MONITORING BIRD POPULATIONS ON NATIONAL FOREST LANDS: CHIPPEWA NATIONAL FOREST, 1992

A summary report submitted to:

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Submittal date: December 1992

Budget Period: 1 January - 31 December 1992
Project Period: 1 May, 1991 - 31 December 1993

CNF Report No. 2, 1992
NRRI/TR-92/21

INTRODUCTION

A habitat specific bird monitoring was established on the Chippewa National Forest in 1991 (see Hanowski and Niemi 1991a, 1992). The objectives of the program were to: (1) establish the physical layout of the monitoring program (2) monitor abundance of indicator bird species that have been specified by the Forest; (3) monitor abundance of common bird species in the Forest; and (4) begin refining avian/habitat relationships used to assess forest management activities on breeding bird abundance and distribution. Additional goals for 1992 monitoring were to: (1) make statistical comparisons between 1991 and 1992 bird abundance; (2) determine the power of statistical analyses in terms of detecting annual differences for a variety of bird community, guild, and species specific parameters; and (3) explore similarities and differences in habitat data collected and the U.S. Forest Service forest types.

STUDY AREAS

A major goal this year was to compare habitat data collected within each point count to forest cover type assigned by the Forest Service. We examined data collected at each point in both 1991 and 1992 and identified points where major tree species (forest type) not included in our habitat data. For example, we identified stands that were classified as red pine stands, but where red pine was not included as one of five tree species listed on any of three points within the stand in either 1991 or 1992. We then examined the habitat data in more detail and if it was clear that the stand was misclassifed, we reclassified the stand into a more appropriate forest type. This step was extremely important and was necessary to complete before we begin to furthur analyze habitat associations of birds in the forests. Stands and points where forest type were changed are in Table 1. Note that some stands were harvested between 1991 and 1992 and these stands were changed to regenerating age. General locations of sample areas are shown in Figure 1. See Hanowski and Niemi (1991a) for a description of study area selection.

Some stands listed in Table 1 where n < 3 were dropped from the analyses because it was determined that the stand was too heterogenous in terms of habitat. For example, one point may have been classified as an oak type while the other two points were classified as aspen. Two stands were dropped (not sampled in 1992) because one of three points were not sampled due to inability to locate a point. Forest type changes were made either due to logging (e.g., type 1 to 91), misclassification (e.g., 25 to 71), or judgement (e.g., 71 to 18). This represents a small proportion of the total number of stands sampled (5%). We will examine habitat types for stands that have less than three points to determine if a point can be relocated in another portion of the stand.

All stands were relocated in spring of 1992 and census points were remarked. This was necessary because stands were marked primarily with flagging in 1991 and the condition of flagging deteriorates especially in open areas and in areas where there are high densities of deer and humans. More paint was used this year to permanently mark points and routes between points. We anticipate that this time consuming process will not have to be repeated in subsequent years.

Table 1. Stands that were not included in annual variation comparisons or where forest type was changed from 1991 to 1992.

District	Compartment	Stand	Previous Forest type	Present Forest type
9031	48	24	99	not sampled in 1992
9031	281	28	25	71
9032	10	1	82	n < 3
9032	10	4	91	n < 3
9032	10	18	11	n < 3
9032	10	20	2	91
9032	11	123	91	n < 3
9032	110	29	15	n < 3
9032	112	33	1	not sampled in 1992
9032	112	46	1	91
9033	167	9	91	11
9034	121	15	71	18
9035	12	36	55	partially logged
9035	103	8	1	2

METHODS

Bird census. We conducted one bird census (10 minutes in duration) at each point during a two week period in June using the point-count method (Reynolds et al. 1989). This is an excellent method for determining relative abundance of singing passerine species, but is inadequate for raptors and waterfowl species. In addition, because only one census is conducted in June, this method probably underestimates relative densities of early nesting species (e.g., most permanent residents including woodpeckers and chickadees).

Four trained (see observer training section below) observers conducted the censuses which were done from 0.5 hours to 4 hours after sunrise. Censuses were conducted only during good weather (e.g., wind < 15 mph and no precipitation). Types of stands censused (forest cover type) were stratified by time of morning. For example, we avoided sampling all upland pine stands early or late in the morning. Forest cover types censused were also stratified by observer; each observer sampled relatively the same number of stands in each forest type.

We recorded weather (cloud cover, temperature, and wind speed) and time of day the census was conducted. All birds heard or seen from the center point were recorded in a circle with estimates of their distance from the center point. Numbers of individuals observed for each species were summed for three, five, and ten minute periods (see Hanowski and Niemi 1991a).

Observer training. Two of the four observers in this study had conducted systematic bird counts in 1991. Tapes of bird songs were provided as a learning tool for all observers and all were required to pass an identification test of 75 bird songs made by Cornell University's Laboratory of Ornithology. A standard for number of correct responses was established by giving the test to observers trained in identification of birds by sound and that had four to five years of experience. This was done to identify songs on the tape that were not good representations of songs heard in northern Minnesota. Based on results of trained observers, we set the standard for passing at 85% correct responses. Songs on the tape were grouped by habitat (e.g., upland deciduous) to simulate field cues that would aid in song identification.

Observer field training was done in late-May. Observers were first instructed on the methods for recording data on the field sheets. Observers then conducted simultaneous counts (four mornings; 40 points) and were allowed to ask questions about unknown birds after each count (10 minute count). Count information was compiled for each observer and new observer data was compared to the experienced observer data. Species lists and number of individuals recorded on the count by each observer were compared. Deviations from the average or species missed were noted on the field sheets and returned to each observer.

In addition to training and testing, all observers were required to have a hearing test to ensure that their hearing was within normal ranges for all frequencies (125 to 8000 hertz). Normal ranges were standards established by audiologists.

Habitat data. We collected information on habitat structure and plant species composition at the center of each point. We estimated canopy height (m) and recorded tree and shrub species (up to five each). Tree and shrub density was estimated and coded by abundance (see Hanowski and Niemi 1991a). Percent coverage of vegetation layers at the high canopy, subcanopy, understory and ground levels were also estimated and coded. Codes were also recorded for topography and special features (e.g., snags). These data will ultimately be used to identify habitat features that may be important to bird species within individual forest cover types and ages.

Stand size. We separated each forest cover type into three groups based on age or stand origin and stocking density. We used the Forest Service classification of stand size density for three classes: regenerating, pole size, and saw size. This information was obtained from the VMIS database or the compartment maps. We changed the stand size if, after field verification the stand had changed since the database or compartment map had been updated (e.g., especially regenerating stands).

Data management. All data were entered into a Paradox file directly from the field data sheet. Several checks were made of the data file by someone other than the person who entered the data. After the data files were checked, information on birds within a stand were grouped (i.e., three points). Stands where we were not able to place three points were not included in this summary file. In addition, we assigned each species into groups based on migration strategy, feeding method and substrate, and nest location (see Hanowski and Niemi 1991a).

Density calculations. We calculated relative abundance values for each species. This information was necessary to determinea rleative index for indicator species in each forest. We calculated numbers of territorial males / 40 acres by summing numbers of individuals for each species in three points within each stand. We determined the area of each sample (point count) based on a radius of 100 m for most species. We used a smaller radius of 75 m for Brown Creeper, Cape May Warbler, Golden-crowned Kinglet, and Bay-breasted Warbler because we were not confident that we could detect these species beyond that distance. A priority for work in subsequent years is to determine detection limits for a variety of species. A relative abundance value for each bird in the forest can be calculated by multiplying the relative index value of a species within each habitat by the total amount of that habitat in the forest. Because we have presented densities as number of territorial males / 40 acres, these values must then be divided by 40 to establish number of males in the forest. Relative index for each species within each forest type and stand size (e.g., pole size) can be summed to determine total numbers of territorial males in all cover types.

The relative index calculations should be used with caution. They are not meant to be a density for the Forest. Rather, they should be viewed as base values upon which future monitoring data can be compared to determine whether the relative number of individuals observed in each cover type tend to be decreasing, increasing, or remaining the same. More importantly, as these data are coupled with forest change, they will allow an approximate measure of the effects of these changes on a forest-wide basis.

Statistical methods. We used a repeated measures analysis of variance (ANOVA) to test for differences in bird abundance between stands sampled in 1991 and 1992. Because bird species composition changes with change in forest type, we did not include stands that had changed or that were not sampled in both years. These comparisons would identify changes due to habitat and not to annual variation. A repeated measures ANOVA is relevant when several measurements (e.g., multiple years) are taken on each experimental unit and the measurements are correlated. The test is essentially a multivariate technique to take correlations among the dependent variables into account while testing for treatment effects (Freund et al. 1986). Data were examined separately for each species (all stands and by habitat type), providing that the mean observed/stand was ≥ 0.2 in one year.

Annual differences were also examined for total number of species and individuals observed/stand and numbers of individuals within all guild types. The same model was used for these tests. All variables were examined for normality and homoscedasticity of variances prior to statistical analyses (Sokal and Rohlf 1981) and were transformed when necessary (e.g., logarithmic or square root) to reduce skewness, kurtosis, and heterogeneity of variances.

We calculated the power of statistical analyses (repeated measures ANOVA) using mean and variance data from 1991 and 1992. We used the formula (below) to calculate an effect size (f) which relates to the power of the statistical test. In this case we calculated f in the equation where d.f. = number of years of monitoring - 1 (in this case 2-1 =1): % = percent difference that we would like to be able to detect among years (this is determined by multiplying the percent by the mean value of the variable): and s.d. = standard deviation based on the mean values from 1991 and 1992. We accepted an f value for a percent difference (we used 10, 25, and 50%) if the power was greater than or equal to 0.80.

$$f = \sqrt{\frac{d.f._{num}\left(\frac{\%\bar{x}}{s.d.}\right)}{\#\ yrs}}$$

RESULTS

Bird communities. Overall (all stands) total number of individuals and species observed per stand were lower ($P < 0.05$) in 1992 than in 1991 (Table 2). Eighty-nine species were observed in 1992 compared with 82 species in 1991. Fourteen species were observed only in 1992 and 9 species were observed in 1991 only (Table 2). Most species that were observed in only one year were uncommon and were observed on only one or two stands.

Individual species. Eleven species (35 tested) differed significantly in relative abundance from 1991 to 1992 (Table 2). Eight of the species declined including the Eastern Wood Pewee, Brown Creeper, Winter Wren, Golden-crowned Kinglet, Hermit Thrush, Red-eyed Vireo, Yellow-rumped Warbler, and White-throated Sparrow from 1991 to 1992. Three species, Gray Jay, Nashville Warbler, and Common Yellowthroat increased in relative abundance from 1991 to 1992 (Table 2).

Bird guilds. Bird relative abundance within three of seven habitat guilds decreased significantly from 1991 to 1992 (Figure 2). Decreases were most marked in upland mature (pole and saw size) stands (e.g. upland deciduous, upland coniferous, and upland mixed).

No annual differences were detected for early successional, upland openings, wet shrub, or lowland conifer groups (Figure 2).

Birds that feed on ground invertebrates or ground invertebrates and seeds decreased significantly from 1991 to 1992 (Figure 3). All other groups (except those classified as omnivores) declined slightly but not significantly from 1991 to 1992. The magnitude of the decline from 1991 to 1992 was least among the group of flycatchers (Figure 3).

Number of permanent resident individuals were essentially the same in 1991 and 1992 and long-distance migrant decreased slightly (Figure 4). In contrast, numbers of short-distance migrants declined dramatically ($P<0.01$) from 1991 to 1992 (Figure 4).

Number of males/stand within two of four nesting guilds decreased significantly from 1991 to 1992. Numbers of individuals within canopy and cavity nesting groups decreased whereas numbers within the shrub nesting type increased slightly (Figure 5). Numbers of individuals within the ground nesting guild also decreased, but the change was not significant (Figure 5).

Habitat specific comparisons. Total individuals observed in pole and saw size upland deciduous forests did not differ significantly between 1991 and 1992 (Table 3). Five of 26 species tested differed in abundance from 1991 to 1992. The Brown Creeper and Red-eyed Vireo decreased, while the Black-and-white Warbler, Common Yellowthroat and Rose-breasted Grosbeak increased (Table 3).

Total number of individuals and species within upland coniferous stands (saw and pole size) decreased from 1991 to 1992 (Table 3). Six of 29 species tested differed significantly in this habitat type from 1991 to 1992. The Golden-crowned Kinglet, Yellow-rumped Warbler, Pine Warbler, and Mourning Warbler all decreased from 1991 to 1992. Two species, the Common Yellowthroat and Nashville Warbler showed a significant increase in abundance in upland conifer stands from 1991 to 1992 (Table 3).

Total number of individuals/stand within lowland deciduous habitats (pole and saw size stands) increased from 1991 to 1992, but the difference was not significant (Table 3). The number of species decreased slightly and five of 37 species tested differed annually. The Pileated Woodpecker and Eastern Wood Pewee decreased significantly in lowland deciduous habitat types while the White-breasted Nuthatch, American Redstart, and Scarlet Tanager all increased (Table 3).

Number of individuals and species/stand within lowland conifer habitat types (pole and saw size) were essentially the same in 1991 and 1992 (Table 3). Four of 32 species tested differed significantly from 1991 to 1992. Three species, Brown Creeper, Winter Wren, Swamp Sparrow decreased and the Gray Jay increased in abundance from 1991 to 1992 (Table 3).

In upland early successional habitats, number of individuals observed in 1991 and 1992 were equal, but fewer (not significantly so) species were observed in 1992 (Table 3). Three of 39 species tested changed significantly in abundance from 1991 to 1992. The Eastern Wood Pewee and White-throated Sparrow declined and the Nashville Warbler increased in abundance from 1991 to 1992 (Table 3).

A decrease in numbers of individuals and species was observed from 1991 to 1992 in early successional lowland habitats, but the difference was not statistically significant (Table 3). Only one species of 31 tested, the Golden-crowned Kinglet showed a significant difference; we did not observed in our 1992 censuses 1992 (Table 3).

Overall, of species that differed in relative abundance between 1991 and 1992 more decreased than increased (Figure 6). The number of significant changes within each habitat group is related to the number of stands in the group. This is related to the power of our statistical tests (e.g., with everything else equal a test is more powerful if the sample size is larger). For example, the largest number of species differences between years was noted for analyses based on all stands (n=134) and the fewest number in the early successional lowland habitat group (n=8) (Figure 6).

Power analysis. Results of the power analysis indicated that we should be able to detect a 10% annual change for bird community parameters (e.g., number of individuals and species), for guild parameters, and for two species (Red-eyed Vireo and Ovenbird) with two years of monitoring (Table 4). A 25% difference is detectable for an additional 27 species including two of the Chippewa National Forest's indicator species (Blackburnian Warbler and Pine Warbler) (Table 4). This represents about one third of the total number of species that we observed in the Forest.

Indicator species. Two of three indicator species (Northern Parula and Blackburnian Warbler) declined from 1991 to 1992. The Pine Warbler increased slightly from 1991 to 1992. The Northern Parula decreased by 52% (from 6332 males in 1991 to 3048 males in 1992). The most marked decline (5081 to 1892 males) occurred in saw size stands (Figure 7). The Blackburnian Warbler decreased by 25% (from 7693 males to 5748 males in 1992) (Figure 8). Like the Northern Parula, the largest decline occurred in saw size stands. A substantial increase, however was found in lowland conifer stands (sapling size, Figure 8). Like the other two species, numbers of Pine Warblers declined in saw size stands (Figure 9). However, this species increased in sapling and pole size stands which resulted in its overall increase from 1991 to 1992 (Figure 8).

Relative abundance for each species in 1991 and 1992 for each habitat type were based on the 1991 forest inventory. Therefore, changes in amounts of habitat from 1991 to 1992 have not been factored into calculation of 1992 relative abundance values.

Table 4. Individual species that we were able to detect a 10% or 25% change in abundance based on two years of monitoring and a sample size of 134 stands. See text for furthur description of power analyses.

10% Difference	25% Difference
Red-eyed Vireo	Yellow-bellied Sapsucker
Ovenbird	Eastern Wood Pewee
	Least Flycatcher
	Great Crested Flycatcher
	Blue Jay
	Black-capped Chickadee
	Brown Creeper
	Winter Wren
	Golden-crowned Kinglet
	Veery
	Hermit Thrush
	American Robin
	Nashville Warbler
	Chestnut-sided Warbler
	Yellow-rumped Warbler
	Black-throated Green Warbler
	Blackburnian Warbler
	Pine Warbler
	American Redstart
	Mourning Warbler
	Common Yellowthroat
	Scarlet Tanager
	Rose-breasted Grosbeak
	Chipping Sparrow
	Song Sparrow
	White-throated Sparrow
	Brown-headed Cowbird

DISCUSSION

Bird communities. We present relative abundance of bird abundance for data gathered in 1991 and 1992 but caution that these data are best used for comparisons of annual variation within the Chippewa National Forest. For example, because the sample was allocated to cover types based on amount of that cover type in the Forest we do not have equal sample sizes in each cover type (Appendix 1). Difference in number of stands sampled within each forest cover type (and age) has an affect on relative bird abundance values especially number of species. For example, the number of species observed within a particular cover type is positively correlated with the area of that cover type (number of stands) that were censused. We would expect more species to be recorded in cover types that had the most samples. There are statistical procedures that correct for species/area effects (e.g., rarefaction) and if we intended to compare data collected in the Chippewa National Forest to other areas it would be best to standardize these data. Again, we stress that the objective for the monitoring is to assess annual variation in relative terms for the Chippewa National Forest. Therefore, it is not necessary that we standardize the species counts because the comparison that we used to assess annual variation was based on a comparison of stands among years.

The pattern of decline in numbers of species and individuals from 1991 to 1992 was also observed in the Superior National Forest, but the trend was not significant (Hanowski and Niemi 1993). An overall decline in bird abundance, however was not observed in northern Michigan. In this area, a slight increase in numbers of species and individuals was observed from 1991 to 1992 (Helle et al. in prep.). Annual differences in bird abundance are not unusual and are likely due to a variety of factors including weather and some possibly due to annual differences in song phenology (see Blake et al. 1992).

Bird guilds. Magnitude and direction of annual changes in bird numbers are often different for species that prefer different types of habitat (based on guilds). Annual variation of species within habitat groups observed here agree with changes that we have found in northern Michigan and Wisconsin (see Blake et al. 1992). That is, in years where decreases are detected, declines are more pronounced in individuals that occur in upland habitats. In the Chippewa National Forest, this was most evident for total numbers of individuals in upland deciduous, mixed, and coniferous stands (Figure 2). Similar results were observed in the Superior National Forest (Hanowski and Niemi 1993).
Magnitude and direction of change from 1991 to 1992 was also different among birds that have different foraging or nesting preferences. All guilds (except omnivores and shrub nesters) decreased, but the group that feeds on the ground and that nests in the canopy or in cavities illustrated the greatest annual change. In the Superior National Forest, ground feeders and nesters and those species that feed on bark insects declined (Hanowski and Niemi 1993). In both forests, the flycatchers showed the opposite pattern.

Blake et al. (1992) observed that long-distance migrants were more likely to decrease in response to a drought than were permanent residents and short-distance migrants when the drought was most severe in May and June. We observed no difference in numbers of individuals in these two groups from 1991 to 1992, but the number of short-distance migrants declined in both the Chippewa and Superior National forests. This difference may be related to weather, but unlike the drought of the late 1980's, the 1992 breeding season was colder on average than normal. Temperatures in the north central region of Minnesota were below normal in April, June, and July (Table 5). Rainfall during these months were below normal in all months except July. Below normal temperatures may affect short-distance migrants more than long-distance migrants because they normally arrive earlier in the season, begin nesting earlier, and would therefore be more susceptible to cold temperatures such as those observed in April. Affects of cold weather on insect abundance is likely another possible explanation for the overall decline in bird abundance from 1991 to 1992.

Table 5. Deviation from normal temperature and rainfall for the north central and north east regions of Minnesota in April, May, June, and July 1992. Data are from climatological summaries for Minnesota provided by NOAA.

Month	Region	Temperature	Rainfall
April	North central	-2.8	-0.54
	Northeast	-3.3	0.11
May	North central	3.2	-1.44
	Northeast	2.3	0.02
June	North central	-2.9	-0.35
	Northeast	-3.3	-0.53
July	North central	-7.1	0.17
	Northeast	-6.6	-0.16

Individual species. In general, more species declined from 1991 to 1992 than increased and this was also evident in the Superior National Forest (Hanowski and Niemi 1993). Species that decreased in both regions included the Red-eyed Vireo, White-throated Sparrow, and Yellow-rumped Warbler. Two of these species (White-throated Sparrow and Yellow-rumped Warbler) are short distance migrants. One species, the Common Yellowthroat increased in the Chippewa National Forest, but showed a significant decline in the Superior National Forest. Of the species that increased in the Chippewa National Forest (Gray Jay, Nashville Warbler, Common Yellowthroat) all occur in highest densities in wetland community types. Annual variation on a species specific level based on two years of monitoring are difficult to explain. Based on previous data from the Great Lakes region, significant annual differences detected in any year are likely not to be repeated in subsequent years (Blake et al. 1992). Many years of data are required to detect significant trends.

Although there was a decrease in the number of males of two indicator species from 1991 to 1992 (Northern Parula and Blackburnian Warbler), no significant annual differences were detected based on all stands sampled or for individual habitat types. The Blackburnian Warbler however, declined significantly in the Superior National Forest in 1992 (Hanowski and Niemi 1993). In contrast, numbers of Pine Warblers increased (not significantly so) overall, but a significant decrease was noted for this species in the upland conifer habitat type. Again, it is difficult to interpret these changes based on trends from two years of data.

Power of statistical analyses. Percent difference detectable for individual species is dependent primarily on the relative abundance of the species in the Forest. For example, the Red-eyed Vireo and Ovenbird are the most abundant birds in the Forest and we were able to detect a 10% change in abundance between years for these species. These species also occur over a wide range of habitat types. A 25% difference was detectable for a variety of species including woodpeckers (1), flycatchers (3), warblers (10), sparrows (3), thrushes (3), icterids (3), jays and chickadees (2), and kinglets, creepers, wrens (3). Power of detecting differences decreases for less common species like the Gray Jay (100% change) and it is not realistic to detect differences for species that are observed in only of few stands. It is possible to detect a 25% change for about one third of the species that we have observed on our point counts.

Summary. We established a monitoring program in the Chippewa National Forest that was designed to assess annual changes in bird numbers and to attribute possible changes in numbers as a response to habitat changes that have occured in the forest or to natural fluctuations in bird numbers. Data collected in 1991 and 1992 have provided information on relative abundance of bird species within representative cover types in the Chippewa National Forest and annual variation among guilds and species. The next step is to link habitat data and forest type to determine critical habitat needs on a species specific basis. This information can be used to aid forest management by providing information to establish harvesting and regenerating guidelines for individual forest cover types. Power of statistical analyses calculations indicated that we should be able to detect less than a 10% annual change in bird numbers (individuals/40 acres), a 10% change for two species, and a 25% change for an additional 27 species. These numbers indicate that a sufficient sample size is in place to detect the magnitude of difference that we feel is adequate for many species.

LITERATURE CITED

Blake, J. G., G. J. Niemi, and J. M. Hanowski. 1992. Drought and annual variation in bird populations. In J. M. Hagan III and D. W. Johnston, eds. Ecology and Conservation of Neotropical Migrant Landbirds. Smithsonian Institution Press, Washington, D.C.

Freund, R. J., R. C. Littell, and R. C. Spector. 1986. SAS system for lineal models. SAS Institute, Inc. Cary, NC. 210 p.

Hanowski, J. M. and G. J. Niemi 1991a. Monitoring bird populations on National Forest lands: Superior National Forest, 1991. SNF Report No. 1, NRRI/TR-91/21. Duluth, MN: Center for Water and the Environment, Natural Resources Research Institute, University of Minnesota.

Hanowski, J. M. and G. J. Niemi 1991b. Monitoring bird populations on National Forest lands: Chippewa National Forest, 1991. CNF Report No. 1, NRRI/TR-91/20. Duluth, MN: Center for Water and the Environment, Natural Resources Research Institute, University of Minnesota.

Hanowski, J. M. and G. J. Niemi 1993. Monitoring bird populations on National Forest lands: Superior National Forest, 1992. SNF Report No. 2, NRRI/TR-93/xx. Duluth, MN, Center for ater and the Environment, Natural Resources Research Institute, University of Minnesota.

Helle, P., J. G. Blake, J. M. Hanowski and G. J. Niemi. in prep. ELF communications system ecological monitoring program: bird species and communities.

Hanowski, J. M. and G. J. Niemi. 1992. Experimental design and statistical considerations for establishing a regional monitoring program using point counts. In: Monitoring bird population trends by point counts. in press.

James, F. C. and S. Rathbun. 1981. Rarefaction, relative abundance, and diversity of avian communities. Auk 98: 785-800.

Reynolds, R. T., J. M. Scott, and R. A. Nussbaum. 1980. A variable circular-plot method for estimating bird numbers. Condor 82: 309-13.

Robbins, C. S., D. K. Dawson, and B. A. Dowell. 1989. Habitat area requirments of breeding forest birds of the middle atlantic states USA. Wildlife Monographs 103: 1-34.

Sokal, R. R. and F. J. Rohlf. 1981. Biometry 2nd Edition. W. H. Freemen and Co., San Francisco, CA. 859 p.