URBAN CEMETERIES AS BIRD REFUGES

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The value of urban cemeteries as bird sanctuaries has long been recognized (Pearson 1915). With the growth of cities around cemeteries, many have become habitat islands (Erz 1966), and island biogeographic methods can be used to study avian response to them. In the present study, I compared birds breeding in urban cemeteries with birds observed in the surrounding city to determine what factors control bird species numbers in urban refuges.

I planned this study to test factors that MacArthur and Wilson (1967) suggested would be most important in determining species numbers on mainland habitat islands such as urban cemeteries which are recolonized each spring. These authors hypothesized that for migratory species, immigration rates would not be much affected by distance (in this case, distance from the edge of the city). Extinction rates, they argued, would be primarily determined by: (1) island area or correlates of area; and (2) spillover of competitors from surrounding habitats. To investigate the area effect, I compared the number of bird species nesting in cemeteries from 2 to 136 ha in size with the number nesting in equal-sized neighboring urban areas. To examine the spillover effect, I compared the relative abundance of birds surrounding the cemetery with abundance in the city, and I looked for correlation between density of Starling (*Sturnus vulgaris*) nests and nests of other hole-nesting species limited to cemeteries.

STUDY SITES AND METHODS

The cemeteries used are in the central part of Chicago, Cook Co., Illinois, where human population density ranged from 35 to 156 individuals per hectare (U.S. Bureau of the Census 1973). To ensure the island nature of the sites, cemeteries studied were at least 0.4 km from the nearest park, forest preserve, or other cemetery. The cemeteries were also islands in that the fauna was protected from human disturbance during the morning and evening periods of greatest avian activity, because cemetery gates were only open eight hours a day during spring and summer (except for Mt. Auburn, St. Peter's, St. Paul's).

I sampled three kinds of areas: cemeteries; city blocks surrounding the seven largest cemeteries, called "adjacent areas"; and nearby portions of the city, called "neighboring areas." Neighboring areas were equal in size to each cemetery and were in the same local community as defined by Kitagawa and Taeuber (1963). Location of adjacent and neighboring areas in the same community is important because it assures demographic and architectural similarity: the direction of each neighboring area from a cemetery was randomly chosen.

I visited study areas between 26 March and 25 June 1974, from sunrise until midmorning. In cemeteries an exhaustive search was made for nests of all diurnal birds except Chimney Swifts (*Chaetura pelagica*). I visited each cemetery 3 to 12 times, and averaged 0.31 h/ha in each.

In adjacent and neighboring areas I recorded relative abundance—not numbers of nesting birds—using the strip census method described by Woolfenden and Rohwer (1969b). The method requires counting birds seen or heard as streets and alleys are walked systematically along a predetermined route. Woolfenden and Rohwer (1969b) compared the strip census method with a nest count in suburban Tampa Bay, Florida. They found that the strip census sampled only a third of the actual number of nesting birds, but all of the species present. For this reason data obtained by strip census (Table 1) are referred to as relative abundances and are used only for within-study comparisons. The number of species breeding in adjacent and neighboring areas was determined accurately by including unusual urban species only if nests could be found. I spent an average of 0.10 h/ha censusing neighboring and adjacent areas. In all areas censused, the city blocks were the same size; for this reason estimates are expressed as birds/ha instead of birds/km. The strip censuses were relatively consistent; for no species was the standard deviation more than 15% of the mean for the 2 to 3 censuses in each area.

Human population density for both adjacent and neighboring areas was estimated using data for census tracts which overlapped these areas (U.S. Bureau of the Census 1973). The presence or absence of vegetation within five height intervals was determined following the point sampling method of Karr (1971). Vegetation cover was sampled in at least 10% of each cemetery and neighboring area by randomly choosing cemetery sections or groups of city blocks; in these, transects for point sampling were laid out in a regular pattern. In large heterogeneous cemeteries, I used stratified random sampling. Sampling points were located in the cemeteries by pacing off random distances, and vegetation height was determined with a range finder. I located sampling points in neighboring areas by dividing city blocks lengthwise into three portions; a middle strip (composed of outer halves of the lots), and half of each side street. Sampling points were located by pacing off random distances on sidewalk or alley center lines and using sets of random numbers giving the distance within blocks where the sample was located.

RESULTS

Neither cemeteries nor neighboring areas differed significantly among themselves in vegetation cover. At each height interval, the 95% binomial confidence limits of the proportion

TABLE 1. Cemetery area (ha), human population density (individuals/ha), and strip census estimates of avian relative abundance (birds/ha) in nearby urban areas.

		Human density		Avian relative abundance	
Cemetery	Area	adjacent	neighboring	adjacent	neighboring
Rosehill	136	87	92	6.87	3.77
Oakwoods	73	—	—	—	—
Graceland	54	113	83	7.83	6.07
Mt. Olive[a]	50	49	66	8.78	6.11
Calvary	42	125	59	5.83	3.98
Mt. Auburn	34	43	43	5.04	6.42
St. Boniface	14	156	117	7.78	5.88
Union Ridge	5	47	47	5.21	7.56
St. Paul's	4	35	35	—	—
St. Peter's	2	35	35	—	—

[a] Includes Mt. Maryriv and Rosemont cemeteries.

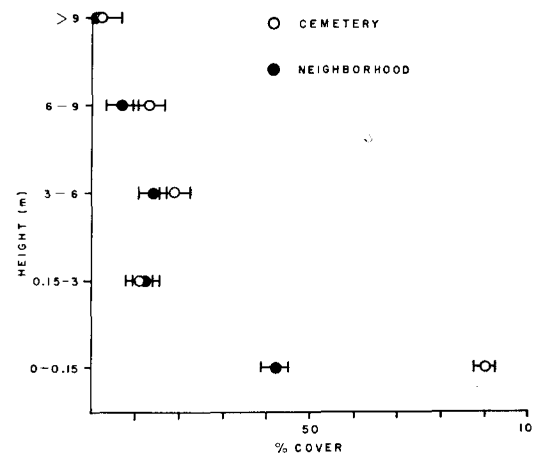

FIGURE 1. Percent vegetation cover in Chicago cemeteries and neighboring areas. Circles indicate weighted means of the proportion of sample points with vegetation in the height interval indicated. The 95% binomial confidence intervals for cemeteries (n = 1,164) and neighboring areas (n = 1,270) are shown.

of vegetation cover in each of the cemeteries or neighboring areas overlapped with the others. For this reason, percent vegetation cover for cemeteries was pooled as were percent vegetation cover values for neighboring areas. At ground level, the percent vegetation cover in neighboring areas was less than that in cemeteries, reflecting greater ground coverage by buildings, streets, and sidewalks. The 95% binomial confidence intervals in Figure 1 do not overlap at ground level. In both areas, cover by trees greater than 9 m high was relatively low because neighboring areas included business districts and apartments as well as single family residences, while in cemeteries, only some sections had extensive tree cover.

The bird species observed can be categorized into three groups. Rock Doves (*Columba livia*), House Sparrows (*Passer domesticus*) and Mourning Doves (*Zenaida macroura*) nested in urban areas but not in cemeteries. Species of a second group—Starlings, Cardinals (*Cardinalis cardinalis*), Common Grackles (*Quiscalus quiscula*), American Robins (*Turdus migratorius*), Blue Jays (*Cyanocitta cristata*), Common Flickers (*Colaptes auratus*), Chipping Sparrows (*Spizella passerina*) and Brown Thrashers (*Toxostoma rufum*)—were found in both cemeteries and neighboring areas. A third group subsumed those species that nested almost exclusively in cemeteries. These included hole-nesters, aerial feeders, and species nesting in ruderal vegetation (Table 2).

Numbers of birds of all species observed in strip censuses adjacent to cemeteries were not greater than numbers in neighboring areas (Table 1; *t*-test of paired differences, $P > 0.20$). This indicates lack of aggregation of Rock Doves, House Sparrows, and Starlings around cemeteries. Since I did not find Rock Doves and House Sparrows nesting in cemeteries, lack of greater urban bird density around cemeteries suggests that there is no spillover into cemeteries. Starlings did nest in cemeteries and they might be expected to reduce the numbers of other hole-nesting species [Common Flickers, Red-headed Woodpeckers (*Melanerpes erythrocephalus*), and Great Crested Flycatchers (*Myiarchus crinitus*)]. In the five largest cemeteries, however, where a total of 57 Starling pairs and 21 pairs of other hole-nesting species occurred together, variation in Starling density from 0.09 to 0.46 pairs/ha was uncorrelated with density of the three other hole-nesting species (Table 2; $r = -0.12$, $P > 0.25$). In addition, I observed the eviction of three Starling pairs from nest holes in Rosehill Cemetery by Common Flickers. These observations and the lack of correlation between Starling and other hole-nester densities suggest that the other hole-nesters are sufficiently aggressive to obtain suitable nest holes.

Instead of spillover of urban birds into cemeteries, I found spillover of species typical of cemeteries into the city. Six pairs, belonging to species which in the present study normally nested inside cemeteries, were found nesting adjacent to cemeteries in which dis-

TABLE 2. Density of breeding birds in Chicago cemeteries (individuals/100 ha) in 1974 as determined by nest counts. An "x" indicates a species which built nests in the neighboring area but foraged in the cemetery. Cemeteries are listed from largest to smallest.

Species	Rose-hill	Oak-woods	Grace-land	Mt. Olive	Calvary	Mt. Auburn	St. Boniface	Union Ridge	St. Paul's	St. Peter's
Mallard (*Anas platyrhynchos*)	1	3						38		
American Kestrel (*Falco sparverius*)				4						
Common Flicker (*Colaptes auratus*)	6	5	15	8	5					
Red-headed Woodpecker (*Melanerpes erythrocephalus*)	1	x		4	5	6	5	38		
Eastern Kingbird (*Tyrannus tyrannus*)		3		4	x					
Great Crested Flycatcher (*Myiarchus crinitus*)	1	3	4	4		6				
Eastern Wood Pewee (*Contopus virens*)	1									
Blue Jay (*Cyanocitta cristata*)	4		4			6		38		
Common Crow (*Corvus brachyrhynchos*)	3		4	8	5			38		117
Mockingbird (*Mimus polyglottos*)						x				
Catbird (*Dumetella carolinensis*)	3		4	4		12		x		
Brown Thrasher (*Toxostoma rufum*)	4	5		12		12				
American Robin (*Turdus migratorius*)	7	8	11	16	9	71			108	
Starling (*Sturnus vulgaris*)	34	46	22	44	9				108	
Redwinged Blackbird (*Agelaius phoeniceus*)	9			12		18				
Northern Oriole (*Icterus galbula*)						6				
Common Grackle (*Quiscalus quiscula*)	9	33	19	16		71	5	38		
Brown-headed Cowbird (*Molothrus ater*)	1		4			6				
Cardinal (*Cardinalis cardinalis*)	3	x		4	x	6				
Indigo Bunting (*Passerina cyanea*)	4			4		12				
Chipping Sparrow (*Spizella passerina*)	4			4	14				54	117
Song Sparrow (*Melospiza melodia*)	4			8		9				
Number of Species	18	8	9	16	6	13	2	5	3	2
Total Density	99	106	87	156	47	241	1	191	270	234

turbance or size may have affected habitat suitability (Table 2). These pairs were nesting adjacent to cemeteries where large numbers of American Elms (*Ulmus americana*) had been lost (Calvary), where extensive spring planting of flowers occurred (Oakwoods), or where the cemetery was small (Union Ridge).

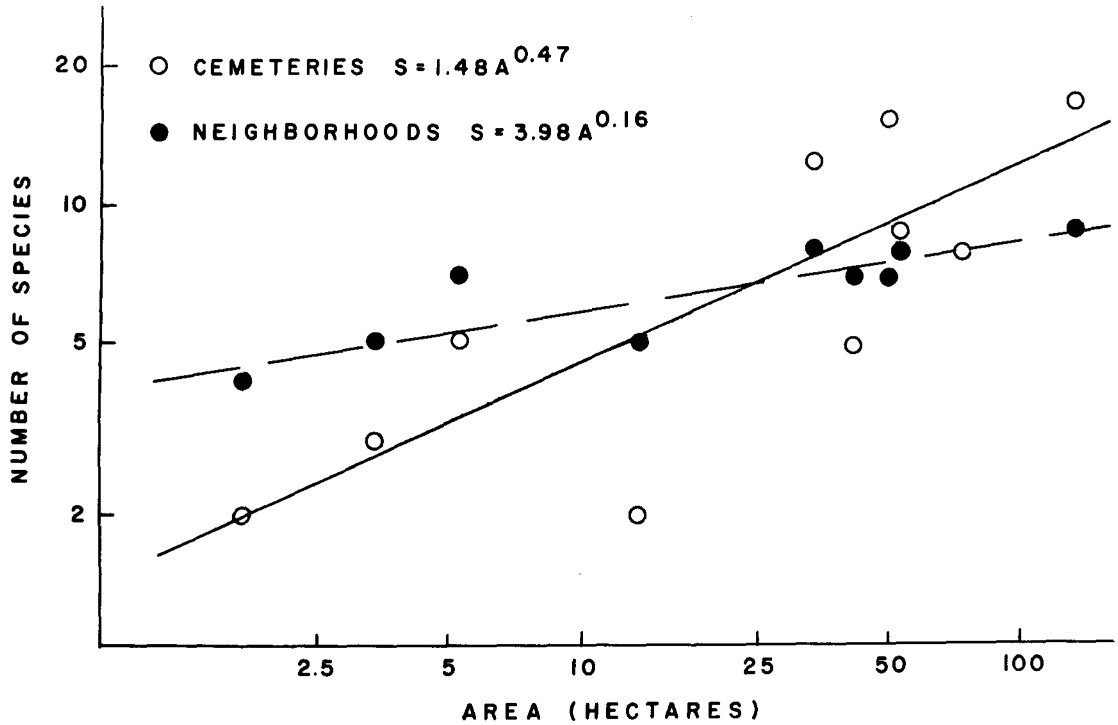

FIGURE 2. Species-area regressions for birds nesting in Chicago cemeteries and for strip-census estimates of bird species nesting in neighboring areas (Oakwoods neighboring area omitted).

The number of bird species in cemeteries and neighboring areas increased with area (Fig. 2). Data for cemeteries are more variable than those for neighboring areas; fewer species than expected occurred in Calvary, St. Boniface and Oakwoods cemeteries. Disturbance seems to be responsible for fewer than expected species in these cemeteries. Yet, if the five nesting pairs which have spilled over into the city as a result of disturbance in two of these cemeteries are added to the cemetery species totals, the sums are about those predicted by the regression equation in Figure 2. The exception, St. Boniface, is in the area of highest human density encountered in this study, and suitable nesting sites outside the cemetery may not be available.

The rapid increase of species with area in cemeteries, but not in neighboring areas, reflects coarse-grained patchiness on a scale greater than 25 ha (where the regression lines cross) due to developed portions of cemeteries as well as to undeveloped land, ruderal vegetation, or ponds in three cemeteries. Nests of Indigo Buntings (*Passerina cyanea*), Song Sparrows (*Melospiza melodia*) and Northern Orioles (*Icterus galbula*) were found only in undeveloped or ruderal portions of Rosehill, Mt. Olive, and Mt. Auburn cemeteries. If these and other species which occasionally nest in undeveloped areas are excluded, and only those species nesting in developed portions of cemeteries are plotted against the developed area in cemeteries, the new regression, $S = 1.55A^{0.44}$, predicts two less species in the largest cemetery if it were completely developed.

Neighboring areas were patchy on a more local scale (under 25 ha) than cemeteries owing to: juxtaposition of apartment buildings, factories, and business districts along arterials with parks; vacant lots; single-family homes with yards; and ruderal vegetation along railroad tracks. Because of this fine-grain pattern, even small neighboring areas contained more than one of these habitat types. Consequently, relatively more bird species occurred in small neighboring areas than in small cemeteries. Therefore, the intercept of the lines for neighboring areas is higher ($P < 0.05$) than that for cemeteries. In addition to being a result of local heterogeneity, height of the intercept can also be a function of counting species whose ranges are only partly included in the sample. In neighboring habitats, however, the high intercept seems primarily due to the fine-grained, repetitive nature of urban habitats because relatively few species are added as sample area is enlarged.

DISCUSSION

Eleven species of birds nested in the neighboring and adjacent areas censused in the present study, a number similar to that found in urban habitats of other central cities and lower than numbers in suburban habitats. For example, 14 species were found in suburban Tucson (Emlen 1974), 16 in St. Petersburg, Florida (Woolfenden and Rohwer 1969a), 19 in northern Illinois (Graber and Graber 1963), and 24 in Kiel, West Germany (Erz 1964). The number of species was lower in central portions of cities: 8 in central Kiel and 13 in central Dortmund, West Germany (Erz 1964).

The potential immigrants to Chicago urban cemeteries are the 106 bird species (Smith 1958) which regularly nest within 70 km of Chicago in natural habitats similar to those offered by cemeteries, and thus have "the potential of reproducing" (MacArthur and Wilson 1967:64) in cemeteries. Most of these 106 potential immigrants migrate through the cemeteries each year, but only 22 species nested in the Chicago cemeteries studied in 1974. These 22 represent, in my opinion, a species equilibrium. This equilibrium should be the same whether resulting from brief, or from continual, periods of immigration and extinction during successive migratory seasons.

I hypothesize that failure of potential immigrants to nest in cemeteries (extinction) is determined primarily by lowered habitat patchiness and secondarily by human activity. Urban birds did not appear to spill over into cemeteries, increasing extinction rates of the species characteristic of cemeteries. Thus, the cemeteries I studied contrast with tropical mainland habitat islands where species equilibria are lowered by loss of species due to reduced immigration rates and constant extinction rates (Willis 1974, Wilson and Willis 1975).

The number of bird species in neighboring areas increased with area at about the same rate (0.12–0.17 log species/log area) as the mainland samples tabulated by MacArthur and Wilson (1967). The intercept of the lines for neighboring areas is higher than that of cemeteries, another characteristic mainland-island contrast. Cemeteries showed a much greater increase in species with area than did neighboring areas. The slope for cemeteries, 0.47, is above the range (0.20–0.35 log species/log area) tabulated by MacArthur and Wilson (1967) for island plants and animals.

Distinct scales of patchiness in cemetery and neighboring areas are indicated by the slopes and intercepts of the species-area regressions. In cemeteries, as in natural habitats, patchiness is strongly correlated with area. The importance of habitat patches to cemetery birds is demonstrated by the regression of lower slope and higher intercept ($S = 1.55A^{0.44}$) obtained when the area of ponds, ruderal, and undeveloped vegetation as well as the species nesting in those areas are omitted. In contrast, the low slope and high intercept of the neighboring area species-area regression indicates the fine-grained patchiness of urban habitats. This local patchiness of urban habitats was quantified by Emlen (1974), who calculated higher perch-height diversity and habitat-feature diversity indices for suburban Tucson than for a nearby desert habitat.

Human disturbance and cemetery development will limit future value of urban cemeteries as bird refuges. The recreational pressure on urban cemeteries in Boston was graphically described by Thomas and Dixon (1973). In Chicago, greater recreation pressure would probably eliminate aerial feeders listed in Table 2 because, considering the similarity in vegetation and lack of recent insecticide spraying in either habitat, human activity levels appear to be the major difference between cemeteries and the city.

Spillover of urban birds into cemeteries was not apparent. Instead, spillover from cemeteries to urban habitats appears to be occurring. House Sparrows and Rock Doves, which might be expected to compete for food with species limited to cemeteries, were not more abundant adjacent to the cemeteries than elsewhere in the city. Starlings, the only urban species nesting in cemeteries, did not show increased density in habitats favorable to other hole-nesters. The nesting of bird species typical of cemeteries in residential areas adjacent to cemeteries where they forage, indicates that spillover of native bird species into urban habitats occurs. The nesting of non-urban bird species in the city suggests that on an evolutionary time scale cemeteries may lose their insularity. Many of the bird species found nesting in cemeteries in the present study are typical of the forest islands in the deciduous forest-prairie transition zone. For these species, cemeteries may be less islands than enclaves from which invasion of additional kinds of urban habitat islands is occurring.

SUMMARY

Nests of birds breeding in 10 Chicago cemeteries were located in the spring of 1974. In addition, strip censuses in urban sample areas associated with cemeteries were used to estimate species numbers and abundance of birds in the city surrounding nine of the cemeteries, as well as in portions of the cemetery neighborhood equal in area to the cemetery. Percent vegetation cover did not differ between cemeteries and neighboring areas in any height interval except at ground level.

The number of bird species in cemeteries and neighboring areas increased with area; the rate of species addition was greater in cemeteries than in neighboring areas. Cemeteries larger than 25 ha supported more bird species than the surrounding city because of large-scale heterogeneity provided, in part, by ponds, ruderal vegetation, and undeveloped land. Complete development of the cemeteries would probably result in loss of about two bird species. Increased human disturbance would probably cause loss of three additional species. On the other hand, in cemeteries where suitable nesting sites were apparently limited, native species were found nesting in the adjacent city and foraging in the cemeteries. This suggests that urban bird refuges would attract more species than knowledge of their area alone would predict.

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