 0030-0950/81/0001-0029 $2.00/0

THE BIRDS OF SUGARCREEK, AN OHIO NATURE RESERVE[1]

REED FREDERICK NOSS,[2] Graduate Program in Ecology, University of Tennessee, Knoxville, TN 37916

Abstract. During the breeding and postbreeding seasons of 1978, the avifauna of the internally heterogeneous Sugarcreek Reserve in southwestern Ohio was censused to discern trends in species composition and richness. With 61 species of breeding birds, Sugarcreek Reserve contains a richer avifauna than comparable temperate areas for which diversity values have been reported in the literature. This high bird species richness results from high internal habitat heterogeneity and edge effects, the comparatively large size of the study area (228 ha), and the recent insularization and concomitant supersaturation of the reserve as surrounding habitat became unsuitable for many species. The observed bird species composition indicates a disturbed community. Future management of Sugarcreek Reserve should emphasize preservation of extinction-prone species assemblages rather than high habitat and species diversity *per se*.

OHIO J. SCI. 81(1): 29, 1981

When large blocks of natural forest are fragmented into smaller pieces by land development, changes in the biota are known to occur. Nature reserves are destined to resemble islands as the land around them becomes more and more exploited for human purposes and hence inhospitable to many indigenous species of wildlife. Although a reserve may begin as a sample of some larger natural community, it becomes an isolate to a certain degree when surrounding habitat is extensively modified. This process of insularization is of interest to conservationists because of the species loss or changes in composition that will inevitably occur. In such cases, preventive and corrective management may be necessary to mitigate some of the detrimental changes.

In my study, the avifauna of a semi-insularized 228 ha nature reserve, Sugarcreek Reserve, was censused during the breeding and postbreeding seasons of 1978. The objective was to determine species richness and composition and to interpret the findings in terms of ecological and sanctuary management theory.

STUDY AREA

Sugarcreek Reserve in southwestern Ohio (Greene County), about 24 km southeast of Dayton and immediately southwest of the small town of Bellbrook, is a nature reserve administered by the Dayton-Montgomery County Park District (DMCPD). The reserve (figure 1) comprises approximately 228.25 ha (564 a) of old farmland and woodlot in varying stages of secondary succession. One major stream (Sugar Creek), 2 small tributaries and various springs and marshes contribute aquatic habitats to the reserve.

The original presettlement vegetation of the Sugarcreek area consisted of beech forests with mixed oak areas and elm-ash swamps, the latter located along creeks and floodplain (see DMCPD). Several small to moderate sized stands of mature beech-maple and mixed mesophytic associations remain on the reserve, and the bottomlands bordering the creek branches are dominated by mixed stands of sycamore, cottonwood, hackberry, chinquapin oak, box elder, slippery elm and buckeye. A more detailed account of the geology and vegetation of Sugarcreek Reserve is in Noss (1979). Al-

[1]Manuscript received 3 March 1980 and in revised form 8 May 1980 (#80-7).
[2]Present address: Ohio Dept. Natural Resources, Division of Parks and Recreation, Fountain Square, Columbus, OH 43224.

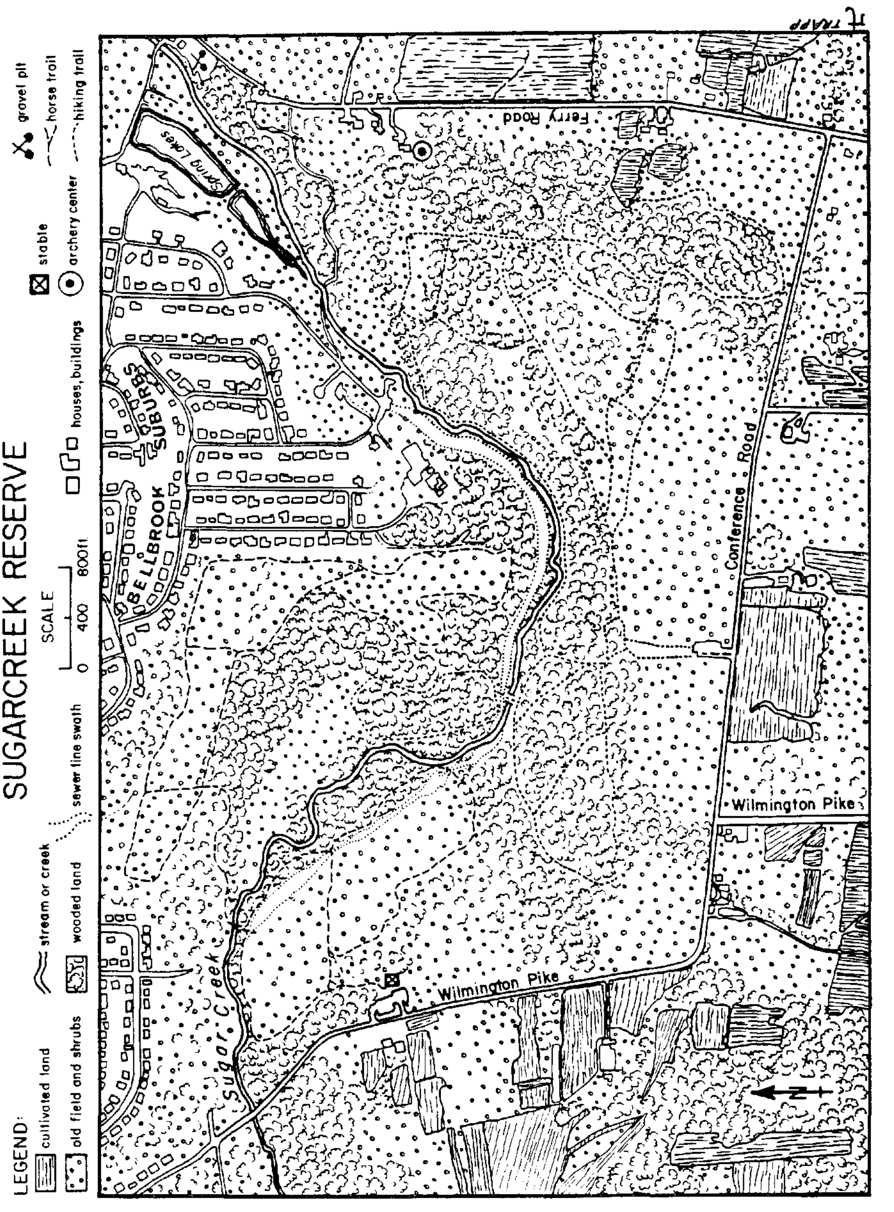

FIGURE 1. Sugarcreek Reserve in Greene Co. near Bellbrook, Ohio. Redrawn from an aerial photograph taken in 1975. Note encroachment from the north of suburbs of Bellbrook. Additional housing development has taken place around the reserve since the aerial photograph was taken, isolating the reserve from other natural habitats.

though the majority of Sugarcreek Reserve could be classified as mixed forest, most of it is not mature forest but successional patches of variable age, the youngest being less than 10 years into secondary succession. Some mowed areas are maintained and an approximately 20 m wide swath extending west to east, cut through the bottomland in 1972 for the installation of a sewer line, has subsequently grown up to wet meadow. In late summer of 1978, shortly after completion of the field work for this study, a large portion of the front (south) meadow, which was growing up in box elder and wild black cherry, was cut and burned with the intention of introducing a tallgrass prairie community.

Although containing numerous habitat types, Sugarcreek Reserve is relatively distinct as an island of more or less natural vegetation in a sea of intensive use farmland and increasingly invading housing subdivisions. The surrounding landscape is becoming increasingly inhospitable to many species and suitable dispersal corridors are being severed. The major wooded corridor extending from the reserve, along Sugar Creek to the west of the reserve, is no longer there (see fig. 1). This corridor connected Sugarcreek Reserve to another forest island less than a mile to the west and of a size comparable to the forested portion of Sugarcreek. It is significant that in 1978 housing development began south of Sugar Creek in the forest corridor that linked these two forest islands, and it appears that the development will sever any continuous wooded extension between the two insularizing Sugar Creek Reserve.

METHODS

From 31 May to 9 August, 1978, a time period during which resident bird patterns should be most stable, with nearly all breeding birds in territories (Trautman and Trautman 1968, Adams and Barrett 1976), I conducted 33 bird censuses. Three were conducted each week (defined as a Sunday to Saturday interval) except one week (4–10 June) when 5 censuses were conducted and 2 weeks (25 June–1 July and 6–12 August) when only 2 were conducted due to inclement weather. All censuses began within 0.5 hour of sunrise and continued for precisely 3 hr. They were conducted only on fair (rain-free) mornings to control for possible weather effects on avian activity and detectability.

An auditory/visual fixed strip technique was used, wherein I walked slowly (averaging perhaps 1.5 km/hr) with frequent brief pauses to look and listen, a method described by Emlen (1971). I kept my strip width constant at 40 m, recording all birds observed within 20 m in both lateral directions of my path. For completeness, I included birds flying directly over the strip as well as those seen or heard within the strip width in front of or behind me. I walked different parts of the reserve on different days in an alternating fashion so that over a week's time all parts of the study area received approximately equal coverage. I followed maintained trails whenever possible but departed from trails when necessary to adequately cover back areas or other important habitat types. The intention was to determine the avifauna of the mixed-forest and edge habitats that comprise the majority of Sugarcreek Reserve and which distinguish it as a habitat island with respect to the surrounding developed landscape. For a more detailed account of the study method, see Noss (1979).

Bird species diversity was calculated with the aid of the computer program for the Shannon measure described by Zar (1968). All statistical analysis was executed by computer using the SPSS package (Nie *et al* 1975) and interpreted with the aid of Sokal and Rohlf (1969).

RESULTS AND DISCUSSION

Eleven continuous weeks of study (31 May—9 August, 1978) with an average of three 3-hr censuses per week yielded a total count of 77 species (table 1). Since each week of censusing covered the same study area and most species counted are assumed to be territorial and remain on territory throughout the study period, the cumulative number of individuals in table 1 refers only to cumulative sample size, not to population size, for it was not intended to distinguish between individual birds of a species or to map territories.

The relative abundance value for a given species can be thought of as the proportion of potential encounters that is intraspecific for an individual of that species wandering freely through the study area (table 1). The importance value (Kricher 1973) is defined as the relative abundance plus the relative frequency (percent of the total number of censuses in which a given species appeared). The maximum value that a species could have is 200. The importance value allows the consideration of species that are periodically common along with species that may be consistently uncommon but nevertheless regular members of the community. Table 2 provides a comparison of relative abundance and importance value rankings for Sugarcreek birds, listing the top 30 species in each category. Note that the first 6 species in each category are in identical order, indicating that these species were both highly abundant in terms of numbers of individuals and regularly recorded in censuses. In fact, these 6 species were each recorded in all 33 censuses as were the top 16 species in the importance value ranking.

TABLE 1

Summary of individual species census data. Species are ordered taxonomically in accordance with Trautman and Trautman (1968).

Species	Status	Cumulative No. Individuals after (x) Weeks Study Time						Rel. Abund. (%)	Rank†	Import. Value	Rank†
		2	4	6	8	10	(cum.)**				
Great Blue Heron (*Ardea herodias*)	SM						1	0.01	(60t)	3.04	(67t)
Green Heron (*Butorides virescens*)	SLM	1	3	4	7	14	15	0.20	(48)	27.47	(49)
Mallard (*Anas platyrhynchos*)	PR	6	7	8	20	20	20	0.26	(43)	15.41	(57)
Wood Duck (*A x sponsa*)	SM	3	3	3	3	3	3	0.04	(58t)	6.10	(64t)
Turkey Vulture (*Cathartes aura*)	SM	2	2	2	2	2	2	0.03	(59t)	6.09	(65t)
Red-tailed Hawk (*Buteo jamaicensis*)	PR	1	2	3	3	4	4	0.05	(57t)	12.17	(62t)
American Kestrel (*Falco sparverius*)	PR					1	1	0.01	(60t)	3.04	(67t)
Bobwhite (*Colinus virginianus*)	PR	5	5	6	7	9	9	0.12	(52)	24.36	(51)
Ring-necked Pheasant (*Phasianus colchicus*)	PR	7	9	12	17	18	19	0.25	(44)	48.73	(42)
Killdeer (*Charadrius vociferus*)	PRM		1	3	6	9	10	0.13	(51)	18.31	(54)
American Woodcock (*Philohela minor*)	SM		1	2	2	3	3	0.04	(58t)	9.13	(63t)
Spotted Sandpiper (*Actitis macularia*)	LM				1	2	3	0.04	(58t)	9.13	(63t)
Rock Dove (*Columba livia*)	PR	10	42	42	45	59	89	1.17	(27)	28.44	(48)
Mourning Dove (*Zenaidura macroura*)	PRM	5	10	14	23	33	37	0.49	(35)	61.09	(41)
Yellow-billed Cuckoo (*Coccyzus americanus*)	LM	16	34	49	68	87	93	1.22	(26)	101.22	(16)
Black-billed Cuckoo (*Coccyzus erythropthalmus*)	LM	2	9	14	19	25	27	0.36	(40t)	70.05	(36)
Great Horned Owl (*Bubo virginianus*)	PR	1	1	1	1	1	1	0.03	(60t)	3.04	(67t)
Barred Owl (*Strix varia*)	PR		2	3	3	3	3	0.04	(58t)	6.10	(64t)
Chimney Swift (*Chaetura pelagica*)	LM	29	44	57	81	116	129	1.69	(19)	98.66	(18)
Ruby-throated Hummingbird (*Archilochus colubris*)	LM	2	2	2	5	6	7	0.09	(54t)	18.27	(55t)
Belted Kingfisher (*Megaceryle alcyon*)	PR	5	13	18	23	29	31	0.41	(38)	64.04	(38)
Common Flicker (*Colaptes auratus*)	PRM	16	25	39	58	84	99	1.30	(25)	98.27	(19)
Pileated Woodpecker (*Dryocopus pileatus*)	PR	7	10	13	14	16	17	0.22	(46)	42.65	(44)
Red-bellied Woodpecker (*Centurus carolinus*)	PR	12	24	34	42	55	58	0.76	(31)	91.67	(27)
Red-headed Woodpecker (*Melanerpes erythrocephalus*)	PRM		1	1	2	4	5	0.07	(56t)	15.22	(58)
Hairy Woodpecker (*Picoides villosus*)	PR	1	1	1	1	3	4	0.05	(57t)	12.17	(62t)

*PR=permanent resident, SM=short distance migrant (wintering in southern U.S.), LM=long distance (neotropical) migrant, PRM=permanent resident or short distance migrant, SLM=short distance or long distance migrant; determined by Robbins *et al* (1966) and Trautman and Trautman (1968).

**The cumulative total number of individuals after 11 weeks of censusing.

†Where a species placed in a ranking by relative abundance or importance value; "t" indicates that a species tied with at least one other for that position in the ranking.

TABLE 1. *Continued.*

Species	Status	Cumulative No. Individuals after (x) Weeks Study Time						Rel. Abund. (%)	Rank†	Import. Value	Rank†
		2	4	6	8	10	(cum.)**				
Downy Woodpecker (*Picoides pubescens*)	PR	14	30	54	91	122	128	1.68	(20)	95.62	(21)
Eastern Kingbird (*Tyrannus tyrannus*)	LM					7	8	0.11	(53t)	12.23	(60)
Great Crested Flycatcher (*Myiarchus crinitus*)	LM	6	10	12	17	25	27	0.36	(40t)	63.99	(40)
Acadian Flycatcher (*Empidonax virescens*)	LM	59	105	140	193	235	249	3.27	(13)	103.27	(10)
Willow Flycatcher (*Empidonax traillii*)	LM	16	29	36	51	61	62	0.84	(30)	85.66	(29)
Eastern Wood Pewee (*Contopus virens*)	LM	24	43	58	77	98	103	1.35	(24)	101.33	(15)
Tree Swallow (*Iridoprocne bicolor*)	LM		2	2	2	2	2	0.05	(59t)	3.06	(66)
Rough-winged Swallow (*Stelgidopteryx ruficollis*)	LM	6	13	21	26	34	39	0.51	(33)	45.97	(43)
Barn Swallow (*Hirundo rustica*)	LM	2	6	7	11	19	22	0.29	(41)	30.59	(47)
Purple Martin (*Progne subis*)	LM					9	16	0.21	(47t)	12.33	(59t)
Blue Jay (*Cyanocitta cristata*)	PR	17	28	33	47	61	65	0.86	(29)	91.76	(26)
Common Crow (*Corvus brachyrhynchos*)	PR	35	76	103	135	158	173	2.27	(17)	99.24	(17)
Carolina Chickadee (*Parus carolinensis*)	PR	67	142	225	336	415	447	5.87	(3)	105.87	(3)
Tufted Titmouse (*Parus bicolor*)	PR	36	71	95	135	178	185	2.43	(16)	102.43	(13)
White-breasted Nuthatch (*Sitta carolinensis*)	PR	5	9	14	21	29	30	0.39	(39t)	73.12	(34)
House Wren (*Troglodytes aedon*)	SLM	31	53	67	85	108	113	1.48	(22)	95.42	(23)
Mockingbird (*Mimus polyglottos*)	PR	1	1	2	3	3	3	0.04	(58t)	9.13	(63t)
Gray Catbird (*Dumetella carolinensis*)	SM	6	10	19	21	34	38	0.50	(34t)	67.17	(37t)
Brown Thrasher (*Toxostoma rufum*)	SM	12	22	36	54	67	68	0.89	(28)	73.62	(31)
American Robin (*Turdus migratorius*)	PRM	25	46	75	163	244	264	3.47	(11)	97.41	(20)
Wood Thrush (*Hylocichla mustelina*)	LM	6	12	17	24	33	36	0.47	(36t)	70.17	(35)
Blue-gray Gnatcatcher (*Polioptila caerulea*)	SLM	101	180	262	317	363	385	5.51	(6)	105.06	(6)
Cedar Waxwing (*Bombycilla garrulus*)	PR	1	1	2	2	4	16	0.21	(47t)	12.33	(59t)
Starling (*Sturnus vulgaris*)	PR	192	242	263	294	338	351	4.61	(7)	92.49	(25)
White-eyed Vireo (*Vireo griseus*)	SM	13	24	33	42	54	57	0.75	(32)	82.57	(30)
Yellow-throated Vireo (*Vireo flavifrons*)	LM	8	16	20	23	28	30	0.39	(39t)	64.03	(39)
Red-eyed Vireo (*Vireo olivaceus*)	LM	58	94	141	198	241	251	3.30	(12)	103.30	(9)
Warbling Vireo (*Vireo gilvus*)	LM	1	1	2	8	12	13	0.17	(49)	36.53	(45)
Black-and-white Warbler (*Mniotilta varia*)	LM		4	4	7	9	11	0.144	(50)	27.42	(50)
Blue-winged Warbler (*Vermivora pinus*)	LM	1	6	7	7	7	7	0.09	(54t)	18.27	(55t)
Yellow Warbler (*Dendroica petechia*)	LM	12	15	15	24	35	38	0.50	(34t)	67.17	(37t)

TABLE 1. *Continued.*

Species	Status	Cumulative No. Individuals after (x) Weeks Study Time						Rel. Abund. (%)	Rank†	Import. Value	Rank†
		2	4	6	8	10	(cum.)**				
Cerulean Warbler (*Dendroica cerulea*)	LM	45	69	96	111	120	122	1.60	(21)	95.54	(22)
Yellow-throated Warbler (*Dendroica dominica*)	LM	9	14	20	33	34	34	0.45	(37)	73.17	(33)
Ovenbird (*Seiurus aurocapillus*)	LM	3	4	8	8	8	8	0.11	(53t)	21.32	(52)
Kentucky Warbler (*Oporornis formosus*)	LM	4	15	22	28	34	36	0.47	(36t)	73.20	(32)
Common Yellowthroat (*Geothlypis trichas*)	SM	33	64	96	137	185	200	2.63	(15)	102.63	(12)
Yellow-breasted Chat (*Icteria virens*)	LM	33	52	77	99	111	112	1.47	(23)	95.41	(24)
American Redstrart (*Setophaga ruticilla*)	LM	9	15	19	19	20	21	0.28	(42)	33.61	(46)
House Sparrow (*Passer domesticus*)	PR	3	7	7	13	18	18	0.24	(45)	18.42	(53)
Eastern Meadowlark (*Sturnella magna*)	PR	1	2	4	4	5	5	0.07	(56t)	12.19	(61)
Red-winged Blackbird (*Agelaius phoeniceus*)	PRM	96	167	234	344	416	432	5.68	(4)	105.68	(4)
Northern Oriole (*Icterus galbula*)	LM	1	3	4	5	6	6	0.08	(55)	18.26	(56)
Common Grackle (*Quiscalus quiscula*)	PRM	134	293	390	482	516	533	7.00	(1)	107.00	(1)
Brown-headed Cowbird (*Molothrus ater*)	SM	98	160	205	267	285	285	3.74	(10)	91.62	(28)
Scarlet Tanger (*Piranga olivaceae*)	LM			2	2	2	2	0.03	(59t)	6.09	(65t)
Cardinal (*Richmondena cardinalis*)	PR	99	169	243	325	421	448	5.89	(2)	105.89	(2)
Indigo Bunting (*Passerina cyanea*)	LM	97	155	205	254	308	329	4.32	(8)	104.32	(7)
American Goldfinch (*Spinus tristis*)	PRM	65	127	202	288	366	397	5.22	(5)	105.22	(5)
Rufous-sided Towhee (*Pipilo erythrophthalmus*)	PRM	47	84	116	162	211	231	3.03	(14)	103.03	(11)
Field Sparrow (*Spizella pusilla*)	PRM	50	89	135	212	293	315	4.14	(9)	104.14	
Song Sparrow (*Melospiza melodia*)	PRM	30	60	81	108	137	152	2.00	(18)	102.00	(14)
Total		1743	3030	4272	5641	6998	7613	100.0			

It is obvious that the relative abundance ranking gives, with my study method, what is probably disproportionately high weight to those flocking species that are periodically found in extremely high abundance in particular censuses. For example, the 10 June census recorded 120 starlings, almost all of which comprised a single flock departing the roosting area in the bottomland forest at about dawn. This flock was possibly of the type described by Bent (1950), consisting of juveniles from the first brood which band together and forage in fields by day and return to roost in the woods for the night. Such flocks have been reported to number in the thousands by mid-July. As a result of this flocking behavior, the starling ranks seventh in relative abundance but only 25th in importance value. The importance value thus corrects somewhat for the periodic occurrence of flocks which may bias relative abundance rankings. Birds such as the red-eyed vireo, Acadian flycatcher, rufous-sided towhee, common

TABLE 2

Comparison of relative abundance and importance value rankings for Sugarcreek birds—top 30 species in each ranking.*

	By Relative Abundance (%)		By Importance Value
1	Common Grackle	1	Common Grackle
2	Cardinal	2	Cardinal
3	Carolina Chickadee	3	Carolina Chickadee
4	Red-winged Blackbird	4	Red-winged Blackbird
5	American Goldfinch	5	American Goldfinch
6	Blue-gray Gnatcatcher	6	Blue-gray Gnatcatcher
7	Starling	7	Indigo Bunting
8	Indigo Bunting	8	Field Sparrow
9	Field Sparrow	9	Rey-eyed Vireo
10	Brown-headed Cowbird	10	Acadian Flycatcher
11	American Robin	11	Rufous-sided Towhee
12	Red-eyed Vireo	12	Common Yellowthroat
13	Acadian Flycatcher	13	Tufted Titmouse
14	Rufous-sided Towhee	14	Song Sparrow
15	Common Yellowthroat	15	Eastern Wood Pewee
16	Tufted Titmouse	16	Yellow-billed Cuckoo
17	Common Crow	17	Common Crow
18	Song Sparrow	18	Chimney Swift[+]
19	Chimney Swift[+]	19	Common Flicker
20	Downy Woodpecker	20	American Robin
21	Cerulean Warbler	21	Downy Woodpecker
22	House Wren	22	Cerulean Warbler
23	Yellow-breasted Chat	23	House Wren
24	Eastern Wood Pewee	24	Yellow-breasted Chat
25	Common Flicker	25	Starling
26	Yellow-billed Cuckoo	26	Blue Jay
27	Rock Dove[+]	27	Red-bellied Woodpecker
28	Brown Thrasher	28	Brown-headed Cowbird
29	Blue Jay	29	Willow Flycatcher
30	Willow Flycatcher	30	White-eyed Vireo

*Kricher (1973).

+No good evidence for nesting within the study area.

yellowthroat, song sparrow, eastern wood pewee and yellow-billed cuckoo, all consistently common but found in small numbers, accordingly rank higher in importance values than in relative abundances. Neither of the 2 values, however, can realistically be considered to provide more than a rough estimate of the true ecological importance of a species in the community. Such real importance is conceptually better defined by the sum of the ecological changes that would take place should the particular species be removed from the community (Hurlbert 1971) but is not generally amenable to testing when so defined.

Of the 77 species observed in Sugarcreek Reserve during the study period, good evidence for breeding and/or nesting within the study area was found for only 61 species. For the remaining 16 species, the evidence for breeding was insufficient, or judging from considerations of temporal occurrence over the study period (table 1), spatial location (*e.g.*, consistently by a reserve boundary), or from various observed behavioral or known life history characteristics, the birds are assumed to have bred outside the study area and utilized the reserve only for foraging. These nonbreeding species are the great blue heron, wood duck, turkey vulture, red-tailed hawk, American kestrel, killdeer, spotted sandpiper, rock dove, chimney swift, red-headed woodpecker, eastern kingbird, tree swallow, purple martin, mockingbird, cedar waxwing and scarlet tanager. Although these species probably did not nest within the study area, the persistent appearance of some (*e.g.*, chimney swift) in the censuses suggests ecological importance in the community. Furthermore, the number of breeding bird species in the 1978 study may be lower than that of most years within the last decade. In particular, I observed evidence of nesting in the following species in previous years: Cooper's hawk, red-tailed hawk, mockingbird, Carolina wren and eastern bluebird. The latter 2 species disappeared abruptly from the avifauna during the severe winter of 1976–77, indicating the importance of critical events in the nonbreeding season to the structure of the breeding community. Over the past few years of birding in Sugarcreek Reserve, I have recorded a total of 134 species over all seasons.

By all comparisons with similar temperate areas studied, Sugarcreek Reserve is exceedingly rich in bird species. Karr (1968), in a study of Illinois avifaunas, found highest diversities in a bottomland forest study area where 100 acres of forest yielded a cumulative sample of 489 individuals comprising 32 species. This sample size is comparable to my third cumulative census, where a sample of 537 individuals comprised 51 species. My second cumulative census had a sample size of 336 individuals comprising 46 species. Remarkably, my first census of 173 individuals comprised 36 species, a value still higher than Karr's. Karr (1968) notes that the bird species diversities reported in his study are higher than those reported by MacArthur and MacArthur (1961) for other locations in the eastern United States, as well as higher than similar measurements from Puerto Rico and all but the mature and young tropical forests in Panama surveyed by MacArthur *et al* (1966). Adams and Barrett (1976) censused birds in 2 southwestern Ohio beech-maple forests, one virgin (Hueston Woods located within about 50 km of Sugarcreek Reserve) and one selectively cut (Lewis Woods) and found breeding bird species richness values of 38 and 32, respectively. This finding is in marked contrast to the 61 species apparently breeding within Sugarcreek Reserve, representing a richer summer and/or breeding avifauna than any corresponding temperate area for which I have found diversity values reported in the literature. This high species richness results from 3 primary factors:

1. high internal habitat heterogeneity and edge effect
2. the comparatively large size of the study area
3. the recent insularization and concomitant supersaturation of the reserve as surrounding habitat has become unsuitable for many species.

Of direct concern in this study were the proximate environmental factors influencing bird species diversity on an ecological time scale. There is no attempt to explain the ultimate factors underlying species diversity, such as those determinants which operate on an evolutionary time scale. It has been abundantly documented that the structural characteristics of vegetation are highly related to the bird species diversity of a given region (MacArthur and MacArthur 1961, MacArthur *et al* 1962, Roth 1976, among others). These studies have shown that the complexity of the vertical distribution of leaves, as measured by foliage height diversity, is a good predictor of bird species diversity.

The number of vertical layers of vegetation alone may account for breeding bird species diversity within relatively homogeneous habitats, but is insufficient to account for diversity within areas that are more patchy. Such patchiness or horizontal variability in the types of profiles in a habitat may be the principal factor determining the variety of birds that breed in a particular area (MacArthur and MacArthur 1961, Roth 1976). The abundance of a given species in an area has been shown to be proportional to the number of patches of vegetation whose foliage profile is acceptable to that species, since breeding individuals of a species select sites of a certain vegetational configuration that is more or less unique to that species. The correct structure is ecologically important to birds in providing display perches, shelter and nest sites and suitable foraging areas (Wiens 1973).

It follows that for additional species to be accommodated in an area, there must be either an increase in the number of kinds of patches available, or else more spatial overlap by species in their utilization of available patches (Roth 1976). Willson (1974) demonstrated that the greatest increase in bird species occurs with the addition of shrub and tree layers to a vegetational series, providing for the addition of new avian guilds. As accounted in my study area description, Sugarcreek Reserve constitutes a mosaic of habitat types and seral stages but is nevertheless distinct as an island of more or less natural vegetation in a sea of developed land. This internal habitat heterogeneity, intensified by the relatively large size of the study area (228 ha), is one factor responsible for the exceptionally high number of bird species when compared to other temperate localities.

A problem yet to be solved is how to quantify the extent of insularization for a given habitat island. Functional insularity generally is determined by the degree of isolation and independence from forces external to the unit of habitat under consideration. A nature reserve may be contiguous enough with surrounding natural habitat that it represents simply a sample from some larger community and is therefore not a self-contained unit that can be legitimately characterized as insular. As the area around a reserve becomes more developed, however, and hence inhospitable to many species, the reserve becomes isolated and a greater species-area relationship is observed. Insularization is therefore a dynamic process. At a given point in time, a nature reserve may fall anywhere along the sample-isolate continuum. Eventually, fewer species may be found in the insularizing reserve than in sample areas of equal size (Miller and Harris 1977). Alternately, the species richness may not change much, or may even increase, but species composition will transmute such that "edge" species are favored while size dependent forest species that require certain minimum areas for long-term survival will disappear. The latter situation was found in New Jersey by Forman *et al* (1976) where a forest island of a given size contained more species than did a sample plot of equal size within an extensive forest, but the additional species were birds that primarily inhabited the forest edge, such as the gray catbird, rufous-sided towhee and common flicker. Birds of the forest interior, such as ovenbirds, black-and-white warblers, black-billed cuckoos and red-shouldered hawks, were limited to the larger forest islands.

Consideration of the species-area relation has led most observers to favor one large reserve over 2 or more smaller reserves of equivalent total area in any given case. Soulé and Wilcox (1980) provide a succinct and up-to-date summary of the general principles and controversies involved in extrapolating island biogeography to the design of nature reserves. Most importantly, "the question is not which reserve system contains more species, but which contains more species that would be doomed to extinction in the absence of refuges" (Diamond 1976). Species-area relations suggest that if a large area of natural habitat is destroyed with a small portion retained as a nature reserve, the reserve will initially contain more species than appropriate for its area at equilibrium. Such temporary diversity on newly formed islands was called "supersaturation" by Diamond (1973). Species will go extinct until the new equilibrium number is reached. The relaxation rate for a given island is the rate at which its species number drops to the new equilibrium value appropriate for an island of that area.

Although the degree of insularization of Sugarcreek Reserve has not been quantified, the reserve clearly is isolated at least from the standpoint of those species that are ecologically confined to the forest interior. Furthermore, the surrounding habitat is becoming increasingly inhospitable as farmland gives way to housing subdivisions and dispersal corridors are severed. Sugarcreek presently is supersaturated with bird species and is not in equilibrium either in the biogeographic sense or the successional sense. This supersaturation may be partly due to an influx of species from surrounding forests that have been recently destroyed, a "crowding on the ark" as suggested by Leck (1979).

Unless land areas around Sugarcreek are permitted to remain as or to grow back to forest, we can expect large-scale extirpations of many species in the coming decades.

Island biogeographic theory predicts high species turnover rates on small isolated islands. Terborgh (1976) and Whitcomb *et al* (1976) have shown that the combined processes of relaxation and turnover in forest fragments result in a community composed almost entirely of widespread, ecologically generalized "weedy" species. These species are generally common in edge habitats and early successional stages and are therefore quite capable of long-term survival around farms and suburbs and not in any need of protection at present. Whitcomb and co-authors (1976) point out that 92% of the breeding avifauna in extensive forest tracts in eastern North America is composed of neotropical migrants. In fragmented forests, many of the neotropical migrant species disappear and the avifauna of such tracts comes to be dominated by species that are either permanent residents or short distance migrants. In Sugarcreek Reserve, only 25 (41%) of the 61 breeding species are neotropical migrants (table 1). The area censused in Sugarcreek Reserve is not all mature forest, so these figures cannot be compared to other studies without qualification. The presence of vegetation patches of an earlier successional age may increase the proportion of permanent residents and short-distance migrants regardless of insularization effects. Nevertheless these species, particularly those attracted to edge habitat, undoubtedly benefit from the insularization process at the expense of the neotropical migrants of the forest.

Whitcomb *et al* (1976) and Whitcomb (1977) also cite evidence that, in areas where forest has been reduced to isolated woodlots (most certainly the case for southwestern Ohio), avian brood parasites (brown-headed cowbirds), nest predators (small mammals, grackles, jays and crows) and nonnative nest-hole competitors (starlings) are usually abundant in the surrounding agricultural and urban environments and often invade small forest tracts. The combined impact of these opportunistic species is probably a major force in the avifaunal changes that accompany forest fragmentation and isolation. In this context it is ominous that the above-named opportunists are highly abundant in Sugarcreek Reserve. In terms of relative abundance in the summer avifauna (table 2), grackles rank first, starlings rank seventh, cowbirds rank tenth, crows rank seventeenth and blue jays rank twenty-ninth out of 77 observed species. Only 2 of the 10 most abundant species were neotropical migrants, and these, the blue-gray gnatcatcher and indigo bunting, utilize edge habitat extensively.

As island biogeography indicates, not only is the size of the reserve crucial, but so also is its isolation from species sources. It has been suggested (Willis 1974, Diamond 1975) that linking devices, such as forested corridors or stepping-stones of small forest tracts, might allow for species or gene flow between reserves and hence balance the effects of insularization. MacClintock *et al* (1977) offer explicit evidence of the importance of forest corridors in maintaining species numbers in fragmented forests. In their study, a small forest tract connected by a corridor to a nearby extensive forest system was characterized by a typical forest-interior avifauna, in contrast to the depauperate condition of similar but isolated forest fragments.

In this regard, the destruction (or at least vast reduction) of the small forest corridor along Sugar Creek to the west of the reserve as development began in 1978, effectively isolating the reserve from any continuous forest, is an egregious example of poor land use planning. The Open Space Committee of the Miami Valley Regional Planning Commission in 1971 studied the Sugar Creek area and recommended that "open space corridors, rather than isolated chunks of open space, be maintained." It can be assumed that "open space" in this sense means undeveloped or natural (forested) areas. The committee furthermore recommended that public ownership would best protect these corridors and that "development proposals should be modified, where necessary, so that land can be dedicated for park purposes within these corridors" (MVRPC 1971). It appears that the planners have not heeded this worthy advice. In evaluating the effects of insularization on the biota of nature reserves, planners must keep in mind that the process of faunal deterioration is, for all practical purposes, irreversible (Whitcomb *et al* 1976).

It appears that the Dayton-Montgomery County Park District has sought to maintain high species diversity through the provision and maintenance of high habitat diversity in their management of Sugarcreek and other reserves. This policy is not conducive to the preservation of long-term regional diversity by protection of the most vulnerable species assemblages. The question of consequence is: Do we want to maximize species diversity *per se* by providing for a heterogeneous assortment of successional habitats in our reserves, which is the situation we find now in Sugarcreek, or do we want to preserve particular collections of species that were relatively abundant before human disruption of the landscape but are now declining and faced with regional extirpation? The latter alternative is certainly the most conducive to the maintenance of long-term regional diversity, for the species of undisturbed forests (*e.g.*, the neotropical migrants mentioned above) are those most likely to show area dependence and vulnerability to extinction in fragmented habitats. The species of successional habitats can generally get along fine in the man-altered landscape. Therefore "the most prudent preservation strategies are those that insulate sensitive species from the effects of human disturbance" (Whitcomb *et al* 1976). In the case of Sugarcreek Reserve, the prudent strategy would be to allow the vegetation to return to mature forest, thereby increasing the forest island size and hence the population sizes of the vulnerable forest-interior species. Meanwhile, over the region as a whole, all facets of the natural disturbance regime should be permitted to operate, providing the habitat heterogeneity required by the indigenous flora and fauna.

The past management of Sugarcreek Reserve has been inappropriate and destructive to sensitive species. In particular, the cutting of a wide swath through the bottomland forest in 1972 for the installation of a sewer line was a land use error. Whitcomb *et al* (1976) have reported that when artificial swaths are cut through forests, severe destabilization of the faunal community can occur. In such cases the overall bird species richness may be increased, but only at the expense of the forest-interior species. Furthermore, the creation of such long strips of edge habitat favors colonization by the avian brood parasites, nest predators and nonnative nest-hole competitors that my study showed to be now exceedingly abundant in Sugarcreek Reserve. Although the creation of forest edge habitat attracts a variety and abundance of passerine birds, these edges function as "ecological traps" (Gates and Gysel 1978). Though edges contain the relevant structural cues of the mixed habitat in which such species evolved, birds nesting near man-made habitat discontinuities have smaller clutches and are subject to higher rates of predation and cowbird parasitism. The recent widening of the trails (up to 7 m or more in some places) and expansion of the trail system in Sugarcreek similarly creates artificial edge and has the additional effect of making sensitive areas of the reserve more accessible to visitors and thus to adverse human impact. These modifications of habitat, apparently instrumented to accommodate increasingly large numbers of people and their unimpeded diffusion throughout the reserve, are certainly not examples of sound scientific management.

Sugarcreek Reserve is presently rich in bird species in accordance with the high habitat diversity and edge effect, the comparatively large size of the study area and the recent insularization and concomitant supersaturation of the reserve as surrounding natural habitat has been extensively modified. This richness, however, is probably ephemeral and the species most in need of protection are not being considered by the present managers. Future management of Sugarcreek Reserve should emphasize preservation of extinction-prone species assemblages rather than high diversity *per se*. The long-term maintenance of regional diversity demands such an approach, where nature reserves are seen as more than mere recreation areas.

Acknowledgments. This paper was adapted from a thesis submitted to the Graduate Program in Ecology of the University of Tennessee, Knoxville, in partial fulfillment of the requirements for the degree of Master of Science, June, 1979. I am particularly grateful to my major professor, Dr. A. C. Echternacht, and graduate committee members, Dr. J. T. Tanner and Dr. E. E. C. Clebsch, for their encouragement and critical evaluation during the course of this study and writing.

LITERATURE CITED

Adams, D. L. and G. W. Barrett 1976 Stress effects on bird-species diversity within mature forest ecosystems. Amer. Midl. Nat. 96:179-194.

Adamus, P. R. and G. C. Clough 1978 Evaluating species for protection in natural areas. Biol. Conserv. 13: 165-178.

Bent, A. C. 1950 Life histories of North American wagtails, shrikes, vireos, and their allies. U. S. Natl. Mus. Bull. 197.

DMCPD (Dayton-Montgomery County Park District). Miscellaneous unpublished, undated printed material. Dayton, OH.

Diamond, J. M. 1973 Distributional ecology of New Guinea birds. Science 179: 759-769.

——— 1975 The island dilemma: lessons of modern biogeographic studies for the design of natural preserves. Biol. Conserv. 7: 129-146.

——— 1976 Island biogeography and conservation: strategy and limitations. Science 193: 1027-1029.

Emlen, J. T. 1971 Population densities of birds derived from transect counts. Auk 88: 323-342.

Forman, R. T. T., A. E. Galli and C. F. Leck 1976 Forest size and avian diversity in New Jersey woodlots with some land use implications. Oecologia (Berlin) 26: 1-8.

Gates, J. E. and L. W. Gysel 1978 Avian nest dispersion and fledgling success in field-forest ectones. Ecology 59: 871-883.

Hurlbert, S. H. 1971 The nonconcept of species diversity: a critique and alternative parameters. Ecology 52: 577-586.

Karr, J. R. 1968 Habitat and avian diversity on strip-mined land in east central Illinois. Condor 70: 348-357.

Kricher, J. C. 1973 Summer bird species diversity in relation to secondary succession on the New Jersey Piedmont. Amer. Midl. Nat. 89: 121-137.

Leck, C. F. 1979 Avian extinctions in an isolated tropical wet-forest preserve, Ecuador. Auk 96: 343-352.

MacArthur, R. H. and J. W. MacArthur 1961 On bird species diversity. Ecology 42: 594-598.

———, ——— and J. Preer 1962 On bird species diversity—prediction of bird censuses from habitat measurements. Amer. Nat. 96: 167-174.

———, H. Recher and M. Cody 1966 On the relation between habitat selection and species diversity. Amer. Nat. 100: 319-332.

MacClintock, L., R. F. Whitcomb and B. L. Whitcomb 1977 Island biogeography and "habitat islands" of eastern forest. II. Evidence for the value of corridors and minimization of isolation in preservation of biotic diversity. Amer. Birds 31: 6-12.

MVRPC (Miami Valley Regional Planning Commission Open Space Committee—Natural Areas Task Force) 1971 Unpubl. report on a special study of the Sugarcreek area. Dayton, OH.

Miller, R. I. and L. D. Harris 1977 Isolation and extirpations in wildlife reserves. Biol. Conserv. 12: 311-315.

Nie, N. H., C. H. Hull, J. G. Jenkins, K. Steinbrenner and D. H. Bent 1975 Statistical package for the social sciences. 2nd ed. McGraw-Hill, New York. 675 pp.

Noss, R. F. 1979 The avifauna and its diversity in Sugarcreek Reserve: component trends over a summer and implications for sanctuary management. Unpub. M.S. thesis. University of Tennessee, Knoxville.

Robbins, C. S., B. Bruun and H. S. Zim 1966 Birds of North America. Golden Press, New York. 340 pp.

Roth, R. R. 1976 Spatial heterogeneity and bird species diversity. Ecology 57: 773-782.

Sokal, R. R. and F. J. Rohlf 1969 Biometry. W. H. Freeman Co., San Francisco. 776 pp.

Soulé, M. E. and B. A. Wilcox 1980 Conservation biology: its scope and challenge, pp. 1-8 *In:* M. E. Soulé and B. A. Wilcox (eds.). Conservation biology: an evolutionary-ecological perspective. Sinauer Associates, Sunderland, Mass.

Terborgh, J. 1976 Island biogeography and conservation: strategy and limitations. Science 193: 1029-1030.

Trautman, M. B. and M. A. Trautman 1968 Annotated list of the birds of Ohio. Ohio J. Sci. 68: 257-332.

Whitcomb, R. F. 1977 Island biogeography and "habitat islands" of eastern forest. I. Introduction. Amer. Birds 31: 3-5.

———, J. F. Lynch, P. A. Opler and C. S. Robbins 1976 Island biogeography and conservation: strategy and limitations. Science 193: 1030-1032.

Wiens, J. A. 1973 Interterritorial habitat variation in Grasshopper and Savannah Sparrows. Ecology 54: 877-884.

Willis, E. O. 1974 Populations and local extinctions of birds on Barro Colorado Island, Panama. Ecol. Monogr. 44: 153-169.

Willson, M. F. 1974 Avian community organization and habitat structure. Ecology 55: 1017-1029.

Zar, J. H. 1968 Computer calculation of information-theoretic measures of diversity. Trans. Illinois State Acad. Sci. 61: 217-219.