5-1999

Effects of Relocating Wild Northern Bobwhites into Managed Quail Habitat in Middle Tennessee

Jeffrey G. Jones
University of Tennessee - Knoxville

To the Graduate Council:

I am submitting herewith a thesis written by Jeffrey G. Jones entitled "Effects of Relocating Wild Northern Bobwhites into Managed Quail Habitat in Middle Tennessee." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Wildlife and Fisheries Science.

Ralph W. Dimmick, Major Professor

We have read this thesis and recommend its acceptance:

David A. Beuhler, David A. Etnier

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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We have read this thesis
and recommend its acceptance:

David A Buehler

David A Etnier

Accepted for the Council:

Anne Mayhew

Associate Vice Chancellor and
Dean of The Graduate School

EFFECTS OF RELOCATING WILD NORTHERN BOBWHITES INTO MANAGED QUAIL HABITAT IN MIDDLE TENNESSEE

A Thesis
Presented for the
Master of Science Degree
The University of Tennessee, Knoxville

Jeffrey G. Jones
May 1999

Acknowledgements

I would particularly like to thank my major professor, Dr. Ralph W. Dimmick, for his sage advice, stabilizing guidance, and patience. Others may not have been as tolerant of my lack of diligence. Without Dr. Dimmick's efforts, I would not be where I am today. Also very instrumental in my work at the University of Tennessee were Dr. David A. Beuhler, Associate Professor of Wildlife Science, and Mr. William G. Minser, Research Associate. These 2 always had the time to listen, and provided invaluable advice and guidance. Thanks also go to Dr. David A. Etnier for passing on some of his great wisdom. I feel privileged to have learned from him. I also recognize staff of the University of Tennessee Department of Forestry, Wildlife and Fisheries for their friendship, support, and guidance during my stay at the University.

Many, many students volunteered their time and effort to make this project successful. Many spent hours "busting the brush" on quail censuses, and enduring less than comfortable conditions. But a few of those who deserve special thanks are Billy Wayne Harris, Christopher Kreh, and Troy Etttel, fellow graduate students, as well as Denny Smith, Chad Gann, Jeff Webb, Chris McCall, and David Ward. I hope they benefitted from my work as much as I did from theirs. Two who deserve more credit than I can express in words are Dan Gibbs and Rick Eastridge. Without their help as field technicians, the objectives of this project would not have been met.

This project would not have been completed without the financial support of the Tennessee Wildlife Resources Agency (TWRA), the late Mr. and Mrs. Dan Maddox, and

Mr. and Mrs. Jim Maddox. Mr. Mark Gudlin, TWRA Upland Game Coordinator, and all of the Maddox family demonstrated their devotion to the preservation and increase of the northern bobwhite quail by providing me, and all those associated with this project, the means to carry out the research which made this project a success. The Maddox's graciousness and hospitality made working on their farm a true pleasure; most graduate students only dream of such an opportunity.

I would like to sincerely thank Mr. and Mrs. Larry Sims and Mr. and Mrs. Tracy Stanfill. They were always willing and able to assist Dan, Rick and me in any way possible. Few can appreciate the countless hours of hard work Larry and Tracy did in support of this project, and for the benefit of the wildlife on the Maddox farm. I truly cherish the Sims' and Stanfill's friendship and support.

Lastly, realizing that I could never say enough to express my appreciation, I would like to thank my wife, Catherine, for her total commitment to and support of my pursuit of a career in the wildlife management field. Without her love, and dedication to my goals, none of what I have thus far accomplished would have been possible.

Abstract

The effects and feasibility of relocating wild northern bobwhite (*Colinus virginianus*) quail into managed quail habitat in middle Tennessee were studied on the Maddox farm located in the southeastern portion of Houston County, Tennessee. Data were collected during portions of 2 years beginning in January 1994, and ending in March 1996. The major objectives of the study were to evaluate the effects relocated wild bobwhites might have on an existing resident quail population, and to determine the feasibility of relocating wild quail as a potential management tool. Study objectives were accomplished by obtaining data necessary to compare resident and relocated quail survival, home ranges, reproductive effort, to estimate the change in quail and covey densities on the release area, and to provide an estimate of the cost associated with trapping and relocating wild bobwhites. Data were collected from a sample of 44 resident and 26 relocated quail that were radio-marked and released on the experimental area during the study. Analysis of radio telemetry data indicated there was no difference in spring and summer survival of resident (57%, SE 22%) and relocated (64%, SE 25%) quail. Relocated quail assimilated quickly into the resident population, with 95% of the relocated quail joining resident coveys, on average, in 3.7 days in 1994, and 1.2 days in 1995. Relocated quail remained on the study area (96% over both years). Resident and relocated quail home ranges did not differ ($P > 0.05$) in all cases except the spring of 1994. The mean home range of resident quail during spring 1994 was 4.49 ha, while that of relocated quail was 8.09 ha ($P < 0.005$). Summer 1994 home ranges were 6.57 ha for

residents and 8.33 ha for relocated quail. In 1995, home range during spring was 7.39 ha for residents and 7.49 ha for relocated quail. Finally, during summer 1995, resident home range was 4.21 ha and relocated quail home range was 5.64 ha. During both years of the study, quail nests of 8 resident and 5 relocated quail were found. Standard and Mayfield method probabilities that an incubated egg would hatch for both years of the study were similar at 53.7% and 69.1% for residents, and 59.3% and 68.8% for relocated birds. Clutch sizes averaged over both years were 10.1 eggs for residents, and 12.4 eggs for relocated quail. Egg hatching rates for both years were 96.7% for resident birds and 95.8% for relocated quail. Walking flush censuses of the control and experimental areas throughout the study failed to demonstrate the relocated bobwhites had a positive effect on quail density. Census results indicated a 100% increase in quail density and 25% increase in covey density on the control area, and a 50% increase in quail density and 57% increase in covey density on the experimental area when compared to pre-release densities. Relocation cost was high, requiring an average of 144.2 trap days and 25.1 man hours to capture and transport each relocated quail from the source trapping areas. Results of this study, specifically fidelity to the release site and reproduction of relocated quail, indicate that relocating wild bobwhites may be of potential use to quail managers in middle Tennessee, provided the costs of relocating the birds can be greatly reduced through more successful trapping on source areas.

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Chapter I

Introduction

Northern bobwhite (*Colinus virginianus*) populations have declined significantly over much of the species' range during the past 3 decades. Church et al. (1993) reported a 2.4%/year decrease in the continental bobwhite population from 1966 to 1991. Certainly, widespread changes in land use practices have played a major role in the decline of the bobwhite (Vance 1976, Roseberry et al. 1979, Exum et al. 1982, Klimstra 1982, Brennan 1991). However, even on some lands that have been managed for bobwhites for decades, bobwhite populations have decreased (Curtis 1990). The downward trend in bobwhite populations coupled with its popularity as a game bird have resulted in a resurgence of bobwhite research aimed at determining the causes of decline and strategies for reversing them (Brennan 1993, Robel 1993, Roseberry 1993, Stauffer 1993). Some recent research has focused on releasing pen-reared quail to establish, augment, or simulate wild bobwhite populations. Pen-reared quail have been consistently ineffective in establishing self-sustaining wild populations (Roseberry et al. 1987), and the effects of releasing pen-raised bobwhites on wild quail populations is not well understood (Hurst et al. 1993). The translocation of wild bobwhites, however, is a distinctly different approach for enhancing wild populations, and was the focus of this study.

Translocation of wild birds for the purposes of introduction, reintroduction,

and augmenting existing populations has been effective for the wild turkey (*Meleagris galapavo*) and ring-necked pheasant (*Phasianus colchicus*) (Allen 1956, Griffith et al. 1989, Dickson 1992). The wild turkey was once close to extirpation in a majority of its historic range. Now, largely as a result of trapping and relocating wild birds, wild turkey populations have been restored. Healthy populations exist throughout, and even outside their historic range (Lewis 1987, Kennamer and Kennamer 1990). Ring-necked pheasant populations were established in the United States in the late 1800s from wild birds brought to this country from Asia. Since their initial establishment, wild ring-necked pheasants have been successfully trapped and relocated within the U.S. to establish new populations or augment existing populations (Allen 1956, Mabie 1981, Wilson et al. 1992).

On the other hand, ruffed grouse (*Bonasa umbellus*) relocations have experienced mixed results. Relocations in northern Indiana, Missouri, and Michigan have successfully established wild breeding populations of these woodland birds (Moran and Palmer 1963, Kelly and Kirkpatrick 1979, Hunyadi 1984, Robinson 1984). Other attempts have resulted in apparently marginal success at establishing self-sustaining wild populations (White and Dimmick 1979, Gudlin 1984, Gudlin and Dimmick 1984, Wentworth et al. 1986, Kalla and Dimmick 1987, Kurzejeski and Root 1988 and 1989).

Prairie chicken (*Tympanuchus cupido*), sage grouse (*Centrocercus urophasianus*), and sharp-tailed grouse (*Tympanuchus phasianellus*) relocations have met with limited success or failure (Toepfer et al. 1990). Even in apparently suitable habitat, relocated prairie grouse have demonstrated high post release mortality shortly following relocation

(Amman 1957, Jacobs 1959, Toepfer et al. 1990, Rodgers 1992). Rodgers (1992) documented successful releases of sharp-tailed grouse, and Musil et al. (1993) reported success in translocating sage grouse. Still, many more prairie grouse relocations have shown poor results (Toepfer et al. 1990, Rodgers 1992).

Turkey and pheasant relocations have been more successful than either ruffed grouse or prairie grouse relocations. The differences in success may be explained by the fact that turkeys and pheasants are much more sedentary than most, if not all of the grouse species. Ruffed and prairie grouse disperse widely at certain times of the year, even in suitable habitat, making them more susceptible to predation (Toepfer et al. 1990). The apparently innate tendency of grouse to disperse or wander may cause them to stray from the target release area into areas with unsuitable habitat. The gregarious nature of wild turkeys (Healy 1992), when compared to the grouse species (Patterson 1952, White and Dimmick 1979, Kuzejeski and Root 1988, Toepfer et al. 1990), may also be a factor favoring the relocation of turkeys into suitable range. Flocking or coveying behavior likely increase the probability of males and females encountering one another during the breeding season potentially offsetting through reproduction the effects of post release mortality.

Large seasonal dispersals, such as those shown by the grouse species, are not common in bobwhite quail. Bobwhites demonstrate coveying behavior similar to the flocking behavior of wild turkeys. They are sedentary in nature, similar to the ring-necked pheasant and wild turkey. (Stoddard 1931, Allen 1956, Rosene 1969, Dimmick 1992, Healy 1992). Given the behavioral similarities among bobwhites, wild turkeys,

and ring-necked pheasants, and the successes seen relocating the latter 2 species, it is almost intuitive that wild bobwhites could be relocated successfully.

Stoddard (1931) commented that wild quail on hunting plantations could be moved effectively to fill "voids" of suitable quail habitat not occupied by resident birds. He also oversaw the relocation of more than 2500 bobwhites from south Texas onto quail hunting plantations in Georgia. Stoddard suggested that survival of the relocated quail was lower than that of the resident bobwhites, but that the surviving birds' reproductive output helped to increase the local quail population.

More recently, Osborne (1993) released 71 wild quail during late January to early March onto a public wildlife management area in northern Indiana that had no extant population. Nineteen quail were radio-marked to monitor their behavior and survival; 18 of these died by the end of March. However, 7 male bobwhites were heard whistling on the area the following summer, and 4 coveys were found on the area the following fall. A further increase in the number of whistling male bobwhites was observed 2 summers after the release.

In the piney woods of east Texas, B. Mueller (unpubl. data, mimeographed report, Temple-Inland Corp.) compared the effectiveness of relocating 2 different groups of bobwhites. One relocated group was captured in an area within 13 km of the release site, while the other group was captured in south Texas, a few hundred km distant. Eighty-one wild quail (50 from south Texas and 31 from east Texas) were released into an area that had undergone an intensive quail habitat improvement program but had a very low resident quail population. In each of 2 subsequent years, 50 south Texas and 50 east

Texas quail were released on the study site. All relocated quail were radio-marked, as were a number of resident birds on a nearby control area for comparison. Survival estimates for the relocated quail from east Texas were similar to those of resident quail on the control area. However, survival of the bobwhites relocated from south Texas was lower than that of the resident and relocated east Texas quail.

At Tall Timbers Research Station in Leon County, Florida, 3 partial coveys totalling 20 bobwhites were relocated into suitable quail habitat that was not occupied by other quail (T. DeVos and B. Mueller unpubl. data, mimeographed report, Tall Timbers Res. Sta.). The relocated quail and 20 bobwhites from 3 coveys on nearby areas were radio-marked, and the activities of both groups were monitored. Relocated quail exibited normal movement patterns, but had larger home ranges than the quail on the other areas. Survival of the relocated birds was similar to that of the resident bobwhites.

The results of bobwhite relocation studies done in Indiana, Texas, and Florida, as well as the behavioral similarities among quail, wild turkeys, and ring-necked pheasants encouraged researchers at the University of Tennessee and the Tennessee Wildlife Resources Agency to conduct a 2-year study of this nature. The objectives of this study were to:

1) compare the survival of relocated bobwhites with resident birds.

2) evaluate the assimilation of relocated bobwhites into the resident population.

3) compare the reproductive output of relocated quail with that of resident bobwhites.

4) determine the effect of the introduction of alien wild birds on the local quail population density.

5) evaluate the economic feasibility of relocating wild northern bobwhites into managed quail habitat.

Results demonstrating acceptable survival, fidelity to the release site, and reproduction of relocated birds might indicate that moving wild bobwhites to areas managed for quail in middle Tennessee would be a viable management technique. However, given even highly favorable results, high costs may preclude the use of bobwhite relocation as a quail management practice.

Chapter II

Study Area Description

The study was conducted on the Maddox farm, an approximately 1230-ha privately held tract in the southeastern portion of Houston County, Tennessee. The farm is located in northwestern middle Tennessee approximately 96 km northwest of Nashville, and 44 km south-southwest of Clarksville (Figure 1). The farm has been intensively managed for wild bobwhite quail since 1987. Quail management practices included the scheduled use of prescribed fire, planting of numerous small annual food plots of corn, sunflowers, milo, and browntop millet, strip discing, chopping and mowing of selected cover, and maintenance of extensive bicolor lespedeza (*Lespedeza bicolor*) strips. Some predator control has also been used. Raccoon (*Procyon lotor*), opossum (*Didelphis virginiana*), striped skunk (*Mephitis mephitis*), and coyote (*Canis latrans*) were taken by farm workers during legal hunting and trapping seasons.

The study area lies within the western Highland Rim section of the state (Wildermuth 1958). The topography of this part of the county is characterized by relatively steep walled but somewhat shallow valleys with narrow ridges, excluding the Tennessee Divide which is typically much broader than the other ridges in the area. Elevations on the farm range from approximately 152 m above sea level (ASL) to nearly 262 m ASL on the Tennessee Divide.

Soils of this portion of the county are chiefly of the Bodine-Mountview-Greendale

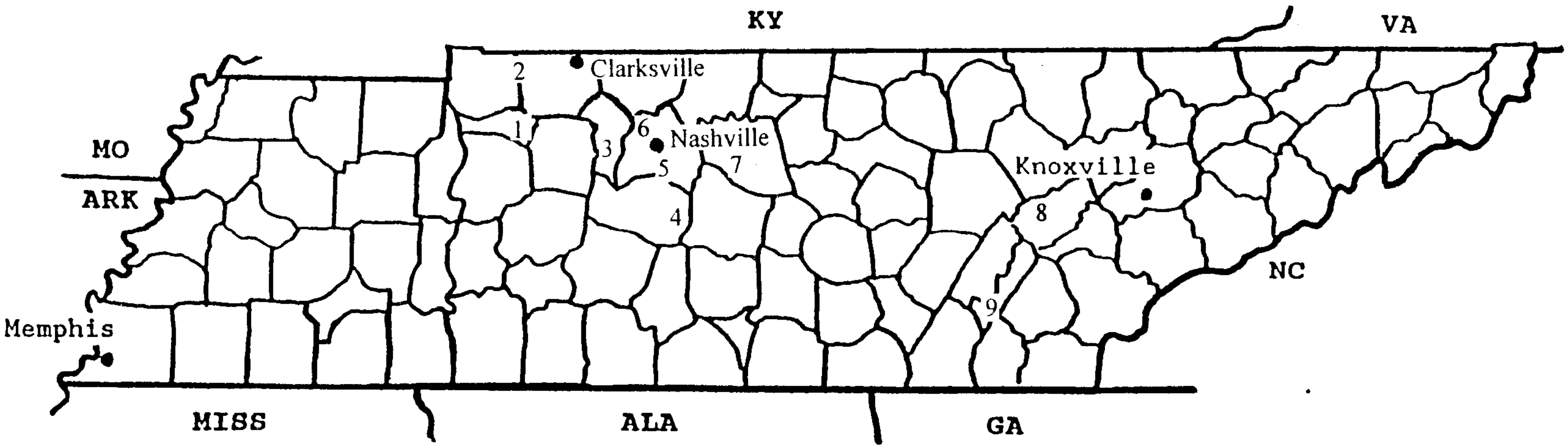

Figure 1. Locations of Maddox farm study area and source trapping areas in Tennessee.

1 - Maddox farm, Houston County.
2 - Fort Campbell Military Reservation, Montgomery and Stewart Counties.
3 - Cheatham Wildlife Management Area (WMA), Cheatham County.
4 - Haley-Jaqueth WMA. Williamson County.
5 - Ellington Agricultural Center, Davidson County.
6 - Fulner farm, Davidson County.
7 - Gudlin residence, Wilson County.
8 - Hartman farm, Roane County.
9 - Hiwassee National Wildlife Refuge, Meigs County.

-Ennis association. These soils are the product of weathered cherty limestone, with chert free silt occurring on the broader ridges and some of the more gradual slopes. Most of the area is covered by Bodine soils, which are the least fertile and occur on the steeper slopes. Mountview soils, which are somewhat fertile, occupy the tops of ridges, while the most fertile and least cherty Greendale and Ennis soils occur in the wider bottoms.

Oak-hickory woodlots occupy most forested areas of the farm. Several oak (*Quercus* spp.) and hickory (*Carya* spp.) species occur on the farm and are the most common tree species. Less abundant tree species include tulip poplar (*Liriodendron tulipifera*), black cherry (*Prunus serotina*), black gum (*Nyssa sylvatica*), red and sugar maple (*Acer rubrum* and *A. saccharum*), dogwood (*Cornus florida*), and redbud (*Cercis canadensis*). Additionally, some white pines (*Pinus strobus*) and loblolly pines (*P. taeda*) have been planted on the farm.

Significant portions of the farm resemble an oak savannah cover type as a result of frequent prescribed fires. These areas contain large amounts of native warm season grasses including broomsedge (*Andropogon virginicus*) and little bluestem (*A. scoparius*). Also abundant in these areas are partridge pea (*Cassia fasciculata*) and beggar weeds (*Desmodium spp.*).

The climate in Houston County is typical of middle Tennessee with hot, humid summers and relatively mild winters (Wildermuth 1958). Annual precipitation averages 124.46 cm. Temperatures rarely exceed 35^{o} C or reach below -18^{o} C with seasonal averages of 5^{o}, 15^{o}, 25^{o}, and 15.6^{o} C (winter, spring, summer, and fall).

Two portions of the Maddox farm were selected as control and experimental

areas. The control area was approximately 152 ha. and the experimental area was approximately 162 ha. These 2 areas were selected for the study due to their similarity in size, and quantity and quality of bobwhite quail habitat. The 2 areas are separated by a minimum distance of 0.8 km. The area between the 2 study areas contains 2 densely wooded draws and comparatively small amounts of quail habitat. Both areas were censused for bobwhites before the relocation of any quail, and were censused periodically throughout the study. On the experimental area, resident bobwhites were trapped and radio-marked, and radio-marked relocated quail were released. Quail hunting was suspended on both the control and experimental areas during the entire study. Deer (*Odocoilius virginiana*), turkey (*Meleagris galapavo*), raccoon, and eastern cottontail (*Sylvilagus floridanus*) were hunted on both study areas.

Eight source areas in Tennessee were trapped to capture quail for relocation. The source areas included a portion of the Fort Campbell Military Reservation located near Clarksville, 2 areas of the Cheatham Wildlife Management Area (WMA) located near Ashland City, the Haley-Jaqueth WMA near College Grove, a small portion of the Hiwassee Wildlife Refuge near Birchwood, the Ellington Agricultural Center in Nashville, Tennessee, the Gene Hartman farm south of Kingston, the Scott Fulner farm in Joelton, and the Mark Gudlin residence in Wilson County (Figure 1).

Chapter III

Methods

Radio telemetry was the primary technique used for detemining survival, home ranges, and the reproductive performance of resident and relocated quail. Additionally, flush censuses were used to estimate bobwhite densities on the 2 study areas. The economic feasibility of relocating wild bobwhites was evaluated by determining the expenditures in terms of man-hours necessary to trap and relocate quail.

Bobwhite Censusing

Walking flush censuses as described by Dimmick et al. (1982) were used to estimate quail densities for comparing population densities on the control and experimental areas. This method detects roughly 50% of the bobwhites in the area censused. Censuses were conducted on both study areas in January 1994 prior to the trapping or release of any quail. The experimental area was censused again in March 1994. Both areas were censused in December 1994, March 1995, December 1995, and March 1996. Estimates of bobwhite abundance on the 2 study areas were determined by doubling both the number of coveys and the number of quail flushed during the censuses. Density was expressed as quail/ha and coveys/100 ha.

Quail Trapping, Handling and Marking

Wild bobwhites were captured using 2 techniques, both employing walk-in funnel type traps (Stoddard 1931). The first method involved baiting the trap site and short bait

trails leading to the funnels with cracked corn or chicken feed. This method was used during late winter and early spring when the quail were still in coveys and food was relatively scarce. The second method, commonly referred to as the "cock and hen" trap (Stoddard 1931), was used as coveys began to disassociate and bobwhites were actively seeking mates. In this method, a pen-raised female bobwhite was placed in a small cage inside the trap and used to call wild quail into the trap. The "cock and hen" method is effective for capturing male, but not female, bobwhites.

When baited traps were used, general trap locations were selected using pointing bird dogs or the walking flush census to locate coveys. The locations of flushed coveys were prominently marked with flagging tape. After marking, field personnel returned to the marked location to select specific trap sites. Traps were placed in locations deemed to be likely to intercept feeding quail coveys. The traps were checked twice daily. The first trap check was made during the late morning hours, the second just after dark.

"Cock and hen" traps were used only on source areas. Traps were placed in areas known to have whistling bobwhites. Traps were placed closed enough to whistling birds so that the bird would hear the hen calling from the trap. Traps were quickly placed on the ground, covered, and left for a period of 2 to 4 hours, and then checked. The "cock and hen" traps were checked one time after setting, and removed along with the female and any captured bobwhites usually before noon.

Captured quail were sexed and aged (Rosene 1969), weighed to the nearest 5 grams, banded with an individually numbered aluminum leg band, and fitted with a small neck mounted radio transmitter. The radio transmitters were similar to those described by

Shields and Mueller (1982), excluding the body loop, and were manufactured by Holohil Systems Ltd. or American Wildlife Enterprises. The transmitters had adjustable neck loops, 26 cm antennae, and weighed between 6.5 and 7.0 g; life expectancy was approximately 90 days. Transmitter frequencies ranged from 150.011 MHz to 151.498 MHz.

Resident quail were released at their point of capture. Relocated quail were transported by the most direct route in quail crates from source areas to the Maddox farm. They were prepared for release in the same manner as resident quail. All birds that could not be fitted with a radio transmitter and released prior to nightfall were held overnight and released the following morning. In 1994, relocated quail were released at 1 of 3 centrally located release points on the experimental area. In 1995, relocated birds were released either with just-captured resident quail at their point of capture or in an area known to be used by a resident covey.

Trapping, handling, transporting, and marking of all bobwhites were carried out in accordance with the guidelines set forth by the American Ornithologits Union Report on the Use of Wild Birds in Research (Am. Ornithol. Union 1988).

Radio Telemetry

Radio telemetry was used to monitor the movements, survival, home ranges, reproduction, and interactions among resident and relocated quail. Nineteen radio telemetry points of known location were selected in and around the experimental area for obtaining azimuths to each of the radio-marked quail's location. Locations to each of the 19 telemetry points were determined with a real time, Rockwell Corporation global

positioning system accurate to within 5 m. At least 3 azimuths, obtained within a 20-minute interval, were used to triangulate each marked bird's position (Mech 1983). At least 1, but more often 2 locations were obtained for each bird each day. Homing was also used to locate nesting quail, and to locate transmitters and remains of bobwhites that had been killed by predators or had died of some other cause. All azimuths were obtained using a hand held Telonics receiver, Yagi antenna, and lensatic compass.

An estimate of radio telemetry error was made to ensure that the locations obtained using the hand held antenna and lensatic compass were accurate enough to be used in home range calculations. Radio transmitters were placed in 20 different locations throughout the experimental area by an observer; the receiver operator did not know the locations of the transmitters. The receiver operator then estimated the locations to each of the 20 transmitters by obtaining 3 or 4 azimuths to the transmitters from the known telemetry points. After all azimuths were recorded, the observer flagged the location of each transmitter. Once flagged, true azimuths to each transmitter location were determined using a surveyor's transit. These azimuths were taken from the same telemetry points as those obtained using the radio telemetry equipment. Both sets of azimuths were then used to calculate the estimated and true location of the 20 transmitters, and the mean difference between the actual and estimated locations was determined. The mean difference between the actual transmitter locations and estimated locations was 11.7 ± 6 m. This error was considered acceptable, and was not factored into the home range calculations.

While the birds were in coveys, telemetry work focused on determining home

ranges and movements, and determining if the relocated bobwhites assimilated into the resident population. After coveys disassembled and breeding began, the priority for telemetry work shifted to attempting to locate nesting and incubating quail. Home range data were also collected during this period.

Survival Rates

Several survival distributions were estimated from the telemetry data. Survival rates for 1994 and 1995 were calculated and compared independently for resident and relocated quail. Following these comparisons, the pooled 1994 and 1995 survival rate of resident quail was compared to the pooled 1994 and 1995 survival rate of relocated birds. Pooled survival of resident males was compared to that of the pooled relocated males, as was the pooled survival of resident females to the pooled survival of relocated females. Finally, the survival curve for all of the males in the study was calculated and compared to the survival curve calculated for all of the females.

The Kaplan-Meier method (Kaplan and Meier 1958), generalized for the staggered entry of individuals into the sample (Pollock et al. 1989), was used to estimate survival rates. This method assumes that the radio-marked bobwhites represent a random sample of the population, the survival distributions for left-censored (staggered entry) individuals were similar to those already entered, the survival of individual quail is not dependent on the survival of another in the sample, loss of a transmitter or transmitter failure (right-censoring) is independent of the fate of the bird, and finally, trapping and radio-marking has no effect on the quail's survival (White and Garrott 1990, Pollock et al. 1989).

Bobwhites for which the cause of transmitter loss or transmitter failure could not be determined were right-censored as were any quail that were still being monitored at the end of each field season. No radio-marked quail in either year of the study died or was censored within 10 days of being marked, thus all radio-marked birds were used in the calculation of survival distributions. Additionally, no quail right-censored during the first field season were recaptured or detected during the second year of the study.

Comparisons of survival distributions were made for the relocated vs. resident quail and males vs. females using the log-rank test also generalized for the case of staggered entry into the sample (Pollock et al. 1989). A 2-way frequency table generated from the survival estimates being compared was used to form the Chi-square statistic used for the comparison. I tested the hypothesis that there was no difference in the survival distributions of the 2 groups being compared.

Home Ranges

Bobwhite home ranges were determined for all radio-marked quail for which enough locations were gathered (White and Garrott 1990, Kenward 1992). These home ranges were determined for 2 time periods during both years of the study. The spring period was 3 March through 31 May, and the summer period 1 June through 17 August. The separation point between these 2 periods was based on the timing of covey break up on the study area. In both years, no coveys were known to remain intact after 1 June. However, coveys were flushed as late as 27 May and 24 May in 1994 and 1995, respectively. The beginning of the spring period, 3 March, coincided with the capture of the first radio-marked quail, and 17 August was arbitrarily selected as the end of radio

tracking.

Minimum convex polygon home ranges (MCP) and average center points were computed using the Telem PC computer program (Coleman et al. 1986). Telem triangulated each location from at least 3 azimuths recorded at different telemetry points, and determined the minimum convex polygon formed by these locations. The center point calculated was the arithmetic mean center of the polygon. Minimum convex polygons were chosen as the method of home range analysis for 2 reasons: 1) they have been widely used in past studies of home range, which facilitates comparison with results from other studies (Harris et al. 1990, White and Garrott 1990, Kenward 1992), and 2) this method appeared to represent accurately what was known about the quails' locations from field observations.

Plots of mean percentage of area used by the quail versus the number of locations, and percentage of radio-marked quail that had used greater than or equal to 90% of the area versus number of locations were used to determine the minimum number of locations needed to capture a quail's home range during each time period (White and Garrott 1990, Kenward 1992). Only home ranges and center points of radio-marked quail meeting this requirement were used for comparisons.

Home ranges and center points for resident and relocated quail were compared on a covey by covey basis for the spring time period. If more than 1 relocated or resident quail was known to be in the same covey, the mean center point and home range size were calculated for the multiple resident or relocated birds in the covey before being compared to the opposite group or individual in the same covey. In 1994, some relocated

quail assimilated into resident coveys in which no resident birds were ever marked, and some marked resident coveys had no relocated bobwhites join them. In these cases, no direct comparison of center point locations could be made. Home range sizes of individuals only were compared during the summer time period, as the quail were not assembled into coveys. Comparisons were also made between 1994 and 1995 summer home ranges. Proximity of home range center points to one another was used as a measure of assimilation of the relocated quail into the resident coveys and was determined by calculating the distance between the mean center points for resident versus relocated quail in the same covey. The t-test procedure in SAS was used to test for differences between the home range sizes of resident versus relocated birds during each time period (SAS Inst. Inc. 1989).

Reproduction

Radio telemetry was used to locate incubating quail, to determine the fate of quail nests, and to monitor the activities of quail broods. Quail nests were located by carefully homing in on bobwhites that were thought to be incubating clutches. Once a nest was found, a marker was placed several meters from the nest, and the distance and compass heading from the marker to the nest were recorded. This marking method enabled observers to relocate quail nests, and approach them cautiously to avoid disturbing the incubating bird. Routes to the quail nests were changed during monitoring.

Two methods were used to compare the reproductive output of the resident and relocated quail, and to determine the likelihood that an incubated egg would produce a quail chick (Probability of Successful Incubation, P_{si}). The first was to calculate the nest

surviving incubation, egg surviving incubation, egg hatching, and chick survival rates by dividing: 1) the number of nests that hatched all or part of a clutch by the number of nests found, 2) the number of eggs that hatched by the number of eggs being incubated, and 3) the number of eggs that hatched by the number of eggs present at the time of hatching for nests that successfully hatched. These 3 values were then multiplied to determine P_{sis} (Probability of Successful Incubation, simple method). The number of chicks present at 2 weeks of age divided by the total number of chicks produced at hatching or observed when the brood was initially located prior to 2 weeks of age was also calculated and reported with these simple percentages. The second was to calculate the probability of an individual, incubated quail egg producing a chick (P_{sim}) by multiplying the nest and egg surviving incubation rates and egg hatching rates together using the method described by Mayfield (1961, 1975). Using the Mayfield method the probabilities that a nest or egg will hatch are calculated as follows:

1) Nests Surviving Incubation Rate (Mn).

Mn = [1-(# nests lost during incubation/# nest days incubating)] ^{23*}

* where 23 days is the mean incubation period for northern bobwhites.

2) Eggs Surviving Incubation Rate (Me).

Me = [1-(#eggs lost during incubation/# egg days during incubation)] ^{23*}

* where 23 days is the mean incubation period for northern bobwhites.

In my study, Me is 1.0 since no individual eggs were lost from otherwise successful nests.

3) Egg Hatching Rate (HR).

HR = (# eggs that hatch/# eggs present in nest at hatching).

The probability of an incubated egg producing a chick was then determined using the following formula:

Probability of an Incubated Egg Producing a Chick (P_{sim}) = Mn x Me x HR, or Mn x HR, since Me = 1.0.

Due to the small sample size, both years of reproductive data were combined to calculate each group's simple and Mayfield probabilities. All data were combined to calculate the overall simple and Mayfield method probabilities.

Clutch sizes were recorded for all nests. These data were used to make the above calculations. Nests were observed at least once daily during incubation, and the status of the nest was recorded . Quail broods were observed at least once weekly after hatching. The observer recorded the number of quail chicks sighted.

Relocation Effort

Information pertinent to determining the economic feasibility of relocating wild bobwhites was recorded throughout the 2 years of the study. The number of man-hours spent building traps, selecting trap sites, setting traps, checking traps and transporting captured quail was recorded and is reported. The number of man-hours spent per quail captured was calculated by dividing the number of man hours spent setting and checking traps by the number of quail captured. Also reported are measures of trap success. These are the number of bobwhites captured per trap set, and the number of trap days per quail captured. A trap day consists of 1 quail trap being set for 1 entire day.

Chapter IV

Results

Population Densities

Pre-release censuses conducted in January 1994 indicated there were 14 coveys totaling 166 quail on the experimental area, and 8 coveys totaling 74 birds on the control area, yielding density estimates of 1.02 and 0.49 quail per ha, respectively, on the experimental and control areas (Table 1). Subsequent censuses estimated densities as low as 0.13 quail/ha on the control area in March 1995, and as high as 1.53 quail/ha on the experimental area in December 1995. Covey density on the 2 areas ranged from a low of 1.3 coveys/100 ha on the control area in December 1994 to highs of 14.0 coveys/100 ha on the experimental area in December 1995 and March 1996. In all cases, the population density on the experimental area was greater than on the control area. However, similar trends were observed on both the control and experimental areas. Based on the initial censuses, both areas experienced a population decline from January 1994 to December 1994 and then increased from December 1994 to December 1995.

Winter censuses of the control and experimental areas in December 1995, indicated a 100% increase in quail density and 25% increase in coveys on the control area, and a 50% increase in quail density and a 57% increase in coveys on the experimental area when compared to pre-release (January 1994) population estimates.

Table 1. Quail and covey density estimates per 100 hectares as determined by the walking flush census technique on the control and experimental areas of the Maddox farm, Houston County Tennessee from January 1994 to March 1996.

	Control Area (152ha)					Experimental Area (162ha)				
	Jan 1994	Dec 1994	Mar 1995	Dec 1995	Mar 1996	Jan 1994	Dec 1994	Mar 1995	Dec 1995	Mar 1996
Coveys	5	1	3	7	7	9	9	12	14	14
Quail	50	20	10	100	80	100	50	100	150	120

Quail Trapping, Handling and Marking

A total of 78 bobwhites was captured on the Maddox farm and all source trapping areas during the course of the study (Table 2). Twenty-six quail were captured on source areas and 52 on the Maddox farm. Twenty-six bobwhites were captured in 1994 and again in 1995 on the Maddox farm. Twelve quail were captured on Fort Campbell in 1994 and also in 1995. One quail was captured each on the Haley-Jaqueth and Cheatham WMAs in 1995. All of the quail captured on the source areas were banded and radio-marked.

There were no trap-related mortalities nor injuries for quail trapped on source areas. Forty-six of the 52 quail captured on the Maddox farm were banded and radio-marked. In 1994, there were 2 trapping mortalities and 4 quail not radio-marked. Fifty of the 52 bobwhites captured on the Maddox farm were captured on the experimental area. Two cock birds were captured in 1995 on the control area. The activities of these two quail were monitored, but no data collected from these birds were used in any calculations for the study. Trapping and telemetry data for all quail captured during the study are presented in Appendices A and B.

Of the 52 quail captured on the Maddox farm, 31 (60%) were males and 21 females (40%). Fifty percent (13) of the quail captured on the source areas were female. The mean weights for all resident birds captured ranged from 162 g for juvenile females to 174 g for juvenile males and for all relocated quail 162 g for juvenile females to 172 g for adult males (Table 3).

Table 2. Number and sex of 78 northern bobwhites captured in 1994 and 1995 on the Maddox farm study area, Houston County, Tennessee, Fort Campbell Military Reservation, Montgomery County, Tennessee, Haley-Jaqueth Wildlife Management Area, Williamson County, Tennessee, and Cheatham Wildlife Management Area, Cheatham County, Tennessee.

	1994		1995	
Capture Area	Male	Female	Male	Female
Maddox farm	16	10	15	11
Fort Campbell	6	6	5	7
Haley-Jaqueth WMA	0	0	1	0
Cheatham WMA	0	0	0	1
Total	22	16	21	19

Table 3. Mean weight in grams by sex and age for 78 northern bobwhite quail captured on the Maddox farm, Houston County, Tennessee, Fort Campbell Military Reservation, Montgomery County, Tennessee, Haley-Jaqueth Wildlife Management Area, Williamson County, Tennessee, and Cheatham Wildlife Management Area, Cheatham County, Tennessee in 1994 and 1995.

	Maddox Farm		Source Areas	
	Male	Female	Male	Female
Juvenile	174(18)[1]	162(15)	165(5)	162(14)
Adult	170(13)	163(6)	172(7)	n.a.

1 - (n) = number of quail in each group.

Radio Telemetry

Radio telemetry yielded 5371 locations for resident and relocated quail. Eighty-seven percent (4673) of the locations were obtained by triangulating at least 3 azimuths from known telemetry points. The remaining 13% (698) of the locations were obtained by homing.

In 1994, 1 relocated male failed to assimilate into a resident covey before his death 17 days after his release. Also in 1994, 1 relocated female was flushed with a resident covey 6 days after her release, but not again during the 26 days she was radio-marked. Nine quail were relocated prior to covey disassociation in 1994. Excluding the male bird that did not assimilate into a resident covey, the average assimilation time was 3.7 days. In 1995, relocated quail were released with resident birds or near known resident covey locations, enhancing their assimilation into the resident coveys. For the 11 relocated quail released before covey disassociation in 1995, average assimilation time was 1.2 days. All relocated birds released in 1995 before covey break-up assimilated into resident coveys. A 2-sample t-test indicated a significant difference between the 2 release techniques in the assimilation times for relocated quail ($P < 0.05$). All but 1 relocated quail (96%), a juvenile female whose fate was undetermined due to loss of her transmitter, remained on the experimental area during the study. This bird's transmitter was found approximately 200m north of the northeastern boundary of the experimental area.

Survival Rates

The combined spring and summer survival rate of radio-marked resident quail in

1994, 0.65 ± 0.24 (95% C.I.), did not differ from survival of resident quail in 1995, 0.51 ± 0.40 (95% C.I.) (χ^2 = 1.13, 1 df, P = 0.2) (Figure 2). Survival estimates for relocated quail for both periods did not differ between years. For 1994, survival was 0.65 ± 0.34 (95% C.I), and 1995 survival was 0.61 ± 0.37 (95% C.I) for weeks 1 to 23 (χ^2 = 0.05, 1 df, P = 0.82) (Figure 3). The pooled survival for relocated quail did not differ from that of the pooled resident quail. For the entire radio telemetry period, the pooled survival estimate for both field seasons for relocated quail was 0.64 ± 0.25 (95% C.I), and that for residents was 0.57 ± 0.22 (95% C.I.); the period evaluated included weeks 1 through 23 combined for both 1994 and 1995 (χ^2 = 0.05, 1 df, P = 0.82) (Figure 4).

The survival estimate for relocated males for the entire field season in both years was 0.42 ± 0.36 (95% C.I.). For resident males, it was 0.45 ± 0.29 (95% C.I.). These 2 survival estimates did not differ significantly (χ^2 = 0.31, 1 df, P = 0.57) (Figure 5). The pooled survival estimate of 0.80 ± 0.29 (95% C.I.) for relocated females also failed to differ significantly from that for resident females of 0.70 ± 0.31 (95% C.I.) (χ^2 = .56, 1 df, P = 0.46) (Figure 6). However, the pooled survival estimate for all male radio-marked quail, 0.49 ± 0.24 (95% C.I.) did differ significantly (α = 0.10) from the pooled survival estimate for all female quail, 0.74 ± 0.21 (95% C.I.) (χ^2 = 2.71, 1 df) (Figure 7).

Home Ranges

Home ranges were based on a minimum of 35 independent radio telemetry locations. Additional locations changed the home range boundaries little, as 95% of the home range was defined by 30 locations (Figure 8). Using 35 locations enhanced the quality of the home range definition.

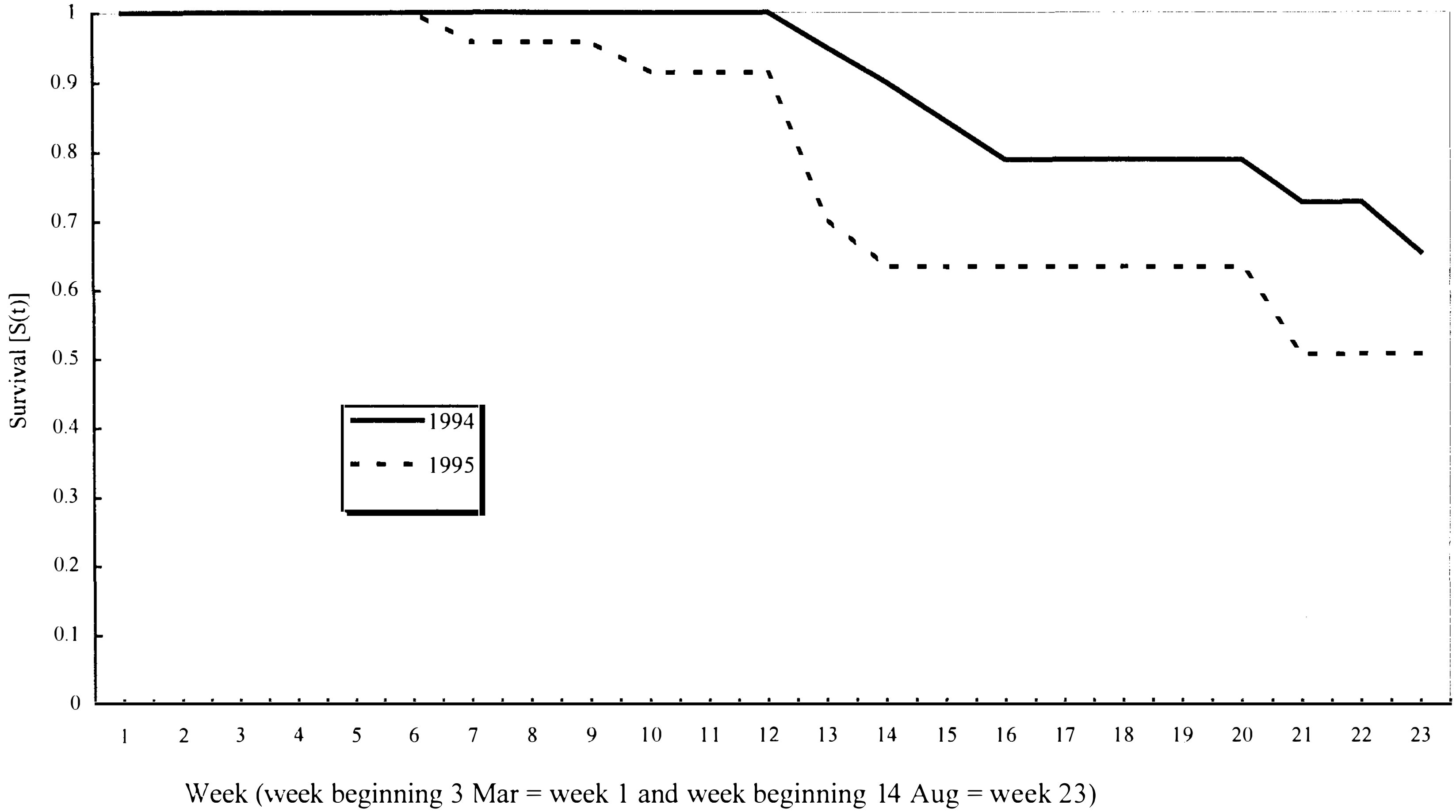

Figure 2. Spring through summer Kaplan-Meier survival distribution estimates for radio-marked resident quail on the Maddox farm experimental area, Houston County, Tennessee, 1994 and 1995.

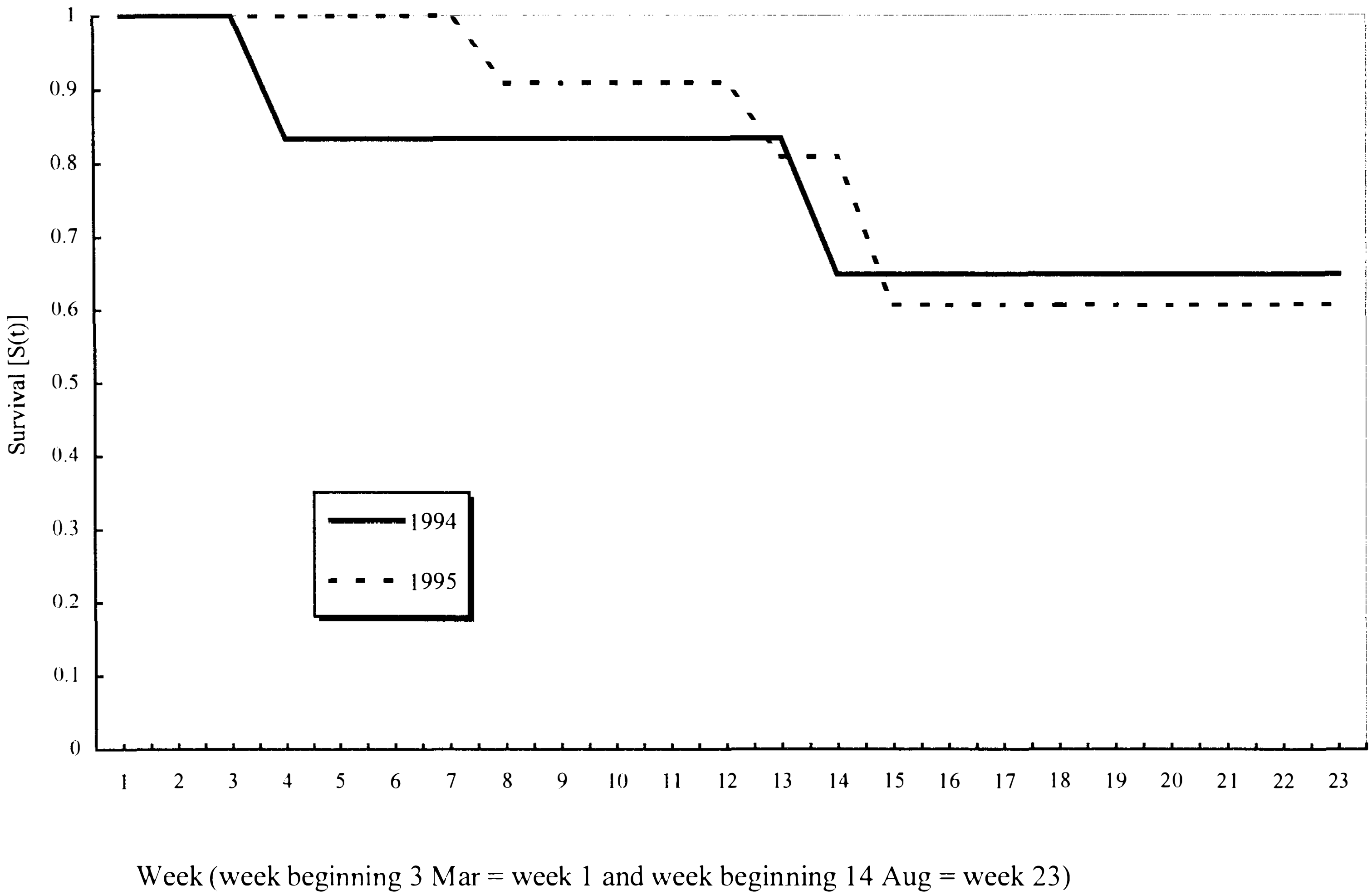

Figure 3. Spring through summer Kaplan-Meier survival distribution estimates for radio-marked relocated quail on the Maddox farm experimental area, Houston County, Tennessee, 1994 and 1995

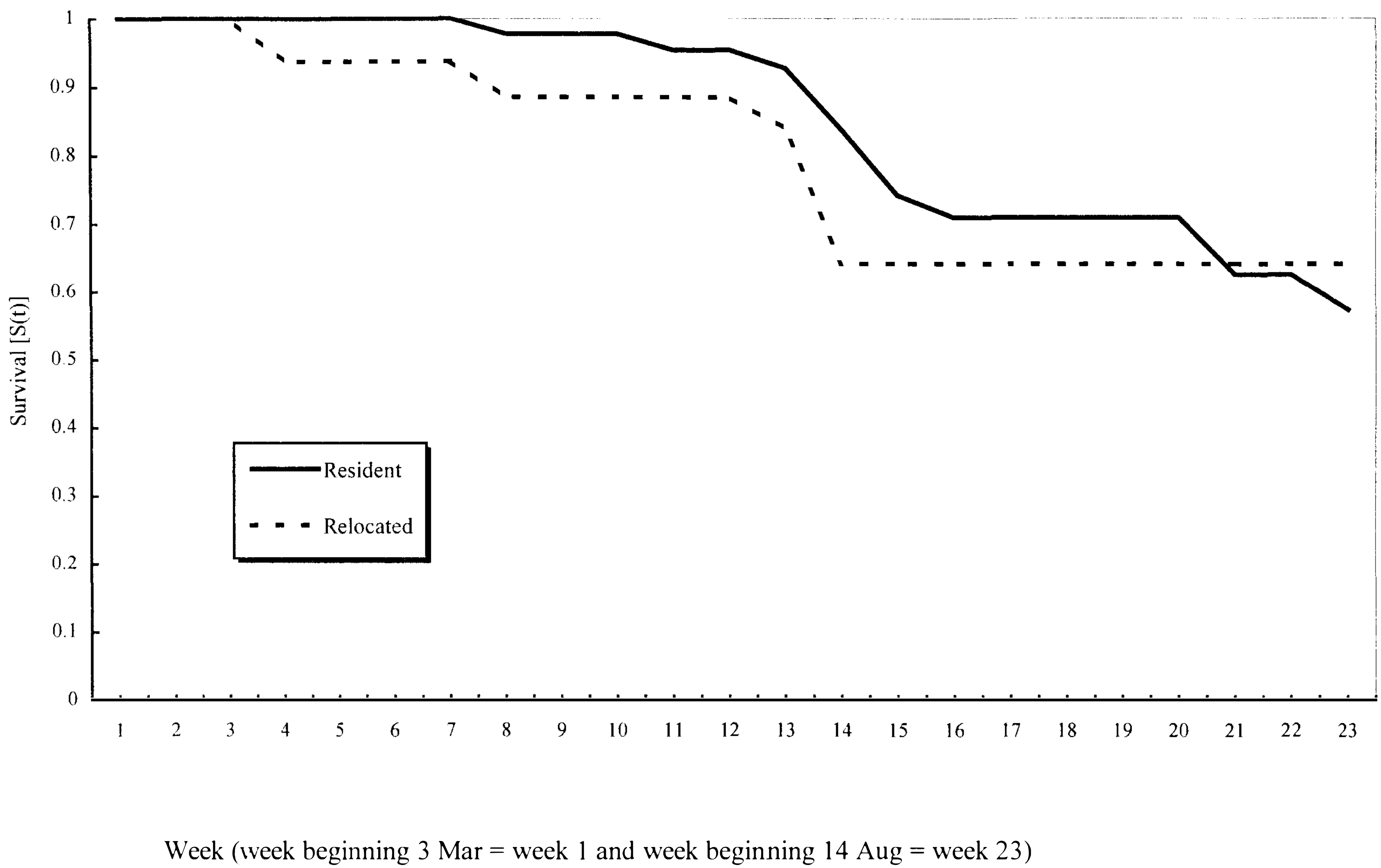

Figure 4. Spring through summer Kaplan-Meier survival distribution estimates pooled over 1994 and 1995 for resident and relocated radio-marked quail on the Maddox farm experimental area, Houston County, Tennessee.

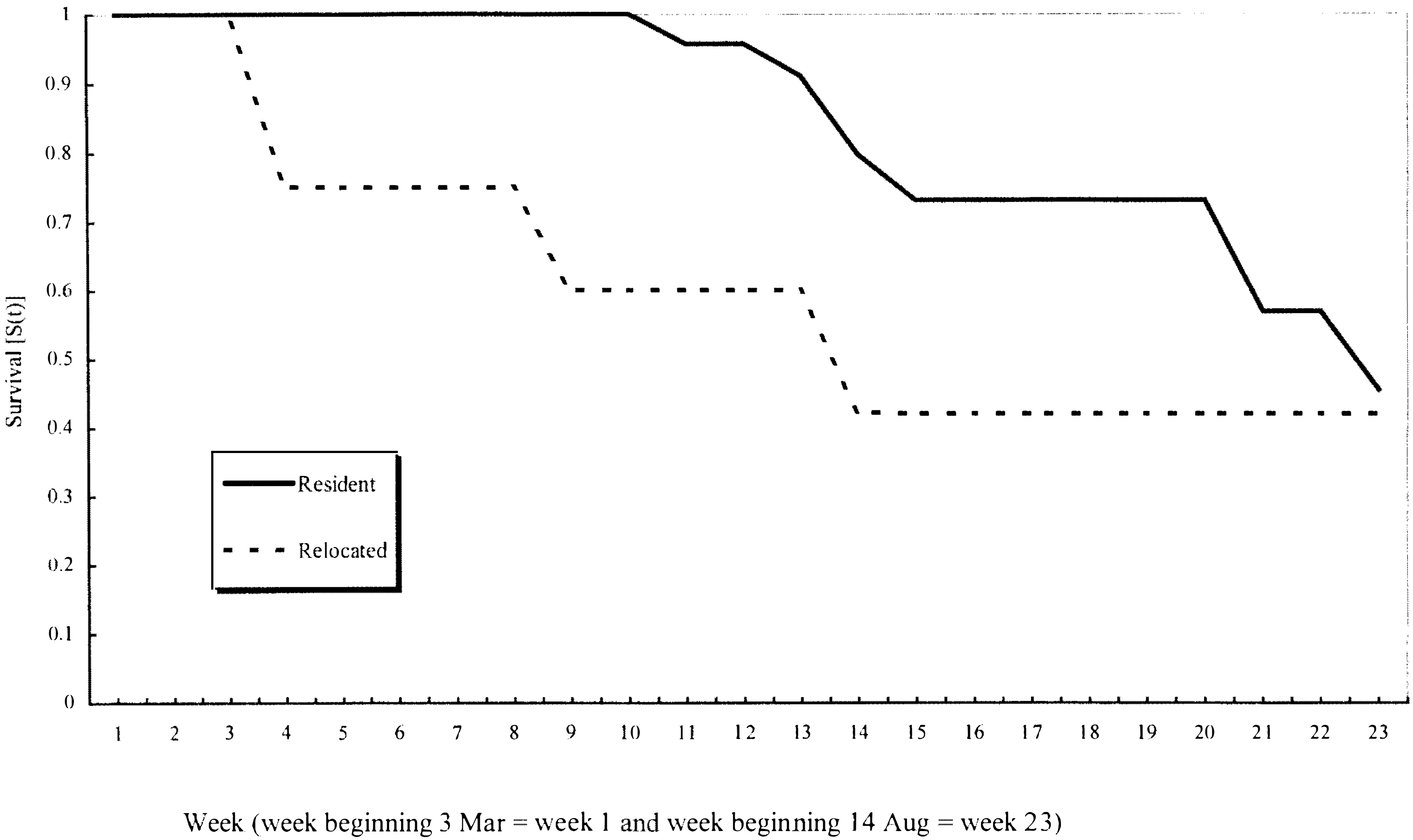

Figure 5. Spring through summer Kaplan-Meier survival distribution estimates pooled over 1994 and 1995 for radio-marked resident and relocated male northern bobwhites on the Maddox farm experimental area, Houston County Tennessee.

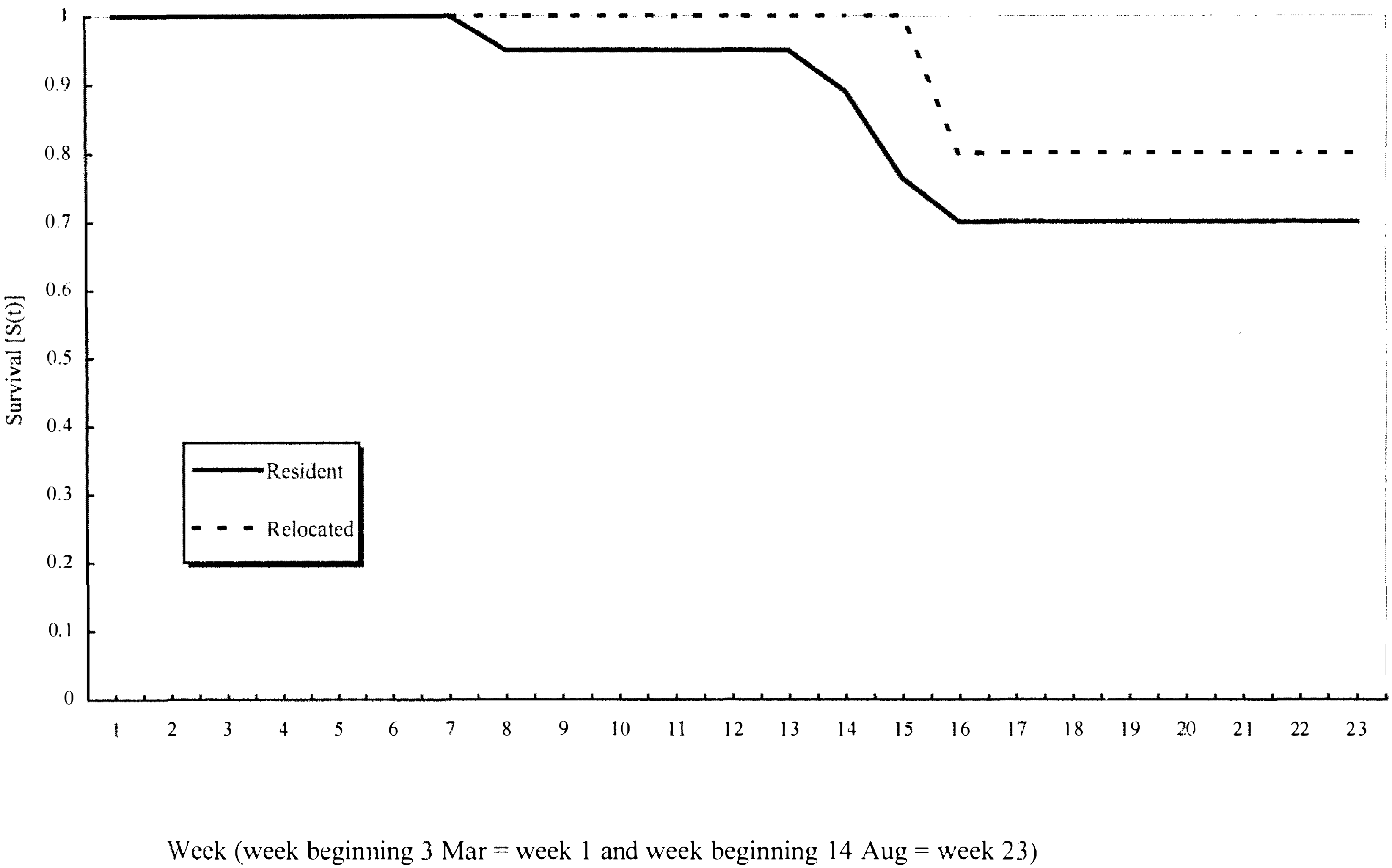

Figure 6. Spring through summer Kaplan-Meier survival distribution estimates pooled over 1994 and 1995 for radio-marked resident and relocated female northern bobwhites on the Maddox farm experimental area, Houston County, Tennessee.

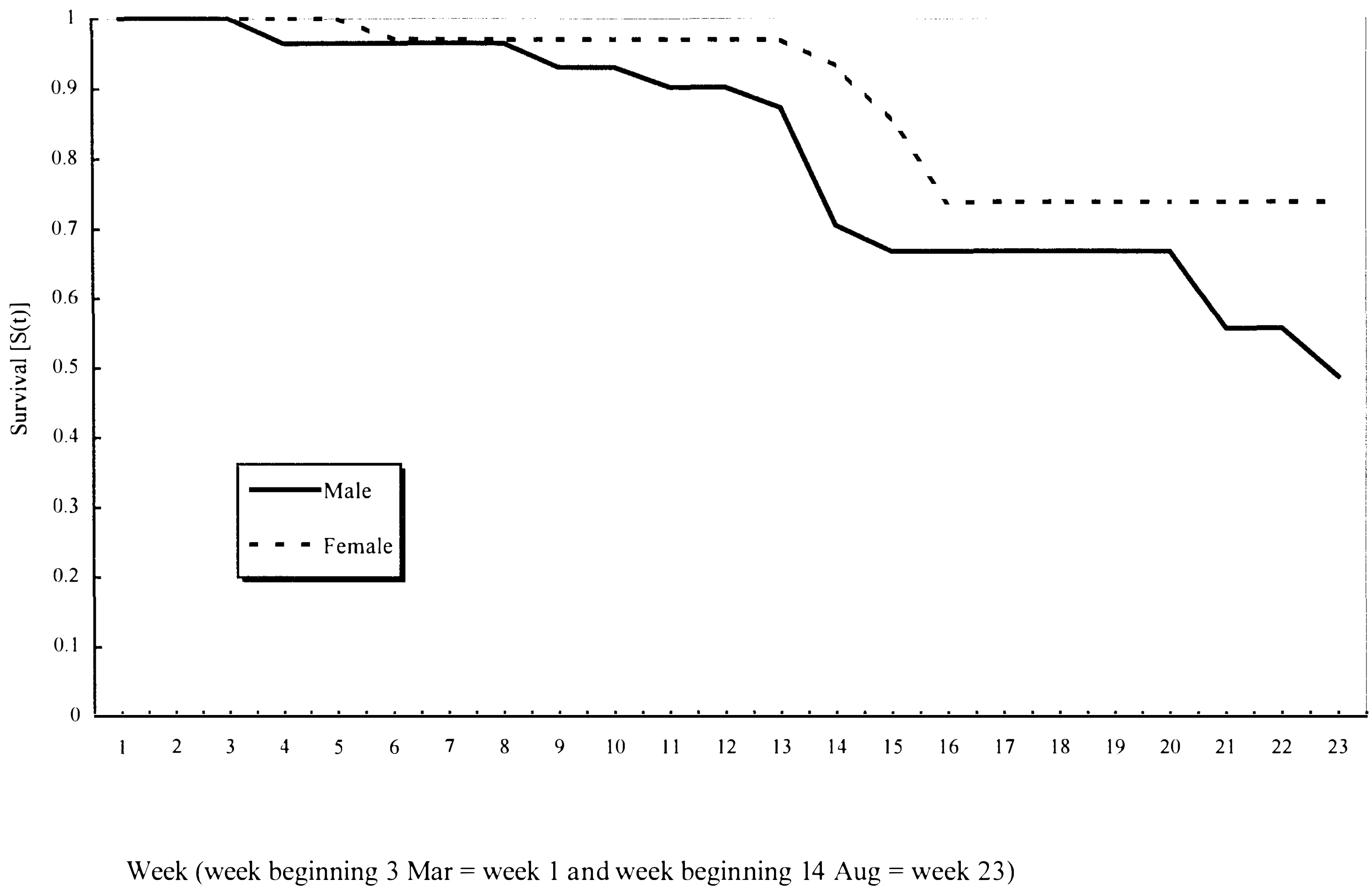

Figure 7. Spring through summer Kaplan-Meier survival distribution estimates pooled over 1994 and 1995 for all male and female radio-marked northern bobwhites on the Maddox farm experimental area, Houston County, Tennessee.

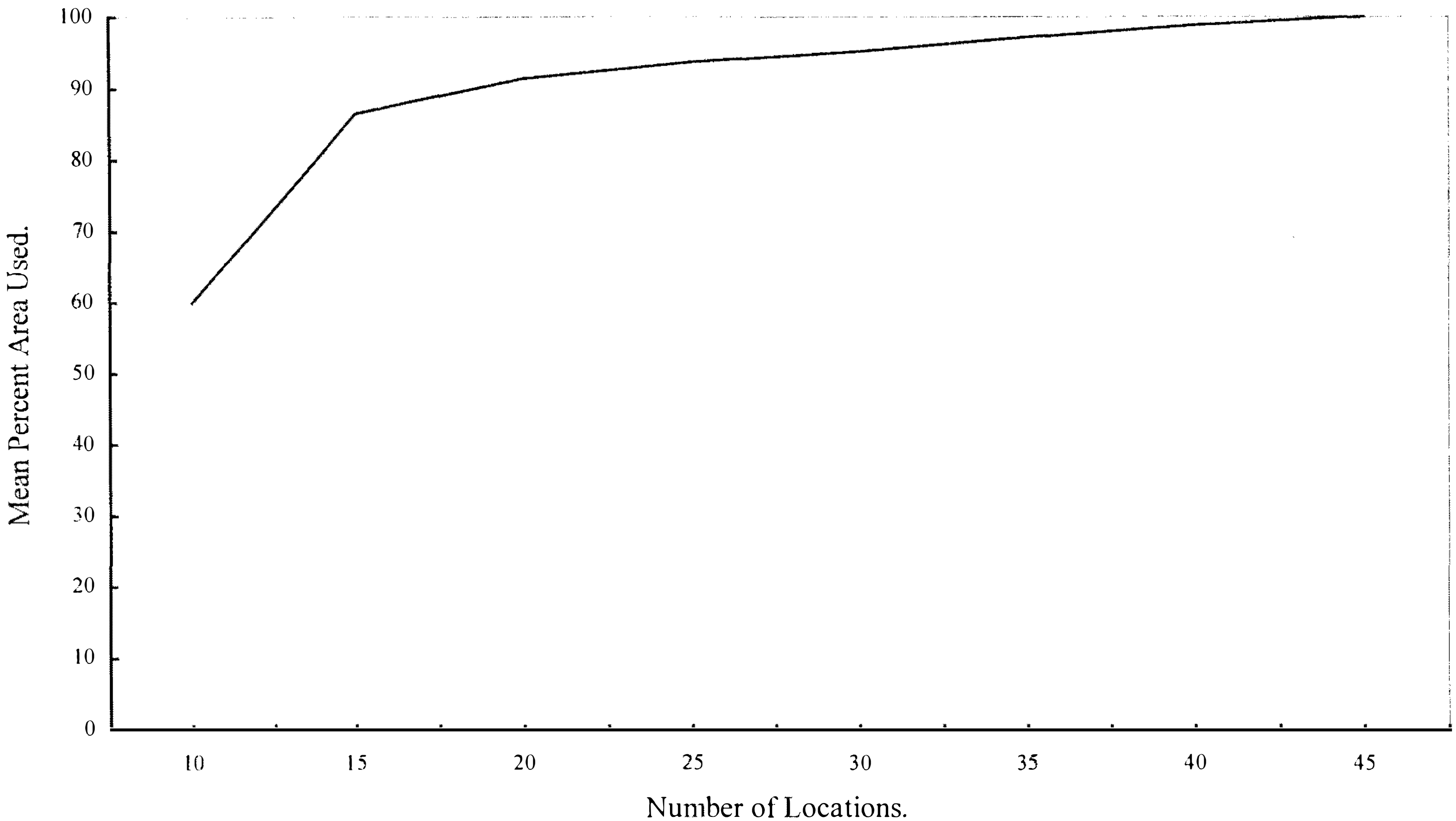

Figure 8. Plot of the mean percentage of area used versus the number of independent telemetry locations for radio-marked northern bobwhites on the Maddox farm experimental area, Houston County, Tennessee in 1994 and 1995.

In 1994, the mean home range of resident quail (4.49 ha) was smaller than that of relocated quail (8.09 ha) during spring ($P = 0.005$) (Table 4.). In the summer of 1994, however, there was no difference in the mean home ranges of resident and relocated quail. In 1995, home range size did not differ between these groups for either season ($P > 0.05$). Comparisons between 1994 and 1995 summer home ranges resulted in no differences ($P > 0.05$). This was the case for comparisons made between 1994 and 1995 resident quail and 1994 and 1995 relocated quail, as well as a comparison made between 1994 and 1995 resident quail versus 1994 and 1995 relocated quail combined.

During the spring of 1994, relocated quail assimilated into 2 resident coveys, each of which also had at least one radio-marked bird (Figure 9). One relocated hen became part of a resident covey which had 3 other radio-marked quail (Figure 9, Covey 1). Her spring home range including all telemetry locations was 16.32 ha, and the mean spring home range of the 3 resident birds was 6.06 ha. However, when the first 5 days of independent locations were dropped from the relocated hen's spring home range (thus omitting those locations gathered before the relocated bobwhite was known to be in the resident covey), her home range decreased to 6.75 ha. Three relocated quail released together assimilated into a resident covey in which 1 bird was radio-marked (Figure 9, Covey 2). The mean of the 3 relocated birds' spring home ranges was 5.35 ha, while the resident quail's spring home range was 5.04 ha (Table 5). No tests were performed to determine if the home ranges in either case differed, because in both cases there was only 1 radio-marked individual in 1 of the groups.

In the spring of 1995, there were 5 instances in which at least 1 relocated quail

Table 4. 1994 and 1995 seasonal home ranges in hectares with standard error [SE] and (n) for radio-marked northern bobwhites on the Maddox farm experimental area, Houston County, Tennessee.

	1994		1995	
	Resident	Relocated	Resident	Relocated
Spring Home Range	*4.49[0.59](13)	*8.09[1.06](4)	7.39[0.44](24)	7.49[0.59](13)
Summer Home Range	6.57[1.22] (9)	8.33[1.64](5)	4.21[1.49] (6)	5.64[1.49] (6)

* home range sizes differed significantly $P < 0.05$.

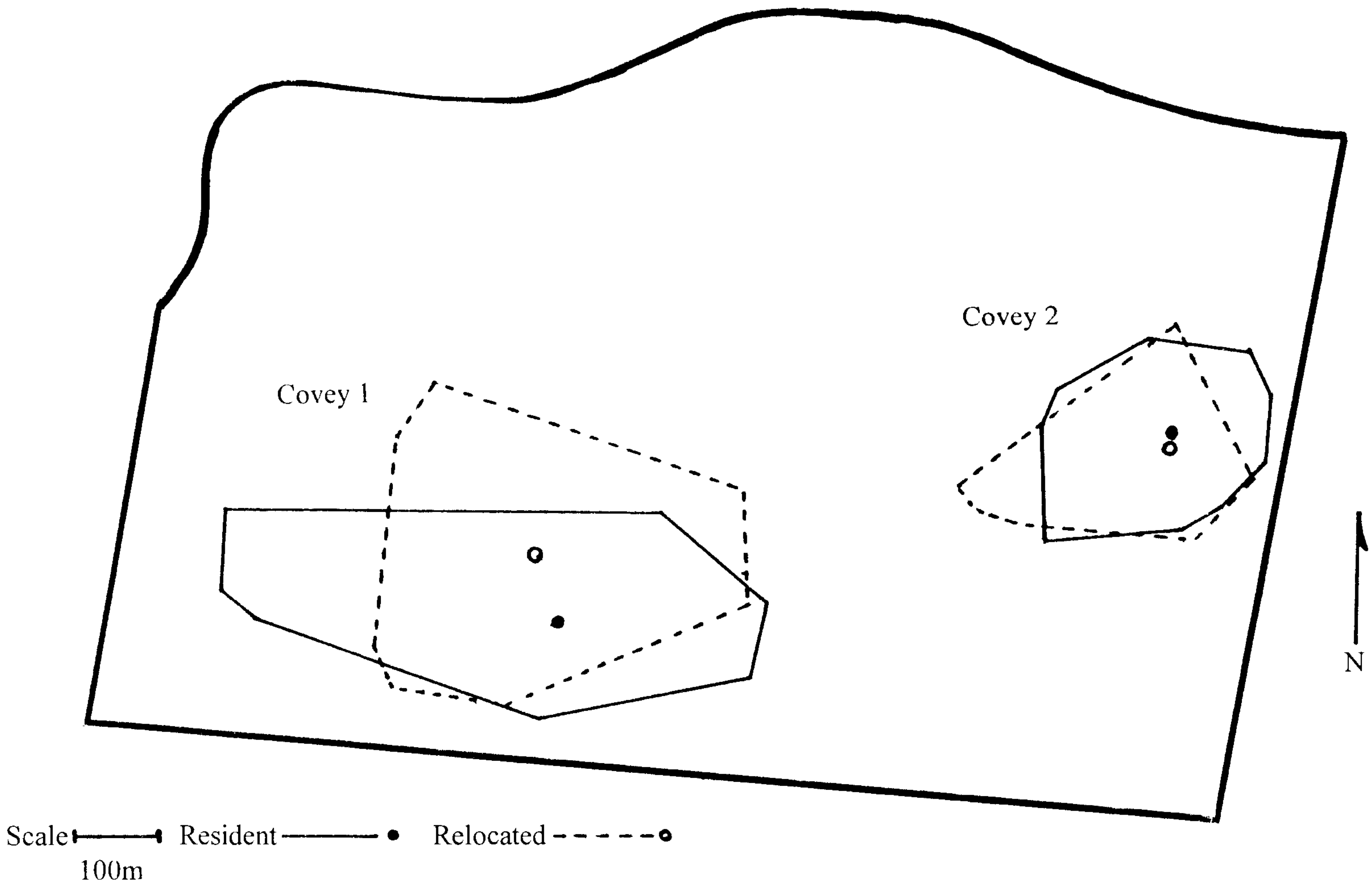

Figure 9. Spring 1994 minimum convex polygon home ranges and arithmetic mean home range center points for resident and relocated radio-marked northern bobwhites on the Maddox farm experimental area, Houston County, Tennessee illustrating assimilation of relocated quail into resident coveys.

Table 5. 1994 and 1995 spring home ranges in hectares for resident and relocated northern bobwhites in coveys known to have both resident and relocated radio-marked quail. Maddox farm experimental area, Houston County, Tennessee.

	1994			1995	
	Resident	Relocated		Resident	Relocated
Covey 1	6.06	6.75*	Covey 1	8.12	8.01
Covey 2	5.04	5.35	Covey 2	6.41	6.22
			Covey 3	9.02	8.83
			Covey 4	8.78	8.29
			Covey 5	5.44	5.27

* Home range of relocated quail after it was known to have assimilated into the resident covey (5 days after release).

joined a resident covey that included radio-marked bobwhites (Figure 10). In the first covey (Figure 10, Covey 1), 3 relocated quail joined a resident covey with 5 radio-marked quail. The mean spring home range of the resident birds was 8.12 ha, and the mean spring home range of the relocated quail was 8.01 ha. In the second case (Figure 10, Covey 2), 1 relocated bird assimilated into a resident covey with 5 radio-marked quail. In this covey, the mean spring home range of the resident quail was 6.41 ha, and the spring home range of the relocated bobwhite was 6.22 ha. In a third instance (Figure 10, Covey 3) 3 relocated quail joined a resident covey with 4 radio-marked bobwhites. The mean home ranges in this covey were 9.02 ha for residents and 8.83 ha for relocated quail. Another 3 relocated radio-marked quail joined a resident covey with 4 radio-marked bobwhites (Figure 10, Covey 4). The mean spring home range for the resident quail was 8.78 ha, and that of the relocated birds was 8.29 ha. In the final case (Figure 10, Covey 5), 3 relocated birds joined a resident covey with 6 radio-marked quail. The mean spring home ranges for the birds in this covey were 5.44 ha for the resident bobwhites and 5.27 ha for the relocated quail (Table 5). In all cases, excluding Covey 2, there were no significant differences in the resident and relocated quail home ranges ($P > 0.10$). For covey 2, no statistical tests were performed since only 1 radio-marked relocated bird assimilated into that covey.

Reproduction

All reproductive data are based on nests that were first observed after incubation was initiated. No nests were found prior to the initiation of incubation.

Thirteen of the 23 (56.5%), 8 resident and 5 relocated, radio-marked females still

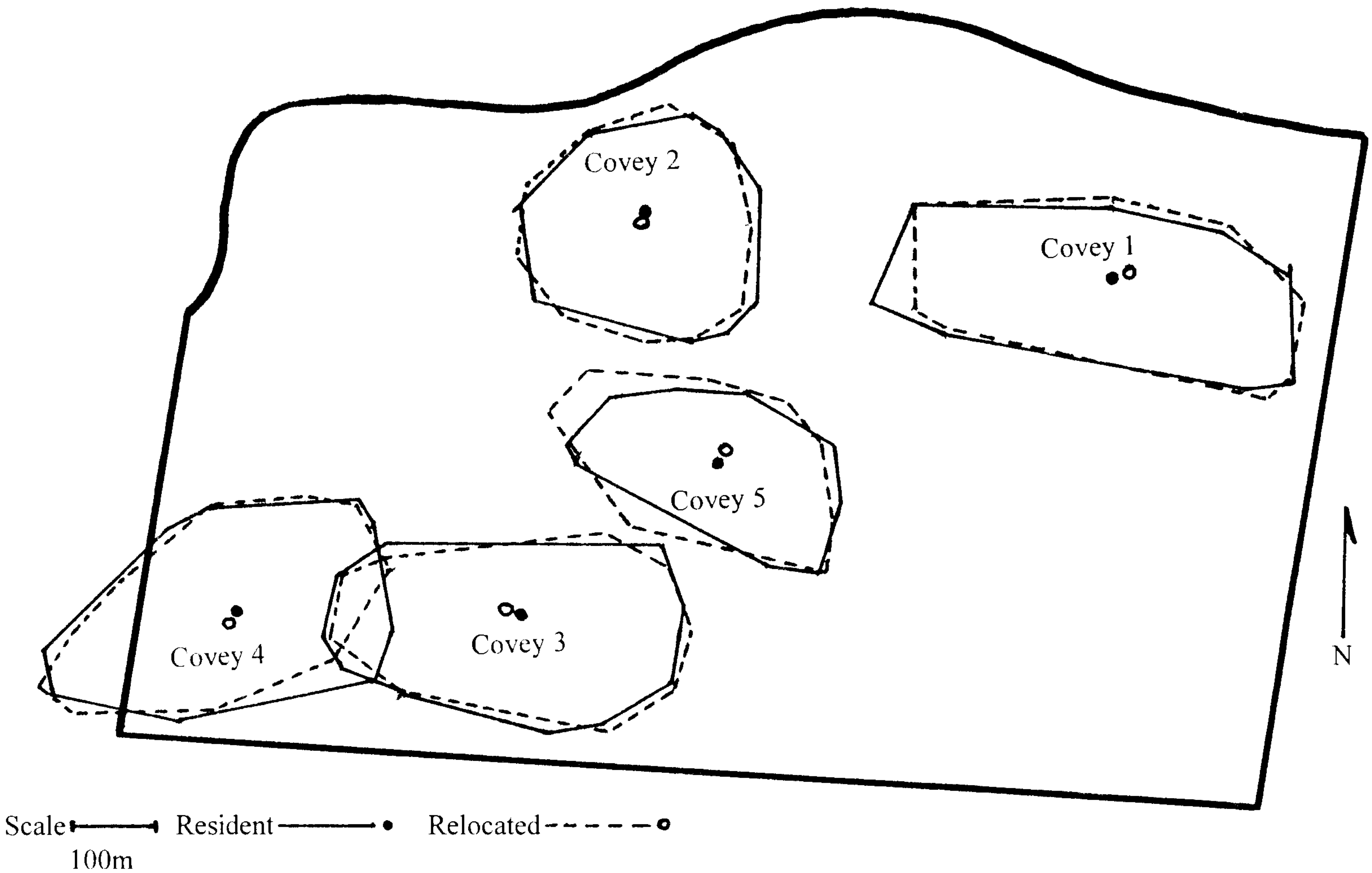

Figure 10. Spring 1995 minimum convex polygon home ranges and arithmetic mean home range center points for resident and relocated radio-marked northern bobwhites on the Maddox farm experimental area, Houston County, Tennessee illustrating the assimilation of relocated quail into resident coveys.

alive at the beginning of each nesting season were known to have incubated nests during the 2 nesting seasons. Ten of the 23 (43.5%) successfully hatched all or a portion of their clutches. Two radio-marked hens apparently failed to incubate a clutch of eggs while still radio-marked in 1994, while no radio-marked birds demonstrated this behavior in 1995. The other 8 hens were lost to mortality, or censured due to transmitter loss or failure. Four nests (3 resident and 1 relocated) were found in 1994, and 9 (5 resident and 4 relocated) in 1995 (Table 6) (Appendix C). Additionally, in 1994, 1 relocated hen was found with a brood of quail chicks after hatching, although her nest was never located. No males were verified as incubating eggs during either year of the study, although telemetry data indicated that 1 resident and 1 relocated male may have incubated nests in 1994.

Simple Reproduction Calculations

Three of 13 incubated nests (23.0%) were destroyed before hatching (1 resident in 1994, and 1 resident and 1 relocated in 1995), yielding an overall success rate of 77.0% for nests that survived to reach incubation. The success rate of residents for both years combined was 75.0% (6 of 8 nests hatched); for relocated quail the success rate for both years of the study was 80.0% (4 of 5 nests hatched). In 1994, clutch size of resident quail averaged 8.0 eggs; the 1 relocated female had 11 eggs. In 1995, quail clutch size averaged 11.4 for residents and 12.8 for relocated birds. The egg hatching rate for resident quail with successful nests was 96.7% (58 of 60 eggs hatched), for relocated quail it was 95.8% (46 of 48 eggs hatched). Egg survival was 74.1% (60 of 81 eggs found hatched) for resident birds, and 77.4% for relocated quail (48 of 62 eggs found hatched).

Table 6. 1994 and 1995 incubated nest data for resident and relocated quail on the Maddox farm experimental area, Houston County, Tennessee.

	Resident		Relocated	
	Nests/Eggs Found	Nests/Eggs Hatched	Nests/Eggs Found	Nests/Eggs Hatched
1994	3/24	2/14	1/11	1/10
1995	5/57	4/44	4/51	3/36
Percent Total Nests/Eggs Hatched	75/74		80/74	

Based on these probabilities, the likelihood that an egg in a nest incubated by a resident quail would hatch was $P_{sisresident} = 53.7\%$. The same probability for a relocated quail over both years was $P_{sisrelocated} = 59.3\%$. This probability for the 2 groups combined was $P_{siscombined} = 55.9\%$.

Survival of broods of resident females to 2 weeks of age during both years of the study was 58.6%, and for relocated birds it was 58.7%. For the 10 nests that hatched, the mean hatching date was 15 July, with the earliest hatch date being 5 July in 1995, and latest being 3 August in 1994.

Mayfield Method Calculations

The Mayfield method produced estimates of reproductive output for relocated and resident quail, and both groups combined, that were higher than those determined using the simple method. The Mayfield probability that an incubated egg of a resident quail would produce a chick was $P_{simresident} = 69.1\%$ for both years of the study (Table 7). This probability for relocated birds was $P_{simrelocated} = 68.8\%$. Combining data for the 2 groups yielded a Mayfield probability of $P_{simcombined} = 68.9\%$ that an incubated egg would produce a chick.

Relocation Effort

Over the course of the entire study, 85.6 trap days (TD) were required to capture 1 quail on the Maddox farm, and 144.2 TD on the source trapping areas. During the entire study, 118 quail traps produced 78 captures, or 0.66 quail per trap set (Table 8).

The cock and hen trapping method was more efficient than bait trapping. Eight male bobwhites were captured using the cock and hen method in just 19 trap days

Table 7. Results of Mayfield method incubated nest analyses for resident and relocated radio-marked bobwhites on the Maddox farm experimental area, Houston County, Tennessee, combined over 1994 and 1995 nesting seasons.

	Resident	Relocated	Combined
Nests Found/Lost	8/2	5/1	13/3
Nest Days	138	70	208
Eggs Found/Lost	81/21	62/14	143/35
Eggs Hatched/Present at Hatching	58/60	46/48	104/108
P_{sim}	.691	.688	.689

Table 8. Trap days, bobwhites captured, and trap days per quail captured for the Maddox farm study area, Houston County, Tennessee, Fort Campbell Military Reservation, Montgomery County, Tennessee, and all other source trapping areas for 1994 and 1995 combined.

	Area Trapped			
	Maddox Farm	Fort Campbell	Other Source Areas	Combined
Trap Days	4449	2380	1370	8199
Birds Captured	52	24	2	78
Trap Days per Capture	86	99	685	105

resulting in 2.4 TD per quail captured. However, although highly effective at capturing male bobwhites, this method was ineffective for capturing females.

A total of 1955.5 man hours was spent capturing and relocating or releasing 78 bobwhites during both years of the study, resulting in 25.1 man hours spent capturing each bird. These hours include all time spent selecting trap sites and setting the traps (371.5 hrs./1.6 hrs. per trap), relocating quail (137 hrs./5.3 hrs. per quail), and checking, baiting and maintaining quail traps (1388.5 hrs.). An additional 48.5 man hours were spent assembling 118 wire quail traps used during the study (0.41 hrs. per trap). Finally, approximately 19.5 man hours were utilized attaching radios and recording data for the captured quail (0.25 hrs. per quail).

Chapter V

Discussion

Given the long term decline in bobwhite populations over much of the species range (Church et al. 1993) and growing concern and efforts to reverse this trend, it is important that quail research produce results that will add to understanding the causes of this decline and/or ultimately reverse it. Two results of my study, in particular, show promise for reversing bobwhite population declines. The similarities among resident and relocated quail reproduction, and fidelity of relocated birds to the release area indicate that translocating wild bobwhites into managed quail habitat with an increasing resident population of birds may help to move the local bobwhite population toward the carrying capacity of the release area.

Survival

Due to the small samples of radio-marked birds in my study, standard errors about the survival estimates were large and lacked definitive statistical power. However, the trends in the survival estimates indicated that translocated quail survived at a rate similar to that of residents (64% and 57% respectively) for the spring and summer periods combined. These survival estimates are higher than the spring to fall survival estimate reported for a similar period by Burger et al. (1995a) (33%); the spring to fall period defined in that study included the 6 months from 1 April through 30 September. Survival estimates in my study are comparable to those reported by Curtis et al. (1988)

for spring (March through May) and summer (June through August) survival rates of 2 radio-marked samples of quail at Fort Bragg, North Carolina and Tall Timbers Research Station, Florida. Spring survival at Fort Bragg was 62%; it was 57% at Tall Timbers. Summer survival rates were 53% for the Fort Bragg radio-marked birds, and 70% at Tall Timbers. Survival rates of resident and relocated quail on the Maddox farm experimental area were higher than those reported by Pace (1998) for a western Tennessee sample of radio-marked quail. Pace recorded survival of 54% during spring and 40% during summer. The seasons defined by Pace were similar to those in my study. Mean distance moved from the initial telemetry location in the western Tennessee study was 824.4 m, indicating wide movements following covey disassociation (Pace 1998); this may have resulted in increased mortality. None of the radio-marked quail on the Maddox farm experimental area displayed large movements following covey break-up. All birds remained almost entirely within the study area boundaries. All nests found were located less than 500 m from the spring home range center point of the incubating bird, and were situated within the study area boundaries. Lack of lengthy movements may have contributed to the higher survival of the radio-marked quail in my study compared to that reported by Pace (1998).

Bobwhite survival estimates in my study were comparable to those found in successful wild turkey and ring-necked pheasant relocations. In east Texas, Campo et al. (1984) reported a survival rate for relocated birds of 62% after 1 year and 48% after the second year (n = 65). Swank et al. (1990), also in Texas, reported first year survival of 67% and second year survival of 38.7% for relocated turkeys (n = 74). In another

telemetry study of 16 relocated wild turkeys in Iowa, Little and Varland (1981) found that 100% of the males and 4 of 9 hens that still had functioning transmitters survived 1 year. Miller et al. (1990) reported that 50% (n = 33) of the radio-marked wild turkeys that were relocated into fragmented Indiana farmland on 2 separate study areas survived after release. Mabie (1981) estimated annual survival of 33% for wild ring-necked pheasants relocated from California to the central gulf coast of eastern Texas. In another study, spring to autumn and autumn to spring survival of 122 radio-marked relocated ring-necked pheasant females were 49% and 86% respectively (Wilson et al. 1992). The sedentary nature of bobwhites is similar to that of wild turkeys and ring-necked pheasants, and the coveying behavior of quail is similar to the flocking behavior of wild turkeys; the lack of large movements and flocking likely increase survival (Stoddard 1931, Allen 1956, Rosene 1969, Dimmick 1992, Healy 1992). Behavioral similarities among these 3 species may help to explain the survival of the relocated quail in my study.

Nielsen (1988) commented that the minimization of stress, presence of the same species on the release area, and similarity of habitat found at the capture and release areas help to increase the survival of wild translocated animals. Several factors present in this study may have enhanced survival of the relocated quail. First, bobwhites to be relocated were held for a short period from the time of capture to the time of release, and were handled but 2 times each, once for removal from the trap and once for collecting biological data and affixing leg bands and transmitters. Secondly, the relocated quail were transported a relatively short distance from capture site to release area, in no case a distance of more than 160km (100 miles). These 2 factors may have reduced the stress

placed on the relocated quail. Another factor believed helpful was the presence of resident coveys of bobwhites on the study area, into which the relocated quail readily assimilated. Once relocated quail joined a resident covey, their movements were essentially indistinguishable from that of the resident radio-marked quail in that covey. The time of year during which the relocation of quail took place probably was favorable. Late winter or early spring survivors were moved not long before the disassociation of quail coveys, and the passing of harsh winter weather, a time of year that appears to be characterized by high survival of bobwhites (Stoddard 1931, Rosene 1969, Curtis et al. 1988, Burger et al. 1995a). Food and cover increase rapidly during this time, aiding the relocated quail to adapt to their new surroundings (Nielsen 1988). Kreh (1997) reported that survival rates for radio-marked quail in southwestern Tennessee from January through March were 94.4% and 72.8% in 1995 and 1996, respectively, indicating high late winter and early spring survival. Kreh's data suggest that relocating quail earlier in the winter may be successful. In my study, the experimental and source areas lay within the same geographic region and have similar quail habitats. Habitat similarities at source and release areas and habitat quality on the release area may be the factors that contributed most to the survival of relocated quail.

Assimilation of Relocated Bobwhites into Resident Quail Coveys

The rapidity with which relocated quail assimilated into a resident covey is significant (95% over both years). Also important is that all but 1 relocated bobwhite (96%) remained entirely within the boundaries of the experimental release area during the period monitored. This behavior would be particularly desirable if quail were moved to

small tracts of suitable habitat, or to fill areas of suitable habitat on larger properties that were under populated relative to carrying capacity.

Factors that likely contributed to the assimilation of relocated birds into the resident population and their fidelity to the release area are much the same as those affecting survival of relocated quail. The presence of suitable habitat similar to that from which the relocated quail were moved almost certainly afforded relocated birds the opportunity to adjust rapidly to their new environment. Also, the fact that a resident population of bobwhites existed on the release area when the relocated birds arrived appeared to enable the relocated quail to associate with and benefit from the experience of quail familiar with their new home (Nielsen 1988). Evidence of this was seen during the second year of the study when relocated quail were released either with resident radio-marked birds at their point of capture, or very near known covey locations, significantly decreasing the time for relocated birds to assimilate into resident coveys. This technique did not, however, increase the survival of the relocated birds. Suitable habitat on the release area, and/or the absence of severe weather might explain the similarity of the survival of the relocated birds for 1994 and 1995. Stoddard (1931), referring to the relocation of quail native to the Southeastern plantations on which the majority of his studies took place, commented that "data at hand thus indicate that native bobwhites may be trapped and moved about with satisfactory results, usually locating near the point of release, for no long moves have been recorded". The relocated quail of this study, though translocated greater distances than those Stoddard (1931) discussed, displayed quite similar behavior.

The fidelity of relocated quail to the release area was similar to that demonstrated by successfully relocated ring-necked pheasants and wild turkeys, and supportive of bobwhite relocation as a quail management practice. Myers (1970) concluded that the movements and lack of dispersal demonstrated by 1006 wild trapped pheasants moved to a release area in Centre County, Pennsylvania were comparable to those observed in "prime" pheasant range. Wilson et al. (1992) reported that 95% of the radio telemetry locations determined for 122 relocated female pheasants were within 1.6 km of their release point, and that all of the birds remained within 3 km of the release site. Movements of the relocated hens were similar to those of established wild populations. In an Iowa study, Little and Varland (1981) reported that all 16 of the radio-marked wild turkeys moved remained within the 35 km^2 target area. Miller et al. (1990) found that wild turkeys relocated to 2 Indiana study sites remained mostly or completely within the target areas. At one release site turkeys stayed in a 96 km^2 area; the target area totaled 88.6 km^2. Activity centers for these birds were within the target area. The turkeys released on the other site remained within an area of 32 km^2, well contained in the study area that totaled 49.2 km^2. The behavioral similarities among relocated bobwhites, wild turkeys, and ring-necked pheasants, given the successful relocations of the latter 2 species and the results of this study, indicate that relocation of wild bobwhites may be an effective quail management practice.

The assimilation of the relocated radio-marked bobwhites into the resident population, and sedentary nature of their activities after release are encouraging for the technique of translocating wild quail for establishing or enhancing wild populations. On

large land holdings or management areas, whether or not relocated quail remain near their release site may not be important. However, for successful augmentation of the population on smaller tracts it could be essential that relocated birds remain near the release location. The behavior of relocated quail in this study indicates that given suitable habitat and a resident population of bobwhites, relocated quail settle near their release point.

Reproduction by Relocated Quail

Although the nests of only 5 relocated bobwhites, and a brood of another relocated quail were observed during both years of the study combined, the reproductive success of these birds is of significance. Both the simple and Mayfield methods of calculating and reporting reproductive effort of the resident and relocated quail indicated similar success for the 2 groups. The probabilities that an incubated egg would hatch were similar calculated using either the simple method ($P_{sisresident}$ = 53.7%, and $P_{sisrelocated}$ = 59.3%) or Mayfield method ($P_{simresident}$ = 69.1%, and $P_{simrelocated}$ = 68.8%). Average clutch size was larger for relocated quail. The survival of broods to 2 weeks of age for both groups was nearly identical, as was the egg hatching rate.

The nest incubation rate of female radio-marked quail (56.5%) in my study was much higher than that reported by Pace (1998) of 21.9% for a western Tennessee sample, but similar to that reported by Burger et al. (1995b) of 66.1% for a Missouri sample of radio-marked birds. The presence of suitable quantity and quality of nesting habitat on the Maddox farm study area, adequately juxtaposed with late winter and early spring habitat, likely explains the similarity between my observations and Burger's et al.

(1995b). The difference in the nest incubation rate that I found versus those reported by Pace (1998) might be explained by the lack in the quantity and/or quality of nesting habitat on his study area. Sufficient amounts of at least adequate nesting habitat, situated close to winter range may have reduced the need for quail to make large movements in search of a suitable nest site, thereby reducing their susceptibility to predation during the nesting season. Pace (1998) felt that the lack of suitable amounts of high quality nesting habitat on his study area contributed to increased bobwhite movement in search of an adequate nest site, and likely increased mortality. Similarly, Burger et al. (1995b) thought that bobwhite vulnerability to predation during the nesting season was reduced by the presence of adequate amounts of sufficient quality nesting cover.

In Pace's (1998) study, 6 of 13 nests found were incubated by male bobwhites. I put forth little effort to locate incubating males, even though male bobwhites are known to frequently incubate quail nests (Stoddard 1931, Klimstra and Roseberry 1975, Burger et al. 1995b). Failure to locate incubating males may have underestimated reproduction in my study.

Nest success following the onset of incubation for both the resident and relocated birds was comparable to the success of a much larger sample reported by Harris (1995) in which 181 of 282 incubated nests (64.2%) hatched. Based on Mayfield's technique, the probability of an egg successfully producing a quail chick in my study (68.9% for resident and relocated quail combined) was similar to that reported by Pace (1998) of 54.4% for a west Tennessee sample of 13 incubated bobwhite nests.

Reproductive success may have been helped by the reduction in some nest

predators on the Maddox farm prior to and during the study. Raccoon hunters occasionally shot raccoons during hunts on the farm. Several skunks (*Mephitis mephitis*) and opossums *(Didelphis virginiana*) were also killed prior to and during the study. The presence of the researcher also may have contributed to the high nest success rate. Frequent visits around or to the actual nest site may have caused some potential nest predators to avoid the area. On 3 occasions, the nest observer encountered potential nest predators close to the nest. Twice, black rat snakes (*Elaphe obsoleta*) were encountered, and once an opossum was seen. In all 3 cases, the potential nest predators quickly left the immediate area of the nest. All 3 of these nests were successful. However, this is contrary to the observer effects reported by Rosene (1969) or suggested by Harris (1995), who felt that repeated visits by researchers to known quail nests may have contributed to nest predation by creating paths for potential predators to follow to the nests. Stoddard (1931), on the other hand, felt that if care was taken, nests could be observed without affecting the outcome.

Percentages of eggs hatched in successful nests by the relocated (95.8%) and resident quail (96.7%) were comparable to those reported in other bobwhite studies (Dimmick 1968, Klimstra and Roseberry 1975, Roseberry and Klimstra 1984, Harris 1995). Such an egg hatching rate is typical of bobwhites (Dimmick 1992), probably an adaptation to the high overall nesting failure rates associated with their reproductive attempts (Stoddard 1931, Rosene 1969, Roseberry and Klimstra 1984, Harris 1995).

Stoddard (1931) reported that bobwhites from Mexico and Texas relocated to the large plantations of the Southeast made their most significant contribution to the quail

populations on these preserves not during the hunting season, but during the subsequent breeding season. Their offspring almost certainly helped to increase the bobwhite density on the release area the following season. This study produced some data that also suggests this may be the case. The increase in winter quail density (50%) on the experimental area during the study (from 100quail/100ha in January 1994 to 150quail/ha in December 1995), and perhaps more importantly the increase in the covey density (56%) on the experimental area from 9coveys/100ha to 14coveys/100ha may be, at least in part, directly due to the reproductive efforts of the relocated quail. The increase in covey density perhaps indicates that the quail population on the experimental area moved closer to the carrying capacity of the habitat found there. By the same token, it is also possible that, barring the addition of any relocated birds, the resident quail on the study area may have produced offspring in sufficient numbers to achieve the same results. That individual quail and covey densities may have increased without the relocation of wild birds was evidenced by population data from the control area. Winter quail density increased 50%, and covey density increased 40% from the beginning to the end of the study. Improvements in habitat conditions may account for the increases in both quail and covey densities on both areas. Field workers and others, including individuals with extensive experience in bobwhite management, visiting the Maddox farm during the study felt that quail habitat conditions on both the control and experimental areas improved similarly. In addition, the chronology of habitat improvements, and resident quail response to them, may help to explain initial differences and subsequent changes in quail density estimates on the control and experimental areas. Habitat improvements on

that portion of the Maddox farm encompassing the experimental area began at least 1 year prior to the same improvements on the control area. It is possible that census results detected a chronological change in quail density related to habitat changes and nothing more.

The reproductive contribution to the quail population on the study area made by the relocated quail is perhaps the one result most supportive of moving wild bobwhites from one location to another to enhance an existing quail population. Still, the small sample obtained for this study warrants caution with making such a claim.

Cost of Relocation

Offsetting the encouraging biological results is the high cost associated with capturing and relocating bobwhites. At 25.1 man hours per mature quail captured, a technician employed at $6.00/hour would cost $150.60 per mature bird captured. When the reproductive output of the mature captured quail are included, the decreased cost of relocation is tempered considerably. At the same rate stated above, the cost per bird drops to $78.60 when the cost is adjusted to account for chicks produced by relocated quail that survived to 2 weeks of age. These figures do not include the expenses associated with trap materials, transportation vehicles, etc.

Trapping effectiveness may have been hampered by low quail densities and/or the lack of trapper familiarity with the locations of quail coveys on the source areas. Undetected shifts in food and available habitat selection by quail on source areas during late winter and early spring, even on source areas with low quail densities, would likely result in decreased trapping success. Trapping source areas earlier in the winter or fall

may have increased trapping success, provided winter food was scarce and quail would more readily respond to baiting. However, quail relocated earlier in the year may have had low survival after release, countering effects of relocating more birds. Kreh's (1997) data, however, which showed high late winter quail survival, is supportive of the practice of relocating birds earlier in the winter. Those data indicate that relocating quail during the winter months may be more cost effective, and merits further study.

The seemingly high cost of relocating each quail does not completely overshadow the positive results of relocated quail survival and reproduction, and the increase in quail and covey density on the experimental area. Comparable survival and reproduction between resident and relocated quail demonstrated the biological feasibility of relocating wild bobwhites.

What must be determined is the value in relocating 1 wild bobwhite. Wild turkeys are regularly relocated at a cost of between \$300 and \$600 per bird, with adult males often costing nearly \$1000 per relocated bird (G. Wright, Kentucky Dept. of Fish and Wildl. Res., Frankfort, pers. commun.). At some juncture, it was decided by wildlife managers and professionals that the high cost of relocating wild turkeys was worth the associated costs. The same decision was made in the case of white-tailed deer. Deer relocations are also costly in terms of man-power, time, and equipment, with costs per relocated animal reaching well into the hundreds of dollars (Halls 1984). Wildlife management agencies can justify relocating wild turkeys and white-tailed deer due to the great successes they have had at reestablishing huntable populations of both species (Dickson 1992, Halls 1984). The return on investment of the time and money spent

relocating turkeys and deer is large considering the income wildlife agencies gain through the sale of deer and turkey hunting licenses, tags, and permits. A higher value is placed on big game than small game; deer and turkey are considered big game in Tennessee and almost all other states. This is apparent in the cost of licenses, tags, or permits hunters must purchase in order to legally take big or small game. For example, in Tennessee the basic hunting and fishing license that enables an individual to hunt small game, including quail, costs $21. An additional $18 is required for each weapon type permitted for use in the taking of big game. In Tennessee, this can be as high as $54 if an individual chooses to hunt with modern firearms, muzzleloader, and archery equipment. It may be that wildlife agencies cannot justify high relocation costs for relocating bobwhites until their inherent value to sportsmen and the agencies increases significantly. The decision to use quail relocation as a management tool may eventually be made for bobwhites. Replicate studies to determine the effects of relocating wild quail to enhance or reestablish a population may provide much more powerful support for using relocation as a quail management practice.

Chapter VI

Management and Research Implications

Three factors that appeared to have some positive bearing on survival and subsequent reproductive success of relocated quail in this study, and that may have quail management implications were: 1) suitable quail habitat on the release area, 2) the presence of a resident quail population on the release area, and 3) the timing of the relocation.

Griffith et al. (1989) and Nielsen (1988) stressed that suitable habitat is essential to the success of wildlife relocations. The presence of a resident population of bobwhites on the experimental area indicates that the habitat on the area was sufficient to sustain a population of wild quail. Also, having a resident quail population on the release area should aid relocated quail in becoming accustomed to their new surroundings, once they have assimilated into a resident covey. Although there was no difference in relocated quail survival using 2 different release methods (random vs. with or near known resident coveys), releasing relocated birds near local coveys may be of particular importance if the relocated quail were being moved a long distance from their point of capture, were relocated from dissimilar habitat, were being held in captivity for an extended period of time, or were subjected to excessive stress during translocation (Griffith et al. 1989, Nielsen 1988).

The relocated quail in this study demonstrated survival equal to, and reproduction

very similar to resident birds when captured and released prior to the disassociation of quail coveys, but after the passing of severe winter weather. Recent studies by Burger et al. (1995a), Curtis et al. (1988), and Curtis (1990) demonstrated higher bobwhite survival in spring and summer than in other times of the year. However, Kreh's (1997) data indicated that relocation of wild birds earlier in the winter may also be feasible. It seems intuitive in the case of bobwhites that relocating them as close to the breeding season as possible would maximize the chances of the relocated birds contributing through reproduction to the following fall population on the release area (Stoddard 1931). Relocating wild quail as close to the onset of the breeding and nesting seasons would minimize the time the relocated quail would be exposed to various sources of mortality present on the release area.

Questions raised by this study include: 1) What is the best time of year to relocate wild quail into currently occupied or unoccupied suitable bobwhite habitat? 2) Does the presence of an existing population of quail increase survival and reproduction of relocated wild bobwhites? 3) Given the presence of an existing bobwhite population, does the proximity of the release point of relocated wild birds to resident coveys affect relocated quail survival and/or reproduction? and 4) What are the effects of removing wild bobwhites for relocation on source populations? Answers to these and other quail relocation questions may result in an efficient bobwhite relocation protocol (see Nielsen 1988 and Dickson 1992). When successful bobwhite relocation procedures become well defined and cost effective, they may be adopted as quail management practices.

Assuming quail relocation protocols are established, the need to expend resources

to move wild birds to a release area will still require justification. Foremost is the determination of the quality and quantity of bobwhite habitat, either existing or planned, and the quail population objective on the potential release area. If an acceptable bobwhite population already exists, and that population is known to be self-sustaining, it is likely that relocating additional birds to the area would be unwarranted. Should the quail population on the potential release area number significantly less than the existing or near future habitat is, or will be, capable of sustaining, then relocating wild bobwhites may be a prudent endeavor. This may be the case in restored quail habitat that is isolated from a potential founding population, or when a large restored area has a small existing population that is not expanding at a rate sufficient to meet the quail population objective for the area (Nielsen 1988, Griffith et al. 1989).

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Appendices

Appendix A. Trapping and telemetry data for resident northern bobwhites captured on the Maddox farm during the 1994 and 1995 field seasons.

Year	Band Number	Radio Frequency	Age[1]	Sex[2]	Weight(g)	Radio-monitoring Period Begin	End	Locations	Fate
1994	141	150.518	J	M	180	4/4/94	8/21/94	72	mortality
1994	142	150.140	J	M	170	4/4/94	7/18/94	37	transmitter failure
1994	143	150.959	J	M	150	4/4/94	6/13/94	16	dropped transmitter
1994	146	150.490	J	M	190	4/4/94	6/15/94	18	transmitter failure
1994	148	150.519	J	M	170	4/4/94	7/31/94	45	mortality
1994	149	150.540	J	M	185	4/6/94	8/12/94	49	transmitter failure
1994	150	150.011	J	M	170	4/6/94	8/21/94	70	end monitoring period
1994	156	none	J	M	180	4/8/94			
1994	157	none	J	M	170	4/8/94			
1994	136	150.219	A	M	160	3/27/94	6/11/94	17	mortality
1994	137	150.979	A	M	165	3/27/94	8/2/94	50	transmitter failure
1994	140	none	A	M	160	4/4/94			
1994	151	150.800	A	M	200	4/8/94	8/21/94	68	end monitoring period
1994	none	none	A	M	190	4/8/94			trapping mortality
1994	153	150.669	A	M	180	4/8/94	8/21/94	71	end monitoring period
1994	158	none	A	M	170	4/8/94			
1995	APD13	150.701	J	M	180	3/4/95	6/6/95	88	mortality
1995	APD15	150.674	J	M	175	3/4/95	5/24/95	76	dropped transmitter
1995	APD16	150.779	J	M	180	3/4/95	5/31/95	81	transmitter failure
1995	APD18	150.610	J	M	165	3/5/95	6/2/95	87	transmitter failure
1995	APD23	150.151	J	M	150	3/5/95	5/18/95	72	mortality
1995	APD28	150.637	J	M	190	3/18/95	5/31/95	78	transmitter failure
1995	APD31	150.936	J	M	190	3/18/95	7/27/95	88	transmitter failure
1995	APD33	150.431	J	M	165	3/21/95	5/31/95	76	transmitter failure
1995	APD38	150.475	J	M	170	5/11/95	8/3/95	57	transmitter failure
1995	APD20	150.805	A	M	170	3/5/95	6/6/95	87	mortality
1995	APD22	150.493	A	M	160	3/5/95	5/5/95	50	dropped transmitter
1995	APD25	150.924	A	M	170	3/15/95	7/16/95	154	dropped transmitter
1995	APD35	150.679	A	M	160	3/21/95	6/11/95	82	mortality
1995	APD36	150.733	A	M	145	3/22/95	7/25/95	124	mortality

Appendix A continued.

Year	Band Number	Radio Frequency	Age	Sex	Weight(g)	Radio-monitoring Period Begin	End	Locations	Fate
1995	APD37	150.441	A	M	175	5/10/95	5/31/95	21	transmitter failure
1994	134	150.190	J	F	150	3/17/94	8/18/94	76	transmitter failure
1994	135	150.769	J	F	145	3/26/94	6/21/94	25	mortality
1994	138	150.688	J	F	170	3/27/94	6/14/94	20	mortality
1994	139	150.820	J	F	150	3/30/94	8/10/94	51	transmitter failure
1994	144	150.121	J	F	170	4/4/94	6/30/94	27	mortality
1994	147	150.630	J	F	160	4/4/94	8/21/94	72	end monitoring period
1994	none	none	J	F	160	4/6/94			trapping mortality
1994	155	none	J	F	150	4/8/94			
1994	145	150.538	A	F	150	4/4/94	8/21/94	72	end monitoring period
1994	152	150.098	A	F	200	4/8/94	8/21/94	69	end monitoring period
1995	APD14	150.530	J	F	180	3/4/95	7/11/95	156	transmitter failure
1995	APD17	150.646	J	F	160	3/5/95	5/26/95	78	dropped transmitter
1995	APD21	150.881	J	F	150	3/5/95	8/17/95	200	end monitoring period
1995	APD26	150.602	J	F	175	3/15/95	7/13/95	91	transmitter failure
1995	APD27	150.719	J	F	155	3/18/95	8/17/95	150	end monitoring period
1995	APD32	150.711	J	F	185	3/21/95	4/27/95	21	mortality
1995	APD34	150.854	J	F	170	3/21/95	5/25/95	64	transmitter failure
1995	APD19	150.654	A	F	160	3/5/95	7/18/95	97	transmitter failure
1995	APD24	150.554	A	F	150	3/5/95	5/19/95	67	transmitter failure
1995	APD29	150.690	A	F	160	3/18/95	6/14/95	86	mortality
1995	APD30	150.773	A	F	155	3/18/95	8/17/95	222	end monitoring period

1 - A = adults, J = juveniles

2 - M = males, F = females

Appendix B. Trapping and telemetry data for relocated northern bobwhites captured on source trapping areas during the 1994 and 1995 trapping seasons.

Year	Band Number	Radio Frequency	Age[1]	Sex[2]	Weight(g)	Radio-monitoring Period Begin	Radio-monitoring Period End	Radio-monitoring Period Locations	Fate
1994	APD3	150.098	J	M	120	3/22/94	4/7/94	11	mortality
1994	APD5	150.089	J	M	190	4/1/94	8/21/94	80	end monitoring period
1994	APD7	150.412	A	M	170	4/13/94	6/13/94	18	transmitter failure
1994	APD10	151.469	A	M	180	5/18/94	8/21/94	67	end monitoring period
1994	APD11	151.487	A	M	180	5/19/94	8/21/94	63	end monitoring period
1994	APD12	151.493	A	M	170	5/26/94	6/13/94	10	mortality
1994	APD1	150.800	J	F	140	3/14/94	4/7/94	13	dropped transmitter
1994	APD2	150.909	J	F	160	3/14/94	8/21/94	90	end monitoring period
1994	APD4	150.629	J	F	200	4/1/94	7/13/94	42	transmitter failure
1994	APD6	150.458	J	F	190	4/1/94	8/21/94	80	end monitoring period
1994	APD8	150.236	J	F	155	4/13/94	7/7/94	33	transmitter failure
1994	APD9	150.312	J	F	165	4/23/94	6/11/94	12	transmitter failure
1995	202	150.665	J	M	165	3/18/95	7/8/95	133	transmitter failure
1995	208	150.765	J	M	180	3/20/95	5/4/95	45	mortality
1995	214	150.502	J	M	170	5/16/95	7/8/95	59	dropped transmitter
1995	211[3]	150.575	A	M	150	4/5/95	6/8/95	66	mortality
1995	212	150.583	A	M	175	5/9/95	6/2/95	27	transmitter failure
1995	213	150.757	A	M	180	5/9/95	6/1/95	27	transmitter failure
1995	201	150.116	J	F	155	3/18/95	5/17/95	64	dropped transmitter
1995	203	150.827	J	F	160	3/18/95	8/17/95	237	end monitoring period
1995	204	150.872	J	F	155	3/18/95	6/21/95	86	mortality
1995	205	150.465	J	F	150	3/18/95	6/22/95	87	mortality
1995	206	150.475	J	F	160	3/19/95	8/17/95	218	end monitoring period
1995	207	150.486	J	F	155	3/19/95	6/1/95	77	transmitter failure
1995	209	150.818	J	F	160	3/21/95	8/17/95	122	end monitoring period
1995	210[4]	150.513	J	F	165	3/21/95	8/17/95	226	end monitoring period

1 - A = adults, J = juveniles

2 - M = males, F = females

3 - bird captured on Haley-Jaqueth WMA

4 - bird captured on Cheatham WMA. All others captured at Fort Campbell.

Appendix C. Reproductive data collected in 1994 and 1995 for 8 resident and 6 relocated radio-marked northern bobwhite hens on the Maddox farm experimental area.

Group/Year	#eggs in nest	#eggs hatched	date hatched	#chicks in brood week 1	week 2
Resident/1994	8	8	13 Jul	7	6
Resident/1994	6	6	8 Jul	5	4
Resident/1994	10	0	Nest destroyed 1 Aug		
Relocated/1994	unk.	unk.	unk.	5	5
Relocated/1994	11	10	3 Aug	8	7
Resident/1995	12	11	11 Jul	9	6
Resident/1995	11	0	Nest destroyed 13 Jul		
Resident/1995	11	11	9 Jul	8	5
Resident/1995	12	11	21 Jul	8	6
Resident/1995	11	11	27 Jul	10	7
Relocated/1995	12	12	10 Jul	9	6
Relocated/1995	14	0	Nest destroyed 12 Jul		
Relocated/1995	13	12	17 Jul	10	7
Relocated/1995	12	12	5 Jul	9	7
Mean (Res/Rel)	10.1/12.4	9.7/11.5	14 Jul/16 Jul	7.8/8.2	5.7/6.4
Mean Total	11	10.4	15 Jul	8.0	6.0

VITA

Jeffrey G. Jones was born in Ripley, West Virginia on 6 December 1963. He graduated from Princeton High School in Cincinnati, Ohio in May of 1982, and in July of the same year entered the United States Military Academy at West Point, New York. He graduated from West Point in May of 1986 with a B.S. in mechanical engineering, and was commissioned as a Second Lieutenant in the U.S. Army infantry. He served from 1986 to 1991 in the 82d Airborne Division, then left the service in pursuit of a degree in the wildlife and fisheries science field. He attended 1 semester of classes working toward this degree at North Carolina State University in the fall of 1992. He then enrolled at the University of Tennessee in the spring of 1993, and after completing additional under-graduate courses, entered the graduate school in pursuit of a M.S. in Wildlife Science. He was a research assistant in the Department of Forestry, Wildlife and Fisheries at the University of Tennessee from the spring of 1993 until the summer of 1996. He is currently the Fish and Wildlife Program Manager at the Fort Campbell Military Reservation near Clarksville, Tennessee.