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A COMPARISON OF THE EMLEN TRANSECT TECHNIQUE

AND A TIME-AREA COUNT

By

Dennis Fijalkowski

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ABSTRACT

A COMPARISON OF THE EMLEN TRANSECT TECHNIQUE
AND A TIME-AREA COUNT

by

Dennis Fijalkowski

The ability to determine bird populations in a relatively short period of time is a worthwhile goal. In this research the Emlen transect technique (1971) was compared to a time-area count (Robbins, 1970) to determine the effectiveness of both methods in accurately representing bird communities. The methods were tested on two sites in mid-Michigan during the preparation of reconnaissance environmental analyses conducted by a team of investigators from MSU.

No significant difference was found between the methods in contacting numbers of species and numbers of individuals. The time-area count was, however, found to be significantly more efficient (α = .10) at contacting species/minute and individuals/minute.

Low similarity was found between census efforts, and even between actual replicates, which illustrated how difficult it was to choose areas representative of the major habitats from aerial photos and distant observations.

Visibility, the observers ability to first contact birds by sight, was almost three times higher using the

Emlen technique than the time-area method. Almost half of the Emlen contacts were visible ones. Visibility data for the two observers was almost equal in all habitat types.

Sources of error were analyzed and discussed. The estimation of contact distances was thought to be the largest source of error using both methods. Distances to audible contacts were easier to estimate using the time-area count.

Other sources of error were caused by lack of homogeneity within areas chosen to be censused, flocking of birds, observer differences, and double recording.

Observers found the time-area count easier to use under reconnaissance conditions. The Emlen technique was estimated to be twice as labor intensive as the time-area count.

Recommendations were made for future bird censusing during environmental analyses. Problems in the reporting of data were discussed and recommendations made for future reporting of bird census information.

"Only men of leisure have time to wonder, or wander, which-ever the case."

A man of leisure - 1976

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INTRODUCTION

Man has long tried to determine the value of a particular area for a certain species of wildlife. These determinations were for the most part made by scientists for their own benefit, and seldom was there any practical use for this information. The exceptions, of course, were for managing a species of economic or sporting value, or for preserving an endangered species.

All that changed with the advent of the National Environmental Policy Act (NEPA) of 1970. Section 102(2)(C) of NEPA requires federal agencies to prepare environmental impact statements on "proposals for legislation and other major federal actions significantly affecting the quality of the human environment." One requirement of these environmental impact statements is an evaluation of the importance of affected areas to man and wildlife. To meet this provision, agencies have sought ways to evaluate wildlife resources. Primary to any evaluation is some estimate of the actual population of wild animals.

Estimating wildlife numbers is a difficult task even with intensive study. Ideally, a method for estimating bird populations should be simple and efficient and should be adaptable to reconnaissance situations as well as intensive analyses. It should yield species composition and densities. Lastly, since a census method may have to be used in different habitat types, and should be adaptable to such situations.

In the past, simple transect counts were used to census birds (Robbins, n,d.; Kendeigh, 1956; Enemar and Sjostrand, 1967). These yielded fairly accurate species composition but such terms as rare, common, and abundant lack definition when used to indicate species abundance. Even professional investigators define these terms differently, and they can be highly misleading.

In this research project, two methods of censusing birds are investigated for reconnaissance type surveys that would appear to yield density values and meet the requirements previously stated. Both methods were tested between June 13 and July 26, 1973 on two separate study areas being considered by the Consumers Power Company of Michigan as possible sites for power plant development. The two methods tested and compared were the Emlen transect technique (Emlen, 1971) and a time-area count (Robbins, 1970). Since the Emlen technique, a moving strip census, has been used successfully to determine density and composition of bird populations, it was given primary consideration. The time-area count was used for comparison. In this study contrasts are made between the two methods and an observer's ability to contact birds using them. No attempt is made to assess the accuracy of either method in determining density values.

STUDY AREAS

FOWLER SITE

The first study area, referred to as the Fowler Site (Figure 1), consists of 11,267 hectares (27,840 acres) located in Clinton County, Michigan. It is characterized by level to gently rolling land traversed by several streams which have been largely altered by dredging. Approximately 85 percent of the land is devoted to agriculture. An aerial view shows a grid pattern imposed on the landscape as a result of the early division of the land into square mile sections. Most sections contain one to several woodlots, located either in the center or on the more poorly drained soils (Fijalkowski *et al.*, 1973). Farming practices are intensive with little fence row or roadside vegetation.

The natural vegetation of the site was divided into five types for the purpose of an environmental analysis. Due to the variety of management practices prevailing over such a large area, the vegetative communities of any one type varied considerably. It was also common to find ecotones and small areas of one type within another type. These areas were not censused separately and probably accounted for some of the variability of data within each type. A description of the five natural vegetative types is presented below.

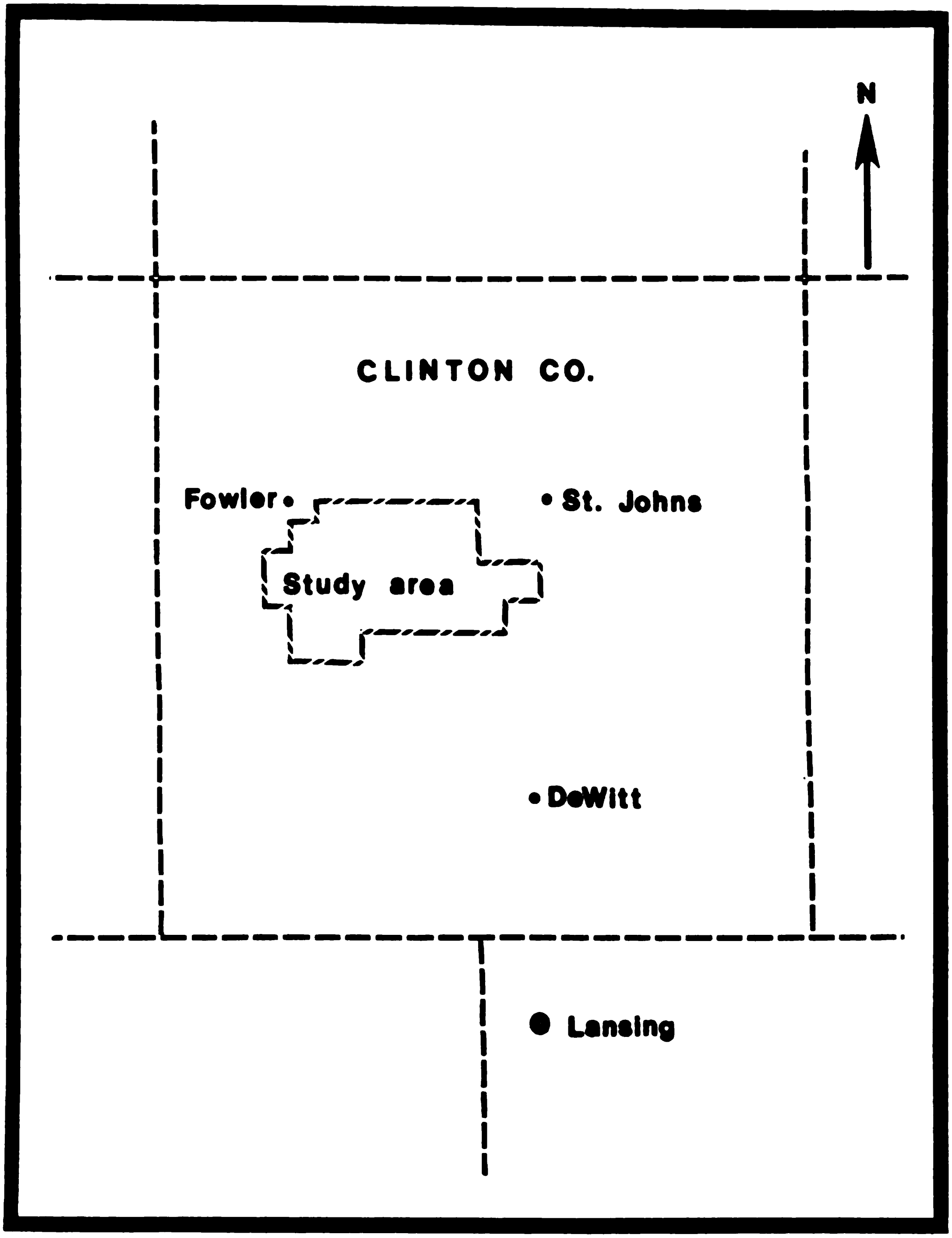

Figure 1. Fowler Study Area

Type 1: Wet Area Vegetation

Open water marshes and water-course vegetation were combined under the category of wet area vegetation for the purposes of censusing birds during the environmental analysis. Few open water marshes existed on the area, the largest being less than five acres. Water in temporary marshes persisted into early summer in years of normal rainfall. Water-course vegetation is composed of floodplains or lowland communities within the four remaining types, but usually with denser lower strata of willows (*Salix spp*), dogwoods (*Cornus spp*), or other brushy vegetation.

Type 2: Old Field Communities

An old field is described as an area which was previously cleared but has lain fallow long enough for the first stages of woody vegetation to appear, with up to 40 percent woody crown cover. This overstory is typically comprised of hawthorns (*Crataegus spp*), green ash (*Fraxinus pennsylvanica*), and slippery elm (*Ulmus rubra*) to heights of 25 feet.

Type 3: Shrub-Sapling Communities

Shrub-sapling communities are those which are beyond the old field stages, but not mature enough to be classified as woods. Type 3 is most commonly composed of dense stands of hawthorns, prickly ash (*Zanthoxzlum americanum*), elms, and tree species associated with nearby woodlots, with an average dbh of 2-4 inches and heights to about 30 feet.

Type 4: Immature Woods

Immature woods are those with trees predominately 6-10 inches dbh, and heights generally less than 60 feet. Often larger trees were found in various densities (probably the result of selective forestry or high-grading), but not until this larger stratum reached 50 percent density was it considered Type 5 (old-growth woods). Due to the large size of the study area and existing management practices, a variety of composition, density, and structure is found within this type.

Type 5: Old-Growth Woods

In general, old-growth woods are like Type 4, but are more mature second growth. Those woodlots with an upper stratum of 60 feet or more and density of greater than 50 percent, and with an average dbh greater than 10 inches are classified old-growth woods.

TRUFANT SITE

The second study area consisted of 8,223 hectares (20,320 acres) located in Kent and Montcalm Counties (Figure 2). The area is generally level to gently rolling in nature with low-lying pockets of organic soils. Approximately 60 percent of the study area is devoted to agriculture of some type. The remaining land is in natural vegetation, usually on the wetter sites due to the difficulty of removing timber and preparing the soil for agriculture. These wetter or organic soils are generally correlated with

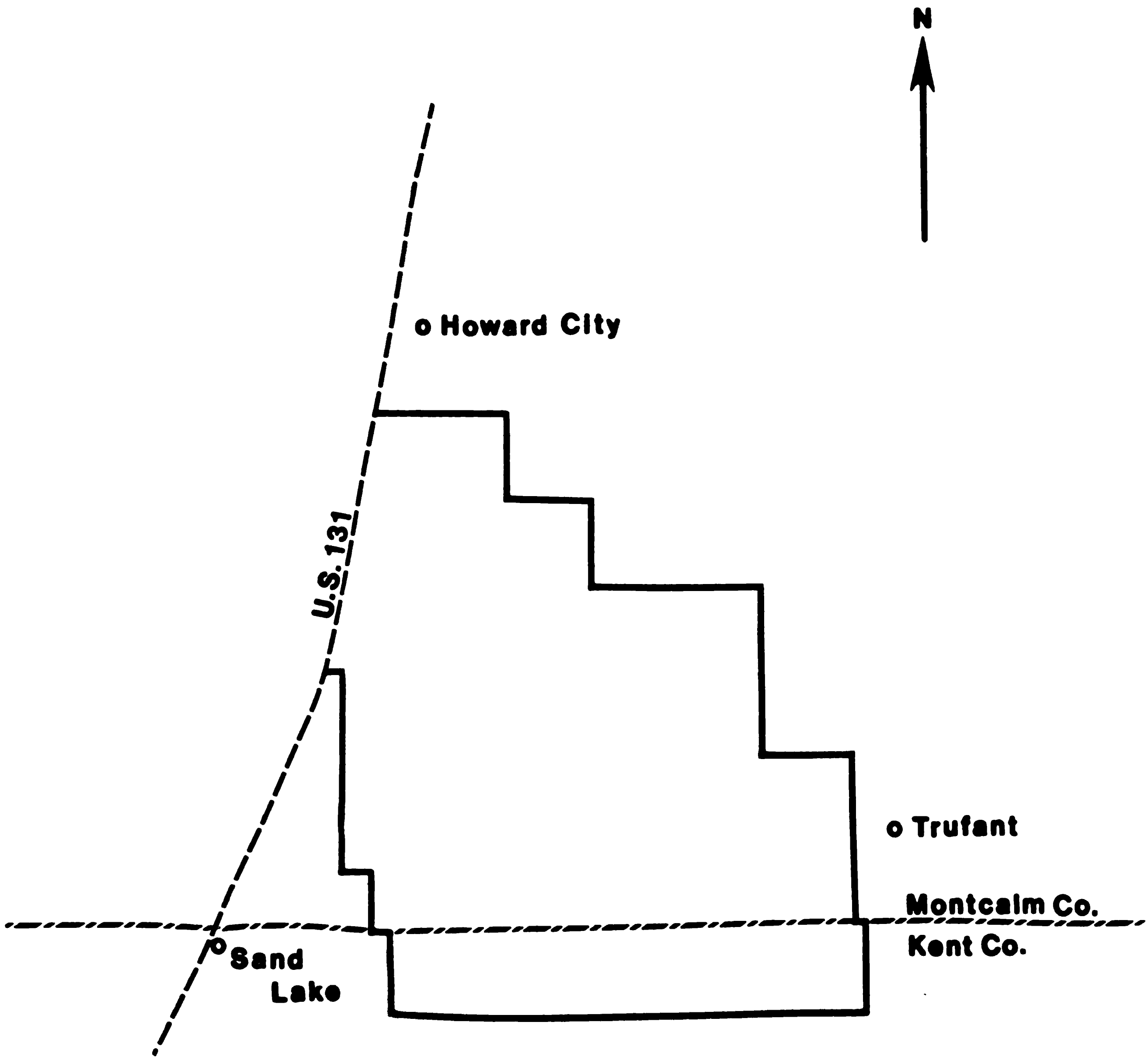

Figure 2. Trufant Study Area

the drainage pattern for the area. The natural vegetation of the site was divided into four types. The two types described below were used in all analyses.

Type 1: Early Succession

Early succession vegetation is composed of old fields, shrub communities, shrub-sapling communities, and immature woods or some combination of these. By definition a wide variety of seral conditions were lumped as one type. This was necessary to inventory the bird fauna in a limited time span.

Type 2: Dry Woods

Dry woods were those immature and mature stands on the more mesic sites.

METHODS

A reconnaissance of each study area was done by auto and airplane and the natural vegetation divided into seral stages or types suitable for sampling. It was often difficult to classify an area by type because its vegetation was not uniform or because it was borderline between types, however, a decision was always made as to which type it closest fit.

Considerations for choosing a plot were threefold: (1) the area must be large enough for a suitable transect to run through it (generally at least 1/4 mile long and 1/8 mile wide); (2) it must be relatively uniform in composition, density, and structure; and (3) sampling of the area must be consistent with other objectives of the environmental analysis, which were to collect data on all environmental parameters of the site.

With each census, the observer(s) was given data recording sheets (Appendix A) and a panchromatic aerial photograph (1:14,400) marked with designated transects to be walked. Distances were marked on the photograph to help the observer start a transect or find his way to other transects.

Portable cassette recorders were carried by observers during all field sampling. When unknown species were encountered, the songs or calls were taped and later checked against various bird song recordings.

Even though density values were not used in this study, contact distances were recorded. Rangefinders were used by observers for a short period of time to develop proficiency at estimating distances.

Birds were censused on the study areas to provide estimates of densities and relative abundance. The two methods used for all nonflocking land birds were an Emlen (1971) technique, a moving transect count, and a time-area count (Robbins, 1970). Using the Emlen technique the number of individuals seen or heard for each species and contact distances were used to determine distribution patterns in relation to observers on the transect. It was assumed that birds were distributed randomly at the beginning of each census, and that they tended to move away from approaching observers.

Emlen felt that a minimum of five transect miles were needed to obtain reliable data for density estimates. On the reconnaissance surveys done in conjunction with this study as little as two miles of transect were used for estimating densities.

For use in the time-area count method the photos also had stations marked on the transects for observers to listen from. In woodland plots the stations were 400 feet apart with the first one located 200 feet from the beginning of the transect. In field communities the stations were spaced 800 feet apart. Transects were generally at least one quarter mile in length and the census plot usually contained at least two transects, spaced far enough apart so that the observer would not easily contact the same bird from both lines. The first transect was located 200-300 feet inside the plot and running parallel to the edge so that species frequenting the edge would be contacted, but not overrepresented.

Two principle investigators and two recorders did the censusing, working in teams. A census effort was defined as one team of observers (a principle investigator and a recorder) censusing one morning, on one area. The principle investigators were experienced birders and considered equal in proficiency during the study.

When encountering more than two individuals of the same species they were recorded as one contact. This was found to be necessary to avoid overestimating densities of flocking species, since flocked birds are not randomly distributed. After young birds fledged flocking was a serious problem in some species.

Using the time-area count, the observer stopped at intervals (stations) along the transect for three minutes, recording all contacts with birds either by sight or sound (Robbins and VanVelsen, undated). Density values from time-area data could be calculated as in the modified Emlen method.

The basic difference between the methods was birds were recorded continuously along the line of travel for the Emlen technique, whereas for the time-area count birds were only recorded at specific intervals along the transect.

When an area was censused using one method, it was usually censused the next day using the other method. It was hoped that any error caused by seasonal variations could be eliminated and results compared if census methods were tested on consecutive days. In most cases the same investigator used both census methods on an area so valid comparisons could be made.

COLLECTION OF CENSUS DATA

Censuses were conducted in the early morning, starting about 1/2 hour after local sunrise (Emlen, 1971) and generally not continuing more than two hours. One or two observers walked transects which were picked to cover areas representative of the major nonagricultural vegetative types, and laid out so that observers contacted birds on the edges as well as the interiors of areas censused. When two observers worked together, one would collect data and give it to the other verbally, who would record the data on field sheets.

Data collected using either method was the same: species, sex, mode of contact (sight or sound), and estimated distance from the observer. Contact distances were estimated in 10-foot intervals to 100 feet, then single intervals of 100-200 feet, 200-400 feet, and 400 feet plus.

In accordance with the Emlen method, the observer(s) walked the specified route at a slow pace pausing briefly to look and listen. Long stops were avoided to reduce the danger of double recording, and birds ahead of the observer were not recorded until they were within 100 feet. Speeds averaged about one mile per hour. The lateral distance from the transect to the initial point of detection of the bird was estimated. Squeaking and pishing sounds were made by observers to lure birds from hiding for identification purposes.

Time-area count census efforts were conducted in the same manner except that birds were recorded at specific intervals (stations) along the transect rather than continuously. For the time-area method, distance was estimated from the bird to the observer.

When three or more birds of a single species were contacted together, they were plotted as a single contact in order to reduce the possibility of overestimating species density. Immature birds were recorded in the same way as adults, but nestlings were not recorded.

Time was kept by the observers for computation of efficiency values. Time began when the first transect was started and ending when the last transect was finished. No attempt was made to standardize time on census efforts or make it equal using the two methods.

ANALYSIS OF CENSUS DATA

Since this research compared two census methods, the beginning hypothesis to be tested was H_o: Modified Emlen = time-area count. The alternate hypothesis was H_1:

Modified Emlen $\neq$ time-area count. If H_o was rejected, the question was which method was the better. Several methods were used to test H_o. The α level was set at .10 for all statistical tests due to the small sample size and the imprecise nature of the census methodologies. The higher α (.10) resulted in lower Type II error.

Efficiency is an important consideration in choosing any census method, especially on a reconnaissance survey. Efficiency in this study was measured in terms of time, and accuracy or completeness. The primary concern of how much time was required to census an area was evaluated using the parameters of species and individuals contacted per minute.

Species per minute was defined as the total number of taxa contacted during a given census effort divided by the number of minutes spent censusing. Individuals per minute was the total number of individual contacts during a census effort divided by the number of minutes spent censusing.

Completeness, the most direct measure of accuracy this research yielded, was simply a comparison of total species and total individuals values using each method on the same area. The method contacting the greatest amount of species or individuals was more complete.

Time efficiency and completeness data were analyzed using the paired Wilcoxon Signed Rank test. When there were more than one census of the same area using the same method, mean values were used.

Similarity, a measure of variability, was used to gauge the effectiveness of both methods in representing the avian communities of the area censused. Although Murdoch (1973) developed the index to measure the similarity between two vegetative communities, in this study the index was used to measure the similarity of two avian communities. The similarity index (I) is defined as:

$$I = 1-0.5(\sum_{i}^{s}|a_i-b_i|),$$

where a_i is the proportion of the total individuals in sample A that belongs to species i and b_i is the proportion in sample B belonging to species i, and there is S species. Complete similarity will yield I = 1, and complete dissimilarity gives I = 0. Since the I value does not portray any bias of the two methods, it should not be considered a measurement of accuracy. Methods tested can be considered accurate only in the sense that replication of the same area should yield high similarity if the census method is efficient at contacting a representative sample of the avian community. If two or more censused of the same area are very similar, then we can assume the method used was fairly repeatable.

Visibility, or the chance of an observer contacting individual birds by sight, was compared using the two methods, by species and overall.

Observers were compared by the use of efficiency and visibility measurements from the two methods.

Three computer programs were used in the analysis of the data. They were written in FORTRAN IV for the CDC 6500 system at Michigan State University. The first program (SINDEX) was designed to compare the census efforts with each other and determine the similarity index.

A second computer program (TOTALS) summed the number of visible and audible contacts, and computed the percent of visible contacts for each of the species contacted for each census effort and overall.

The third program (PRINCE) totaled the contacts by group (a combination of method and habitat type) yielding total visible, total audible, percent visible, and percent audible for each species.

Tests were run of selected samples to check the accuracy of all computer analyses.

RESULTS AND DISCUSSION

Forty census efforts were conducted in seven habitat types on the two study areas (Table 1) during this research. A total of 115 species (Appendix B) were contacted 3,175 times using the two methods. Of the 115 species contacted, 84 species were nonflocking land birds used in this study to test the methods.

Of the 3,175 contacts, 1,317 or 41.48 percent were visible contacts. The mean number of contacts per census effort was 79.38 of which 32.93 were visible contacts.

The most frequently contacted species during the study was the song sparrow which was contacted 425 times (Table 2). Four other species were contacted greater than 200 times: the redwing blackbird, grackle, robin, and cowbird, with 300, 275, 269, and 219 contacts respectively. Twenty-two species were contacted greater than 50 times during the study (Table 2).

EFFICIENCY OF THE METHODS

Since this study was intended to evaluate two census methods under reconnaissance conditions, efficiency of the methods was analyzed. In this study efficiency was seen as having two components: time and accuracy.

Time efficiency was analyzed in terms of species per minute contacted and individuals per minute contacted. Completeness was evaluated as an indirect measure of accuracy.

Table 1. Mean Number of Species and Individuals per Census Effort by Habitat Type for Each Method

Habitat Type	Emlen			Time-Area		
	Census Efforts	Species[a]	Individuals[a]	Census Efforts	Species	Individuals
Fowler						
1	4	20	76	2	18	50
2	4	19	82	2	17	70
3	2	27	96	2	20	56
4	4	23	74	3	24	68
5	2	20	55	2	24	79
Trufant						
1	7	26	111	1	28	156
2	3	20	44	2	28	83

[a]Mean

Table 2. Most Frequently Contacted Species, Their Percent Visibility by Method, and Total Percent Visibility

Rank	Species	Total Contacts	Total Visibility	Emlen Visibility	T-A Visibility
1	Song Sparrow	425	26	35	7
2	Redwing	300	73	82	27
3	Grackle	275	81	88	39
4	Robin	269	72	80	37
5	Cowbird	219	79	85	56
6	Starling	176	74	82	45
7	Goldfinch	159	61	75	14
8	Cardinal	155	14	19	7
9	Catbird	115	24	29	16
10	Red Eyed Vireo	111	7	13	2
11	Flicker	98	38	51	7
12	Mourning Dove	92	55	64	20
13	Field Sparrow	77	16	22	9
14	Blue Jay	72	32	48	4
15	Bunting	71	12	13	8
16	House Wren	68	14	18	11
17	Pewee	62	4	7	3
18	Crow	61	16	37	0
19	Townee	61	14	21	0
20	Crested Flycatcher	61	12	23	0
21	Yellow Warbler	56	39	55	6
22	Red Headed Woodpecker	52	69	97	25

Time Efficiency

The Wilcoxon Signed Rank Test was used to compare the time efficiency of both methods. Twelve sample pairs of species per minute data from seven habitat types were used in the test. When more than one census existed on the same area using the same method, the mean was used. The results at the $\alpha = .10$ level were found to be significantly different ($\alpha^* = .084$)[1]. The time-area count method showed a markedly higher species per minute rate than the Emlen method (Figure 3).

Twelve sample pairs of data were used in a Wilcoxon Signed Rank Test to compare individuals per minute data from seven habitat types using both methods. When more than one census was done on the same area using the same method, the mean value was used in the test. The time-area count method did show a significantly higher individual per minute count at $\alpha = .10$ ($\alpha^* = .092$) (Figure 4).

Completeness

Number of species and individuals contacted using both methods were compared. When there was more than one census of the same area using the same method, mean values were used. Thirteen pairs of values representing seven different habitat types were listed and compared using the Wilcoxon Signed Rank Test. The census methods were not

[1](α^*) is the smallest level at which the hypothesis (H_o) would be rejected.

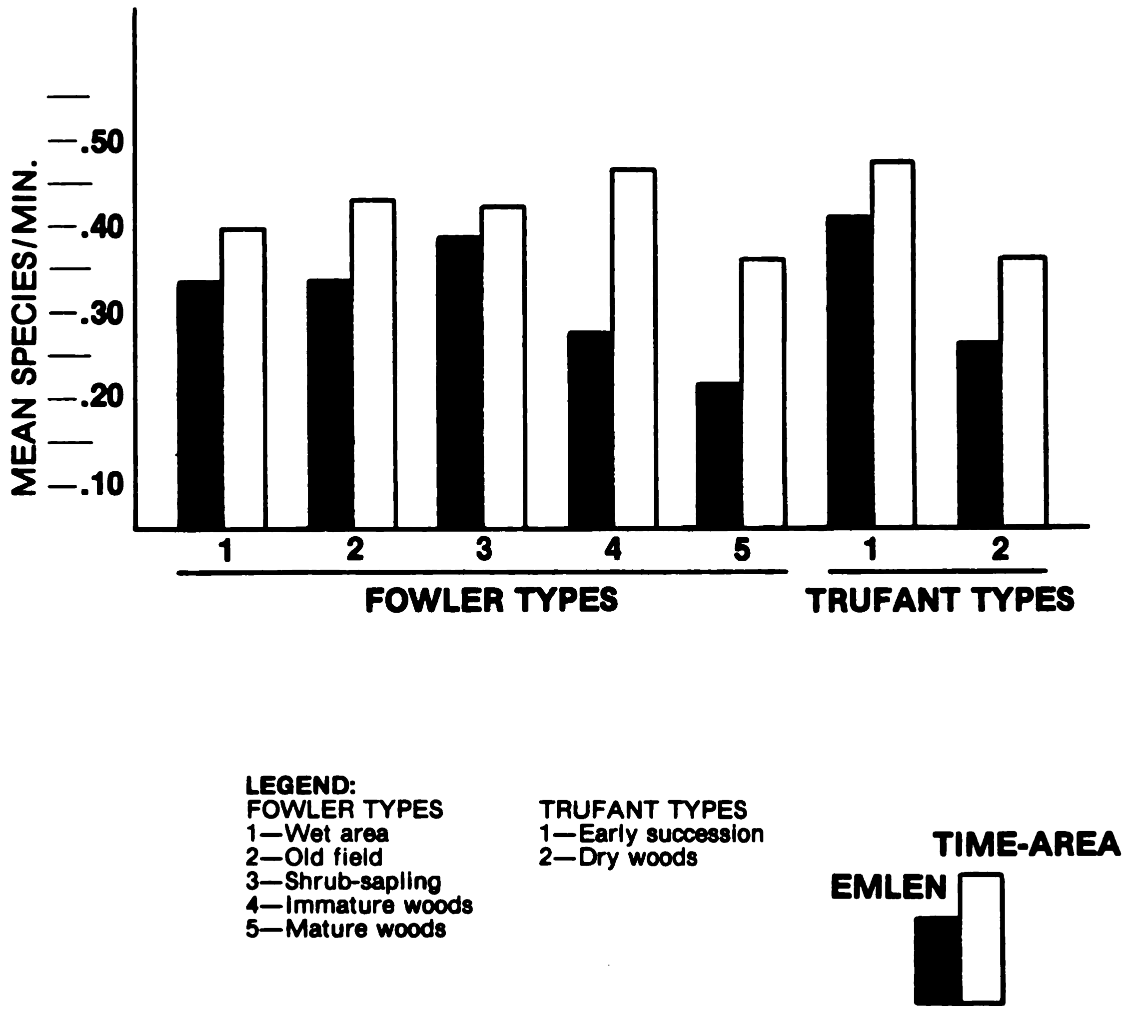

FIGURE 3. Comparison of species/minute data for the two methods.

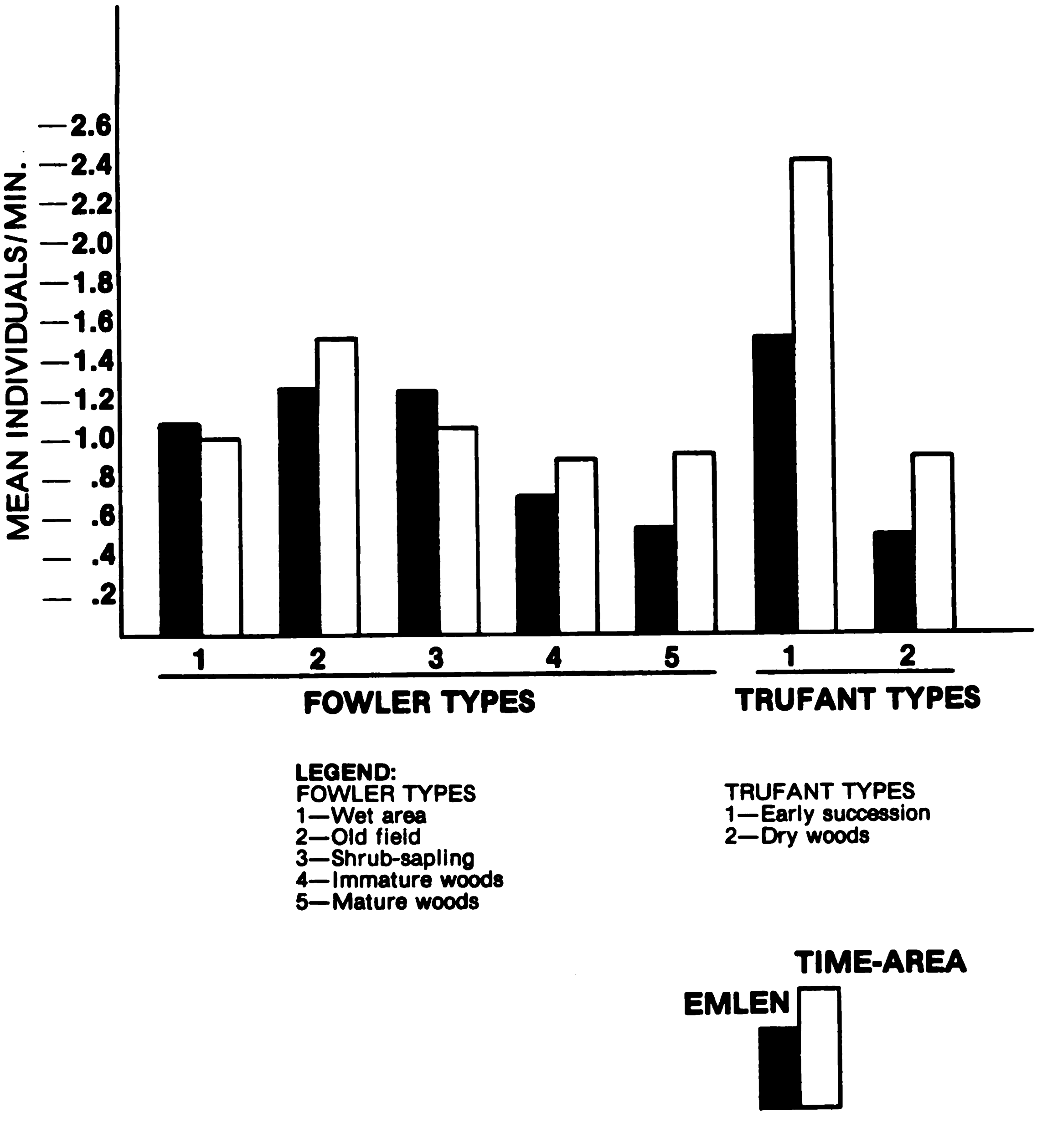

FIGURE 4. Comparison of individuals/minute data for the two methods.

found to be significantly different at $\alpha = .10$ ($\alpha^* = .396$) when species contacted data for the two methods were compared.

A Wilcoxon Signed Rank Test was used to compare total individuals contacted data for the same thirteen sample pairs. The methods were not found to be significantly different in total contacts at $\alpha = .10$ ($\alpha^* = .420$).

SIMILARITY MEASUREMENTS

A measurement of variability used in this study was a similarity index (I) (Murdoch _et al._, 1973). The similarity index was used to evaluate the efficiency of an investigator in choosing representative communities in an area to be studied. This point can be especially critical on reconnaissance surveys since time is limited. The observers' ability to quickly reconnoiter a study site and choose areas representative of the dominant vegetative communities for analysis can be the most important task of the investigator. For this reason, a similarity index program (SINDEX) compared the 40 census efforts with each other to determine I values. It must be remembered that this index is a relative value. An I value of 1.0 would be complete similarity, an almost impossible occurance in natural communities. An I value of 0.0 would mean complete dissimilarity between two communities.

Mean similarity indices of all censuses on areas of the same type were compared using both methods. The mean I (computed by averaging all similarity indices between censuses on the same type using the same method) for the Emlen census was .476 while the mean I for the time-area count was .550. A Wilcoxon Ranked Sum Test was used to compare these mean I values. The time-area count efforts were significantly more similar at $\alpha = .10$ than Emlen efforts which meant simply a time-area effort was more repeatable.

The mean I values appeared to be low, therefore, I values for actual replicates of the same area, by the same observer, using the same method were investigated. The mean value for actual replicates using the Emlen method was .659, and .679 for the time-area count. This comparison of replicates in part explains why more similarity was not seen in avian communities on areas picked as representative of the same habitat type.

To compare the two census methods used on the same area two mean values were calculated. A mean I of .566 irrespective of observer was about equal to the value of .560 for both methods on the same area by one observer. The mean I value for comparisons between observers on the same area using the Emlen method was computed to be .539. These data indicate there was as much variability between methods as there was between observers, and no conclusions can be drawn. Similarity measurements illustrated the difficulty in choosing similar communities to sample from aerial photos and distant observations.

VISIBILITY

One factor influencing the effectiveness of any census is visibility. Although a very complex phenomenon, in this study visibility was considered as having three components affecting the observer's ability to visibly contact individual birds: (1) habitat characteristics; (2) conspicuousness of the species (size, coloration, and behavioral characteristics); and (3) observation conditions such as weather, time of day, etc. The last factor was an independent variable and controlled in the study.

Visibility in this study was defined as the observers ability to first contact birds visibly. The bird may also have been heard, but was sighted first. Visibility data in this study may not accurately reflect a species true visibility (an observer's ability to contact a bird by sight). The factor most influencing whether a contact would be audible or visual was the individual species behavioral characteristics. Species that actively forage, react quickly to an observers presence, or are reluctant to vocalize tend to be contacted visibly rather than audibly. Therefore, any measure of visibility here must not be taken out of context or used as a comparison for visibility from other studies. It is merely intended as a mode of comparison between the two census methods, observers, habitat types and individual species. In the analysis visibility is expressed in terms of the percentage of visible contacts of the total.

Program TOTALS computed contacts and visibility by census effort (Table 3). Mean percent visible contacts averaged almost three times higher using the Emlen method compared to the time-area count. The greatest difference occurred in Type 5 from the Fowler area where an observer using the Emlen method was almost five times more likely to contact birds visibly than the time-area method. The Dry Woods on the Trufant area showed that the Emlen method was less than twice as efficient at contacting birds visibly as the time-area.

With almost half of the contacts being visible using the Emlen method, and considering how many of the audible contacts are also observed, it may be possible to compute visibility ratios for each species so that an observer not proficient in identifying calls could conduct a census, and density figures could be computed using visibility ratios. An extreme case would be to have a deaf observer do the censusing and carry a tape recorder so that a competent person could review the recording for completeness of the data afterwards. Relying solely on visible contacts, however, may tend to omit or underrepresent seldom-seen species such as the ovenbird or pewee.

A comparison of percent visible contacts using replicates of the Emlen method by different observers was done (Table 4). The percent visibility was nearly equal in all comparisons between the two observers.

Table 3. Total Contacts and Percent Visible Contacts by Habitat.

		Mean Contacts			Mean % Visibility	
Habitat	Study Area	Emlen	Time-Area		Emlen	Time-Area
1	Fowler	75.75	49.50		67.64	15.23
2	Fowler	82.00	69.50		69.84	28.92
3	Fowler	96.00	56.00		60.40	20.12
4	Fowler	73.75	67.67		28.70	8.33
5	Fowler	54.50	79.00		31.54	6.66
1	Trufant	111.00	156.00		61.96	27.70
2	Trufant	43.67	82.50		19.99	11.59
				MEAN	48.58	16.94

Table 4. Percent Visible Contacts by Observers Using Emlen Method.

Habitat Type	Site	Observer A	Observer B
1	Fowler	58.75	54.35
		73.17	84.27
		65.96[a]	69.31[a]
2	Fowler	67.90	70.00
		72.97	68.49
		70.44[a]	69.25[a]
1	Trufant	36.67	52.94
		70.00	
		53.34[a]	52.94
2	Trufant		22.22

[a]Means

In order to provide more exact data the percent visibility by census effort and total visibility during the study were determined for each species. Total percent visibility of the top 22 species ranged from 4.35 for the pewee to 80.71 for the grackle (Table 2). The second and third most visible species were the cowbird and starling with 78.85 and 74.04 percent visibility, respectively. The second least visible species was the red-eyed vireo with only 7.26 percent of the 111 contacts being visible ones.

EASE OF SAMPLING

One point which must be considered when choosing any sample method is the ease with which the observer, especially an inexperienced one, can use the method. The time-area count method was found to be the easiest of the two methods to use. The observers found it easier to walk to the next station than to follow an unmarked north/south or east/west transect line and felt more comfortable censusing while stationary than while walking.

Since transects were marked on photos to be used with both methods, and stations were chosen for the time-area method by merely telling the observer how far to walk between stations, both methods required an equal amount of preparatory time before censusing. However, without a second observer, or with one of questionable proficiency, it would have been difficult to conduct an Emlen count in very dense vegetation while maintaining a compass direction, warding off biting insects, and making sure to record every contact accurately. Therefore, if two observers are required to insure reasonable accuracy using the Emlen method, it must be considered about twice as labor intensive as the time-area count.

Estimating distances to audible contacts is difficult, and in this study observers felt more confident in their estimates using the time-area method than the Emlen method. However, since estimating visual distances is easier than audible distances, the Emlen method had the advantage because using it observers were three times as likely to contact birds visibly.

ERRORS IN SAMPLING

When doing any research it is important to test the hypothesis under ideal conditions. In this study data was collected during an actual reconnaissance survey where certain variables were not controllable (i.e., observer differences, habitat variability). Much of the variability or error in the data is certainly a result of the less than ideal conditions under which information was collected. Probably the most important source of error resulted from estimating distances to contacts.

Enemar and Sjostrand (1967) determined that estimation of distances by eye was impossible and, therefore, data collected on a strip survey should not be used to calculate density values. Emlen, on the other hand, found no problem estimating distances, especially those less than 100 feet which are the most critical, after practicing with a range-finder and setting mental references.

Estimating distances was at times difficult, especially in dense vegetation. Observers practiced estimating distances and then checking their estimates with range-finders and by pacing. Since the methods being tested were so dependent upon an observer's ability to accurately record contact distances, this factor could be a considerable source of error in some circumstances, especially when trying to identify the location of an audible contact that can not be seen. As was already discussed, the error in estimating distances to audible contacts was thought to be higher using the Emlen method, but using the Emlen method an observer was much less likely to contact birds audibly. No measurement of this source of error was attempted in the study.

Because more than one investigator was used in this study, there was a theoretical error introduced by differences in proficiency between observers. Kendeigh (1944) found that when censusing birds the degree of accuracy varied widely between observers and times of year. Enemar and Sjostrand (1967) stated only that the differences between census takers was considerable. Using any census method differences exist between the color and hearing perception of observers, as well as their ability to recognize song and call notes. Often times a contact has to be identified by silhouette or be recorded as an unknown.

When comparing observers using data from this study, there did not appear to be a significant difference. The third observer in this study, who recorded data for both of the primary observers, thought there might have been a difference between observers in their willingness, or reluctance, to record a questionable contact. Naturally, because of differences in proficiency and confidence of the observers, differences in willingness to record a contact certainly did exist. However, it was felt that these differences were more a function of the observer than of the census methods used and were discounted since they could not be tested.

Important to the question of observer error is the use of tape recorders for recording questionable contacts. Many times a recorder was used in the study to record an unknown, and was later identified after comparison with known sound recordings. In the case of call notes, the bird was not always identified by sound and since birds were not chased far from the transect they were recorded as unknowns.

Since birds were censused in small tracts of natural vegetation on areas largely altered by man, a question of whether these areas were large enough and homogeneous enough for accurate estimates arises. Williamson (1967) felt that because of edge effect, areas smaller than 100 acres should not be considered for density figures as they would tend to inflate estimates due to the large number of birds in the edge. Kendeigh (1944) felt that population densities for forest-edge and forest-interior birds should be separated because densities of forest-edge species during the breeding season equal more than one-third of the population. This, of course, could not be true in all cases because of the variability in size, configuration, and structure of the edge and also the corresponding size of the interior. Nonetheless, Kirkland (1969) in his research of southeast Michigan woodlots censused interior and edge separately.

Emlen did not consider edge effect a problem but did try to pick census areas of at least 50 acres in size. On smaller tracts, he crisscrossed routes and repeated traverses to obtain an adequate sample size. In this study, a concerted effort was made to choose the largest, most homogeneous sites, and most often they were about 50 acres. In this study the lack of homogeneity in the areas censused was probably the second most important source of error.

Adverse weather can affect any census method. Although wet conditions were encountered many times, only once did it rain hard enough to affect census results in the investigators opinion. That census was not used in the analysis of data for this study. At other times, light precipitation did not appear to affect census data. Many mornings investigators encountered heavy dew without noticeable effect. No attempt to correlate barometric pressure with census data was made.

The Emlen transect count, because of the method of computing density values, is supposed to be unaffected by seasonal variation of populations and individual species conspicuousness. However, as the season progresses and young birds fledge, flocking of family units becomes prevalent in some species. For this reason, when three or more birds of a single species were contacted together they were counted as one to avoid overestimating the true population. Either way, flocking probably leads to a source of error. This is the reason Emlen does not attempt to use his method on flocking species.

A last source of error was the possibility of contacting the same bird twice. Using the Emlen method it did not matter if the same bird was contacted from different transects. However, if a bird was contacted twice on the same transect, it was a source of error. Emlen did not discuss this source of error using his technique. Although a conscious effort was made to avoid this source of doubling, it must have occurred. The problem of doubling on the time-area count (contacting the same bird from different stations) was not considered to be a serious source of error because observers attempted to mentally note location of contacts and would not count them again at consecutive stations. Also, distance between stations was chosen so as to minimize the error for most species.

SUMMARY AND CONCLUSIONS

The Emlen transect technique and a time-area count were tested and compared on two reconnaissance surveys to determine density values of bird populations. The study was done during the preparation of two environmental impact statements on sites in the mid-Michigan area. The two methods were not shown to be significantly different (α = .10) in terms of number of species and individuals contacted. The time-area count was, however, significantly more efficient (α = .10) at contacting species per unit time and individuals per unit time than the Emlen method.

A similarity index was used as an indirect measurement of accuracy of the two methods. The time-area count censuses were significantly more similar at α = .10. Similarity of bird communities in areas classified as the same vegetative type was low, which indicated that although vegetation looked similar in structure and age class there may have been substantial differences between them. For this reason on larger study areas grouping vegetation into types for sampling purposes is difficult and was probably the second most important source of error.

Probably the most important source of error was the difficulty in estimating contact distances, especially audible ones. Lesser sources of error included flocking of birds, observer differences and double recording birds.

An observer using the Emlen method had almost three times the chance of contacting birds visibly than using the time-area count, which might make it easier for a less proficient observer to use. However, the Emlen technique appeared to be more disruptive, which might explain the significantly lower species per minute and individual per minute rate at contacting birds. This disruption in the community might also be responsible for the higher visibility rates for the Emlen technique.

Overall visibility was nearly equal for two observers using the Emlen method. The grackle was the most visible of the twenty-two most contacted species, and the pewee the least. The song sparrow was the most frequently contacted species followed by the redwing blackbird, grackle, robin, and cowbird.

The investigators in this study preferred the time-area count for ease of sampling. They were more comfortable censusing at stations than along the entire transect. Without a second observer on the census or with one of questionable proficiency, it was felt the Emlen method would have lacked accuracy. This might have been different if the transects were marked or had followed trails.

Observer error on identifying aural contacts was minimized by having investigators carry tape recorders and comparing questionable contacts with known recordings.

Although the Emlen transect count is to be used for censusing nonflocking land birds, many species not considered to flock are contacted in groups. This phenomenon can be a problem during the latter part of the breeding season when birds are fledging and family units are contacted. Robins are an example of this phenomenon.

Approximately one-third the total hours of the two reconnaissance surveys was spent either censusing, compiling, or calculating density values of avian populations. Since two methods were being used, approximately one-fourth the total hours would be required to use one method. This may represent too much time for one facet of a reconnaissance environmental analysis. However, as the intensity of the study increases, collection of density information would represent a smaller fraction of the total effort. During this study the Emlen technique was found to be about twice as labor intensive as the time-area count.

In conclusion, I am not sure that density values are important enough in a reconnaissance analysis to warrant the time required. In the five years since this research began, the state of the art has not progressed to where density values are reported even for intensive surveys. Although it may be desirable to report density values, it is questionable whether it will ever be the practice in reconnaissance surveys. More important is the reporting of less common species, and an estimation of the sites importance to those species. Since the time-area count was more time efficient at contacting numbers of species and individuals, I recommend this method be used.

A further recommendation would be to test a combination of the simple transect walk and the time-area count. An investigator could record contacts while walking a transect and stopping at specified locations along the route to record for a specified period of time. Various station times could be easily tested for efficiency. This combination may be more efficient at contacting birds than either of the methods tested in this research.

Since lack of standardization of reporting results has always been a problem, I recommend that species per minute and individuals per minute be reported for each habitat type followed by the number of transect miles in parentheses. Although data reported in this manner would not indicate densities, it would serve as an index. Species per minute and contacts per minute can be easily calculated from simple transect or station counts and are a measure of relative abundance. Using data expressed in this manner along with a species list, a diversity index (MacArthur and MacArthur, 1961), and a report of less common species (i.e., threatened and endangered) comparisons can be made between communities on the same site or between sites and would be adaptable to any habitat.

APPENDIX A

APPENDIX A: Bird Census Data

Date: Observer(s): Site: Area:

Time Start: Time Finish: Photo #:

Temp: Wind: Cloud Cover: Precipitation:

CONTACTS

Species	Sex M	Sex F	Visual	Song-Call	Distanct From Transect 0-100	100-200	200-400	400+	angle in degrees

APPENDIX B

APPENDIX B

SPECIES CONTACTED DURING THE STUDY

Common Name	Scientific Name[a]
Pied-billed grebe	Podilymbus podiceps
Great blue heron	Ardea herodias
Green heron	Buterides virescens
American bittern	Botaurus lentiginosus
Mallard	Anas platyrhymchos
Green-winged teal	Anas carolinensis
Blue-winged teal	Anas discors
Wood duck	Aix sponsa
Turkey vulture	Cathartes aura
Sharp-shinned hawk	Accipiter striatus
Cooper's hawk	Accipiter cooperii
Red-tailed hawk	Buteo jamaicensis
Red-shouldered hawk	Buteo lineatus
Marsh hawk	Circus cyaneus
Kestrel	Faleo tinnunculus
Ruffed grouse	Bonasa umbellus
Bobwhite	Colinus virginianus
Ring-necked pheasant	Phasianus colchicus
Virginia rail	Rallus limicola
Sora	Porzana carolina
American coot	Fulica americana
Killdeer	Charadrius vociferus
Woodcock	Philahela minor
Common snipe	Capella gallinago
Spotted sandpiper	Actitus macularia
Solitary sandpiper	Tringa solitaria
Rock dove	Columba livia
Mourning dove	Zenaidura macroura
Yellow-billed cuckoo	Coccyzus americanus
Black-billed cuckoo	Coccyzus erythropthalmus
Screech owl	Otus asio
Great horned owl	Bubo virginianus
Whip-poor-will	Caprimulgus vociferus
Common nighthawk	Chordeiles minor
Chimney swift	Chaetura pelagica
Ruby-throated hummingbird	Archilochus colubris
Belted kingfisher	Megaceryle alcyon
Yellow-shafted flicker	Colaptes auratus

[a]After A.O.U. check-list (1957).

Common Name	Scientific Name
Red-bellied woodpecker	Centurus carolinus
Red-headed woodpecker	Melanerpes erythrocephalus
Yellow-bellied sapsucker	Sphyrapicus varius
Hairy woodpecker	Dendrocopus villosus
Downy woodpecker	Dendrocopus pubescens
Eastern kingbird	Tyrannua tyrannus
Great crested flycatcher	Myiachus crinitus
Eastern phoebe	Sayornis phoebe
Acadian flycatcher	Empidonax virescens
Willow flycatcher	
Least flycatcher	Empidonax minimus
Eastern wood pewee	Contopus virens
Horned lark	Eremophila alpestris
Tree swallow	Iridoprocne bicolor
Rough-winged swallow	Stelgidopteryx ruficollis
Barn swallow	Hirundo rustica
Cliff swallow	Petrochelidon pyrrhonota
Purple martin	Progne subis
Blue jay	Cyanocitta cristata
Common crow	Corvus brachyrhynchos
Black-capped chickadee	Parus atricapillus
Tufted titmouse	Parus bicolor
White-breasted nuthatch	Sitta cardinensis
House wren	Troglodytes aedon
Winter wren	Troglodytes troglodytes
Catbird	Dumetella carolinensis
Brown thrasher	Toxostoma rufum
Robin	Turdus migratorius
Wood thrust	Hylocichla mustelina
Swainson's thrust	Hylocichla ustulata
Veery	Hylocichla fuscescens
Eastern bluebird	Sialis sialis
Blue-gray gnatcatcher	Polioptila cacrulea
Golden-crowned kinglet	Regulus satrapa
Cedar waxwing	Bombycilla cedrorum
Starling	Sturnus vulgaris
Yellow-throated vireo	Vireo flavifrons
Red-eyed vireo	Vireo olivaceus
Philadelphia vireo	Vireo philadelphicus
Warbling vireo	Vireo giluus
Black-and-white warbler	Mniotilta varia
Golden-winged warbler	Vermivora chrysoptera
Tennessee warbler	Vermivora peregrina
Yellow warbler	Dendroica petechia
Magnolia warbler	Dendroica magnolia
Myrtle warbler	Dendroica coronata
Black-throat green warbler	Dendroica virens
Blackbur	Dendroica fusca
Chesnut-sided warbler	Dendroica pensylvanica
Bay-breasted warbler	Dendroica castanea

Common Name	Scientific Name
Ovenbird	Seiurus aurocapillus
Yellowthroat	Geothlypus trichas
American redstart	Setophaga ruticilla
House sparrow	Passer domesticus
Bobolink	Dolichonyx oryzivorus
Eastern meadowlark	Sturnella magna
Red-winged blackbird	Agelaius phoeniceus
Orchard oriole	Icterus spurius
Northern oriole	Icterus gallenla
Common grackle	Quiscalus quiscula
Brown-headed cowbird	Molathrus ater
Scarlet tanager	Piranga olivacea
Cardinal	Richmondena cardinalis
Rose-breasted grosbeak	Pheucticus ludovicianus
Indigo bunting	Passerina cyanea
Dickcissel	Spiza americana
American goldfinch	Spinus trestes
Rufous-sided towhee	Pipilo erythrophthalmus
Savannah sparrow	Passerculus sandwichensis
Henslow's sparrow	Passerherbulus henslowii
Vesper sparrow	Pooecetes gramineus
Chipping sparrow	Spizella passerina
Field sparrow	Spizella pusilla
White-crowned sparrow	Zonotrichea leucophrys
White-throated sparrow	Zonotrichea albicollis
Swamp sparrow	Melospiza georgiana
Song sparrow	Melospiza melodia

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