SURVIVAL AND HOME RANGE ESTIMATES OF PEN-RAISED NORTHERN BOBWHITES IN BUFFER STRIP AND NON-BUFFER STRIP HABITATS

Michael J. Oakley
Maryland Cooperative Fish & Wildlife Research Unit, Biological Resources Division, United States Geological Survey, University of Maryland Eastern Shore, 1120 Trigg Hall, Princess Anne, MD 21853, USA

Dixie L. Bounds
Maryland Cooperative Fish & Wildlife Research Unit, Biological Resources Division, United States Geological Survey, University of Maryland Eastern Shore, 1120 Trigg Hall, Princess Anne, MD 21853, USA

Theodore A. Mollett
Department of Agriculture, University of Maryland Eastern Shore, 1121 Trigg Hall, Princess Anne, MD 21853, USA

Edward C. Soutiere
Tudor Farms Inc., 3675 Decoursey Bridge Road, Cambridge, MD 21613, USA

ABSTRACT

We investigated the effect of agricultural buffer strips on survival and home range estimates of pen-raised northern bobwhites (*Colinus virginianus*) at Tudor Farms on the Eastern Shore of Maryland. In September 2000 we released groups of bobwhites into 9 buffer strip (treatment) areas and 9 non-buffer strip (control) areas among 11 agricultural farms. Each group consisted of 4 radiomarked bobwhites and 26 non-radiomarked bobwhites. To maintain contact with the established coveys, additional radiomarked bobwhites ($n = 177$) were introduced into the coveys as radiomarked birds died. Survival for bobwhites released in buffer strip areas was lower ($P < 0.001$) than survival in non-buffer strip areas. None of the radiomarked bobwhites released in the buffer strip areas survived past 27 weeks, whereas 11% of radiomarked bobwhites in non-buffer strip areas survived to 27 weeks and 1 bird survived to 41 weeks. Predation was the primary mortality factor (88%), followed by unknown causes (7%), stress (2%), hunting (2%), and road kill (1%). Mean fall and winter home range (95% minimum convex polygon) for 21 bobwhite coveys was 24.2 ± 3.5 ha, ranging from 1.7 to 65.8 ha. Home range areas of bobwhite coveys in buffer strips ($n = 12$, $\bar{x} = 15.0 \pm 2.7$ ha) was significantly smaller ($P = 0.002$) than non-buffer strip coveys ($n = 9$, $\bar{x} = 36.4 \pm 4.9$ ha). We conclude that the smaller home ranges in buffer strip areas seem to indicate better habitat quality; however, high mortality rates of pen-raised bobwhites limited our ability to confirm this.

Citation: Oakley, M. J., D. L. Bounds, T. A. Mollett, and E. C. Soutiere. 2002. Survival and home range estimates of pen-raised northern bobwhites in buffer strip and non-buffer strip habitats. Pages 74–80 *in* S. J. DeMaso, W. P. Kuvlesky, Jr., F. Hernández, and M. E. Berger, eds. Quail V: Proceedings of the Fifth National Quail Symposium. Texas Parks and Wildlife Department, Austin, TX.

Key words**:** buffer strips, *Colinus virginianus,* habitat analysis, home range, Maryland, mortality, northern bobwhite, radiotelemetry, survival

INTRODUCTION

Nationwide, northern bobwhite populations have declined at an estimated rate of 2.4% per year (Church et al. 1993). Bobwhite populations have experienced excessive declines in Maryland and throughout the southeast (Brennan 1991, Church et al. 1993, Maryland Department of Natural Resources 1999). Maryland's estimated annual bobwhite harvest has declined an estimated 95% from 1975 to 1997 (Maryland Department of Natural Resources 1999). Several possible factors may explain why bobwhite populations have declined, including modernization of agricultural practices (Minser and Dimmick 1988, Burger et al. 1990, Brennan 1991), predators (Mueller 1989, DeVos and Mueller 1993, Rollins and Carroll 2001, Fies et al. In Press), and weather (Speake and Haugen 1960, Speake 1990, Bridges et al. 2001).

Researchers have suggested that habitat improvements may reverse the population decline of bobwhites (Stoddard 1931:359, Rosene 1969:224, Brennan 1991). Historically, agricultural fields were small with considerable edge habitats (hedgerows and fence lines). However, modernization of agriculture has led to an increase in farm field size and removal of edges (Langer 1985), which reduced the amount of habitat available for bobwhites (Brennan 1991). One type of habitat improvement is buffer strips, also called filter strips, conservation buffers, or transitional bands. Establishment of buffer strips is a practical, economical, and effective technique for managing northern bobwhite habitat (Puckett et al. 2000). Recently, federal farm programs, such as the Conservation Reserve Program (CRP), have compensated private landowners for providing buffer strip habitat (Isaacs and Howell

1988). In addition, the United States Department of Agriculture has developed a National Conservation Buffer Initiative with the goal of establishing 2 million miles of buffer habitat by the year 2002.

Researchers have studied the effects of buffer strips on wildlife, particularly bobwhites. For example, Rosene (1969:286) found that buffer strips between forests and planted crops produced more food and cover for bobwhites. Buffer strips provided bobwhites with nesting cover and insects in summer, and seeds in winter (Rosene 1969:289). Stinnett and Klebenow (1986) found California quail (*Callipepla californica*) preferred buffer strip habitats to other habitats throughout the year. Puckett et al. (2000) reported buffer strip drainage ditches received more use than non-buffer strip ditches in North Carolina.

Given the dramatic declines in bobwhite populations, some managers have used pen-raised bobwhites to augment wild populations. Pen-raised bobwhites are hatched and reared in captivity and later released into the wild. The release of pen-raised bobwhites to augment wild populations is generally considered unjustified by biologists (Beuchner 1950, DeVos and Mueller 1989, DeVos and Speake 1995, Fies et al. In Press); however, it is often accepted as a common management technique to facilitate a greater harvest (DeVos et al. 1991, Mueller et al. 1997). Only recently have the interactions of released bobwhites on native bobwhite populations been evaluated. Some researchers have found no difference in habitat use (DeVos and Speake 1993) and home range (DeVos and Speake 1993, Mueller et al. 1997) between pen-raised and wild bobwhites.

We estimated survival and home range for pen-raised northern bobwhites in habitat with buffer strips (treatment) and without buffer strips (control). The use of buffer strips by pen-raised bobwhites and the effect they have on survival is unknown. Therefore, we tested the null hypothesis that bobwhite survival and home range would be the same on study areas with and without buffer strips.

STUDY AREA

Our study area consisted of 11 farming units; 4 farms (Collins, Merrill, Sandhill, and Storr) had buffer strips, 5 farms (Lowe, McCollister, Mowbray, Fork Neck, and Willey) had no buffer strips, and 2 farms (Cephas and Walnut Hill) had areas with and without buffer strips. All farming units were on Tudor Farms or adjacent farms leased by Tudor Farms. Tudor Farms is about 3,900 ha and is a private game and wildlife management area located in Dorchester County on the Eastern Shore of Maryland. The management area consists of 1,608 ha of wetlands, 1,301 ha of forests and forested wetlands, 567 ha of agriculture and upland wildlife cover, and 421 ha of fresh and tidal water.

Tudor Farms has developed and annually maintains about 48.6 ha of buffer strips. The buffer strips are designated areas of planted vegetation established between croplands and forests to provide additional wildlife habitat. This area buffers about 11.5 linear km of agricultural edge. Buffer strip widths averaged 36 m (range: 30–41 m). Mowed paths 4.6 m wide were maintained throughout the year at the immediate edge between the woods and buffer for 71% of the total linear buffered edge. Use of these paths by all-terrain vehicles, automobiles, and agricultural equipment was common on about one-third of all buffer strips with mowed paths. Prescribed burning was conducted in portions of the buffer strips annually.

Tudor Farms buffer strips were planted with a mixture of warm-season grasses, which included big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), Indiangrass (*Sorghastrum nutans*), switchgrass (*Panucum virgatum*), and lovegrass (*Eragrostis* spp.). Shrubs in the buffer strips included bicolor lespedeza (*Lespedeza bicolor*), thunberg lespedeza (*L. thunbergii*), sericea lespedeza (*L. cuneata*), autumn olive (*Elaegnus umbellata*), baccharis bush (*Baccharis halimifolia*), and bayberry (*Myrica cerifera*). Crops planted in the buffer strips included sorgum, and trailing soybeans. Few areas in the buffer strip contained invasive native vegetation. Most common annual grass and forbs were blackberry (*Rubus* spp.), goldenrod (*Solidago* spp.), ragweed (*Ambrosia* spp.), aster (Aster spp.), foxtail grass (*Setaria* spp.), broomsedge (*Andropogon glomeratus*), and barnyard grass (*Digitaria* spp.).

The non-buffer strip areas were fields of annually harvested agricultural crops adjacent to mixed pine and hardwood forested edge habitats. Agricultural practices on both buffer and non-buffer strip areas were typical of modern farming methods. No-till and tilled corn, soybeans, wheat, barley, and sorgum were cultivated on the area. Drainage ditches (0–3 m) were within and around some agricultural fields.

METHODS

Field Procedures

The wild bobwhite population at Tudor Farms was not sufficient to mark an adequate sample to research. Wild bobwhites did occur, however, at Tudor Farms at unknown densities. Therefore, we used pen-raised bobwhites to evaluate buffer and non-buffer strip habitats. Day-old bobwhite chicks from a Pennsylvania hatchery were raised in an indoor–outdoor holding facility in Cambridge, Maryland. When the chicks were 13 weeks old, they were released at Tudor Farms, 11.3 km from the holding facility.

We established an Anchor Covey Release System (Haaland 1996) at 18 release sites, 9 in treatment and 9 in control areas. Each release system contained a camouflaged shelter, a feeder tube (filled with wheat and sorgum), and a call box set on a nearby tree. A water tube was not provided because water was readily available in adjacent habitats. An adult male bobwhite was placed in the call box to encourage bobwhites to return to the release area. Release systems were established and maintained in good cover on the edge of forests adjacent to fields or within the buffer strips for

2 weeks. After 2 weeks, the call bird was removed from the call box and the Anchor Covey Release System was no longer maintained. All release sites were at least 520 m apart to minimize intermixing among release groups.

Initially, we radiomarked 72 pen-raised bobwhites with 6.8 g necklace transmitters (American Wildlife Enterprises, Monticello, Florida). All radiomarked bobwhites weighed >138 g, in accordance with the University of Maryland Institutional Animal Care and Use Committee guidelines (transmitter must not weigh $>5\%$ of an animal's total body weight). After all bobwhites were radiomarked, they were transported to Tudor Farms and released in a flight pen. Bobwhites were kept in the pen 8 days before release to allow for acclimation to the transmitter. Each transmitter was equipped with a mortality indicator.

The 72 radiomarked bobwhites were divided into 18 release groups. Each group consisted of 30 individuals, of which 4 bobwhites were radiomarked and 26 were not radiomarked. All released bobwhites (n = 540) were banded with uniquely numbered leg bands. In August 2000, 9 groups were released in treatment areas with buffer strips and 9 groups released in control areas without buffer strips. We began locating the bobwhites 24 hours after the release.

After release, the bobwhites appeared to form coveys, which were individually recognized according to daily social interactions and group movements. We defined a covey as a group of bobwhites >2 individuals. Each covey represented a single sample for home range estimates. Coveys were located 2–5 times per week, using a random sample of daily activity periods. Each covey was located ≥ 1 time per week for each AM period (pre-sunrise-1100 hours), mid-day period (1100–1400 hours), and PM period (1400 hours-post-sunset). We used the homing method (Mech 1983) to locate each marked covey, or approached the covey to within about 5 m if visual observations were not possible.

We identified the cause of mortality based on evidence at the transmitter recovery site, damage to transmitter, and criteria suggested by Dumke and Pils (1973). The causes of mortality were recorded as predation (avian, mammalian, reptilian), hunting, road kill, stress, or unknown. Because of high mortality rates, we radiomarked an additional 177 bobwhites from September 2000 to January 2001 to maintain locations for all coveys.

When mortality occurred and ≤ 2 radiomarked bobwhites remained in a covey, we reintroduced bobwhites in 1 of 3 ways. First, pen-raised bobwhites in the flight pen were radiomarked and given ≥ 24 hours to acclimate to the transmitter. These bobwhites were carried to the location of the deficient covey, and 1–3 radiomarked bobwhites were released into the existing covey. Second, we located a covey deficient of radiomarked bobwhites and used a net to capture unmarked birds. We marked and released bobwhites in the locations they were captured. Third, we used a modified Stoddard funnel trap (Stoddard 1931:442), to trap coveys in a predetermined, prebaited location commonly used by the target covey. All trapped individuals were marked and released at the location where they were trapped.

Data Analysis

We estimated survival for bobwhites using the Kaplan-Meier staggered entry design (Kaplan and Meier 1958, Pollock et al. 1989). The staggered entry design allowed us to include additional bobwhites throughout the study, and to eliminate bobwhites that emigrated out of the treatment or control areas in which they were released. Survival was estimated in treatment and control areas. Log-rank tests were used to compare survival between bobwhites released in treatment and control areas (Pollock et al. 1989).

The computer program HOME RANGE (Samuel et al. 1985) run from ArcView geographic information system (GIS) (ESRI 1989) was used to estimate 95% minimum convex polygon (MCP) home range sizes. We developed home range estimates using data collected for the individual radiomarked bobwhites with the greatest number of survival days in each covey. We considered statistical tests to be significant at $P \leq 0.05$.

RESULTS

Although we planned to release 72 radiomarked bobwhites, 1 radio transmitter failed. Therefore, 36 bobwhites were released in treatment areas and 35 in control areas. We found that survival was greater in non-buffer strip areas than in buffer strip areas ($P < 0.001$) for the originally released bobwhites. Of the originally released bobwhites, the longest a bobwhite survived in the buffer strip areas was 26 weeks compared to 35 weeks in the non-buffer strip areas.

Because of the high mortalities of the originally released bobwhites, we released additional birds (Sep 2000–Jan 2001) for a total of 249 radiomarked bobwhites. We monitored 119 bobwhites released in buffer strips and 103 released in non-buffer strips. The remaining bobwhites (n = 27) moved from one treatment type to another (i.e., treatment to control or vice versa) and were censored from the data set. Log-ranked tests indicated survival was greater ($P < 0.001$) for the originally released bobwhites in non-buffer strip areas than buffer strip areas (Fig 1). We also found the survival for all quail released in non-buffer strip areas was greater ($P < 0.005$) than in buffer strip areas (Fig 2). For all bobwhites released in non-buffer strips, the longest survival was 41 weeks, while the longest survival in buffer strip areas was 27 weeks.

Predators were the primary cause of mortality (88%), followed by other causes including unknown causes (7%), stress (2%), hunting (2%), and road kill (1%) (Fig.3). Predation accounted for 97% of the mortalities in buffer strip areas and 78% in non-buffer strip areas. Avian predators were responsible for most mortalities in buffered (42%) and non-buffered (41%) areas. Mammalian predation accounted for 27% and 12% of mortalities in buffered and non-buffered areas,

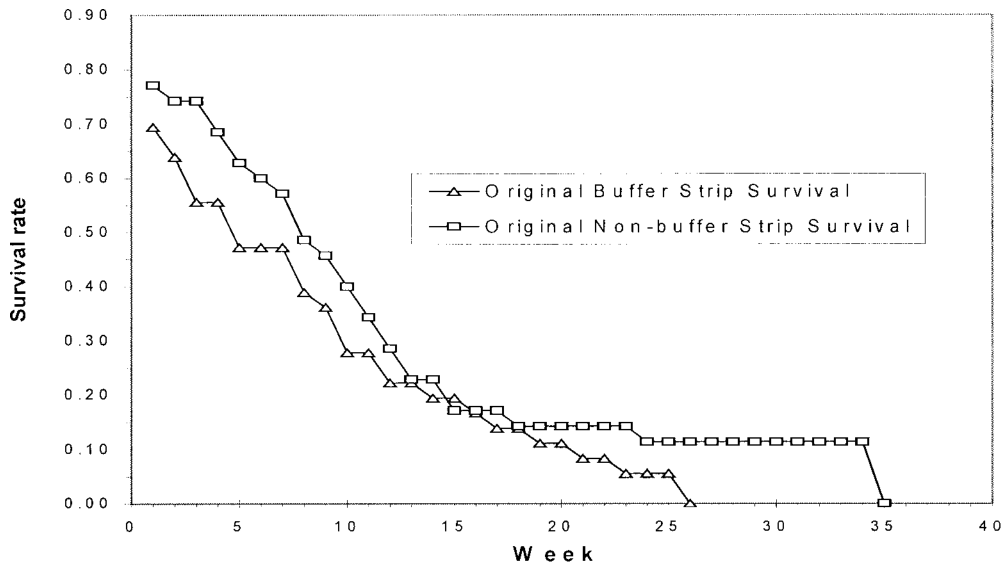

Fig. 1. Weekly survival rates of original pen-raised northern bobwhites released in buffer strip and non-buffer strip areas on Tudor Farms in Dorchester County, Maryland, Sep 2000 to Apr 2001.

respectively. While unknown predation accounted for 26% in buffered areas and 25% in non-buffered areas.

After the release, some groups of bobwhites divided into 2 or more coveys. We identified 27 coveys throughout the study period. Six coveys were eliminated from the home range analysis because they were released in a treatment area and later moved into a control area or vice versa. We estimated home range areas for 12 coveys that remained in treatment areas and 9 coveys in control areas (Table 1). Estimated home range areas for bobwhite coveys ranged from 1.7 ha to 65.8 ha ($\bar{x}$ = 24.2 ± 3.5 ha). The estimated home range of buffer strip coveys ($\bar{x}$ = 15.0 ± 2.7 ha) was smaller (P = 0.002) than non-buffer strip coveys ($\bar{x}$ = 36.4 ± 4.9 ha).

DISCUSSION

The survival of our original release of pen-raised bobwhites was higher than what Fies et al. (In Press) reported in Virginia. Fies et al. (In Press) reported that all radiomarked pen-raised bobwhites died within 9 days after release in Virginia. Other researchers reported higher survival rates for pen-raised bobwhites. In Alabama, DeVos and Speake (1995) reported 18% survival of pen-raised bobwhites after 22 weeks. In South Carolina, Mueller et al. (1997) found pen-raised bobwhite survival was 55% in 12 weeks. In Alabama, DeVos and Speake (1993) reported 20% of pen-raised bobwhites survived to April. None of the radiomarked bobwhites from our original release in buffer strip ar-

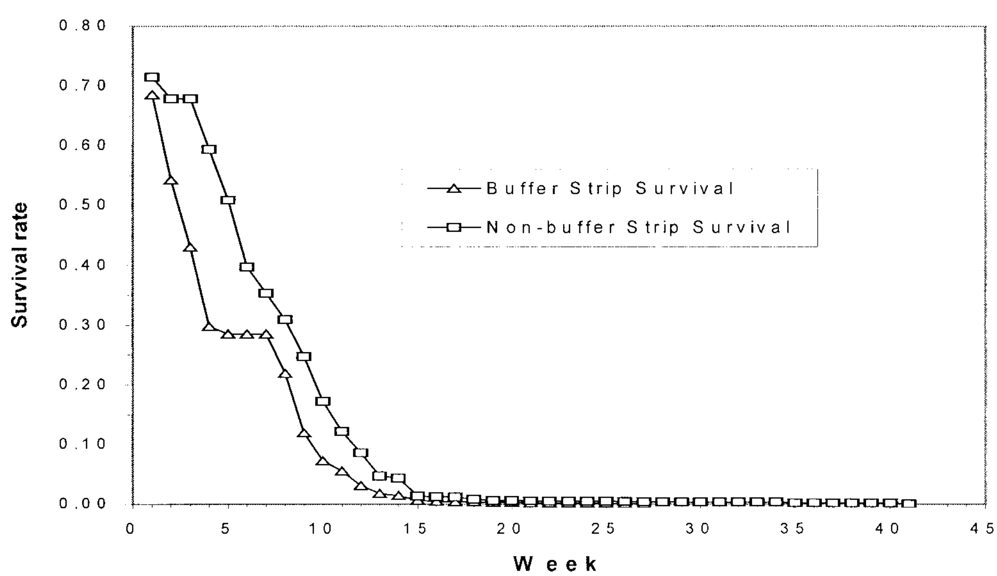

Fig. 2. Weekly survival rates of all pen-raised northern bobwhites released in buffer strip and non-buffer strip areas on Tudor Farms in Dorchester County, Maryland, from Sep 2000 to Apr 2001.

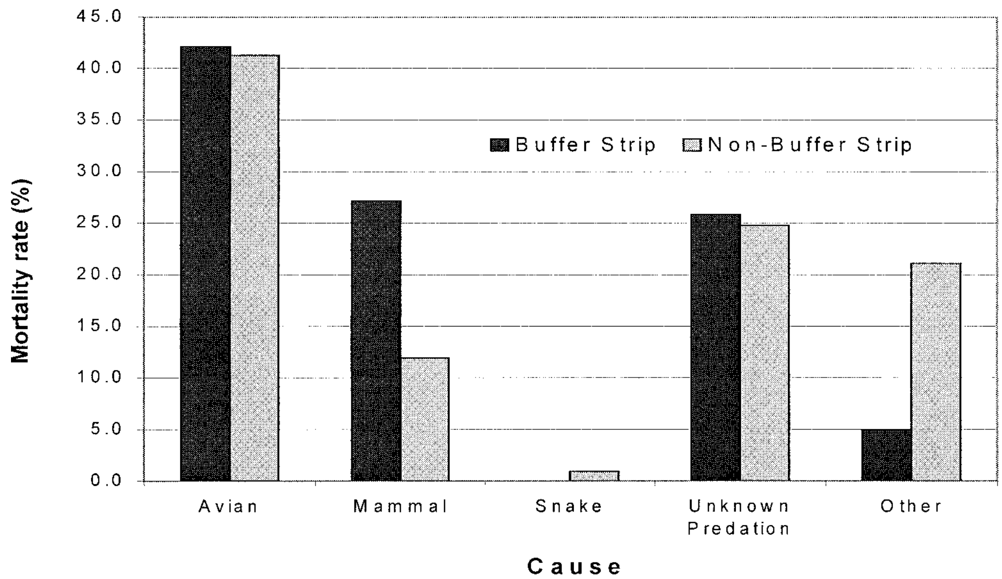

Fig. 3. Predation rates compared to other causes of mortality for pen-raised northern bobwhites in buffer strip and non-buffer strip areas at Tudor Farms in Dorchester County, Maryland, from Sep 2000 to Apr 2001.

eas survived to April, while 11% of the bobwhites in non-buffer strip areas survived to April.

The low bobwhite survival in buffer strip areas may indicate these areas lacked adequate cover for protection from predators. Predation affected bobwhite survival in both buffered and non-buffered areas. Our personal observations were consistent with those of Sisson et al. (2000) who observed many species of bobwhite predators, especially hawks and owls, were attracted to release sites to prey on released birds. Bryan and Best (1991) found that most bird species, in Iowa, preferred the habitat in buffer strips. Bryan and Best (1991) reported total bird abundance was three times higher in buffer strips than in field plots. With an increase in the availability of prey, predators may respond with greater efficiency in their search effort for prey in buffer strip areas and less effort in non-buffer strip areas.

Table 1. Minimum convex polygon (MCP) home range estimates of pen-raised northern bobwhite coveys in buffer strip and non-buffer strip areas at Tudor Farms in Dorchester County, Maryland, from Sep 2000 to Apr 2001.

Treatment type	Coveys	95% MCP (hectares)	Number of locations	Survival days
Buffer Strip	Cephas—4	1.75	41	66
	Sandhill—4	3.89	8	17
	Sandhill—3	5.95	18	48
	Cephas—3	10.01	128	167
	Sandhill—2	13.41	54	119
	Walnut Hill—5	13.70	25	48
	Sandhill—1	13.75	140	163
	Walnut Hill—1	16.69	109	86
	Storr—1	19.94	49	81
	Cephas—1	23.31	38	79
	Collins—1	24.96	92	176
	Collins—2	32.87	65	155
Non-buffer Strip	Fork Neck—2	15.27	43	51
	McCollister—1	23.81	53	89
	Lowe—2	27.55	115	205
	Mowbray—1	30.45	36	102
	Mowbray—2	34.00	21	70
	Walnut Hill—3	40.55	121	228
	Lowe—1	44.69	104	99
	Walnut Hill—2	45.17	125	193
	McCollister—2	65.78	81	78

We found the main cause of predation was similar to those of DeVos and Speake (1995) in Alabama, and Mueller et al. (1997) in South Carolina, which indicated avian predators were the most common of the known causes of mortality to pen-raised bobwhites. However, Mueller (1984) found 68% of all predations on pen-raised bobwhites in the spring were attributed to mammalian predators, 18% to avian predators, and 14% to unknown predators. The release of other pen-raised birds such as ring-necked pheasant (*Phasianus colchicus*), and gray partridge (*Perdix perdix*) in managed areas may augment the concentration of bobwhite predators in buffer strip areas. In addition, the mowed roads maintained between the buffer and forests at the treatment locations may have caused bobwhites to be more exposed to avian predators as they traveled from the buffer to forest habitats.

The small home range sizes we found in buffer strip areas may be an indication that bobwhites did not need to move as far to acquire the food and cover resources as did bobwhites in the non-buffered areas. For example, in our study the minimum home range size of 1.7 ha was in a buffer strip area and the maximum home range size of 65.8 ha was in a covey in a non-buffered area. Overall, our average MCP home range size (24 ha) was somewhat larger than those reported in other studies (Dixon et al. 1996, Mueller et al. 1997). Dixon et al. (1996) reported a mean home range size of 11.1 ha, while Mueller et al. (1997) reported a larger mean home range size of 17.2 ha. Wild bobwhite coveys in North Carolina had mean home range sizes of 28 ha in buffer strip areas and 89 ha in non-buffer strip areas (Puckett et al. 2000). Our mean home range size in buffer strip areas and non-buffer strip areas was 15 ha and 36 ha, respectively.

In addition, the timing of agricultural crop harvest may also have affected home range size. Covey movements were larger prior to crop harvest than after crop harvest. The presence of standing crops seemed to provide coveys greater protection in their daily movements. The larger range in movements could be due to reduced pressure from predators. These movements could also be imitating bobwhites during the ''fall shuffle'' when family groups of wild bobwhites disperse.

Although covey home ranges were significantly larger in non-buffered areas, the larger range of movement in these areas did not result in a higher mortality rate, as reported in the literature. This may indicate that predators were not as aggressively searching for prey in the non-buffer strip areas as they were in the buffer strip areas.

From these data, we suggest that the presence of buffer strips did not improve survival of pen-raised bobwhites at Tudor Farms. This data, however may indicate that buffer strips may provide suitable habitat due to the smaller home range size of coveys in buffer strips compared to those in non-buffer strips. We suggest that buffer strips did not provide adequate protection from predators. Although pen-raised bobwhites may not adequately represent wild bobwhite survival, our results may support the need to test the effects of buffer strips on wild bobwhite survival.

ACKNOWLEDGMENTS

We thank Tudor Farms Inc. for funding the study, and C. Lewis for her dedicated fieldwork and technical assistance. We thank A. Bradshaw who raised the bobwhites and provided technical assistance, and M. Airey, A. Jolicouer, and B. Lowe for their technical assistance. We appreciate cooperation of landowners who allowed us access to their property. We also thank M. Tome and J. Wiley for review of this manuscript.

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