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August 12, 1982

Mr. A. Schwencer, Chief
Licensing Branch No. 2
Division of Licensing
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Subject: Limerick Generating Station, Units 1 and 2
Request for Additional Information

Reference: Letter, A. Schwencer to E. G. Bauer, Jr.
dated June 23, 1982

Dear Mr. Schwencer:

The reference letter transmitted question E 290.13 which requested a copy of EROL references 6.1-57 and 6.1-58. In response, 5 copies of reference 6.1-57, "An International Standard for a Mapping Method in Bird Census Work Recommended by the International Bird Census Committee", and 5 copies of reference 6.1-58, "An Evaluation of Winter Bird Population Studies", are enclosed.

Very truly yours,

EJ Bradley
E. J. Bradley

JLP/pb/H-22

Enclosures

cc: See attached service list

Co02 B

cc: Judge Lawrence Brenner
Judge Richard F. Cole
Judge Peter A. Morris
Troy B. Conner, Jr., Esq.
Stephen H. Lewis, Esq.
Mr. Frank R. Romano
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Ornithological
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*An International Standard for a Mapping Method in Bird Census Work
 Recommended by the International Bird Census Committee*

The Hillerød Conference

The International Study Conference on Bird Census Methods and Results, held at Hillerød, Denmark, from July 28 to August 3, 1968, considered the problem of comparing bird census results obtained with the mapping method by different workers, in different habitats, or in the same type of habitat in different regions or countries.

The Conference observed that often direct comparison could not be made because a number of details of the mapping method were not identical. However, this difficulty could be overcome if a standard method were available and extensively used. The Conference understood that it might not be possible, or sensible, to ask all workers everywhere to use precisely the same method. But the difficulty could still be overcome if, in each case when a comparison should be made, some representative plots were censused using carefully standardized techniques of planning, field-work and evaluation, thus constituting a basis for comparisons.

The Conference stressed the importance of achieving international agreement on a standard procedure for a mapping method. It further noted that such a standard procedure could be useful as a basis for countries or organizations about to start census work for the first time.

The Conference therefore resolved that an international standard for a mapping method in bird census work should be worked out, and drew up the broad lines for a proposal to establish international standardization. A draft prepared by S. Svensson and S. M. Taylor was adopted.

The International Bird Census Committee

The Hillerød Conference appointed a Committee, the International Bird Census Commit-

tee (Chairman: S. Svensson, Secretary: K. Williamson, Members: C. Ferry, A. Holm Joensen, D. Lea, H. Oelke and C. S. Robbins). The draft proposal was left to the Committee for further consideration and decision.

The Committee circulated the draft among its members and other workers in this field asking for their comments and suggestions for amendments.

The Ammarnäs Meeting

The Committee held its first meeting at Ammarnäs, Sweden, on June 26, 1969 in connection with the Conference on 'Bird Census Work and Environmental Monitoring' held at Ammarnäs from June 27 to 29, 1969. The Draft Proposal was discussed in detail and all suggestions for amendments were considered and decided upon.

The International Bird Census Committee presents on the following pages its recommendations for an international standardization of a mapping method for bird census work.

THE INTERNATIONAL BIRD
 CENSUS COMMITTEE

Sören Svensson, Chairman
 Kenneth Williamson, Secretary

Secretary's address:
 British Trust for Ornithology,
 Beech Grove, Tring,
 Hertfordshire, England

Note: Editorial comments, in square brackets, have been inserted for clarification by the American member of the committee.

Recommendations for an International Standard for a Mapping Method in Bird Census Work

1. APPLICABILITY OF THE MAPPING METHOD

The mapping method cannot be used for censusing all species of a bird community or all categories of birds within a particular population. Further, it cannot be used at all seasons. The details are laid out below.

1.1 Species applicability

The mapping method applies primarily to territorial and non-colonial passerines and other species of birds that have similar dispersion mechanisms and distribution patterns.

Birds belonging to most non-passerine groups (for example ducks and geese, sea-birds and some waders) cannot be adequately censused with the mapping method. Birds belonging to some other non-passerine taxa (for example owls and woodpeckers) can, however, be censused with the mapping method.

1.2 Category applicability

The individuals of any bird population will belong to one of three categories during the breeding season. The division into categories is based on the two criteria, breeding and stationary.

	<i>Breeding</i>	<i>Not Breeding</i>
Stationary	Category A	Category B
Not Stationary		Category C

Category A. Birds which are both stationary and breeding will normally constitute the major part of any passerine-like population.

Category B. Birds which are stationary but not breeding can sometimes constitute a substantial part of a population in the breeding season.

Category C. Birds which are not breeding and not stationary usually form a certain percentage of any population in the breeding season. They are called the 'floating' part of the population. Their significance is poorly understood and their general level of abundance unknown.

The mapping method, as described in this document, applies only to categories A and B, e.g. those birds of a population which are stationary, whether they are breeding or not.

1.3 Season applicability

Since, according to 1.2 above, the mapping method only applies to stationary birds, the method will normally be confined to the breeding season. However, since many migratory species take up territories in the winter quarters and many non-migratory species keep territories all the year round, the mapping method can probably be used outside the breeding season too.

1.4 Summary of applicability

The mapping method can normally be used only for censusing the stationary part of non-colonial passerine and passerine-like bird populations during the breeding season.

2. CENSUS AIMS

The aims of a census with the mapping method will be one or more of the following:

- i) to establish annual indices of population levels
- ii) to estimate densities of populations
- iii) to investigate the species composition of a community and the relative abundance of different species.

3. TERMINOLOGY

The following terms are recommended for use with the mapping method:

PLOT: the defined area of terrain over which a census is made.

CONTACT: a single field record of a bird, either by sight or sound.

CONTEMPORARY CONTACTS: contacts made simultaneously with more than one individual of a species, so that it is certain that they are different birds.

REGISTRATION: a record, made by the observer on the visit map, of a contact.

VISIT MAP: the map taken on to the plot by the observer for the purpose of registering contacts.

SPECIES MAP: the map, one for each species, to which all registrations are transferred from the visit maps for cluster evaluation.

CLUSTER: the registrations, which on final analysis of a species map appear to be associated with a territory held by one male.

SURPLUS REGISTRATION: a registration, which, on final analysis of a species map, does not appear to belong to any bird holding a territory (i.e. does not fit into any cluster) on the plot.

STATIONARY MALE: in the restricted sense of the mapping method, a male whose presence on the plot results in the formation of a cluster.

TERRITORY: in the restricted sense of the mapping method, the area over which the registrations of a cluster are distributed.

POPULATION: the birds of one and only one species within a defined area.

STATIONARY POPULATION: the particular part of a population that is censused by the mapping method.

POPULATION DENSITY: the number of stationary males (mapped territories) per unit area.

COMMUNITY: the aggregate of all the populations within a defined area.

DOMINANCE POSITION: the relative abundance, expressed as a percentage of the total of the populations comprising the community.

4. RECOMMENDATIONS FOR PLANNING, FIELD-WORK AND EVALUATION

4.1 Organization of the Plot

4.1.1 *Size.* The minimum size should in general be 40-100 hectares [100 to 250 acres] in an open habitat, or 10-30 hectares [25 to 75 acres] in a closed habitat, depending on the complexity of the community and the general level of [bird] density.

4.1.2 *Shape.* The shape of the census plot should be as near as is practicable to a square, unless it is constrained by physical features [or proximity to habitat boundaries] to reduce the amount of edge effect.

4.1.3 *Description.* A detailed description of the plot must be provided. The description should contain the following information.

a) Identification of the plot (reference to existing names on official maps, latitude and longitude and/or coordinates in any

other national or international geographical grid system).

b) Reference to an official topographical map of a large scale (in the range 1:10,000—1:100,000), with [the name,] number or code of the particular sheet where the plot can be found. [Our 7½-minute Topographic maps (scale 1:24,000), published by the U. S. Geological Survey, are very adequate.]

c) General characteristics of the landscape on the plot and around it (for example, farmland, mixed deciduous woods, savanna, spruce forest, bog with scattered pines, tundra etc.).

d) Size of the plot in hectares or square kilometers [in addition to the size in acres.]

e) Altitude above sea-level in meters [as well as in feet], or, if on a slope, aspect and maximum and minimum altitudes.

f) Soil and/or bedrock. Only general information that can easily be obtained during the census work need be given (for example: dry sandy ground, peat, clay).

g) General topography of the plot (mountain peaks, hills, valleys, streams, ponds, major roads, etc.) preferably on a sketch map. This information should be provided only if the information on the official maps is not detailed enough or if major changes have occurred since publication of the maps.

h) A large-scale map, with the boundaries of the plot marked on it, showing the major vegetation types and their distribution, comprising:

i) Tree-layer (dominant and other important species, height, age, closed or open canopy, forest management, etc.).

ii) Shrub-layer (dominant and other important species, height, approximate extent and whether sparse, medium or dense)

iii) Field or ground layer (dominant and other important species with approximate extent). [See article by Dr. Frances James, p. 727, for recommended procedures for habitat description.]

i) Any other pertinent information (for example number of nest-boxes, cropping plan, number and kinds of grazing animals, etc.).

4.1.4 *Grids.* It must be possible for the observer to know with sufficient accuracy his

own position, and that of a bird contacted, anywhere within the plot. If this cannot be done by reference to physical features, then a system of grid marks must be provided on the plot. The grid size should not be larger than 100x100 meters in an open habitat, or 50x50 meters in a closed habitat [100x100 meters (110 yards) is considered adequate in most North American habitats].

4.1.5 Visit and species maps. A number of outline maps of the plot should be prepared. A separate map should be used for each visit. The scale of the map should be suitable for its purpose, and should show the necessary physical features or the grid system for orientation on the plot. Recommended scales are 1:1250—1:2500 [1 inch to 100 feet; 1 inch to 200 feet] in woodland and 1:2000—1:5000 [1 inch to 165 feet, 1 inch to 415 feet] in open habitats, depending on the general level of bird density [or on size of one's clipboard]. Each visit map should be marked with the following information: identification of the plot, year, date, times of start and end of visit, name(s) of observer(s), weather, and a note of any part of the plot that was not visited. Copies of the outline maps should be used as species maps, unless special standards for the species maps have been worked out.

4.2 Organization of Census Work

4.2.1 Starting time and duration. These must be chosen to include the breeding season of the majority of the species involved. The duration should be as short as possible consistent with the previous sentence and the aims.

4.2.2 Time of day. When possible, visits should be concentrated at times when most bird song activity occurs. Usually, this is in the [early] morning. Some species, however, sing most frequently or are otherwise more conspicuous at other times of the day.

4.2.3 Route. Different routes through the plot should be used, with different starting and ending points, distributed as evenly as practicable among the visits. Except in the case of certain habitats where special considerations apply (for example, farmland with standing crops) no part of the plot should be more than 100 meters [110 yards] away from the route in an open habitat, or more than 50 meters away in a closed habitat.

4.2.4 Number of visits. The minimum number of visits needed in a closed habitat is ten

(10) and in open habitat eight (8). Visits should be spaced as uniformly as possible. Two visits should normally not be made on the same day.

4.2.5 Repeat censuses. When a census is repeated on the same plot in a later year, the earlier year's pattern should be followed as closely as possible.

4.3 Methods of Recording

4.3.1 Abbreviated names. The use of local abbreviations of bird species names on visit maps and during analysis is recommended. The list of abbreviations should be standardized within a country [this can be done in Europe where countries are smaller and breeding species are fewer; but it will not be practical in North America.]

4.3.2 Standard symbols for activities. There are at present three different symbol systems in use. One system, which is here called the International System, has been accepted by the following countries: Denmark, France, Great Britain, Norway, Sweden, Canada and the United States of America. The two other symbol systems are already well established in the German Democratic Republic and the German Federal Republic. The standard symbols for activities, according to the International System, are as follows:

W

A simple sight or sound contact with a bird of species W. (The sex symbol ♂ or ♀ may be added where appropriate.) In the case of a sound contact, this symbol is used when the sound cannot be classified as belonging to any category below or when the sound is not believed to have a high territorial significance, or when activities not covered by the standard symbols should be registered. A contact with a bird of species W, giving any vocal utterance (except song) thought to have territorial significance.

W

W

A contact with a singing bird of species W which has been seen or precisely located by song.

W

A song contact with a bird of species W not precisely located. (Useful only in the case of birds with large ter-



W——W

W-----W

W*

ritories [or birds heard at a distance].)

An aggressive encounter between two birds of species W.

Two contacts with the same bird of species W. The addition of an arrow can be used to indicate observed movement.

Contemporary contact of two different birds of species W. [Used to denote separate singing males or separate pairs rather than members of the same pair or same family group] (In the last two cases the symbols may be ringed or underlined, or any non-standard symbol may be added, as appropriate).

A nest of species W (number of eggs or young or other information on the nest may be added).

4.3.3 Local symbols for activities. Local symbols for other activities, such as carrying food or nest-material, are acceptable. However, it should be noted that different countries already use some symbols with different meanings; so if any symbols besides those listed above are used in international comparisons, they must be defined.

4.4 Evaluation Procedure

4.4.1 Clusters. The minimum number of registrations required before a cluster can be accepted is related to the number of valid visits as follows:

Number of valid visits	10	9	8	7	6	5
Number of registrations	3	3	3	2	2	2

It is emphasized that the number of valid visits means the greatest number on which a bird of a given species could have been observed. (For late migrants, visits made before the first record of the species on the plot during the census are disregarded.) At least two registrations should have high territorial significance (e.g., song).

4.4.2 Adjacent clusters. Where a group of registrations might represent either one or two clusters, it is to be accepted as two clusters if there is:

- i) one pair of contemporary registrations, each supported by other observations; or

- ii) at least two pairs of non-contemporary registrations.

For species with a low number of valid visits, one pair of non-contemporary registrations is enough.

If the above requirements cannot be satisfied, then common sense in combination with knowledge of the species' territory size, habitat requirements, and general territorial behavior must be used in evaluation.

4.4.3 Edge clusters. Clusters that overlap the edge of the plot will be counted as belonging to the plot only if more than half of the registrations lie within the plot or on the boundary. Otherwise they will not be counted. [This procedure is valid only on large study plots. Audubon Field Notes will continue to recognize fractional territories, counting the fractional portion of each boundary territory that is within the study plot and then rounding the total for each species to the nearest half-territory.]

4.5 Standard Measurement Units

4.5.1 Measurement of plot size. All measurements should be reported in the metric system. Size of plot should be reported in hectares or square kilometers. (National or other units may be appended in parentheses.) [Audubon Field Notes will publish plot size in both hectares and acres, followed by the actual units used by the census taker in measuring the area. Example: Size: 6 ha = 15 acres (rectangular, 110 X 660 yards, measured longitudinally and estimated laterally.)]

4.5.2 Population density. The population (or community) density should be stated as the number of stationary males (mapped territories) per ten hectares or per square kilometer.

[For all species represented by 3 or more territorial males, Audubon Field Notes will give total territorial males, followed in parentheses by first the density in males per square kilometer, then males per hundred acres, all numbers in parentheses rounded to the nearest whole number. Example: Tufted Titmouse, 3.5 (58, 23). Plot totals for all species combined will be expressed as follows, Total: 25 species; 35.5 territorial males (592 per square kilometer, 237 per 100 acres). Note: 1 square kilometer = 100 hectares = 247.1 acres; so to convert males per hundred acres to males per square kilometer, divide males per hundred acres (before rounding to the nearest whole number) by 2.471.]

AN EVALUATION OF WINTER BIRD POPULATION STUDIES

RICHARD BREWER

The only large body of data on population sizes of birds in winter is that contained in the winter bird population studies published annually since 1943 in *Audubon Field Notes* (now *American Birds*). The method used in these studies (Kolb, 1965) is that an observer traverses an area of known size six or more times (hereafter termed "visits") during the winter and records all birds observed. After the last visit, the total number of individuals recorded is divided by the number of visits to give an average. This number is then multiplied by the appropriate factor to express results in birds per hundred acres. The same calculations may be made for individual species.

The method appears to have been developed more as a device to make wintertime use of plots established for breeding bird censuses than for any other reason; however, no discussion of the development of the method has been published so far as I know. In the course of conducting such studies it became clear that interpretation of the results was uncertain. This same conclusion has been reached by other workers and, in fact, the difficulty of analysis and comparison has been a persistent theme in the comments by the editor of the winter bird population studies (Kolb, 1961, 1962).

This paper reports results from a model devised to assess the meaning of the figures resulting from the use of the *Audubon Field Notes* (hereafter "AFN") method of studying winter bird populations. I take as a starting point the view that the most desirable datum is density, that is, the number of birds per unit area. For any given area, density changes more or less continually as birds enter the area or leave it. If we visualize a tract of 20 acres on which 10 birds occur but all of which have some portion of their home range lying outside the boundaries of the tract, it is clear that the instantaneous density of the tract can vary between 0, when all of the birds are in those portions of their home ranges off the tract, and 10 when all by chance happen to be on the tract. These figures have some interest but a more valuable figure is some appropriate average of the instantaneous densities. If the average fraction of the home range of the 10 birds included on the study tract was 0.6, then the average density would be 6 birds per 20 acres (assuming that a bird spends equal time in all areas of its home range). An accurate estimate of density would be provided by the AFN method if each bird were recorded on the fraction of visits corresponding to the fraction of its home range included on the tract.

Scientific names of birds mentioned in later sections are Ruffed Grouse, *Tomasa umbellus*; Red-bellied Woodpecker, *Centurus carolinus*; Hairy Wood-

pecker, *Dendrocopos villosus*; Downy Woodpecker, *D. pubescens*; Blue Jay, *Cyanocitta cristata*; Black-capped Chickadee, *Parus atricapillus*; Tufted Titmouse, *P. bicolor*; White-breasted Nuthatch, *Sitta carolinensis*; Brown Creeper, *Certhia familiaris*.

THE MODEL

The basic method used was this: a board was constructed on which were drawn to scale a census tract of 23 acres and the home ranges of eight birds with varying fractions of their home ranges included on the tract. The whole board was the equivalent of about 275 acres and was covered by a grid with coordinates the equivalent of 100 feet apart. The census tract was divided into a grid by lines 200 feet apart (corresponding to every other 100-foot coordinate in the section of the board occupied by the census tract). A simulated observer moved systematically over the tract following the 200-foot coordinates at the same time that a simulated bird (represented by a transparent plastic disk of known diameter) moved within its home range. If the plastic disk touched or overlapped a point occupied by an observer, the bird was considered to be observed and was counted.

Although some simplifications were necessary, the model was made as realistic as possible. Because a primary aim was the eventual assessment of studies conducted from 1966 to 1970 on five study tracts in oak and oak-pine forests of Allegan County, Michigan, the features of the model were based as far as possible on the biological features of the bird community of those areas. On these areas, which varied in size from 9.6 to 18.4 acres, about 20 species of birds were observed on more than 150 visits between November and March. Only 7 species were seen on all five tracts. Populations were low, AFN estimates being in the range from about 5 to 8 birds per study tract or about 30 to 55 birds per hundred acres. Black-capped Chickadee was the most common species with an AFN estimate of about 20 birds per hundred acres. White-breasted Nuthatch, Blue Jay, and Tufted Titmouse were the next most common species.

Specific features of the model were as follows:

1. Home range sizes varied from 9 to 76 acres, with six between 22 and 38 acres (Table 1). These are reasonable sizes for home ranges of forest birds based on our unpublished determinations and the literature (see, for example, Butts, 1931; Fitch, 1958; Kilham, 1969; Robins and Raim, 1971). The percentages of the simulated home ranges lying on the tract varied from 1 to 100 per cent.

2. The initial position of the observer at the beginning of a trial, or simulated visit, was at the southeast corner of the tract. His movement was then systematically across the tract. Systematic movement along coordinates was

TABLE 1
RESULTS OF THE MODEL EVALUATING AFN WINTER BIRD STUDY METHODS.
Trials = 25 except as indicated.

Home range	Percentage on tract	Size (acres)	Occurrence (Percentage of trials recorded)		
			30' radius	75' radius	250' radius
Normal speed					
J	4	34	0	7	12
A	14	37	4	22*	48
C	30	76	20	56*	92
G	45	38	32	56*	88
D	65	22	24	63*	96
E	65	35	36	64	84
H	100	8.6	24	39*	100
B	100	23	24	65	100
Half-normal speed					
J	4	34		8	
A	14	37		32	
C	30	76		48	
G	45	38		44	
H	100	8.6		64	
Twice-normal speed					
J	4	34		12	21**
C	30	76		76	93**
G	45	38		88	100**
D	65	22		64	100**
E	65	35		88	100
H	100	8.6	60***	92	100**

* 27 trials
** 14 trials
*** 20 trials

the method employed in the field by us and by many participants in the AFN studies, but it is not a requirement of the method (Kolb, 1965).

3. The initial position of the bird was determined by the use of randomly chosen numbers indicating a coordinate position on the board. The direction of the bird's first movement was determined randomly from among the eight primary compass directions. After the first movement, the three opposing directions were eliminated for subsequent movements. For example, if the first movement was east, then west, northwest, and southwest were eliminated. The possible actions for the bird on its second movement were six of equal probability: north, northeast, east, southeast, south, and no movement. Tests in the development of the model showed that if all eight directions were re-

tained the simulated bird tended to stay in a restricted area near its initial position rather than to move over its home range in a manner corresponding more closely to the actual movements of birds in the field.

Eventually movement of the simulated bird might bring it to the edge of its home range. At this point all directions were again made available and the no-movement possibility was eliminated. Certain movements, those which would take the bird outside its home range, were impossible in this situation and were rejected; other movements would move the bird along the edge of its home range. The first move which took it away from the edge into its home range was used as a new direction and the procedure of discarding the three opposing points of the compass was again followed (and the no-movement possibility re-instated).

The paths taken by the simulated birds under these procedures seemed realistic when compared with our maps of actual paths taken by birds in the field.

4. Three different speeds of movement of the bird relative to the speed of the observer were used. These were approximately one-half the speed of the observer (termed "normal speed"), one-fourth the speed of the observer (half-normal speed), and the same as the speed of the observer (twice-normal speed). In our censusing of oak forests, the actual speed of the observer (median values) varied by area from about 56 to 69 feet per minute (fpm), or about 0.6-0.8 miles per hour (mph). In subsequent sections 67 fpm is used as the speed of the observer. Although slightly faster than our actual overall average, it is convenient as a rate taking exactly 3 minutes from one stake to the next.

The actual movements on the board were as follows: For half and full speeds the observer went from one grid intersection to the next (200 feet) in two moves of 100 feet (that is, from one board coordinate to the next). The bird took one move (normal speed) or two moves (twice-normal speed) for each move of the observer. The moves of the bird were one-half square. Going north, south, east, or west, one move of the bird was 50 feet; going one of the four intermediate directions it was about 71 feet. For half-normal speed the observer went from one grid intersection to the next (200 feet) in a single move and at the same time the bird took one move.

At any time the possibilities for movement for the bird were 3 50-foot moves, 2 71-foot moves, and no movement. Consequently, the average distance per move was about 49 feet. Twice-normal speed for the bird, accordingly, was about 65 fpm, normal speed 33 fpm, and half-normal speed 16 fpm.

There is relatively little information in the literature on the rate of travel of birds. Yapp (1956) commented that he had timed feeding winter tit flocks at speeds from one-eighth to two mph (that is, about 10-175 fpm). Odum

TABLE 2
RATE OF MOVEMENT OF THREE SPECIES OF OAK FOREST BIRDS, ALLEGAN COUNTY, MICHIGAN, FEBRUARY-MARCH, 1969

Species	Number of observations	Total minutes	Feet per minute	
			Range	Median
Downy Woodpecker	7	140	12-71	23
White-breasted Nuthatch	14	229	9-122	21
Black-capped Chickadee	9	149	15-64	32

(1942) reported rates of movement of Black-capped Chickadees, based on all-day observation of flocks, from 18 to 40 fpm. He observed that speeds varied by time of day and by weather conditions and commented that movement was not uniform, periods of rapid movement (up to 350 fpm) alternating with periods of little or no movement.

Our own observations made on one of our study areas at Allegan (the Small Oak area) in February and March 1969 generally agree with these findings. The observations were made (in connection with studies designed to determine home range boundaries) by following birds for as long as possible and mapping the observations. Measurement of distance was along the actual path followed and speed was calculated using the time elapsed from the first to the last observation of the bird. Obtaining data on speed that are unbiased is difficult. For example, the speed of birds which travel by moving slowly through the forest and then taking a long flight to another area beyond the range of observation will be generally underestimated because the long flights will be omitted from the sample. Also it is important that short observations as well as lengthy ones be included, inasmuch as observations of greater duration may be of birds traveling slowly enough that they can be readily followed. I used a lower limit of four minutes for the practical reason that estimates of speed based on shorter durations might be too inaccurate owing to our recording times only to the nearest minute.

The data seem to indicate that birds may travel at speeds from less than 10 to more than 100 fpm and that variability is appreciable (Table 2). They indicate also that for the time and place they were gathered speeds of three important species of the forest are in the range between 20 and about 40 fpm.

5. Differences in conspicuousness were taken into account by using plastic disks of three radii corresponding to 36, 75, and 250 feet. The circle of 36-foot radius represents a very inconspicuous species, the circle of 250-foot radius, a very conspicuous one. If the disk touched or overlapped the point occupied by the observer or his path in moving from one point to the next,

the bird was counted. This corresponds to a situation in which a bird is totally observable up to a given distance from an observer and is never censurable beyond that distance (curve 1 in Fig. 2 of Eberhardt, 1968), an obviously unrealistic situation. It also corresponds, however, to a situation in which the radii represent median distance of observability (defined as probability of observation). For example, the 75-foot circle represents a situation in which the number of birds nearer than 75 feet that are missed is the same as the number of more distant birds that are observed.

The relationship in the field between observability and distance from the observer is difficult to approach directly. We may visualize the observer in the center of a space that can be subdivided by circles drawn at equal distances going outward from him. The area of the concentric rings so produced increases outward. For example, if 50-foot intervals are used, the ring from 50-100 feet away is larger than the circle from 0-50 feet and the ring from 100-150 feet is larger still. Assuming a homogeneous distribution of birds in the space, the number of birds present in each ring will, accordingly, increase going outward. The increase in area of the concentric rings is linear and so, consequently, is the increase in number of birds present at given distances from the observer. Discussions germane to these ideas but developed in connection with strip censuses are given by Anderson and Pospahala (1970) and Emlen (1971).

If there were no decrease with distance in the ability of an observer to detect birds, the number of birds seen at increasing distances would increase, following curve A in Fig. 1. In fact, we expect observability to decline with distance. Curve B represents a linear decline in observability from 100 per cent at the point occupied by the observer. In this case, the number of birds actually observed would be related to distance from the observer as shown in curve C.

A linear decline in observability with distance is not an unreasonable assumption but other reasonable relationships can be envisaged. I approached the question indirectly in the following manner. During routine visits to the oak forest study areas in the winter of 1968-9, the observer recorded the distance from each stake on each plot at which any bird could be observed by sight or sound. Estimating distances in the field is not easy but was facilitated by the observers' familiarity with the study areas, by the areas being staked at 200-foot (in some cases, 100-foot) intervals, and by the use of maps showing any prominent topographic and vegetational features. Data deemed sufficient for analysis were obtained for the White-breasted Nuthatch (Table 3) on one study area, the Black-capped Chickadee on three study areas, and the Ruffed Grouse on one study area (Table 4).

Grouping of observations by distance (observations falling at a class

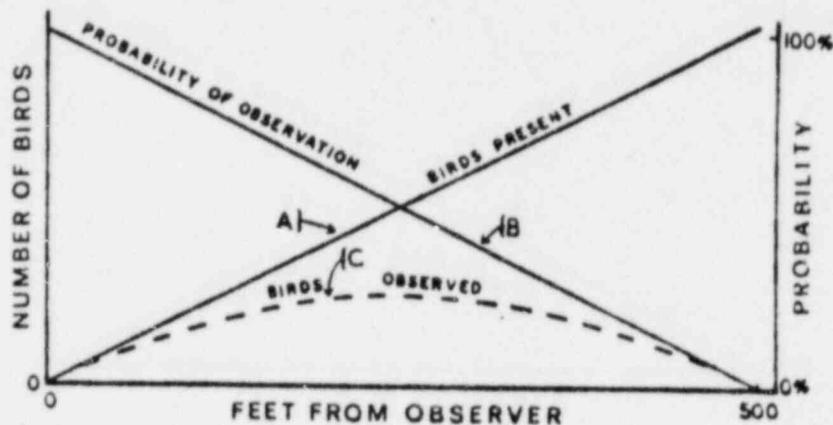


FIG. 1. Relationship between the number of birds present, their probability of being observed (observability), and the number of birds actually observed in ten concentric zones centered on the observer. A linear decline of observability from 100 per cent at distance 0 to 0 per cent at 500 feet is assumed.

boundary, as for example at 100 feet in Table 3, were counted as one-half observation in each class) and plotting the result gives curves corresponding to C in Figure 1. Making the assumption that observation is 100 per cent efficient in the closest zone, the actual number of birds present in each zone can be calculated as in Table 3 (cf. Anderson and Pospalala, 1970: 142-145).

TABLE 3

RELATIONSHIP OF NUMBER OF WHITE-BREASTED NUTHATCHES OBSERVED AND PROBABILITY OF OBSERVATION TO DISTANCE FROM OBSERVER (LARGE OAK AREA, ALLEGAN CO., MICHIGAN, WINTER 1968-9).

Number of birds estimated as actually present in each zone is calculated by determining density for zone 1 (0.00077 per square foot in this case) and multiplying this value by the area of the other zones.

Zone (Distances in feet)	Area of zone (square feet)	No. of observations	No. birds calculated as present	Probability of observation
1 (0-100)	31416	6	6	100
2 (100-200)	94248	5.5	18	31
3 (200-300)	157080	5	30	17
4 (300-400)	219912	2.5	42	6
5 (400-500)	282744	1	54	2
6 (500-600)	345576	0	66	0
7 (600-700)	408408	1	78	1

TABLE 4
RELATIONSHIP OF NUMBER OF BLACK-CAPPED CHICKADEES AND RUFFED GROUSE OBSERVED AND PROBABILITY OF OBSERVATION TO DISTANCE, ALLEGAN CO., MICHIGAN, WINTER 1968-9

Zone (distances in feet)	Black-capped Chickadee						Ruffed grouse	
	Large Oak		Small Oak		Large Pine		Small Pine	
	No. Obs.	Prob.	No. Obs.	Prob.	No. Obs.	Prob.	No. Obs.	Prob.
1 (0-40)	2	100	5	100	6.5	100	4	100
2 (40-80)	5	83	7	47	11.5	60	6	50
3 (80-120)	1	10	5	20	2.5	8	1.5	8
4 (120-160)	1	7	2	6	1.5	3	0.5	2
5 (160-200)	0	0	—	—	—	—	—	—
6 (200-240)	1	4	—	—	—	—	—	—

and Emlen, 1971: 329-333). If these figures were plotted they would correspond to curve A of Fig. 1. Dividing the number of birds observed by the number calculated to be present gives a curve relating probability of observation of distance (Table 3), corresponding to curve B of Figure 1. The assumption of 100 per cent efficiency in zone 1 is probably erroneous (see, for example, Enemar, 1959: 78-89, and Emlen, 1971), but this will not affect the shape of the probability curve derived. The shape would be affected if the distribution of birds were not homogeneous around the observer; bias might be serious if the presence of the observer affected the distribution by attracting birds or driving them away. My impression is that for winter studies in oak forest this was not a serious problem in that any such movements tended to be within zone 1 rather than between zones.

The results suggest that probability of observation declines rapidly at first and then more slowly (Tables 3 and 4). It is clear that a straight-line relationship does not hold over the whole distance from zero to the limits of observation. A negative exponential relationship like that suggested by Gates et al. (1968) for the flushing of Ruffed Grouse is a possibility, but it is also possible that the relationship is a reversed sigmoid curve like curve in Fig. 2 of Eberhardt (1968), with a short upper limb hidden within zone 1.

I return now to the suggestion that the radius used for the plastic disk simulating a bird should represent the median distance of observability. This distance, at which the number of near birds missed is equal to the number of far birds seen, shifts depending upon the observability curve. Calculation of the median distance of observability appears to require a knowledge of this curve, information which, as I have indicated, is not readily obtained. One can, however, fairly readily obtain actual distances of observation in

TABLE 5
 DATA FOR COMPARISON OF MEDIAN DISTANCE OF OBSERVATION AND MEDIAN DISTANCE OF OBSERVABILITY, USING AN ARBITRARY DENSITY OF 0.0026 BIRDS PER SQUARE FOOT AND AN ARBITRARY REVERSE SIGMOID RELATIONSHIP BETWEEN PROBABILITY OF OBSERVATION AND DISTANCE FROM OBSERVER.

Distance from observer (feet)	Number of birds present	Probability of observation	Number of birds seen	Cumulative numbers		
				Birds seen	Near birds missed	Far birds seen
0-50	2	0.99	2	2	0	27
50-100	6	0.95	6	8	0	25
100-150	10	0.75	7.5	15.5	2.5	19
150-200	14	0.30	4	19.5	12.5	11.5
200-250	18	0.15	3	22.5	27.5	7.5
250-300	22	0.07	1.5	24	38.0	4.5
300-350	26.5	0.05	1	25	73.5	3
350-400	31	0.03	1	26	103.5	2
400-450	35	0.02	1	27	137.5	1
450-500	39	0.01	0	27	176.5	0

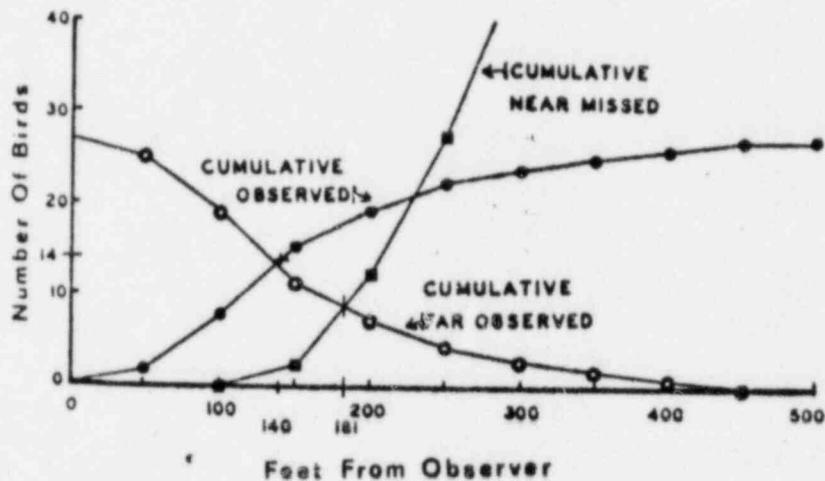


FIG. 2. Comparison of median distance of observation and median distance of observability for data in Table 5. Median distance of observation is the distance below which and above which half of the birds were observed. A total of 27 birds was observed; consequently, the median is the distance at which the 14th bird was seen, or about 140 feet. Median distance of observability is the distance at which the number of near birds missed is equal to the number of far birds observed, or about 181 feet.

some manner such as that described on page 266; from such data one can calculate a median distance of observation. The median distance of observation is the distance below which and above which half of the actual observations lie. I have investigated the relationship between the median distance of observation and the median distance of observability using models based on various observability curves. Table 5 and Fig. 2 illustrate the method for an arbitrary reverse sigmoid relationship between observability and distance. Graphical solution (Fig. 2) indicates that the median distance of observation is about 110 feet and the median distance of observability is about 181 feet. All of the observability curves which I have tested, including most of the biologically reasonable ones, yielded a similar relationship of the median distance of observation lying within the median distance of observability; the quantitative relationship between them, however, varied considerably depending on the exact nature of the observability curve. For birds in oak forests the median distance of observation lies between 40 and 200 feet and several are clustered between 50 and 100 feet (Table 6; see also the appropriate species in Table 9 of Kendeigh, 1944. The latter figures apparently are means rather than medians; because of the occasional bird observed at a great distance, the mean will usually exceed the median for data of this sort.) Presumably these medians are all in some degree underestimations of the median distance of observability. In sum, the oak forest data seem to justify the radii of 30 feet as a very inconspicuous species, 250 feet as a very conspicuous one, and 75 as a species of average conspicuousness.

6. As soon as a given simulated bird was tallied, the trial was discontinued; this corresponds to a situation in which an observer can invariably avoid counting the same bird more than once on a visit. This is undoubtedly unrealistic, but I have no information on the frequency with which birds are counted more than once, nor on how often birds are not counted in the belief that they had already been recorded.

Fourteen to 27 (mostly 25) trials, or simulated visits, were used for each home range under each set of radius-speed conditions. In all, 1000 simulated visits were used (Table 1).

RESULTS

The relationship of basic importance is that between the percentage of visits on which a bird is recorded (hereafter this percentage is called "occurrence") and the percentage of the bird's home range lying on the study tract. For the AFN method to indicate accurately the contribution of a given individual bird to the density of birds on the tract, the two values must agree. This relationship is indicated by the diagonal line in Figs. 3 and 4.

For all conditions occurrence was positively related to the percentage of

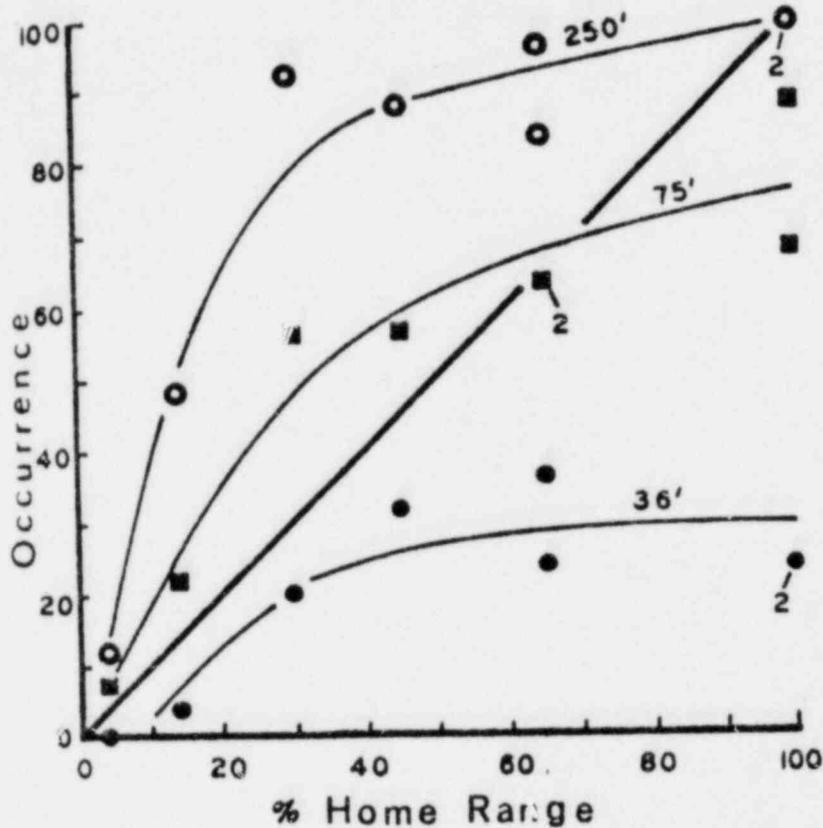


FIG. 3. Relationship between occurrence (percentage of simulated visits on which a bird was counted) and percentage of the bird's home range on the study tract (birds flying at normal speed) for highly conspicuous birds (circle, 250-foot radius of observability), moderately conspicuous birds (squares, 75-foot radius), and inconspicuous birds (dots, 36-foot radius). Lines were fitted by eye.

the home range on the tract. In no case, however, did the curve relating occurrence to home range follow the required diagonal (Figs. 3 and 4, Table 1). Both conspicuousness of the bird and its speed relative to that of the observer influenced occurrence. The closest approach to the diagonal and, thus, the closest approach to an accurate reflection of density was given by the combination of a 75-foot median distance of observability and normal speed. All of the other combinations gave curves lying further from the diagonal.

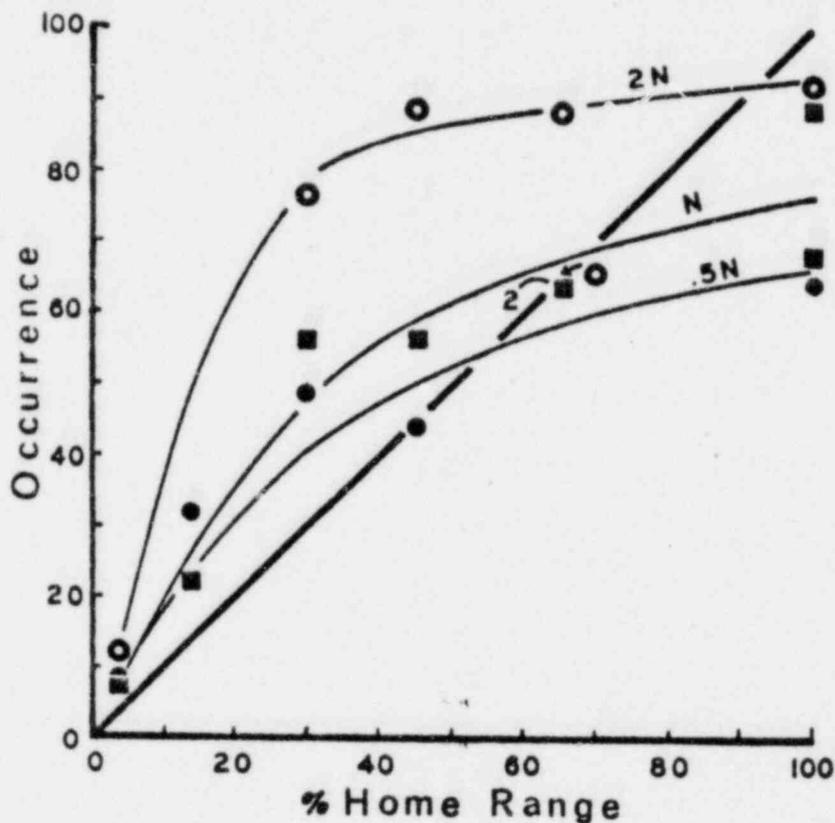


FIG. 4. Relationship between occurrence (percentage of simulated visits on which a bird was counted) and percentage of the bird's home range on the study tract for birds (moderate conspicuousness) moving at normal speed (squares), twice-normal speed (triangles), and half-normal speed (dots). Lines were fitted by eye.

For any conspicuousness: speed combination the basic curve relating occurrence to per cent home range on the tract showed a fairly sharp initial rise and then tended to level off (Figs. 3 and 4, Table 1). The AFN method, accordingly, is relatively insensitive to changes in percentage of home range on the tract from 30 or 40 to 100 per cent.

Occurrence increased with increased conspicuousness but the exact relationship was complex. The same increase, either actual or proportionate, in median distance of observability was more effective in increasing occurrence when the increase was in the range from 36 to 75 feet than when in the range

from 75 to 250 feet (Table 1). Also, the increase in occurrence was greater for a given increase in median distance of observability for birds with large percentages of their home range on the tract than for those with small (Table 1).

Occurrence increased with increased speed of the bird relative to that of the observer (Fig. 4, Table 1). Increasing to twice-normal the speed of birds with a median distance of observability of 75 feet moved their curve far above the diagonal into about the same position occupied by highly conspicuous birds (250-foot radius) traveling at normal speed.

There was no consistent indication that size of home range had an effect on occurrence (cf. home ranges D with E, and H with B in Table 1).

DISCUSSION

It is clear that the AFN method fails in most situations to indicate accurately the contribution of an individual bird to the mean population of a study tract. To recapitulate, the relationship between occurrence and percentage of home range on the tract is non-linear, such that occurrence increases only slightly for home ranges 100 per cent on the tract compared with those 10 per cent on the tract. Occurrence is also affected by the conspicuousness of the bird and the speed of the bird relative to that of the observer.

Other things being equal, the 75-foot radius of observability gave best results. I suspect that this is true because this value, among the three used, most nearly approximates half the distance between census-plot coordinates. With the 36-foot radius a bird may be within a square adjacent to the observer and escape observation. With the 250-foot radius, a bird may be beyond the adjoining coordinate and still be observed; consequently, if the bird has any substantial part of its range on the tract, the probability of tallying the bird at some time during the visit becomes very high, approaching 100 per cent once half or more of the home range is included on the tract (Table 1, Fig. 3). It is a matter of some interest that, with the 75-foot radius, even birds whose home ranges are wholly on the tract, whether contained within it or coincident with it, were not invariably encountered on a visit (Table 1). This was made possible by the movements of the bird producing a path that avoided the observer.

Presumably a bird which remained stationary for the length of a visit and which was of sufficient conspicuousness to be seen from one point on the tract, if it were on the tract, would be recorded on the number of trials corresponding to its percentage of home range on the tract. Increasing the speed of the bird increases its exposure to the observer, at least for home ranges having a small percentage of their area on the tract and, thus, results in these birds being observed too often. Allowing birds with a very high percentage

of their home range on the tract to move, however, introduces the possibility of their eluding the observer, as described above. It is unclear whether birds moving at one-fourth the speed of the observer are censused much more poorly than birds moving at one-half the speed of the observer (Table 1, Fig. 4); it is, however, clear that birds moving at the same speed as the observer are generally observed far too often.

The aim of the AFN method is to estimate abundance—ideally density—of the total bird community and its constituent species. This is slightly different from the question of how well the method assesses the contribution to density of an individual bird and is worth examining directly. To begin with, very conspicuous birds and birds having speeds equal to that of the observer will almost invariably be overestimated. The Blue Jay is probably an example of a species which will be overestimated. Very inconspicuous birds (the Brown Creeper, perhaps) will invariably be underestimated, possibly excepting cases in which they are very fast moving.

Birds of medium conspicuousness and moving at speeds one-half to one-fourth that of the observer will produce estimates that may be close to the actual density on the tract. The occurrence curve for such birds cuts the diagonal in such a way that birds having a small percentage of their home range on the tract will be overestimated and birds having a large percentage will be underestimated. If birds of both categories occur on the tract, the errors will be in opposing directions. It would be too much to expect that the errors would cancel one another but the tendency would be in this direction. Unfortunately, the extent and direction of the final error will be impossible to calculate.

Possibly some species of birds of the oak forests fit reasonably well the conditions of conspicuousness and speed which allow fair estimates of density (Tables 2 and 6). More information on conspicuousness and speed could be used, however, before drawing such a conclusion. These topics are worth some further research. Persons making AFN studies could contribute data on conspicuousness and help to interpret their own figures by recording distances at which birds are observed. It is certain that variations in speed and conspicuousness will affect estimates greatly; consequently, if a bird is fast moving at one period of the year and slow at another, or if it is more conspicuous in one vegetation type than another, the figures derived in these separate situations will not be comparable.

One important consideration in the winter study of populations not dealt with directly in the model is the tendency of many species to occur in flocks. If only mathematical considerations were involved, the effect would be simply to increase variability over the situation in which each bird moves independently. This is undoubtedly one of the reasons for the visit-to-visit vari-

TABLE 6

MEDIAN DISTANCE OF OBSERVATION FOR SEVERAL OAK FOREST BIRDS. THE STUDY AREAS WERE LARGE OAK (LO), SMALL OAK (SO), LARGE PINE (LP), SMALL PINE (SP), AND GREENBRIER (GB).

Species (Study Area)	No. of observations	Median distance (feet)
Brown Creeper (LP)	3	40
Brown Creeper (SO)	3	90
Ruffed Grouse (SP)	12	50
Black-capped Chickadee (LP)	22	60
Black-capped Chickadee (SO)	19	60
Black-capped Chickadee (LO)	10	50-75
Tufted Titmouse (GB)	5	70
Tufted Titmouse (LO)	9	100
White-breasted Nuthatch (GB)	7	70
White-breasted Nuthatch (LO)	21	200
Blue Jay (LO)	15	175
Red-bellied Woodpecker (LO)	9	200

ability in actual counts which, in my field experience, is substantial. In light of this variability, the six visits minimally required by the AFN method may, by chance, give very atypical results and will give a variance so large that statistical demonstrations of any except enormous differences between years or areas may be impossible. Other, biological, considerations may, however, also be involved. Probably the presence of a bird in a flock increases its likelihood of being seen. This is so because the flock tends to be more conspicuous than a single bird and once any member of a flock is detected, the observer is likely to observe most or all of the other members. Individual conspicuousness and flock conspicuousness may, then, be different things. Values such as those given in Table 6 will, however, tend to reflect the conspicuousness of the usual unit (flocks for chickadees, individuals for creepers, twosomes for nuthatches) so that we are led again to the conclusion that the most important effect of conspecific flocking on AFN results will be to increase variability.

Because of the severe biasing effect of bird speeds that are high relative to the observer's speed, I would recommend that in conducting AFN studies the observer move at the most rapid pace compatible with his ability to detect birds in his vicinity. Doubtless this pace will vary among habitats. It is perhaps worth emphasizing that this recommendation is designed to increase the likelihood that AFN figures will approximate densities; if the aim is to include as many as possible of the birds whose ranges touch the tract, an ex-

tremely slow pace would be best but the estimates derived will then be overestimates for all except the very inconspicuous species.

This discussion has emphasized the fact that AFN figures are full of imponderables. It may be desirable to conclude with a point that, if not optimistic, is at least moderately firm. In the special situation in which the study tract is so isolated or circumscribed that all birds have their home ranges entirely within it, all species except the most conspicuous ones will be underestimated.

SUMMARY

A model was designed to evaluate estimates of bird numbers derived by methods employed in *Audubon Field Notes* winter bird population studies. Strictly accurate estimates of density would result if the percentage of visits to a study tract on which a bird was seen (called "occurrence") was the same as the percentage of that bird's home range lying on the tract. This linear relationship was not found; instead occurrence tended to level off at percentages above 40. Occurrence was also affected by the conspicuousness of the bird and by the speed of movement of the bird relative to that of the observer.

It was concluded that in field situations fulfilling the conditions of the model very conspicuous birds would be overestimated and very inconspicuous birds underestimated. Estimates for species of medium conspicuousness might be fair approximations of actual density, owing to the tendency of the method to underestimate the contribution to density of birds with a high percentage of their home range on the tract and to overestimate the contribution of birds with a low percentage. These conclusions hold for birds moving slowly relative to the observer. Density of birds moving as fast as the observer will be drastically overestimated, except for very inconspicuous species.

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PUBLICATION NOTES AND NOTICES

OBSERVATIONS ON DUCK HUNTING IN EASTERN CANADA IN 1968 AND 1969. By H. Boyd. Occasional Paper No. 12, Canadian Wildlife Service, 1971; 6½ × 9 in., paper covered, 24 pp. No price given.

(From the author's abstract) "Observations of hunter performance provide information on specific differences in crippling losses and on factors governing the choice by hunters of what ducks they shot at, how effectively they shot at different times during the season and in various kinds of weather and what proportions of the ducks brought down were retrieved and kept."—G.A.H.