobwhites, respectively, and 31, 50, and 55 East Texas bobwhites, respectively, were released on the study area. In 1990, 13 resident bobwhites were captured, aged, sexed, banded, radio-marked, and released at the point of capture. In 1991 and 1992, 69 and 57 resident birds were likewise captured, processed, and released.

Survival and Mortality

Among-group Survival

In 1990, the Kaplan-Meier procedure was applied to data collected during the first 18 weeks after the release of the birds (i.e., from 27 February to 2 July). Thereafter, low sample size precluded meaningful statistical analysis. During that period, East Texas relocated birds had higher survival than resident birds ($P \leq 0.05$) (Figure 1). However, there were no differences in survival distributions between South Texas relocated birds and either resident ($P > 0.05$) or East Texas relocated ($P > 0.05$) birds. In 1991, trapping was

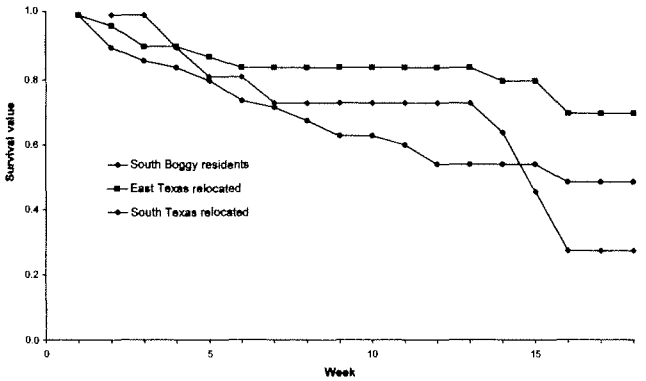

Fig. 1. Survival of northern bobwhites on the Temple-Inland study area, Trinity County, Texas, 1990; the first day of week 1 was 27 February and the last day of week 18 was 2 July.

discontinued in the last week of February; thus, survival analyses were initiated on 4 March. During the 36-week period between that date and 10 November 1991, survival distributions did not differ among the 3 groups of bobwhites (Figure 2). During 1992, bobwhites in both East Texas and South Texas were easy to capture. As a result, survival analyses were initiated on 17 February and carried until 25 October (36 weeks), when the project ended. Although survival distributions of East Texas and resident bobwhites were strikingly similar and different from that exhibited by South Texas relocated birds (Figure 3), the log-rank tests were not significant ($P>0.05$).

Within-group Survival

Log-rank tests showed no significant among-year differences within each group. However, South Texas relocated birds showed high consistency in their survival distributions among the 3 years, whereas residents and East Texas relocated bobwhites exhibited among-year variation (Figures 4, 5, and 6).

Breeding-season Survival

On the study area, the breeding season started in early April each year, when the birds began to whistle;

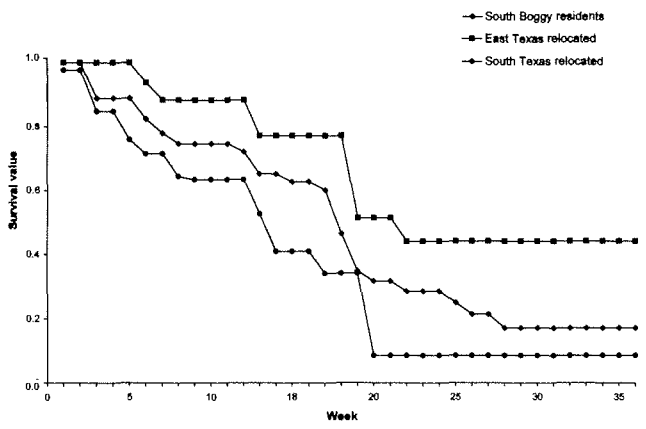

Fig. 2. Survival of northern bobwhites on the Temple-Inland study area, Trinity County, Texas, 1991; the first day of week 1 was 4 March and the last day of week 36 was 11 November.

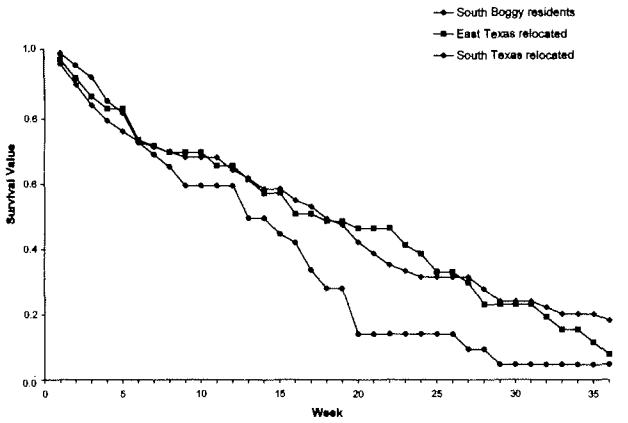

Fig. 3. Survival of northern bobwhites on the Temple-Inland study area, Trinity County, Texas, 1992; the first day of week 1 was 17 February and the last day of week 36 was 25 October.

covey break-up began in early to mid-April. By early May, some females had started nesting. Although bobwhites were recorded on nests or with flightless chicks from May to late September, the majority of the nesting activities were concentrated between May and mid-July (Parsons 1994). Each year during that period, survival distributions showed the steepest decrease (Figures 1, 2, and 3).

Bobwhites relocated from East Texas had higher survival values than South Texas relocated birds during each of the 31 weeks included in the pooled nesting seasons (Table 1). Likewise, South Boggy bobwhites had higher survival values than South Texas birds for 26 weeks. Finally, East Texas bobwhites showed better survival than South Boggy birds in 1990 and 1991, but the relationship was generally reversed in 1992 (Table 1). During the 3-year study period, 68.4% of the known-fate South Texas birds that were alive at the beginning of May died of predation by the middle of July. During that same period, 37.7% of East Texas relocated birds were lost to predators as were 39.7% of resident bobwhites.

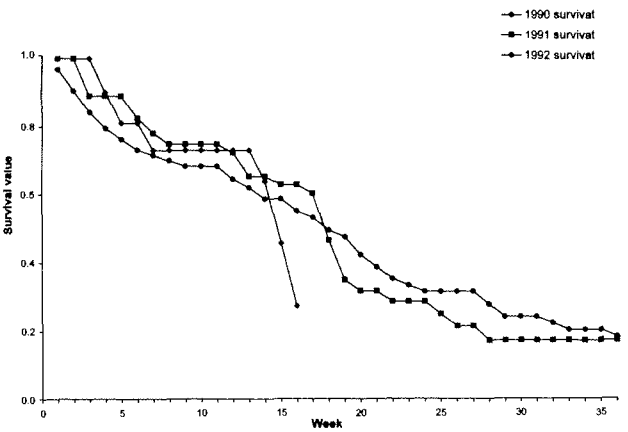

Fig. 4. Survival of resident northern bobwhites on the Temple-Inland study area, Trinity County, Texas; the first day of week 1 was 27 February, 4 March, and 17 February in 1990, 1991, and 1992, respectively.

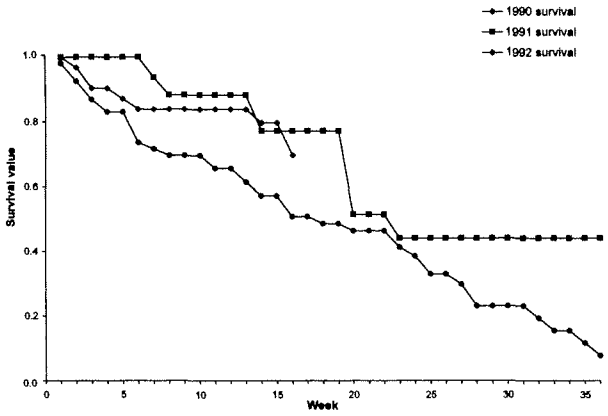

Fig. 5. Survival of East Texas relocated northern bobwhites on the Temple-Inland study area, Trinity County, Texas; the first day of week 1 was 27 February, 4 March, and 17 February in 1990, 1991, and 1992, respectively.

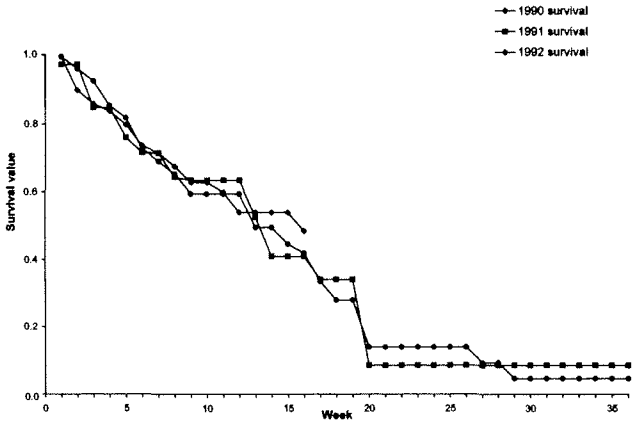

Fig. 6. Survival of South Texas relocated northern bobwhites on the Temple-Inland study area, Trinity County, Texas; the first day of week 1 was 27 February, 4 March, and 17 February in 1990, 1991, and 1992, respectively.

Table 1. Weekly Kaplan-Meier survival distribution values during the nesting season, and results of simple *Z*-tests comparing these values between South Boggy resident and East Texas and South Texas relocated northern bobwhites on the South Boggy Slough study area, Trinity County, Texas.

Week ending	Kaplan-Meier survival distribution values			*Z*-values		
	S. Boggy residents	E. Texas relocated	S. Texas relocated	S. Boggy versus E. Texas	S. Boggy versus S. Texas	E. Texas versus S. Texas
1990[a]	(*n* = 13)	(*n* = 31)	(*n* = 50)			
7 May	0.7290	0.8387	0.6284	−1.2421	1.0785	1.9783*[b]
14 May	0.7290	0.8387	0.5999	−1.2041	1.3176	2.2077*
21 May	0.7290	0.8387	0.5399	−1.1899	1.8910	2.7391*
28 May	0.7290	0.8387	0.5399	−1.9690*	0.8562	2.5163*
4 June	0.6379	0.7968	0.5399	−2.9258*	−0.6181	1.8444
11 June	0.4556	0.7968	0.5399	−4.0262*	−1.8659	1.7770
18 June	0.2734	0.6972	0.4859	−3.0271*	−1.4629	1.4024
25 June	0.2734	0.6972	0.4859	−2.6966*	−1.3204	1.3155
2 July	0.2734	0.6972	0.4859	−2.4227*	−1.1824	1.2473
1991	(*n* = 71)	(*n* = 52)	(*n* = 54)			
5 May	0.7471	0.8824	0.6348	−1.3267	0.7061	1.6160
12 May	0.7471	0.8824	0.6348	−1.2785	0.7111	1.5767
19 May	0.7471	0.8824	0.6348	−1.2617	0.7061	1.5767
26 May	0.7222	0.8824	0.6348	−1.5344	0.5385	1.5907
2 June	0.6523	0.8824	0.5267	−2.2040*	0.9719	2.6512*
9 June	0.6523	0.7721	0.4097	−1.0198	1.9002	2.5952*
16 June	0.6281	0.7721	0.4097	−1.1719	1.4758	2.2389*
23 June	0.6281	0.7721	0.4097	−1.1245	1.4592	2.2055*
30 June	0.6019	0.7721	0.3414	−1.9920*	1.8999	3.6271*
7 July	0.4651	0.7721	0.3414	−2.2331*	0.8598	2.5292*
14 July	0.3489	0.7721	0.3414	−3.1031*	0.0525	2.5292*
1992	(*n* = 62)	(*n* = 60)	(*n* = 58)			
3 May	0.6825	0.6568	0.5949	0.2948	0.9794	0.6599
10 May	0.6349	0.6568	0.5949	−0.2464	0.4417	0.6419
17 May	0.6190	0.6144	0.4958	0.0505	1.4040	1.2643
24 May	0.5856	0.5720	0.4958	0.1467	0.9118	0.7367
31 May	0.5856	0.5720	0.4462	0.1403	1.4145	1.2162
7 June	0.5501	0.5085	0.4200	0.4435	1.2945	0.8556
14 June	0.5318	0.5085	0.3360	0.2342	2.0195*	1.6834
21 June	0.4938	0.4864	0.2800	0.0751	2.2412*	2.0640*
28 June	0.4748	0.4864	0.2800	−0.1154	1.7286	1.7699
5 July	0.4220	0.4643	0.1400	−0.4459	3.4712*	3.6258*
12 July	0.3869	0.4643	0.1400	−0.7779	2.5466*	2.9982*

[a] Sample size at the beginning of the ratio-locating year (i.e., 27 Feb., 4 March, and 17 Feb. in 1990, 1991, and 1992, respectively); for 1991 and 1992, sample size includes carryovers from the previous year.
[b] An * indicates a significant difference at the 0.05 level.

Table 2. Causes of mortality of 243 known-fate northern bobwhites on the Temple-Inland study area, Trinity County, Texas, 1990–1992.

Year	Bird group	Cause of death					Total
		Avian	Mammal	Snake	Capture-related	Unknown	
1990	Residents	5	1	0	0	3	9
	East Texas relocated	9	3	0	1	0	13
	South Texas relocated	19	4	0	1	1	25
	Subtotal	33	8	0	2	4	47
1991	Residents	15	3	0	10	3	31
	East Texas relocated	4	0	0	3	1	8
	South Texas relocated	9	0	0	3	8	20
	Subtotal	28	3	0	16	12	59
1992	Residents	24	6	1	3	10	44
	East Texas relocated	27	2	1	1	4	35
	South Texas relocated	28	3	1	0	4	36
	Subtotal	79	11	3	4	18	115
	Total	140	22	3	22	34	221
	Percent	57.6	9.1	1.2	9.1	14.0	90.9

Causes of Mortality

In this study, avian predation was the most important cause of mortality (Table 2). It claimed 140 birds or 57.6% of the known-fate bobwhites. Mammalian predators and capture processes each caused 9.1% mortality, and slightly over 1.2% of the birds died of snake predation. It should be noted that all snake mortality was recorded in 1992, when a different model transmitter was used. Thirty-four deaths resulted from unidentifiable causes, which accounted for 14.0% of all fate-known birds; the remaining 9.1% were alive at the end of the year.

DISCUSSION

Due to the extremely small initial population size (13 individuals), survivorship estimates of 1990 resident bobwhites were highly susceptible to stochastic events such as predation. Between weeks 13 and 16 only 3 birds were lost, but weekly survival values dropped from 0.729 to 0.2734 (Table 1). Due to extensive transmitter failure in 1991, 76% of the East Texas birds were classified as missing and removed from the analysis. Likewise, large proportions of the other 2 groups were classified as missing. No doubt many of these birds died but were misclassified due to transmitter failure. As a result, the 1991 survival estimates and predation rates were confounded by transmitter failure. On the other hand, the transmitters used in 1992 were very reliable. There were also more radio-marked birds in each group in 1992 than in 1990 or 1991. These facts make clear that 1992 survival distributions and predation rates were probably more representative of the 3 groups than were those of 1990 or 1991. Although there were no significant differences among the 3 groups, the survival distributions for South Texas relocated birds were the lowest each year, indicating that both resident and East Texas relocated bobwhites survived better than South Texas relocated birds.

The relatively high variation in annual survival estimates for both East Texas and resident bobwhites is an indication that annual changes in environmental factors had more influence on the survival of these 2 eastern Texas groups than on that of South Texas birds. The consistent annual survival patterns of the latter group (Figure 6) suggest that inherent characteristics of South Texas bobwhites had a more profound negative impact on their survival than did annual environmental changes.

Three major factors might have caused the among-year difference in survival. First, the response of predators to biological changes on the study area might have had an important impact. Habitat manipulations, i.e., thinning of the forest, establishment of food plots, and annual prescribed burning, returned much of the study area to early successional vegetation stages. These changes caused a drastic increase in early successional animal species, especially cotton rats (*Sigmodon hispidus*). Drive-counts and Lincoln Index estimates suggested that the bobwhite population on the study area increased from zero birds in February 1989 to approximately 225 birds in early January 1992.

The second factor, which was particularly important in this study, is it was necessary to prebait trap sites each year in order to capture the resident bobwhites. Prebaiting generally lasted from mid-December to mid-January, except in 1992 when the prebaiting started in late November. The prebaiting attracted a wide variety of small mammals and birds, which in turn attracted predators, especially hawks. Radio-marked resident bobwhites were released at the point of capture (i.e., trap sites); thus, this group was probably subjected to greater predation pressure than the 2 relocated groups during the early weeks of each study period. This was probably the most important factor that caused the residents to have lower survival than East Texas birds.

Survival of bobwhites during the breeding season directly affects the following year's population size. Therefore, in terms of bobwhite relocation, survival of relocated birds during the breeding season is apparently more important than survival throughout the year.

High mortality of the South Texas relocated birds during the breeding season was probably caused by

their lack of adaptation to the East Texas habitats and predators. Because these birds were from a totally different ecological region, they were apparently less adapted to the environment of the study area than the other 2 groups. Although all 3 groups selected relatively open macro-habitat (Liu 1995, Liu et al. 1996), there could have been subtle differences in behavior and micro-habitat selection between South Texas birds and the 2 eastern Texas groups that exposed South Texas bobwhites to relatively high risks of predation. In contrast, the East Texas relocated and resident birds were apparently more adapted to the forested environment; thus, behavior that exposed them to high predation pressure would be less likely.

Burger et al. (1995) found that bobwhite losses to mammalian and avian predators were about equal, 25.7 and 28.7%, respectively. In our study, avian predators caused 6 times more mortality than mammalian predators (Table 1). Differences between the 2 study areas in species composition and relative abundance of predators are not known. However, it is likely that differences in habitat characteristics and predator communities resulted in the distinctively different causes of mortality in these 2 studies.

Some bobwhites relocated from South Texas survived the reproductive season into the fall each year and there was reproduction by these birds (Parsons 1994). However, from a survivorship point of view, it is a much better alternative to relocate bobwhites from other East Texas areas. In fact, with appropriate baiting techniques, bobwhites relocated from East Texas proved easy to capture. In 1991 and 1992, 76 and 68 bobwhites were captured in 4 and 7 days, respectively, and all were captured in forested, not agricultural, ecosystems.

MANAGEMENT IMPLICATIONS

Caution should be taken when relocating bobwhites. First, the origin of birds to be relocated should be carefully chosen. As shown in this study, birds from different habitat types may not survive as well as those from similar areas. Depending on the extent of differences between the habitat types, reproduction may also be impacted. If relocated birds are not adapted to the new system, low survival may occur.

Second, habitat improvement before relocating bobwhites will be necessary in areas with low bobwhite densities. Habitat of the study area used for this research was extensively modified for bobwhites. Timber density was reduced, food plots and cover blocks were established, and burning was prescribed every year to improve macro- and micro-habitat conditions. These necessary habitat improvements are costly and may negatively affect other management goals. Therefore, cost effectiveness and compatibility with other land management goals need to be considered when attempting to relocate bobwhites.

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