

SPECIES-AREA REALTIONSIPS OF PRARIRIE BIRDS
WITHIN ILLINOIS

Illinois Nongame Wildlife Conservation Fund
Final Report

Submitted by

James Herkert
Department of Ecology, Ethology, and Evolution
University of Illinois
Champaign, Illinois 61820

INTRODUCTION

Urban and agricultural development has severely reduced the amount of native habitat throughout the Midwest. This extensive habitat loss has resulted in a highly fragmented landscape. In Illinois, habitat fragmentation has been especially severe with native prairie currently occupying considerably less than one percent of its former range (Schwegman 1983). The process of habitat fragmentation sets off a series of events that can ultimately have major impacts on breeding bird communities. The major changes associated with increased habitat fragmentation include a decrease in the total amount of habitat, a decrease in the average size of habitat patches, increased patch isolation, and an increase in the ratio of edge to interior habitat, all of which may have important consequences for breeding birds (Wiens 1989).

Remarkably, in light of such extensive habitat loss, only three species of prairie birds have been extirpated from Illinois (Bowles et al. 1980). Another 12 prairie bird species, however, are presently considered to be threatened or endangered within Illinois (Bowles et al. 1980). Moreover, recent data from some long-term censuses have documented population declines of even once common prairie bird species within Illinois and throughout the Midwest. For example, data from the United States Fish and Wildlife Services' cooperative breeding bird survey from Illinois (USFWS unpublished data) document population declines of over 50% for four common prairie bird species, the bobolink (-90%), eastern meadowlark (-67%), savannah sparrow (-59%), and grasshopper sparrow (-56%) over the last twenty-three years (1967-89). Additional data from Illinois indicate that populations of prairie birds have declined not only due to loss of habitat but due to declines in densities within suitable habitat as well. Richard

and Jean Graber documented population declines of over 80% for six prairie species (upland sandpiper, Henslow's sparrow, dickcissel, savannah sparrow, grasshopper sparrow and bobolink) within Illinois between 1957 and 1978 (Illinois Natural History Survey Reports, May 1983, No. 227). The reasons for the declines in these species remain poorly understood.

Despite ample evidence of prairie bird species declines and common knowledge as to the extent of habitat loss for these species, study of the ecology of prairie birds has receive little attention within Illinois. The following report summarizes the results of a study, partially funded by the Illinois non-game wildlife conservation fund, aimed at investigating the effects of habitat fragmentation on prairie birds within Illinois.

STUDY AREAS AND FIELD METHODS

Study areas

The breeding birds of 24 grassland areas located in north-eastern and north-central Illinois were studied between 1987-90. Study areas included a variety of grassland types including native and restored prairie, and cool-season grass and fallow fields. Three categories of grasslands were identified and used in subsequent analyses - native prairie (12 sites, range 0.5-650 ha.), restored prairie (4 sites, range 4-20 ha.), and non-prairie grasslands (8 sites, range 6-238 ha.). Dominant grass species from the native and restored prairie study areas include: Big Bluestem (Andropogon gerardi), Indian Grass (Sorghastrum nutans), Switch Grass (Panicum virgatum), Prairie Cordgrass (Spartina pectinata), Prairie Dropseed (Sporobolus heterolepis), and upland sedges (primarily Carex stricta). Dominant grass species from the non-prairie areas include:

Kentucky Blue-grass (Poa prantensis), Meadow Fescue (Festuca pratensis), Smooth Brome (Bromus inermis), Timothy (Phleum prantensa), Orchard Grass (Dactylis glomerata), and Red-top (Agrostis alba).

Bird composition

Only birds considered to be potential breeders in grassland habitat within Illinois were included in the analyses. The list of potential breeders was constructed from previous work within Illinois (Graber and Graber 1963, 1976, Bohlen 1978, 1989). Breeding birds were classified into three habitat categories based on historical habitat preferences using data from the literature and historical accounts (Ridgway 1873, 1889, 1895, Nelson 1876, Graber and Graber 1963, Bohlen 1978, 1989). Three categories: all grassland species (AGS), including all potential grassland breeding species; typical prairie species (PS), a subgroup of AGS that includes true prairie bird species; and non-prairie species (NPS), a subgroup of AGS including bird species capable of breeding in grassland habitat but whose primary or historical habitat preference was not prairie. Group classifications for the 19 bird species encountered in the study are given in Table 1.

Birds censusing was conducted using 4.5 hectare strip transects (300 x 150 meters). Transects were censused 3-4 times between 15 May and 30 June between 0600 and 1000 hours. Portions of study areas not covered by strip transects were systematically searched in order to supplement a site's species list. Census effort was proportion to fragment size such that coverage per unit area was approximately equal for all sites. Records from all visits to a site were combined to yield a total species list. For analyses the average number of territorial males encountered from each

route was used. Since census route size on some of the smallest areas (<4.5 ha.) was less than those on other plots, bird densities were standardized to the average number of territorial male birds/100 hectares before all analyses.

Data analysis

The relationship between area and bird species richness was examined with three regression functions: linear (untransformed), the exponential function (Semi-log), and the power function (log-log). The model ultimately chosen was the one that provided the best fit to the data (Conner and McCoy 1979).

The density of breeding birds and species richness/unit area were examined as a method of determining if the distribution of species was random within sites. If the birds on small fragments are merely subsamples of birds found within large fragments then you would expect bird densities and species richness/area to be the same for all areas regardless of their size. In this case large areas would possess more species simply because they possess more individuals, and therefore contain a larger sample of the regional avifauna (Conner and McCoy 1979, Coleman 1981, Coleman et al. 1982). If the birds within small areas are not random subsamples of the birds found within large patches, then area would be expected to affect the densities and species richness/area with smaller areas containing lower densities and fewer species/unit area than large fragments.

RESULTS

Bird species composition

Nineteen species of grassland birds were encountered during the study. Species' average densities and number of sites of occurrence are given in Table 1. The response of individual species to area was variable. Some species exhibited apparently low minimum area thresholds whereas a few species were consistently found only on areas in excess of 100 hectares. A listing of the smallest area in which individual species were encountered is given in Table 2. Incidence functions for the 15 species occurring on at least 15% of the fragments are shown in Figure 1. The incidence analysis identified the Henslow's sparrow, bobolink, savannah sparrow, and grasshopper sparrow as the four prairie bird species influenced the greatest by changes in area. Whereas the red-winged blackbird, common yellowthroat, dickcissel, and American goldfinch were identified as four species which demonstrated little response to changes in area among study sites. Surprisingly, the upland sandpiper showed only a moderate response to area. The probability of encountering an upland sandpiper was relatively low (36%) even on the largest sites indicating that other factors besides area must also play an important role in determining sandpiper distributions within fragments.

Area and bird species richness

The number of breeding bird species for all three bird groups increased significantly with grassland fragment area (Figures 2 & 3). There was no

significant year effect (AGS, $p > .50$; PS, $p > .21$; NPS, $p > .47$) nor was there a significant effect of grassland type (AGS, $p > .32$, PS, $p > .30$, NPS, $p > .17$) in any of the species area regressions. Hence, data from all years and grassland types were combined for further analyses. Area accounted for a high percentage of the variation in species richness for both the AGS ($R^2 = .80$) and the PS ($R^2 = .68$) groups, but not for the NPS group ($R^2 = .36$). The prairie bird group showed a stronger response to area than did the non-prairie group with a regression slope of .39 compared to .20 respectively. The regression of core area (area greater than 50 meters from primary plot boundaries) produced a worse fit to the data for all three bird species groups than did the regression of total area (AGS $R^2 = .69$, $R^2 = .80$; PS $R^2 = .62$, $R^2 = .68$; NPS $R^2 = .29$, $R^2 = .36$ respectively).

Bird densities and species richness/area

The total density of breeding grassland birds (AGS) was not significantly influenced by fragment size. The density of both the PS and NPS bird groups, however, were significantly influenced by area (Figure 4). The density of prairie birds within large grasslands was significantly greater than prairie bird densities within small fragments. Whereas the density of non-prairie birds exhibited just the opposite response, with non-prairie densities being significantly greater on small fragments than they were on large areas. The opposite response of these two groups resulted in small fragments being dominated by non-prairie birds and large grasslands generally being dominated by prairie bird species.

The analysis of species richness/unit area patterns for the three bird groups showed that area also significantly affected species richness within census routes, for both the AGS and PS groups (Figure 5) but not for the

NPS group. Both the density and species richness analyses demonstrate that small grasslands contain impoverished breeding bird communities, and are consistent with the hypothesis of a non-random distribution of bird species within fragments.

DISCUSSION

The results of this study along with Samson's (1980) earlier work on prairies in Missouri indicate that grassland bird communities within habitat fragments, are strongly influenced by area. Small grasslands are usually dominated by non-prairie, edge and shrub bird species, and contain few if any true prairie species. Moreover, several of the true prairie bird species are restricted to grasslands of intermediate or large size.

Although the distinction between grasslands and agricultural crops is often not as sharp as it is for forests, area still accounted for a high proportion (80%) of the variation in species richness between fragments in the present study. This was somewhat lower than Samson's (1980) study of prairie fragments (98%), but higher than most values typically reported for forests fragments (48%, Ambuel and Temple 1983; 50%, Freemark and Merriam 1986; 27%, Lynch and Whigham 1987; 55% Opdam et al. 1987; but see Blake and Karr 1987 87-98%). Therefore, birds apparently perceive these grassland fragments as distinct entities.

The results from this study also demonstrate that bird distributions between fragments are not random but rather follow a regular pattern. A predictable subset of birds are regularly found on large fragments but absent from small areas.

The results from the species-area regressions can also be useful in guiding prairie bird management. The regression equations, given in the

results section, can be used to determine the expected number of species for a grassland of a given size. This represents an average only, some areas will fall above and others below this number. Grasslands which consistently possess more than the expected number of species represent 'high quality' areas (in terms of prairie birds), whereas areas consistently below this number represent 'low quality' areas. This tool could be especially useful when comparing the quality of grasslands of different sizes.

One aspect of the species-area relationship that was not specifically addressed in this study was the importance of isolation on grassland bird populations within fragments. I believe that isolation does affect grassland bird distributions, to some degree, but that the regional composition of the surrounding landscape probably has a greater influence on prairie bird populations within fragments. Several agricultural crops, such as hay, oat, and wheat fields, have been shown to support a number of prairie bird species (Graber and Graber 1963, Howe et al. 1985). The number, type, and acreage of these crops in a given region may exert a strong influence on grassland bird populations within adjoining fragments. Moreover, the regional composition of any given location can change dramatically both between and within years as crops are rotated and hayfields mowed. This persistent addition and deletion of habitat undoubtedly affects prairie bird populations by packing permanent grasslands when these alternative grasslands are scarce, and by diluting populations when alternative grasslands are abundant. Warner (1989, 1990) has described such a pattern for road rights-of-way and grassland corridors in Ford county, where the regional abundance and proximity of hay and small grain fields was shown to affect the density of breeding birds in these habitats. Therefore it seems likely that a similar process would operate in

grassland fragments.

Management Implications

The results of the present study indicate that relatively large unbroken grasslands are necessary in order to support a diverse prairie bird fauna. Small grasslands are dominated by non-prairie species and are of little value to the majority of prairie birds. Moreover, several species, such as Henslow's sparrow, upland sandpiper, and the northern Harrier, occur only on relatively large grassland fragments.

The finding of no significant difference between grassland types, with respect to the species-area curve, is important since it indicates that prairie bird conservation efforts need not be restricted to prairie habitat. This is encouraging since prairie now occupies such a small percentage of Illinois. The results also indicate, however, that other factors besides area must be important in determining prairie bird distribution and abundance patterns within fragments. Therefore conservation plans or policies that address only the issue of area may meet with limited success. Unfortunately, the identity of these other factors is currently not well known and is only starting to emerge. Habitat structure, and perhaps species interactions, may exert some influence on species distributions but these factors, however, generally account for less than half of the variation in species densities within and between plots (Herkert 1990). Therefore it seems likely that the interaction of a large number of factors is determining bird distributions within fragments. The influence of other factors such as isolation and region landscape composition, however, remain poorly understood. Furthermore, rates of nest predation and parasitism have recently been linked to specific features of

grassland fragments, notably distance to nearest woody cover, fragment size, and time since last burning (Burger 1988, Johnson and Temple 1990, Herkert unpublished data). How these processes might be affecting prairie bird distributions, however, are also not yet clear.

Finally, although none of the breeding birds of the eastern tallgrass prairie region are in danger of global extinction, many species are experiencing significant population declines throughout much of the Midwest. For example, dickcissels and grasshopper sparrows have declined by 94% and 93% respectively in Wisconsin, bobolinks have declined by 90% within Illinois, savannah sparrows have declined in Indiana by 66%, and eastern meadowlarks have declined by 66% in Iowa (USFWS cooperative breeding bird survey, unpublished data). These trends indicate that although global extinction may not be a threat to these species local or even regional extinctions are perhaps likely, especially if loss of grassland habitat continues.

LITERATURE CITED

- Ambuel, B., and S.A. Temple 1983. Area-dependent changes in the bird communities and vegetation structure of southern Wisconsin forests. *Ecology* 64:1057-1068.
- Blake, J.G. and J.R. Karr. 1987. Breeding birds of isolated woodlots: area and habitat relationships. *Ecology* 68:1724-1734.
- Bohlen, H.D. 1978. An annotated check-list of the birds of Illinois. Illinois State Museum Popular Science Series Vol. IX 156 p.
- Bohlen, H.D. 1989. The birds of Illinois. Indiana University Press. Bloomington. 221 p.
- Bowles, M.L., K. Kerr, R.H. Thom, and D.E. Birkenholz. 1980. Threatened,

- endangered, and extirpated birds of Illinois prairies. Illinois Audubon Bulletin 193:2-11.
- Burger, L.D. 1988. Relations between forest and prairie fragmentation and depredation of artificial nests in Missouri. Unpublished M.A. theses, University of Missouri, Columbia. 62 p. Coleman, B.D. 1981. On random placement and species-area relations. Math. Biosci. 54:191-215.
- Coleman, B.D., M.A. Mares, M.R. Willig, and Y. Hsieh. 1982. Randomness, area, and species-richness. Ecology 63:1121-1133.
- Conner, E.F. and E.D. McCoy. 1979. The statistics and biology of the species-area relationship. American Naturalist 113:791-833.
- Freemark, K.E. and H.G. Merriam. 1986. Importance of area and habitat heterogeneity to bird assemblages in temperate forest fragments. Biological Conservation 36:115-141.
- Graber, R.R., and J.W. Graber. 1963. A comparative study of bird populations in Illinois, 1906-1909, and 1956-58. Illinois Natural History Bulletin 28:383-519.
- Graber, J.W. and R.R. Graber. 1976. Environmental evaluations using birds and their habitats. Biological Notes No.97 Illinois Natural History Survey.
- Herkert, J.R. 1990. An ecological study of the breeding birds of grassland habitats within Illinois. Ph.D. thesis. University of Illinois, Champaign-Urbana.
- Howe, R.W., D.M. Roosa, J.P. Schaufenbuel, and W.R. Silcock. 1985. Distribution and Abundance of Birds in the loess hills of western Iowa. Proceedings of the Iowa Academy of Sciences 92:164-175.
- Johnson, R.G., and S.A. Temple. 1990. Nest predation and brood parasitism of tallgrass prairie birds. Journal of Wildlife Management 54:106-111.
- Lynch, J.F. and D.F. Whigham. 1984. Effects of forest fragmentation on

- breeding bird communities in Maryland, USA. *Biological Conservation* 28:287-324.
- Nelson, E.W. 1876. Birds of Northeastern Illinois. *Bulletin of the Essex Institute*, 8:89-155. Opdam, P., G. Rijdsdijk, and F. Hustings. 1987. Bird communities in small woods in an agricultural landscape: effects of area and isolation. *Biological Conservation* 34:333-352.
- Ridgway, R. 1873. The prairie birds of Southern Illinois. *American Naturalist* 7:197-203.
- Ridgway, R. 1889. The ornithology of Illinois. Vol. I. Illinois. State Laboratory of Natural History.
- Ridgway, R. 1895. The ornithology of Illinois. Vol. II. Illinois State Laboratory of Natural History.
- Samson, F.B. 1980. Island biogeography and the conservation of prairie birds. *Proceedings of the North American Prairie Conference*. 7:293-305.
- Schwegman, J. 1983. Illinois prairie: then and now. *Illinois Audubon Bulletin* 205:2-14.
- Warner, R.E. 1989. A landscape perspective of farmland corridors and their use by avifauna in Central Illinois, USA. Unpublished manuscript.
- Warner, R.E. 1990. Nesting by grassland passerines on road rights-of-way in Central Illinois. *Biological Conservation* (in press).
- Wiens, J.A. 1989. The ecology of bird communities. Vol. 2. 316 p. Cambridge University Press.

TABLE 1. Bird group classification (PS=prairie species, NPS=non-prairie species), average density (territorial males/100 ha), and number of routes of occurrence for the nineteen species of grassland birds encountered in the study.

Species	Group	Average density	# of routes
red-winged blackbird	NPS	47.3 (3.8)	84 (93%)
eastern meadowlark	PS	21.1 (1.8)	72 (80%)
bobolink	PS	20.9 (5.9)	23 (25%)
grasshopper sparrow	PS	14.5 (2.3)	42 (47%)
dickcissel	PS	13.2 (2.1)	44 (49%)
common yellowthroat	NPS	10.2 (1.7)	38 (42%)
field sparrow	NPS	8.3 (1.7)	27 (30%)
American goldfinch	NPS	7.6 (1.3)	35 (39%)
savannah sparrow	PS	6.5 (1.8)	23 (25%)
song sparrow	NPS	5.1 (1.5)	20 (22%)
sedge wren	PS	5.2 (1.6)	12 (13%)
swamp sparrow	NPS	2.4 (1.3)	9 (10%)
Henslow's sparrow	PS	3.0 (1.0)	13 (14%)
ring-necked pheasant	NPS	1.2 (0.4)	11 (12%)
northern bobwhite	NPS	1.1 (0.5)	7 (7%)
upland sandpiper	PS	1.7 (0.5)	14 (15%)
horned lark	PS	0.8 (0.5)	4 (4%)
vesper sparrow	PS	0.4 (0.3)	3 (3%)
western meadowlark	PS	0.1 (0.1)	1 (1%)

TABLE 2. Minimum areas of encounter for 17 grassland bird species from 24 grassland fragments located in north-eastern and east-central Illinois. Grasslands ranged from 0.5 to 650 hectares.

< 10 Hectares

field sparrow	common yellowthroat
American goldfinch	red-winged blackbird
song sparrow	northern bobwhite
dickcissel	eastern meadowlark
ring-necked pheasant	vesper sparrow
sedge wren	

10-30 Hectares

bobolink	grasshopper sparrow
savannah sparrow	Henslow's sparrow

> 30 Hectares

upland sandpiper	northern harrier
------------------	------------------

FIGURE 1. Incidence functions for 15 of the most common prairie bird species. Incidence (y-axis) is the probability of encountering a species within small (0-20 ha), medium (20-100 ha), and large (100+ ha) grassland fragments within north-eastern and east-central Illinois.

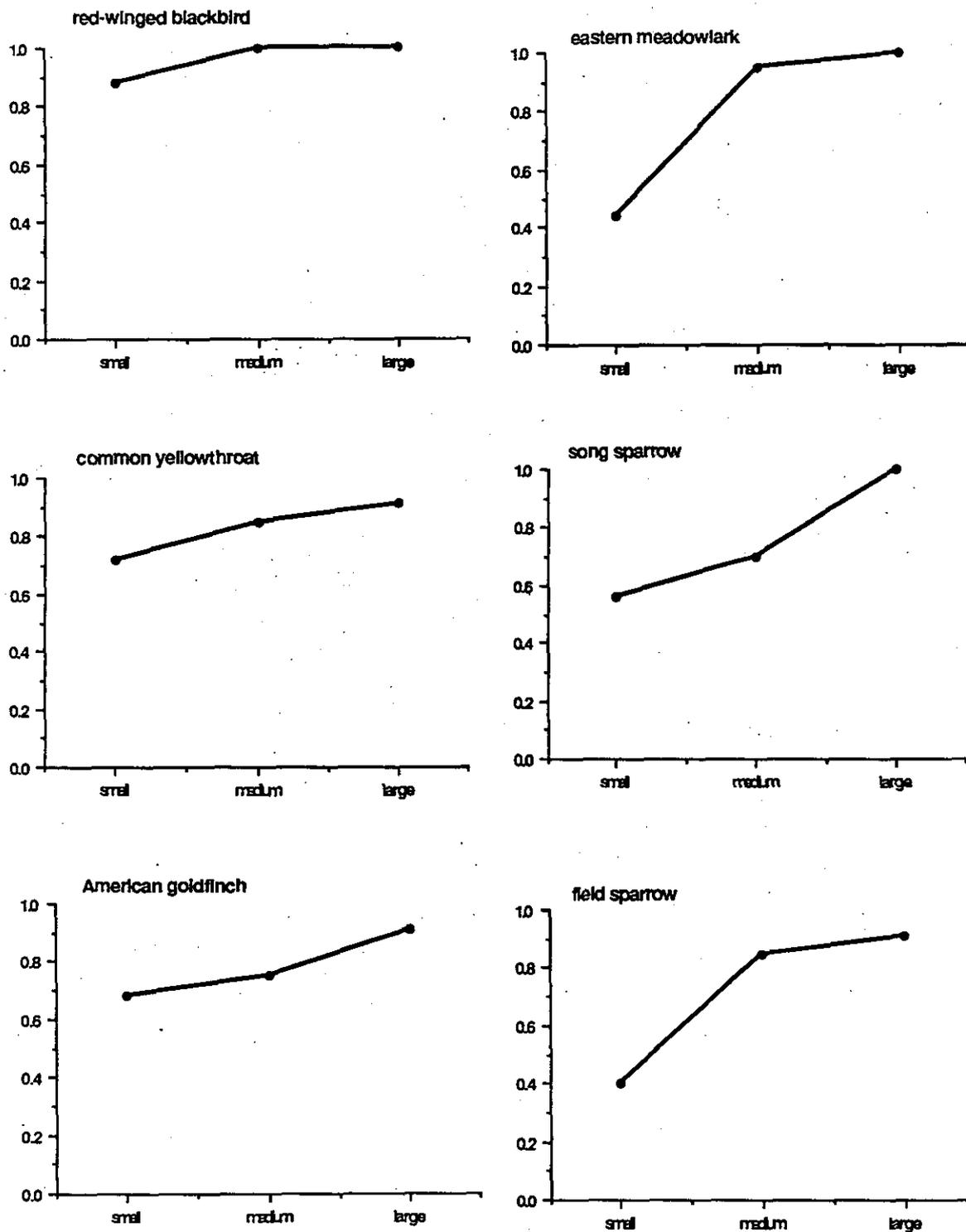


FIGURE 1 (Continued)

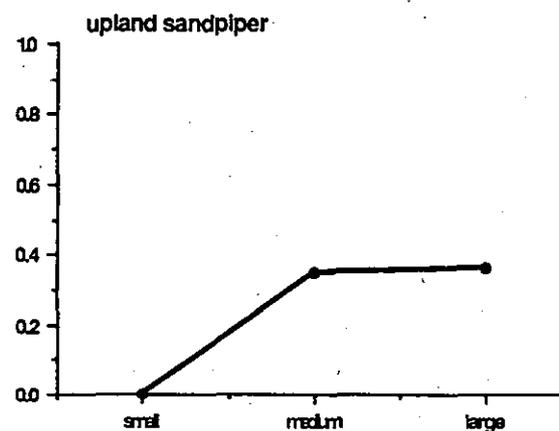
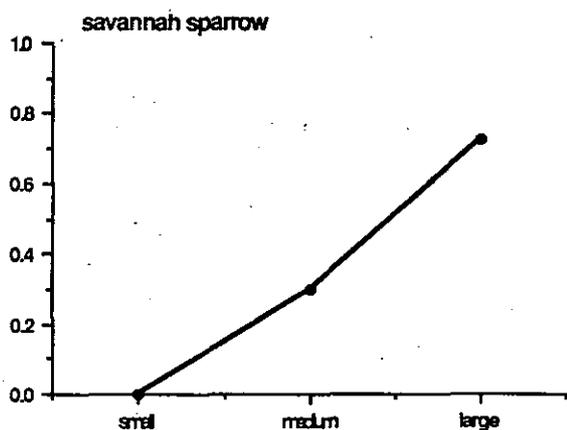
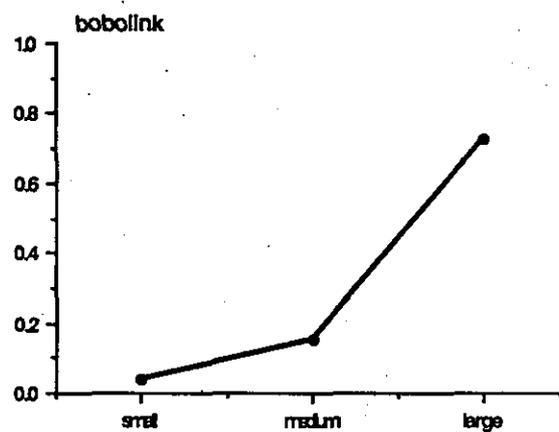
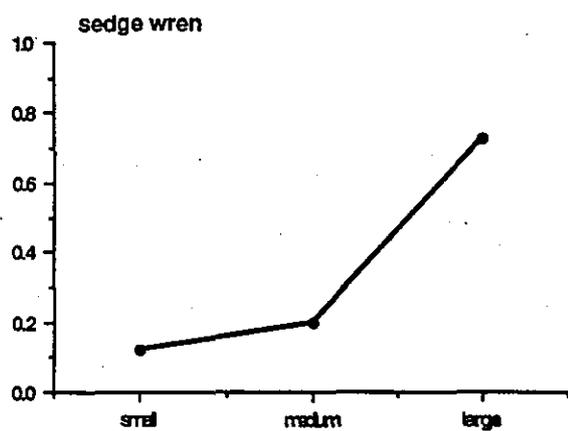
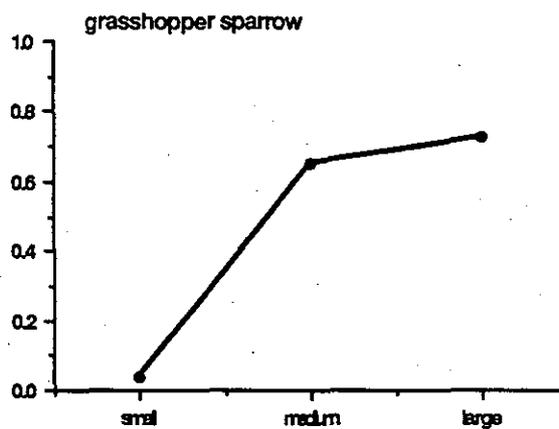
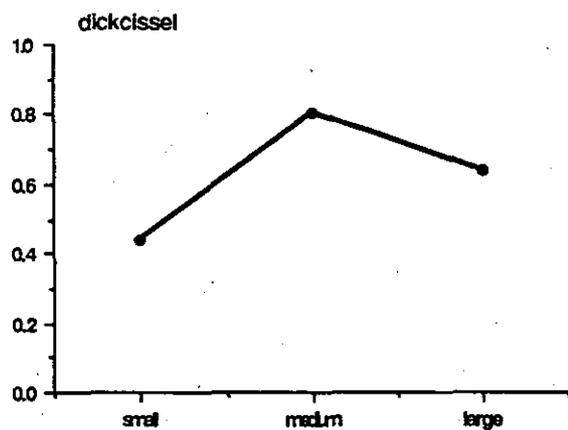


FIGURE 1 (Continued)

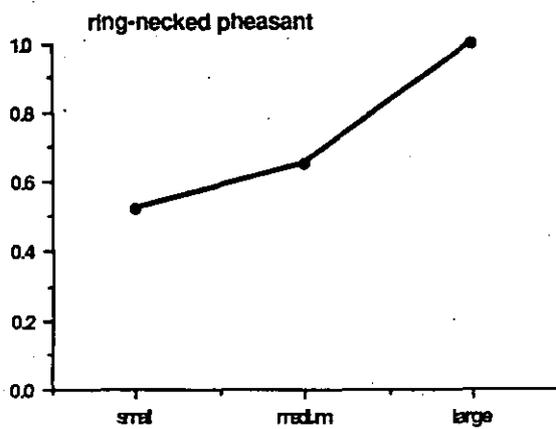
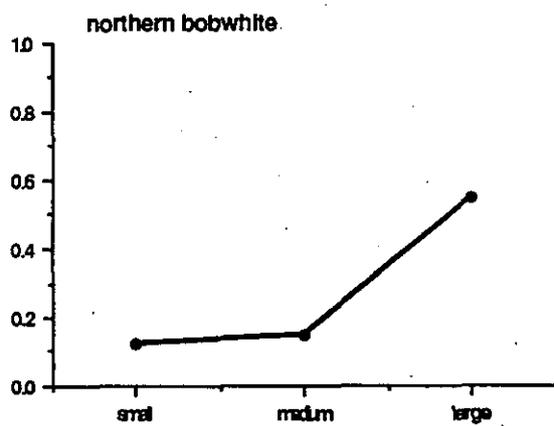
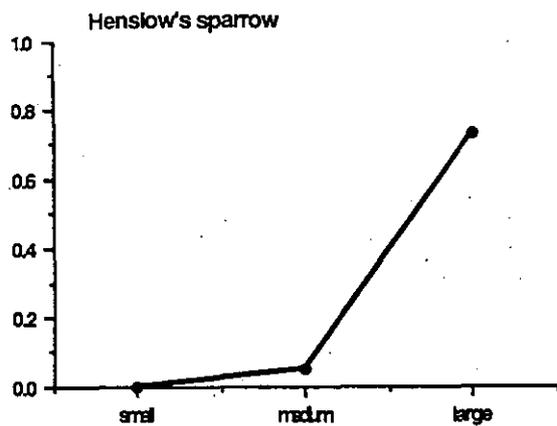


FIGURE 3. Species-area regression between (A) the number of breeding prairie bird species, and (B) the number of non-prairie bird species as a function of grassland fragment size.

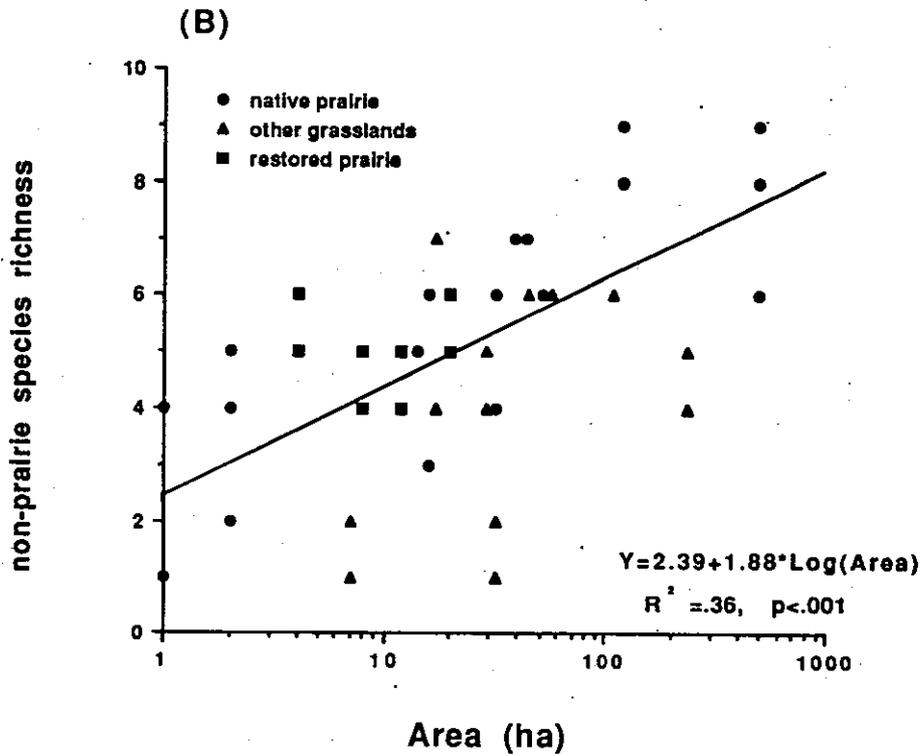
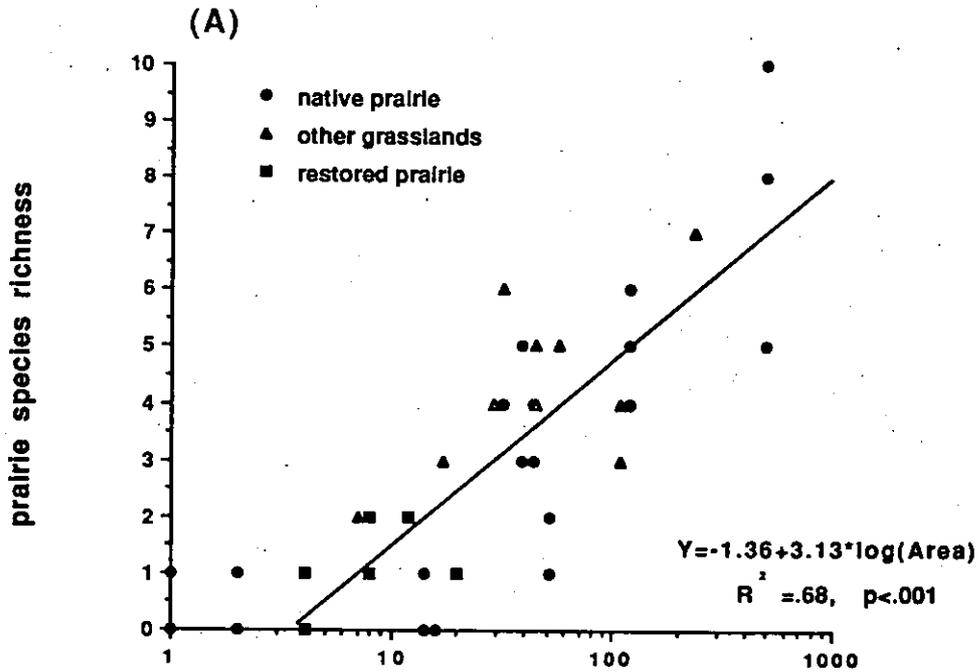


FIGURE 4. The relationship between (A) prairie bird, and (B) non-prairie bird densities and grassland fragment size. Data obtained from 90 strip transects located within 24 Illinois grassland fragments.

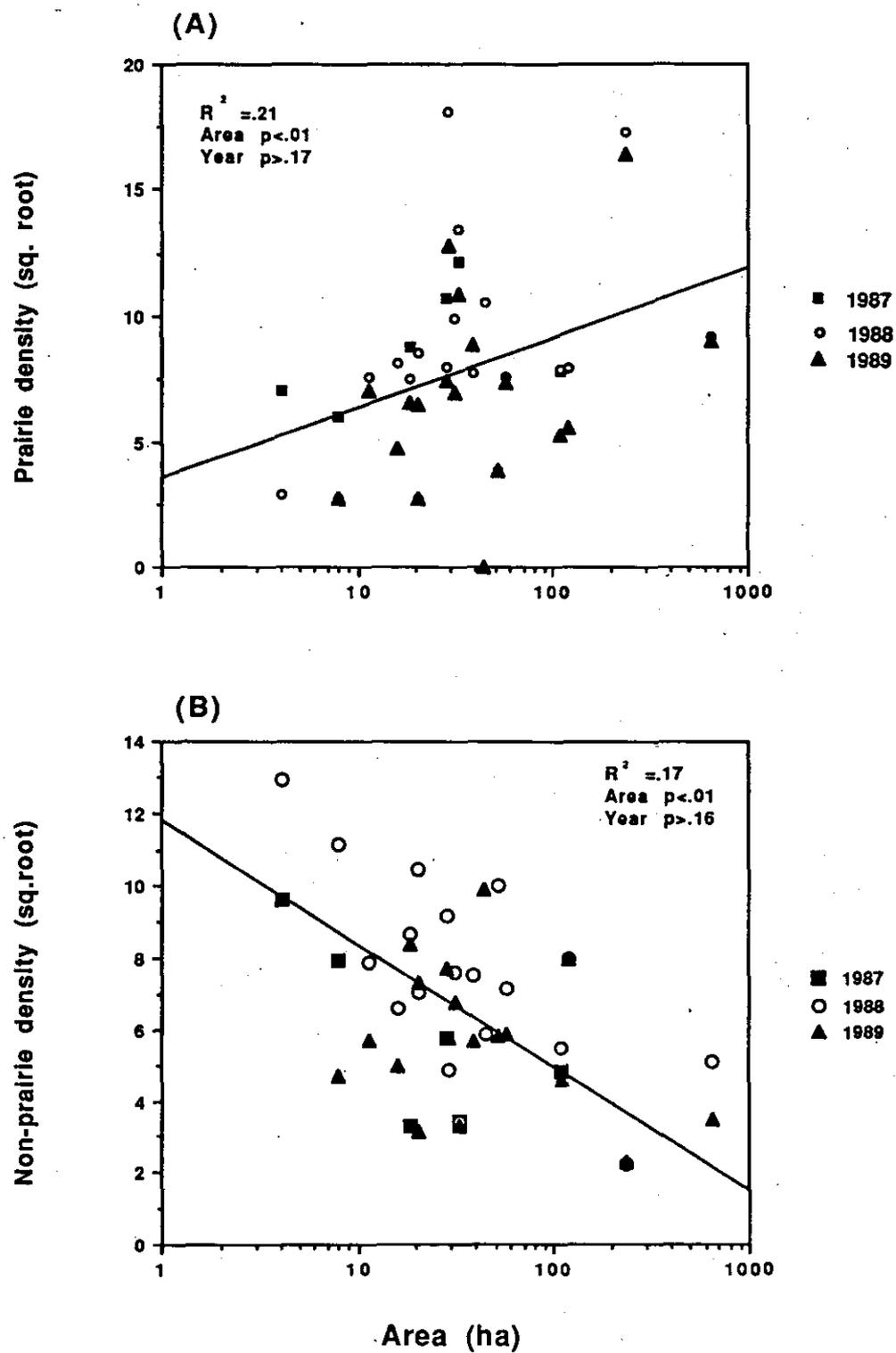


FIGURE 5. The relationship between bird species richness/4.5 hectares and overall fragment size for (A) all grassland breeding bird species, and (B) prairie bird species richness.

