ENVIRONMENTAL EVALUATIONS USING BIRDS AND THEIR HABITATS

Jean W. Graber
Richard R. Graber

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Since the passage of the U. S. National Environmental Policy Act of 1969, the number of requests for bird population data to be used in environmental-impact studies has increased annually at the Illinois Natural History Survey. The problem of evaluating the natural environment is both extremely important and extremely complicated, and no one investigator can know enough to make such an evaluation with complete accuracy. Such evaluations often concern large acreages of land, and the biological investigator is, thus, confronted with an array of habitats that may support thousands of species of organisms, most of them specifically unknown to the investigator and poorly known even to science except by name. Though the Environmental Policy Act did not place strict time limitations on the preparation of impact statements, in practice the investigator is often asked for a report within a time schedule that is wholly unrealistic in view of the magnitude of the task.

Hopkins et al. (1973) discussed environmental-impact statements and their potential contents in a general way, but did not deal with the biological aspects of the problem. A practical standard upon which to base evaluations of biological communities has been lacking. Although land can be considered in terms of the economic value of its various uses, natural communities are beyond the realm of human economics, as there is no place where they can be fabricated or purchased. For this reason ecological values must take precedence over economic ones in the evaluation of natural communities.

Even to attempt to standardize something so complex as an evaluation of natural populations will strike many biologists as ludicrous. Yet there are strong arguments for making the attempt. Presently, all too often, neither the writer nor the reviewer of an environmental-impact statement is fully qualified to make a judgment on the value of a given report or the true impact of a given action upon the environment. With a standard scale upon which impacts can be measured quantitatively, judgments can become more objective regardless of who makes them. The problem of standardizing environmental evaluations seems particularly difficult when it is remembered that the method must be practicable for a large number of different investigators with varied backgrounds. It must, therefore, be simplified as much as possible. From such considerations we developed our method on what we believe to be logical grounds. The method can apply not only to impact studies that involve the potential destruction or gross alteration of terrestrial habitats, but also to the acquisition of land for nature preserves.

For practical reasons we have restricted our consideration to Illinois, and although the same principles can be applied to other geographic areas, we have provided basic evaluation data only for Illinois. We did so because Illinois is the area we know best and because certain types of background data — for example, habitat inventories and census data — have traditionally been organized and presented according to state boundaries.

We have based our method of environmental evaluation on bird populations and their gross habitats. Ideally, all elements of the environment — floral, faunal, geologic, and others — should be considered in calculating environmental value. In practice, however, more components of the environment are ignored than are considered in impact studies, with the vast invertebrate populations being particularly slighted. The omissions are understandable. Few investigators are competent to identify all the plant species they encounter in their field work, let alone animals and many other constituents of the environment. The use of bird data in our method of evaluation is not intended to diminish the consideration of other environmental components. The greater the number of groups considered, the more valuable will be the final statement and judgment. As a practical matter, however, especially in view of the limitations of time and the capabilities of any one investigator, it is reasonable to base the standard on one faunal group and its gross habitats. The fauna and associated habitats in this case serve as an index to general biological richness. As will be explained, other faunal or floral groups can be used as we have used bird populations.

There are arguments both for and against the use of bird data in this capacity. Bird populations have several characteristics that make them useful in a consideration of environmental quality. Birds are relatively conspicuous and easy to detect. They are virtually omnipresent — occurring in nearly all terrestrial and aquatic habitats throughout the world excepting water below 200 feet or even (except briefly) at shallower depths. Their populations are measurable and better known than are those of most other groups. In Illinois the number of breeding species occurring regularly each year (about 180) is no

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an overwhelming number with which to work. Birds occupy all gross habitats, and their variety in a given habitat reflects the complexity of the habitat. Birds make contact with nearly all facets of the environment in a number of ways, including the intake of a great variety of food.

Perhaps the worst characteristic of birds for their use as environmental indicators on a specified area is their great mobility, which enables them to migrate hundreds and even thousands of miles and changes populations overnight at a given place both quantitatively and qualitatively (Fig. 1 and Table 1). Most Illinois bird populations are migratory. Few are wholly nonmigratory, and even most of the species that are seen year round in the state have migratory populations. Thus, any student of bird populations is confronted with the problem of migration and how it is affecting the populations he is studying.

All bird populations are more or less dependent upon the habitats they occupy, regardless of season, but the populations that are most stable and most uniformly distributed from day to day and area to area are the breeding populations. Because of this stability and the importance of the nesting habitat to the survival of the population, we have, in our consideration of environmental value, used only the nesting species as faunal indicators.

In identifying and characterizing habitats we have used Illinois references if available. Otherwise, we have used references on areas as close to Illinois as we could find. This paper is not intended as an inventory of plant communities such as that for southern Illinois by Voigt & Mohlenbrock (1964).

Table 1. — Overnight variation in numbers of warblers seen on an area in central Illinois near the Illinois River, May 5 and 6, 1969.

Species	Warblers Seen	
	May 5	May 6
Black-and-white warbler	1	0
Prothonotary warbler	9	3
Tennessee warbler	26	44
Nashville warbler	20	19
Yellow warbler	14	19
Magnolia warbler	0	12
Myrtle warbler	2	5
Black-throated green warbler	1	8
Cerulean warbler	0	1
Blackburnian warbler	0	3
Chestnut-sided warbler	1	2
Bay-breasted warbler	0	1
Blackpoll warbler	1	8
Palm warbler	0	12
Ovenbird	3	5
Northern waterthrush	11	11
Kentucky warbler	3	1
Common yellowthroat	29	20
Yellow-breasted chat	4	1
Canada warbler	1	0
American redstart	39	24
Total birds	*165*	*199*
Number of species	16	19

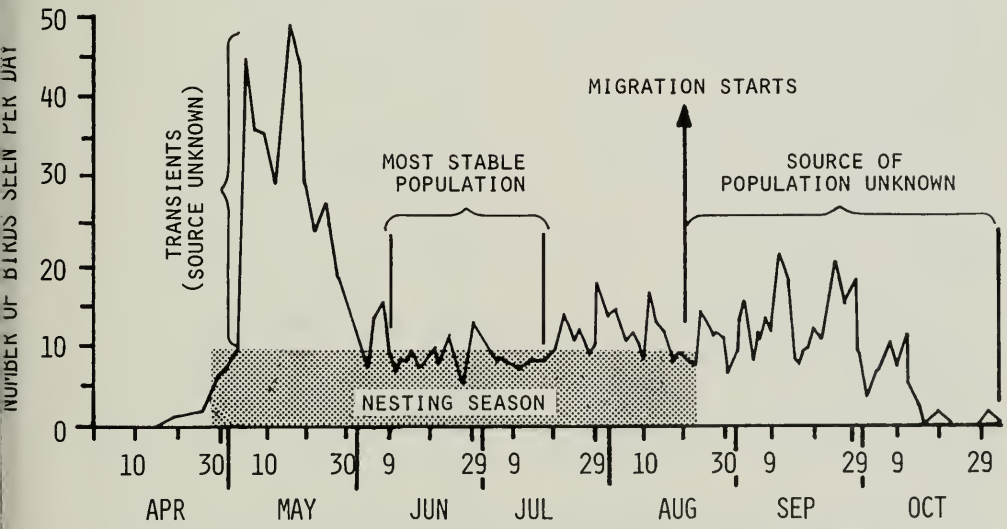

Fig. 1. — Fluctuations in daily counts of a typical migrant species (gray catbird, *Dumetella carolinensis*) that breeds in Illinois. Counts are highest during May when large numbers of migrants and breeding birds are present. Counts are elevated in late summer because of reproduction and possibly some migration; however, by this time some breeding birds may have left. In the fall there is fluctuation and constant turnover during migration.

Plant nomenclature in this paper follows Jones (1963), and the nomenclature for birds follows the American Ornithologists' Union *Check-list of North American Birds* (1957) and its supplements. We have created names for the various factors used in calculating environmental quality, and these are capitalized in the text and tables.

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DERIVATION OF THE EVALUATION METHOD

Regardless of which or how many faunal or floral groups are considered in evaluating an area, investigators are always dealing with habitats of various types, and the fundamental value of the natural environment is the value of the habitat, usually defined by its vegetation. In essence, our method of evaluation is based upon: (1) the "cost" of each habitat, specifically its replacement cost as measured in time; (2) the availability of each habitat, as indicated by its total area in the state or a region of the state; (3) the changing availability (if changing) of each habitat; (4) the amount of each habitat in the impact area; and (5) the faunal and/or floral complexity of each habitat.

We use these factors in calculating indices to environmental value by converting the factors to numerical values that reflect natural parameters of

TABLE 2. — Estimated replacement times for gross habitats in Illinois.

Gross Habitats	Years of Successional Lead-in Time	Years of Replacement Time	References
Bottomland forest			
Oak-gum-cypress	100–150	20–600	Anderson & White (1970), Shelford (1954)
Elm-ash-cottonwood by age			
5–29 years (willow-cottonwood)	35	5–29	Shelford (1954)
30–59 years (willow-cottonwood-maple)	35	30–59	"
60–99 years (hackberry-gum)	35	60–99	"
100+ (hackberry-gum, elm-oak-hickory, and succession to climax)	135–600	100–500[a]	"
Upland forest by age			
10–29 years (black cherry-elm-hawthorn, elm-persimmon-sassafras)	25	10–29	Bazzaz (1968), Beckwith (1954)
30–59 years (elm-oak-hickory)	50	30–59	
60–99 years (oak-hickory)	100	60–99	Odum (1953)
100+ (oak-hickory with possible succession to maple-beech)	100+	100–500[a]	
Maple-beech	150–200+	35–500+[a]	
Aspen	5	5–39	Essex & Gansner (1965)
Pine forest by age			
10–39 years	25	10–39	Odum (1953)
40+	25	40–100+	
Shrub areas	3	3–30	Bazzaz (1968), Beckwith (1954)
Residential habitat	...	1–100+	This paper
Marsh, natural	1,000+	600+	"
Marsh, man-made	3	3–100+	"
Prairie	10–15	10–30+	Booth (1941), Thomson (1940), Weaver (1961)
Ungrazed and fallow fields	...	1–10	This paper
Pastures	...	1–10	"
Hayfields	...	1–3	"
Small-grain fields	...	1	"
Row-crop fields	...	1	"

[a] Time based on sizes of largest trees in Illinois (Mohlenbrock 1973) and growth rates for these species.

habitats. We then use the number values in simple equations to determine two indices of environmental value — the Habitat Evaluation Index and the Faunal (or Floral) Index. We will first define the five factors and then the gross habitats to which they apply. Finally, we will explain how our method of evaluation is used and provide examples.

Replacement Cost of the Habitat

Replacement cost is defined as the time required to re-establish a particular biocommunity. Although natural communities cannot be purchased, they can perhaps be developed, given enough time. Even such development, however, is problematical, as every natural community is unique. The possibility of reproducing, after its destruction, precisely the same natural community in terms of mineral, floral, and faunal composition seems remote even given large amounts of time. On the other hand, the community itself is not static, but changes day to day, season to season, and year to year. Once a natural community has been destroyed, about the best that can be hoped for by way of replacement is that the forces which formed it in the first place, with or without human intrusion, will, in time, bring something similar into being. Such replacement, however, is contingent upon an absolute and irrefutable requirement — that the living components of the community have not been removed to extinction.

There is a relationship between the age of a given habitat and its value that concerns the time cost of developing the habitat once it is destroyed. Thus, a plowed field has essentially zero replacement time compared to a centuries-old forest. For the practical purposes of our evaluation, we can use as the replacement cost a numerical factor equal to the age of the habitat in years plus, in some cases, a successional lead-in period. We call this the Replacement Factor, and its range of values for the gross habitats in Illinois are given in Table 2. The replacement times given in that table refer to situations in which the soil is left in place. On impact areas where the soil is removed or substantially altered, a successional lead-in time must be added to the regrowing period. A further explanation of the Replacement Factor and its use is presented in the discussion of each habitat type and in the section on The Method in Practice.

Habitat Availability

Habitat availability refers simply to the amount — the acreage — of a particular gross habitat in a specified geographical area. After the replacement cost of the habitat, we consider the next most important factor to be the availability of the habitat. We at first considered the matter of availability of habitats on a county-by-county basis, but the available acreage data were not sufficiently refined for this method. We were also concerned about the possibility that impact areas would often cross county lines, thus complicating calculations of environmental value. We finally compromised by considering the state in terms of three regional divisions (Fig. 2). The regions, as drawn, are artificial, but have some general biological significance. For example, cypress forest occurs naturally only in the southern region, and white pine only in the northern region. The factor for availability, then, is based on the estimated acreages of each gross habitat in each region of the state (Table 3).

In seeking acreages for the different habitats, we

Fig. 2. — The limits of the three Illinois regions (north, central, and south) referred to in this paper.

TABLE 3. — Acreage estimates of gross habitats in three regions of Illinois as of 1973. Because of the rounding of figures to the nearest 100 acres, columns may show discrepancies in subtotals and totals.

Gross Habitats	North	Central	South	State
Land and water	8,694,100	16,050,900	10,374,400	35,119,400
Inland impoundments	60,000	94,100	119,800	273,800
Rivers and streams	106,400	161,000	113,700	381,100
Land area	8,527,700	15,795,800	10,140,900	34,464,400
Bottomland forest				
Oak-gum-cypress by age				
to 99 years	...	...	4,200	4,200
100+	...	...	8,400	8,400
Subtotal	...	...	12,600	12,600
Elm-ash-cottonwood by age				
to 29 years	20,900	75,200	170,500	266,600
30–59	31,400	112,900	256,000	400,300
60–99	11,300	40,500	92,000	143,800
100+	1,300	4,400	9,800	15,500
Subtotal	64,900	233,000	528,300	826,100
Upland oak-hickory by age				
to 29 years	39,100	145,100	309,800	494,000
30–59	66,500	246,700	526,800	840,000
60–99	44,400	164,800	351,900	561,100
100+	10,500	38,800	82,900	132,200
Subtotal	160,500	595,400	1,271,500	2,027,400
Maple-beech by age				
to 49 years	1,100	3,100	3,700	7,900
50+	1,000	2,700	3,100	6,800
Subtotal	2,100	5,800	6,800	14,700
Aspen	6,400	3,000	...	9,400
Pine forest by age				
to 39 years	2,600	8,400	36,400	47,400
40+	800	2,600	11,400	14,800
Subtotal	3,400	11,000	47,800	62,200
Shrub areas	35,600	100,000	184,200	319,900
Residential habitat	958,300	543,000	303,600	1,804,900
Marshes	31,700	16,700	3,400	51,800
Prairie	5,300	1,700	1,400	8,500
Ungrazed and fallow fields	596,600	702,100	436,500	1,735,200
Pastures	750,200	1,563,400	1,115,900	3,429,500
Hayfields	451,600	452,800	389,100	1,293,500
Small-grain fields	371,800	650,500	980,700	2,003,000
Row-crop fields	4,764,000	10,618,500	4,141,500	19,524,000
Habitat acreage	8,202,600	15,496,800	9,423,300	33,122,600
Nonhabitat acreage (hard surfaces of roads, railroads, and airstrips)	112,100	177,800	113,800	403,700
Land accounted	8,314,600	15,674,600	9,537,100	33,526,400
Land unaccounted	213,100	121,200	603,800	938,100

found that no two authorities give even the same land acreage for Illinois though all indicate a figure of around 36 million acres. Lopinot's (1973) inventory of surface water areas is the most recent and comprehensive report on water, versus land, areas in the state, and we used his figures on land and water areas of the counties as a starting place. There is no complete detailed inventory of natural habitats in Illinois, or any sizeable part of the state, and such an inventory is very much needed. Our estimates for the acreages of natural habitats are rough at best, but they are based wherever possible on published census figures. The published sources we used have their own built-in errors, as the authors usually explain, and the user of our work should refer to the original references for information on ranges of error and data reliability. Our estimates probably compound the errors of the original sources, because we have attempted to bring the acreage estimates up to the year 1973. This is the most recent year for which crop acreage figures were available, and crop acreages are probably the most comprehensive estimates, since agricultural land accounts for most of the land in the state. Acreages of all habitats are changing rapidly now, and so we attempted to bring the acreage estimates up to date as much as possible.

Our sources and methods of estimating the 1973 acreages are presented in the discussion of each type of habitat.

Though we made extensive searches of the Illinois literature in an effort to account for all the land acreage, when the task was completed we could not account for 938,000 acres of Illinois (Table 3). The accounted-for land (33,526,400 acres) included about 404,000 acres of what we term non-habitats — the hard (or gravel) surfaces of roads, railroads, and airstrips. To some extent the unaccounted acreage represents errors in our habitat estimates, but it also includes rural cemeteries, rural factories, and some parts of military reservations for which we had no data. In calculating Availability Factors, we have used only the accounted acreage, because unaccounted acreages differed greatly between regions.

The Availability Factor was calculated simply by dividing the acreage of each habitat (Table 3) into the total accounted acreage in the region, and then dividing the quotient by 10 to reduce numbers for convenient calculation. The value of the Availability Factor thus increases as the acreage decreases. The calculation was made on a regional basis, except in the case of the one gross habitat (gum-cypress forest) which is restricted to one region of the state. In this case, to emphasize the reduced availability of the habitat on a statewide basis, we calculated its Availability Factor by dividing the habitat acreage into the accounted acreage for the entire state. The numbers were rounded to the nearest whole number, excepting numbers lower than 1.6, which were rounded to the nearest one-tenth. As better acreage data become available, the factors can be refined for better accuracy; in any case the Availability Factors will have to be updated from time to time as habitat acreages change.

Changing Availability of Habitats

Changing availability refers to the rate at which the state or regional acreage of a given habitat is increasing or decreasing. In considering the habitat evaluation, it seemed important to take into account not only the present availability of the habitat, but its potential availability in the future. A habitat that is declining in acreage should get extra consideration in the environmental evaluation.

The changing availability was determined on the basis of the estimated acreage of the habitat at two points in time (Table 4). We used the most recent acreage data we could find and tried to find figures that spanned the most recent decade. Where such figures were not available, we tried to base the estimate on logical grounds and our own observations. For details, see the discussions of each habitat.

The Changing Availability Factor is merely the estimated percentage change in acreage of a given habitat for a decade. The factor is used as a positive value for declining habitats and a negative value for increasing habitats. It is an additive or subtractive modifier of the Availability Factor. In practice, if the Changing Availability Factor is equal to or exceeds the Availability Factor of an increasing habitat,

TABLE 4. — Changing Availability Factors for gross habitats in Illinois, based on estimated acreages of the habitats in the years listed.

Gross Habitat	Percentage of Change Per Decade				Years	Sources of Data and Remarks
	North	Central	South	State		
Bottomland forest						
Oak-gum-cypress	..	..	−25[a]	..	1962–1973	Essex & Gansner (1965), U.S. Dept. of Commerce (1972), and this paper.
Elm-ash-cottonwood	−56	−47	−35	..	"	"
Upland forest						
Oak-hickory	−41	−27	−17	..	"	"
Maple-beech	−49	−37	−26	..	...	No specific data. Use average for upland and bottomland forest.
Aspen	−41	−27	−17	..	...	No specific data. Use data for upland oak-hickory.
Pine forest	..	..	..	+8	1961–1973	U. S. Dept. of Agriculture (1968) and this paper.
Shrub areas	−43	−26	−16	..	1961–1973	"
Residential habitat	..	..	..	+19	1950–1960	U. S. Dept. of Commerce (1960, 1972).
Marshes	..	..	..	−22	1922–1954	Shaw & Fredine (1956).
Prairie	..	..	..	−6	1800–1970	King & Winters (1952) and this paper.
Ungrazed and fallow fields	..	..	..	−19	1954–1964	U. S. Dept. of Commerce (1972).
Pastures	..	..	..	−30	1959–1969	"
Hayfields	..	..	..	−50	"	"
Small-grain fields	..	..	..	−50	"	"
Row-crop fields	..	..	..	+27	"	"
Impoundments	..	..	..	+6	1963–1972	Lopinot (1973).

[a] A (−) sign indicates loss of acreage, a (+) sign indicates gain of acreage during the period of years. To calculate Changing Availability Factors, simply reverse the signs given in the table.

then the Final Availability Factor is not reduced below 0.1, as the full subtraction would result in a zero or a negative value and complicate further calculations. This exception applies only to row-crop habitat and residential habitat. The Final Availability Factor has been computed and is presented for the user's convenience in Table 5. It is the Availability Factor plus or minus the Changing Availability Factor. For example, an estimated 1,000 acres of maple-beech habitat over 50 years old exist in the northern region of Illinois (Table 3). This 1,000 acres divided into 8,314,600 acres (total accounted acreage in this region, see Table 3) gives a figure of 8,314.6, which, divided by 10, equals 831, the Availability Factor. Maple-beech acreage has been declining, with an estimated loss of 49 percent in a recent decade (Table 4); therefore, 49 is added to 831, giving a Final Availability Factor of 880 for this habitat (Table 5). The Final Availability Factor is used as a multiplier with the Replacement Cost Factor.

Acreage Factor

The Acreage Factor is an index of the amount of a given habitat in the impact area and, in use, is a percentage — the number of acres of the habitat divided by the number of acres in the impact area, the quotient expressed as a decimal, or 1.0 for a single-habitat impact area. The Acreage Factor is used as a multiplier in the computation of the Habitat Factor.

TABLE 5. — Final Availability Factors for habitats in three regions of Illinois, based on estimated acreages of the habitats in the state (Table 3). The Changing Availability Factor (Table 4) has been incorporated in these figures.

Gross Habitat	North	Central	South
Bottomland forest			
Oak-gum-cypress to 99 years	...	...	823
100+	...	...	424
Elm-ash-cottonwood to 29 years	95	68	41
30–59	82	61	39
60–99	130	86	45
100+	696	403	132
Upland forest			
Oak-hickory to 29 years	62	38	20
30–59	54	33	19
60–99	60	37	20
100+	120	67	28
Maple-beech to 49 years	805	543	284
50+	880	618	334
Aspen	171	549	...
Pine forest to 39 years	312	179	18
40+	1,031	595	76
Shrub areas	66	42	19
Residential habitat	0.1	0.1	0.1
Marshes	48	116	303
Prairie	163	928	687
Ungrazed and fallow fields	20	21	21
Pastures	31	31	31
Hayfields	52	53	52
Small-grain fields	52	52	51
Row-crop fields	0.1	0.1	0.1
Impoundments	8	11	2
Rivers and streams	8	10	8

The Faunal (Floral) Index

The Faunal Index, as we use it, is an avifaunal index. It consists of a sum of numerical values assigned to the nesting species that occupy a given area of habitat.

Living organisms do not differ in intrinsic value, but because the environmental investigator must be concerned with the ultimate survival of all living components of a community, it may be necessary to emphasize the value of those in shortest supply or those populations that seem most vulnerable to extinction for whatever reason. On the other hand, there is a distinct danger of overemphasizing rarity as a criterion of value — deciding whether to recommend the preservation of an area in its natural state on the basis of the presence or absence of rare or endangered species. From such a viewpoint, no effort would be made to preserve populations until they became rare and endangered. In general, common populations have greater ecological effects than rare ones, and common populations should always be considered in the calculation of environmental value. Accordingly, in our point system for bird species the values we assigned are not strictly proportional to population. We assigned values to the species on two considerations: (1) a base value reflecting the state population of each species, and (2) a doubling of the base value for species with a high degree of specialization for a single gross habitat. The relationship between any organism and its habitat is always specialized, but there are apparent degrees of specialization, with some species appearing to be more particularly dependent upon a given habitat than others. Black terns, for example, do not nest except in a certain type of marsh, whereas catbirds nest in a variety of woody habitats. Because this specialization relates to survival, we have given it definite emphasis in the point system.

The base values we assigned are: (1) species with a state breeding population of 50 000 or more birds — 10 points; (2) species with 10 000–49,999 birds — 20 points; (3) species with 2,500–9,999 birds — 40 points; (4) species with 500–2,499 birds — 100 points; and (5) species with less than 500 nesting birds in the state are in a special category to be considered above and beyond any numerical value. Population estimates are based on our field work (Graber & Graber 1963 and later).

The weights of the point values for the Faunal Index were arbitrary, but were designed to have some reasonable relationship to the acreage values upon which the Faunal Index is finally standardized (see The Method in Practice). We tested different values and found that a base value of 1 for each bird species was insignificant in the final numerical evaluation. A base value of 10 proved to be significant and also convenient for ease of calculation. The point values for each species are given in Tables 6–12.

TABLE 6. — Faunal Index point values for breeding birds of forest habitats[a] in three regions of Illinois. The list includes only species that nest in the habitat, not those that only forage in the habitat. See text for explanation of value assignments.

Species	North		Central		South		Habitat Specialty
	Base	Special[b]	Base	Special	Base	Special	
Great blue heron	...	80	...	80	...	80	Bottomland
Green heron	20	...	20	...	20	...	Bottomland
Little blue heron	...	...	...	...	...	X[c]	Bottomland
Cattle egret	...	80	...	80	...	80	Bottomland
Great egret	...	200	...	200	...	200	Bottomland
Snowy egret	...	...	...	...	...	X[c]	Bottomland
Black-crowned night heron	40	...	40	...	40	...	...
Yellow-crowned night heron	...	200	...	200	...	200	Bottomland
Wood duck	20	...	20	...	20	...	...
Hooded merganser	...	200	...	200	...	200	Bottomland
Turkey vulture	40	...	40	...	40	...	...
Black vulture	...	...	...	...	100	...	...
Mississippi kite	...	...	...	...	...	X[c]	Bottomland
Sharp-shinned hawk	...	X[c]	...	...	...	...	...
Cooper's hawk	100	...	100	...	100	...	...
Red-tailed hawk	...	40	...	40	...	40	Upland
Red-shouldered hawk	...	80	...	80	...	80	Bottomland
Broad-winged hawk	100	...	100	...	100	...	...
Bald eagle	...	...	...	...	...	X[c]	...
Osprey	...	...	...	...	...	X[c]	...
Ruffed grouse	...	...	...	...	...	X[c]	...
Turkey	...	80	...	80	...	80	Extensive tracts
Mourning dove	10	...	10	...	10	...	...
Yellow-billed cuckoo	20	...	20	...	20	...	...
Black-billed cuckoo	40	...	40	...	40	...	...
Barn owl	...	X[c]	...	X[c]	...	X[c]	...
Screech owl	20	...	20	...	20	...	...
Great horned owl	20	...	20	...	20	...	...
Barred owl	20	...	20	...	20	...	...
Long-eared owl	...	X[c]	...	X[c]	...	X[c]	...
Saw-whet owl	...	X[c]	...	X[c]	...	X[c]	...
Chuck-will's widow	...	80	...	80	...	80	Upland
Whip-poor-will	...	40	...	40	...	40	Upland
Chimney swift	10	...	10	...	10	...	...
Ruby-throated hummingbird	20	...	20	...	20	...	...
Belted kingfisher	20	...	20	...	20	...	...
Yellow-shafted flicker	10	...	10	...	10	...	...
Pileated woodpecker	20	...	20	...	20	...	...
Red-bellied woodpecker	10	...	10	...	10	...	...
Red-headed woodpecker	10	...	10	...	10	...	...
Yellow-bellied sapsucker	...	200	...	200	...	...	Bottomland
Hairy woodpecker	10	...	10	...	10	...	...
Downy woodpecker	10	...	10	...	10	...	...
Great crested flycatcher	10	...	10	...	10	...	...
Eastern phoebe	20	...	20	...	20	...	...
Acadian flycatcher	...	20	...	20	...	20	Bottomland
Least flycatcher	100	...	100	...	...	...	...
Eastern wood pewee	10	...	10	...	10	...	...
Blue jay	10	...	10	...	10	...	...
Common crow	10	...	10	...	10	...	...
Fish crow	...	...	...	...	...	80	Bottomland
Black-capped chickadee	10	...	10	...	10	...	...
Carolina chickadee	...	...	10	...	10	...	...
Tufted titmouse	10	...	10	...	10	...	...
White-breasted nuthatch	20	...	20	...	20	...	...
Red-breasted nuthatch	...	X[c]	...	...	...	...	Conifers
Brown creeper	...	200	...	200	...	200	Bottomland
House wren	10	...	10	...	10	...	...
Carolina wren	10	...	10	...	10	...	...

(Table 6 continued on page 10.)

[a] Includes all types of forest (see Table 3) and forest edge as well as interior.

[b] Species with values in the special columns are found as nesting birds primarily in only one gross habitat. Their base values have been doubled.

[c] Indicates species in a very special category with a state breeding population of less than 500 birds. They are to be considered above and beyond the numerical value in a class by themselves.

TABLE 6. — Continued

Species	North		Central		South		Habitat Specialty
	Base	Special[b]	Base	Special	Base	Special	
Gray catbird	10	...	10	...	10	...	...
Brown thrasher	10	...	10	...	10	...	...
American robin	10	...	10	...	10	...	...
Wood thrush	10	...	10	...	10	...	...
Veery	...	200	...	200	...	...	Bottomland
Eastern bluebird	10	...	10	...	10	...	...
Blue-gray gnatcatcher	10	...	10	...	10	...	...
Cedar waxwing	40	...	40	...	40	...	...
White-eyed vireo	10	...	10	...	10	...	...
Yellow-throated vireo	10	...	10	...	10	...	...
Red-eyed vireo	10	...	10	...	10	...	...
Warbling vireo	...	40	...	40	...	40	Bottomland
Black-and-white warbler	...	80	...	80	...	80	Upland
Prothonotary warbler	...	40	...	40	...	40	Bottomland
Swainson's warbler	...	...	...	...	...	200	Bottomland
Worm-eating warbler	...	40	...	40	...	40	Upland ravine
Nashville warbler	...	X[c]	...	...	...	...	...
Parula warbler	...	40	...	40	...	40	Bottomland
Cerulean warbler	...	20	...	20	...	20	Bottomland
Yellow-throated warbler	...	...	...	80	...	80	Bottomland
Chestnut-sided warbler	40	...	...	...	...	...	...
Pine warbler	...	...	...	...	...	200	Pines
Ovenbird	20	...	20	...	20	...	...
Louisiana waterthrush	...	40	...	40	...	40	Forest rill
Kentucky warbler	10	...	10	...	10	...	...
Yellow-breasted chat	10	...	10	...	10	...	...
Hooded warbler	...	...	20	...	20	...	...
American redstart	...	20	...	20	...	20	Bottomland
Baltimore oriole	20	...	20	...	20	...	...
Common grackle	10	...	10	...	10	...	...
Brown-headed cowbird	10	...	10	...	10	...	...
Scarlet tanager	20	...	20	...	20	...	...
Summer tanager	10	...	10	...	10	...	...
Cardinal	10	...	10	...	10	...	...
Rose-breasted grosbeak	10	...	10	...	10	...	...
Indigo bunting	10	...	10	...	10	...	...
Rufous-sided towhee	10	...	10	...	10	...	...
Field sparrow	10	...	10	...	10	...	...

These tables include virtually all of the known breeding species of birds in Illinois, even rarities that have been known to nest in the state within recent decades but which may now be extirpated (e.g., the peregrine falcon). Such species are included because of the possibility that they may still be found nesting in the state. Some of the species listed in Table 12 are not listed in any other table because they have special nesting habitats or special nest-site requirements and may be found in one or more of the gross habitats of our habitat classification. When these species are found nesting in an impact area, they are counted in the same way as any other species in whatever gross habitat(s) they are found.

We made our species lists as complete as possible, but occasionally an investigator may find a species that we have not included in our list for that habitat. In such cases the species is counted, of course, and the investigator should merely refer to the other habitat tables to ascertain the assigned value for the species in question. Such an occurrence is most likely in the case of residential habitat, as many species not listed in Table 8 occasionally nest in this habitat.

We elected not to put additional weight on the *extremely* rare populations, such as the last known colony of double-crested cormorants in the state. Where the impact area in question involves such last remnants, the mere presence of such a population becomes the overriding consideration as a value beyond the computed Habitat and Faunal Indexes. This is as true for other living things as it is for birds, and the impact investigator must make every effort to find such populations, both plant and animal, on every impact area. In the faunal lists (Tables 6–12) we have marked such populations of Illinois birds.

The question arises: Why be concerned with the loss of populations in Illinois when all of the species are represented elsewhere? There are at least two important reasons: (1) The alteration of habitats that is occurring in Illinois is also occurring elsewhere. The inevitable result, if each state allows its own populations to slip away, is the ultimate extinction of species by default. (2) Every species is comprised of numerous populations, and the genetic breadth of the species is the sum of the genetic breadth of the populations. Some of the populations are morpho-

logically distinct, others not, but all are probably unique if only in the problems they face. Therefore, in the conservation of species we must be concerned for the welfare of all the populations that comprise the species.

In any consideration of population survival we must be particularly aware of endemism. In Illinois the only possibly endemic bird population of which we know is the Mississippi kite of the southwestern part of the state, primarily near the Mississippi valley from St. Louis south. The endemism in this case may be more apparent than real. Presently the distribution records imply that this kite population is isolated during the nesting season from the more sub-

TABLE 7. — Faunal Index point values for breeding birds of shrub habitats[a] in three regions of Illinois. The list includes only species that nest in the habitat, not those that only forage in the habitat. See text for explanation of the value assignments.

Species	North		Central		South		Habitat Specialty
	Base	Special[b]	Base	Special	Base	Special	
Green heron	20	...	20	...	20	...	...
Bobwhite	10	...	10	...	10	...	...
American woodcock	...	40	...	40	...	40	Shrub areas
Mourning dove	10	...	10	...	10	...	...
Yellow-billed cuckoo	20	...	20	...	20	...	...
Black-billed cuckoo	40	...	40	...	40	...	...
Downy woodpecker	10	...	10	...	10	...	...
Eastern kingbird	...	20	...	20	...	20	Savannah
Western kingbird	...	200	...	200	...	200	Savannah
Willow flycatcher	...	40	...	40	...	40	Shrub
Least flycatcher	100	...	100	...	100	...	...
Blue jay	10	...	10	...	10	...	...
Black-capped chickadee	10	...	10	...	10	...	...
Carolina chickadee	...	...	10	...	10	...	...
Tufted titmouse	10	...	10	...	10	...	...
House wren	10	...	10	...	10	...	...
Bewick's wren	40	...	40	...	40	...	...
Carolina wren	10	...	10	...	10	...	...
Mockingbird	10	...	10	...	10	...	...
Gray catbird	10	...	10	...	10	...	...
Brown thrasher	10	...	10	...	10	...	...
American robin	10	...	10	...	10	...	...
Eastern bluebird	10	...	10	...	10	...	...
Blue-gray gnatcatcher	10	...	10	...	10	...	...
Loggerhead shrike	...	80	...	80	...	80	Shrub
White-eyed vireo	10	...	10	...	10	...	...
Bell's vireo	...	80	...	80	...	80	Shrub
Golden-winged warbler	...	X[c]	...	...	...	...	Shrub areas
Blue-winged warbler	...	80	...	80	...	80	Shrub areas
Yellow warbler	...	40	...	40	...	40	Shrub areas
Prairie warbler	...	80	...	80	...	80	Shrub areas
Mourning warbler	...	X[c]	...	...	...	...	Wet shrub areas
Common yellowthroat	10	...	10	...	10	...	...
Yellow-breasted chat	10	...	10	...	10	...	...
Red-winged blackbird	10	...	10	...	10	...	...
Orchard oriole	...	20	...	20	...	20	Shrub
Brewer's blackbird	...	X[c]	...	...	...	...	...
Common grackle	10	...	10	...	10	...	...
Brown-headed cowbird	10	...	10	...	10	...	...
Cardinal	10	...	10	...	10	...	...
Blue grosbeak	...	80	...	80	...	80	Shrub
Indigo bunting	10	...	10	...	10	...	...
Dickcissel	10	...	10	...	10	...	...
American goldfinch	...	20	...	20	...	20	Shrub
Rufous-sided towhee	10	...	10	...	10	...	...
Vesper sparrow	10	...	10	...	10	...	...
Lark sparrow	20	...	20	...	20	...	...
Bachman's sparrow	...	...	...	X[c]	...	X[c]	Shrub areas
Chipping sparrow	20	...	20	...	20	...	...
Field sparrow	10	...	10	...	10	...	...
Song sparrow	10	...	10	...	10	...	...

[a] Includes all types of shrub habitat, including linear and hedges, but excludes shrubs in residential areas.

[b] Species in the special columns are found as nesting birds primarily in only one gross habitat. Their base values have been doubled.

[c] Indicates species in a very special category with a state breeding population of less than 500 birds. They are to be considered above and beyond the numerical value in a class by themselves.

TABLE 8. — Faunal Index point values for breeding birds of residential habitats, including new suburban and old residential habitats in urban and rural areas. The list includes only species that nest in the habitat, not those that only forage in the habitat. See text for explanation of value assignments.

Species	North		Central		South		Habitat Specialty
	Base	Special[a]	Base	Special	Base	Special	
Wood duck	20	...	20	...	20	...	...
Sparrow hawk	...	40	...	40	...	40	Savannah
Mourning dove	10	...	10	...	10	...	...
Barn owl	...	X[b]	...	X[b]	...	X[b]	...
Screech owl	20	...	20	...	20	...	...
Common nighthawk	...	40	...	40	...	40	Flat roofs
Chimney swift	10	...	10	...	10	...	...
Yellow-shafted flicker	10	...	10	...	10	...	...
Red-bellied woodpecker	10	...	10	...	10	...	...
Red-headed woodpecker	10	...	10	...	10	...	...
Downy woodpecker	10	...	10	...	10	...	...
Eastern kingbird	...	20	...	20	...	20	Savannah
Great crested flycatcher	10	...	10	...	10	...	...
Eastern phoebe	20	...	20	...	20	...	...
Eastern wood pewee	10	...	10	...	10	...	...
Horned lark	10	...	10	...	10	...	...
Barn swallow	...	20	...	20	...	20	Buildings
Purple martin	...	20	...	20	...	20	Bird houses
Blue jay	10	...	10	...	10	...	...
Black-capped chickadee	10	...	10	...	10	...	...
Carolina chickadee	...	...	10	...	10	...	...
Tufted titmouse	10	...	10	...	10	...	...
White-breasted nuthatch	20	...	20	...	20	...	...
Red-breasted nuthatch	...	X[b]	...	...	...	...	Conifers
House wren	10	...	10	...	10	...	...
Bewick's wren	40	...	40	...	40	...	...
Carolina wren	10	...	10	...	10	...	...
Mockingbird	10	...	10	...	10	...	...
Gray catbird	10	...	10	...	10	...	...
Brown thrasher	10	...	10	...	10	...	...
American robin	10	...	10	...	10	...	...
Wood thrush	10	...	10	...	10	...	...
Eastern bluebird	10	...	10	...	10	...	...
Cedar waxwing	40	...	40	...	40	...	...
Warbling vireo	...	40	...	40	...	40	Bottomland
Baltimore oriole	20	...	20	...	20	...	...
Common grackle	10	...	10	...	10	...	...
Brown-headed cowbird	10	...	10	...	10	...	...
Cardinal	10	...	10	...	10	...	...
Chipping sparrow	20	...	20	...	20	...	...
Song sparrow	10	...	10	...	10	...	...

[a] Species with values in the special columns are found as nesting birds primarily in only one gross habitat. Their base values have been doubled.

[b] Indicates species in a very special category with a state breeding population of less than 500 birds. They are to be considered above and beyond the numerical value in a class by themselves.

stantial populations to the south and west. The kite is a strongly migratory species, and, depending upon its homing characteristics, there is the annual possibility of genetic exchange between Illinois birds and other populations. Until more complete information is available, the Illinois kite population can be considered endemic. We have not put an extraordinary value on the kite in our faunal valuation, feeling that the presence of any endemic population of any organism, plant or animal, on an impact area is an overriding factor beyond the index values calculated by our method.

Species of accidental occurrence in a habitat or a region we consider to have zero value, as there is no indication that such a population is dependent upon this state for survival or that it has any significant effect upon the state. We exclude introduced bird species from our calculation of environmental value, because we feel that the evaluation should be based on native species.

Though we have used birds and their gross habitats in our evaluation method, other faunas and floras can be used in exactly the same way, provided they are represented in all the gross habitats. It is not necessary that a particular taxonomic category of organisms — for example, a Class of vertebrates (birds) or an Order of insects (Lepidoptera) — be used. More important is the number of species in the group or groups. If another faunal group (than birds) or floral group is used in the evaluation, the

number of species in that group should be compared with the number of species (about 180) in the bird fauna that we have used. The value placed on each species can then be related to the values placed on the bird fauna. If the new fauna (flora) has 360 species, for example, then the base value of each species should be set at 5 instead of 10 as used for bird species, and the values for specialization and rarity would be comparably reduced. By this means the standard upon which the evaluation is based is kept the same regardless of what faunal or floral groups are used.

If more than one faunal (floral) group is used in the evaluation, the impact area will be represented by a series of Faunal (Floral) Indexes.

As an indication of the number of bird species that might be found on a given acreage of a particular gross habitat in Illinois we refer the reader to Fig. 3–7. These figures show what could be called "species-area curves" for birds in different Illinois habitats. In general, the number of species seen in a given habitat increases as the amount of habitat censused increases. Our figures apply only to species that nest in a particular habitat, not to species that only forage in the habitat.

The curves were constructed from data collected

TABLE 9. — Faunal Index point values for breeding birds of marshes[a] in three regions of Illinois. The list includes only species that nest in the habitat, not those that only forage in the habitat. See text for explanation of value assignments.

Species	North		Central		South		Habitat Specialty
	Base	Special[b]	Base	Special	Base	Special	
Pied-billed grebe	...	200	...	200	...	200	Marsh
Least bittern	...	80	...	80	...	80	Marsh
American bittern	...	200	...	200	...	200	Marsh
Canada goose	...	80	...	80	...	80	Marsh areas
Mallard	...	40	...	40	...	40	Marsh areas
Black duck	...	200	...	...	...	...	Marsh areas
Pintail	...	X[c]	...	...	...	...	Marsh areas
Green-winged teal	...	X[c]	...	X[c]	...	...	Marsh areas
Blue-winged teal	...	80	...	80	...	80	Marsh areas
American wigeon	...	X[c]	...	...	...	...	Marsh areas
Shoveler	...	X[c]	...	...	...	...	Marsh areas
Redhead	...	X[c]	...	...	...	...	Marsh areas
Canvasback	...	X[c]	...	...	...	...	Marsh areas
Lesser scaup	...	X[c]	...	...	...	...	Marsh areas
Ruddy duck	...	X[c]	...	...	...	...	Marsh areas
Marsh hawk	...	200	...	200	...	...	Marsh areas
King rail	...	80	...	80	...	80	Marsh
Virginia rail	...	80	...	80	...	80	Marsh
Sora	...	80	...	80	...	80	Marsh
Black rail	...	X[c]	...	X[c]	...	X[c]	Marsh
Common gallinule	...	200	...	200	...	200	Marsh
Purple gallinule	...	...	...	...	...	X[c]	Marsh
American coot	...	80	...	80	...	80	Marsh
Killdeer	10	...	10	...	10	...	...
Common snipe	...	X[c]	...	...	...	...	...
Spotted sandpiper	...	80	...	80	...	80	Water edge
Wilson's phalarope	...	X[c]	...	...	...	...	...
Forster's tern	...	X[c]	...	...	...	...	Marsh
Common tern	...	X[c]	...	...	...	...	Water edge
Black tern	...	80	...	80	...	...	Marsh
Long-billed marsh wren	...	80	...	80	...	...	Marsh
Short-billed marsh wren	20	...	20	...	20	...	...
Common yellowthroat	10	...	10	...	10	...	...
Yellow-headed blackbird	...	80	...	...	...	...	Marsh
Red-winged blackbird	10	...	10	...	10	...	...
Brewer's blackbird	...	X[c]	...	...	...	...	...
Common grackle	10	...	10	...	10	...	...
Brown-headed cowbird	10	...	10	...	10	...	...
Savannah sparrow	10	...	10	...	...	...	...
Leconte's sparrow	...	X[c]	...	...	...	...	Wet meadow, marsh
Henslow's sparrow	...	80	...	80	...	80	Meadow
Swamp sparrow	...	40	...	40	...	...	Marsh
Song sparrow	10	...	10	...	10	...	...

[a] Includes marshes of all types, from cattails and scirpus to lotus beds and wet meadows.

[b] Species with values in the special columns are found as nesting birds primarily in only one gross habitat. Their base values have been doubled.

[c] Indicates species in a very special category with a state breeding population of less than 500 birds. They are to be considered above and beyond the numerical value in a class by themselves.

TABLE 10. — Faunal Index point values for breeding birds of grasslands, including dry prairie, ungrazed grass, fallow fields, pastures, and hayfields. The list includes only species that nest in the habitat, not those that only forage in the habitat. See text for explanation of value assignments.

Species	North		Central		South		Habitat Specialty
	Base	Special[a]	Base	Special	Base	Special	
Greater prairie chicken	...	...	...	...	...	X[b]	Grassland
Bobwhite	10	...	10	...	10	...	...
Killdeer	10	...	10	...	10	...	...
Upland sandpiper	...	80	...	80	...	80	Grassland
Mourning dove	10	...	10	...	10	...	...
Short-eared owl	...	X[b]	...	X[b]	...	X[b]	Grassland
Common nighthawk	20	...	20	...	20	...	...
Horned lark	10	...	10	...	10	...	...
Short-billed marsh wren	20	...	20	...	20	...	...
Common yellowthroat	10	...	10	...	10	...	...
Bobolink	...	20	...	20	...	...	Hayfields
Eastern meadowlark	...	20	...	20	...	20	Grassland
Western meadowlark	...	20	...	20	...	...	Grassland
Red-winged blackbird	10	...	10	...	10	...	...
Brown-headed cowbird	10	...	10	...	10	...	...
Dickcissel	10	...	10	...	10	...	...
Savannah sparrow	...	20	...	20	...	...	Grassland
Grasshopper sparrow	...	20	...	20	...	20	Grassland
Henslow's sparrow	...	80	...	80	...	80	Grassland
Vesper sparrow	10	...	10	...	10	...	...
Lark sparrow	20	...	20	...	20	...	...
Field sparrow	10	...	10	...	10	...	...
Song sparrow	10	...	10	...	10	...	...

[a] Species with values in the special columns are found as nesting birds primarily in only one gross habitat. Their base values have been doubled.

[b] Indicates species in a very special category with a state breeding population of less than 500 birds. They are to be considered above and beyond the numerical value in a class by themselves.

TABLE 11. — Faunal Index point values for breeding birds of small-grain fields and row-crop fields in three regions of Illinois. The list includes only species that nest in the habitats, not those that only forage in the habitats. Those marked with (R) are known to nest in row-crop fields. See text for explanation of value assignments.

Species	North	Central	South
	Base	Base	Base
Bobwhite	10	10	10
Killdeer (R)	10	10	10
Horned lark (R)	10	10	10
Bobolink	10	10	10
Eastern meadowlark	10	10	10
Red-winged blackbird	10	10	10
Brown-headed cowbird	10	10	10
Grasshopper sparrow	10	10	10
Vesper sparrow (R)	10	10	10

using the strip census method of censusing birds (Graber & Graber 1963). As the strip censuses were made on straight-line transects, habitats encountered varied from small tracts of an acre or less to 50 acres or more. We constructed the curves by arranging the bird census data from the smallest-sized area censused to the largest. We then summed both the acreages and the numbers of different species of birds and plotted the cumulative sums on graph paper (Fig. 3–7). Because our data are from quantitative strip censuses, they are not strictly comparable to the qualitative censuses that the impact investigator will make, but the figures are at least roughly indicative of what the investigator can expect to find. We did not have sufficient samples to construct curves for all habitats, but the habitats included represent most of the grassland and woody habitat faunas. The most serious omission is marsh habitat. We did not plot a curve for row-crop habitat, as it usually supports only two or three nesting species even on a very large acreage. A discrepancy may exist between the number of bird species accounted for in our habitat tables (Tables 6–12) and the number in the illustrations. This discrepancy occurs because the tables have a complete list of species for each habitat, whereas the figures include only the species most likely to be found in the habitat.

THE GROSS HABITATS

We have considered the Illinois bird habitats in their gross forms. Every gross habitat may include numerous microhabitats or niches, but in any consideration of whether the habitats in an area shall be altered, it is axiomatic that the niches will not survive the destruction of the gross habitats. Thus, from a practical standpoint investigators of environmental impact can concern themselves with habitats in their gross forms. To some degree the avifaunal variety, which is taken into account in our evaluation method, is a measure of, or at least an index to, the number of niches.

Anyone who has done much biological field work knows that habitats are not always neatly compartmentalized and defined. Neither do biologists always agree on how habitats should be defined or what they should be called. In deciding what habitat classifica-

tion to use in the present case we were governed to some extent by certain concerns outside the biological problems. We felt obligated to keep the classification as simple as possible in the interest of the

TABLE 12. — Faunal Index point values for breeding birds of special habitats not included in the gross habitat classifications in three regions of Illinois. The list includes only species that nest in each habitat, not those that only forage in the habitat. See text for explanation of value assignments.

Species	North		Central		South		Nesting Site or Habitat
	Base	Special[a]	Base	Special	Base	Special	
Swainson's hawk	...	X[b]	...	...	...	...	Savannah
Peregrine falcon	...	X[b]	...	X[b]	...	X[b]	High cliffs
Sparrow hawk	...	40	...	40	...	40	Savannah
Piping plover	...	X[b]	...	...	...	...	Lake Michigan beach
Spotted sandpiper	...	80	...	80	...	80	Water edge
Ring-billed gull	...	X[b]	...	...	...	...	Water edge, sand bars
Least tern	...	X[b]	...	X[b]	...	X[b]	Sand bars
Belted kingfisher	20	...	20	...	20	...	Stream and other erosion banks
Tree swallow	20	...	20	...	20	...	Dead stumps
Bank swallow	10	...	10	...	10	...	Stream and other erosion banks
Rough-winged swallow	10	...	10	...	10	...	Stream and other erosion banks
Cliff swallow	20	...	20	...	20	...	Rock cliffs and culverts

[a] Species with values in the special columns are found as nesting birds primarily in only one gross habitat. Their base values have been doubled.

[b] Indicates species in a very special category with a state breeding population of less than 500 birds. They are to be considered above and beyond the numerical value in a class by themselves.

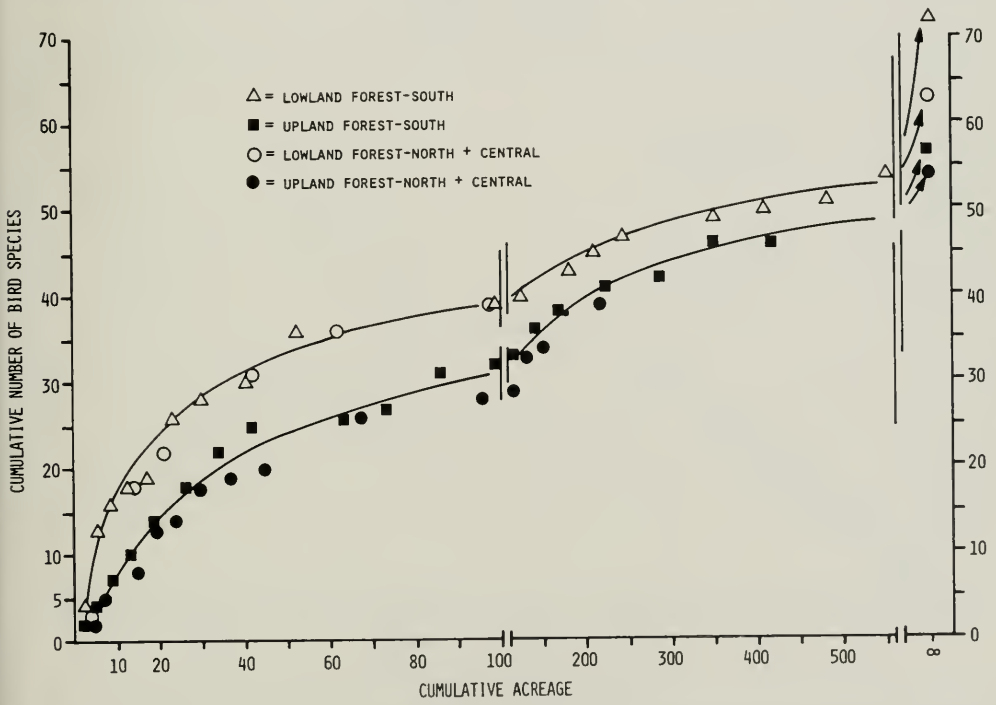

Fig. 3. — Numbers of bird species found nesting in different-sized tracts of upland and lowland forest in the three regions (Fig. 2) of Illinois.

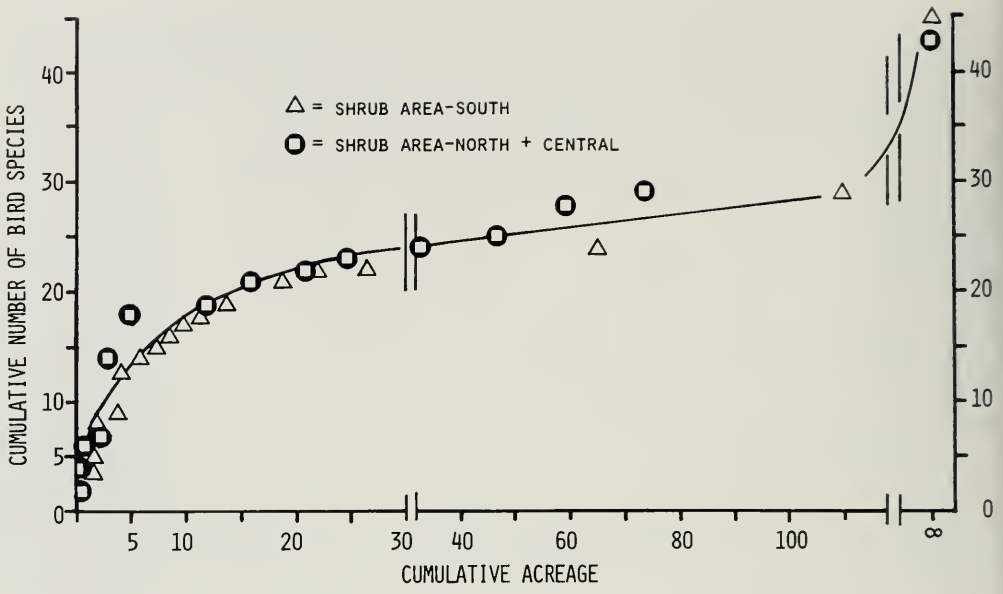

Fig. 4. — Numbers of bird species found nesting in different-sized tracts of shrub habitat in the three regions (Fig. 2) of Illinois.

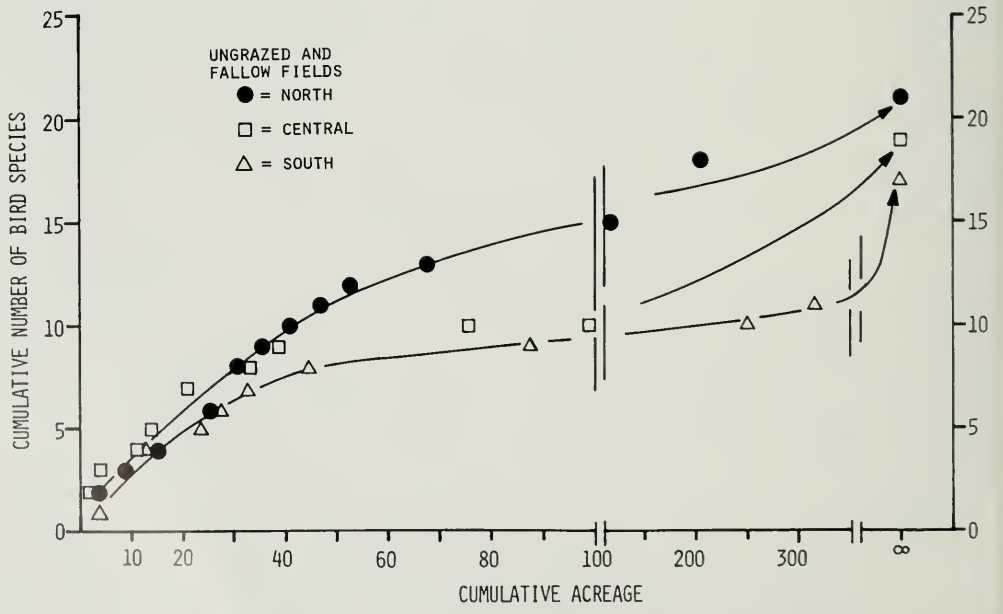

Fig. 5. — Numbers of bird species found nesting in different-sized tracts of ungrazed and fallow fields in the three regions (Fig. 2) of Illinois.

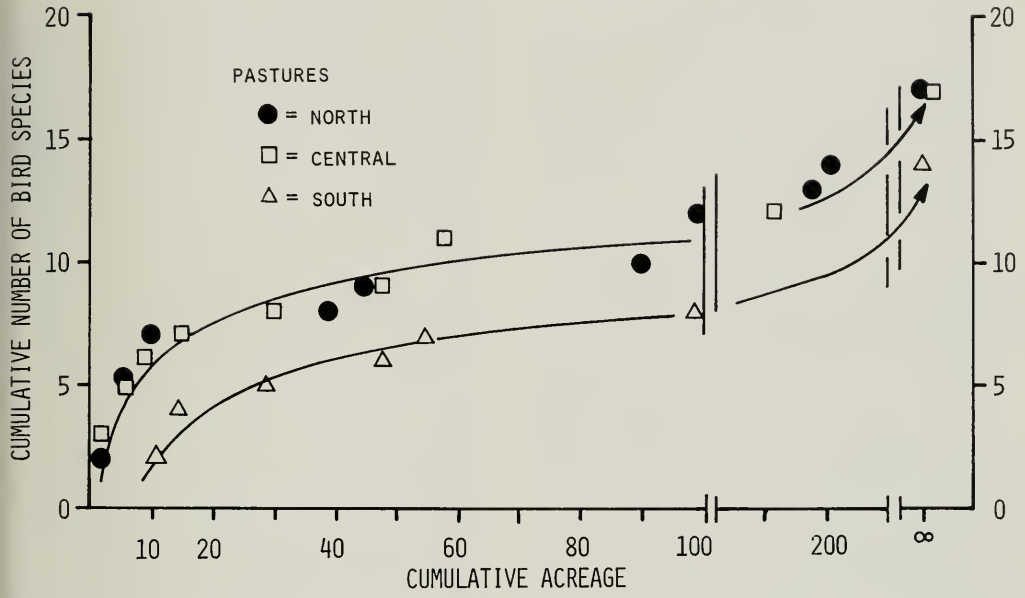

Fig. 6. — Numbers of bird species found nesting in different-sized tracts of pastured grasslands in the three regions (Fig. 2) of Illinois.

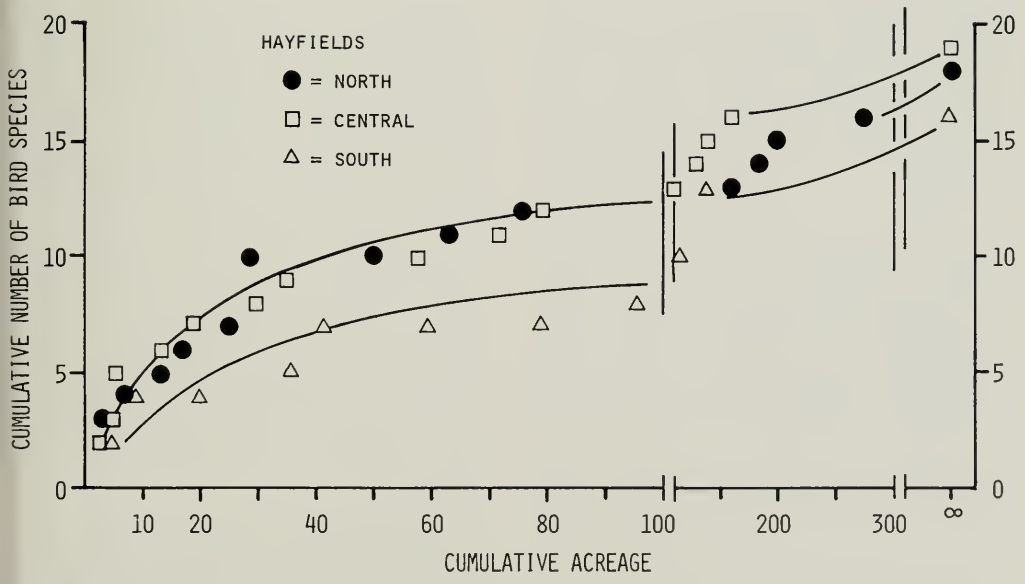

Fig. 7. — Numbers of bird species found nesting in different-sized tracts of hay land in the three regions (Fig. 2) of Illinois.

wide variety of investigators who might use the system. Another consideration was the matter of acquiring acreage data for the habitats. The habitat divisions could not be more refined than the available acreage data, as acreage data are vital to the system. Even our gross classification required some tenuous estimates in this regard. We also had to be able to interpret the habitat classification in terms of bird populations and account for all or nearly all of the species.

In general, we have used available published classifications of habitats that provided acreage data. In some cases we have made our own modifications for reasons that are explained. Our definitions of the gross habitats and the sources of data we used are given in the following accounts. In considering the floral aspect of habitats, we are forced to deal with exotic and adventitious species, as some gross habitats (row crops, hayfields, pine plantations) are composed almost entirely of introduced plants. These habitats are often inferior as substrates for bird populations, probably because they lack floral variety and perhaps to some degree because of their exotic character.

Forest Habitats

The classification of gross forest habitats (Table 3) is that of Essex & Gansner (1965) because this reference was the source of most of the acreage data for these habitats.

The oak-gum-cypress forest includes the wettest lowland woods (swamps) and occurs only in the southern part of the state. By Essex & Gansner's definition, 50 percent or more of the trees in this type are gum (*Nyssa aquatica*), cypress (*Taxodium distichum*), and or oaks, the most characteristic being pin oak (*Quercus palustris*), basket oak (*Q. michauxii*), overcup oak (*Q. lyrata*), Shumard's oak (*Q. shumardii*), and cherrybark oak (*Q. falcata pagodaefolia*).

The other bottomland forest type occurs in all regions of the state. It is characterized by Essex & Gansner as consisting of 50 percent or more elm (*Ulmus americana*), ash (*Fraxinus* spp.), or cottonwood (*Populus deltoides*), and it is found particularly on the floodplains of rivers and streams. With the dying of elms from Dutch elm disease, elms have become less important in this association. Other representative tree species of this forest type in various parts of the state are silver maple (*Acer saccharinum*), swamp white oak (*Q. bicolor*), bur oak (*Q. macrocarpa*), pecan (*Carya illinoensis*), bitternut hickory (*C. cordiformis*), hackberry (*Celtis occidentalis*), red maple (*A. rubrum*), river birch (*Betula nigra*), and sycamore (*Platanus occidentalis*). This association is present even on relatively small hill streams if they have definite floodplains.

The oak-hickory forest type is described as woodland in which 50 percent or more of the trees are upland oaks — white (*Q. alba*), black (*Q. velutina*), red (*Q. rubra*), Spanish (*Q. falcata*), chestnut (*Q. muhlenbergii*), blackjack (*Q. marilandica*), and post (*Q. stellata*) — and hickories, such as pignut (*C. glabra*), shagbark (*C. ovata*), and mockernut (*C. tomentosa*). Sugar maple (*A. saccharum*), black walnut (*Juglans nigra*), and black locust (*Robinia pseudoacacia*) are also characteristic tree species of this forest type. We have also included in this acreage category oak-pine forests in which the forest is primarily deciduous, as the fauna in such areas is essentially the deciduous forest fauna.

As a practical matter the two large forest types — elm-ash-cottonwood and upland oak-hickory, which together comprise more than 95 percent of all Illinois forest habitat — can usually be identified on the basis of topography even before their vegetation is studied.

Left undisturbed, plants will invade bare ground, and over a period of years the kinds of plants will gradually change in a predictable sequence known as succession. Finally a stage is reached where conspicuous change is no longer evident, and this stage of more or less stable vegetation is called climax. Sometimes continuing disturbance or particular soil or topographic conditions exist that prevent the succession from proceeding to the ultimate climax association for the region and climate. Then one of the successional stages will appear to be stable in a local area.

Clements & Shelford (1939) described five different woodland successions, and Shelford (1954) gives a table showing the time required for the development of the various associations, such as those occurring in bottomland forest in the southern part of Illinois. From these data we can predict the dominant species of bottomland forest on a time schedule. Bottomland woods less than 30 years of age will be largely willow (*Salix* sp.) or cottonwood or a mixture of these species. Those woodlands 30–65 years old will be cottonwood with younger silver maple, ash, and hackberry coming in as the shade-intolerant willow dies out. The 60- to 100-year-old bottomland forest will be predominantly hackberry-ash-silver maple with some elm and oak saplings. After 200 years, one begins to find an elm-oak-hickory association. This type is followed by regional or site climaxes for Illinois, maple-basswood (*Acer saccharum-Tilia americana*), oak-hickory (*Quercus* sp.-*Carya* sp.), or maple-beech (*Acer saccharum-Fagus grandifolia*). Because of the slow growth rate of beech, forests with large beech trees are known to be among Illinois' oldest woodlands.

The succession for upland woods proceeds from shrubs, after 25–40 years following the abandonment of cropland, to a tree growth of shade-intolerant species, i.e., tree species whose early development is inhibited by shade, such as elms, black cherry (*Prunus serotina*), hawthorns (*Crataegus* sp.) (Beckwith

1954), persimmon (*Diospyros virginiana*), and sassafras (*Sassafras albidum*) (Bazzaz 1968). After 60–100 years an oak-hickory woodland develops, and after 150–200 years in suitable situations a maple-beech climax may arise. In sand areas around Lake Michigan an initial growth of cottonwood may be followed by pines (*Pinus banksiana* and *P. strobus*), which are followed by oak or oak-hickory (Steyermark 1940). Aspen (*Populus grandidentata* and *P. tremuloides*) woodland occurs as forest edge or develops as a result of disturbance (removal of the canopy) and is relatively short-lived, being replaced as a canopy of other species develops.

Various local disturbances often lead to a number of different-aged associations within a small area. Hence, each woodland is distinctive in its constitution but can be fitted into the gross habitat classification.

With the exception of relatively few acres of naturally occurring pines, which are often a small part of a deciduous forest, most of the pine stands in Illinois are managed plantations, often of introduced species. There are only three or four native species — white pine (*Pinus strobus*), jack pine (*P. banksiana*), shortleaf pine (*P. echinata*), and possibly red pine (*P. resinosa*) in very restricted numbers. Pine plantations have consistently poor faunas. Most of the stands are relatively young (under 40 years) and if left undisturbed, will eventually be replaced by native deciduous trees.

The availability data (acreage) of forest habitats were based initially on Essex & Gansner (1965). In using the 1962 acreages of Essex & Gansner, including their stand-age data, we considered the noncommercial forest acreage (110,000 acres) to have the same habitat and age classification as the commercial forest acreage (3,761,400 acres) that they account for. Though this assumption is not strictly true, it was the only logical basis on which to account for the noncommercial forest.

From the 1962 base we estimated the 1973 acreages from data in the *1969 Census of Agriculture* (U. S. Department of Commerce 1972), which indicated that woodland on farms — most of the Illinois forest — declined at the rate of 2.6 percent per year in the southern counties, 2.7 percent in the central counties, and 4.2 percent in the north between 1964 and 1969. As the increasing human population of the world depleted U. S. grain reserves, the prices of farm products began to rise, and farmers began sacrificing forest, especially flatland forest, to increase cropland. The rate of change may have been greater after 1969 than before, but with no objective basis for refining the estimate, we used the 1969 data to estimate the 1973 acreages (Table 3). Our field observations indicated that most of the loss of forest acreage in the 1960's and 1970's involved flatland, mainly bottomland, and our acreage calculations reflect this fact.

As even the 1962 acreages given for the less abundant forest types — aspen and maple-beech — were likely to be inaccurate (see Essex & Gansner 1965 on acreage reliability for smaller areas), it seemed futile to attempt to update these acreages to 1973, and we used the 1962 figures. Essex & Gansner (1965) accounted for only 500 acres of pine in northern and central Illinois, perhaps reflecting a special definition they gave that forest type. As we included Christmas tree and other plantations, we could account for much more acreage from our own field work, and we have used our own estimates of pine acreage for those regions (Table 3).

The tamarack (*Larix laricina*) stands of the northeastern Illinois bogs can be considered as forest habitat, but as bogs are such unique relicts in Illinois, the presence of a bog in an impact area is an overriding consideration beyond our evaluation method.

Shrub Habitats

All Illinois shrub habitat is successional — it will eventually be succeeded by woodland — with the possible exception of small thickets of woody prairie plants. Shrub habitat occurs as a result of the abandonment of cropland ("old fields") or the clear-cutting of forest or as edge (fencerows, ditches, hedges, or forest edge). Hawthorns (*Crataegus* spp.), dogwoods (*Cornus* spp.), sumacs (*Rhus* spp.), plums (*Prunus* spp.), briers (*Rubus* spp.), filbert (*Corylus americana*), and elderberry (*Sambucus canadensis*) are typical species found in shrub habitat, as well as young red cedars (*Juniperus virginiana*), sassafras, persimmon, winged elm (*Ulmus alata*), and willows in certain situations. A distinguishing characteristic of shrub habitat, as opposed to young forest, is the irregular spacing of plants often in considerable areas of grass. Both types ultimately result in forest, of course, but for a period of up to 30 years the open shrub-grass areas support certain faunal elements not found in any other habitat.

Notable among the birds in this habitat are the prairie warbler and Bachman's sparrow. We have included orchards and hedgerows in this gross habitat type because their faunal associations are similar to that of shrub habitat. Young willow clumps in open grassland or marsh areas are also included for the same reason. Where shrubs are interspersed with areas of grass and other herbaceous vegetation, we include as part of the shrub habitat the grass matrix to the outer circumference of the shrub-grown area.

The replacement time for shrub habitat is 3–25 years (Odum 1953; Bazzaz 1968), and the length of time an area remains in shrub growth is relatively short, unless disturbance is continuing, as in dunes or some pastureland.

The only estimate of shrub acreage in the state is ours for 1957–1958 (Graber & Graber 1963). Our estimate of about 500,000 acres of shrub areas in Illi-

nois was based on the amount of shrub land we encountered in the cross-country censuses of 1957–1958 compared with the amount of row-crop acreage we encountered. The U.S. Forest Service (1968) provided acreage data for "brush and open land" (17,000 acres) on its land holdings (206,000 acres) in the Shawnee National Forest. If a similar proportion (8 percent) of potential shrub area to forest occurs outside the forest holdings, there would be about 240,000 acres of shrub habitat in the state, most of it (154,000 acres) in the southern region. The 240,000-acre figure for the state should be considered a maximum estimate, as the amount of shrub acreage outside forest holdings is probably less than that within. Nonetheless, the estimate, rough as it is, seems reasonable in relation to our 1957–1958 estimates, as we are certain that shrub acreage has declined drastically in recent decades. We have seen the destruction of this habitat in the course of our field work throughout the state. We have used this estimate because no other information on the matter exists, and for the purposes of our evaluation method even rough acreage estimates are usable.

The acreage of orchards included in this gross habitat is from the *1969 Census of Agriculture* (U.S. Department of Commerce 1972), and the edge shrub (road and railroad rights-of-way and similar areas) acreage is from observations made during our cross-country censuses.

Residential Habitats

Residential habitat includes all land occupied primarily by buildings and dwelling places of humans and their livestock and the associated vegetation. It includes inner city and suburban as well as farm residences. It offers vegetative cover varying from open grass lawns in new suburbs to modified open woodland in older areas to business districts with relatively little vegetation. The fauna is relatively poor, considering the amount and diversity of woody habitat, and is characterized particularly by three exotic pest species — rock dove, starling, and house sparrow — and three native species — common nighthawk, chimney swift, and purple martin. This habitat may not often be involved in impact areas, but we have included it for the sake of completeness, as it comprises a large and growing acreage.

Replacement time for the habitat is estimated on the basis of the age of the associated vegetation, which can usually be determined from local inquiry. If age is based on tree size, it should be remembered that growth rates are faster for trees in the open than for trees in a forest (see The Method in Practice).

Our sources for acreage of residential habitat (Table 3) were the U.S. Bureau of the Census *Area Measurement Reports* (U.S. Department of Commerce 1960) and the *1969 Census of Agriculture* (U.S. Department of Commerce 1972). Since no area data were given for towns with populations under 1,000, we extrapolated, using area data for towns with populations of 1,000–1,100 and a ratio of population to area. Rural residential habitat was estimated from the number of farmsteads, from acreage given in the *1969 Census of Agriculture,* from farmstead acreage given by Fisher (1969) for Edwards County, and from our own observations.

Marsh Habitats

Marsh is the open (unforested) area occupied by vegetation in water from about 3 feet in depth to waterlogged soil (sedge meadows), as described by Splettstaszer & Manke (1955). The bulk of marsh vegetation is made up (varying with the site) of bulrushes (*Scirpus* spp.), spike rushes (*Eleocharis* spp.), sedges (*Carex* spp. and *Cyperus* spp.), bur reeds (*Sparganium* spp.), cattails (*Typha* spp.), and certain grasses, such as manna grass (*Glyceria* spp.), common reed grass (*Phragmites communis*), cord grass (*Spartina pectinata*), rice grass (*Leersia oryzoides*), and wild rice (*Zizania aquatica*).

Succession proceeds from deeper water, as deposits of alluvial material and humus build, to shallower water to saturated soils to soils above the water table (moist meadows), and ultimately to the drier soils that support mesophytic prairie. Characteristic plants of the deeper water marsh are cattails (*Typha angustifolia*), bulrushes, coontail (*Ceratophyllum* spp.), and lotus (*Nelumbo lutea*). Cattails (*T. latifolia*) also occcur in the medium and shallower water marshes, along with bulrushes, sedges, and bur reeds. Characteristic of wet meadows are a number of species of sedges, water hemlock (*Cicuta maculata*), swamp goldenrod (*Solidago uliginosa*), and species of *Polygonum*. The drier successional associations of marsh are not sharply delineated from those of the prairie. The open water around marshes can, to a certain extent, be considered as part of the habitat. In measuring marshes, open water acreage up to the equivalent of the acreage of marsh vegetation can be included as marsh. This is the only habitat in which open water is included.

From a practical standpoint, in calculating replacement time for marshes two categories can be recognized — natural marshes and man-made marshes. A man-made marsh can be dated historically from the construction of the site. Natural marshes, such as occur most notably in northeastern Illinois, have a very long evolution reaching back to the last glaciation. Though the individual plants of marshland require much less growth time to maturity than do trees, we have given natural marshes a comparably high replacement value because of the long developmental history, manifested to some extent in the underwater soil development (Griffiths 1932; Veatch 1933). Man cannot readily duplicate the very special conditions (edaphic, climatic, geographic) that gave rise to the

marshes and allowed them to be perpetuated for thousands of years; hence, such marshes may be considered irreplaceable. Man-made marshes, such as those that occur around ponds and lakes, develop fairly rapidly floristically, but usually support only a few of the characteristic marsh birds. Marsh does not readily develop to any extent around the larger reservoirs because of the extreme fluctuations in water levels of these bodies of water (Penfound 1953).

Our source of acreage data for marsh was Splettstaszer & Manke (1955). We found no data from which to update their acreage figures to 1973, but their inventory omitted numerous small marshes; so even though marsh acreage is declining (Shaw & Fredine 1956), the 1955 data may still be fairly accurate. In any case they are, along with those of Shaw & Fredine (1956), the only inventory of marshes for the state. Acreage figures in these two publications are very similar and may represent the same inventory.

Grassland Habitats

Gross habitats in this category include prairie, ungrazed (fallow fields) and grazed grassland (pastures), and hayfields. Under ungrazed grassland, we have also included much (excepting shrub areas) of the acreage of road and railroad rights-of-way (598,900 acres).

Prairie, one of the climax vegetations in Illinois, now occupies a very small portion of the state, some of it in preserves, such as Goose Lake Prairie (Grundy County) and the Henry Allan Gleason Preserve (Mason County).

The bulk of prairie vegetation is grasses although in numbers of species the grasses are often equalled or exceeded by the composites. The grass species in Illinois prairies constitute less than 20 percent of the species in the habitat, but may account for up to 98 percent of the foliage area (Evers 1955). The grass associations are accompanied by a variety of other plant species, of which 63 are listed by Jones (1963) as occurring on prairie soil. Sampson (1921) recognized two major prairie successions in Illinois, for both of which the characteristic end point is big bluestem (*Andropogon furcatus*). In dry situations the successional precursor to big bluestem is little bluestem (*A. scoparius*), and in very dry situations the succession may stop with this precursor. In moist situations the successional precursor to big bluestem is switch grass (*Panicum virgatum*), which may sometimes be the hydrarch succession end point.

Other typical prairie indicators among the grasses are Indian grass (*Sorghastrum nutans*), side-oats grama (*Bouteloua curtipendula*), and porcupine grass (*Stipa spartea*) and such forbs as pasque flower (*Anemone ludoviciana*), smooth silkweed (*Asclepias sullivantii*), aster (*Aster ericoides*), wild indigo (*Baptisia leucantha*), pale coneflower (*Echinacea pallida*), rattlesnake master (*Eryngium yuccifolium*), blazing star (*Liatris spicata*), obedient plant (*Physostegia virginiana*), and compass plant (*Silphium lacinatum*) (Evers 1955; Fell & Fell 1957; Jones 1963).

Depending upon the amount of soil destruction, the replacement development of prairie may take from 10 to 30 years or longer (Table 2) through natural succession (Thomson 1940; Booth 1941; Weaver 1961). In practice, if the age of the stand cannot be determined, the higher replacement time should be used, as subtle but important physical and chemical development may occur in the older prairie just as they occur in other habitats with increasing age (Kershaw 1973).

Our data on the availability of prairie come from the Illinois literature (Evers 1955; Schramm 1970; Illinois Department of Conservation & Illinois Nature Preserves Commission 1972; Sanderson et al. 1973) and our own field data. Our acreage figure for prairie (Table 3) is probably low, as there may be numerous small areas of prairie unrecorded in the literature and unknown to us.

The prairie fauna (Table 10) now survives mainly in managed or fallow habitats that bear some resemblance to prairie in the growth form of their vegetation but are not characterized by a particular flora.

In the broad category of ungrazed and fallow habitats we include fallow agricultural fields, embracing old fields before shrub development; abandoned fields of all types with herbaceous vegetation; the successional stages to prairie; and ungrazed grass areas, much of which is along roadways and railroad rights-of-way with some on airfields. This assemblage has no distinctive flora, but the old-field succession follows a definite pattern characterized by annual weeds the first 1–2 years and progressive increases in grasses thereafter. Species of three-awned grass (*Aristida*) and broom-sedge (*Andropogon virginica*) may be present 10 years or longer. In many areas of this gross habitat the dominant stable vegetation is blue grass (*Poa pratensis*), an indicator of sustained disturbance. Blue grass is also present on many roadways, as are species of fescue grass (*Festuca*) and brome grass (*Bromus*).

This gross habitat supports elements of the prairie grassland fauna and is one of the reservoirs, along with pastures and hayfields, for what is left of the prairie fauna in Illinois. The fauna may vary with litter depth (Tester & Marshall 1961), and litter depth, in turn, with the age of the stand and amount of disturbance.

Our sources of acreage data for this gross habitat were the *1969 Census of Agriculture* (U. S. Department of Commerce 1972), Illinois Division of Highways' *Highway Mileage* (Illinois Department of Transportation 1970), *Rand McNally Handy Railroad Atlas of the United States* (1971), and our own measure-

ments of rights-of-way for various highways, roads, and railroads. We measured airfield turf from aerial photographs in the *Illinois Airport Directory* (Illinois Department of Transportation 1973).

The pasture gross habitat is defined on the basis of land use and differs from ungrazed and fallow habitat only in the presence or recent presence of grazing livestock. The acreage excludes all woodland pasture, which is considered to be forest. Shrub areas in pasture are considered shrub habitat. The pasture habitat category is an open field habitat of grassland. The vegetation is commonly blue grass in the north and central regions and fescue (*Festuca arundinacea*) in the south, but also includes numerous other grasses and forbs. Hog pastures are among the poorest bird habitats and degenerate progressively as they are used. Most pastureland is cow pasture, which supports a varied (and different) fauna, depending upon the amount of grazing pressure.

Our source of acreage data for this gross habitat was the *1969 U. S. Census of Agriculture* (U. S. Department of Commerce 1972), and the Availability Factor is based on both rangeland and cropland used as pasture.

Hayfields are managed habitats characterized by vegetation containing large amounts of herbaceous legumes, often mixed with grasses, cultivated and cropped in the warm season for livestock forage in the cold season. This is an important habitat for the prairie fauna, but the flora is primarily cultivated exotics.

Replacement time for this habitat is relatively short, and though there is some development beyond the first year, notably in stand and duff development, in most cases duff development is likely to be poor because the fields are raked and the vegetation is removed periodically. Hayfields are often rotated with other crops after 3 years, which is about the time required for maximum development of the habitat.

Our acreage data for this gross habitat are from the *1969 Census of Agriculture* (U. S. Department of Commerce 1972), and *Illinois Agricultural Statistics* (Illinois Cooperative Crop Reporting Service 1974).

Small-Grain Fields

Small-grain fields are a monoculture habitat comprising fields of oats, wheat, barley, or rye. In aspect it resembles grassland and supports a few elements of the prairie fauna in very low population densities. Of the four crops, oat fields have the best faunal diversity, especially where fields have been heavily invaded by weeds to provide some floral diversity. These grains are annual crops, and replacement time does not exceed 1 year.

Our acreage data for this gross habitat are from *Illinois Agricultural Statistics* (Illinois Cooperative Crop Reporting Service 1974).

Row-Crop Fields

The row-crop habitat category includes primarily the monocultures of corn and soybeans and also the acreages of cotton and vegetable crops of all kinds. This is the poorest of Illinois habitats, and the associated fauna has more to do with the bare ground around the plants than with the flora. These are annual crops, and replacement time does not exceed 1 year.

Our source of acreage data for this gross habitat was *Illinois Agricultural Statistics* (Illinois Cooperative Crop Reporting Service 1974).

THE METHOD IN PRACTICE

Although we have provided certain basic data essential to the calculation of environmental indices, each investigator must provide the field data that apply to his impact area. No two areas are likely to be exactly the same; however, two areas may have similar values, and by calculating the Habitat Evaluation Index and the Faunal Index, any area can be compared with any other area in Illinois with regard to ecological value. The indices are calculated from field data for the specific impact area and from factors given in this paper.

Nothing is more important at the start than a clear and precise understanding of the limits of the impact area. We recommend that the investigator work on and from aerial photographs of the area, usually available at the U. S. Department of Agriculture, Agricultural Stabilization and Conservation Service (ASCS) office in the county seat(s) of the county or counties that include the impact area. The photographs usually may not be taken out of the ASCS offices, but copies can be ordered at cost through the ASCS office. Filling the order may take up to 2 months; so if the investigator is short of time, he may work from tracings of the office copy of the photograph.

We recommend that the investigator use a photograph with a scale of 1 inch to 330 feet, or similar detail, especially for impact areas under 2,000 acres. The next common size scale (1 inch to 660 feet) is also adequate. The aerial photo, or tracing, should be taken into the field. If a tracing is used, the investigator should trace the boundaries of all habitats within the impact area. Bear in mind that the photographs are likely to be at least slightly out of date. From his field work, the investigator must verify the habitats and their boundaries and correct any acreage changes that have occurred since the photographs were taken.

Also helpful are the topographic (quadrangle)

maps showing forest cover, available at cost, from the Illinois State Geological Survey, Urbana, Illinois. These maps vary greatly in preparation date, and many are too old to be of much help except for topographic features and historical data on habitat- and land-use patterns. For the greatest detail, use the 7½-minute quadrangles with forest cover (scale: 1:24,000) if available. The 15-minute quadrangles (scale: 1:62,500) are also useful. Again, bear in mind that the habitat boundaries on the maps are likely to have changed since the maps were prepared; so the investigator must verify boundaries. The combination of the most recent ASCS photograph with recent quadrangle maps makes an excellent working tool for almost any kind of field investigation. For some areas other good reference maps are available. The U. S. Army Corps of Engineers, for example, has photographs and maps of many of the major streams in the state. Also, some cities, colleges, and universities have excellent map libraries that may prove helpful to the investigator.

From the aerial photographs, maps, and, most important of all, actual measurements in the field, the next step is to determine the acreage of every gross habitat within the impact area. It is essential that all of the habitats be observed by the investigator in the field so that the habitat classification and acreage data may be accurate. Some of the acreages can be taken directly from the ASCS photographs. The ASCS staff generally will have recorded acreages of cropland. The acreages of the natural habitats can also be worked out from the aerial photographs, once they are identified and properly verified in the field and the appropriate changes have been made on the photograph or tracing. Especially where there is considerable variation in topographic relief, acreages should be checked in the field. For the purposes of the evaluation, simple pacing measurements are sufficiently accurate, providing the investigator is experienced in making such measurements.

Acreages of habitats in the impact area can be determined either directly on the photograph (Fig. 8) or on an overlay of onionskin paper by fitting the habitat areas as closely as possible into geometric figures (squares, rectangles, triangles, and circles) (Fig. 9) and calculating the areas of the figures, using standard equations. The areas may also be outlined on onionskin paper, then cut out and weighed on a sensitive balance. The weight of the paper representing the unknown area is then compared to the weight of a piece that represents a known acreage. Acreages can also be estimated by using transparent overlay grids of known acreage, fitting the grids over the habitat areas on the photograph, and recording the acreages as the grid is moved across the photograph. This method may be somewhat less accurate, but it is faster than other methods and may be more practicable for very large impact areas. The acreages of a linear habitat, even a crooked one, can be calculated from its length on the photograph and a figure for average width based on measurements in the field at three or more places along the length of the habitat.

While in the field checking the identities and acreages of the different habitats in the impact area, the investigator can also be determining the ages of the different habitats. Cropland, for the most part, can be considered to have an age of 1 year regardless of its stage of development or harvest, and so the investigator should concentrate his efforts on the natural habitats. Local inquiry can be helpful here, as many farmers, for example, know the histories of tracts of land in their neighborhoods. Perhaps the most difficult habitat to age, because of its long life, is forest. If the history of the tract is not known, the age can be estimated at least roughly on the basis of tree size (Table 13). We are fully aware of the large variability in growth rates of trees on different sites (Carmean 1971). Nonetheless, there is correlation between age and tree size, regardless of site, and for the purposes of our evaluation method this procedure is adequate. Generally, there is no other reliable source of data on ages of forest tracts. We do not recommend core drilling, as it damages trees, and ring counts are little better than diameter measurements for the purpose of ageing trees (Glock 1941 and 1955; Studhalter 1955). Drilling is also time-consuming. The growth rates in Table 13 are based on average sites, where site data were provided, and on areas in Illinois or as close to Illinois as we could find.

To determine the age of a stand of trees, if the history is unknown, the investigator should measure a sample of dominant (larger) trees in each tract of notably different age or composition. The sampling method is not critical. We suggest measuring about one tree per acre or fewer in large tracts (50 acres or more). Run a transect through the tract on its longest axis or on the diagonal in a squarish tract. Measure oaks, preferably, because they are almost always present and better growth data are available for oaks than for other species (Table 13). Otherwise, use any of the other species listed in Table 13. In walking the transect, which need not be a straight line, measure the largest tree seen every 50–100 feet or so. This technique is not intended to be an exhaustive search for the largest trees. All that is necessary is that some of the larger trees encountered be measured. Measure the diameter of the trunk about 4–4.5 feet above ground (DBH). If available, use calipers or diameter tapes to make the measurements. An ordinary measuring tape can be used, but care must be taken, especially with big trees, to

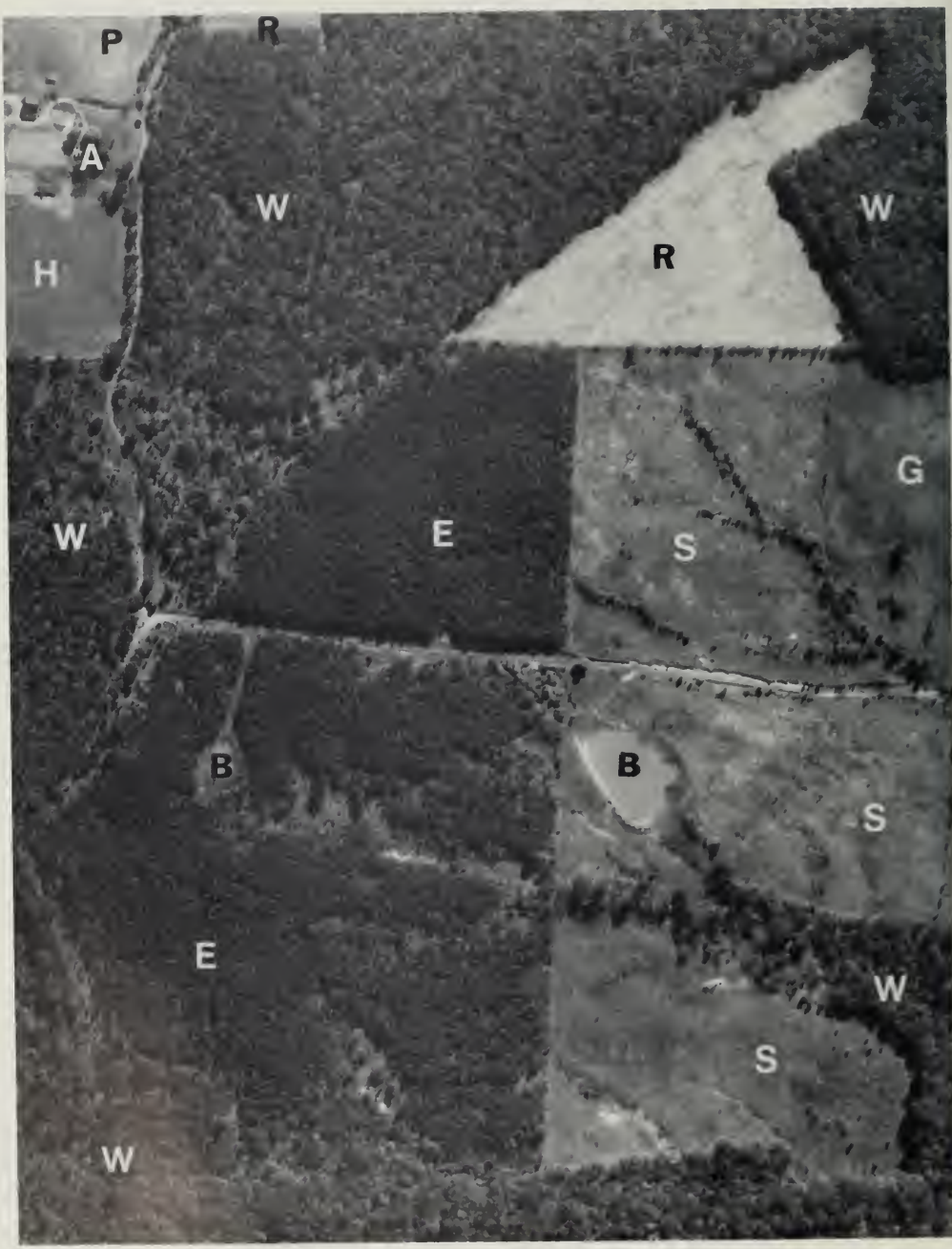

Fig. 8. — Aerial photograph showing a portion of the experimental impact area used to test the method presented in this paper. The scale of the photo is 330 feet per inch, or 2 square inches equals 10 acres. Note that pines (E) are distinguishable from deciduous hardwoods (W). Bare field (R), ponds (B), residential area (A), and shrub habitat (S) are easily identified. Ungrazed grass (G), hayfield (H), and pasture (P) are difficult to distinguish in aerial photos and must be identified by examination in the field.

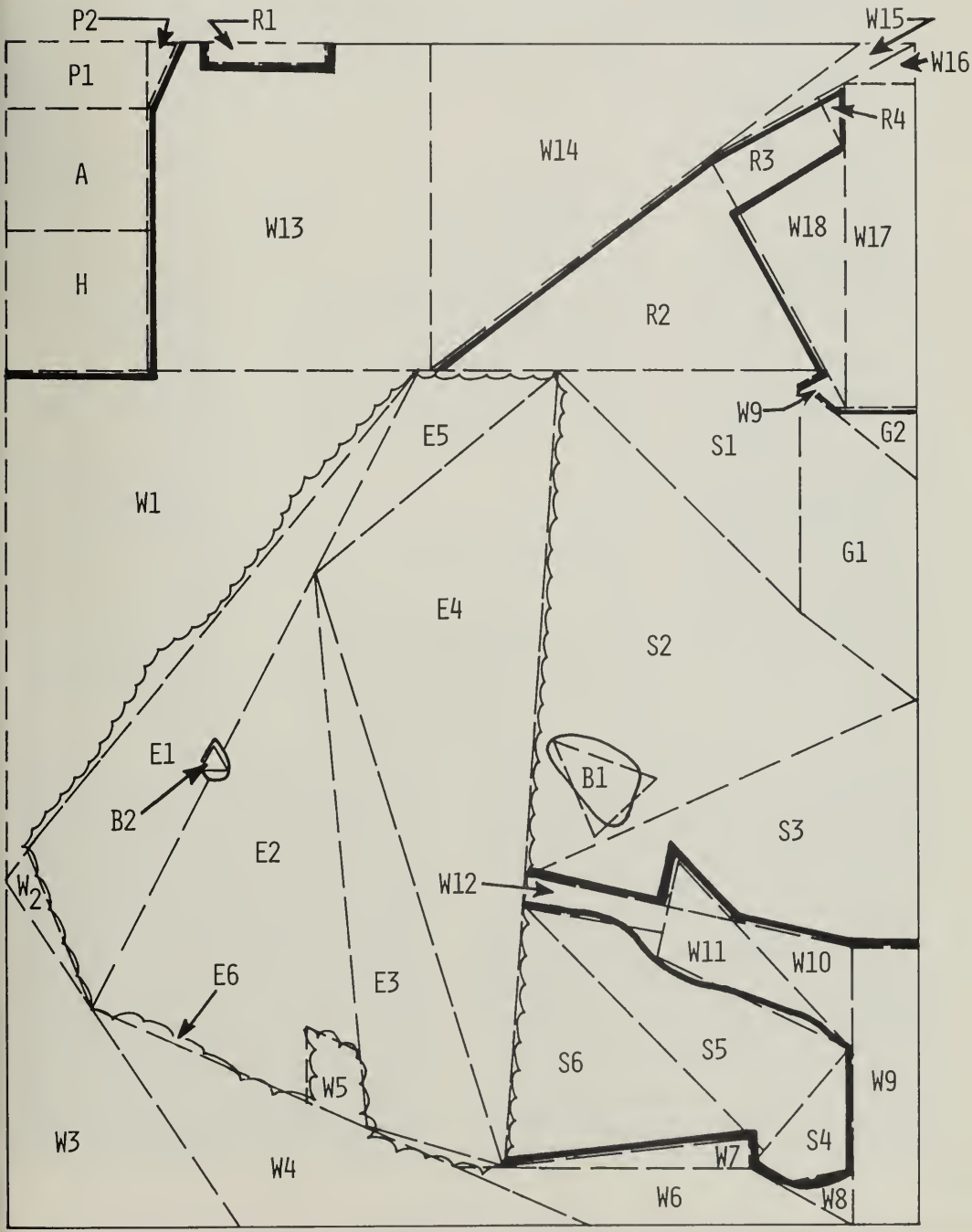

Fig. 9. — Example of onionskin overlay for aerial photograph (Fig. 8), showing irregularly shaped areas divided into geometric figures for acreage measurements (based on the scale of the photo) of different habitats.

TABLE 13. — Growth rates of representative tree species. This table is to be used to determine approximate ages of trees and replacement times for forests.

Species	Annual Growth Rate[a]	Comment on Use of Growth Rate	Reference and Locality of Reference Data
Ash, green and white *Fraxinus pennsylvanica* and *F. americana*	0.22		Lorenz (1962) Central Illinois
Basswood *Tilia americana*	0.22		Chittenden & Robbins (1930) Southern Michigan
Beech, American *Fagus grandifolia*	0.12		Chittenden & Robbins (1930)
Box-elder *Acer negundo*	0.24		Lorenz (1962)
Cherry, black *Prunus serotina*	0.27		Conard (1918) Central Iowa
Cottonwood *Populus deltoides*	0.60 0.56 0.53	Use this rate for 4–15″ DBH Use this rate for 16–25″ DBH Use this rate for over 25″ DBH	Williamson (1913) Mississippi Valley Gilmore et al. (1973*a*) Southern Illinois
Cypress, bald *Taxodium distichum*	0.20 0.13	Use this rate for 4–40″ DBH Use this rate for over 40″ DBH	Mattoon (1915*b*) Maryland, Louisiana
Elm, American *Ulmus americana*	0.31 0.25 0.19	Use this rate for 4–10″ DBH Use this rate for 10–15″ DBH Use this rate for over 15″ DBH	Lorenz (1962) Chittenden & Robbins (1930)
Elm, red *U. rubra*	0.49		Conard (1918)
Gum, sweet *Liquidambar styraciflua*	0.30		Gilmore et al. (1973*b*) Southern Illinois
Hickory, shagbark *Carya ovata*	0.22		Conard (1918)
Maple, silver *Acer saccharinum*	0.45		Lorenz (1962) Conard (1918)
Maple, sugar *A. saccharum*	0.15 0.10	Use this rate for 4–14″ DBH Use this rate for over 14″ DBH	Chittenden & Robbins (1930)
Oak, black *Quercus velutina*	0.24 0.15 0.10	Use this rate for 4–10″ DBH Use this rate for 11–15″ DBH Use this rate for over 15″ DBH	Vestal (unpublished) Southern Illinois Gevorkiantz & Scholz (1944) Southwestern Wisconsin
Oak, bur *Q. macrocarpa*	0.26 0.16 0.11	Use this rate for 4–10″ DBH Use this rate for 11–15″ DBH Use this rate for over 15″ DBH	Lorenz (1962) Conard (1918)

get an accurate measurement. If slopes are involved, trees should be measured on different faces (north-facing, south-facing slope) and at upper and lower levels of the slopes. If there is a definite floodplain, look for a change in species composition to elm-ash, as this is treated as a different gross habitat.

The field work is best done by two persons, one used primarily as a recorder of data. We have found it convenient to designate each tract of habitat with a code letter directly on the photograph of the impact area or the overlay tracing and then to record the field data by using the code letters. Record the tract and the species and size of each tree measured.

After the measurements have been made for each tract, age the trees on the basis of the growth rates given in Table 13 ($\text{age} = \frac{\text{diameter of tree}}{\text{growth rate of species}}$). Finally, select the 10 oldest trees of each 20 measured, and use the average age of these oldest trees as the age of the stand. Do not be concerned if the tree ages are not uniform. In virtually every stand are some older trees spared in earlier cuttings, and your sample will include some of these — roughly proportional to their numbers — as well as younger trees.

Once the habitats and their acreages and ages are known, the Habitat Evaluation Index (HEI) can be calculated as a first step (Table 14). To compute the HEI, consider each area of each gross habitat with a different age as a distinct unit. Different areas of the same gross habitat can be considered as a unit (summed) if they are of the same or nearly the same age. For example, in the case of forest we sum the acreage of tracts within 20-year age classes (90 to 110 years = 100-year class). Prepare a tabulating sheet like Table 14. Enter each area of each gross habitat of a different age as shown, with the habitat name first, next its acreage, then the Re-

TABLE 13. — Continued

Species	Annual Growth Rate[a]	Comment on Use of Growth Rate	Reference and Locality of Reference Data
Oak, pin *Q. palustris*	0.34		Vestal (unpublished) Southern Illinois
Oak, post *Q. stellata*	0.17		Vestal (unpublished) Southern Illinois
Oak, red *Q. rubra*	0.152		Robbins (1921) Missouri
Oaks *Quercus* spp.	0.16 0.128 0.104	Use this rate for 4–12″ DBH Use this rate for 13–18″ DBH Use this rate for over 18″ DBH	Gevorkiantz & Scholz (1944)
Pine, loblolly *Pinus taeda*	0.30 0.25 0.20	Use this rate for 4–10″ DBH Use this rate for 11–15″ DBH Use this rate for over 15″ DBH	Forbes & Demmon (1929) Virginia, Florida, Texas Arnold (1973) Southern Illinois
Pine, shortleaf *P. echinata*	0.29 0.25 0.20 0.15 0.10	Use this rate for 4–8″ DBH Use this rate for 9–12″ DBH Use this rate for 13–17″ DBH Use this rate for 18–20″ DBH Use this rate for over 20″ DBH	Mattoon (1915*a*) Western Arkansas Arnold (1973) Forbes & Demmon (1929)
Pine, white *P. strobus*	0.23 0.12	Use this rate for 4–15″ DBH Use this rate for over 15″ DBH	Lorenz (1962) Dwight (1926) Ontario, Canada
Sassafras *Sassafras albidum*	0.27		Rennels (1971) Central Illinois
Sycamore *Platanus occidentalis*	0.44		Vestal (unpublished) Gilmore (1973) Southern Illinois
Walnut, black *Juglans nigra*	0.43 0.30	Use this rate for 4–15″ DBH Use this rate for over 15″ DBH	Conard (1918) Losche (1973) Southern Illinois Lorenz (1962) Smith (1973) Central Missouri
Willow, black *Salix nigra*	0.54 0.46 0.28	Use this rate for 4–20″ DBH Use this rate for 21–26″ DBH Use this rate for over 26″ DBH	Lamb (1915) Arkansas

[a] Given in inches. This figure divided into the diameter (in inches) of a tree will give the approximate age of the tree in years.

placement Factor for the habitat area. In the fourth column enter the Final Availability Factor for the habitat and region from Table 5. Note that the Availability Factors given in Table 5 already have the Changing Availability Factors incorporated.

With these tabulations made, the computations can be started. For each habitat area of different age, multiply the Replacement Factor (age) by the Availability Factor and record the product (Replacement-Availability Product) in the fifth column. The next step in the computation is to calculate the ratio of each habitat-age group to the total acreage in the impact area ($\text{ratio} = \frac{\text{acreage of habitat-age group}}{\text{total acreage of impact area}}$). Thus, in our example (Table 14) the ratio for the first age group of bottomland forest habitat $= \frac{6.9 \text{ acres}}{643.9 \text{ acres}} = 0.0107$. Record this ratio after the appropriate category in column six. After all ratios are recorded, multiply the Replacement-Availability Product of each habitat-age group (column five) by the ratio of total acreage in the impact area (column six) and enter the resulting product in column seven. We call this product the Habitat Factor for each habitat-age group, and the sum of all the products (column seven) we call the Habitat Factor for the impact area.

Although we have said nothing about biological richness *per se*, the Habitat Factor is an indicator of biological richness, because the richest habitats tend to have the highest Habitat Factor values. After the Habitat Factor for the impact area has been calculated, a final procedure is required to standardize the evaluation. The standardization is obtained by comparing the Habitat Factor for the impact area with the Regional Average Habitat Factor (Table 15) for the region that contains the impact area. If the impact area crosses regional boundaries, the Habitat Factor of the impact area can be compared to the Regional Average Habitat Factor of the region that includes *most* of the impact area. Preferably, however,

TABLE 14. — Example showing the tabulation of data for the calculation of the Habitat Factors and Habitat Evaluation Index on a sample impact area in southern Illinois. The Habitat Availability Factors used were for the southern region (Table 5).

Gross Habitat	Acres of Habitat in Impact Area	Replacement Factor	Final Availability Factor	Replacement Availability Product	Part of Impact Area Acreage	Habitat Factor
Bottomland forest	6.9	146	132	19,272	0.0107	206.21
Bottomland forest	26.3	97	45	4,365	0.0408	178.09
Upland oak-hickory	88.8	100[a]	20	2,000	0.1379	275.80
Upland oak-hickory	55.7	120	28	3,360	0.0865	290.64
Upland oak-hickory	4.9	146	28	4,088	0.0076	31.06
Upland oak-hickory	26.2	175	28	4,900	0.0406	198.94
Upland oak-hickory	45.8	200	28	5,600	0.0711	398.16
Pines	61.6	25	18	450	0.0956	43.02
Shrub	78.0	17	19	323	0.1212	39.15
Residential	1.1	20	0.1	2	0.0017	0.003
Residential	3.3	157	0.1	16	0.0052	0.08
Ungrazed grass	35.5	10	21	210	0.0551	11.57
Pasture	141.2	10	31	310	0.2192	67.95
Hayfields	44.1	3	52	156	0.0685	10.69
Small grain	7.1	1	51	51	0.0111	0.57
Row crop	17.4	1	0.1	0.1	0.0270	0.003
Total	*643.9*				*0.9998*	*1,751.94*

Regional Average Habitat Factor (for southern region) = 397.46

$$\text{Habitat Evaluation Index (HEI) for impact area} = \frac{1{,}751.94}{397.46} = 4.41$$

Average Habitat Factor for state = 267.97

$$\text{HEI (state) for impact area} = \frac{1{,}751.94}{267.97} = 6.54$$

[a] Indicates age class between 90 and 110 years. The 120- and 200-year classes were similarly treated.

the impact area will be considered as two units divided along regional boundaries (Fig. 2), and the data for each unit will be considered separately.

The Regional Average Habitat Factors (Table 15) were calculated in the same way that the Habitat Factors for the impact area were calculated, except that average, or in several cases median, values were used for the Average Replacement and Availability Factors. The Regional Factor is thus not strictly an average, but it is the closest approximation we could make of an average or median value for each habitat, based on the references given under the habitat discussions and in Table 2. Ideally, the Regional Average Habitat Factor would be a true average, but the present knowledge of habitats is inadequate for such an attainment, and our best estimate is adequate as a value for comparison. The habitat with which we had the most difficulty in determining an Average Regional Factor was marsh, because of the great disparity in replacement age between natural and man-made marshes. The best estimate we could make of the average replacement time for this habitat was based on the acreage ratio between natural and artificial ponds and lakes (in which the marshes develop) in the three regions of the state from data presented by Lopinot (1973). Also difficult was the calculation of the average age of residential habitat, which we finally based on the growth of the human population in the three regions of the state.

The Regional Average Habitat Factor (RHF) varies from region to region, the south being the richest in habitats by far, as is clearly reflected in the factor (RHF = 397.46 in the south, 231.80 for the north, and 208.38 for the central region). The Average Habitat Factor for the state (267.97) is the average for the regional factors multiplied by their respective regional acreages and divided by the state acreage.

The final step in standardizing the Habitat Factor for the impact area is to divide the Regional Average Habitat Factor into the Habitat Factor for the impact area. The quotient from this division we call the Habitat Evaluation Index, or HEI (HEI = $\frac{\text{Habitat Factor for the impact area}}{\text{Regional Average Habitat Factor}}$). The HEI is an index to the wealth of habitats on the impact area. An HEI of 1.0 indicates that the area is average for the region, while an HEI of 4.4, as in our example (Table 14), means that the area is 4.4 times above the average for the region. An HEI of 0.5 means that the impact area is only half as rich in habitats as is the region. By this method every area in the state can be compared with every other area in terms of habitat richness on a standardized base. To com-

TABLE 15. — Regional Average Habitat Factors for gross habitats in three regions of Illinois.

Gross Habitat	North				Central				South			
	Average Replacement Factor	Average Availability Factor	Part of Total Acreage	Regional Average Habitat Factor	Average Replacement Factor	Average Availability Factor	Part of Total Acreage	Regional Average Habitat Factor	Average Replacement Factor	Average Availability Factor	Part of Total Acreage	Regional Average Habitat Factor
Oak-gum-cypress	...	...	...	...	...	...	...	...	101.0	557.0	0.001338	75.27
Elm-ash-cottonwood	45.6	106.8	0.007910	38.52	45.5	74.1	0.015032	50.68	45.5	42.4	0.056063	108.16
Oak-hickory	54.2	61.9	0.019563	65.63	54.2	37.5	0.038423	78.09	54.2	20.1	0.134928	146.99
Maple-beech	49.3	840.7	0.000256	10.61	49.1	577.9	0.000374	10.61	49.1	307.1	0.000722	10.89
Aspen	34.0	171.0	0.000780	4.53	34.0	549.0	0.000194	3.62	...	...	...	...
Pine	21.6	481.1	0.000414	4.30	21.6	277.3	0.000710	4.25	21.6	31.8	0.005072	3.48
Shrub	15.0	66.0	0.004346	4.30	15.0	42.0	0.006452	4.06	15.0	19.0	0.019552	5.57
Residential	60.0	0.1	0.116833	0.70	60.0	0.1	0.035038	0.21	60.0	0.1	0.032218	0.19
Marsh	385.5	48.0	0.003863	71.48	233.1	116.0	0.001076	29.09	108.2	303.0	0.000365	11.97
Prairie	20.0	163.0	0.000652	2.13	20.0	928.0	0.000109	2.02	20.0	687.0	0.000152	2.09
Ungrazed and fallow	5.0	20.0	0.072739	7.27	5.0	21.0	0.045303	4.76	5.0	21.0	0.046316	4.86
Pasture	5.0	31.0	0.091464	14.18	5.0	31.0	0.100886	15.64	5.0	31.0	0.118415	18.35
Hayfields	2.0	52.0	0.055056	5.73	2.0	53.0	0.029219	3.10	2.0	52.0	0.041291	4.29
Small grain	1.0	52.0	0.045325	2.36	1.0	52.0	0.041978	2.18	1.0	51.0	0.104070	5.31
Row crop	1.0	0.1	0.580797	0.06	1.0	0.1	0.685205	0.07	1.0	0.1	0.439495	0.04
Total			*0.999998*[a]	*231.80*			*0.999999*[a]	*208.38*			*0.999997*[a]	*397.46*

State Average Habitat Factor = 267.97

[a] A discrepancy exists in these sums, as the original calculations were made with seven-place figures, reduced here because of space limitations.

pare areas between regions, use the state Average Habitat Factor as the divisor instead of the Regional Factors for each impact area. Any area with an HEI above 1.0 must be given careful consideration for preservation, and the higher the value reaches above 1.0, the greater the concern should be for the preservation of the area. The highest HEI we have found for any area in Illinois is 386, calculated for the oldest forest stand on the island of the Horseshoe Lake Nature Preserve in Alexander County. Few areas will even approach such a high index.

The Habitat Evaluation Index is the first of two indices used in the evaluation of an impact area. The HEI tells us something of the potential value of the habitats in an area but nothing about the actual biological value of the habitats. This is the function of the second index, the Faunal (Floral) Index. This index adds greatly to the evaluation, but requires considerably more study and perhaps the help of a specialist in the field, depending upon the background of the investigator. Only rarely will the biological data have been collected and even more rarely will it have been published for the specific impact area in question. Considering birds, for example, recent breeding population data are available on less than 2,000 acres of Illinois land, making the probability about 1 in 18,000 that data will be available for a specific area, and the data for this index should be current. Floral studies are probably just as scarce. Therefore, the investigator will probably save time by assuming that the biological data on his impact area have not been collected. If the investigator has had sufficient training, he can acquire the data by himself. If not, he may be able to get help from one or more of the biologists in the state — in colleges and universities or other state agencies.

The goal of the bird studies is to acquire a good estimate of the number of breeding species of each gross habitat in the impact area. This work is best done in June and July to eliminate migrant species as much as possible, but it can start as early as March or April to get the early nesters, such as the hawks and owls. Ideally, the investigator might survey on foot all of the gross habitats in the impact area at least once a month from March through July, listing the potential nesting species for each habitat. This aspect of the study can begin when the first habitat measurements are made for the HEI determination. If the investigator is short of time, however, the bird data can be collected in June and July. The survey should include several night trips to detect nocturnal species. This survey for bird species need not be a quantitative census for the purposes of the impact-area evaluation. The investigator should look for evidence of nesting for all species, but absolute proof of breeding is not essential. The presence of territorial birds in the habitats of the impact area will usually be

indicative of breeding. The most common source of error stems from the fact that birds often forage in habitats other than the nesting habitat. Even a very experienced investigator should cover the impact area at least twice for the bird surveys.

A problem that arises in evaluating a fauna with a number system is that the number of species to be found in a given habitat is finite, so that as the habitat area increases beyond a certain size, increased coverage does not result in the finding of an increased number of species. To circumvent this problem, it is necessary to divide large impact areas into faunal units, each of which, for the purpose of the faunal evaluation, is treated as a separate impact area. This problem does not arise in the case of the Habitat Evaluation Index, only in calculating the Faunal Indices. We suggest that each 500 acres of a given habitat be treated as a separate unit in the faunal evaluation. Thus, after the investigator has developed sufficient familiarity with the impact area and knows the tracts and acreages of each gross habitat, he must divide those habitat areas that exceed 500 acres into geographic faunal units of about 500 acres each and then collect and segregate the bird data within each unit. The drawing of the unit lines is not critical. If the total acreage of, say, bottomland forest on the impact area were 520 acres, there would be little point in splitting the extra 20 acres off as a separate unit. If, on the other hand, the bottomland forest area were 600 acres or more, then the faunal data for the area in excess of 500 acres should be considered separately.

The calculation of the Faunal Index differs in yet another major way from that of the Habitat Evaluation Index, as the Faunal Index does not take into account row-crop and small-grain acreage. This difference occurs because the Faunal Index has a different function than the HEI. While the HEI refers to the overall habitat composition of the impact area, the Faunal Index refers to the *quality* of the habitats in the impact area. Row-crop and small-grain habitats are essentially *without* quality as natural habitats, and they support no faunal specialties (species nesting in only one gross habitat) (Table 11); therefore, it is pointless to include these habitats in the calculation of the Faunal Index.

After all the faunal data have been collected on all habitats in the impact area (excluding row-crop and small-grain acreage), the point evaluations can be made (Table 16). List the breeding species found for each gross habitat, bearing in mind that for a gross habitat including more than 500 acres the data should be segregated by 500-acre units. After you have completed the bird list(s) for a given habitat, turn to the appropriate table for that habitat (e.g., Table 6 for forest, Table 7 for shrub habitat) and put the point value for each species after the species name. Note that in Tables 6–11 we have recorded

TABLE 16. — Example showing the tabulation of data for the calculation of the Faunal Indices for habitats on a sample impact area (see Table 14).

Habitat	Acres	Number of Species	Total Species Points	Expected Species Points	Point Difference	Average Species Index	Expected Average Index	Point Difference	Common Log of Acreage	Faunal Index	Expected Faunal Index
Bottomland forest	33.2	25	520	310	+210	20.8	12.4	+8.4	1.52114	342	237
Upland forest	221.4	38	680	540	+140	17.9	14.2	+3.7	2.34518	290	256
Pines	61.6	8	300	90	+210	37.5	11.2	+26.3	1.78958	168	190
Shrub	78.0	25	790	380	+410	31.6	15.2	+16.4	1.89209	418	217
Residential	4.4	15	180	210	−30	12.0	14.0	−2.0	1.30103*	138	42
Ungrazed grass	35.5	4	120	70	+50	30.0	17.5	+12.5	1.55023	77	113
Pasture	141.2	3	40	50	−10	13.3	16.7	−3.4	2.14983	19	139
Hayfields	44.1	5	80	90	−10	16.0	18.0	−2.0	1.64444	49	120

* The smallest divisor used in calculating the Faunal Index is the log of 20 acres (1.30103) even when the acreage is less. Distortion increases greatly below that acreage.

the special (doubled base) value for the habitat specialties (e.g., red-shouldered hawk — a bottomland forest specialty). The special value is applied to a species even when, as occasionally happens, it is found nesting in a habitat other than its primary, special one. Such occasional occurrences do not change the fact that the species is still *primarily* dependent for survival upon one habitat.

After all the assigned values have been recorded for the breeding species of the habitat under consideration, they are next summed. From this sum two faunal indices are derived. The first is the Average Species Index, calculated simply by dividing the number of species into the sum of points. The second is the Faunal Index for the habitat, calculated by dividing the sum of the species values by the common logarithm of the number of acres of a particular habitat on the impact area (Table 16). Note that in cases of small-acreage habitats, particularly under 20 acres, the Faunal Index becomes distorted, increasing out of proportion as the acreage declines. Therefore, in practice, we never use a divider lower than the log of 20 acres (1.30103) no matter how low the acreage goes.

To see the meaning of the Total Species Points and the Average Species Index, turn to Fig. 10–15. These figures, each for a different major habitat type, present a graph line showing the relationship between species variety and species abundance (plus habitat specialization) and the size of the area surveyed through the simple numerical code we have derived. The point evaluation system of the faunal indices is based on the elementary observation that in a census of any habitat the most common species are likely to be encountered first, the rarer species later. Thus, in a point system such as ours, based in part on population levels, the average point value per species will increase as the number of species or the acreage censused, or both, increase. The richer the habitat is in both common and rare species, the higher will be the Average Species Index value. Also, as the ratio of rare to common species increases and as the ratio of habitat specialties to non-specials increases, so will the Average Species Index increase. Counterbalancing the increasing point value of the species as more acreage is censused is the decline in number of additional species found. For a given acreage of habitat both the Total Species Points and Average Species Index reflect the quality of the habitat. A tract that supports only a few of the most common and presumably most tolerant species is, biologically, less valuable than a tract that supports a large variety of both common and rare species.

Fig. 10–15 were derived from our statewide censuses. Not only was this the only set of Illinois data from which to judge different Illinois habitats in relationship to their bird populations, it was data reasonably well suited as a basis upon which to make comparisons, because the censuses represent a cross section of Illinois bird populations and their habitats. Because the habitats were censused as they were encountered on a series of straight-line transects and not selected in advance for richness or any other quality, the bird-habitat data are probably reasonably representative of Illinois habitats in general. The greatest shortcomings of the censuses are that they represent only 2 years and only about 1 acre in 5,000 of Illinois land. The data are, however, much more complete than those available for most states.

In interpreting the indices, it is best to consider each major habitat separately although a single index for the impact area can be calculated, as will be explained. The main reason for considering the habitats separately relates to the varying situations that may be encountered on any sizeable tract of land. Not all habitats in an area will be equally rich faunistically — just because the forest habitat on an area is rich does not mean that the grassland habitats on the area will be rich also. In determining the fate of a tract of habitats, we are most concerned about the fate of the richest areas, because they and not the average habitats in the impact area determine its value. It is the responsibility of the impact investigator to find and evaluate those areas of habitats on the impact area that are particularly deserving of special consideration.

In considering the different habitats on an impact area, the investigator should be aware of a truism about Illinois habitats that affects the interpretation of the data. In Illinois, grassland and marshland habitats become biologically richer as one goes north, whereas forest habitats increase in richness as one goes south. The contrast is most radical at the geographic extremes in both cases.

Considering each habitat separately and with the appropriate habitat graph in hand (e.g., Fig. 10 for bottomland forest), first follow the line that represents the number of nesting species in your sample of habitat from the top scale down to the habitat-fauna curve line. At the coordinate of the species-number line and the habitat-fauna curve line, lay a straightedge horizontally across the page parallel to the top scale and read the Expected Total Species Points on the left scale and the Expected Average Species Index on the right scale. If the index values on the graph are higher than the values obtained for the habitat in the impact area, then the habitat is not exceptional or perhaps is even poor in quality (depending upon the difference in the two readings). If the values for the habitat in the impact area are well above the expected values on the graph, then the habitat can be considered superior in faunal quality and must be given extra consideration in the final plans for the impact area. Note that all grassland habitats (grazed, ungrazed and fallow, prairie, and hayfields) are evalu-

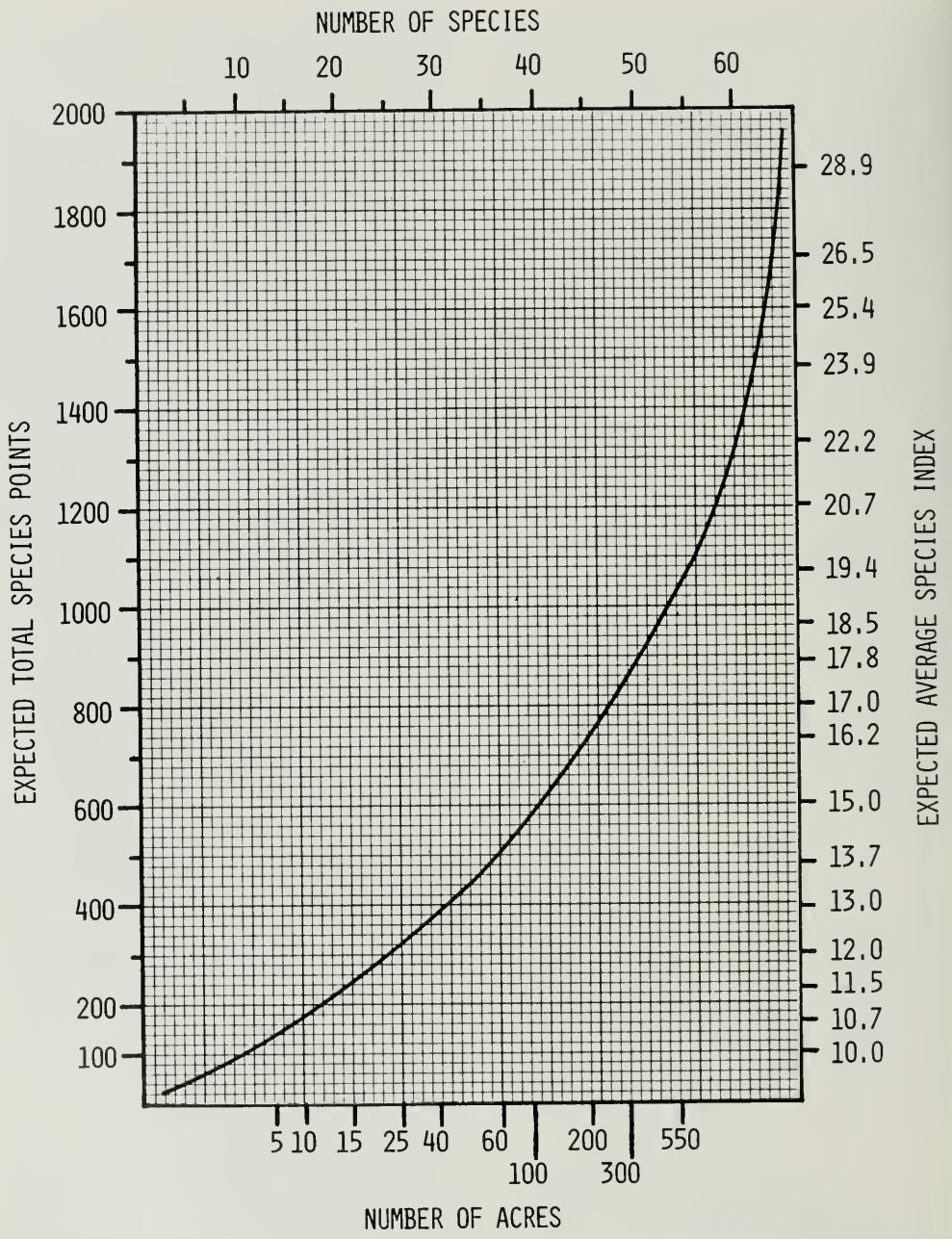

Fig. 10. — Relationship of numbers of species and their assigned index values (based on population levels and habitat specialization) to acreage censused in bottomland forest habitat in Illinois. The graph line is used to interpret calculated Faunal Indices in evaluating impact areas. See text for explanation.

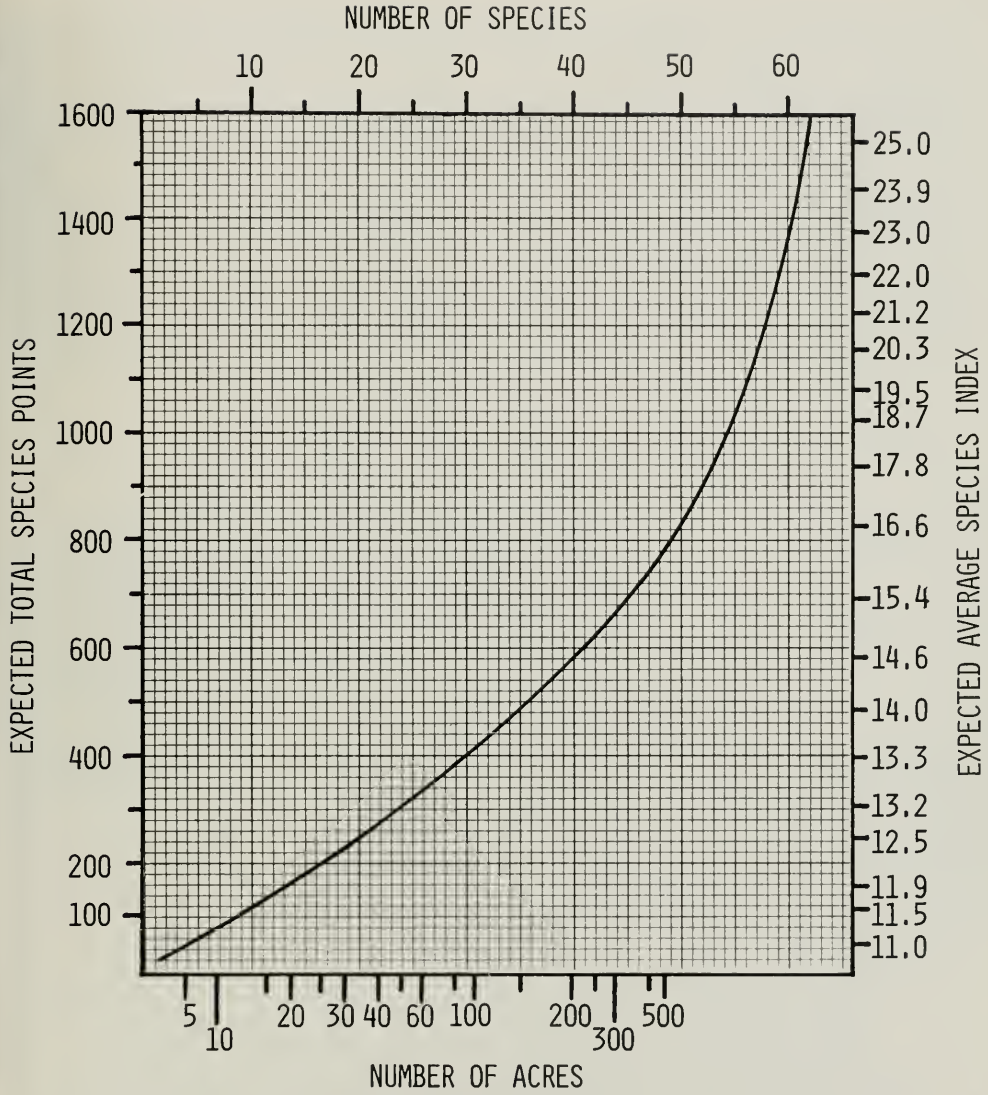

Fig. 11. — Relationship of numbers of species and their assigned index values (based on population levels and habitat specialization) to acreage censused in upland forest habitat in Illinois. The graph line is used to interpret calculated Faunal Indices in evaluating impact areas. See text for explanation.

ated on Fig. 15; all bottomland forest, including gum-cypress, is evaluated on Fig. 10; and all other forest, including pine, is evaluated on Fig. 11. Note also that, though it is easy to read the graphs, care must be taken to read them precisely. Slight discrepancies in the readings are, however, not a significant source of error in the final calculation of the indexes.

The values of the Expected Total Species Points and Expected Average Species Index (Table 16) will not always indicate the same evaluation and should not necessarily do so, as they are measurements of different characteristics. The Total Species Point value may be high either because the habitat has many species or because it has a high proportion of uncom-

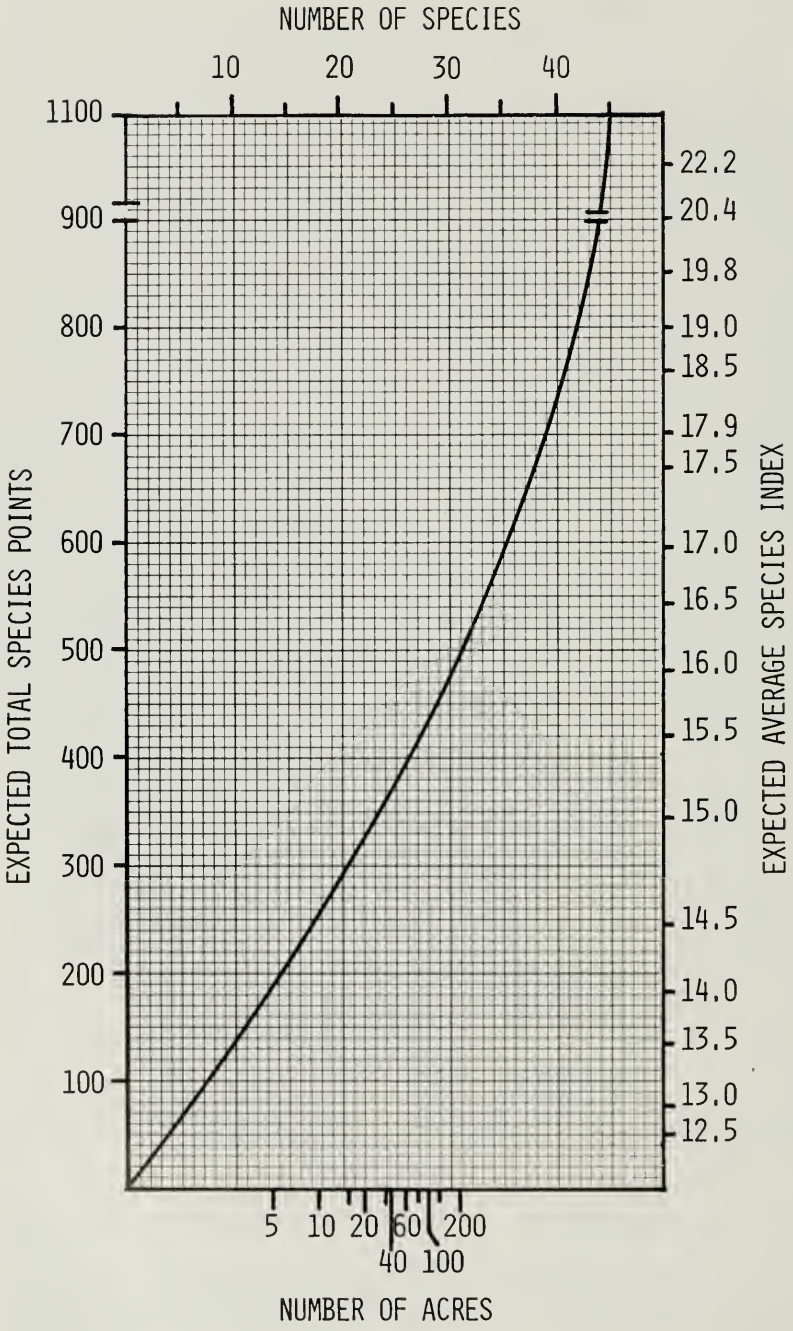

Fig. 12. — Relationship of numbers of species and their assigned index values (based on population levels and habitat specialization) to acreage censused in shrub habitat in Illinois. The graph line is used to interpret calculated Faunal Indices in evaluating impact areas. See text for explanation.

mon species and/or habitat specialties. The latter is, of course, indicated by a high Average Species Index.

The Faunal Index is perhaps the best single indicator of habitat quality. It takes into account the acreage of the habitat and the Total Species Points without direct reference to the number of species. The Faunal Index is interpreted from the same graph as is the Average Species Index, but in the case of the Faunal Index, the interpretation is made from the acreage scale at the bottom of the graph rather than the number-of-species scale. Turn to the appropriate graph for the habitat under consideration (e.g., Fig. 10 for bottomland forest). From the bottom axis (number of acres) follow the indicator line that most closely represents the acreage of your sample of habitat (here you may have to extrapolate between acreage points, but a good approximation is adequate) upward until it intersects the habitat-fauna curve. At the coordinate of the acreage-indicator line and the habitat-fauna curve, follow the abscissa line to the left-hand scale and read another value for Total Species Points. This is the Expected Total Species Points for that acreage. Into that value divide the common logarithm of the acreage of your habitat sample, as was done to calculate the Faunal Index for your habitat sample. This division gives the Expected Faunal Index. If the Faunal Index of your impact area is well above the Expected Index, it indicates that *that* habitat on your area is of superior quality.

If a single index figure is desired for the entire

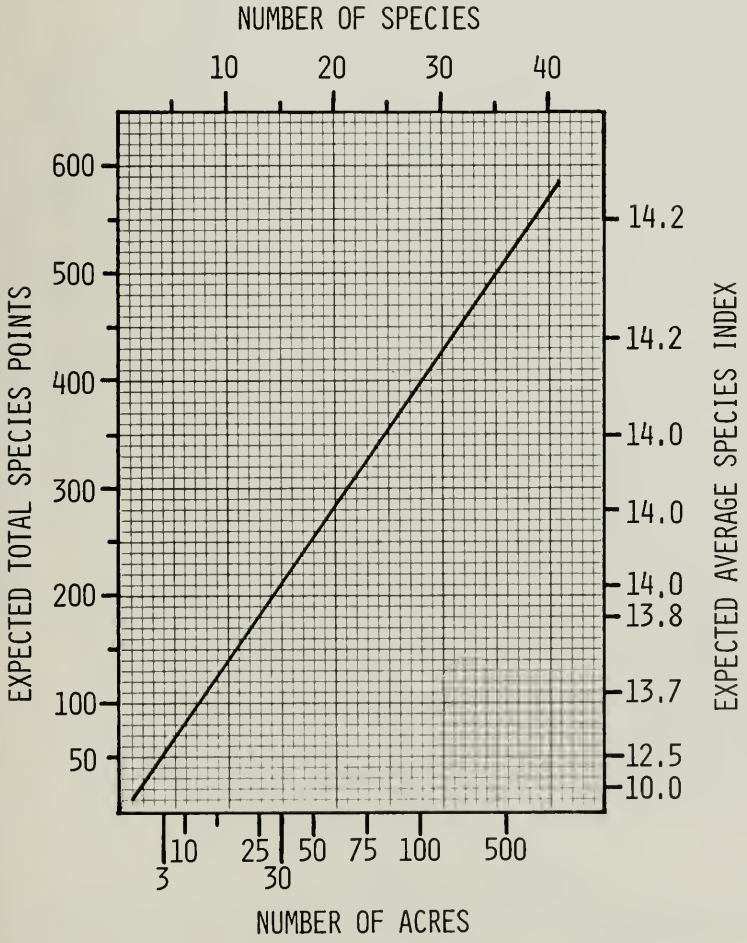

Fig. 13. — Relationship of numbers of species and their assigned index values (based on population levels and habitat specialization) to acreage censused in residential habitat in Illinois. The graph line is used to interpret calculated Faunal Indices in evaluating impact areas. See text for explanation.

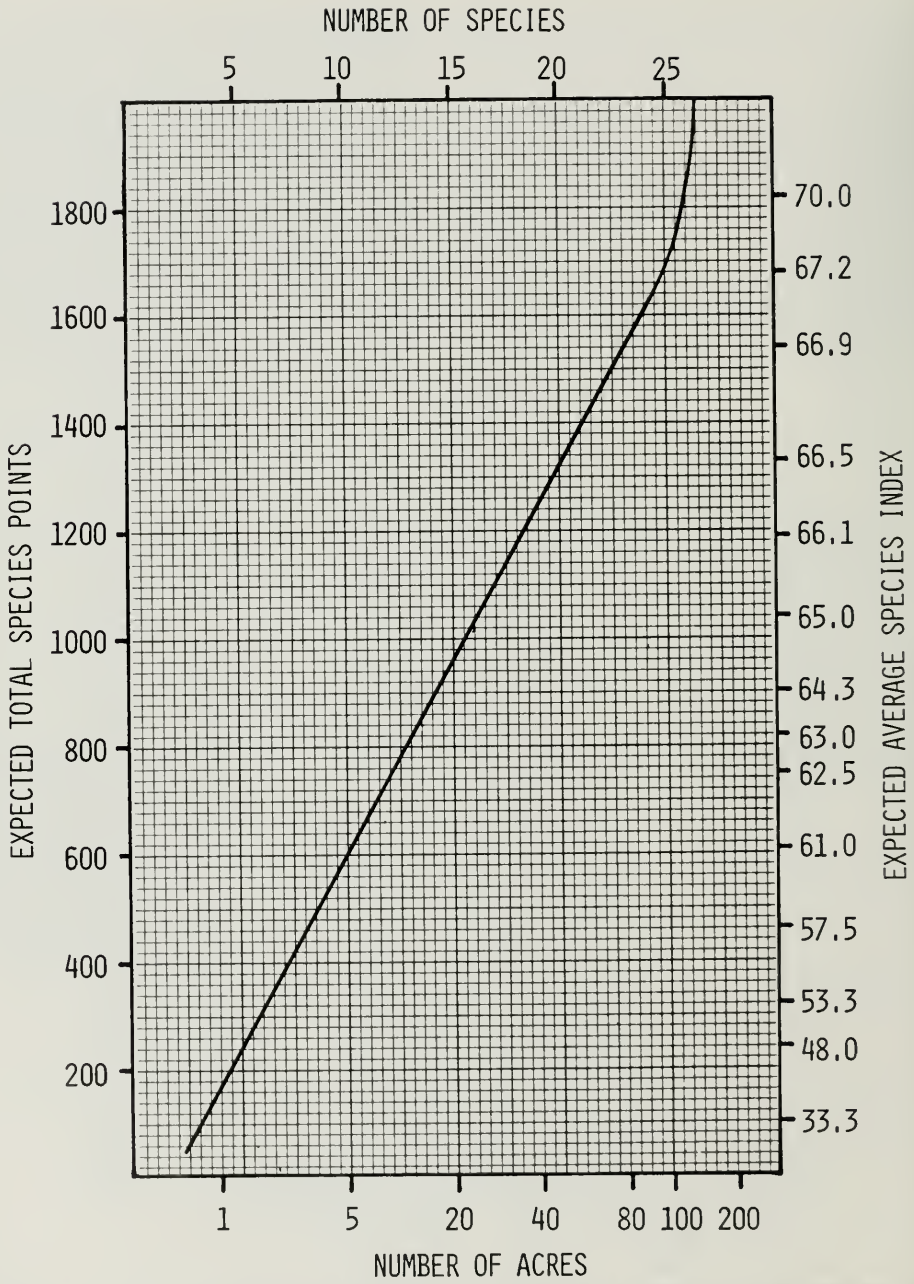

Fig. 14. — Relationship of numbers of species and their assigned index values (based on population levels and habitat specialization) to acreage censused in marsh habitat in Illinois. The graph line is used to interpret calculated Faunal Indices in evaluating impact areas. See text for explanation.

impact area (note the cautionary comments above), the investigator can sum the individual habitat indices. Tabulated Faunal Index values (Table 16) above the habitat-fauna graph line can be counted as positive (+) points, and Faunal Index values that fall below the graph line as negative (—) points. The sum of indices for all tested habitats in the impact area is then an index for the entire area, and a positive final value indicates high average quality of habitats in the impact area.

It should be obvious that the indices, if based on thorough, accurate field work, are indicative only of the present condition of the habitats, not of their future potential. To some extent the Habitat Evaluation Index takes future potential, or at least future availability, into account, and in the final evaluation the Faunal Indices for an impact area should be considered in combination with the HEI for the area.

In setting up our method of evaluation we have tried to test the method in different ways, but it is not possible to foresee all of the possibilities and problems that investigators will encounter. It is entirely possible that some modifications, particularly of the Faunal Indices, will evolve as the method is used. For this purpose the authors will try to be available for consultation at least in the early historical stages of the method's use.

Investigators will undoubtedly be concerned about the time requirements of the procedure. As an indication of the time required for the field work, we

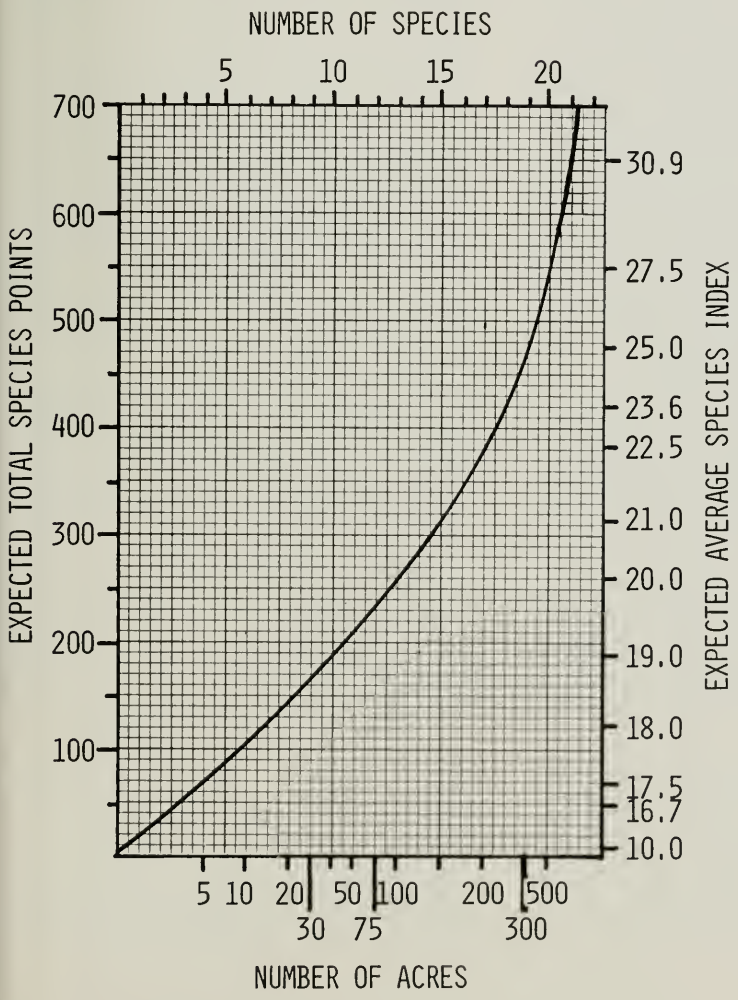

Fig. 15. — Relationship of numbers of species and their assigned index values (based on population levels and habitat specialization) to acreage censused in grassland (prairie, ungrazed and fallow fields, pastures, and hayfields) habitats in Illinois. The graph line is used to interpret calculated Faunal Indices in evaluating impact areas. See text for explanation.

can refer to our investigation of the test impact area (Table 14). The area of about 644 acres was as complicated in its habitat structure and diversity as any likely to be encountered in the state, with numerous small patches of different habitats. It included about 200 acres familiar to us but which we had never measured or evaluated on any quantitative basis. We did have an aerial photograph of the area (scale: 1 inch to 330 feet) and we used the photograph as recommended in our procedure. The two of us, working as a team, made all of the field measurements of habitats of different ages and acreages, as outlined in the procedure for the Habitat Evaluation Index, in 2 days. Determining the corrected acreages on the photograph and analyzing the data required 2 additional days in the office for the calculation of the HEI for the area.

We did know the birds of the impact area from previous years of observation; so our estimate of the time requirement for the collection of the bird data is based on observations at other, unfamiliar areas. We have estimated that collecting the qualitative bird data will take about twice as long as gathering the field data for the HEI, depending upon the types of habitats present. This estimate was made for an area similar in complexity to our test area. In an area with as much as 50 percent forest cover, the investigator should allow 1–2 days per 100 acres for the collection of the faunal data. The time requirement increases as the percentage of complex habitats, versus simple open field habitats, increases.

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