An evaluation of methods used in the Breeding Bird Census

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INTRODUCTION

THE BREEDING BIRD CENSUS (BBC) and Winter Bird-Population Study (WBPS) are the largest sources of data on bird communities in North America. Studies of bird communities in different habitats, and over time at the same sites, have been conducted according to standard spot-mapping procedures. The data have been used to study avian communities in various ways. For example, Lynch and Whitcomb (1978) examined the relationship between forest fragmentation and patterns of species abundance; Wiens (1975) summarized regional patterns of species richness in coniferous forests; and James and Boeklen (*in press*) analyzed interspecific relationships between morphology and density in a bird community over time.

Such comparative studies are possible because for both the BBC and WBPS, the National Audubon Society has encouraged participants to use standardized field techniques. Recommended procedures for the spot-mapping method of bird censusing have been published periodically to encourage adherence to guidelines (Hall 1964; Kolb 1965; Anon. 1970, Van Velzen 1972). The use of standardized methods improves the reliability of comparisons among censuses, but it is very important to acknowledge sources of bias or unreliability in census data. We describe first, a particular source of bias in the BBC territory mapping method, censusing speed, and second, we evaluate the effectiveness of the 0.04-ha circular sample method of vegetation sampling (James and Shugart 1970) that has been recommended to accompany BBCs and WBPSs. The importance of adhering to the recommendations for dates, speed of censusing and size of plot in BBCs will be discussed.

Part I. Census duration

SOME SOURCES OF BIAS in the spot-map census method (Williams 1936; Kendeigh 1944) are well known. Examples include between-observer variability (Enemar *et al.* 1978; O'Connor 1981), season (Best 1981), time of day (Shields 1977), plot size (Engstrom and James 1981), edge effect, and census duration. With attention to variation caused by these factors, the spot-map censusing method is considered to be "the best we have been able to devise" (Emlen 1981). Except for between-observer variability, sources of between-census biases can be minimized by adherence to census standards. In particular, we will discuss census duration as a possible source of bias that could easily be reduced by more careful adherence to general censusing guidelines.

METHODS

TWO STUDY SITES were chosen to represent extremes in the openness of habitat structure. The relatively open Wade Tract is a Longleaf Pine (*Pinus palustris*) - Wiregrass (*Aristida stricta*) association south of Thomasville, Georgia. It has an average of 139 trees/ha >8 cm dbh with visibility up to 0.5 km. Woodyard Hammock is a densely wooded Southern Magnolia (*Magnolia grandiflora*) - American Beech (*Fagus grandifolia*) forest located on the grounds of the Tall Timbers Research Station in Leon County, Florida. This forest has an average of 587 trees/ha >8 cm dbh per ha of both study areas.

Robbins (1972) recommended spending approximately 12 min/ha (5 min/acre) in closed habitats for Winter Bird-Population Studies. We adopted this speed for the BBC in Woodyard Hammock. We used a faster speed, 8 min/ha (3.5 min/acre), for the open Wade Tract because it seemed reasonable that less time is necessary for censusing open habitat with good visibility and lower bird density. These subjective categories of habitat structure (open and closed) are extremes. Most Eastern Deciduous Forests are intermediate in structure between them. Breeding Bird Censuses (8 trips) were completed in Wade Tract (Apr. 11-May 31) and Woodyard Hammock (Apr 12-May 29) according to these census speeds (Engstrom 1981a; 1981b). Four additional censuses were taken on each plot: two longer (4.5 hr in Wade Tract and 4.0 hr in Woodyard Hammock) and two shorter (1.5 hr in Wade Tract and 2.0 hr in Woodyard Hammock) in duration in the last week in May. With a 50 m grid distance in closed habitats and 100 m grid for open (Anon. 1970), the recommended walking speed of 100 m/8 min takes 3 hours in the open 20-ha Wade Tract and a speed of 6 min/100 m takes 3 hours in the 15.75-ha Woodyard Hammock. Censuses proceeded at a fairly constant rate through each study site for the established length of time regardless of avian activity.

To examine the census speeds that other observers are using in Breeding Bird Censuses, we have plotted census duration versus plot size for Eastern Deciduous Forest census data published in *American Birds* in 1982 (Fig. 1). The census speed recommended for WBPS in closed habitats (Robbins 1972) is drawn in for comparison. Minimum plot size most frequently recommended is 8.1 ha (Kolb 1965; Anon. 1947), although a larger plot size is clearly better (Engstrom and James 1981; Verner 1980) Plot sizes in BBCs are compared to the recommended minimum size of 8.1 ha (Fig. 1).

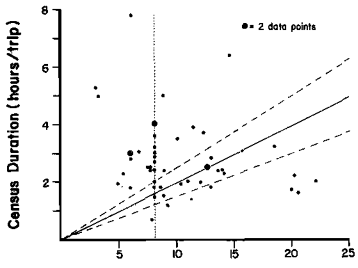

Figure 1. Census duration versus plot size for Breeding Bird Censuses in closed habitats in the Eastern Deciduous Forest. The census duration suggested by Robbins (1972) for the plot size in closed habitat is represented as a straight line. Dashed lines represent ± 25% of this suggested duration. Data are from *American Birds*, vol. 36, no. 1, for censuses conducted in 1981. The vertical dotted line at 8.1 ha represents the recommended minimum plot size.

In addition, we analyze census data from an 11-year study of a Southern Mixed Hardwood Forest in Chatham County, Georgia (Davenport 1963-73) as a case study of possible confounding influences of census effort and seasonal effects on census results. Hours per census trip, number of trips, number of species, number of territories, total number of census hours, and mean census date are summarized (Table 1). Partial correlation analysis was used to examine the relationship between components of census effort (number of censuses, total number of hours, hours per census trip, and season) and results (total number of species and total number of territories).

RESULTS

As expected, increased census duration results, on average, in detection of more species. In the Wade Tract, an average of 26 species/trip was encountered during the two fast censuses, 29 species at the suggested census rate, and 31 in the two conducted at the slower speed. For Woodyard Hammock, 17 species/trip were recorded at the fast speed, 21/trip at the suggested rate, and 23/trip at the slowest speed. The number of species/trip at the intermediate census speed represents the average number of species in pairwise combinations of the 8 census trips conducted at the intermediate speed.

A plot of census duration versus plot size for BBCs conducted in 1981, in the closed habitat of the Eastern Deciduous Forest shows that participants are not following the census speed recommended by Robbins (1972) (Fig. 1). Instead of the expected positive relationship between census duration and plot size, small plots tended to be oversampled and large plots (≥ 20 ha) to be undersampled. Fourteen of 51 BBCs (27%) fell below the recommended 8.1 ha minimum area.

Summarized data for 11 consecutive years of one Breeding Bird Census (Southern Mixed Hardwood Forest, Davenport 1963-73) suggest that species number, the number of territorial individuals, declined over the study period. In addition, total census hours, the number of censuses and census duration, also declined and mean census date occurred successively later in the spring (Table 1). The number of species and number of territories decline through the years and so do the number of hours/trip and the total number of census hours. These relationships should be warning signals to someone interested in population trends because the apparent decline in birds might be attributable to variation in census techniques.

When census date is held constant in partial correlation analysis, the number of species and the number of territories still showed significant positive correlations with census duration (hours/trip). The negative correlation between the number of territories and mean census date ($r = -.62$) was reduced ($r = -.06$) when the census duration (hours/trip) was held constant. This means that in this data set, the seasonal effect on the number of territories may not be important after the influence of census duration has been removed. The weak negative correlation between the number of species and mean census date ($r = -.39$) changes sign ($r = .22$) when the hours/trip was held constant. Neither of these correlation coefficients is significant, but the shift suggests that census speed may have a strong influence on census results The breeding birds on this plot may have really declined, but because the sampling procedure changed with time the results as published in AMERICAN BIRDS should be interpreted only with attention to these confounding effects.

Part II. Evaluation of 0.04 ha (0.1-acre) circular sampling method of vegetation sampling

The 0.04-ha circular quantitative sampling habitat method (James and Shugart 1970) has been widely used in bird censuses to characterize forest vegetation structure. We evaluate here the effectiveness of the method by comparing sample results to complete censuses of all trees in the two study sites.

METHODS

In 1980 Wade Tract and Woodyard Hammock were sampled according to the 0.04-ha circular sampling method (James and Shugart 1970). In the 20-ha study plot within the Wade Tract, 30 randomly selected circular samples were taken. Twenty-five samples were taken in a stratified random pattern in Woodyard Hammock.

S. Rathbun completely censused all trees ≥2 cm dbh over the entire 20-ha Wade Tract study site (4721 trees total) Similarly, Hirsh (1981) censused all trees ≥2 cm dbh in a 4.5-ha plot within the

Table 1. Censusing effort and results for 11 consecutive Breeding Bird Censuses conducted in a 10.1-ha Southern Mixed Hardwood Forest in Chatham Co., Georgia (Davenport 1963-73).

	1963	*1964*	*1965*	*1966*	*1967*	*1968*	*1969*	*1970*	*1971*	*1972*	*1973*
# trips	12	10	10	9	9	9	10	10	9	9	9
# census hours	42	40	39	33	34	35	30	30	31	29	28
Hours/trip	3.5	4.0	3.9	3.7	3.8	3.9	3.0	3.0	3.4	3.2	3 1
Mean census date*	40.9	32.2	39.5	40.4	33.8	47.1	49.7	51.5	46.0	43.0	46 7
# territories	94	74	89	83.5	75.5	78.5	56.5	31	54	37.5	45 5
# species**	21	18	23	20	21	21	20	15	17	15	14

*The mean census date is calculated by numbering sequentially all dates from April 1 through June 30. The numbers representing dates for the censuses of a given year are then added and divided by the number of censuses in that year.

**This is the number of species excluding visitors and species with less than one full territory on the plot.

Table 2. Comparison of quantitative habitat descriptions by the 0.04-ha circular sample method versus a complete survey of all trees within the 20 ha Wade Tract site. Randomly selected circular samples are summarized in increments of 5. Size classes G and H are not included in this comparison because they each contained fewer than 1 tree per ha. Size classes in cm are A (8-15), B (15-23), C (23-38), D (38-53), E (53-69), F (69-84).

	Trees/ha							*Rel. Density*						*Rel. Dominance*					
	A	*B*	*C*	*D*	*E*	*F*	*Total*	*A*	*B*	*C*	*D*	*E*	*F*	*A*	*B*	*C*	*D*	*E*	*F*
5 circles (.2-ha)	20	5	15	40	20		100	20	5	15	40	20		.3	.9	6.6	55.5	36.6	
10 circles (.4-ha)	17	7	32	17	3	3	93	18	8	18	34	18	3	.5	1.5	8.2	48.0	34.1	7.7
15 circles (.6-ha)	31	10	17	30	18	3	109	29	9	15	27	17	3	1.6	2.0	7.7	43.5	35.1	10.1
20 circles (.8-ha)	53	26	21	31	14	4	149	36	18	14	21	9	3	3.2	5.1	9.7	44.8	26.0	11.2
25 circles (1.0-ha)	50	24	23	30	13	3	143	35	17	16	21	9	2	3.2	5.0	11.1	45.4	25.9	9.5
30 circles (1.2-ha)	56	25	24	27	11	3	146	38	17	16	19	7	2	3.9	5.5	12.3	44.2	22.9	11.2
Rathbun's complete survey	43	26	24	26	12	2	127	33	20	18	19	9	1	3.3	5.9	12.8	43.6	26.6	7.8

15 75-ha Woodyard Hammock study site (4453 trees total, including 794 trees 2-4 cm dbh). An additional tree-size class (S, 4-8 cm dbh) was added to the 0.04-ha circles in Woodyard Hammock to include saplings. Only the 10 circular samples in Woodyard Hammock located within or close to Hirsh's study plot were included in the comparison with the complete census data. These two excellent data sets of total tree counts permitted an evaluation of the accuracy of estimates of tree species composition and size class distribution based on 0.04-ha circular samples in two habitats of very different tree density and diversity.

RESULTS

A summary of the data from Rathbun's complete census of all trees ≥8 cm dbh within the 20-ha Wade Tract site reveals the striking homogeneity (Longleaf Pine comprises >90% relative density and basal area) and openness (139 trees/ha). A quantitative description of the habitat using the 0.04-ha circular sampling method in increments of five randomly selected circles is compared to the description from the complete census in Table 2. Circular sample estimates of trees/ha (density) and dominance in the size classes (Table 2) were not significantly different from the census results (Kolmogorov-Smirnov 2-sample test, Hollander and Wolfe 1973). However, as the number of circular samples increased (5, 10, 15, etc.), the fit with the census results improved. The overall tree density (≥8 cm dbh; A-H size classes) in the complete census is 139 trees/ha, compared to estimates ranging from 89-169 trees/ha from the summarized 0.04-ha circular sample data.

The tree species making up the top 90% of the total number of trees in both the complete census of all trees in the 4.5-ha subplot within the Woodyard Hammock site and the summary of 10 0.04-ha circular samples are very similar (Table 3). The lists of species in order of decreasing relative density are the same except that Flowering Dogwood is included in the census instead of Pignut Hickory. The species order and relative dominance is very close between the two lists. The size-class distribution as estimated by the ten 0.04-ha circular samples agrees well with the complete census results (Table 4). One difference between the sample and census size class distributions is an overestimate of the relative dominance of the D and G size classes in the samples. The distribution of tree density and basal area within the size classes estimated by the circular samples is not statistically different from the census results (Kolmogorov-Smirnov 2-sample test).

DISCUSSION

A quick review of census speed in the BBCs in Eastern Deciduous Forest in the 1982 *American Birds* (Fig. 1) reveals that many participants are intensively censusing small plots. Only 35% of the BBCs were conducted within a ± 25% range of the speed suggested by Robbins (1972) for the WBPS. Fifty percent of the BBCs were above this range (more time per census) and 15% were

Table 3. Estimated number of trees/ha, relative density and relative dominance of most abundant species comprising 90% of the total number of trees within a completely censused 4.5-ha plot in Woodyard Hammock and estimates derived from 10 0.04-ha circular samples taken within the same area.

		Trees/ha	*Rel. Dens.*	*Rel. Dom.*
	Summary of complete census			
Sweetgum	*Liquidambar styraciflua*	119	14.9	12.1
American Beech	*Fagus grandifolia*	96	11.9	14.9
American Hornbeam	*Carpinus caroliniana*	92	11.4	3.2
American Holly	*Ilex opaca*	86	10.7	4.4
Eastern Hophornbeam	*Ostrya virginiana*	80	9.7	3.1
Swamp Chestnut Oak	*Quercus michauxii*	77	9.6	3.0
Southern Magnolia	*Magnolia grandiflora*	63	7.9	33.1
Spruce Pine	*Pinus glabra*	43	5.4	11.5
Blackgum	*Nyssa sylvatica*	26	3.2	6.2
Water Oak	*Quercus nigra*	26	3.2	1.9
Flowering Dogwood	*Cornus florida*	25	3.1	0.4
	Summary of 10 0.04-ha circular samples			
Swamp Chestnut Oak	*Quercus michauxii*	102	13.9	6.4
Sweetgum	*Liquidambar styraciflua*	90	12.2	7.3
American Hornbeam	*Carpinus caroliniana*	85	11.5	2.8
American Beech	*Fagus grandifolia*	80	10.8	17.8
Eastern Hophornbeam	*Ostrya virginiana*	70	9.5	4.9
American Holly	*Ilex opaca*	67	9.2	2.6
Southern Magnolia	*Magnolia grandiflora*	57	7.8	22.9
Spruce Pine	*Pinus glabra*	35	4.7	8.3
Blackgum	*Nyssa sylvatica*	27	3.7	9.0
Water Oak	*Quercus nigra*	25	3.4	1.6
Pignut Hickory	*Carya glabra*	22	3.1	2.2

Table 4. Comparison of structural characteristics as determined by 10 0.04-ha circular samples versus a complete survey of all trees within a 4.5-ha subplot of the Woodyard Hammock site.

	Size classes (DBH in cm)	*Complete survey*	*Ten 0.04-ha samples*
Trees/ha	S (4- 8)	212	220
	A (8- 15)	244	220
	B (15- 23)	154	135
	C (23- 38)	103	95
	D (38- 53)	56	85
	E (53- 69)	31	18
	F (69- 84)	6	8
	G (84-102)	2	5
	Total	813	786
Relative density	S	27	28
	A	30	28
	B	19	17
	C	13	12
	D	7	11
	E	4	2
	F	1	1
	G	<1	1
Relative Dominance	S	2	2
	A	6	5
	B	11	9
	C	18	15
	D	31	42
	E	22	12
	F	7	8
	G	3	8

below. The Eastern Deciduous Forest category undoubtedly includes a mixture of subhabitats. Some variation in census duration is probably necessary to accommodate differences in vegetation structure, topography, and the ability of observers. However, if small plots are oversampled and large plots undersampled as indicated in Figure 1, a bias in the results is introduced.

Rarefraction, a statistical procedure, can be used to compare species richness of bird communities between plots of different sizes (Engstrom and James 1981; James and Rathbun 1981; James and Wamer 1982). However, to increase the value of the data, especially for between-observer comparisons, small plot sizes should be avoided. BBCs conducted on plots smaller than 8.1 ha are of limited usefulness for making population estimates (Engstrom and James 1981).

The case study of the 11-year census of the Southern Mixed Hardwood Forest (Davenport 1963-1973) illustrates the reason for adhering to standards over time. The disappearance of some species of birds from the study plot was probably a real phenomenon. Yet, how are we to distinguish biological changes from artifactual change caused by an alteration of method? Partial correlation analysis indicates that the number of hours/trip influences the number of species and territories even when the influence of censusing date is held constant. In this data set, censusing date is not significantly correlated with the number of species and territories when census duration (hours/trip) is held constant. This emphasizes the importance of using a standardized census duration or speed. Slagsvold (1969) and Wooten (1982) came to similar conclusions.

The 0.04-ha circular vegetation sampling method is a simple, effective, quantitative method of characterizing forest vegetation structure. The size-class distribution of trees in the Wade Tract (Table 2) indicates that all estimates of relative density and relative dominance (%) for each size class (A-H), based on 20 or more samples, fall within 5% of the true values as established in the complete survey. This suggests that in habitat with few trees, just a few random 0.04-ha circular sample/hectare may provide a good approximation to the actual vegetation structure. Estimates of shrubs is an important aspect of the vegetation structure that is not included in this analysis, and one that needs to be addressed.

The habitat structure and tree species composition of Woodyard Hammock is very different from that of Wade Tract The two habitats provided an opportunity to test the 0.04-ha circular sample method in extremely different forests. Species composition and order of abundance of the most common trees in the sampled population in Woodyard Hammock are nearly identical to the complete survey (Table 3). Tree density/ha as estimated from the samples is within 4% of the actual density (Table 4). The distribution of tree densities within the size classes is very close (all values within 5%). Distribution of relative dominance within the size classes is less accurately measured by the samples, but the shape of the distribution is similar.

Adherence to standard methods of territory mapping such as promoted by the International Bird Censusing Committee (Anon. 1970) has been criticized for a variety of reasons: (1) strict standards discourage amateur participation (Oelke 1981); (2) the territory mapping method is not appropriate when censusing colonial species (Slagsvold 1973) or in tropical regions with high bird species diversity (Oelke 1981); and (3) to use the censuses comparatively, observer equality is assumed (Enemar *et al.* 1978)

If amateur-conducted BBCs and WBPSs are to be encouraged as sources of scientifically valuable data some compromises must be made between the amount of effort and the degree of census efficiency. Nevertheless, tightening up the standards, establishing clearer guidelines in certain areas such as census speed, putting greater emphasis on recording simultaneous contacts (the 'combined method' of Tomialojc 1980, see also Paul and Roth 1983) would greatly improve the comparability of the data

SUMMARY

BREEDING BIRD CENSUSES were conducted in a mature Longleaf Pine-Wiregrass association and a mature Southern Magnolia-American Beech forest. In addition to 8 census trips at an intermediate census speed, two censuses at a faster pace and two at a slower pace were made. The average number of bird species encountered in both of these habitats decreased as censusing speed increased. Speed of movement of the ob-

server during a bird census influenced the results. Eleven years of BBC data from one location were analyzed. The results show that the reduction of birds over time may be caused by the confounding influence of reduced bird census effort. The value of BBCs could be improved by better adherence to standards. In closed habitat, such as the Southern Magnolia-American Beech forest in this study, 12 min/ha, as recommended by Robbins (1972) for the WBPS seems reasonable. For the open Longleaf Pine Forest, 8 min/ha was sufficient.

The accuracy of the James-Shugart quantitative method of habitat sampling which is frequently used in Breeding Bird Censuses and Winter Bird-Population Studies is assessed. Data from circular samples are compared to complete tree censuses in two habitats of very different structure. The size-class distribution and composition of tree species of the samples were close to results of the complete tree census results.

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