Breeding Birds in Early Successional Oldfields: the Effect of Area on Community Structure

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The area of a particular habitat type affects the number of breeding birds the habitat contains. Much of what has been discovered about area effects has come from studies of fragmented natural habitats such as forests and prairies. In the present study, human-induced habitats, such as oldfields, were studied to determine whether or not area had similar effects on the avian community. A total of 11 early successional fields were censused for birds throughout the breeding seasons of 1989 and 1990. Results indicated a significant difference in the number of breeding species occurred between small, medium and large fields. In addition, a linear relationship between field size and corresponding number of species was evident. Species that increased with field area were permanent residents and neotropical migrants. The latter group is of primary interest because of area sensitivity reported from other habitats, e.g., forests. Results from studies of forest fragments suggest that because predator and brood parasite densities are greater in and around small woodlots, many species may have poorer reproductive success in forest fragments compared to forests with greater core areas. Some evidence from this study and others suggest that a similar phenomenon may occur in birds breeding in oldfield habitats, with migratory species being the most susceptible.

INTRODUCTION

As habitat area increases, so does the number of animal species (e.g., *1-4*). Explanations for species-area relationships have largely been based on the island biogeographic theory of MacArthur and Wilson (*5*). However, much ecological debate and controversy on the mechanisms behind the relationship exist (see *6*).

With the increase in forest fragmentation and the subsequent creation of smaller (and isolated) woodlots, much interest and effort has been directed toward understanding how forest bird communities respond to habitat area (e.g., *7, 8*). Researchers have identified the migratory species (e.g., warblers, vireos, flycatchers, tanagers; reviews *9,10*) as being the most susceptible to the effects of forest size. The reason for this susceptibility may be due to specialized food habits (*11*), the lack of appropriate microhabitats (*12*) or because life history traits (e.g., low, open cup nesting and small clutch size) make them more vulnerable in the smallest forest islands (e.g., *13-16*).

Within the past decade, ecologists studying non-forested habitats have also identified species-area patterns in the breeding bird community. For instance, Bolger et al. (*17*) found that some resident bird species were absent from small chaparral fragments in California. Furthermore, the decline of species in small grassland fragments appears evident (*18,19*).

Oldfields, like chaparral and grasslands, represent open habitat (little or no canopy), but differ in being created by human disturbance, usually for agricultural purposes. These habitats begin secondary succession after abandonment and offer a variety of plant cover for wildlife species, particularly breeding birds. At present, few if any studies have investigated fields of similar successional age to determine whether birds respond to variation in the size of these fields. Because some species of birds, including neotropical migrants, prefer oldfield habitat for breeding (e.g., *20*), it may be hypothesized that these birds, like their forest counterparts, respond to habitat area.

In this study, I examined several oldfield habitats to determine the size and composition of the breeding avifauna and the effect of area on community structure.

METHODS

Eleven oldfield habitat islands ranging from 1.0 to 30.0 ha in size were selected for study in Washington County, northwestern

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Arkansas. Ten fields were investigated in the spring and summer of 1989 and 11 in 1990. All sites were initially located using aerial photographs (1:660 scale) obtained from the United States Soil Conservation Service in Fayetteville, Arkansas. For the purpose of comparison, fields were classified as "small" if they were < 0.5 ha, "medium" if between 5.0 and 10.0 ha, and "large" if they were > 10.0 ha.

Fields selected for the avian census were in early stages of succession, approximately 10 to 15 years after abandonment. The ground cover on each study site was primarily grasses with numerous sapling trees (stem diameter <7.5 cm, and height >0.6 m). The fields showed no evidence of disturbance (plowing or grazing) and were bounded by forests or some other type of non-oldfield habitat (e.g., plowed fields, roads or human dwellings).

Fields were censused for birds weekly from 25 May through 15 July, beginning at 0600 and ending before 1000 hours, using a plotted transect. A transect path was marked through the center of each field, at some distance from the edge habitat boundary. Because all fields were relatively small (all boundaries could be seen from transect path), the entire area of each field was included in the survey for birds. To insure adequate sampling of species and populations within the habitat, species accumulation curves and population mean stabilization curves were used (*21* and references therein). Species accumulation curves involve plotting cumulative species numbers against census effort. As census effort increases, fewer new species will be detected, if species number within the habitat is stable. Mean stabilization curves are based on a running average of population sizes divided by the number of census efforts. If populations within the habitat are relatively stable, the population curve will level off at the value representing a reasonable estimate of the population within the habitat island. A total species list and a breeding or resident species list was compiled after the fields had been adequately sampled as determined by these curves. Only birds utilizing the habitat for breeding were included in this analysis. To help increase the probability that species counted were actually breeding and not just passing through, only those detected on at least 70% of the visits to a given field (*22-24*), were assumed to be nesting there. Although this method does not insure that species encountered within a field on numerous occasions were breeding there, it does decrease the chance that nonbreeding species or those that are simply passing through were counted as breeding species.

After compilation of lists, each species was then grouped into migratory status categories because this has been identified as an important criterion in determining area sensitivity (*8,12*). Migration status was based on descriptions of Whitcomb et al. (*8*) and James and Neal (*25*): "permanent" residents" remain in Arkansas year-round, "short-distance migrants" winter along the Gulf Coast, and "long-distance migrants" winter in the neotropics.

In the analysis of the species-area relationship, both the exponential function (species number plotted against natural log of area) (*26*) and the power function (area and species number log transformed) (*27*) were used because both methods fit the data equally well. In this paper, I present only the log-log plot for the regression.

RESULTS

Avian Community Composition. A total of 42 species was recorded on all fields sampled in 1989 and 39 species were recorded in 1990. However, only 40.4% and 43.5% respectively, were considered to be breeding birds. Of those breeding species, eight were permanent residents, two were short-distance migrants and six were long-distance migrants (Table 1). Between year similarity for oldfield breeding species was 88.2%. Species censused in fields but considered nonbreeding are listed in Table 2.

Species-area Relationships. The mean number (±s.d.) of breeding species for oldfields was 2.1 (±1.3) in small, 5.5 (±2.1) in medium, and 10.3 (±1.6) in large fields. This difference is significant (F=14.8, $P<0.05$) and indicates that larger fields support more breeding species than smaller ones. Furthermore, breeding species richness was shown to be a linear function of area in 1989 (r=0.957, d.f.=8, $P<0.001$) and in 1990 (r=0.888, d.f.=9, $P<0.001$) (Fig. 1).

TABLE 1. List of breeding species in oldfields in northwestern Arkansas.

Species Common Name (*Scientific Name*)	Migration Strategy[a]	Percent[b] 1989	1990
Eastern Kingbird (*Tyrannus tyrannus*)	LDM	20	18
Northern Bobwhite (*Colinus virginianus*)	PR	10	27
Eastern Meadowlark (*Sturnella magna*)	PR	20	27
Eastern Bluebird (*Sialia sialis*)	PR	30	18
Northern Mockingbird (*Mimus polyglottos*)	PR	30	0
White-eyed Vireo (*Vireo griseus*)	LDM	10	9
Common Yellowthroat (*Geothlypis trichas*)	SDM	30	45
Yellow-breasted Chat (*Icteria virens*)	LDM	40	36
Northern Cardinal (*Cardinalis cardinalis*)	PR	60	45
Blue Grosbeak (*Guiraca caerulea*)	LDM	10	9
Indigo Bunting (*Passerina cyanea*)	LDM	80	100
Rufus-sided towhee (*Pipilo erythrophthalmus*)	SDM	60	18
Field Sparrow (*Spizella pusilla*)	PR	100	100
Dickcissel (*Spiza americana*)	LDM	10	9
Brown-headed Cowbird (*Molothrus ater*)	PR	20	36
American Goldfinch (*Carduelis tristis*)	PR	70	73

a PR = permanent resident, LDM = long-distance migrant, SDM = short-distance migrant.

b Represents the percentage of fields (1989 = 10, 1990 = 11) in which the species was detected as a breeding resident.

TABLE 2. Non-breeding species censused in oldfields.

Common Name	Scientific name
Yellow-billed Cuckoo	*Coccyzus americanus*
Ruby-throated Hummingbird	*Archilocus colubris*
Red-bellied Woodpecker	*Melanerpes carolinus*
Yellow-shafted Flicker	*Colaptes auratus*
Downy Woodpecker	*Picoides pubescens*
Great-crested Flycatcher	*Myiarchus crinitus*
Eastern Phoebe	*Sayornis phoebe*
Eastern Wood Pewee	*Contopus virens*
Blue Jay	*Cyanocitta cristata*
Carolina Chickadee	*Parus carolinensis*
Carolina Wren	*Thyrothorus ludovicianus*
Blue-gray Gnatcatcher	*Polioptila caerulea*
Brown Thrasher	*Toxostoma rufum*
Gray Catbird	*Dumetella carolinensis*
American Robin	*Turdus migratorius*
Red-eyed Vireo	*Vireo olivaceous*
Northern Parula	*Parula americana*
Black-and-White Warbler	*Mniotilta varia*
Common Grackle	*Quiscalus quiscula*
Orchard Oriole	*Icterus spurius*
Baltimore Oriole	*Icterus galbula*
Summer Tanager	*Piranga rubra*

TABLE 3. Distribution of breeding birds in oldfields.

Area (ha)	No. of Species	Bird Species[a]
	1989	
30.0	13	A B C D E F G H I J K L * N *
14.2	9	A B C D E * * * * * K L M * O
14.0	9	A B C * * F G * I J * * * * O P
7.6	7	A * C D E F G * I
5.3	5	A B C D E
5.0	4	A B C D
3.5	6	A B C * E F - H
2.3	3	A B - - E
2.1	2	A * * D
1.0	2	A B
	1990	
30.0	11	A B C D E F G H I * K * M * *
14.2	8	A B C * * * * H * J K * M * O
14.0	11	A B C * * F G H I J K * * * O P
7.6	9	A B C D E F G * * * * * M N
5.3	5	A B C D * * G
3.5	6	A B C D - F - H
3.1	3	A B C
2.3	3	A B C
2.1	3	A B * D
1.0	3	A B - - - - G

a A = Field Sparrow, B = Indigo Bunting, C = American Goldfinch, D = Northern Cardinal, E = Rufous-sided Towhee, F = Yellow-breasted Chat, G = Common Yellowthroat, H = Brown-headed Cowbird, I = Eastern Bluebird, J = Eastern Kingbird, K = Eastern Meadowlark, L = Northern Mockingbird, M = Northern Bobwhite, N = White-eyed Vireo, O = Blue Grosbeak, P = Dickcissel. Deviation from perfect nested pattern indicated by an asterisk.

The distribution of species in study fields reveals a nonrandom nested pattern (Table 3), which is evident by observing that most species present in the small fields are also present, with additional species, in the larger fields. The types of species that increased with field size were permanent residents (Fig. 2) and long-distance migrants (Fig. 3). Only two short-distance migrants were counted as breeding residents, and thus accounted for only a small additional increase in the number of species as area increased.

DISCUSSION

Oldfields represent another example of the avian species-area relationship, with larger fields containing more breeding species than smaller ones. At least two possibilities may explain this relationship. First, it could be argued that an increase in area could incorporate a greater amount of habitat or variety of vegetative types and contain more species (*28,29*). Also, some fields could be more heterogeneous and thus contain different avian communities or species numbers. However, Bay (*30*) found no significant differences in vegetational composition among the same fields. Moreover, other than variation in field size, little additional change in species number was explained by vegetational variables using multiple regression analysis. In sum, vegetational structure between study fields was very similar and had minimal influence on the species-area relationship (*30*).

Another plausible explanation could be that predators and brood parasites are more common or exist in higher densities in smaller fields and exclude many species. In forest studies, most excluded species were long-distance migrants that suffer greater predation rates (*16,31*) or were too specialized (e.g., in food preferences; *11*) to compete with generalist species that maintain higher densities in smaller habitat islands. Higher densities of generalist species such as Brown-headed Cowbirds *(Molothrus ater),* Common Grackles (*Quiscalus quiscula*), and Starlings (*Sturnus vulgaris*) occur because small islands have a greater ratio of edge to core area (*32*) and thus provides generalists with ideal habitat (*13,14*).

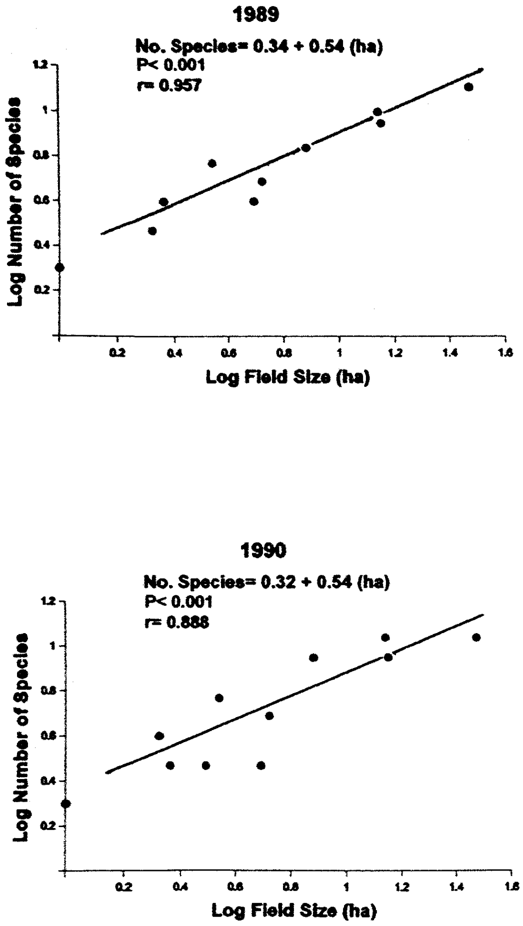

Figure 1. Log species number plotted against log field size for 1989 and 1990 data.

Like forest habitat, oldfields also contain migratory species that appear more frequently as breeding residents in the largest fields sampled (> 7 ha). As a group, long-distance migrants make up only a small portion (37%) of the total breeding community. However, evidence indicates that some migratory species, such as the Dickcissel *(Spiza americana),* rely heavily on oldfield habitat and even select oldfields over more natural open areas, like prairies (*20*). In my study, Dickcissels were found only in the largest fields (> 10 ha). However, they were considered to be breeding residents (based on count replications) in just one large field (14.0 ha). In contrast, another migratory species, the Indigo Bunting *(Passerina cyanea),* was found to be a breeding resident in most of the oldfields studied (Table 1). This species appears to be adapted to a variety of habitats (both forests and fields) (*8,25*) and is thus insensitive to the area of a particular habitat type. In comparison to forest studies, the Indigo Bunting was also found to be a resident in almost all woodlots censused, regardless of size (*7,14*).

Data on the breeding success of oldfield birds, especially migratory species, are scant. However, a study by Gottfried and Thompson (*33*) revealed a high incidence of nest failure from experimental nests in an oldfield less than 10 ha in size. These results were similar to those from a study of natural nests (*34*). Data from an experiment in a 12-ha oldfield, also indicate high

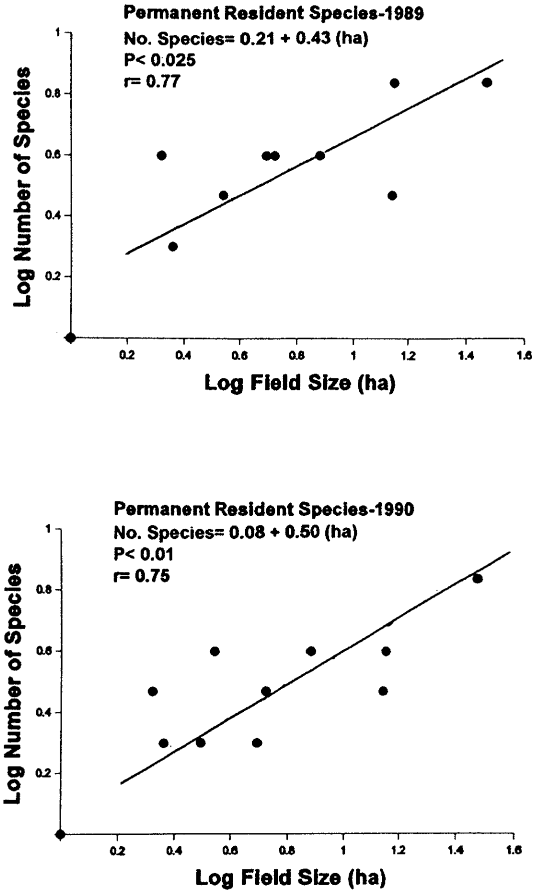

Figure 2. Log species number for permanent residents plotted against log field size for 1989 and 1990.

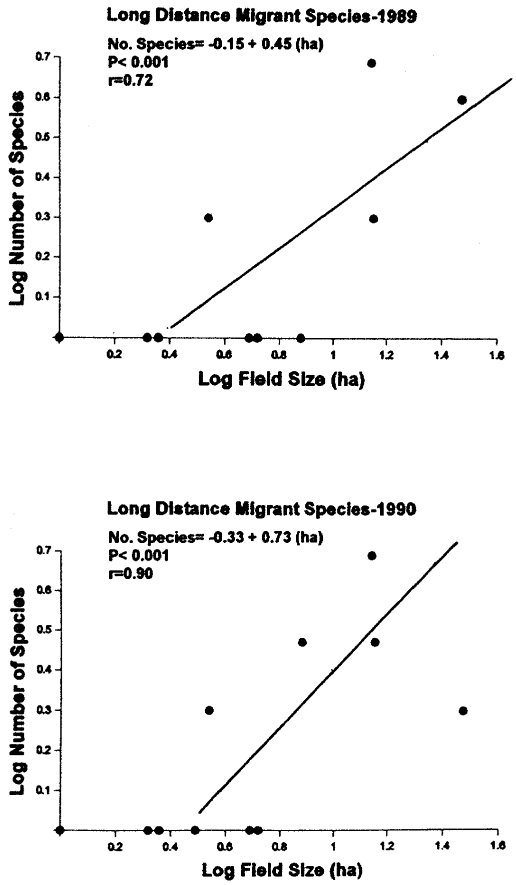

Figure 3. Log species number of long-distance migrants plotted against log field size for 1989 and 1990.

nest mortality ranging from 60% in May to 41% in August (*35*). Although field size was not considered by Zimmerman (*36*), he reported a failure rate surpassing 50% by mid July of Dickcissel nests in Kansas oldfields, particularly during the incubation period. This was the result of higher densities of both predators and brood parasites (*36*), which possibly was correlated with field size (i.e., small fields have greater predator densities than larger ones). Bay (*30*) found that the highest density of Brownheaded Cowbirds occurred in the smallest oldfields sampled (<5.0 ha). Potential nest predators such as Blue Jays *(Cyanocitta cristata)* and Common Grackles (*Quiscalus quiscula*) were also more frequently encountered in smaller fields (pers. obser.). High predator densities may also be the reason that tallgrass prairie birds suffer higher rates of predation and brood parasitism in smaller prairie fragments (*19*).

Another important consideration about oldfield breeding birds is the status of their populations; are their numbers on the decline? James et al. (*37*) reported that Prairie Warbler *(Dendroica discolor)* populations have declined considerably in the Ozark Ouachita Plateau, the area of the present study. No Prairie Warblers were seen on any field throughout the study. Other declines have been recorded from populations of the Common Yellowthroat *(Geothlypis trichas)* and the Yellow-breasted Chat *(Icteria virens)* (*37*), the latter being a long-distance migrant. All of these declines could be due to a combination of heavy predation and brood parasitism in small fields in conjunction with an overall decline in oldfield habitat nationwide (*37*).

In summary, the area effect on the species diversity of breeding birds has largely been investigated in forest habitats.

However, human-induced habitats, such as oldfields, provide suitable sanctuary for many species, and because they vary in size, act as habitat islands that affect species diversity. Much of the influence of area on breeding bird species diversity may be the result of greater predator and brood parasite densities in smaller fields. Some migratory species could be the most suceptible to predators because migration strategy may preclude the ability to re-nest after a failed attempt.

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