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BREEDING BIRD ABUNDANCE AND DISTRIBUTION
IN FENCE ROW HABITAT

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BREEDING BIRD ABUNDANCE AND DISTRIBUTION IN FENCE ROW HABITAT

By

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ABSTRACT

BREEDING BIRD ABUNDANCE AND DISTRIBUTION
IN FENCE ROW HABITAT

By

Scott Dee Shalaway

Breeding bird abundance, distribution, and nesting success were determined for 4.6 km of fence row habitat during a two-year study in south-central Michigan. Nested plots (.001 ha) were used to sample habitat variables associated with nest sites and fence rows in general. Breeding bird abundance and diversity were measured in 100 m long fence row plots and related to habitat variability. A total of 152 nests representing 16 species was located. Song Sparrows (*Melospiza melodia*), Robins (*Turdus migratorius*), Cardinals (*Richmondena cardinalis*), and Red-winged Blackbirds (*Agelaius phoeniceus*) were the most common nesters. Nest density averaged 19 nests/km of fence row (43 nests/ha of fence row habitat). A discriminant function analysis of the nest site habitat variables showed that three guilds of breeding birds and three types of fence rows could be distinguished. Cavity nesters, ground nesters, and shrub/tree nesters were distributed over grassy, shrubby, and wooded fence rows. Multiple regression and canonical correlation analyses indicated that fence row width, adjacent field type, and the amount of shrubs were the most important habitat variables associated with changes in breeding bird abundance and diversity. Nesting success was unexpectedly high (58%) and seemed to be associated with the apparent absence of common nest predators (e.g.,chipmunks and arboreal snakes). It is argued that fence rows can be considered preferred nesting habitat for species with flexible habitat requirements. Implications for farm wildlife management are discussed, and recommendations for management and future research are offered.

To the memory of my father -

and our autumn walks in Niantic

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (cont'd.)

LIST OF FIGURES

INTRODUCTION

A major problem facing wildlife populations is habitat loss to land developments associated with our society. Most important in terms of total area is habitat loss to agriculture, which has resulted in the clearing and draining of our most fertile land for over 200 years. Consequently, 60% of our nation's land area is now in private ownership, and 47% of this land is devoted to agriculture (Horvath 1976).

Fertile farmland is also potentially prime wildlife habitat. Man's needs for food, fiber, and economic return justify the priority given to agriculture on these fertile areas, but wildlife production and conservation are not necessarily incompatible with agriculture. Conservation plans instituted by the Soil Conservation Service since the 1930s have resulted in the widespread use of agricultural practices which also benefit wildlife -- strip cropping, contour farming, crop rotation, minimum tillage, and grass waterways, to mention a few. As a result farmland today supports over 75% of the nation's wildlife (Dale 1956, Horvath 1976).

Farmland has an even greater potential for wildlife production if fence rows are considered. Fence rows are distinct, linear strips of vegetation which become established along stone, rail, and wire fences. They are typically dissimilar in structure and composition from adjacent fields, and serve as field dividers. Their structure ranges from simple grass borders to more complex associations of trees and shrubs.

Fence rows represent an extreme habitat discontinuity that may function ecologically as an edge, though lacking ecotonal qualities. They are typically narrow and do not change structurally in cross section as a true edge does, but they do form a distinct community between two adjacent habitat types. The concept of edge effect suggests that the abundance and diversity of organisms tend to increase wherever two or more vegetation types meet (Odum 1971). Gates and Gysel (1978) reviewed this concept and emphasized its applicability to avian populations. Edges have become critically important to wildlife management projects which include habitat manipulation. Many wildlife species benefit by the creation of a mosaic of vegetation types in management areas.

The objectives of this study were to: 1) identify bird species that nest in fence row habitats, 2) determine which habitat variables are most responsible for the observed differences in nest habitat preferences, and 3) report nesting success and comment on the role of predators as a limiting factor in fence row bird populations. Hopefully this paper will demonstrate that fence rows are productive wildlife habitat and stimulate further studies so that future recommendations regarding fence rows are based on reliable ecological principles.

Edminster (1938) pointed out that fence row management was the only way to provide permanent wildlife habitat on cultivated land. Yet fence rows provide a wildlife habitat whose potential is still undetermined. The value of fence rows to wildlife has been intuitively obvious for decades (Leopold 1933, 1945; Steavenson et al. 1943, Johnson 1948, Allen 1949, DeVos and Mosby 1969). Governmental agencies have promoted their benefits (Grange and McAtee 1934, Darling et al. 1936, Stevens 1937, Hill and Bradt 1940, Edminster 1941, Anderson and Compton 1965), and many states have spent millions of dollars establishing thousands of miles of fence rows. But documentation of wildlife use of fence rows has been limited. Olgilvie and Furman (1959) noted small mammal use of fence rows, but most accounts of bird use have been casual and subjective. Petrides (1942) reported that fence rows provided food and cover for a variety of wildlife types, but his conclusions were based on winter observation of birds, old nests, and mammal tracks. Many papers have emphasized the importance of fence rows to farm wildlife species, but no discrete measure of fence row value has been reported (Dambach 1943, Allen 1952, Dale 1956). In studies which considered the effects of clean farming on wildlife, Kabat and Thompson (1963) and Vance (1976) concluded that widespread elimination of fence rows resulted in severe declines in populations of quail and rabbits. In a study that included habitats structurally similar to fence rows, Dow (1969) reported that male Cardinal densities were disproportionally high in narrow, wooded habitats.

Recently, British ecologists have similarly documented the importance of hedges as wildlife habitat (Moore et al. 1967, Pollard et al. 1974). However, hedges differ from fence rows in that they are tall, planted, homogeneous stands of vegetation. The value of hedges has been demonstrated for insects (Pollard 1968), birds

(Hooper 1970), and mammals (Pollard and Relton 1970). These linear strips of vegetation became increasingly important as wildlife habitat as native shrubs and forest vegetation were reduced or eliminated.

It therefore follows that, as destruction of wildlife habitat continues, fence rows may become equally important in this country. This is especially true in the Midwest and Great Plains, where farms are characterized by huge expanses of unbroken crop fields. Occasional vegetation barriers provide food, cover, and travel lanes for wildlife as well as windbreaks, snow fences, and erosion barriers for farmers.

STUDY AREA

The study was conducted on 4.6 km of fence rows within 170 ha (420 ac) of level to gently sloping farmland in Ingham County, Michigan. The area is located just south of Okemos in Section 32 of Meridian Township on either side of Hulett Road. Approximately 139 ha (82%) of the study area were under cultivation and 17 ha (10%) were old fields. Fence rows comprised only 2 ha (1%) of the study area. The remaining 12 ha (7%) consisted of woodlots, wetlands, and residential property. Land use patterns and fence row distribution are illustrated in Figure 1.

Soils on this farmland are primarily Conover loam (Udollic Ochragualfs) and Brookston loam (Typic Argiquolls) with small areas of Miami sandy loam (Typic Hapludalfs). These soils are on level to nearly level areas of glacial till plains. The Conover and Brookston series are imperfectly to poorly drained soils developed on calcarious loam or silt loam till materials. The Miami series is well-drained soil of similar origin.

The climate of the area is quasi-marine in spite of Michigan's mid-continent location. Prevailing westerly winds and the ameliorating effect of the Great Lakes are primarily responsible for this condition (Strommen 1967). Because of the lake waters' slow response to air temperature changes and the dominant westerlies, summer and winter are delayed. Winter temperatures are moderated by increased cloudiness

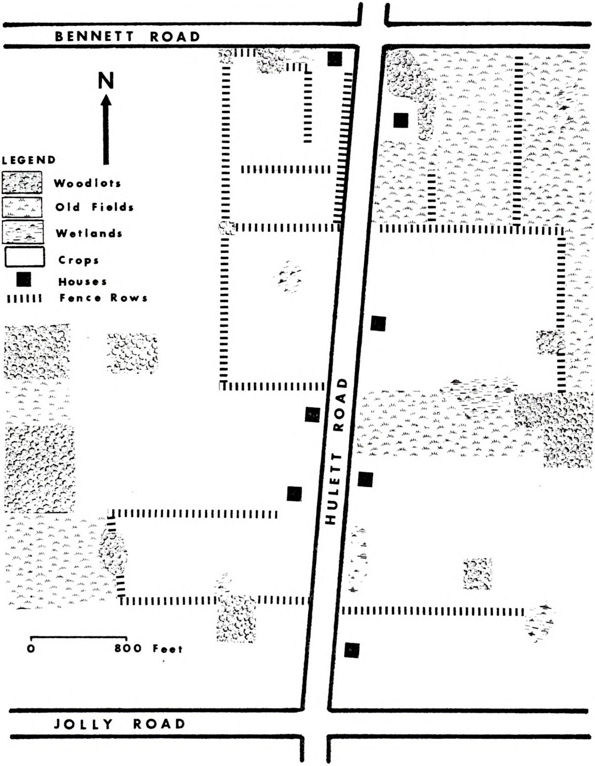

Figure 1. Major land uses and fence row distrbution at the study site.

caused by the lake effect. Mean minimum temperatures are above freezing from April through October (United States Department of Commerce 1977, 1978). Mean maximum temperatures are above freezing from March through November. Precipitation averages 787.4 mm annually. Summer moisture falls primarily as showers or thundershowers, while steadier precipitation of less intensity occurs the rest of the year. Thirty to 40 sometimes violent thunderstorms are not uncommon throughout the summer months.

METHODS

Habitat Analysis

Three discrete habitat analyses were performed to determine 1) the general composition and structure of fence rows, 2) nest site habitat structure of each breeding bird species, and 3) the components of fence row habitat structure that were associated with changes in the abundance and variety of nesting birds.

General fence row characteristics were determined by the results of a nested plot sampling technique. Fence rows were marked with numbered, red flags at 50 m intervals. Sixty randomly chosen flags were used as sampling points for this analysis, which was made in June and July, 1977. Each sample point was considered the center of a 2.5 m x 4.5 m nested plot (Fig. 2). The longer edge of the plot was oriented along the linear axis of the fence row. Within this plot all stems greater than one inch (2.54 cm) dbh were recorded by size and species. All other woody stems were counted and identified in the center half of the plot. Relative frequency and relative density were calculated for all woody species; relative dominance was calculated for all species in the larger plot. These parameters indicate the relative "importance" of each species to the fence row plant community (Whittaker 1970). Absolute measurements in conventional area terms (ha or ac) would be difficult to relate to this unique, linear community. At each end of the larger plot a 1 m^2 circular plot was used to estimate

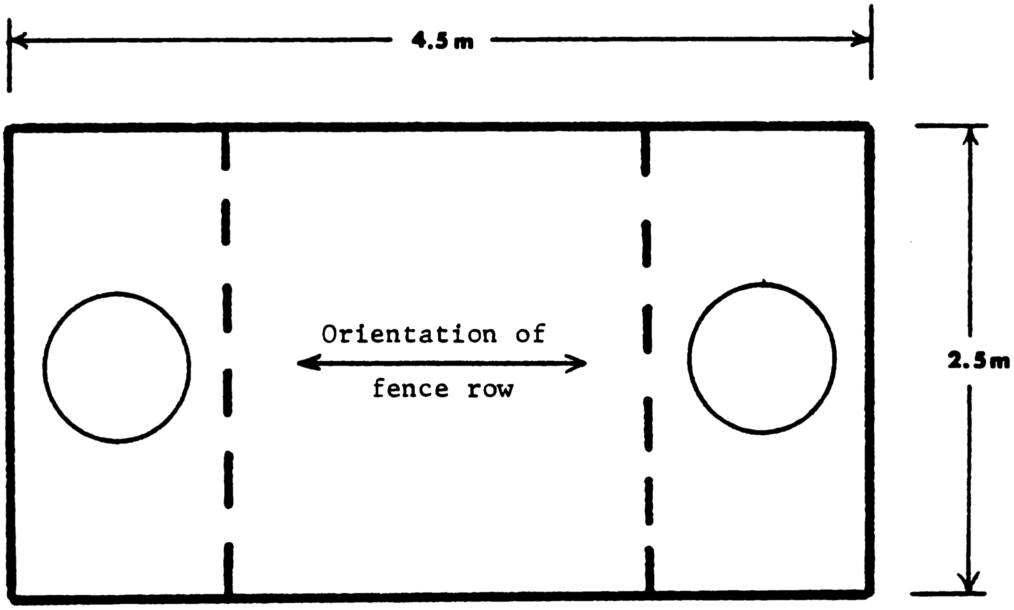

Figure 2. Diagram of the nested plots used for vegetation analyses. All stems $\geq$ 2.54 cm dbh were recorded. Stems $<$ 2.54 cm dbh were counted in the center half of the plot. The circles represent 1 m^2 ground cover plots.

ground cover. Horizontal cover was estimated at the center and each end of the large plot using a density board (Nudds 1977).

Nest site habitat variables were measured in the same manner, within a week after nest activity ceased. The nest was considered the center of the plot, and density board readings were taken only at the nest. Each nest was evaluated according to degree of concealment (Gottfried and Thompson 1978). Nests were ranked as concealed (2), intermediate (1), or exposed (0) from each of three perspectives, i.e., above, below, and to the sides. The ranks were summed to give a cover rating for each nest. Completely concealed nests were rated as 6, totally exposed nests as 0. Table 1 summarizes the habitat variables measured at each vegetation sample point and nest site. The results of the nest site habitat analysis were used to delineate the fence row types used by different groups of nesting species.

Fence row habitat components associated with the abundance and diversity of nesting birds were determined by the third sampling procedure. Fence rows were too heterogeneous in structure to establish large plots of uniform fence row type. Instead, forty-six 100 m-long plots were established. Eight habitat variables were measured at each plot. The first four variables were the proportion of grass, open shrubs, dense shrub, and wooded fence row per plot, determined by assigning these habitat designations at 5 m intervals within each plot. These distinctions were based on fence row height and woody stem density. The number of habitat changes per plot, fence row width, and adjacent field type were also recorded. The total number of nests and nesting species were recorded for each plot. Table 2 summarizes the habitat variables recorded at each 100 m plot.

Table 1. Key to symbols of the habitat variables measured at each nest and in each vegetation plot.

Variable name	Description
ADJF	Adjacent field type. Code: 1=crop/crop; 2=crop/road; 3=road/old field; 4=old field/crop; 5=old field/old field.
FRWID	Fence row width in meters
FRHT	Fence row height in meters
GRD	Percent ground cover
C1M	Percent horizontal cover at 1 meter (density board). Code: 1=0-20%; 2=21-40%; 3=41-60%; 4=61-80%; 5=81-100%
C2M	Percent horizontal cover at 2 meters. Same code as C1M.
CNEST*	Nest cover index. Range: 0 (poor) to 6 (excellent)
HB	Number of herbaceous plant species
S	Number of shrub species
T	Number of tree species
NST	Sum of S + T
DGT4	Number of stems greater than 10.2 cm (4 in) dbh
D14	Number of stems 2.54 cm (1 in) to 10.2 cm (4 in) dbh
DLT1	Number of stems less than 2.54 cm (1 in) dbh
VINE	Number of vine stems
SNAG	Number of snags

*Nest plots only

Table 2. Key to symbols of the habitat variables measured at each 100 meter fence row plot.

Variable name	Description
GRASS	Percent of plot in grass; less than 1.5 m high
OSHR	Percent of plot in open shrubs; 1.5 - 3.5 m high
DSHR	Percent of plot in dense shrubs; 1.5 - 3.5 m high
ALLSHR	Sum of OSHR + DSHR
TREE	Percent of plot in trees; greater than 3.5 m high
CHNG	Number of fence row type changes per plot
ADJF	Adjacent field type. See Table 1 for code.
FRWID	Fence row width in meters

During the first year 3.5 km of fence rows were studied. An additional 1.1 km were added in 1978 because my nest finding ability had improved and a larger area could be efficiently searched. The 11 additional 1978 plots included only one year's data for number of nests per plot. In the data analysis the number of nests per plot for these additional 11 plots was doubled to approximate two years of data. The number of species per plot was not changed because the original 35 plots showed no change from year to year.

Bird Nest Data

Nest searches began in April and continued through September, 1977 and 1978. Nests were sought at least five days per week by walking the fence rows and carefully searching areas from which a bird flushed, sang, or exhibited any type of nesting behavior. Birds were flushed from particularly dense areas by gently beating the vegetation with a stick. Once a nest was located, its contents were checked daily. I considered a nest successful if at least one nestling fledged (Nolan 1963). A pole and mirror device was used to examine nests higher than 2 m (Parker 1972). Nest locations were mapped, and particularly well concealed nests were marked by placing a small flag on the edge of the fence row farthest from the nest. Precautions were taken to reduce the likelihood of predation due to the frequency and exposure of nest checks (Gates and Gysel 1978). Nest check disturbances were minimized by walking in the fields along the fence rows and going into the fence row only where a nest was located. Recent studies indicate that nest visits do not affect nest fate (Willis 1973 , Anderson and Storer 1976, Gottfried and Thompson 1978).

Nesting bird species diversity (BSD) and abundance were calculated for each fence row type. Simpson's diversity index was used to measure BSD (Krebs 1978):

$$D = 1 - \sum_{i=1}^{S} (p_i)^2$$

where

D = Simpson's diversity index

p_i = proportion of the nests belonging to species i

Simpson's index ranges from a minimum value of zero to a maximum of (1 - 1/S), where S is the number of species. Species richness was measured by the number of species present. The cumulative richness of each fence row type indicates its relative value as bird nest habitat.

Other Fence Row Wildlife

Mammals and nonbreeding birds were noted wherever observed on the fence rows. In September 1978 small mammals were snap trapped for 10 nights. Seventy randomly selected points yielded a total of 700 trap nights. Winter bird activities were observed, and all spring and fall migrants were noted.

Data Analysis

Habitat differences between fence row types were tested with non-parametric statistics because the assumptions of normality could not be met (Sokal and Rohlf 1969). I used the Kruskal-Wallis one-way analysis of variance to test for differences between fence row types and the Kolmogorov-Smirnov goodness-of-fit test to compare the distribution of nests to the distribution of fence row types (Siegel 1956).

Chi-square tests were used to compare observed and expected values of nest success and Song-Sparrow nest distribution (Siegel 1956).

The importance of the various habitat variables was detected by several multivariate statistical procedures (Nie et al. 1975). Stepwise procedures were used so that variables which did not contribute significantly to the discriminating power of the tests were eliminated. Multiple regression analysis and canonical correlation were used to determine which habitat variables were responsible for changes in nest abundance and diversity on the 100 m fence row plots. Discriminant function analysis was used to determine habitat differences between species and between successful and unsuccessful nest sites. Habitat variables which could individually account for at least 10% of the discriminating power of the function were considered important. Data not meeting the assumptions of these techniques (Green 1979) were transformed by square root procedures (Sokal and Rohlf 1969).

RESULTS

Nest Site Habitat Ordination

During the two-year study 152 nests of 16 bird species were found in fence rows. Table 3 summarizes the number of nests for each species.

The discriminant analysis of bird species' nest sites produced three significant functions that accounted for 56, 28, and 5 percent of the among-group (species) variation (Table 4). Using the habitat variables associated with each nest site, 49% of all nests were correctly identified according to species ($p < .001$). In Function I snag density and fence row height were the most discriminating variables. Fence row height, cover a 2 m, and density of stems greater than 10.2 cm dbh were the important variables in Function II. Although the number of vines did not meet the criteria for importance, their presence was noted at almost all shrub nests. Species richness of woody vegetation and cover at 1 m were the most important variables in Function III.

When the functions are combined to form a three-dimensional representation of habitat volume (Fig. 3), three nesting guilds and three types of fence rows can be distinguished. Cavity nesters require snags and are grouped at the distal end of Function I. Within this guild these species are more finely separated by differences in nest site habitat characteristics which are associated with Function II.

Table 3. Summary of bird nest distribution, diversity, and success by species and fence row type. Number of successful nests is in parentheses.

Species	Code	Fence Row Type			Total	% Successful
		Grassy	Shrubby	Wooded		
Mallard (*Anas platyrhynchos*)	M	2(0)			2(0)	0.0
Kestrel (*Falco sparverius*)	K	2(2)			2(2)	100.0
Ring-necked Pheasant (*Phasianus colchicus*)	RNP	7(2)			7(2)	28.6
Mourning Dove (*Zenaidura macroura*)	MD			3(1)	3(1)	33.3
Black-billed Cuckoo (*Coccyzus erythropthalmus*)	BBC		1(1)		1(1)	100.0
Flicker (*Colaptes auratus*)	F	2(1)		4(3)	6(4)	66.7
Blue Jay (*Cyanocitta cristata*)	BJ		1(1)		1(1)	100.0
Black-capped Chickadee (*Parus atricapillus*)	BCC		2(2)		2(2)	100.0
Brown Thrasher (*Toxostoma rufum*)	BT		4(1)	3(3)	7(4)	57.1

Table 3 (cont'd.).

Species	Code	Fence Row Type			Total	%
		Grassy	Shrubby	Wooded		Successful
Catbird (*Dumetella carolinensis*)	CAT		3(3)	2(0)	5(3)	60.0
Robin (*Turdus migratorius*)	R		3(2)	22(13)	25(13)	58.9
Cedar Waxwing (*Bombycilla cedrorum*)	CW		1(1)		1(1)	100.0
Starling (*Sturnus vulgaris*)	S	6(4)		1(1)	7(5)	71.4
Red-winged Blackbird (*Agelaius phoeniceous*)	RWB	7(5)	5(2)		12(7)	58.3
Cardinal (*Richmondena cardinalis*)	C		9(5)	6(4)	15(9)	60.0
Song Sparrow (*Melospiza melodia*)	SS	37(19)	17(12)	2(2)	56(33)	58.9
Totals		63(33)	46(30)	43(25)	152(88)	57.9
% of total nests		41.4	30.3	28.3	100.0	
% successful		53.2	65.2	58.1		

Table 3 (cont'd.).

Species	Code	Fence Row Type			Total	% Successful
		Grassy	Shrubby	Wooded		
Bird species richness		7	10	8	16	
Cumulative richness		7	17	16		
Simpson's diversity index (D)		.62	.79	.69	.81	

Table 4. A comparison of habitat use by 14 species groups of nesting birds expressed by three discriminant functions (I, II, III). The percent of among group (species) variation is a measure of the importance of each function. The amount of group overlap is expressed by the percent of nests correctly identified, with 100 % indicating no overlap. Habitat variables contributing the greatest separation between groups are identified by the largest absolute discriminant function coefficients. See Table 1 for habitat variable symbols.

	Discriminant Function			Percent of nests correctly identified
	I	II	III	
Percent of among group variation accounted for	56.5	27.6	5.3	
Group (sample size)				
Mallard (2)				100.0
Kestrel (2)				100.0
Ring-necked Pheasant (7)				71.4
Mourning Dove (3)				33.3
Flicker (6)				66.7
Blue Jay, Cedar Waxwing, Black-billed Cuckoo (3)				33.3
Black-capped Chickadee (2)				100.0
Brown Thrasher (7)				0.0
Catbird (5)				20.0
Robin (25)				68.0
Starling (7)				42.9
Red-winged Blackbird (12)				8.3
Cardinal (15)				53.3
Song Sparrow (56)				50.0

Table 4. (cont'd.).

Habitat Variable	Discriminant Function I	II	III
	Standardized discriminant function coefficients		
ADJF	.21	.17	-.38
FRWID	.37	.06	-.07
FRHT	-.41	1.40	-.41
GRD	.08	.03	-.25
C1M	-.06	.07	-.83
C2M	-.07	.29	-.06
NTS	-.03	-.12	.85
DGT4	.17	.41	.39
D14	-.31	.11	-.60
DLT1	.10	-.05	-.24
VINE	.19	.23	-.06
SNAG	2.27	-.27	-.46

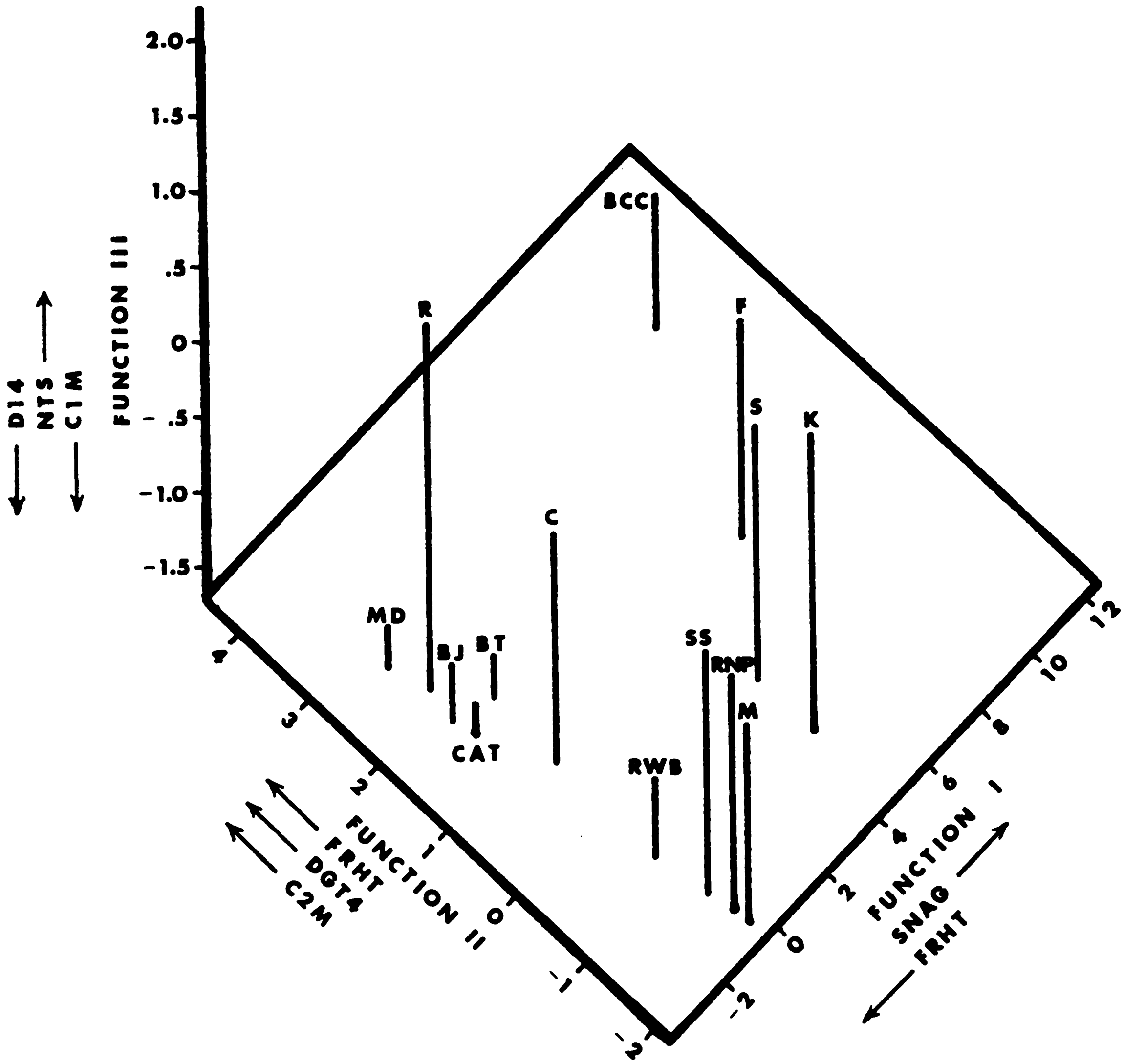

Figure 3. A three-dimensional ordination of breeding bird nesting habitat. The group centroid for each species is plotted in standardized discriminant space. Arrows indicate the direction of increase for the major discriminating variables. See Table 1 for habitat symbols and Table 3 for species symbols.

Ground nesters prefer low, grassy fence rows with few large trees. They are grouped at the lower end of Function II and are separated by species by differences in fence row height preference. The third nesting guild, shrub/tree nesters, is found at the distal end of Function II. Although Robins and Mourning Doves were tree nesters, no distinct break is evident between these species and shrub nesters. Therefore they are considered a single guild. It should be noted, however, that the tree nesters are located on the upper end of this distribution, while the shrub nesters are at the lower end (Fig. 3). Tree nesters prefer tall, wooded fence rows that have many stems greater than 10.2 cm dbh. Shrub nesters prefer shrubby fence rows which have many small woody stems, but few large woody stems. The shrub nesters were the most difficult to classify (Table 4) due to the similarity of their nest site characteristics. A detailed description of each fence row type -- grassy, shrubby, and wooded -- follows in the next section.

Fence Row Vegetation

The discriminant analysis of nest site habitat characteristics indicated that each species of breeding birds preferred one of the three distinct fence row types. A detailed description of these fence row types was obtained from the results of the initial habitat analysis. Grassy and shrubby fence rows were equally distributed and comprised 80% of the total. Wooded fence rows accounted for the remainder. Tables 5 and 6 summarize the species composition of the fence rows, while Table 7 compares structural features associated with each fence row type. Figures 4, 5, and 6 illustrate an example of each fence row type.

Table 5. Relative frequency, relative density, and relative dominance of trees (>2.54 cm dbh) in fence row habitat based on sixty .001 ha (.003 ac) plots.

Species	Relative Frequency (%)	Relative Density (%)	Relative Dominance (%)
Prickly ash (*Zanthoxylum americanum*)	20.0	60.0	18.0
American elm (*Ulmus americana*)	26.0	16.0	28.0
Snags (Various species)	9.0	4.0	23.0
Black cherry (*Prunus serotina*)	15.0	4.0	11.0
Hawthorn (*Crataegus* spp.)	9.0	6.0	7.0
Choke cherry (*Prunus virginiana*)	6.0	3.0	2.0
Dogwood (*Cornus* spp.)	2.0	5.0	1.0
White ash (*Fraxinus americana*)	5.0	1.0	2.0
White oak (*Quercus alba*)	4.0	1.0	3.0
Red mulberry (*Morus rubra*)	1.0	.5	5.0
Staghorn sumac (*Rhus typhina*)	1.0	.5	.5
Apple (*Pyrus malus*)	1.0	.5	.5

Table 6. Relative frequency and relative density of shrubs ($<$2.54 cm dbh) in fence row habitat based on sixty .001 ha (.003 ac) plots.

Species	Relative Frequency (%)	Relative Density (%)
Dogwood (*Cornus* spp.)	13.0	29.0
Summer grape (*Vitis aestivalis*)	20.0	12.0
Blackberry, Raspberry (*Rubus* spp.)	11.0	20.0
Virginia creeper (*Parthenocissus quinquefolia*)	17.0	12.0
Multiflora and pasture rose (*Rosa* spp.)	8.0	5.0
Honeysuckle (*Lonicera* spp.)	5.0	6.0
White oak (*Quercus alba*)	3.0	1.0
Black cherry (*Prunus serotina*)	3.0	1.0
American elm (*Ulmus americana*)	2.0	1.0
Hawthorn (*Cratageus* spp.)	1.0	1.0
Choke cherry (*Prunus virginiana*)	1.0	1.0
Staghorn sumac (*Rhus typhina*)	1.0	1.0

Table 7. Means and standard deviations of habitat variables used to describe each fence row type. Kruskal-Wallis (H) tests were used to determine if observed differences were significant. See Table 1 for key to habitat variable symbols.

Habitat Variable	Fence Row Type: Grassy (N=24)	Fence Row Type: Shrubby (N=24)	Fence Row Type: Wooded (N=12)	H	p
FRWID	5.8 ± 4.3	5.8 ± 8.2	4.7 ± 1.7	2.56	<.300
GRD	94.0 ± 9.0	56.0 ±27.0	48.0 ±32.0	21.77	<.001
C1M	3.8 ± .9	4.3 ± .7	4.2 ± .9	2.56	<.300
C2M	1.6 ± .9	3.3 ± 1.2	2.8 ± .8	22.56	<.001
CNEST	4.6 ± 1.6	5.3 ± 1.0	4.4 ± 1.3	23.51	<.001
HB	3.9 ± 1.0	2.9 ± 1.6	2.9 ± 1.7	1.23	<.700
S	1.3 ± 1.1	1.8 ± 1.1	1.6 ± .9	3.24	<.100
T	.8 ± .7	1.2 ± .8	3.2 ± 1.2	25.22	<.001
DGT4	.1 ± .4	.4 ± .7	2.7 ± 1.6	15.20	<.001
D14	1.6 ± 2.6	6.4 ± 9.9	13.6 ±10.5	57.43	<.001
DLT1	10.0 ±11.4	26.0 ±18.9	11.9 ± 9.4	1.03	<.700
SNAG	.04	.04	1.20	15.50	<.001

Figure 4. Grassy fence row vegetation was less than 1.5 m in height and had few woody stems. Notice the change to a shrubby fence row in the background.

Figure 5. Shrubby fence row vegetation was 1.5 to 3.5 m in height and was characterized by many woody stems less than 1 inch (2.54 cm) dbh.

Figure 6. Wooded fence row vegetation was greater than 3.5 m in height and characterized by many woody stems greater than 4 inches (10.2 cm) dbh.

Grassy fence rows were dominated by dense, herbaceous vegetation less than 1.5 m in height. Ground cover averaged 94%, while horizontal cover at a height of 2 m was less than 20%. Woody vegetation was sparse or absent. Brome grass (*Bromus inermis*) was the dominant ground cover species in all fence row types. Reed canary grass (*Phalaris arundinacea*) and timothy (*Phleum pratense*) were of secondary importance. Associated forbs included golden rod (*Solidago* spp.), burdock (*Arctium minus*), sourdock (*Rumex crispus*), cinquefoil (*Potentilla recta*), and wild carrot (*Daucus carota*).

Shrubby fence rows included both dense, impenetrable thickets and more open plots with scattered shrubs. Dogwood, summer grapes, blackberries, raspberries, Virginia creeper, and prickly ash were the dominant species. These plots were characterized by many stems less than 2.54 cm dbh and few trees larger than 10.2 cm dbh. Horizontal cover exceeded 80% at 1 m and 60% at 2 m. Ground cover averaged 56%.

Woody fence row vegetation exceeded 3.5 m in height and was dominated by stems greater than 2.54 cm dbh. Snags were common. Prickly ash, American elm, black cherry, and hawthorn were the characteristic species. Horizontal cover a 1 m was equal to that of shrubby fence rows, while cover at 2 m was less. Ground cover averaged 48%.

Bird Response to Fence Row Structure

Fence row width, type of adjacent fields, and the proportion of open shrub habitat emerged as the most important habitat variables influencing bird nest abundance and diversity in both the multiple regression and the canonical correlation analyses. A summary of these results is presented in Table 8.

Almost 60% (R^2 = .592) of the variation in number of nests is

Table 8. Summary of the results of the multiple regression and canonical correlation analyses. R-square represents the proportion of variation in Y accounted for by X. Absolute values of canonical coefficients represent the degree of importance of each variable.

	Multiple Regression		Canonical Correlation
	R^2 Value		
X	Y	Y	
Habitat Variables	NNEST[1]	NSPP[2]	Canonical Coefficient
Fence row width	.499	.310	.95
Adjacent field type	.062	.115	.30
% open shrub	.030	.043	-.26
% dense shrub	.001		-.13
% total shrub		.004	
% grass			-.04
No. of habitat changes			.01

[1] Number of nests per plot

[2] Number of nesting species per plot

accounted for by the above three habitat variables in the multiple regression. Similarly, 47% (R^2 = .468) of the variation in species richness is accounted for by these same variables. Individually, fence row width was the most important variable. Increasing width along a given length of fence row provides more total area, thereby providing greater nest site potential. Wider fence rows were expected to have more nests.

The canonical correlation analysis corroborates the results of the multiple regression. Only the first correlation was significant ($p < .001$). A canonical correlation of .786 (Eigenvalue = .617) was obtained, indicating that over 60% of the variation in nest abundance and richness (the first canonical variate) was accounted for by the habitat variables in the second canonical variate. Of the habitat variables, fence row width, adjacent field type, and the proportion of open shrub habitat accounted for 89% of the discrimination in the analysis.

The importance of adjacent field types is related to the attractiveness of these fields to birds. Fence rows bordered by old fields had more nests than those bounded by crop fields ($p = .05$, $t = 2.24$, $df = 26$). Fence rows serve as a habitat discontinuity to adjacent fields and act as an edge. This combination of edge and adjacent field attracts birds of both habitat types. Bobolinks and Meadowlarks which nested in the old fields used the fence rows as singing perches. Fence row nesters forage and gather nest material in adjacent old fields. Crop fields have no analagous bird community so their fence rows attract fewer birds.

Increasing nest density and diversity was associated with shrub abundance, but the analyses provided no way to predict optimum shrub allocation. The importance of shrubs in each fence row type should not be overlooked. In grassy fence rows shrubs provide singing, feeding, and lookout perches. Shrubby fence rows also provide heavy nesting cover. In wooded fence rows shrubs add a second nesting niche by providing understory structure. Most Cardinal, Brown Thrasher, and Catbird nests found in wooded fence rows actually occurred in the shrubby undergrowth. The importance of shrubs is further underscored by significant correlations between the two key habitat variables and measures of shrub abundance. Fence row width is positively correlated with the proportion of total shrub habitat ($r = .347$, $p = .009$). Adjacent field type is positively correlated with the proportion of dense shrub habitat ($r = .415$, $p = .002$).

Nest Density and Distribution

Fence rows averaged 19 nests/km/yr or 43.5 nests/ha if only total fence row area is considered. This is about 10 times greater than the density of nesting birds found on natural deciduous shrub habitat (Nolan 1963). Nest density is summarized and compared to breeding bird densities in other habitat types in Table 9. Table 3 summarizes nest distribution, success, and species diversity by fence row types for each nesting species.

The distribution of nests was tested against the distribution of fence row types present using the Kolmogorov-Smirnov goodness-of-fit test (Siegel 1956). No significant difference was found between the two distributions ($p = .05$). Grassy fence rows contained 63 nests, shrubby fence rows 46, and wooded fence rows 43.

A total of seven species nested on the grassy fence rows. Nesting

Table 9. Comparison of bird nest densities between fence rows and other habitats.

Habitat	Nests/km of fence row	Nests or breeding pairs/ha	Source
Fence row	19.0	43.5	This study (mean)
Fence row	8.9	25.5	Petrides 1942
Park-like resort		29.6	Pitelka 1942
Modified deciduous forest		19.8	Johnston 1970
Deciduous shrub		4.2	Nolan 1963
Pasture		1.2	Dambach & Good 1940
Cropland		.1	Good & Dambach 1943

bird species diversity was .62 (Table 3). Song Sparrows were dominant (59%), but their nest site preference was seasonal (Fig. 7). Most early nests (73%) were on the ground in grassy areas, while late nests were almost exclusively elevated in shrubs (95%). This seasonal difference in nest site preference was statistically significant ($X^2 = 22.10$, df = 3, $p < .001$). No other species showed a similar phenological nest site preference, although a change in the total number of ground nests was observed between 1977 and 1978.

The number of ground nests almost doubled from 1977 to 1978. Figure 8 illustrates the annual differences by species. These comparisons include only the original 3.5 km of fence rows. Red-winged Blackbirds showed the greatest annual increase in number of ground nests. In 1977 only 28% of their nests were on the ground; in 1978 all were. This shift in nest placement was associated with precipitation. Grass growth was reduced in 1977 due to a lack of rain in May (15.7 mm). As a result spring ground cover was sparse and Red-wings nested in shrubs. The following year May precipitation was higher (52.3 mm), grass growth was lush, and Red-wings nested exclusively in the grass. Similarly, more Song Sparrow, Ring-necked Pheasant, and Mallard ground nests were found in 1978, though the differences were not statistically significant ($p > .05$). Spring precipitation may be a critical limiting factor for ground nesting birds by regulating the amount of nest cover available.

Starlings and Kestrels, though cavity nesters, preferred open, grassy fence rows whenever large snags were present. Abandoned Flicker holes in such areas attracted these species. Two active Flicker nests were found in similar areas. One particular snag housed a Kestrel,

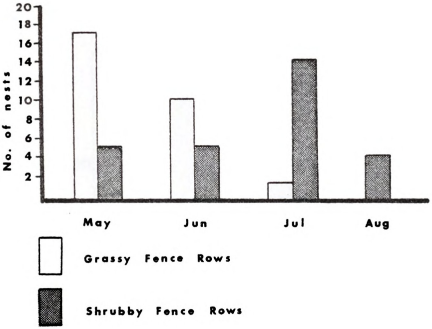

Figure 7. Seasonal Song Sparrow nest distribution by fence row type.

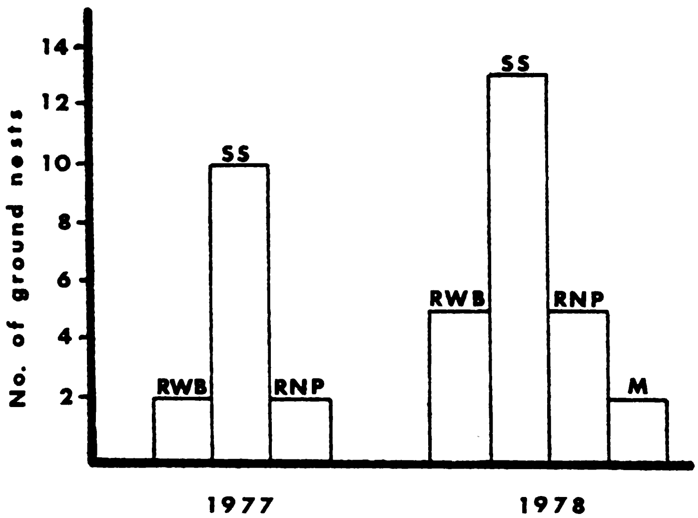

Figure 8. Annual change in the number of ground nests by species. See Table 3 for species symbols.

Flicker, and two Starlings simultaneously for several days while their nesting periods overlapped.

Nesting bird species diversity was higher (.79) in the shrubby fence rows than in grassy fence rows, although the number of nests was fewer. Eight of the 10 species were found exclusively in shrubby fence rows. Thus 94% of all nesting species were found in grassy or shrubby fence rows. This implies that wooded fence rows are relatively unimportant as an attraction for nesting birds. Song Sparrows were again the dominant species (37%). Open shrubs were preferred nest sites during the second half of the breeding season (Fig. 7). Cardinals, Catbirds, and Brown Thrashers, birds commonly associated with shrubby habitat (Bent 1948, Nickell 1965, Dow 1969), accounted for 35% of the nests. Two Black-capped Chickadee nests were found in this fence row type. The presence of small, rotting snags attracted these birds to the same nest site each year.

Wooded fence rows were intermediate in species richness and diversity. Only Mourning Doves were restricted to this fence row type. Robins preferred woody fence rows (88%), but also nested in shrubby areas. Most wooded Robin nest sites had many shrubs and vines and were less than 5 m in height. For these reasons Robins cannot be considered strict tree nesters. Their primary habitat requirement seems to be at least one tree large enough to hold their large nests. The heterogeneous structure of many of the wooded fence rows attracted the three aforementioned shrub nesters. Unlike grassy and shrubby fence rows, wooded fence rows were not associated with a unique set of breeding birds.

Breeding Success

Nesting success. -- Nest success by species is presented in Table 3, and mortality factors are summarized in Table 10. Of 152 nests, 88 (58%) successfully fledged at least one chick. This is significantly higher ($p < .001$) than the 10-30% rate that was expected based on the results of Nolan (1963), Gates and Gysel (1978) and Best (1978). Predators were responsible for most of the losses, but nest desertion and inclement weather were responsible for the failure of 12 (9%) nests. Two Mourning Dove nests were blown to the ground during violent storms, and one Song Sparrow nest and one Red-wing nest were flooded during heavy rains.

Nest success was highest in shrubby fence rows (65%), but the differences were not significant ($p<.50$). These shrubby fence rows had significantly more horizontal cover at 2 m (C2M) and more cover at the nest(CNEST) than any other fence row type (Table 5). This suggests a relationship between cover and nest success. A discriminant analysis was performed on nest site habitat data to determine if habitat differences existed between successful and unsuccessful nest sites. The resultant function ($p = .185$) indicated that the measured nest site variables could not be used to predict nest success. This suggests that the fate of fence row nests is based primarily on chance encounters with predators or factors other than those studied.

Fence row width had no predictable effect on nest success. A regression of width on success was not significant, and there was virtually no correlation between the two variables. Only nests in the narrowest fence rows (1-2 m) were routinely unsuccessful.

Nest predators. -- The surprisingly high rate of nest success was

Table 10. Summary of nest mortality for fence row nesting birds during the 1977 (72 nests) and 1978 (80 nests) breeding seasons.

Nest fate	1977		1978		1977 and 1978 combined	
	No. of nests	% of total	No. of nests	% of total	No. of nests	% of total
Predation	21	29.2	27	33.7	48	31.6
Desertion	4	5.5	4	5.0	8	5.3
Inclement weather	2	2.8	2	2.5	4	2.6
Adult death	1	1.4	1	1.3	2	1.3
Unknown loss	2	2.8	0	0.0	2	1.3
Total nests lost	30	41.6	34	42.5	64	42.1

due, at least in part, to the apparent total absence of certain predators commonly associated with nest destruction. Chipmunks (Tamias striatus), 13-lined ground squirrels (Citellus tridecemliniatus), and arboreal snakes were neither observed nor trapped on the area during the two-year study. Chipmunks and snakes are frequently referred to as the most common predators of open nesting birds (Nolan 1963, Thompson and Nolan 1973, Best 1978, Nolan 1978). Brown-headed Cowbirds were also conspicuous by their absence. Large flocks were common during the early spring, but none were seen during the breeding season. Losses to Cowbird brood parasitism are often substantial in other habitats (McGreen 1972, Gates and Gysel 1978, Nolan 1978). An alternative explanation of the high rate of success is that during the two-year study nest success was by chance unusually high, i.e., an atypical sample.

Predation accounted for 75% of the losses that did occur. An attempt was made to identify nest predators by searching the nest sites for evidence after a nest was destroyed. The criteria established by Reardon (1951) were used to identify the predators. Raccoons (Procyon lotor), red foxes (Vulpes vulpes), striped skunks (Mephitis mephitis), and longtail weasels (Mustela frenata) were probably responsible for most losses. Scattered egg shells and a dislodged nest were evidence attributed to raccoons. Ground nests from which the eggs or chicks were removed, with no damage to the nest itself, were identified as fox victims. Typically, egg shells could be found within a 10 m radius of the nest. I considered foxes responsible for the losses of all pheasant and duck nests. Skunks were deemed responsible for ground nests which had been totally uprooted and destroyed. Most losses were attributed to raccoons, red foxes, and skunks.

Several individual cases of nest predation were notable. One Song Sparrow nest containing an unusually large clutch of seven chicks was located on the ground in a grassy area. Less than 12 hours after I last checked it, the nest was empty, and a 2 cm hole led through the base of the nest into the ground. A shorttail shrew (Blarina brevicauda) was most likely responsible. Two other ground nests, one Song Sparrow and one Red-wing, each contained three chicks one day and only one the next day. The nests were undisturbed, and the remaining chick fledged. I attributed these losses to garter snakes. The most perplexing losses were Robin nests, 1-4 m high, from which the contents disappeared in less than 24 hours. The nests were undisturbed, and no egg shell fragments were found. The absence of arboreal snakes from the area and the nocturnal loss eliminated snakes from responsibility. I concluded that longtail weasels were responsible. Flegg and Cox (1977) reported that weasels are important nest predators in Britain. Other potential predators observed in the study area included prairie deer mice, opossum (Didelphis virginianus), domestic cats (Felis catus), Red-tailed Hawks, Kestrels, Blue Jays, and Crows.

Other Fence Row Wildlife

Many other species of mammals and nonbreeding birds were observed in the fence rows. Resident mammals included a large population of cottontail rabbits (Sylvilagus floridanus) and several ground hogs (Marmota monax). Whitetail deer (Odocoileus virginianus) commonly bedded down in old fields adjacent to the fence rows. Several abandoned red fox dens were found on fence rows. The results of the small mammal trapping indicated that prairie deer mice and meadow voles were the most abundant small mammals (Table 11). Appendix A contains a list of all nonbreeding bird species that were observed in the fence rows during the two-year study. Bobolinks and Meadowlarks that nested in adjacent old fields used the fence rows as singing perches. Winter bird populations that frequented the fence rows included Cardinals, Tree Sparrows, Dark-eyed Juncos, Song Sparrows, and House Sparrows.

Table 11. Results of the small mammal trapping by fence row type (700 trap-nights).

Species	Number trapped Grassy	Shrubby	Wooded	Total
Peromyscus maniculatus	3	17	8	28
Microtus pennsylvanicus	12			12
Mus musculus	3			3
Blarina brevicauda	1			1
Total	19	17	8	44

DISCUSSION

Three nesting "guilds" of birds, representing a total of 16 species, nested in farm fence row habitat. Fence row nest density (nests/area of fence row) was about 10 times greater than that in natural deciduous shrub habitat and several hundred times greater than the nest densities reported for cultivated fields and pastures (Good and Dambach 1943). Similar comparisons can be made with Petrides' (1942) data, although the disparity is less emphatic. His results are conservative because he counted old nests found in winter, thereby precluding the possibility of counting ground and cavity nests. Fence rows provide farmlands with a mosaic of habitats that attract nesting birds. Owens and Myres (1973) concluded that edges and shrubby fence lines provide a significant portion of the habitat available to birds in areas where agriculture is widespread. This is especially true in areas such as the Midwest and Great Plains, where vast areas of land are cultivated without interruption. I conclude that on an area basis, fence rows are a recognizable and useful habitat type for nesting birds.

If my entire 170 ha study area (cultivated fields, old fields, etc.) is considered, total nest density would be less than one nest per hectare. This figure is conservative because it does not include nests that were not found, nests in old fields, and nests in odd areas, but it is consistent with earlier findings (Good and Dambach 1943). The importance of fence rows as bird nesting habitat is

obvious. If the fence rows were removed from the farmland I studied, the breeding bird population would be virtually eliminated.

In a study of Cardinal ecology, Dow (1969) incidently discovered that almost half of the territorial males were found in fence rows and other narrowly wooded areas, which comprised only 12% of the available cover. Dow concluded, and I agree, that structurally distinct, narrow habitat types supported high densities of breeding birds because distance between neighbors can be maintained more easily than in expansive areas of shrubby growth where trespassers can approach from all sides. This minimizes aggressive encounters between nesting pairs. Dow, however, refused to call these areas "preferred habitat." He argued that if preferred habitat was defined as that to which a species is best adapted, then the degree of reproductive success attained in it rather than the number of birds attempting to reproduce is the appropriate measure of preference. He had no data on nest success and speculated that these narrow habitats merely had a high density of reproductively unsuccessful birds, which were the overflow populations from preferred habitats.

My data on nest density parallel Dow's, but the high degree of nest success I observed forces me to conclude that fence rows are a preferred nesting habitat. Such a preference could develop in a relatively short period of time. Before fence rows existed, birds presumably nested in what could be called preferred traditional habitats. This would include forests, forest edge, grasslands, etc. depending on the requirements of the bird species. As fence rows became more abundant, their availability as alternative nesting habitat increased. Only individuals which could not successfully

compete for preferred traditional habitats would be forced into "marginal" fence row habitat. If, however, fence row nesters are as successful as my data indicate, then fence rows would have become preferred secondary habitats. They would be preferred because adults that had been raised in fence rows would cue in on fence row habitat characteristics when searching for nest sites since early experience seems to play a role in avian habitat selection (Klopfer 1963). Fence rows would be considered secondary habitats because their original colonizers were less successful competitively in traditional habitats. Through time this process would create two populations: one that nests in traditional, preferred habitats, and one that nests in secondary, preferred habitats. As long as fence rows are reproductively successful habitats, natural selection would continue to favor their use. Fence rows could eventually shed their secondary status by fence row bird populations becoming so skilled at using fence rows that traditional habitats would be suboptimal in comparison.

Fence row preference could be reinforced further if successful breeding _per se_ is a cue (Partridge 1978:370). Hilden (1965) indicated that many young birds from species occupying a wide variety of habitats tend to nest in habitats similar to those in which they were raised. Partridge(1978:370) suggested that the fact that these birds were successfully raised indicates that the nesting habitat was suitable, although other areas may have been even more suitable. In this way "marginal" habitats can attain a preferred status for species with flexible habitat requirements.

Regardless of the mechanism, the distinct, linear configuration of fence rows suggests that fence rows may be detectable patches which

serve as proximate cues (Hilden 1965) in eliciting a nesting response in birds. If young birds learn to perceive fence rows as potential nest sites, then fence rows must be a recognizable habitat.

Important Fence Row Habitat Variables

In each analysis of fence row habitat variables, width emerged as the variable which most significantly affected the number of nests and species present. This result seemed intuitively obvious from the start, simply because a large area can support more individuals (Forman et al. 1976). Its importance, however, has never been documented. Gates and Hale (1975) suggested that increased strip cover width would probably result in more nesting pheasants. While any fence row is better for wildlife than none at all, width should be at least three meters wherever possible. Narrower fence rows will support nests, but they will be sparse and generally unsuccessful. Fence rows less than 2 m in width may allow a predator to pass close to the nest, thereby increasing the likelihood of detection. Wide fence rows attract more species because the greater area offers a greater potential for variation in vegetation. Wide fences typically were more heterogeneous in structure than narrow ones. The presence of a vegetation mosaic increases patchiness which attracts more species (Roth 1976). The structural complexity of a given habitat is directly related to the number of bird species it can support (Recher 1969, Roth 1976).

The importance of adjacent fields is also edge related. Fence rows serve as habitat discontinuities to the fields which they separate. The fence row, depending on its type, will attract certain bird species. The adjacent fields also attract certain species, but old fields attract more species than crop fields. Therefore, edge effect is maximized in fence rows bordered by old fields.

Shrubs were the final habitat variable considered important by the analysis. Their importance is most evident by the fact that this fence row type attracted the largest number of nesting species. Shrubs are also valuable in the other fence row types. In grassy fence rows, shrubs provide singing and lookout perches, while in wooded fence rows shrubs add an understory nesting niche. Beckwith (1954) found shrubby habitats on abandoned farmlands supported the largest number of summer and permanent resident bird species. Gates and Hale (1975) suggested that increasing the shrub component of strip cover would benefit nesting pheasants. Roth (1976) found that patchy shrublands had more bird species than grasslands. He also suggested that decreased patchiness may explain why forests have fewer species than some shrublands despite their having more vegetation layers or volume.

Fence Row Height

Nest distribution paralleled the distribution of fence row types. This implies that fence rows can be managed to maintain a certain distribution of types and coincidentally attract a predictable group of bird species. It is encouraging from the farmer's viewpoint that tall, wooded fence rows attract the lowest diversity of birds, with only Mourning Doves restricted to these fence row types. A major objection farmers raise in reference to fence rows is that crop yield is reduced by root competition and shading by tall vegetation. Another concern is that large branches can fall or break off and injure the operator of a passing tractor. These concerns are justifiable for both economic and safety reasons. A reasonable compromise is to advocate the use of fence rows but to control their heights. If kept to a height of 4-5 m, shading, root competition, and safety problems would be minimized, while the fence rows could continue to serve as windbreaks, erosion controls, and wildlife habitat. Such a strategy would eliminate only one nesting species and preserve the fence row types that account for most species richness and diversity.

Robins preferentially nested in wooded fence rows, but seemed to require only a single tree large enough to hold their large nests. Occasional trees greater than 10.2 cm dbh could be maintained in shrubby fence rows. If tree tops are lopped off at 4 m, a short fence row is maintained, while providing Robin nest sites. The structure of the shrubby fence rows in which I found Robins' nests suggested this technique.

Why Was Nest Success So High?

Nest success was unexpectedly high and was probably due to the absence of common nest predators. Apparently, narrow strips of vegetation are suboptimal habitat for chipmunks, ground squirrels, and arboreal snakes. Perhaps fence rows along stone fences would be more suitable for these predators. Remnant stone walls would provide an additional structural component to fence row habitat that may be required by these smaller predators. In the absence of chipmunks and arboreal snakes, the existing predators (raccoons, red foxes, skunks, and weasels) are unable to make up the difference. Perhaps these predators are less effective than smaller, more abundant predators because they are widely spaced due to their greater home range size. As a result their net effect is less than the effect many small predators have in natural habitats.

Success may be further increased by the physical difficulty these larger predators have in getting to some of the nests. Most of the shrub nests were placed in either the upper, more delicate reaches of a plant or inside a dense, prickly thicket. Larger predators might be more easily discouraged by such nest locations than chipmunks or arboreal snakes. Snow and Mayer-Gross (1967) reported similar differential nest success for British farmland birds. Nesting success was higher in hedges than in native woodlands. They concluded that linear hedges probably supported a lower density of nest predators than woodlands.

Nest success was expected to be low because fence rows serve as travel lanes for predators and seemed likely to serve as an ecological trap (Gates and Gysel 1978). As indicated above, this did not generally occur. However, large ground nesting birds (pheasants, Mallards) did experience low nest success. Evidence at these unsuccessful nests indicated that red foxes were responsible. Coincidentally, a red fox was seen traveling the fence rows on several occasions. Baskett (1947) and Gates and Hale (1975) also found that pheasant nest success was quite low in fence row habitat. Apparently, game bird nests are easier for predators to locate than song bird ground nests because of their size and the conspicuousness of the female's flush. Game birds burst violently from the nest site, while Song Sparrows often leave the nest, run several meters through the grass, and flush quietly.

Other Wildlife Uses of Fence Rows

My research focused specifically on the use of fence rows as nesting habitats for birds. I have demonstrated this utility, and in the course of the two-year study have also noted other benefits of fence rows as well. Fence rows provide year-round benefits to many birds and other types of wildlife. Migrant species rest and feed in fence rows during their spring and autumn flights. Winter residents obtain shelter in the dense thickets and forage for waste grain and seeds deposited by plants such as sourdock and prickly ash. Fruits of plants such as grape, Virginia creeper, dogwood, hawthorn, honeysuckle, *Rubus* spp. and *Rosa* spp. provide abundant summer and winter foods. Rabbit and ground hog burrows were common, and large predators such as foxes and raccoons used the fence rows as travel corridors.

Potential Fence Row Nesters

Many additional species of birds are potentially able to nest in fence rows. Two pairs of Rose-breasted Grosbeaks were observed in the fence rows for about two weeks in May 1978. They eventually left the area, and no nests were found. A Tree Swallow successfully fledged a brood from a nest box on a nearby grassy fence row which was not on the study area. Harrison (1978) noted that these two species, as well as Goldfinches, Indigo Buntings, Rufous-sided Towhees, and Yellow Warblers are all known to nest in fence row type situations. Depending on geographic area, landowners can expect at least some of these species to be attracted by prudent fence row management practices. Appendix B contains a more complete list of potential fence row nesters.

Implications

The implications of my results are important to the future of farm wildlife management. Wildlife habitat is at a premium in agricultural areas where practically all of the land is used for crops. Farmers who want to manage wildlife on their land can be encouraged by my results. Wise planning that includes fence rows will attract abundant bird life on otherwise wildlife-depleted farmland. Existing fence rows can be improved or new fence rows created by planting vegetation which provides food and cover for wildlife. Many state conservation departments offer nursery stock to landowners at little or no cost. Some states assume the responsibility of planting the seedlings. The Wisconsin Department of Natural Resources presently offers to plant fence rows in return for the right to document their use by wildlife (personal communication, Robert Dumke).

In addition to the aesthetic and recreational value that fence row wildlife provides, fence rows also offer tangible benefits to landowners. Fence row birds are insectivorous for at least part of their lives and consume large quantities of harmful insects (Dambach 1942, 1945). Fence rows reduce water runoff, moderate wind action, control soil erosion, and serve as snow fences (Grange and McAtee 1934). The practical and wildlife values of fence rows should convince some landowners that fence rows are worth the limited space they occupy.

RECOMMENDATIONS

The results of this study indicate that fence rows can be a valuable asset in farm wildlife management. Fence rows can be manipulated to increase the abundance and distribution of breeding bird populations. Whether the aesthetic and recreational values provided by fence row management are worthwile is a question that each landowner must answer individually.

The following recommendations are made to establish preliminary guidelines for landowners who choose to manage fence rows. Suggestions for future research are also offered.

Fence Row Management Recommendations

1. Encourage interested landowners to establish, maintain, and manage fence rows to attract breeding bird populations.

2. Simultaneously emphasize the other tangible benefits that fence rows provide; fence rows moderate wind action, reduce sheet erosion, and reduce soil moisture loss.

3. Fence rows should be a least 3 m wide to maximize breeding bird abundance and diversity.

4. Fence row height should be less than 5 m to reduce shading and root competition along field perimeters.

5. Maintain an equal interspersion between grassy and shrubby fence rows to maximize patchiness within the fence rows.

6. Retain all snags for cavity nesting birds until they begin to break apart and pose a safety hazard.

7. Erect and maintain nest boxes along fence rows to attract Eastern Bluebirds, Tree Swallows, and other cavity nesting birds.

Research Recommendations

1. Use banding studies to determine whether fence row bird populations are self-sustaining or dependent on overflow from other habitats. This would clarify the question of fence rows as preferred habitat.

2. Conduct long-term studies (5-10 years) to document bird use and nest success over a longer period of time.

3. Test the hypothesis that fence rows are suboptimal habitat for common nest predators such as chipmunks and arboreal snakes.

4. Determine the distribution and abundance of fence row mammal populations and relate to bird nesting success.

5. Determine the extent to which fence rows are used as travel corridors by wildlife.

6. Test the hypothesis that breeding bird territories elongate to conform to the linear configuration of fence row habitat.

7. Study seasonal use of fence rows by mammals and nonbreeding birds.

8. Measure the production of wildlife foods in fence row habitat.

APPENDICES

APPENDIX A

Table 12. List of nonbreeding, permanent resident (P), winter resident (W), summer resident (S), amd migrant (M) birds observed in fence row habitat during 1977 and 1978.

Common Name	Scientific Name
Blue-winged Teal (S)*	Anas discors
Wood Duck (S)*	Aix sponsa
Red-tailed Hawk (P)	Buteo jamaicensis
Bobwhite (P)	Colinus virginianus
Killdeer (S)	Charadrius vociferus
Rock Dove (P)	Columba livia
Yellow-billed Cuckoo (S)	Coccyzus americanus
Red-headed Woodpecker (S)	Melanerpes erythrocophalus
Downy Woodpecker (P)	Picoides pubescens
Eastern Kingbird (S)	Tyrannus tyrannus
Least Flycatcher (S)	Empidonax minimus
Eastern Wood Pewee (S)	Contopus virens
Horned Lark (P)	Eremophila alpestris
Tree Swallow (S)	Iridoprocne bicolor
Barn Swallow (S)	Hirundo rustica
Common Crow (P)	Corvus brachyrhynchos
White-breasted Nuthatch (P)	Sitta carolinensis
Brown Creeper (W)	Certhia familiaris
Veery (S)	Catharus fuscescens
Ruby-crowned Kinglet (M)	Regulus calendula
Yellow Warbler (S)	Dendroica petechia
Yellow-rumped Warbler (S)	D. coronata
Blackburnian Warbler (M)	D. fusca
Chestnut-sided Warbler (S)	D. pennsylvanica
Palm Warbler (S)	D. palmarum
Common Yellowthroat (S)	Geothlypis trichas
Yellow-breasted Chat (S)	Icteria virens
House Sparrow (P)	Passer domesticus
Boblink (S)	Dolichonyx oryzivorus
Meadowlark (S)	Sturnella magna
Northern Oriole (S)	Icterus galbala

*observed overhead

Table 12 (cont'd.).

Common Name	Scientific Name
Common Grackle (S)	Quiscalus quiscala
Brown-headed Cowbird (S)	Molothrus ater
Scarlet Tanager (S)	Piranga olivacea
Rose-breasted Grosbeak (S)	Pheucticus ludovicianus
American Goldfinch (P)	Carduelis tristis
Savannah Sparrow (S)	Passerculus sandwichensis
Grasshopper Sparrow (S)	Ammodramus savannarum
Henslow's Sparrow (S)	A. henslowii
Vesper Sparrow (S)	Pooecetes gramineus
Dark-eyed Junco (W)	Junco hyemalis
Tree Sparrow (W)	Spizella arborea
White-crowned Sparrow (M)	Zonotrichia leucophrys
White-throated Sparrow (M)	Z. albicollis
Swamp Sparrow (S)	Melospiza georgiana

APPENDIX B

Table 13. List of potential fence row nesting bird species (Harrison 1975).

Common Name	Scientific Name
Bobwhite	Colinus viginianus
Yellow-billed Cuckoo	Coccyzus americanus
Red-bellied Woodpecker	Centurus carolinus
Red-headed Woodpecker	Melanerpes erythrocephalus
Eastern Kingbird	Tyrannus tyrannus
Great-crested Flycatcher	Myiarchus Crinitus
Least Flycatcher	Empidonax minimus
Eastern Wood Pewee	Contopus virens
Tree Swallow	Iridoprocne bicolor
Carolina Wren	Thryothorus ludovicianus
Mockingbird	Mimus polyglottus
Eastern Bluebird	Sialia sialis
Loggerhead Shrike	Lanius ludovicianus
White-eyed Vireo	Vireo griseus
Bell's Vireo	V. bellii
Yellow-throated Vireo	V. flavifrons
Philadelphia Vireo	V. philadelphicus
Warbling Vireo	V. gilvus
Golden-winged Warbler	Vermivora chrysoptera
Blue-winged Warbler	V. pinus
Yellow Warbler	Dendroica petechia
Chestnut-sided Warbler	D. pennsylvanica
Prairie Warbler	D. discolor
Mourning Warbler	Oporornis philadelphia
Yellowthroat	Geothlypis trichas
Yellow-breasted Chat	Icteria virens
American Redstart	Setophaga ruticilla
Rose-breasted Grosbeak	Pheucticus ludovicianus
Blue Grosbeak	Guiraca caerulea
Indigo Bunting	Passerina cyanea
Painted Bunting	P. ciris
American Goldfinch	Spinus tristis
Rufous-sided Towhee	Pipilo erythrothalmus
Field Sparrow	Spizella pusilla

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