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EFFECTS OF FILTER STRIPS ON HABITAT USE AND HOME RANGE OF BOBWHITES ON MODERN GRAIN FARMS

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Abstract: Habitat for breeding northern bobwhite (*Colinus virginianus*) may be limiting on landscapes dominated by agriculture. This is especially evident during spring and early summer when most row crops have not matured. Therefore, we examined the effects of adding filter strips around crop fields and along crop field drainage ditches on habitat use and home range of quail during the breeding seasons of 1993 and 1994. To examine the potential of soybean/filter strip farming systems to serve as quail brood habitat, we compared fallow field brood ranges (N = 4) to brood ranges in soybean/filter strip areas (N =

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5). Two farms on Alligator River National Wildlife Refuge were sub-divided into filter strip(FS) and non-filter strip (NFS) sections. A greater number of bobwhite were found on FS sections than on NFS sections during flush counts (4.3X more on FS ares)($P<0.000$), primarily before 15 July. The distribution of locations ($N = 1796$) of radio-transmittered quail ($N = 218$) was examined across 5, 4.6m bands paralleling drainage ditches using log-linear analysis. Bobwhite locations were skewed towards ditches, particularly on FS sections before crops matured and provided canopy cover (before 15 July). After soybeans attained a canopy, quail increased their use of crop fields and decreased their use of filter strips. Bobwhite 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-August) ranges ($N = 23$) averaged 32 ha ($SE = 26$) and 182 ha ($SE = 41$) on FS and NFS sections , respectively. Brood ranges to 14 days ($N = 5$) in crop fields averaged 1.4 ha ($SE = 0.8$) and 2.2 ha ($SE = 0.9$) using harmonic mean (HM) and minimum convex polygon (MCP) estimation, respectively. Brood ranges ($N = 4$) in fallow fields averaged 0.8 ha ($SE = 0.3$) and 2.2 ha ($SE = 0.9$) using HM and MCP estimation, respectively. Presence of filter strips shifted habitat use patterns, especially during spring and early summer, and improved crop fields as breeding and brood-rearing habitat.

Key Words: bobwhite quail (*Colinus virginianus*), agriculture, Alligator River National Wildlife Refuge, North Carolina, telemetry, filter strip, home range, flush count, broadcast-planted, soybeans (*Glycine max*)

The continental bobwhite population has declined at a rate of 2.4% per year since 1966 (Church et al. 1993). It is accepted that one reason for the decline is habitat lost to agricultural modernization (Brennan 1991, Minser and Dimmick 1988, Burger et al. 1990). Much of the habitat lost was prime nesting and broodrearing cover, habitat critical to quail population recovery from 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 decline must be simple, practical and affordable. We believe filter strips meet these criteria. Great potential for addressing habitat loss and wildlife population declines exist in Federally sponsored agriculture programs, e.g. the Conservation Reserve Program, Wildlife Habitat Incentives Program and Environmental Quality Incentives Program (and many state sponsored programs).

For these reasons, we investigated the implementation of drainage ditch filter strips as replacements for lost habitat on modern soybean and small grain farms. By combining telemetry and flush counting techniques, we examined the null hypotheses that bobwhite habitat selection and use and home range size would be identical in farming systems with and without drainage-ditch filter strips.

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STUDY AREA

Study areas (Western Study Area, WSA, and Eastern Study Area, ESA) were 2 farming units on Alligator River National Wildlife Refuge (ARNWR) in Dare Co. North Carolina located in the state's northeastern coastal plain. 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 farming units was unpopulated pocosin and mixed-pine/bottomland hardwood (approx. 80,000 ha). 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. The WSA's FS section (WSFS) and NFS section (WSNFS) equalled 281.6 ha and 218.8 ha respectively for 1993 and 1994. The ESA's FS section (ESFS) equalled 640 ha. The ESA's NFS section (ESNFS) equalled 217.2 ha and 410.8 ha in 1993 and 1994, respectively. All sections (n = 4) were partitioned by drainage ditches. Ditches were parallel and occurred at approximate 100 m intervals. Ditch length averaged 0.9 km (range: 0.3 - 1.3 km). Individual field size within sections averaged 6 ha (range: 4 - 10 ha). Number of fields per section averaged 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, whose primary purpose was filtering runoff and preventing sedimentation, were heterogeneous buffers of planted and natural vegetation along agricultural drainage ditches. ARNWR filter strips were planted with a mixture of kobe lespedeza (*Lespedeza striata*), ladino clover (*Trifolium repens*), and serecia lespedeza (*Lespedeza cuneata*) between 1989-1992. Naturally occurring vegetation had invaded most planted filter strips.

Filter strips averaged 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, ditch banks and road/levees on FS and NFS areas were mowed in winter.

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, USFWS regulations prohibited the use of "restricted-use" pesticides.

METHODS

Bobwhite were captured from February - July using funnel entrance traps similar to Stoddard's (1931). Quail (n = 218, 68% female in 1993, 63% female in 1994), were aged (Stoddard 1931, Leopold 1939, Haugen 1957, Rosene 1969) and fitted with 6.1 g necklace transmitters modified for harnesses. Transmittered quail were located daily by triangulation or homing with 3-element hand-held YAGI systems (White and Garrott 1980). Triangulation error was estimated through field testing and equalled ± 6.4°. Bobwhite estimated to be within 50 m or beyond 300 m from relocation points were located through homing. Approximately 30% of all locations were homings. Hens with broods were located 2-4 times daily the first 14 days post-hatch.

Flush counts.--To examine bobwhite filter strip use through changing habitat conditions, flush counts (3 in 1993, 3 in 1994) were conducted during the months of June, July, and August. Flushing surveys in 1993 were conducted without replication. In 1994 replication was achieved by simultaneously surveying all study area sections. Surveys were conducted by individuals walking approximately equal amounts of FS and NFS drainage ditches and counting flushed quail. To avoid afternoon temperature extremes, surveys were conducted between 0700-1200 hours. The numbers of bobwhite flushed per km of FS and NFS section drainage ditch were compared using tests of proportions (Steel and Torrie 1980).

Brood Range Vegetation Examination.--Brood locations were plotted on study area maps by hand. Brood ranges (n = 9) were demarcated in the field by pacing distances along appropriate azimuths. After ranges were marked, within range vegetation was sampled at ground level along randomly located 2 m line transects (from 5-10 depending on primary habitat) for amounts of grass, forb, debris, woody, and bare ground components. Vegetation heights (n = 12) were measured at 3 points 3 m apart in the 4 cardinal directions along transects perpendicular to ground level transects. An additional transect extending from the end of the ground level transect was examined for amount and spacing of open area at canopy level.

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 for means with equal variances (Steel and Torrie 1980).

Additional Analytical Methods:

Differences between numbers of FS section-captured vs NFS section-captured bobwhite moving from one section type to another were tested using tests of proportions (Steel and Torrie 1980).

Telemetry locations (N = 5083), pooled across years, were incorporated as layers in Atlas GIS study area maps (Strategic Mapping, Inc. 1989) (McManus, 1995; personal communications GEO-GRAPHICS Raleigh, NC 919-859-6217). All bird locations ($\underline{n}$ = 1796) within 22.9 m of a drainage ditch center, excluding the initial 22.9 m along the ditch from a main canal or road, were categorized by their proximity to the ditch center (Atlas, GIS BUFFER Function). Categories were 4.6 m, 9.2 m, 13.8 m, 18.3 m, and 22.9 m bands from ditch centers on both ditch sides. Each band category was discrete, or non-cumulative from all others. All locations falling within these bands were analyzed using multi-way log-linear independence analysis. The analysis components were: band, study area (WSA, or ESA), section (FS, or NFS), and period (early, ≤ 15 July, or late, > July).

Adult/sub-adult and 14 day brood range sizes 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). Adult/sub-adults included in home range analysis were March, April, or May captured quail that survived through the end of 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

Filter Strip Effects on Section (FS or NFS) Selection:

Pooling across areas and years, twenty-one quail (12 FS and 9 NFS) captured on or before 15 April survived to 15 July. One of 12 FS section captured and 2 of 9 NFS section captured bobwhite had moved from their respective capture areas (NFS to FS or FS to NFS) by 15 July. There was no difference in proportion of FS and NFS section captured bobwhite exhibiting section changeover ($P > 0.1$).

Within Section Effects of Filter Strips:

Flush count surveys.--Flush count surveys ($n = 6$) were conducted along 232 km (113 FS, 119 NFS) of drainage ditches.

Pooling data by year and across study areas, a decline in the ratio of FS quail/km to NFS quail/km was noted as the season progressed each year (Tables 2 and 3). There were 1.55 quail/km flushed on FS drainage ditches and 0.36 quail/km flushed on NFS drainage ditches. This 4.3x difference was significant (P <0.000).

In 1993 flushing surveys were not replicated. Individually, there were significantly higher proportions of quail flushed per kilometer on FS ditches regardless of study area (Table 2) (P < 0.05).

Though there were higher proportions of quail flushed per kilometer on FS ditches during 1994, the more substantial effect of filter strips was noted on the WSA (Table 3). Additionally, a seasonal effect was noted. By mid-July, quail use of filter strips appeared to decline on both study areas, most notably on the WSA (Table 3). Some of the apparent decline should 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.

FS and NFS ditch effects on within section location distributions.--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). Graphic representation of bobwhite location percentages by band, study area, section, and period demonstrate the influences not only of filter strips, but, also the effects of period and the early-season effects of non-filter stripped drainage ditches (Figure 1).

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 $\underline{G}$ = 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 $\underline{G}$ = 34.2, P = 0.000), followed by band*section (log-linear $\underline{G}$ = 14.5, P = 0.006)., and band*study area (log-linear $\underline{G}$ = 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 Sub-Adult Range Size:

Pooling data from all sub-adult/adult ranges (n = 23), nesting season ranges (NSR's) averaged 53 ha (SE = 11) and 101 ha (SE = 33) for Harmonic Mean (HM) and Minimum Convex Polygon (MCP) estimators, respectively.

Analysis of variance in NSR sizes using HM ranges revealed significant effects of capture section (FS vs NFS captured) (P = 0.001), but no significant month effect (P = 0.08), or capture month/capture section interaction (P = 0.15). Analysis of variance in NSR sizes using MCP ranges demonstrated significant effects of capture month (P = 0.01), capture section (P = 0.007), and capture month/capture section interaction (P = 0.02). In both cases, capture section effect was most significant, with FS section captured bobwhite having the smaller ranges.

There were differences in NSR sizes using both HM and MCP estimators based on capture month, however, the differences did not depend on the length of time a particular quail had undergone monitoring. 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), and 54 ha (SE = 34), 211 ha (SE = 37), and 55 ha (SE = 53) using HM and MCP estimation, respectively.

Using the HM estimator and pooling across capture months, mean NSR's were 28 ha (n = 15) (SE = 9) and 89 ha (n = 8) (SE =

14) for FS and NFS section captured quail, respectively, and differed significantly (P = 0.001).

Using the MCP estimator and pooling across capture months, mean NSR's were 32 ha (SE = 26) and 182 ha (SE = 41) for FS and NFS section captured quail, respectively, and differed significantly (P = 0.007).

Brood Range Size.--Fourteen day brood ranges (n = 9) 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 or MCP range averages for comparison (P > 0.2, P > 0.5). Using the MCP method, seasonal adult ranges (n = 23) averaged 101 ha (SE = 33) and were 46x larger than the average 14 day brood range.

Brood range vegetation.--Mean cover heights were 67.7 cm (n = 668) (SE = 1.39), 69.01 cm (n = 424) (SE = 2.12), and 64.83 cm (n = 124) (SE = 1.52) for pooled, fallow, and crop range categories, respectively. There was no statistical difference in mean cover height between fallow and crop ranges (P > 0.05).

Mean open area patch sizes at canopy level were 13.58 cm (n = 177) (SE = 1.02) and 15.50 cm (n = 299) (SE = 1.25) for crop and fallow ranges, respectively. There was no statistical difference ($P > 0.05$). Mean distances between open area patches at canopy level were 6.84 cm (SE = 0.76) and 5.86 cm (SE = 0.71) for crop and fallow ranges, respectively, and did not differ ($P > 0.05$). Mean amounts of open area at canopy level were 130.1 cm (SE = 8.59) and 150.4 cm (SE = 7.44) for crop and fallow ranges, respectively, and did not differ ($P > 0.05$).

There was significantly more bare ground in crop ranges ($P > 0.0001$), more forb in fallow ranges ($P < 0.02$), and more grass in fallow ranges ($P < 0.0007$) (Table 4). There was no significant difference in amount of debris between ranges ($P > 0.07$).

DISCUSSION

The smaller nesting season ranges of FS captured quail, the greater number of quail flushed along filter stripped drainage ditches and the skewing of bobwhite telemetry locations towards drainage ditches, particularly FS ditches prior to crop maturation indicate that filter strips influenced local quail ecology during the breeding season. Additional information from our study (Puckett et al. 1997) supports these findings. Pooling nesting data across areas, sections and years, 44 of 53 incubated nests occurred on FS areas (Puckett et al. 1997). There were 1 nest / 3 transmittered quail and 1 nest / 8 transmittered quail on NFS and FS sections, respectively. Movements of NFS section captured quail to first nest site were significantly greater than the same movements for FS captured bobwhite (Puckett et al. 1997).

We did not, however, observe a migration of NFS section captured bobwhite into FS sections during the nesting season, indicating that once bobwhite selected a section type they tended to remain there. Section selection prior to the nesting season could explain the lack of difference in proportions of FS and NFS section captured bobwhite shifting from one section type to another.

Within section movements were strongly affected by drainage ditches. Locations were skewed towards ditches, and revealed that effects generated by FS drainage ditches occurred most notably during the early season. Non-filter stripped drainage ditches also affected quail movements, however, not to the degree of FS ditches. By the late season, both FS and NFS ditch habitat use declined, however, the decline in use of FS drainage ditches was proportionately less than that for NFS ditches.

While filter strips effected habitat use, there were strong filter strip / crop growth interactions. As summer progressed, crops matured, provided cover and insect food and served as an alternative to filter strip and fallow habitats. Additionally, a possible synergistic effect was generated by the mature soybean and filter strip interaction.

All but one brood confirmed alive at 14 days occurred on FS sections. The one that occurred on a NFS section occurred in an area where mature soybeans bordered fallow land. All brood ranges (n = 5) in soybean areas 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 - habitat recognized by quail ecologists as superior for brood-rearing. Similar habitats in small grain agrisystems in Great Britain increased insect abundance and grey partridge (*Perdix perdix*) chick survival (Potts 1986, Sotherton 1993).

Biologists have advanced our knowledge of quail ecology dramatically over the previous 10 years. We now know that monogamy amoung bobwhites is the exception rather than the rule (Curtis et al. 1993). Other breeding strategies have come to light. 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 amoung 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 believed that much of the male incubation, female renesting and female double clutching observed is driven by female early season nesting success (Burger et al. 1995). For the bobwhite to realize its innate reproductive potential, nesting and brood rearing cover must be available the entire breeding season, late-April to mid-September (Burger et al. 1995, Puckett et al. 1997).

While filter strips may not be the panacea, they have the potential to positively influence quail recruitment in modern agricultural systems by providing what is often the only available nesting and brood-rearing cover during spring and early summer, and improving the quality of brood range habitat throughout the breeding season. This may have already been evidenced by another species. 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

Managers should all agree, 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). How can managers influence such a large acreage?

There is hope. After years of exclusion from Federal farmland conservation programs, legislation in the 1996 farmbill makes wildlife a 1/3 partner in our nations 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.

As managers, we don't need the entire 907 million acres. Our study on ARNWR demonstrated the effects positive habitat manipulation can have on local populations when spread over a relatively small area. We manipulated 5% or less of the existing farmland. The inclusion of wildlife stipulations in Federal cost-share programs gives us an opportunity to examine the effects of habitat manipulation on a landscape scale. State sponsored cost-share programs should be aimed at filling in the gaps. The most important goal of today's wildlife managers should be the implementation of a national program to educate agricultural professionals to the needs of wildlife. We must insure that vegetation promoted for wildlife practices is truly wildlife friendly. The next step should be quantifying existing habitat and identifying areas of critical need. Operating together, we can insure conservation programs conserve soil, water and wildlife.

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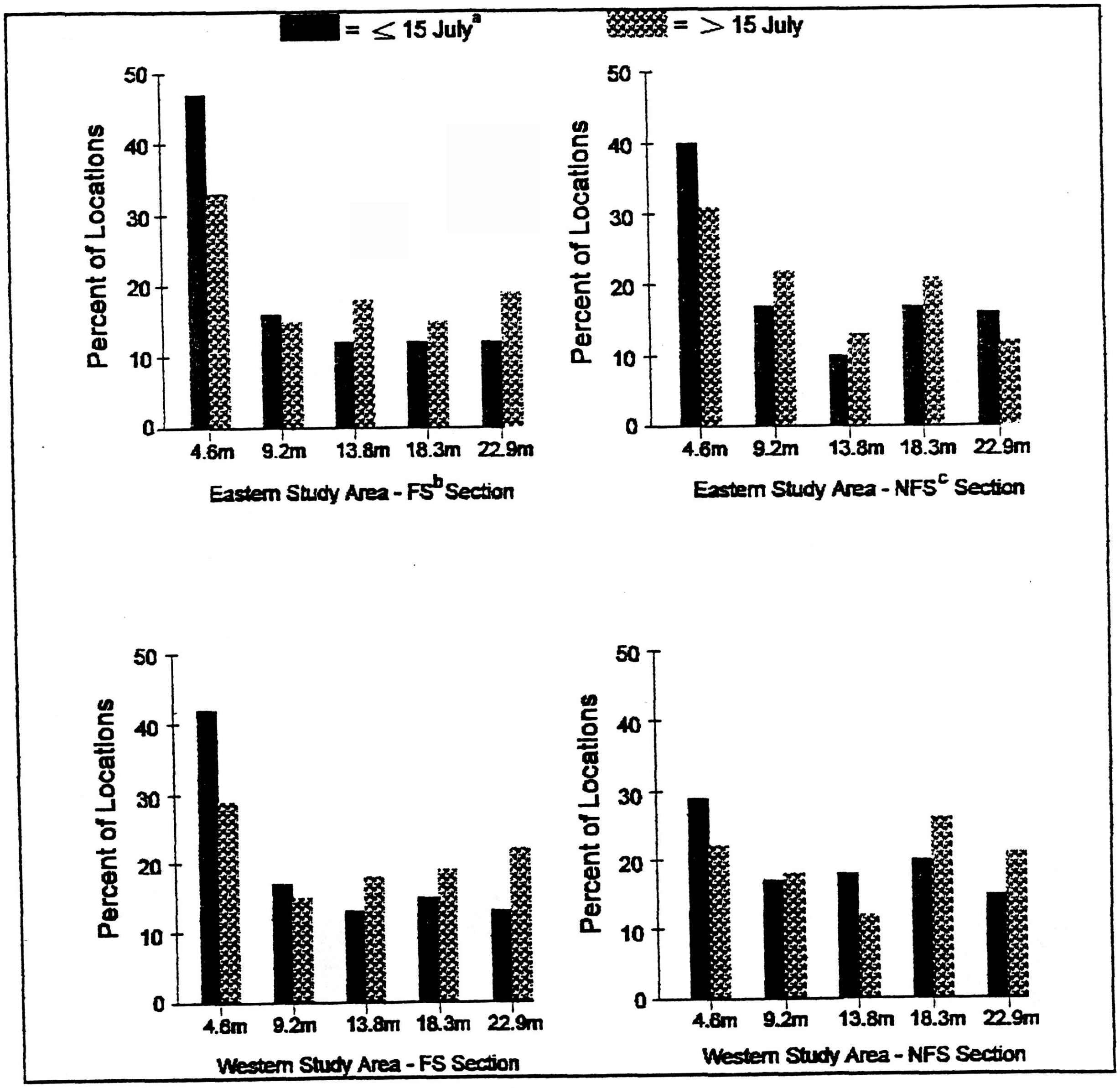
Figure 1. Bobwhite quail location percentages by zone, in increasing increments from drain-age ditch centers, for all study areas and sections on Alligator River National Wildlife Refuge, Dare Co. North Carolina from April-September 1993, and 1994.



[a]For all periods

[b]Filter strip

[c]Non-filter strip

Table 1. Habitat percentages for 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

Table 2. Results of filter stripped vs non-filter stripped drainage-ditch bobwhite quail flushing surveys conducted during June, July, and August of 1993 on Aligator River National Wildlife Refuge, Dare Co., North Carolina.

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

[a]Filter stripped

[b]Non-filter stripped

[c]Western Study Area

[d]Eastern Study Area

Table 3. Results of replicated 1994 filter stripped versus non-filter striped drainage-ditch bobwhite quail flushing surveys by section 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[c]	4.30	0.48	0.99	0.33
17 July[d]	0.19	0.66	0.50	0.44

[a]Filter Strip

[b]Non-Filter Strip

Table 4. Lengths (cm) and percentages of bare ground, forb, grass, debris, and woody components along 2 m line transects in crop (n = 4) and fallow (n = 4) brood ranges on Alligator River National Wildlife Refuge, Summers of 1993 and 1994.

Range type	Mean bare[a]	%	Mean forb	%	Mean grass	%	Mean debris[b]	%	Mean woody
Crop	92.1	46	5.25	2.6	35.5	17.7	67.1	33.5	0.00
Fallow	63.4	32	22.3	11	59.7	29.8	54.6	27.3	0.00

[a]bare ground

[b]all dead vegetation matter