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EFFECTS OF FILTER STRIPS ON HABITAT USE AND HOME RANGE OF NORTHERN BOBWHITES ON ALLIGATOR RIVER NATIONAL WILDLIFE REFUGE

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ABSTRACT

Lack of breeding habitat for northern bobwhites (*Colinus virginianus*) on agricultural landscapes is a factor that limits populations. Therefore, we examined how the addition of filter strips around crop fields and along crop field drainage ditches impacted northern bobwhites. Our study focused on habitat use, home range and brood-rearing range of bobwhites, from April through September 1993–94. Two farms on Alligator River National Wildlife Refuge were sub-divided into filter strip (FS) and non-filter strip (NFS) sections. More bobwhites were found on FS sections than on NFS sections based on flush counts (4.3x more on FS areas; $P = 0.02$). We used log-linear analysis to examine the distribution of telemetry locations ($n = 1796$) of radio-marked bobwhites ($n = 218$) across 5, 4.6m bands parallel to drainage ditches. Bobwhite locations were skewed towards ditches, particularly on FS sections before soybeans matured to a size that was sufficient to provide canopy cover for bobwhites. Bobwhites captured on FS sections had significantly smaller breeding season ranges than those captured on NFS sections ($P = 0.001$). Adult and sub-adult breeding season (May–Aug) ranges ($n = 23$) averaged 32 ha (SE = 26) and 182 ha (SE = 41) on FS and NFS sections, respectively. Brood ranges to 14 days ($n = 9$) ranged from 0.8 ha to 2.2 ha depending on habitat and calculation method. Presence of filter strips shifted habitat use patterns, especially during spring and early summer, and improved crop fields as habitat for breeding bobwhites.

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INTRODUCTION

The continental bobwhite population has declined 2.4% per year since 1966 (Church et al. 1993). Biologists largely agree that one reason for this decline has been habitat loss related to agricultural modernization (Brennan 1991, Minser and Dimmick 1988, Burger et al. 1990). Much of the habitat lost in agricultural settings has been nesting and brood-rearing areas. Such breeding habitat components are critical to quail population recovery after a period of typically high fall-spring mortality (Stoddard 1931, Rosene 1969, Roseberry and Klimstra 1984, Burger et al. 1995, Puckett et al. 1997).

In today's modern agricultural ecosystems, strategies for reversing habitat loss and quail population declines must be practical and affordable. Filter strips and field borders may meet these criteria because they are easily incorporated into row crop agriculture and can be economically feasible for producers to establish (Bromley, unpublished data). Potential for addressing habitat loss through the use of filter strips and field borders exists in federally sponsored conservation programs, such as the Conservation Reserve Program, as well as individual state programs. The U.S. Department of Agriculture's (USDA) National Conservation Buffer Initiative goal of 2,000,000 miles of field borders and filter strips by the year 2000 suggests field borders will become important habitat elements on some agricultural landscapes. However, the biological

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value of filter strips to quail and other wildlife are not known.

For these reasons, we investigated the potential of drainage ditch filter strips to serve as components of bobwhite breeding habitat on modern soybean and small grain farms. Using telemetry and flush counts, we tested the null hypotheses that bobwhite habitat use and home range size during the breeding season would be identical in farming systems with and without drainage-ditch filter strips.

STUDY AREA

Our study areas were 2 farming units (Western Study Area, WSA, and Eastern Study Area, ESA) on Alligator River National Wildlife Refuge (ARNWR) in Dare County region of the northeastern coastal plain in North Carolina. The study areas were separated by a 5 km buffer zone comprised of moist soil waterfowl management units and farm fields. The area surrounding the study areas was uninhabited pocosin and mixed-pine/bottomland hardwood (approximately 80,000 hectares). Bobwhite hunting was prohibited on the study areas.

The study areas were further divided to create one filter strip (FS) and one non-filter strip (NFS) section on each area. FS and NFS sections within study areas were separated by approximately 10 m wide drainage canals. The WSA's FS section (WSFS) and NFS section (WSNFS) were 282 ha and 219 ha, respectively, for 1993 and 1994. The ESA's FS section (ESFS) was 640 ha. The ESA's NFS section (ESNFS) was 217 ha and 411 ha in 1993 and 1994, respectively. Each study section (n = 4) was partitioned by parallel drainage ditches (range, 41 to 84 per section) at 100 m intervals. Mean ditch length was 0.9 km (range: 0.3–1.3 km). Mean field size within sections was 6 ha (range: 4–10 hectares), and mean number of fields per section was 50 (range: 30–81). Habitat categories for all sections included: crop, wooded (peninsulas of wooded land jutting into the farming units), filter strip, road/levee, and fallow (land out of production > 1 year) (Table 1).

Filter strips were designed for the primary purpose of filtering runoff from precipitation. They were heterogeneous buffers of planted and natural vegetation along agricultural drainage ditches. The filter strips were planted with a mixture of kobe lespedeza (*Lespedeza striata*), ladino clover (*Trifolium repens*), and sericea lespedeza (*Lespedeza cuneata*) between 1989–1992. Naturally occurring vegetation (*Solidago* sp., *Aster* sp., *Paspalum* sp., *Eupatorium* sp.) dominated most filter strips.

Mean width of filter strips was 9.2 m (n = 99, SE = 0.14) from edge to edge including the ditch itself. Width of cover from edge to edge along non-filter stripped ditches averaged 2.5 m (n = 99, SE = 0.05) including the ditch width. Filter strips accounted for 4.9–9.4% of treatment sections. While filter strips were not mowed during the study, canal banks and road/levees on FS and NFS areas were mowed during winter.

Table 1. Classification of habitat types during 1993 and 1994 on all sections of the Alligator River National Wildlife Refuge study areas, Dare Co., North Carolina.

1993	Crop	Wooded	Filter strip	Road/ levee	Fallow
WSA[a]	60%	12%	4%	1.8%	22.2%
ESA[b]	63%	1.9%	4.9%	2.2%	28%
WSFS[c]	58%	14%	5.5%	1.7%	20.8%
WSNF[d]	64%	8.8%	2.2%	2%	23%
ESFS[e]	60.5%	2.5%	5.7%	2.3%	29%
ESNFS[f]	70%	0%	2.4%	1.6%	26%
1994					
WSA	77%	12%	6%	1.8%	3.2%
ESA	69%	2.6%	9.4%	2.3%	16.7%
WSFS	73%	14%	8%	1.7%	3.3%
WSNFS	82.8%	8.8%	2.7%	2%	3.7%
ESFS	69%	2.6%	9.4%	2.3%	16.7%
ESNFS	75%	0%	2.3%	1.4%	21.3%

[a] Western Study Area.
[b] Eastern Study Area.
[c] WSFS = WSA filter strip area.
[d] WSNFS = WSA non-filter strip area.
[e] ESFS = ESA filter strip area.
[f] ESNFS = ESA non-filter strip area.

Crop production enterprises on the study areas included continual full season broadcast-planted soybeans (not drilled in rows on 8" centers, but spin seeded behind a tractor and disked into the soil) and winter wheat (*Triticum* sp.), or conventional drill-planted soybeans and winter wheat with little use of corn (*Zea mays*) in the rotation. Additionally, U.S. Department of the Interior, Fish and Wildlife Service (USFWS) regulations prohibited the use of "restricted-use" pesticides.

METHODS

Bobwhites were captured from February–July using funnel entrance traps similar to those described by Stoddard (1931). Bobwhites (n = 218, 68% female in 1993, 63% female in 1994), were aged (Rosene 1969) and fitted with 6.1 g necklace transmitters. Radiomarked bobwhites were located daily by triangulation or homing with 3-element hand-held YAGI systems (White and Garrott 1980). Observers were tested to determine average bearing error by locating 30 transmitters that were hidden at varying distances from 10 telemetry stations. The average bearing error was + 6.4 degrees. Bobwhites estimated to be within 50 m or beyond 300 m from nearest telemetry stations were located through homing. Approximately 30% of all locations were determined by homing. Hens with broods were located 2–4 times daily the first 14 days post-hatch to define the brood-rearing range prior to substantial chick fight capability.

Flush Counts

We conducted flush counts along drainage ditches during June and early July to compare quail use of habitat along ditches with and without filter strips. Different sub-sections, representing 10–20 ditches, of the FS and NFS sections were surveyed in pairs on each

Table 2. Number of northern bobwhites counted per km of drainage ditches, with and without filter strips, during flush counts conducted during June, July, and August of 1993 on Alligator River National Wildlife Refuge, Dare Co., North Carolina.

Date	FS[a] quail/km	NFS quail/km
1993		
15 June (WSA)	1.16	0.38
29 July (WSA)	2.95	0.29
14 August (ESA)[b]	0.78	0.19

[a]FS = filter strip area, NFS = non-filter strip area, WSA = western study area, ESA = eastern study area.
[b]Not used in analyses.

Table 3. Number of northern bobwhites flushed per km along drainage ditches, with and without filter strips, during flush counts conducted during June and July, 1994 on Alligator River National Wildlife Refuge, Dare Co., North Carolina.

	Western Study Area		Eastern Study Area	
Date	FS[a] Quail/km	NFS[b] Quail/km	FS Quail/km	NFS Quail/km
7 June	4.17	0.53	0.54	0.33
16 June	4.30	0.48	0.99	0.33
17 July	0.19	0.66	0.50	0.44

[a] Filter Strip.
[b] Non-Filter Strip.

day. In 1993, 4 sections were surveyed, but surveys were conducted on different days for the 2 study areas (i.e., ESA or WSA). In 1994, flush counts were conducted simultaneously on FS and NFS sections of both study areas. Observers walked along all drainage ditches within each sub-section counting flushed quail. Observers were instructed to avoid counting flushed quail more than once. The number of bobwhite flushed per km of drainage ditch for each section surveyed (n = 16) were compared using t-tests for independent samples, pooling across month. Data from 1994 were analyzed using ANOVA with study area, month and FS treatment as factors. Ratios of quail flushed per km were log-transformed to meet test assumptions.

Brood Range Vegetation

Brood ranges (n = 9) were demarcated in the field from maps of telemetry locations. Coverage by grass, forbs, debris, woody, and bare ground at ground level in brood ranges was measured by randomly placing 5 to 10 two meter line transects. Vegetation height was measured at 3 points, 3 m apart, in the 4 cardinal directions along transects perpendicular to line transects. An additional 2 m line transect was placed above vegetation to determine percent canopy closure.

Vegetation data were analyzed using nested factorial ANOVA (SAS PROC GLM, SAS Inst., 1985). Differences in structure between crop and fallow brood ranges were tested using t-tests (Steel and Torrie 1980).

Additional Analytical Methods

Telemetry locations (n = 5083), pooled across years, were incorporated as layers in Atlas GIS study area maps (Strategic Mapping, Inc. 1989). All locations (n = 1796) within 23 m of a drainage ditch, excluding the initial 23 m along the ditch from a main canal or road, were categorized by their proximity to the ditch center (Atlas, GIS BUFFER Function) into 5, 4.6 m bands, which was the average width of filter strips. Each band category was discrete from all others. Locations within these bands were analyzed using multi-way log-linear independence analysis by band, study area (WSA, or ESA), section (FS, or NFS), and period (early, $<$ 15 July, or late, $>$ 15 July).

Adult and brood range sizes of bobwhite chicks $>$14 days after hatch were calculated using Harmonic Mean and Minimum Convex Polygon estimators in McPAAL version 1.2 (Stuwe and Blohowiak 1985, Dixon and Chapman 1980, Mohr 1947). Bobwhites included in home range analyses were captured in March, April, or May and survived from capture until 30 September. Home range size, area, and month of initial capture interactions were examined using ANOVA (SAS PROC GLM, SAS Inst., 1985). Differences in brood range size between crop and fallow primary habitat types were tested using t-tests for means with equal variances (Steel and Torrie 1980).

RESULTS

Effects of Filter Strips on Habitat Use

Flush Count Surveys

Flush count surveys (n = 16) were conducted along 232 km (113 FS, 119 NFS) of drainage ditches. Over all flush counts, we flushed an average of 1.5 quail/km on FS bordered ditches and 0.4 quail on ditches without filter strips (t = 2.6, df = 7.3, P = 0.02). Though there were more quail flushed per km of FS ditches, the more substantial effect of filter strips was noted on the WSA (Tables 2 and 3). In 1994, analysis of variance indicated more quail were flushed on FS sites (F = 30.5, df = 1,4, P = 0.017), during surveys conducted in June than in July (F = 41.9, df = 1,4, P = 0.003) and on the WSA (F = 25.8, df = 1,4, P = 0.007). A filter strip treatment × month interaction (F = 64.9, df = 1,4, P = 0.001) resulted from greater declines in quail flushed per km on FS ditches from June surveys to July surveys. An area × month (F = 33.7, df = 1,4, P = 0.004) interaction resulted from greater declines in quail flushed per km on the WSA than the ESA from June surveys to July surveys. Finally, a treatment × area × month interaction (F = 35.6, df = 1,4, P = 0.004) resulted from greater numbers of quail being flushed per km of drainage ditch on FS sections of both study areas in June and on the ESA during July, but slightly more quail flushed per km on the western study areas NFS section than FS section in July. Reduced numbers of bobwhites flushed during July can probably be attributed to increased flushing difficulty as summer progressed. Once crops matured and provided cover, quail may have been more likely to run into standing soybeans rather than fly out of the filter strips.

Telemetry Locations and Filter Strips

Categorization of bobwhite locations by band, study area, section, and period resulted in 40 data analysis cells. Number of observations per cell ranged from 8 to 231, with a mean of 45.97 (SE = 6.39). Log-linear analysis demonstrated no 4-way interaction, and indicated only one significant 3-way interaction, section*study area*period (log-linear model deleting section*study area*period $G = 4.34$, $P = 0.037$). Further analysis was conducted to examine the strengths of factors involved in location distribution. Of particular interest were the effects of deleting the 2-way interaction terms band*period, band*section, and band*study area from the saturated model. These deletions were examined under the assumption that bird locations (band categorizations) were by-products of the interaction between period, section, and study area, and could therefore be considered dependent variables. The data suggest these deletions were logical choices.

The largest change in the likelihood-ratio chi square occurred with the deletion of band*period (log-linear $G = 34.2$, $P = 0.000$), followed by band*section (log-linear $G = 14.5$, P = 0.006), and band*study area (log-linear $G = 11.3$, $P = 0.023$). It is important to note in this analysis that large numbers of observations in many cells may have complicated efforts to sort out lack of significance.

Filter Strip Effects on Range Size

Overall mean nesting season range ($n = 23$, pooled 15 FS captured and 8 NFS captured) was 53 ha (SE = 11) and 101 ha (SE = 33) for Harmonic Mean (HM) and Minimum Convex Polygon (MCP) estimators, respectively.

Adult bobwhite nesting season HM estimated ranges differed ($F = 14.4$, $df = 1,17$, $P = 0.001$) based on capture section [FS ($n = 15$) captured versus NFS ($n = 8$) captured], but not among months of capture ($F = 2.9$, $df = 2, 17$, $P = 0.08$). We observed no capture month/capture section interaction ($F = 2.16$, $df = 2,17$, $P = 0.15$). Minimum convex polygon estimated ranges demonstrated significant effects of capture month ($F = 9.7$, $df = 2, 17$, $P = 0.01$), capture section ($F = 9.6$, $df = 1,17$, $P = 0.007$), and capture month/capture section interaction ($F = 4.9$, $df = 2, 17$, $P = 0.02$). Using either estimator, presence of filter strips was most significant, with FS section captured bobwhites having the smaller ranges. Using the HM estimator and pooling across capture months, mean NSR's were smaller for bobwhites captured on FS sections (28 ha, $n = 15$, SE = 9) than for bobwhites captured on NFS sections (89 ha, $n = 8$, SE = 14). Using the MCP estimator and pooling across capture months, mean NSR's were 32 ha (SE = 26) and 182 ha (SE = 41) for quail on FS areas and quail captured on NFS sections, respectively.

There were differences in NSR sizes using both HM and MCP estimators based on capture month. Least squares means indicated that quail captured in May had significantly greater home ranges than quail captured in April or June ($P < 0.10$). Using the HM estimator, ranges for quail captured in March, April and May pooled across capture areas were 46 ha ($n = 9$) (SE = 11), 84 ha ($n = 7$) (SE = 12), and 46 ha ($n = 7$) (SE = 17), respectively. Using the MCP estimator, ranges for March, April and May captured bobwhites were 54 ha (SE = 34), 211 ha (SE = 37), and 55 ha (SE = 53), respectively.

Brood Range Size

Brood ranges ($n = 9$) of bobwhites > 14 days after hatch averaged 1.1 ha (SE = 0.4) and 2.2 ha (SE = 0.5) using HM and MCP estimators, respectively. Brood ranges were in either crop (broadcast-planted soybeans) or fallow fields. There was no overlap. Crop brood ranges ($n = 5$) averaged 1.4 ha (SE = 0.8) and 2.2 ha (SE = 0.6) using HM and MCP estimators, respectively. Fallow brood ranges ($n = 4$) averaged 0.8 ha (SE = 0.3) and 2.2 ha (SE = 0.9) using HM and MCP estimators, respectively. There were no significant differences between crop and fallow range sizes using either HM ($t = 0.13$, $df = 7$, $P = 0.9$) or MCP ($t = 1.12$, $df = 7$, $P = 0.3$) range averages for comparison. Using the MCP method, seasonal adult ranges ($n = 23$) averaged 101 ha (SE = 33) and were 46× larger than the average 14 day brood range.

Brood Range Vegetation

Vegetation in brood ranges of hens using fallow areas and soybeans was very similar in height and canopy closure. Mean cover heights were 67.7 cm ($n = 780$) (SE = 1.39), 69 cm ($n = 480$) (SE = 2.12), and 64.8 cm ($n = 300$) (SE = 1.52) for pooled, fallow, and crop range categories, respectively. Mean length of openings at canopy level were 13.6 cm ($n = 177$) (SE = 1.02) and 15.5 cm ($n = 299$) (SE = 1.25) for crop and fallow ranges, respectively. Mean distances between openings in the canopy were 6.8 cm (SE = 0.76) and 5.9 cm (SE = 0.71) for crop and fallow ranges, respectively. Mean total amounts of opening per 200 cm transect at canopy level were 130 cm (65% of transect) (SE = 8.59) and 150 cm (75% of transect) (SE = 7.44) for crop and fallow ranges, respectively. Bare ground averaged 46% in crop fields and 31% in fallow brood ranges ($P = 0.0001$). Forbs were a greater component of vegetation in fallow brood ranges, averaging 11.3%, than in crop fields where forbs averaged 2.6% of the vegetation ($P = 0.014$). Grasses were more prominent in fallow brood ranges, averaging 30%, than brood ranges in crop fields which averaged 18% grasses ($P = 0.0006$). There was no significant difference in amount of debris between brood ranges in crop fields and fallow habitats ($P = 0.072$), 33% versus 27% coverage, respectively.

DISCUSSION

The smaller nesting season ranges of bobwhites using FS areas, the greater number of quail flushed along filter stripped drainage ditches, and the disproportionate use of drainage ditches with filter strips, particularly prior to crop maturation, indicate that filter strips influenced how quail used the farmed landscape during the breeding season. Filter strips may have been attractive to bobwhites during spring, because little residual herbaceous vegetation from the previous growing season other than filter strips was available to quail on these farms. Filter strips provided travel and escape cover during spring and early summer when crop fields were devoid of cover or nearly so.

Both flush counts and telemetry analysis indicated that FS drainage ditches were used more than NFS ditches. Drainage ditches without filter strips also affected quail movements, however, not to the degree of FS ditches. By the late season, both FS and NFS ditch habitat use declined. As summer progressed, crops provided a habitat alternative to both filter strips and fallow habitats. However, presence of FS appeared to attract quail to farm fields at the beginning of the nesting season; bobwhites remained on FS areas throughout the nesting season. This pattern of quail use of the farmed landscape, in association with presence of more nesting cover at the beginning of the nesting season, resulted in much greater nest production on FS areas than NFS areas. Most (83%) of the 53 incubated nests located during the study occurred on FS areas (Puckett et al. 1997). There were 1 nest per 3 radio-marked quail and 1 nest per 8 radio-marked quail on FS and NFS sections, respectively. On NFS areas, quail remained in wooded areas, habitat along roads and canal banks during spring and exhibited large movements to nesting areas. These movement patterns, and the lack of early nesting cover, resulted in fewer incubated nests and larger nesting season ranges for quail captured on areas without filter strips.

While filter strips served as nesting areas for quail, nest success was low (Puckett et al. 1997) during the early nesting season. As soybeans matured, weedy sections in the crop fields were used for nesting. Klimstra and Roseberry (1975) found that nearly two-thirds of the variation in spring to fall population increases during the course of their study could be attributed to number of chicks produced per hen. In addition, the number of chicks produced per hen was almost equally dependent on both total number of nests per hen and their success rate (Klimstra and Roseberry 1975). Dimmick (1975) found that, of all variables tested, total number of nests constructed was most strongly correlated with December bobwhite densities. The above examples suggest that, though nesting success was low in filter strips, the contribution to the fall bobwhite population may have been positive.

The smaller nesting season ranges of bobwhites inhabiting FS areas compared to those inhabiting NFS areas suggest that habitat quality was enhanced by filter strips. Guthery et al. (2000) recently challenged wildlife managers to think in terms of increasing "usable space" rather than simply thinking about improving habitat quality. In addition, Guthery et al. (2000) pointed out that, within a given boundary, usable space could be maximized with a number of different habitat patch arrangements. The addition of filter strips within a relatively simple farm ecosystem apparently increased usable space during the spring and early summer when the habitat provided by filter strips allowed quail to use portions of farm fields away from "hard" edges that were less "available" to quail on areas without filter strips.

The presence of filter strips may have also improved the suitability of crop fields as brood-rearing cover for bobwhites. In terms of productivity, all but one brood confirmed alive at 14 days after hatching inhabited FS sections. The one occurring on a NFS section inhabited an area where mature soybeans bordered fallow land. All brood ranges (n = 5) found in soybean fields incorporated filter strips. Quail brood survival (percentage of quail chicks surviving to 28 days) in FS sections was high (0.68–0.85), and brood range sizes were small (Puckett et al. 1997). Vegetation analysis within soybean/filter strip brood ranges demonstrated them to be markedly similar to fallow field brood ranges in structure. Similar habitats in small grain agrisystems in Great Britain increased insect abundance and grey partridge (*Perdix perdix*) →chick survival (Potts 1986, Sotherton et al. 1993).

Recent research has revealed that northern bobwhite reproductive potential is higher than biologists previously believed. Monogamy among bobwhites is the exception rather than the rule (Curtis et al. 1993). The importance of the male bobwhite to overall recruitment is greater than previously believed (Curtis et al. 1993, Suchy and Munkel 1993, Burger et al. 1995). Renesting and double clutching among bobwhite hens can contribute significantly to overall chick production (Curtis et al. 1993, Suchy and Munkel 1993, Burger et al. 1995). Late season recruitment can be limited by reduced clutch sizes characteristic of the period and a reduction in the proportion of available hens initiating clutches after mid-summer (Puckett et al. 1997). It is hypothesized that rates of male incubation, female renesting and female double clutching are a function of early season nesting success of hens (Burger et al. 1995). This emphasizes the importance of the availability of nesting and brood rearing cover throughout the breeding season (Burger et al. 1995, Puckett et al. 1997). Researchers in Kansas recently concluded that bobwhite managers should emphasize increasing both quantity and quality of nesting and brood-rearing cover (Taylor et al. *this volume*).

While filter strips may not be the panacea that will solve all problems faced by bobwhites on the modern industrial agriculture countryside, they have the potential to increase quail recruitment by providing what is often the only available nesting and brood-rearing cover during spring and early summer. They may also improve the quality of brood-rearing habitat throughout the breeding season. In a study conducted by Stinnett and Klebenow (1986) in Nevada, California quail (*Callipepla californicus*) were found to prefer filter strip habitats during all seasons.

MANAGEMENT IMPLICATIONS

For any effort at restoring bobwhite populations to be effective, it must first be simple, practical and affordable. Additionally, any effort to reverse the bobwhite decline must be directed at privately owned land. Currently, 50% of our nation, or 907 million acres, is privately owned pasture, range and crop land (USDA 1996). Private landowners may be more willing to accept filter strips than other more restrictive conservation practices such as the idling of entire crop fields.

After years of exclusion from federal farmland conservation programs, legislation in the 1996 farm bill made wildlife a 1/3 partner in our nation's 3 major conservation programs, the Conservation Reserve Program, the Wildlife Habitat Incentives Program and the Environmental Quality Incentives Program. In each program there are provisions for cost-sharing wildlife friendly practices including filter strips and field borders. Most recently, USDA is promoting a "Buffers for Bobwhite" initiative with a goal of 2 million miles of buffer by the year 2000. All these programs have the potential to provide many acres of usable bobwhite habitat. It is up to professional biologists and quail managers, however, to insure they are implemented in the bobwhite's best interest.

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