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A Land Manager's Guide to Point Counts of Birds in the Southeast

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SUMMARY

Current widespread concern for the status of neotropical migratory birds has sparked interest in techniques for inventorying and monitoring populations of these and other birds in southeastern forest habitats. The present guide gives detailed instructions for conducting point counts of birds. It further presents a detailed methodology for the design and conduct of inventorial and monitoring surveys based on point counts, including discussion of sample size determination, distribution of counts among habitats, cooperation among neighboring land managers, vegetation sampling, standard data format, and other topics. Appendices provide additional information, making this guide a stand-alone text for managers interested in developing inventories of bird populations on their lands.

ACKNOWLEDGMENTS

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INTRODUCTION

Concern over declining numbers of neotropical migratory birds has sparked interest among managers in inventorying and monitoring these and other nongame birds (Hunter and others 1993a). Although such assessments are time consuming and costly, they are essential in evaluating the status of these species so that informed management will be ensured. This guide is provided to assist managers in the Mississippi Alluvial Valley (MAV) and throughout the Southeast in accumulating inventories and monitoring changes in nongame birds in southeastern habitats.

This guide is consistent with the guidelines of the monitoring group of the Partners in Flight Neotropical Migratory Bird Conservation Program (Ralph and others in press). The standard handbook for monitoring landbirds, Ralph and others (1993), will be useful to readers of this guide. Intended to assist managers in designing, conducting, and maintaining monitoring, this guide is based on work conducted in the Mississippi Alluvial Valley since 1985, and reflects what will work on the ground. It is not a complete discussion of the various monitoring and inventory techniques, and cannot claim to provide all the answers; accordingly, additional sources of more technical information are indicated. Statistical advice beyond that presented in this guide will be useful to managers as they cooperate and pool their data.

This guide has been written by a group of land managers and research biologists whose individual opinions are strong and frequently opposed to each other. The group has a common focus, however. It believes that an inventory of nontarget resources, such as birds, is essential for wise land management. It is equally convinced that monitoring changes in the status of such nontarget resources is both an urgent and an important part of land management activities. Indeed, for many public land managers, such monitoring is a part of legal requirements for maintaining viable populations. The group believes it is also imperative that managers cooperate with their neighbors in accumulating inventory information. Keeping these complex issues in focus, however, is not easy. Strong efforts have been made to maintain a perspective that is neither of entirely practical land management nor of purely research interest. The group sincerely hopes that it has not lost its audience somewhere between the work center and the ivory tower. Thus, readers are urged to follow the guide closely and not avoid the equations.

As a general approach, this guide strives to present a clear statement of a technique or need in the text; it then provides a more technical or extended discussion of the topic in an appendix. For efficiency of use, each topic is divided into "The Basics" and "More Detail." "The Basics" should be enough for the reader to initiate inventory and monitoring activities. "More Detail" will be available when needed. Still further detail is provided in selected appendices. Some topics, such as the nature of a point count, consist only of "The Basics."

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METHODS PRELIMINARY TO POINT COUNTS

The Basics

The most basic form of bird inventory is the list of the bird species that have been observed on a particular piece of land. This guide assumes that managers have such lists of birds for their properties. Almost spontaneously, those lists will stimulate the curiosity of managers and of their clients. Questions about the birds on the list will arise, leading managers to desire information about variations in inventory among different kinds of habitats, among different management treatments of those habitats, among adjacent properties with different land uses, and about trends in numbers over time. Answering these questions requires monitoring the birds on the property. Managers can refer to a decision tree developed for counting methods to select an inventory and monitoring approach (table 1).

More Detail

Point counts constitute one of several methods of inventorying and monitoring birds. Other techniques include spot mapping, counts on line transects, capture-recapture with mist nets, and nest monitoring. Point counts are most often conducted in the breeding season, but are suitable for work in other seasons as well (Gutzwiller 1993). Although the recommendation of Ralph and others (1993) that monitoring should involve more than point counting is undoubtedly correct, only point counts are treated in this guide. Other methods are explained in Finch and Stangel (1993), Ralph and others (1993), and Wunderle (1994).

Table 1.—Decision tree for matching information needs with various approaches to monitoring birds

I. What level of detail is necessary?

1. Do you want to know about presence/absence?
   NO—Go to 2.
   YES—Simple species list is enough; go to 7.

2. Do you want to know about numbers and trends?
   NO—Go to 3.
   YES—Point counts, and this guide, are for you; go to 4.

3. Do you want to know about population characteristics, such as survival and productivity?
   NO—Point counts, and this guide, are for you; go to 4.
   YES—Demographic methods, such as nest searches or constant-effort mist netting, are for you; see Ralph and others (1993).

II. Which species are of interest?

4. Do you want to know about all species?
   YES—A general method, like point counts, is for you; go to 7.
   NO—Go to 5.

5. Do you want to know about a particular group of species?
   YES—Go to 6.
   NO—A single species? In this case your needs are beyond those of a general guide, and you will likely be doing a specific study with methods tailored directly to that species alone.

6. Which species group interests you?
   Game species—These are beyond the scope of this guide; consult a recognized text on the species of interest.
   Waterbirds—These are beyond the scope of this guide.
   Landbirds—
      Raptors, including hawks and owls—
         Because of low population density, most of these birds are beyond the scope of this guide.

Night birds, including owls, whip-poor-wills, and the like— Most of these require specific nocturnal searches, although nighttime point counts would work for many of them.
Other landbirds, such as flycatchers, woodpeckers, thrushes, warblers, wrens, etc.—Most species belong to this group for which point count monitoring works well; go to 7.

III. What sort of information is needed?

7. Do you have a list of the birds on your property?
   YES—Go to 8.
   NO—Compile one by getting volunteers to share observations with you; go to 8.

8. Is this enough information to support your monitoring needs?
   YES—Continue your existing monitoring scheme.
   NO—Go to 9.

9. Do you know the changes in species occurrence from year to year?
   YES—Go to 10.
   NO—Begin recording an annual birdlist from checklists supplied by volunteers; go to 10.

10. Is this enough information to support your monitoring needs?
    YES—Continue your existing monitoring scheme.
    NO—Go to 11.

11. Do you know changes in relative abundance in your region from year to year?
    YES—Go to 12.
    NO—Participate in the Breeding Bird Survey; go to 12.

12. Do you want to know trends in relative abundance across your property in general?
    NO—Continue your existing monitoring scheme.
    YES—This guide can help; do an annual set of roadside counts; go to 13.

13. Do you want to know trends in relative abundance by habitat for your property?
    NO—Continue your existing monitoring scheme.
    YES—This guide can help; do annual set of habitat-specific, off-road counts; go to 14.

14. Do you want to know how relative abundance responds to specific management actions?
    NO—Continue your existing monitoring scheme.
    YES—This guide can help; arrange off-road counts for before-after comparisons; go to 15.

15. Do you want to know population (demography) responses rather than how relative abundance responds to management treatments?
    NO—Stop; continue your existing monitoring scheme.
    YES—Your needs exceed what this guide can offer; institute demographic monitoring technique such as nest searching or constant-effort mist netting; see Ralph and others (1993).

WHAT IS A POINT COUNT?

The Basics

A point count is a tally of all birds detected visually or aurally by a single observer from a fixed station during a specified period (e.g., 5 minutes). Counts are made in the morning (e.g., before 10:00 a.m. daylight time [09:00 a.m. standard time]) typically during the breeding season (usually May and June) under acceptable weather conditions (e.g., winds less than 20 km/h [12 mi/h] and no rain). In the tally, the birds are identified by species and, where desired, their sex and age are recorded. Their distance from the observer is listed in four categories: from 0 to 25 m (0 to 82 ft), 25 to 50 m (82 to 164 ft), beyond 50 m in the habitat, or as flyovers of the habitat, regardless of distance. The time of first detection is listed in two categories: within the first 3 minutes of a count period or during the last 2 minutes. Where time to travel from point to point exceeds 15 minutes, longer counts of 10 minutes are warranted (Ralph and others, in press). When 10-minute counts are conducted, a third time category is listed for the final 5 minutes. This protocol is almost identical to the standard proposed by Ralph and others (1993, in press).

More Detail

Contrary to the proposed national standard, separate, additional listing of birds within 25 m (82 ft) is recommended. This recommendation is more specific than that of Ralph and others (1993). In the Southeast, three distance bands are desirable because of the relatively dense populations of birds in the forests and the complexity of the vegetation. Recording the field data in a more detailed manner is useful because the distance bands within 50 m (164 ft) can be later collapsed into a single value, whereas birds recorded in the field as only within 50 m (164 ft) can never later be separated into those within 25 m (82 ft) and those between 25 and 50 m (82 and 164 ft).

Because most detections are aural, usually of singing males, singing behavior must be taken into account in designing the surveys. Male song is strongly influenced by breeding status; thus, the timing of surveys is important. Singing frequencies are usually greatest when males are establishing territories and attempting to attract mates; usually, the singing frequencies decline after the eggs are laid. This decline is very noticeable in some species. Thus, the singing frequencies are often greatest in unmated males. Furthermore, nesting dates vary among species; consequently, optimal dates for sampling some species may be inadequate for others. Generally, there exists a 4- to 5-week period that will be optimal for simultaneously counting most species. In the southernmost parts of the Southeast, point count sampling can start around 1 May. In the northernmost parts, sampling should not start before 21 May because not all migrant species will have arrived before that date. Consult local experts or State bird guides for optimal survey times. A useful rule of thumb, in any case, is to make all counts on one piece of property during as few calendar days as possible.

WHO CONDUCTS A POINT COUNT?

The Basics

Unavailability of suitable personnel is a serious problem for a manager designing a point count survey. Identifying birds found on point counts requires great skill. Most of the birds encountered in the field, usually more than 90 percent of them, are heard and not seen. Personnel conducting point counts must be able to identify the species present by sight and sound and be able to estimate the distance to the birds detected. Ideally, they will have some prior experience doing point counts. Finding people with the proper skills to conduct such counts is not easy. Local chapters of the Audubon Society and State ornithological societies are a reliable source of volunteer counters, many of whom are eager to assist in other tasks involving birds and land management.

More Detail

Many people find potential workers, both volunteer and paid, through "The Ornithological Newsletter," a bimonthly publication of the Ornithological Societies of North America (OSNA). The address is "The Ornithological Newsletter," c/o American Ornithologists' Union, c/o OSNA, 810 E. 10th Street, Lawrence, KS 66044–8897, U.S.A.

In the long run, it may be more useful for managers, especially those in charge of larger properties, to train their own staffs to conduct point counts. Training sessions can be arranged through several universities in the Southeast. Approaching schools that currently offer courses in ornithology is one method of determining the availability of such training. It will likely be necessary to use volunteers for some of the work or the training; each State in the Southeast has active local birdwatching groups. Because trained personnel are the most limited resource in a point count survey, managers will do well to use the counters to the fullest extent in conducting as many counts as possible during the brief morning counting period in the short breeding season.

CONDUCTING A POINT COUNT

These procedures are suggested as standards for counts in the Southeast; they are based upon the standard protocol of Ralph and others (in press) as modified by the experience of Smith and others (1993) in the Mississippi Alluvial Valley. The instructions of the Breeding Bird Survey (U. S. Department of the Interior, Fish & Wildlife Service n.d.) are useful as well. A checklist of field equipment is in appendix A.

The Basics

Locate Each Station with Explicit Geographic Coordinates.—Locate each counting station with the greatest practical precision and with an explicit geographic reference, such as Universal Transverse Mercator (UTM) coordinates or latitude-longitude using a Geographic Positioning System (GPS) device, or determine the location in advance on a U. S. Geological Survey 7.5-minute topographic map. Some GPS devices are more difficult to use and less accurate under a dense forest canopy. It will be useful to locate and permanently mark the counting stations in advance, including reference distance markers at 25 m (82 ft) and 50 m (164 ft) from the counting point in the cardinal directions.

Count the Birds.—Steps for conducting the actual point counts in the field are as follows:

1. Approach the location, noting any birds within 50 m (164 ft) of the counting station that are flushed, fly away, or retreat. Mark these birds in the appropriate distance band on the bull's-eye data sheet. Circles on the data sheet (fig. 1) indicate distances of 25 m (82 ft) and 50 m (164 ft).
2. Orient the bull's-eye data sheet to a fixed direction, record the wind and sky conditions (appendix B), date, time, and observer.
3. Position the GPS device and start it recording. Set the thermometer in the shade.
4. As soon as possible, start the count. Use a pocket timer or watch to keep track of the time.
5. Record each bird seen or heard with the appropriate species code (appendix C). Count family groups of juveniles with a single adult as a single bird. It may be useful to note the sex and any other indicator of behavior or breeding status, and keep track of number of juveniles separately from number of adults. The standard protocol does not require this information, but other workers have found that recording only ♀ brown-headed cowbirds (*Molothrus ater*) provides more accurate data related to the intensity of nest parasitism than does the total number of cowbirds.[1]
6. Mark birds on the data sheet in the appropriate distance band and appropriate azimuth; i.e., use the bull's-eye data sheet as a map of the count station and a compass to determine the approximate azimuth. A set of standard coding symbols is included on the actual bull's-eye data sheet (fig. 2) to aid in separating individuals.
7. Record data for the different time intervals of the count in different ways. Some people use a pen with multiple colors and record data for the first 3 minutes in one color only, using a second color for minutes 4 and 5, etc. Others choose to underline those birds observed in the second time interval and circle those observed in the third. Be sure to put a legend of the chosen coding scheme on the bull's-eye data sheet.
8. Holding the sheet in a fixed position, spend part of the time facing in each of the cardinal directions in order to better detect birds in each.
9. Mark each bird once, using the mapped location to judge whether subsequent songs are from new or already mapped individuals. All flyovers are recorded outside the second circle, underneath the word "Flyover".
10. Record birds observed in the different time intervals separately. Mark the birds encountered in the final 2 minutes separately, such as by using a second color, underlining those observations, or otherwise distinguishing them. Be sure to note the chosen method of distinguishing these different time periods on the bull's-eye data sheet. Where longer times are indicated because travel time between points is long, count no longer than 10 minutes, and use a third color or other designation for the 6th to 10th minutes.
11. Do not record any birds believed to have been counted at previous stations.

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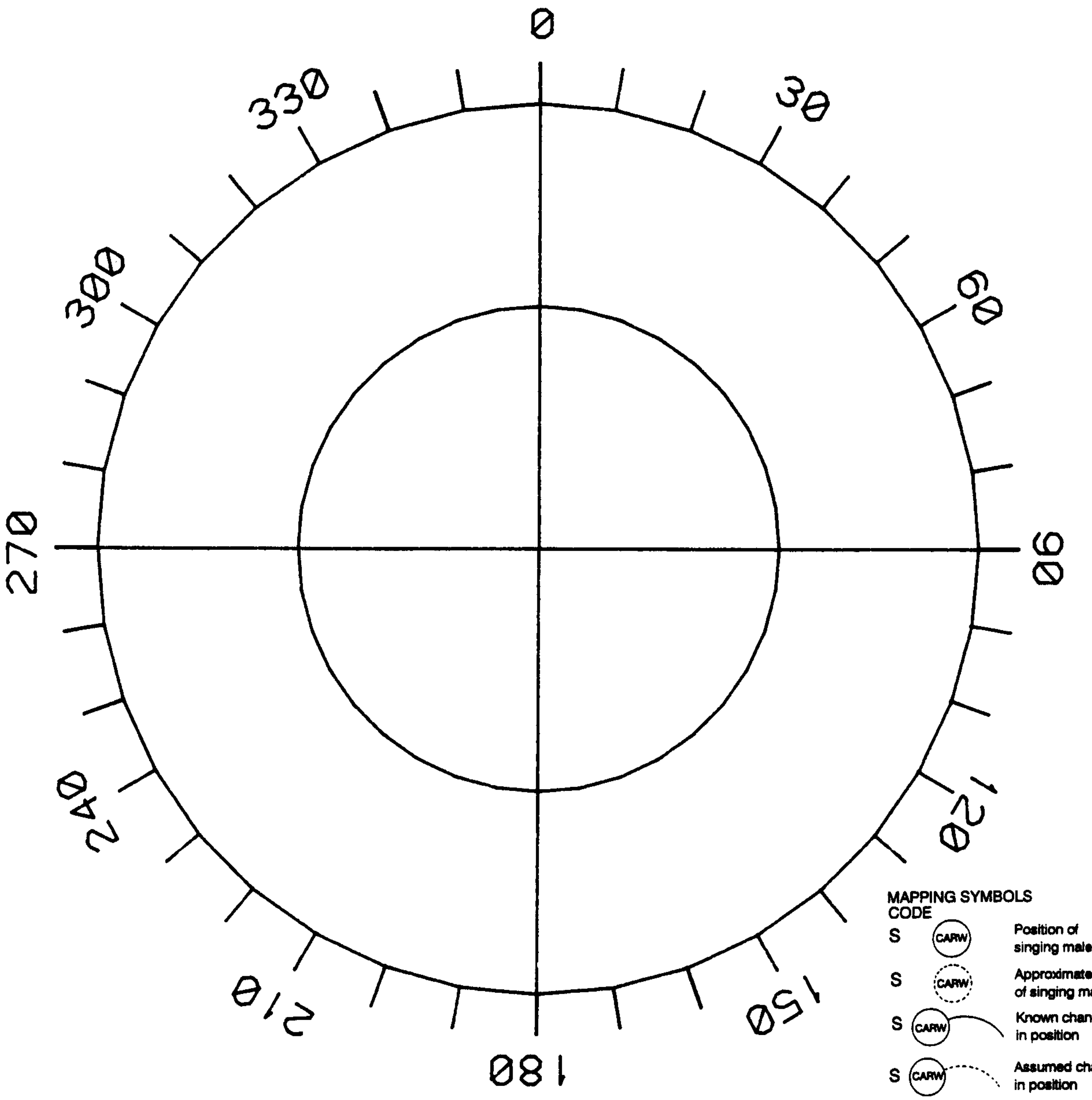
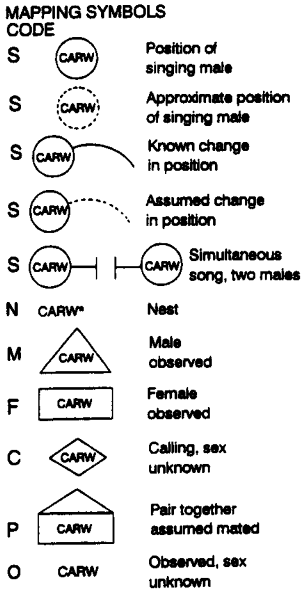
[1] S. Robinson, Illinois Natural History Survey, and F. Thompson, North Central Research Station, personal communication, 1993.

State Region Station Point # Visit # Year Month Day Time

Observer Temp °C Wind Sky Habitat Forest type Stage Zone N-S coordinates E-W coordinates
Geographic coding: Zone=0 for lat-long, else UTM Zone





Flyovers:

Remarks

Figure 1.—***Blank bull's-eye data sheet.***

12. At the end of 10 minutes, stop recording bird observations. Do not record any new birds seen or heard after the 10 minutes have passed.
13. Discontinue logging data on the GPS unit. From the display on the GPS unit, transfer the latitude and longitude to the bull's-eye data sheet. Although these are uncorrected data, they can serve as the back-up in case the electronic data are inadvertently lost from the GPS unit before they can be dumped to the PC for correction.
14. Record the temperature.
15. Mark the location to facilitate a return, at a later time, for appropriate vegetation measurements.

Field notations from the bull's-eye data sheets will be transcribed to bird count data forms and entered into a computer format (appendix D) compatible with the Southeastern standard. A sample completed bull's-eye data sheet appears in figure 2, figure 3 is a blank bird count data form, figure 4 is a sample completed bird count data form for the count in figure 2, and figure 5 is the sample completed bird count data form entered into the Southeastern standard computer format. A blank bulls-eye data sheet and a blank bird count data form are inserted into the back of this book.

WHAT IS A POINT COUNT SURVEY?

A point count survey is a group of point counts, strategically distributed across a property such as a management area, that are visited in a predetermined order at a particular time. The tasks involved in conducting a point count survey or inventory are:

1. Preparation of a survey design, determining where the counts will be conducted;
2. Identifying personnel;
3. Counting the birds, and assessing vegetation appropriate to your needs;
4. Transcribing the field data into a standard form, usually a computer format; and
5. Summarizing the data into reports about the birds.

This section deals with the first stage in the process; separate sections treat the others.

Survey Design

The Basics.—An inventory or monitoring project is designed to find out what bird species occur on a property, where they are, and how their numbers are changing through time. The single most important part of the process is to decide upon the objective of the project. Carefully considering the kind of information wanted, the level of detail required, and the frequency of need to evaluate change will aid greatly in making this decision; the decision tree in table 1 can help.

Point counts are an efficient way to carry out these activities. No inventory or monitoring survey can be done without a map of the property of interest, preferably marked with different forest stands, compartments, ecological classification units, or other areas that the manager wishes to consider as single management types. Management units such as forest types, successional stages, and stand condition classes are the habitat units that monitoring is designed to sample. Results of the activity will then be expressed as numbers of birds in the different management units.

Guidance for monitoring design comes from the studies of Smith and others (1993), from the recommendations of Ralph and others (1993), and from standard statistical considerations of precision. When a point count survey is set up, points are located far enough apart to avoid encountering the same birds; e.g., 250 m (820 ft) apart for off-road counts and approximately 1 km (0.5 mi) apart for roadside counts. As a general rule, point count stations are distributed among habitats in proportion to the number of stands in the different habitats on the property. Counts within habitats are distributed one per stand, wherever practicable. Placing more than one count in a stand will probably constitute a waste of resources. Counts intended to sample particular habitats are located at least 100 m (328 ft) from the edge of the habitat except when habitat patches are too small to permit such positioning. In that case, a counting station should be located at least 50 m (164 ft) from the edge.

Ideally, counts are conducted once a year, at as near the same time as possible; and at the exact same points each year. Where possible, the same personnel conduct the counts each year.

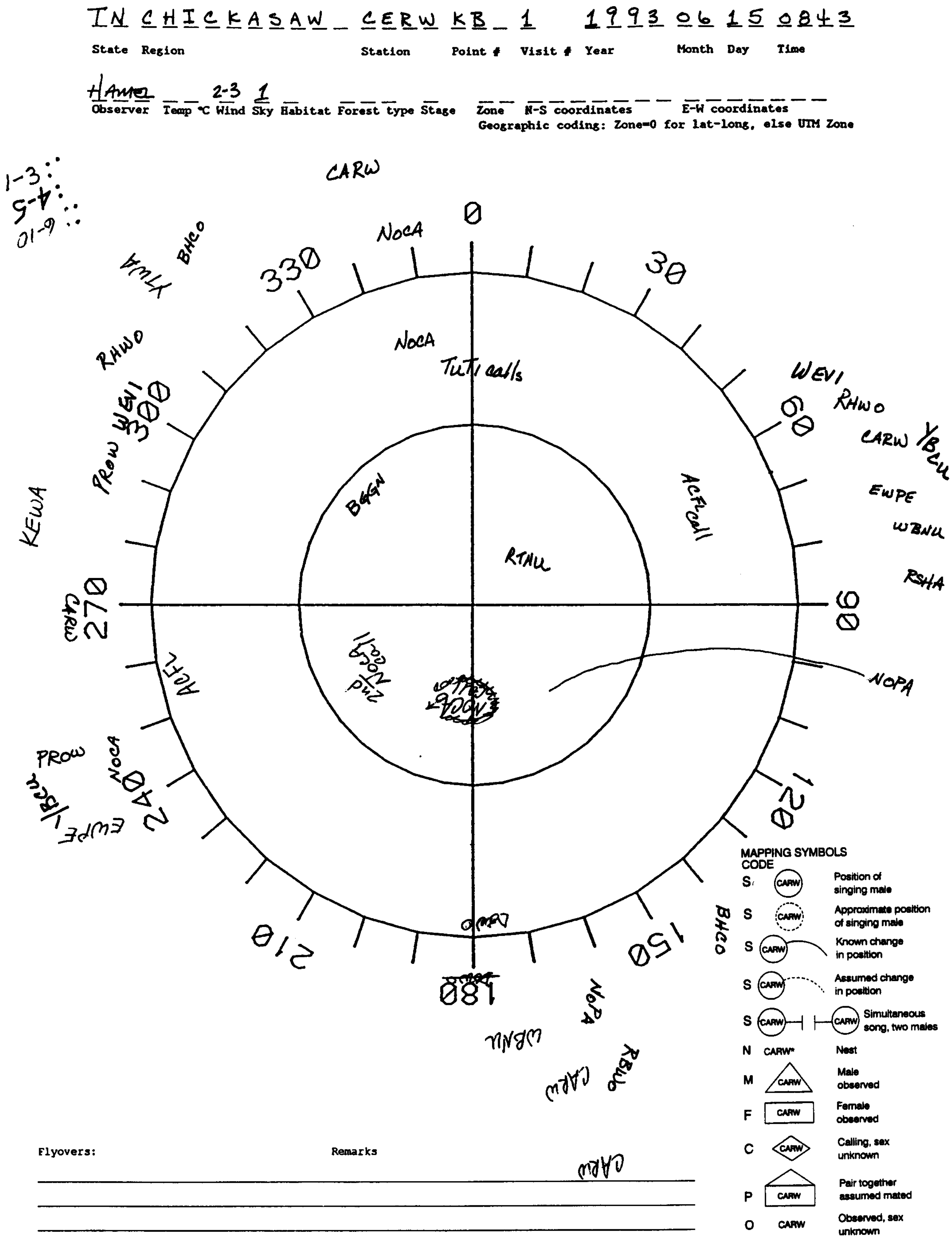


Figure 2.—*Sample of point count made with bull's-eye data sheet.*

State Region Station Point # Visit # Year Month Day Time

Observer Temp °C Wind Sky Habitat Forest type Stage Zone N-S coordinates E-W coordinates

Geographic coding: Zone=0 for lat-long, else UTM Zone

Species Alpha Code	Count < 25 m			25-50 m			> 50 m			Flyovers		
	0-3 min	4-5 min	6-10 min	0-3 min	4-5 min	6-10 min	0-3 min	4-5 min	6-10 min	0-3 min	4-5 min	6-10 min

Submitter Remarks

Figure 3.—*Blank bird count data form.*

State	Region	Station	Point #	Visit #	Year	Month	Day	Time
TN	CHICKASAW	CERW	KB	1	1993	06	15	0843

Observer	Temp °C	Wind	Sky	Habitat	Forest type	Stage	Zone	N-S coordinates	E-W coordinates
PBH		3	1				16	3966520	260530

Geographic coding: Zone=0 for lat-long, else UTM Zone

Species Alpha Code	Count < 25 m			25-50 m			> 50 m			Flyovers		
	0-3 min	4-5 min	6-10 min	0-3 min	4-5 min	6-10 min	0-3 min	4-5 min	6-10 min	0-3 min	4-5 min	6-10 min
BGGN	1											
RTHU	1											
NOCA			2	1			··2					
TUTI				1								
ACFL				1		1						
DOWO						1						
WEVI								2				
RHWO							··2					
YTWA									·1			
BHCO							··2					
CARW							∴3		··2			
YBCU								··2				
EWPE							·1		·1			
WBNU							·1		·1			
RSHA							·1					
NOPA							··2					
RBWO							·1					
PROW							··2					
KEWA									·1			

Submitter: PBH

Remarks: 1 2 3 4 5 6 7 8 9 10

Figure 4.—*Data transcribed from bull's-eye data sheet to bird count data form.*

```
TNCHICKASAW CERWKB 1199306150843PBH  31F 888163966520 260530BGGN 1                                 PBH  WIND BEGAN AT 2
TNCHICKASAW CERWKB 1199306150843PBH  31F 888163966520 260530RTHU 1                                 PBH  WIND BEGAN AT 2
TNCHICKASAW CERWKB 1199306150843PBH  31F 888163966520 260530NOCA     2 1     2                     PBH  WIND BEGAN AT 2
TNCHICKASAW CERWKB 1199306150843PBH  31F 888163966520 260530TUTI       1                           PBH  WIND BEGAN AT 2
TNCHICKASAW CERWKB 1199306150843PBH  31F 888163966520 260530ACFL       1   1                       PBH  WIND BEGAN AT 2
TNCHICKASAW CERWKB 1199306150843PBH  31F 888163966520 260530DOWO           1                       PBH  WIND BEGAN AT 2
TNCHICKASAW CERWKB 1199306150843PBH  31F 888163966520 260530WEVI               2                   PBH  WIND BEGAN AT 2
TNCHICKASAW CERWKB 1199306150843PBH  31F 888163966520 260530RHWO             2                     PBH  WIND BEGAN AT 2
TNCHICKASAW CERWKB 1199306150843PBH  31F 888163966520 260530YTWA                 1                 PBH  WIND BEGAN AT 2
TNCHICKASAW CERWKB 1199306150843PBH  31F 888163966520 260530BHCO             2                     PBH  WIND BEGAN AT 2
TNCHICKASAW CERWKB 1199306150843PBH  31F 888163966520 260530CARW             3   2                 PBH  WIND BEGAN AT 2
TNCHICKASAW CERWKB 1199306150843PBH  31F 888163966520 260530YBCU               2                   PBH  WIND BEGAN AT 2
TNCHICKASAW CERWKB 1199306150843PBH  31F 888163966520 260530EWPE             1   1                 PBH  WIND BEGAN AT 2
TNCHICKASAW CERWKB 1199306150843PBH  31F 888163966520 260530WBNU             1   1                 PBH  WIND BEGAN AT 2
TNCHICKASAW CERWKB 1199306150843PBH  31F 888163966520 260530RSHA             1                     PBH  WIND BEGAN AT 2
TNCHICKASAW CERWKB 1199306150843PBH  31F 888163966520 260530NOPA             2                     PBH  WIND BEGAN AT 2
TNCHICKASAW CERWKB 1199306150843PBH  31F 888163966520 260530RBWO             1                     PBH  WIND BEGAN AT 2
TNCHICKASAW CERWKB 1199306150843PBH  31F 888163966520 260530PROW             2                     PBH  WIND BEGAN AT 2
TNCHICKASAW CERWKB 1199306150843PBH  31F 888163966520 260530KEWA                 1                 PBH  WIND BEGAN AT 2
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Figure 5.—*Sample point count transcribed into standard ASCII flat file format.*

More Detail.—Stands are selected at random, either irrespective of habitat type or by habitat type, so that each stand has an equal chance of being selected at the beginning of the process. Counts are distributed one per stand, wherever practicable. Summaries that managers make of the counts and analyses that managers will ask researchers to conduct on their point count data will be much simpler if this general guideline is followed. Statistical considerations of independence of individual counts are also important in understanding the meaning of results of a point count survey. Generally speaking, counts at least 250 m (820 ft) apart are independent of each other because they count different birds. If, however, a manager wishes to compare habitats but all counts from one habitat were made on one property or one stand, whereas those from another habitat were made from multiple stands, deciding whether differences have to do with that one stand or with the habitat will be difficult. Consulting a statistician for help in designing the study will be useful, particularly if the policy implications of the work are great or the differences in bird numbers among various habitats or years are small.

For practical purposes, only one visit per point count station will be necessary to compare populations from one year to the next. This approach will provide a single estimate of the abundance of birds on the property at that time. The only time that points should be revisited within a year will be when managers wish to examine how birds change during a single season on their properties. The results of such work can show how the populations change during the breeding season.

Determination of Sample Size

The Basics.—No magic formula for determining number of counts is available. The actual number of point counts required to answer a particular question will vary with the question, with the species, with the variability in numbers of birds in each physiographic area, with the habitat, as well as with the desired precision. The two most common sorts of questions relate to changes in bird populations over time and to responses of bird populations to management treatments. Ralph (1993) suggests a minimum total of 250 counts to enable monitoring annual changes in bird populations on a property by roadside counts. Smith and others (1993) showed that, for any given number of counts, visiting a larger number of counting stations once yielded more information about the bird community than did visiting a smaller number of stations more than once. They found that, in any case, no more than five points per stand were necessary for adequate sampling of the bird community. They also found that point counts longer than 10 minutes are not justified because they are less efficient at sampling the bird community and produce more variable results than do counts of 10 or fewer minutes.

A practical method of sample size estimation for land managers is presented in this section. A more detailed and rigorous approach to sample size determination appears in appendix E. The following discussion assumes that individual forest stands are the sampling units and that each stand is sampled by the same amount of effort, usually one point count. It also assumes that a pilot sample of counts has been conducted, such as the 50 to 100 counts that a volunteer observer could gather by doing a roadside survey of a property over a single weekend in late May according to the standard methodology of the U.S. Department of the Interior, National Biological Service, Breeding Bird Survey (Butcher and others 1993).

Determining sample size starts with the question of interest. Land managers may commonly wish to answer one or both of two basic questions: "Are bird populations on my property changing over the years?" or "How did bird populations respond to my management activity in particular habitats?"

A manager who wants to answer the first of these questions should allocate the points for bird counts among the different habitats so that the percentage of points in each roughly corresponds to the percentage of the property in that habitat. This strategy enables the manager to detect trends in population numbers over several years, as long as the points are visited each year. A manager seeking to answer the second question faces a slightly more complicated task in deciding how many points to allocate and where to put them.

More Detail: A "Quick-and-Dirty" Method of Determining Sample Size.—The next issue is, how many points are needed? The answer to that question depends upon the specific question the manager wants to answer. In general, the number of points needed increases as questions get more specific, as one attempts to detect smaller population changes, as the desired confidence level increases, and as the population of interest gets less abundant or more variable. This trend accentuates the importance of deciding in advance exactly what is the objective of the monitoring.

How these factors affect needed sample size can be illustrated by using a set of pilot data from bottomlands in the Mississippi Alluvial Valley (Smith and others 1993) to demonstrate how the required sample size is affected by:

1. The nature of the question (from most general to most specific)
   a. Has the total number of birds or species changed?
   b. Has the total number of neotropical migratory birds changed?
   c. Has the total number of birds with high Concern Scores (Hunter and others 1993a) changed?
   d. Has the total number changed of whatever species is being counted; e.g., wood thrushes (*Hylocichla mustelina*)?
2. The magnitude of population change one desires to detect
   a. 20-percent population change.
   b. 10-percent population change.
3. α = The desired confidence level with which a change is detected
   a. $\alpha = 0.20$, lower confidence.
   b. $\alpha = 0.10$.
   c. $\alpha = 0.05$, higher confidence.

The likelihood that answers of "No" to questions (a) through (d) in 1 are really "No," which is the power of the test ($1-\beta$), will be discussed in appendix E. From their pilot data for these determinations, Smith and others (1993) present in detail the required sample sizes for a selection of species in the Mississippi Alluvial Valley; these are summarized in appendix E, table E.1.

Managers who want to detect population changes between years will compare populations in one year with populations in another year on the same site. Those who want to determine how birds responded to a management activity will need to compare changes in populations on the managed (treatment) sites to changes in populations on nearby untreated (control) sites. In either case, the hypothesis to be tested will be that the average number of birds recorded per count in one year or habitat type or management treatment (μ_1) does not differ from the average in another year, habitat type, management treatment, or control area (μ_2):

$$H_0 \text{ (the null hypothesis): } \mu_1 = \mu_2,$$

and the test will be to compare that hypothesis with the alternative that the average number of birds per count in the 2 years, management treatments, or habitat types differ:

$$H_1 \text{ (the alternative hypothesis): } \mu_1 \neq \mu_2.$$

The test of this hypothesis is the Student's t-test. The estimate of some average count of birds obtained from sampling will be in the form of the mean ± a confidence interval, indicating that there is a specific confidence level that the value of the mean falls within the interval:

$$\bar{x} \pm t\sqrt{\frac{s^2}{n}}$$

where

n = the number of counting points in a pilot sample from a particular habitat or year, etc.,
s^2 = the sample variance of the variable counted in the pilot data,
t = Student's t for a given confidence level,
$\bar{x}$ = the sample mean of the variable counted in pilot data.

The basic problem of sampling design is to limit the size of the confidence interval to the proportional change (*P*) in a population which one desires to detect (Snedecor and Cochran 1967:516). The objective is to ensure that

$$t\sqrt{\frac{s^2}{n}} \leq P\,\bar{x}$$

Solving this inequality for n yields

$$n \geq \frac{s^2 t^2}{p^2\,\bar{x}^2}$$

where

n = the required number of counting points in a particular habitat or year, etc.
P = the proportional population change one desires to detect and s^2, t, and $\bar{x}$ are the same as above.

The manager will choose the value of P desired; e.g., $P = 0.10$ to detect a 10-percent population change, $P = 0.20$ to detect a 20-percent population change, etc. Since t-values are taken from a standard t-table based on the number of degrees of freedom (sample size minus 1), and the sample size is unknown, how does one choose an appropriate t-value? Nearly every point count sampling for birds will exceed 20 points, the equivalent of two mornings in the field. Hence, a conservative estimate of t (one that will ensure a large enough n) can be obtained by selecting t-values for 20 degrees of freedom and the desired confidence level. From appendix E, table E–2, $t = 2.1$ is a conservative estimate for $\alpha = 0.05$, $t = 1.73$ is a conservative estimate for $\alpha = 0.10$, and $t = 1.33$ is a conservative estimate for $\alpha = 0.20$.

Now, all that remains is to obtain estimates of $\bar{x}$ and s^2, the sample mean and sample variance. These estimates can be obtained from pilot study sampling; a separate pilot sample will be required for each habitat. The question now becomes, "How many points are needed to get adequate estimates of $\bar{x}$ and s^2 from pilot data?"

A graphical technique is useful to answer that question. The counts of all birds combined from the pilot data of Smith and others (1993) can be used to illustrate how the sample mean (fig. 6a) and sample variance (fig. 6b) can be estimated. These graphs are obtained by calculating and plotting a new sample mean and sample variance each time the data from an additional counting station is added to the data set. Such graphs of how sample means and sample variances change as additional point counts are added to the sample set typically show the depicted pattern. They tend to have large oscillations initially, and then either approach an asymptote or reach a condition of steady-state, low-amplitude oscillations around a fixed value (see figs. 6c, d). In either case, estimates can be obtained by projecting graphically to the ordinate axis. Because the formula for calculating n has s^2 in the numerator $\bar{x}$ and in the denominator, use of a slightly low estimate for $\bar{x}$ and a slightly high estimate for s^2 is recommended. Such usage will ensure a conservative (probably large enough) estimate for the sample size needed.

Now that estimates of $\bar{x}$ and s^2 have been obtained from pilot data, the question could be asked, "How many points are needed to detect a 10-percent change in the total number of birds with $\alpha = 0.10$?" If $P = 0.10$ is used to represent the proportional population change in question and if $t = 1.73$ while s^2 is estimated from the graphs at 25 and $\bar{x}$ at 16.4, then

$$n \geq \frac{s^2 t^2}{p^2 \bar{x}^2} = \frac{25(1.73)^2}{(0.1)^2(16.4)^2} = 28$$

Now suppose a more specific question is asked; i.e., How many points are needed to detect a change in the number of neotropical migratory birds? Figures

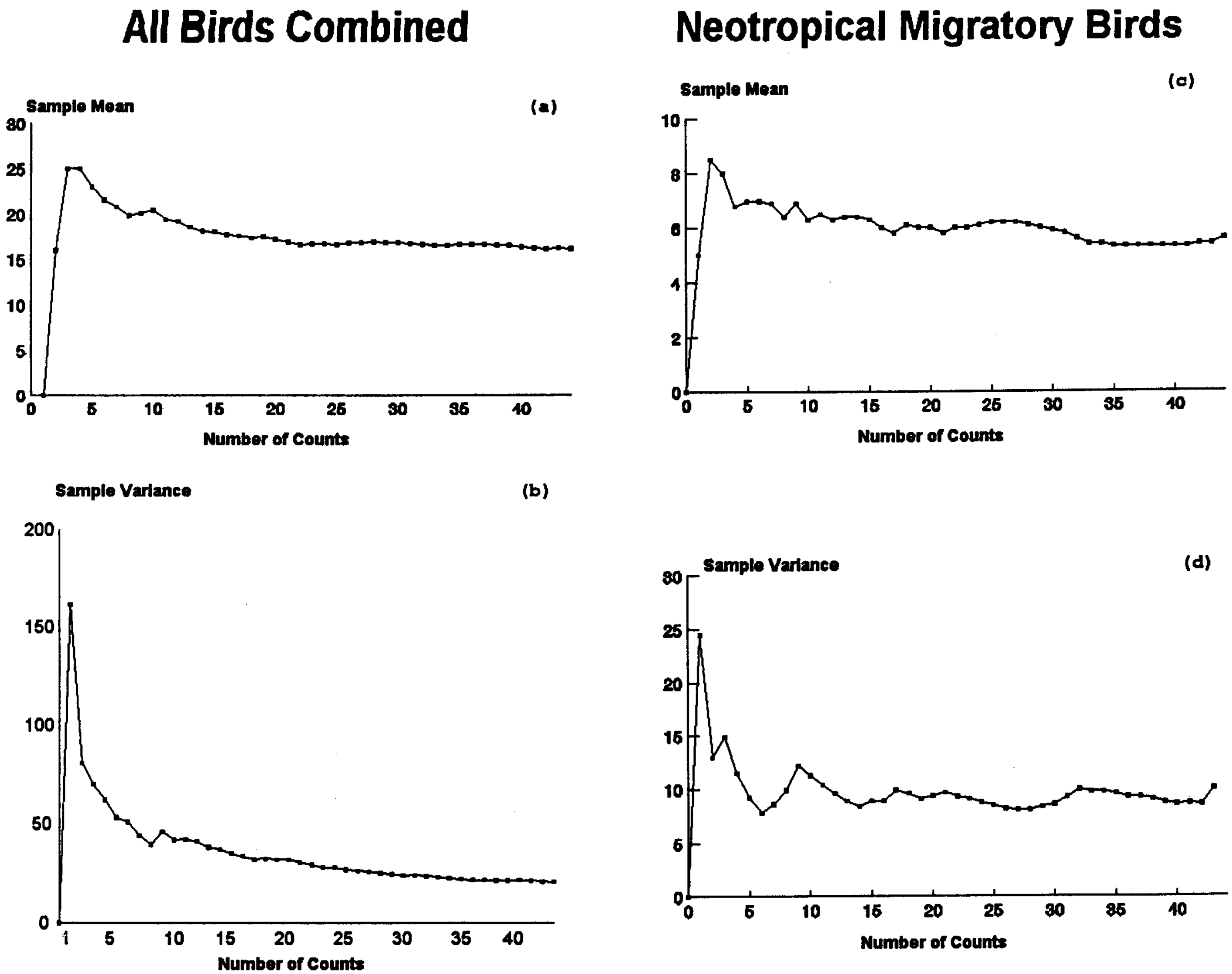

Figure 6.—*Selected variables as functions of the total number of point counts made in the pilot data of Smith and others (1993): a, mean number of birds, drawn from all birds combined; b, variance of number of birds, drawn from all birds combined; c, mean number of neotropical migratory birds; d, variance of number of neotropical migratory birds.*

6c and 6d, which were derived from a subset of the pilot data consisting of counts of neotropical migratory birds only, yield estimates of $\bar{x}$ = 5.8 (fig. 6c) and s^2 = 10 (fig. 6d).

If a 10-percent change in the number of neotropical migratory birds needs to be detected at $\alpha = 0.10$, the number of points needed is

$$n \geq \frac{s^2t^2}{p^2\bar{x}^2} = \frac{10(1.73)^2}{(0.1)^2(5.8)^2} = 89$$

If the same values for the sample means and variances and the same t- values are used, substituting P = 0.2 will give the sample size necessary to detect a 20-percent population difference in neotropical migratory birds—or $n = 23$ for $\alpha = 0.10$ and $n = 33$ for $\alpha = 0.05$.

From the same pilot data, another subset of data points consisting only of counts of birds of species with high Concern Scores ($\geq$ 24) in the MAV (Hunter and others 1993a) was used to estimate s^2 and $\bar{x}$ graphically in the same way, producing estimates of $\bar{x}$ = 2.6 and s^2 = 6. These values yielded a required sample size of n = 266 points to detect a 10-percent population difference at $\alpha = 0.10$ and n = 392 points to detect a 10-percent population difference at α = 0.05. Detecting a 20-percent difference in species with high Concern Scores required sample sizes of n = 67 and n = 98 points for = 0.10 and 0.05, respectively.

The final and most specific question asked was "How many points are needed to detect 10-percent and 20-percent differences in wood thrush populations at α levels of 0.10 and 0.05?" The pilot data and graphical estimates for only wood thrushes yielded estimates of $\bar{x} = 0.4$ and $s^2 = 0.8$. To detect a 10-percent difference in wood thrush numbers at = 0.10 would require a sample size of $n = 1{,}497$ points. To detect the same difference at $\alpha = 0.05$ would require $n = 2{,}205$ points. Detecting a 20-percent difference in wood thrush populations would require $n = 375$ points for $\alpha = 0.10$ and $n = 552$ points for $\alpha = 0.05$.

Thus, for the $\alpha = 0.10$ confidence level, the number of separate points needed in each group to detect a 10-percent population difference between 2 groups of counts increases from 28 for all birds combined to 89 for neotropical migratory birds alone, to 266 for birds with high Concern Scores, to 1,497 for a single species (wood thrush).

In general, increasing the confidence level from $\alpha = 0.10$ to $\alpha = 0.05$ will require about 50 percent more counting points, and it will require four times the number of counting points to detect a 10-percent population difference as are needed to detect one of 20 percent. Hence, detecting a 10–percent population difference at $\alpha = 0.05$ will require roughly six times the number of counting points needed to detect a 20-percent population difference at $\alpha = 0.10$. Note especially that increasing the confidence level from $\alpha = 0.10$ to $\alpha = 0.05$ is far less costly than reducing the size of the detectable population change from 20 to 10 percent.

Furthermore, because the usual annual or seasonal variation of bird numbers on particular properties is not well known, the amount of annual change that a manager should worry about is not well known either. As more data accumulate from actual point count surveys, this issue will clarify itself. Managers interested in monitoring individual bird species should note that the more common and abundant species (relatively high $\bar{x}$) and the more evenly distributed species (relatively low s^2, known as habitat generalists) will require far fewer counting points than relatively scarce (low $\bar{x}$) species with clumped distributions (high s^2, known as habitat specialists). Unfortunately, the relatively scarce habitat specialists are precisely the species most often in greatest need of monitoring and management.

Forming a Group of Cooperators When Sample Size Exceeds Property Size

Monitoring the scarce, habitat-specialist species requires changing the monitoring scale. First, scale down by conducting point counts at the habitat-specific as well as the propertywide scale. For example, if point counts are distributed proportionally across all habitats on a property, counts of species such as the prothonotary warbler (*Protonotaria citrea*), northern parula (*Parula americana*), and Acadian flycatcher (*Empidonax virescens*) will likely produce a low $\bar{x}$ and a high s^2 (yielding a large n), because these species are confined to corridors of riparian habitat where relatively few counting points may have been placed. If a large number of points are placed entirely within riparian habitat, counts of these species will produce a larger $\bar{x}$ and a smaller s^2 (yielding a much lower n) than counts at the propertywide scale. Thus, habitat-specialist species will probably require a separate monitoring program focused upon their specific habitats; this program may be quite different from one in which the habitats are limited in area.

Next, scale up by forming a network of cooperating bird monitors on other properties across the landscape and then pooling the data. This method can increase sample sizes enough to permit the detection of population changes among habitat-specialist species on a landscape scale, even when sample sizes on individual properties may be too small to detect population changes. The Southeast Management Working Group of Partners in Flight, organized along physiographic-area lines, will help with this task (Hunter and others 1993b) and will help managers obtain the proper statistical advice as they cooperate and pool their data. It will be important to ensure that the habitat definitions used by the various cooperators in a physiographic area are clear enough to allow managers to know how to pool their data.

Because of the large sample sizes needed to detect population changes in individual species, especially scarce species, most managers should not expect to detect small population changes in individual species on their own properties and may only be able to detect changes of 30 percent or greater at the = 0.10 level. Moreover, most habitats on an individual property will be too small to contain enough counting points to detect differences in bird populations among habitats. Nevertheless, a propertywide monitoring program is vital to the detection of such population changes on the larger landscape scale.

If point counts are distributed proportionally among habitats on each monitored property, then a cumulative total of 2,000 point counts taken from at least 10 properties spread across a physiographic area should suffice to detect population changes of most individual bird species within that area. The contribution of each property to this total is consistent with the number of point counts, 200 to 250, which can be comfortably completed by one observer on a single property in a sampling season.

If 10 properties large enough to contain 200 point counts each cannot be located or monitored within a physiographic area, then at least 1,000 cumulative point counts should be taken at the propertywide scale from as many properties as possible. In this case, each property manager should also conduct a separate monitoring program at the habitat-specific scale by placing an additional 40 point counts exclusively within those habitats of highest priority that contain the bird species of highest priority in the physiographic area. If the habitats of highest priority on a property are too small to contain 40 counting points, then a manager should take as many point counts as possible in those habitats.

Thus, land managers can best contribute to regionwide bird monitoring by combining a propertywide monitoring program for all bird species with a separate habitat-specific program designed to monitor particular bird species in habitats of special interest and by sharing their data with other bird monitors across the landscape.

The pilot data used in this illustration (figs. 6a, b, c, d) showed that 30 to 40 points were sufficient in the habitats sampled to yield adequate graphical estimates for $\bar{x}$ and s^2, regardless of whether the data graphed were for all birds combined, just neotropical migrants, just birds with high Concern Scores, or just the wood thrush. Thus, pilot study data sufficient to custom-design a monitoring program for an individual property can be obtained by one person in just two to three mornings of preliminary sampling. Using only a hand-held calculator with statistical functions, the necessary calculations to plot the graphs and to determine required sample sizes can be completed in one additional day. As a result, as few as three observer-days of effort are required to design a site-specific bird monitoring program consistent with a land manager's goals, budgets, and staffing limitations.

MEASURING VEGETATION

The Basics

Vegetation measurements of some kind are an essential part of the inventory and monitoring task. How involved those measurements must be is a source of concern for those who pay for and carry out monitoring activities and a source of confusion for those eager to use the data for research purposes. In this section an attempt is made to reduce the concern and the confusion. It is recognized that the effort available for conducting vegetation sampling at point count stations will frequently be limited. No attempt will be made to discourage the conducting of point count surveys by suggesting vegetation sampling standards that are unattainable by most land managers in the Southeast.

Managers should consider this approach to vegetation measurements as a step-down process with at least three steps, each of greater detail than the others; they should select the level of detail appropriate to their needs. The following hierarchical scheme is presented as a method whereby a manager can tailor the sampling intensity to match the available effort without sacrificing quantitative detail at the sampling point. In this section it is shown how different levels of quantitative detail in vegetation measurements can be incorporated into a single point count inventory or monitoring program. The levels of detail may be viewed as nested within each other, with the detail from each level providing more information than that available at the higher levels in the hierarchy, and information at the higher levels being less specific than that available at the lower levels.

The highest level in the hierarchy, Level One, involves associating the point with a particular forest type and successional stage, or with whatever the important habitat units are that the manager uses on a daily basis. This is the most general information and should be available for any point count. Ralph and others (1993) suggest a qualitative evaluation of the vegetation within 50 m (164 ft) of the counting station. Usually this information is available from the management map of the area; it should be gathered. Beyond this minimal requirement, the detail of the measurements will reflect the managers' objectives and their desire to compare their findings with those of other managers.

The second level in the hierarchy, Level Two, is a vegetation measurement scheme tailored to a particular landowner's own land and vegetation classification. The scheme proposed for the National Forests in the Southern Region (USDA FS 1995) is such a vegetation measurement scheme; it is described in appendix F. From the measurements taken in that scheme, each point can be assigned to a broad forest type/successional stage category. In addition, measurements taken in that scheme provide additional information pertaining to the variation within each such category. These qualitative measurements do not allow detailed analysis of relationships between individual bird species and one or more habitat variables. Associating individual bird species with habitat variables requires quantitative measurements of those variables.

At the third level in the hierarchy, Level Three, are quantitative measurements intended to characterize the structure and composition of the vegetation. The quantitative measurements identified in appendices F and G are a suitable set to make at each point counting station, whether on-road or off-road. These measurements will enable managers to assign each of their points to a currently accepted Society of American Foresters' Forest Type, to a Forest Service Forest Type, to a Vegetation Type (Hamel 1992), and probably to a specific cell in other vegetation and ecological classification schemes as well. When other considerations preclude conducting measurements in this detail at each point, conduct them at a random or stratified random subsample, such as at 10 percent of the points. In this way, quantitative measurements will serve several functions. First, they will serve as a check on the qualitative measurements made at each point in the monitoring program. Second, they will be available for use in suggesting hypotheses for more detailed evaluation. Third, they will be available for use by others doing more detailed investigations. Specific detailed study of the habitat requirements of individual species will require more detailed approaches than those of Level Three.

More Detail

A suggested standard set of Level Three measurements is described in appendices F and G. At this level of detail, the specific objectives of a particular study, rather than a general measurement standard, will determine which variables to measure and how those measurements can be made. In some circumstances, such as those involving controlled burning, time at which measurements are taken will be important; in other circumstances, this will not be the case.

The parameters to measure are at least these: canopy closure, canopy height, basal area by species, stem density by species, shrub density, and groundcover. In addition, other variables can also be useful: presence or absence of snags, Spanish moss, vines in the canopy, water, and vegetation profile (or midstory density). The suggested method is reminiscent of that of James and Shugart (1970) and covers an area of approximately 0.04 ha (0.1 acre). Although James and Shugart (1970) utilize a circular plot, a square (20- by 20-m [66- by 66-ft]) or rectangular (16- by 25-m [52.5- by 82-ft]) plot is much easier to use under field conditions.

Two people will probably be required to conduct the vegetation sampling design outlined in appendices F and G; the following tools will be required: density board and pole 5 m (16.4 ft) tall, 15-m (50-ft) tape, ocular tube, clinometer, angle gauge or prism, diameter tape or biltmore stick, flagging tape, hip chain and biodegradable string, pencil or pen, clipboard, and data sheet.

A team of 2 observers (a trained bird counter and a vegetation sampler) might conduct 10 point counts and 10 vegetation samples during a single field day as follows:

> Both proceed to the first station, where the bird counter conducts the first bird count. Upon completion of that count, the bird counter proceeds alone to the next and subsequent stations. When the bird counter has finished the first count, the vegetation sampler measures those vegetation parameters that are relatively easy for a single person to measure; e.g., canopy closure, groundcover, shrub cover, percentage cover of vines and Spanish moss, presence or absence of snags and significant water, species

composition, basal area, stem density, and canopy height. The vegetation sampler can then follow the string of the hip chain through the vegetation to the second station, make the same vegetation measurements there, and continue. When the bird counter finishes the bird counts, the bird counter then joins the vegetation sampler to assist in completion of this subset of measurements at all 10 stations. At this point, it will probably be lunch time. After lunch the two members of the field crew can retrace their steps from the 10th to the 1st station, conducting the measurements of vegetation profile at each station as they return to the vehicle.

It should be noted that measurements such as these are only the beginning of detailed vegetation sampling that may be required by those conducting studies of particular habitat requirements of individual species.

TRANSCRIBING DATA

Transcribing Field Data to a Bird List

The Basics.—Transcribing field data is a tedious, but necessary, process. Often, errors of transcription are inadvertently made at this stage. The field observer should transcribe the data as soon as possible after leaving the field—and only once, if possible. Fortunately, some computer software exists to simplify the process.

If such software is not available, the following process will suffice, but it does require extra care and proofreading. Copy the header information from the bull's-eye data sheet (fig. 2) onto the top of the bird count data form (figure 3). Establish a routine method of copying data from the bull's–eye data sheet to the bird count data form, such as starting in the center and moving clockwise in the 0- to 25-m (0- to 82-ft) band, then moving clockwise in the 25- to 50-m (82- to 164-ft) band, and so forth, until each bird marked on the bull's-eye data sheet has been listed on the bird count data form. Mark the code name of each species (from appendix C) in the appropriate columns. Then mark down each bird in the column as to the time and distance band where it was first encountered; e.g., the northern parula, which was encountered outside 50 m (164 ft) in the first 3 minutes and subsequently flew to within 25 m (82 ft) sometime in the last 5 minutes, was recorded in the 0- to 3-min, >50-m (>164-ft) column. A dot tally works well for recording numerous birds. The simple scheme noted at the bottom of figure 3 is an easy way to tally.

When the information for each bird has been transferred from the bull's–eye data sheet to the bird count data form, proofread the transcription by repeating the process, perhaps putting a small mark on the bull's-eye data sheet beside each bird as its correct transcription to the bird count data form is verified. Figure 4 is a sample filled-out bird count data form for the sample point count recorded on figure 2.

Enter the data into a standard computer-readable format such as the one in appendix D. A completed sample for the point count of figure 2 is presented in figure 5. When the data have been entered into a standard format and verified, they are ready for submission to a repository and for statistical analysis. A repository for point count data will likely be designated in the near future.

More Detail.—The Southern Region of the Forest Service has developed software for use with data gathered on national forests; the software is described in the "Southern National Forest's Migratory and Resident Landbird Conservation Strategy" (USDA FS 1995). The point count data can be related through this system to other data bases in the regional Resource Inventory Tracking and Analysis System.

The U.S. Fish and Wildlife Service, in cooperation with Louisiana State University, has sponsored development of a user-friendly software Bird Count Analysis Database, GSBBase, tailored to the data standards presented here (Guddanti 1994). The system can run on any MS-DOS computer, provides some error trapping to catch field coding errors, and minimizes transcription errors. In addition, it provides some standard reports that will be useful to a land manager. Users in the National Wildlife Refuge System and the National Park System in the Southeast have found this software to be helpful.

Using a software product such as one of these will simplify the job of transcribing the data. A good software product to choose for this task will be one that can accept field data directly, check for simple errors in transcription, and produce output in flexible format for sharing with other workers. In the future, field procedures that permit direct entry of data into hand-held computers, eliminating all transcription errors, will become available.

Summarizing Field Data into Reports

The Basics.—Reports that express the number of birds of each species found on a property, are the desired outcome of the point count survey. The simplest list is one in which the species are listed alphabetically, together with the total number of counts on which each was found, and the total number of birds of each species. Such lists can be tailored to express the number of birds and their frequency per count on separate habitats or in separate years (tables 2,3). Note that an important part of the process of producing bird lists will be to put the species into the standard checklist order (American Ornithologists' Union 1983, table 3). Ornithologists and birdwatchers routinely list birds in this sequence.

More Detail.—Data gathered in point count surveys can be presented in many ways. Convenient examples include Peterjohn and Sauer (1993), Smith and others (1993), and various articles in recent issues of *Journal of Wildlife Management, Southern Journal of Applied Forestry,* and other publications.

Table 2.—*Portion of sample bird lists resulting from point count surveys on hypothetical wildlife management area (simple alphabetical list)*

Species	Point Counts*	Individuals
	----------- *Number*	-----------
Acadian flycatcher	14	19
American redstart	3	3
Blue jay	22	27
Carolina chickadee	27	44
Great crested flycatcher	7	11
Red-eyed vireo	33	61
Red-shouldered hawk	1	1
White-breasted nuthatch	4	6

*Number of counts on which each species was recorded in sample of 52 counts in 1993.

Table 3.—*Portion of sample bird lists resulting from point count surveys on hypothetical wildlife management area (comparison of two years' surveys, species in checklist sequence)*

Species	1993		1994	
	Counts*	Birds	Counts†	Birds
	Number	*Total*	*Number*	*Total*
Red-shouldered hawk	1	1	0	0
Acadian flycatcher	14	19	22	41
Great crested flycatcher	7	11	5	11
Blue jay	22	27	26	29
Carolina chickadee	27	44	38	51
White-breasted nuthatch	4	6	3	3
Red-eyed vireo	33	61	47	55
American redstart	3	3	3	5

*Number of counts on which each species was recorded in sample of 52 point counts in 1993. Total of 525 birds of 65 species recorded in 1993.
†Number of counts on which each species was recorded in sample of 65 point counts in 1994. Total of 663 birds of 63 species recorded in 1994.

HAPPY POINT COUNT CENSUSING!

Monitoring and inventorying with point counts are the beginning, not the end, of information gathering by land managers seeking to incorporate nongame birds into their management of southeastern habitats. Conducting point count surveys will lead logically to identification of situations where more powerful tools, such as nest searching or constant-effort mist netting, will become necessary in gathering sufficient information for making proactive management decisions.

The task of managing birds on one property cannot be accomplished by the manager of that property working alone. For example, factors affecting migratory bird populations extend beyond the limits of any one property. Joining together with other land managers to coordinate monitoring and inventorying on the basis of common physiographic areas will lead individual managers to more effective stewardship of the birds on their own properties. Such stewardship will undoubtedly result in more effective management of birds throughout the Southeast.

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Appendix A. Equipment list for conducting point count surveys.

EQUIPMENT

- _____ Binoculars
- _____ Clipboard
- _____ Field guides
- _____ Gate keys
- _____ GPS (Geographic Positioning System) unit
- _____ Magnetic compass
- _____ Pocket thermometer
- _____ Single-bit hand ax or mallet
- _____ Stopwatch or timer
- _____ Tape player and bird tapes
- _____ Three-color pens (black, red, blue)
- _____ Working vehicle
- _____ _______________
- _____ _______________
- _____ _______________

MATERIALS

- _____ Administrative map
- _____ Aerosol paint
- _____ Aluminum caps
- _____ AOU bird code list
- _____ Bull's-eye data forms
- _____ Compartment maps
- _____ Computer input forms (summary sheets)
- _____ Insect repellent
- _____ 2-cm (1/2-inch) rebar
- _____ Topographic maps (quads)
- _____ _______________
- _____ _______________

ADDITIONAL MATERIALS AND EQUIPMENT FOR VEGETATION SAMPLING

- _____ Angle gauge or prism
- _____ Clinometer
- _____ Density board
- _____ Diameter tape or biltmore stick
- _____ Flagging tape
- _____ Hip chain and biodegradable string
- _____ Ocular tube
- _____ Sturdy pole 5 m (16 ft) tall
- _____ 25-m (82-ft) tape
- _____ Vegetation field data sheet
- _____ _______________
- _____ _______________

Appendix B. Codes for wind speed and sky condition used in conducting point counts.

These codes are those used in the Breeding Bird Survey. Acceptable conditions for counting birds include a sky condition of 0, 1, or 2 and wind speeds of less than 20 km/h (12 mi/h), preferrably less than 13 km/h (8 mi/h).

SKY CONDITION CODES:

Code Number	Sky Condition
0	Clear or a few clouds
1	Partly cloudy (scattered)
2	Cloudy (broken) or overcast
4	Fog or Smoke
5	Drizzle
7	Snow
8	Showers

WIND SPEED CODES:

Beaufort scale Number	Wind speed km/h	Wind speed mi/h	Indicators of wind speed
0	Less than 2	Less than 1	Smoke rises vertically
1	2 to 5	1 to 3	Wind direction shown by smoke drift
2	6 to 11	4 to 7	Wind felt on face; leaves rustle
3	12 to 20	8 to 12	Leaves, small twigs in constant motion; light flag extended
4	21 to 32	13 to 18	Raises dust and loose paper; small branches are moved
5	33 to 39	19 to 24	Small trees in leaf sway; crested wavelets on inland waters

Appendix C. Species codes for birds as found in the North American Bird Banding Manual (USDI 1991).

Alpha Code	Common Name	Alpha Code	Common Name	Alpha Code	Common Name
ABTO	Abert's Towhee	ARTE	Arctic Tern	BLBR	Black Brant
ACFL	Acadian Flycatcher	ARWA	Arctic Warbler	BLGU	Black Guillemot
ACWO	Acorn Woodpecker	AHWA	Arrow-headed Warbler	BLNO	Black Noddy
ADWA	Adelaide's Warbler	ATFL	Ash-throated Flycatcher	BLOY	Black Oystercatcher
ADPE	Adelie Penguin	ASSP	Ashy Storm-Petrel	BLPH	Black Phoebe
AFPE	African Penguin	ATBR	Atlantic Brant	BLRA	Black Rail
AKEP	Akepa	ATPU	Atlantic Puffin	BLRF	Black Rosy-Finch
AKIP	Akiapolaau	AUOR	Audubon's Oriole	BLSC	Black Scoter
ALFL	Alder Flycatcher	AUSH	Audubon's Shearwater	BLSK	Black Skimmer
ACGO	Aleutian Canada Goose	AUWA	Audubon's Warbler	BLSP	Black Storm-Petrel
ALTE	Aleutian Tern	AZTH	Aztec Thrush	BLSW	Black Swift
ALHU	Allen's Hummingbird	BACS	Bachman's Sparrow	BLTE	Black Tern
ALOR	Altamira Oriole	BAWA	Bachman's Warbler	BLTU	Black Turnstone
AMAV	American Avocet	BAMO	Bahama Mockingbird	BLVU	Black Vulture
AMBI	American Bittern	BAHS	Bahama Swallow	BAWW	Black-and-white Warbler
ABDU	American Black Duck	BAWO	Bahama Woodstar	BWAG	Black-backed Wagtail
AMCO	American Coot	BAYE	Bahama Yellowthroat	BBWO	Black-backed Woodpecker
AMCR	American Crow	BATE	Baikal Teal	BBPL	Black-bellied Plover
AMDI	American Dipper	BASA	Baird's Sandpiper	BBWD	Black-bellied Whistling-Duck
AMGO	American Goldfinch	BAIS	Baird's Sparrow	BBCU	Black-billed Cuckoo
AGWT	American Green-winged Teal	BAEA	Bald Eagle	BBMA	Black-billed Magpie
AMKE	American Kestrel	BBOI	Balt X Bull Oriole Intergrade	BBAL	Black-browed Albatross
AMOY	American Oystercatcher	BAOR	Baltimore Oriole	BCCH	Black-capped Chickadee
AMRE	American Redstart	BANA	Bananaquit	BCGN	Black-capped Gnatcatcher
AMRO	American Robin	BANP	Band-rumped Storm-Petrel	BCPE	Black-capped Petrel
ASTK	American Swallow-tailed Kite	BTGU	Band-tailed Gull	BCVI	Black-capped Vireo
ATSP	American Tree Sparrow	BTPI	Band-tailed Pigeon	BCHU	Black-chinned Hummingbird
AWPE	American White Pelican	BANS	Bank Swallow	BCSP	Black-chinned Sparrow
AMWI	American Wigeon	BARG	Bar-tailed Godwit	BCOR	Black-cowled Oriole
AMWO	American Woodcock	BARS	Barn Swallow	BCTI	Black-crested Titmouse
ANMU	Ancient Murrelet	BRNG	Barnacle Goose	BCNH	Black-crowned Night-Heron
ANHI	Anhinga	BAOW	Barred Owl	BEBU	Black-eared Bushtit
ANIA	Anianiau	BAGO	Barrow's Goldeneye	BFGR	Black-faced Grassquit
ANHU	Anna's Hummingbird	BBWA	Bay-breasted Warbler	BFAL	Black-footed Albatross
ANPE	Antarctic Petrel	BEGO	Bean Goose	BHGR	Black-headed Grosbeak
ANTE	Antarctic Tern	BSSP	Belding's Savannah Sparrow	BHPA	Black-headed Parakeet
ACHU	Antillean Crested Hummingbird	BEVI	Bell's Vireo	BLKI	Black-legged Kittiwake
ANEU	Antillean Euphonia	BEKI	Belted Kingfisher	BNTE	Black-naped Tern
ANMA	Antillean Mango	BETH	Bendire's Thrasher	BNST	Black-necked Stilt
ANNI	Antillean Nighthawk	BEHU	Berylline Hummingbird	BRWX	Black-rumped Waxbill
APAP	Apapane	BESW	Bewick's Swan	BSKI	Black-shouldered Kite
APFA	Aplomado Falcon	BEWR	Bewick's Wren	BTGN	Black-tailed Gnatcatcher
ARLO	Arctic Loon	BIOO	Bishop's Oo	BLAG	Black-tailed Godwit

Alpha Code	Common Name	Alpha Code	Common Name	Alpha Code	Common Name
BTBW	Black-throated Blue Warbler	BROC	Bronzed Cowbird	CAKI	Cassin's Kingbird
BTYW	Black-throated Gray Warbler	BRBO	Brown Booby	CASP	Cassin's Sparrow
BTNW	Black-throated Green Warbler	BRCR	Brown Creeper	CAEG	Cattle Egret
BTSP	Black-throated Sparrow	BRJA	Brown Jay	CASW	Cave Swallow
BVOR	Black-vented Oriole	BRNO	Brown Noddy	CAYT	Cayenne Tern
BVSH	Black-vented Shearwater	BRPE	Brown Pelican	CEDW	Cedar Waxwing
BWVI	Black-whiskered Vireo	BRSH	Brown Shrike	CERW	Cerulean Warbler
BLBW	Blackburnian Warbler	BRSK	Brown Skua	CHMA	Chestnut Manakin
BLPW	Blackpoll Warbler	BRTH	Brown Thrasher	CBCH	Chestnut-backed Chickadee
BABI	Blck X Atlant Brant Intergrade	BRTO	Brown Towhee	CCLO	Chestnut-collared Longspur
BLBU	Blue Bunting	BCRF	Brown-capped Rosy-Finch	CSWA	Chestnut-sided Warbler
BLGO	Blue Goose	BCFL	Brown-crested Flycatcher	CHRA	Chihuahuan Raven
BLGR	Blue Grosbeak	BHCO	Brown-headed Cowbird	CHSW	Chimney Swift
BLJA	Blue Jay	BHNU	Brown-headed Nuthatch	CHPE	Chinstrap Penguin
BLPE	Blue Petrel	BUFH	Buff-bellied Hummingbird	CHSP	Chipping Sparrow
BBGR	Blue-black Grassquit	BBFL	Buff-breasted Flycatcher	CHSH	Christmas Shearwater
BECO	Blue-eyed Cormorant	BBSA	Buff-breasted Sandpiper	CWWI	Chuck-will's-widow
BFBO	Blue-footed Booby	BCNI	Buff-collared Nightjar	CITE	Cinnamon Teal
BGGN	Blue-gray Gnatcatcher	BUFF	Bufflehead	CLRA	Clapper Rail
BGNO	Blue-gray Noddy	BUAL	Buller's Albatross	CLGR	Clark's Grebe
BLUH	Blue-throated Hummingbird	BUSH	Buller's Shearwater	CLNU	Clark's Nutcracker
BWTE	Blue-winged Teal	BUOR	Bullock's Oriole	CCRO	Clay-colored Robin
BWWA	Blue-winged Warbler	BUPE	Bulwer's Petrel	CCSP	Clay-colored Sparrow
BLUE	Bluethroat	BUHU	Bumblebee Hummingbird	CLSW	Cliff Swallow
BTGR	Boat-tailed Grackle	BUOW	Burrowing Owl	COLW	Colima Warbler
BOBO	Bobolink	CACG	Cackling Goose	COAM	Common Amakihi
BOWA	Bohemian Waxwing	CACW	Cactus Wren	COBO	Common Barn-Owl
BOGU	Bonaparte's Gull	CALC	California Condor	CBHA	Common Black Hawk
BOPE	Bonin Petrel	CAGU	California Gull	CBHG	Common Black-headed Gull
BOCH	Boreal Chickadee	CATH	California Thrasher	COBU	Common Bushtit
BOOW	Boreal Owl	CAHU	Calliope Hummingbird	COCA	Common Canary
BOSP	Botteri's Sparrow	CAGO	Canada Goose	COCH	Common Chaffinch
BRAM	Brambling	CAWA	Canada Warbler	COEI	Common Eider
BRAC	Brandt's Cormorant	CANV	Canvasback	COGO	Common Goldeneye
BRBL	Brewer's Blackbird	CANW	Canyon Wren	COGR	Common Grackle
BRSP	Brewer's Sparrow	CMWA	Cape May Warbler	COGD	Common Ground-Dove
BREG	Brewster's Egret	CAPE	Cape Petrel	COLO	Common Loon
BRWA	Brewster's Warbler	CSSS	Cape Sable Seaside Sparrow	COME	Common Merganser
BRQD	Bridled Quail-Dove	CARC	Caribbean Coot	COMO	Common Moorhen
BRTE	Bridled Tern	CAEL	Caribbean Elaenia	COMU	Common Murre
BRTI	Bridled Titmouse	CAPA	Caribbean Parakeet	COMY	Common Myna
BTCU	Bristle-thighed Curlew	CACH	Carolina Chickadee	CONI	Common Nighthawk
BBLH	Broad-billed Hummingbird	CARW	Carolina Wren	COPA	Common Pauraque
BBPR	Broad-billed Prion	CATE	Caspian Tern	CPOC	Common Pochard
BTLH	Broad-tailed Hummingbird	CAAU	Cassin's Auklet	COPO	Common Poor-will
BWHA	Broad-winged Hawk	CAFI	Cassin's Finch	CORA	Common Raven

Alpha Code	Common Name	Alpha Code	Common Name	Alpha Code	Common Name
CORE	Common Redpoll	ELTR	Elegant Trogon	GLIB	Glossy Ibis
CORB	Common Reed-bunting	ELEP	Elepaio	GOBI	Golden Bishop
CRPL	Common Ringed Plover	ELOW	Elf Owl	GOEA	Golden Eagle
CORO	Common Rosefinch	EWWA	Elfin Wood Warbler	GCWA	Golden-cheeked Warbler
COSA	Common Sandpiper	EMGO	Emperor Goose	GCKI	Golden-crowned Kinglet
COSN	Common Snipe	EMPE	Emperor Penguin	GCSP	Golden-crowned Sparrow
COTE	Common Tern	EUBU	Eurasian Bullfinch	GOLW	Golden-crowned Warbler
COMW	Common Waxbill	EUDO	Eurasian Dotterel	GFWO	Golden-fronted Woodpecker
COYE	Common Yellowthroat	EUKE	Eurasian Kestrel	GWWA	Golden-winged Warbler
CONW	Connecticut Warbler	EUSK	Eurasian Skylark	GRWA	Grace's Warbler
COPE	Cook's Petrel	EUWI	Eurasian Wigeon	GRSP	Grasshopper Sparrow
COHA	Cooper's Hawk	EUGO	European Goldfinch	GRBU	Gray Bunting
COSH	Cory's Shearwater	EGWT	European Green-winged Teal	GRCA	Gray Catbird
COHU	Costa's Hummingbird	EUST	European Starling	GRFL	Gray Flycatcher
COKI	Couch's Kingbird	ETSP	European Tree Sparrow	GRHA	Gray Hawk
CRMU	Craveri's Murrelet	EUWO	European Woodcock	GRAJ	Gray Jay
CRAU	Crested Auklet	EVGR	Evening Grosbeak	GRAK	Gray Kingbird
CRCA	Crested Caracara	EBTH	Eye-browed Thrush	GRVI	Gray Vireo
CRHO	Crested Honeycreeper	FAPE	Fairy Penguin	GRAW	Gray Wagtail
CRMY	Crested Mynah	FAPR	Fairy Prion	GBSP	Gray-backed Storm-Petrel
CRTE	Crested Tern	FATE	Falcated Teal	GRAT	Gray-backed Tern
CRTH	Crissal Thrasher	FTWA	Fan-tailed Warbler	GBJA	Gray-breasted Jay
CUSA	Curlew Sandpiper	FEHA	Ferruginous Hawk	GBMA	Gray-breasted Martin
CBTH	Curve-billed Thrasher	FEPO	Ferruginous Pygmy-Owl	GCTH	Gray-cheeked Thrush
DRPE	Dark-rumped Petrel	FISP	Field Sparrow	GCRF	Gray-crowned Rosy-Finch
DICK	Dickcissel	FIEL	Fieldfare	GCYE	Gray-crowned Yellowthroat
DCCO	Double-crested Cormorant	FICR	Fish Crow	GHAL	Gray-headed Albatross
DOPR	Dove Prion	FSSP	Five-striped Sparrow	GHJU	Gray-headed Junco
DOVE	Dovekie	FLOW	Flammulated Owl	GSFL	Gray-spotted Flycatcher
DOWO	Downy Woodpecker	FFSH	Flesh-footed Shearwater	GBBG	Great Black-backed Gull
DUNL	Dunlin	FLIN	Flicker Intergrade	GTBH	Great Blue Heron
DUFL	Dusky Flycatcher	FTFL	Fork-tailed Flycatcher	GRCO	Great Cormorant
DSSP	Dusky Seaside Sparrow	FTSP	Fork-tailed Storm-Petrel	GREG	Great Egret
DUTH	Dusky Thrush	FOTE	Forster's Tern	GRFR	Great Frigatebird
DUWA	Dusky Warbler	FOSP	Fox Sparrow	GGOW	Great Gray Owl
DCFL	Dusky-capped Flycatcher	FRGU	Franklin's Gull	GHOW	Great Horned Owl
EAGR	Eared Grebe	FUWD	Fulvous Whistling-Duck	GKIS	Great Kiskadee
EATR	Eared Trogon	GADW	Gadwall	GRSK	Great Skua
EABL	Eastern Bluebird	GALP	Galapagos Penguin	GWHE	Great White Heron
EAKI	Eastern Kingbird	GWCS	Gambel's White-crowned Sparrow	GCFL	Great-crested Flycatcher
EAME	Eastern Meadowlark	GARG	Garganey	GTGR	Great-tailed Grackle
EAPH	Eastern Phoebe	GEPE	Gentoo Penguin	GABU	Greater Antillean Bullfinch
EASO	Eastern Screech-Owl	GIWO	Gila Woodpecker	GAEL	Greater Antillean Elaenia
ETTI	Eastern Tufted Titmouse	GIFL	Gilded Flicker	GAGR	Greater Antillean Grackle
EAWP	Eastern Wood-Pewee	GLGU	Glaucous Gull	GREP	Greater Antillean Pewee
ELTE	Elegant Tern	GWGU	Glaucous-winged Gull	GREF	Greater Flamingo

Alpha Code	Common Name	Alpha Code	Common Name	Alpha Code	Common Name
GRGP	Greater Golden-Plover	HOOR	Hooded Oriole	LALO	Lapland Longspur
GRPE	Greater Pewee	HOWA	Hooded Warbler	LARB	Lark Bunting
GRRO	Greater Roadrunner	HOWF	Hooded Weaver-finch	LASP	Lark Sparrow
GRSC	Greater Scaup	HBKI	Hook-billed Kite	LASF	Lasagra Flycatcher
GRSH	Greater Shearwater	HOGR	Horned Grebe	LAGU	Laughing Gull
GSGO	Greater Snow Goose	HOLA	Horned Lark	LAFF	Lavender Fire-finch
GWFG	Greater White-fronted Goose	HOPU	Horned Puffin	LAGO	Lawrence's Goldfinch
GRYE	Greater Yellowlegs	HOFI	House Finch	LAWA	Lawrence's Warbler
GNLT	Greatr Neckl'd Laughing-thrush	HOSP	House Sparrow	LAAL	Laysan Albatross
GREJ	Green Jay	HOWR	House Wren	LADU	Laysan Duck
GKIN	Green Kingfisher	HUGO	Hudsonian Godwit	LAFI	Laysan Finch
GRMA	Green Mango	HUPE	Humboldt Penguin	LAZB	Lazuli Bunting
GRVE	Green Violet-ear	HUVI	Hutton's Vireo	LCSP	Le Conte's Sparrow
GNBH	Green-backed Heron	ICGU	Iceland Gull	LCTH	Le Conte's Thrasher
GTTO	Green-tailed Towhee	IIWI	Iiwi	LHSP	Leach's Storm-Petrel
GTCA	Green-throated Carib	INDO	Inca Dove	LEAU	Least Auklet
GREL	Greenish Elaenia	IHMY	Indian Hill Myna	LEBI	Least Bittern
GBAN	Groove-billed Ani	INBU	Indigo Bunting	LEFL	Least Flycatcher
GUCO	Guanay Cormorant	IPSP	Ipswich Sparrow	LEGR	Least Grebe
GBTE	Gull-billed Tern	IVGU	Ivory Gull	LESA	Least Sandpiper
GYRF	Gyrfalcon	IBWO	Ivory-billed Woodpecker	LTSP	Least Storm-Petrel
HAWO	Hairy Woodpecker	JACR	Jamaican Crow	LETE	Least Tern
HAFL	Hammond's Flycatcher	JAEL	Jamaican Elaenia	LESB	Lesser Antillean Bullfinch
HRLH	Harlan's Hawk	JAEU	Jamaican Euphonia	LESF	Lesser Antillean Flycatcher
HARD	Harlequin Duck	JAMA	Jamaican Mango	LAPE	Lesser Antillean Pewee
HRSH	Harris' Hawk	JAOR	Jamaican Oriole	LBBG	Lesser Black-backed Gull
HASP	Harris' Sparrow	JATO	Jamaican Tody	LEFR	Lesser Frigatebird
HCRE	Hawaii Creeper	JWEV	Jamaican White-eyed Vireo	LEGP	Lesser Golden-Plover
HACO	Hawaiian Coot	JAWO	Jamaican Woodpecker	LEGO	Lesser Goldfinch
HCRO	Hawaiian Crow	JAWE	Japanese White-eye	LENI	Lesser Nighthawk
HAWD	Hawaiian Duck	JASP	Java Sparrow	LESC	Lesser Scaup
HAGO	Hawaiian Goose	KAMA	Kamao	LESH	Lesser Sheathbill
HWHA	Hawaiian Hawk	KAAK	Kauai Akialoa	LSGO	Lesser Snow Goose
HAMO	Hawaiian Moorhen	KACR	Kauai Creeper	LWFG	Lesser White-fronted Goose
HAST	Hawaiian Stilt	KAOO	Kauai Oo	LEYE	Lesser Yellowlegs
HAWF	Hawfinch	KEWA	Kentucky Warbler	LEWO	Lewis' Woodpecker
HEEG	Heermann's Gull	KEPE	Kerguelen Petrel	LMSA	Light-mantled Sooty Albatross
HESP	Henslow's Sparrow	KETE	Kerguelen Tern	LIMP	Limpkin
HETA	Hepatic Tanager	KWQD	Key West Quail-Dove	LISP	Lincoln's Sparrow
HETH	Hermit Thrush	KILL	Killdeer	LBHE	Little Blue Heron
HEWA	Hermit Warbler	KIEI	King Eider	LIBU	Little Bunting
HERG	Herring Gull	KIPE	King Penguin	LIGU	Little Gull
HPKT	Hispaniolan Parakeet	KIRA	King Rail	LISH	Little Shearwater
HPRT	Hispaniolan Parrot	KIWA	Kirtland's Warbler	LOKI	Loggerhead Kingbird
HORE	Hoary Redpoll	KIMU	Kittlitz's Murrelet	LOSH	Loggerhead Shrike
HOME	Hooded Merganser	LBWO	Ladder-backed Woodpecker	LBCU	Long-billed Curlew

Alpha Code	Common Name	Alpha Code	Common Name	Alpha Code	Common Name
LBDO	Long-billed Dowitcher	MODO	Mourning Dove	OWPA	Orange-winged Parrot
LBTH	Long-billed Thrasher	MOWA	Mourning Warbler	ORAN	Orangequit
LEOW	Long-eared Owl	MUSW	Mute Swan	OROR	Orchard Oriole
LTJA	Long-tailed Jaeger	MYWA	Myrtle Warbler	ORJU	Oregon Junco
LOWA	Louisiana Waterthrush	NAWA	Nashville Warbler	ORGR	Oriental Greenfinch
LUHU	Lucifer Hummingbird	NESH	Newell's Shearwater	OSPR	Osprey
LUWA	Lucy's Warbler	NIFI	Nihoa Finch	OU	Ou
MGWA	MacGillivray's Warbler	NBTY	Northern Beardless Tyrannulet	OVEN	Ovenbird
MACP	Macaroni Penguin	NOCA	Northern Cardinal	PALO	Pacific Loon
MAGU	Magellan Gull	NOFU	Northern Fulmar	PABU	Painted Bunting
MAGP	Magellanic Penguin	NOGA	Northern Gannet	PARE	Painted Redstart
MAFR	Magnificent Frigatebird	NGPE	Northern Giant Petrel	PALI	Palila
MAHU	Magnificent Hummingbird	NOGO	Northern Goshawk	PALB	Pallas' Reed-bunting
MAWA	Magnolia Warbler	NOHA	Northern Harrier	PAAU	Parakeet Auklet
MALL	Mallard	NOHO	Northern Hawk-Owl	PAJA	Parasitic Jaeger
MBDH	Mallard X Black Duck Hybrid	NOJA	Northern Jacana	PETH	Pearly-eyed Thrasher
MACU	Mangrove Cuckoo	NOLA	Northern Lapwing	PEPI	Pechora Pipit
MASH	Manx Shearwater	NOMO	Northern Mockingbird	PESA	Pectoral Sandpiper
MAGO	Marbled Godwit	NOPA	Northern Parula	PECO	Pelagic Cormorant
MAMU	Marbled Murrelet	NOPI	Northern Pintail	PEFA	Peregrine Falcon
MAFD	Marianas Fruit-Dove	NOPO	Northern Pygmy-Owl	PHAI	Phainopepla
MAWR	Marsh Wren	NRWS	Northern Rough-winged Swallow	PHVI	Philadelphia Vireo
MABO	Masked Booby	NSWO	Northern Saw-whet Owl	PHTD	Philippine Turtle-Dove
MADU	Masked Duck	NSHO	Northern Shoveler	PHPE	Phoenix Petrel
MACR	Maui Creeper	NSHR	Northern Shrike	PBGR	Pied-billed Grebe
MAPA	Maui Parrotbill	NOWA	Northern Waterthrush	PIGU	Pigeon Guillemot
MCLO	McCown's Longspur	NOWH	Northern Wheatear	PIWO	Pileated Woodpecker
MKBU	McKay's Bunting	NOCR	Northwestern Crow	PTWH	Pin-tailed Whydah
MEGR	Melodious Grassquit	NUKU	Nukupuu	PIGR	Pine Grosbeak
MELT	Melodious Laughing-thrush	NUMA	Nutmeg Manakin	PISI	Pine Siskin
MERL	Merlin	NWCS	Nuttall's White-crown Sparrow	PIWA	Pine Warbler
MEGU	Mew Gull	NUWO	Nuttall's Woodpecker	PFGO	Pink-footed Goose
MECH	Mexican Chickadee	NUFL	Nutting's Flycatcher	PFSH	Pink-footed Shearwater
MECR	Mexican Crow	OACR	Oahu Creeper	PIJA	Pinyon Jay
MEDU	Mexican Duck	OLDS	Oldsquaw	PIPL	Piping Plover
MIGW	Middendorff's Grasshop-Warbler	OLCO	Olivaceous Cormorant	PLPI	Plain Pigeon
MILL	Millerbird	OLSP	Olive Sparrow	PLTI	Plain Titmouse
MIKI	Mississippi Kite	OLTP	Olive Tree-pipit	PCST	Plain-capped Starthroat
MOCR	Molokai Creeper	OLWA	Olive Warbler	POJA	Pomarine Jaeger
MONP	Mongolian Plover	OLIW	Olive-capped Warbler	POUL	Poo-uli
MODU	Mottled Duck	OSFL	Olive-sided Flycatcher	PRFA	Prairie Falcon
MOPE	Mottled Petrel	OLOM	Olomao	PRAW	Prairie Warbler
MOBL	Mountain Bluebird	OMAO	Omao	PROW	Prothonotary Warbler
MOCH	Mountain Chickadee	ORAW	Orange-cheeked Waxbill	PUAI	Puaiohi
MOUP	Mountain Plover	OCWA	Orange-crowned Warbler	PUEB	Puerto Rican Bullfinch
MWCS	Mountain White-crowned Sparrow	OFPA	Orange-fronted Parakeet	PREM	Puerto Rican Emerald

Alpha Code	Common Name	Alpha Code	Common Name	Alpha Code	Common Name
PRFL	Puerto Rican Flycatcher	RSHA	Red-shouldered Hawk	RWSP	Rufous-winged Sparrow
PRLC	Puerto Rican Lizard-Cuckoo	RTHA	Red-tailed Hawk	RUBU	Rustic Bunting
PRNI	Puerto Rican Nightjar	RTTR	Red-tailed Tropicbird	RUBL	Rusty Blackbird
PRPA	Puerto Rican Parrot	RTLO	Red-throated Loon	SAGU	Sabine's Gull
PRSO	Puerto Rican Screech-Owl	RTPI	Red-throated Pipit	SAFL	Sad Flycatcher
PRTA	Puerto Rican Tanager	RVBU	Red-vented Bulbul	SAFI	Saffron Finch
PRTO	Puerto Rican Tody	RWBU	Red-whiskered Bulbul	SAGS	Sage Sparrow
PRVI	Puerto Rican Vireo	RWBL	Red-winged Blackbird	SATH	Sage Thrasher
PRWO	Puerto Rican Woodpecker	REEG	Reddish Egret	SAND	Sanderling
PSWS	Puget Snd White-crown Sparrow	REDH	Redhead	SACR	Sandhill Crane
PUFI	Purple Finch	REDW	Redwing	SATE	Sandwich Tern
PUGA	Purple Gallinule	REHE	Reef Heron	SAVS	Savannah Sparrow
PUMA	Purple Martin	RHAU	Rhinoceros Auklet	SAPH	Say's Phoebe
PUSA	Purple Sandpiper	RBGU	Ring-billed Gull	SNPI	Scaly-naped Pigeon
PYNU	Pygmy Nuthatch	RNDU	Ring-necked Duck	SCIB	Scarlet Ibis
PYRR	Pyrrhuloxia	RIKI	Ringed Kingfisher	SCTA	Scarlet Tanager
RAZO	Razorbill	RITD	Ringed Turtle-Dove	STFL	Scissor-tailed Flycatcher
REAV	Red Avadavat	ROHA	Roadside Hawk	SCOR	Scott's Oriole
REBI	Red Bishop	ROSA	Rock Sandpiper	SCJA	Scrub Jay
RECR	Red Crossbill	ROWR	Rock Wren	SESP	Seaside Sparrow
REKN	Red Knot	ROCP	Rockhopper Penguin	SEWR	Sedge Wren
REPH	Red Phalarope	RBGR	Rose-breasted Grosbeak	SEPL	Semipalmated Plover
RESI	Red Siskin	RTBE	Rose-throated Becard	SESA	Semipalmated Sandpiper
RBWO	Red-bellied Woodpecker	ROSP	Roseate Spoonbill	SSHA	Sharp-shinned Hawk
RBLE	Red-billed Leiothrix	ROST	Roseate Tern	SHAS	Sharp-tailed Sandpiper
RBPI	Red-billed Pigeon	ROGO	Ross' Goose	STSP	Sharp-tailed Sparrow
RBTR	Red-billed Tropicbird	ROGU	Ross' Gull	SHCO	Shiny Cowbird
RBFL	Red-breasted Flycatcher	RLHA	Rough-legged Hawk	SBDO	Short-billed Dowitcher
RBME	Red-breasted Merganser	ROAL	Royal Albatross	SEOW	Short-eared Owl
RBNU	Red-breasted Nuthatch	ROYP	Royal Penguin	STAL	Short-tailed Albatross
RBSA	Red-breasted Sapsucker	ROYT	Royal Tern	STHA	Short-tailed Hawk
RCCO	Red-cheeked Cordonbleu	RCKI	Ruby-crowned Kinglet	SHOS	Short-tailed Shearwater
RCWO	Red-cockaded Woodpecker	RTHU	Ruby-throated Hummingbird	STSW	Short-tailed Swift
RCCA	Red-crested Cardinal	RUDU	Ruddy Duck	SHAL	Shy Albatross
RCPA	Red-crowned Parrot	RUGD	Ruddy Ground-Dove	SIAC	Siberian Accentor
REVI	Red-eyed Vireo	RUQD	Ruddy Quail-Dove	SIFL	Siberian Flycatcher
RFCO	Red-faced Cormorant	RUTU	Ruddy Turnstone	SIRU	Siberian Rubythroat
RFWA	Red-faced Warbler	RUFF	Ruff	SITI	Siberian Tit
RFBO	Red-footed Booby	RUHU	Rufous Hummingbird	SCJU	Slate-colored Junco
RHWO	Red-headed Woodpecker	RBRO	Rufous-backed Robin	SLAR	Slate-throated Redstart
RLKI	Red-legged Kittiwake	RCWA	Rufous-capped Warbler	SBGU	Slaty-backed Gull
RLTH	Red-legged Thrush	RUFS	Rufous-collared Sparrow	SCGO	Small Canada Goose
RNSA	Red-naped Sapsucker	RCSP	Rufous-crowned Sparrow	SMLO	Smith's Longspur
RNGR	Red-necked Grebe	RSTO	Rufous-sided Towhee	SBAN	Smooth-billed Ani
RNPH	Red-necked Phalarope	RUFH	Rufous-tailed Hummingbird	SNKI	Snail Kite
RSFL	Red-shafted Flicker	RTSO	Rufous-throated Solitaire	SNBU	Snow Bunting

Alpha Code	Common Name	Alpha Code	Common Name	Alpha Code	Common Name
SNPE	Snow Petrel	TEWA	Tennessee Warbler	WAPI	Water Pipit
SBGI	Snow X Blue Goose Intergrade	THGU	Thayer's Gull	WRSP	Wedge-rumped Storm-Petrel
SNEG	Snowy Egret	TBKI	Thick-billed Kingbird	WTSH	Wedge-tailed Shearwater
SNOW	Snowy Owl	TBMU	Thick-billed Murre	WIWD	West Indian Whistling-duck
SNPL	Snowy Plover	TBPA	Thick-billed Parrot	WEBL	Western Bluebird
SNSH	Snowy Sheathbill	TBVI	Thick-billed Vireo	WEFL	Western Flycatcher
SOSA	Solitary Sandpiper	TBPR	Thin-billed Prion	WEGR	Western Grebe
SOVI	Solitary Vireo	TTWO	Three-toed Woodpecker	WEGU	Western Gull
SOSP	Song Sparrow	TOSH	Townsend's Shearwater	WEKI	Western Kingbird
SOAL	Sooty Albatross	TOSO	Townsend's Solitaire	WEME	Western Meadowlark
SOSH	Sooty Shearwater	TOWA	Townsend's Warbler	WPWA	Western Palm Warbler
SOOP	Sooty Storm-Petrel	TRFL	Traill's Flycatcher	WESA	Western Sandpiper
SOTE	Sooty Tern	TRES	Tree Swallow	WESO	Western Screech-Owl
SORA	Sora	TREM	Trembler	WETA	Western Tanager
SPSK	South Polar Skua	TRBL	Tricolored Blackbird	WEWP	Western Wood-Pewee
SBBG	Southern Black-backed Gull	TRHE	Tricolored Heron	WHIM	Whimbrel
SOFU	Southern Fulmar	TRKI	Tropical Kingbird	WPWI	Whip-poor-will
SGPE	Southern Giant Petrel	TRMO	Tropical Mockingbird	WHAU	Whiskered Auklet
SHWR	Southern House Wren	TRPA	Tropical Parula	WHSO	Whiskered Screech-Owl
SPEI	Spectacled Eider	TROU	Troupial	WHSW	Whistling Swan
SPOS	Spoonbill Sandpiper	TRUS	Trumpeter Swan	WHIB	White Ibis
SPDO	Spotted Dove	TUDU	Tufted Duck	WHTE	White Tern
SPOW	Spotted Owl	TUPU	Tufted Puffin	WHWA	White Wagtail
SPSA	Spotted Sandpiper	TUVU	Turkey Vulture	WBDO	White-bellied Dove
SPTO	Spotted Towhee	UDEJ	Unidentified Dark-eyed Junco	WBNU	White-breasted Nuthatch
SPOO	Spotted-breasted Oriole	UNGU	Unidentified Gull	WHIP	White-cheeked Pintail
SPPI	Sprague's Pipit	UNHU	Unidentified Hummingbird	WCPE	White-chinned Petrel
STEI	Steller's Eider	UNTE	Unidentified Teal	WCTH	White-chinned Thrush
STJA	Steller's Jay	UPSA	Upland Sandpiper	WCSE	White-collared Seedeater
STSA	Stilt Sandpiper	VABU	Varied Bunting	WCPI	White-crowned Pigeon
STOF	Stolid Flycatcher	VATH	Varied Thrush	WCSP	White-crowned Sparrow
STRO	Streak-backed Oriole	VATI	Varied Tit	WEHU	White-eared Hummingbird
STRS	Streaked Shearwater	VASW	Vaux's Swift	WETH	White-eyed Thrush
STTL	Streamertail	VEER	Veery	WEVI	White-eyed Vireo
STWO	Strickland's Woodpecker	VERD	Verdin	WFIB	White-faced Ibis
SHTA	Stripe-headed Tanager	VEFL	Vermilion Flycatcher	WFSP	White-faced Storm-Petrel
SBFL	Sulphur-bellied Flycatcher	VESP	Vesper Sparrow	WHWO	White-headed Woodpecker
SUTA	Summer Tanager	VIPE	Victoria Penguin	WNCR	White-necked Crow
SUSC	Surf Scoter	VCHU	Violet-crowned Hummingbird	WRSA	White-rumped Sandpiper
SURF	Surfbird	VGSW	Violet-green Swallow	WRSH	White-rumped Shama
SUWA	Sutton's Warbler	VIRA	Virginia Rail	WTHA	White-tailed Hawk
SWHA	Swainson's Hawk	VIWA	Virginia's Warbler	WTTR	White-tailed Tropicbird
SWTH	Swainson's Thrush	WAAL	Wandering Albatross	WTGD	White-throated Ground-Dove
SWWA	Swainson's Warbler	WATA	Wandering Tattler	WTSP	White-throated Sparrow
SWSP	Swamp Sparrow	WASI	Warbling Silverbill	WHSP	White-throated Storm-Petrel
TSBL	Tawny-shouldered Blackbird	WAVI	Warbling Vireo	WTSW	White-throated Swift

Alpha Code	Common Name
WTDO	White-tipped Dove
WVMY	White-vented Myna
WWCR	White-winged Crossbill
WWDO	White-winged Dove
WWJU	White-winged Junco
WWSC	White-winged Scoter
WWTE	White-winged Tern
WHOS	Whooper Swan
WHCR	Whooping Crane
WILL	Willet
WISA	Williamson's Sapsucker
WIFL	Willow Flycatcher
WIPL	Wilson's Plover
WISP	Wilson's Storm-Petrel
WIWA	Wilson's Warbler
WIPH	Wilsons Phalarope
WIWR	Winter Wren
WODU	Wood Duck
WOST	Wood Stork

Alpha Code	Common Name
WOTH	Wood Thrush
WOWA	Wood Warbler
WEWA	Worm-eating Warbler
WOSP	Worthen's Sparrow
WREN	Wrentit
XAMU	Xantus' Murrelet
YEGR	Yellow Grosbeak
YPWA	Yellow Palm Warbler
YERA	Yellow Rail
YWAG	Yellow Wagtail
YWAR	Yellow Warbler
YBEL	Yellow-bellied Elaenia
YBFL	Yellow-bellied Flycatcher
YBSA	Yellow-bellied Sapsucker
YBSE	Yellow-bellied Seedeater
YBCA	Yellow-billed Cardinal
YBCU	Yellow-billed Cuckoo
YBLO	Yellow-billed Loon
YBMA	Yellow-billed Magpie

Alpha Code	Common Name
YBCH	Yellow-breasted Chat
YBCR	Yellow-breasted Crake
YCNH	Yellow-crowned Night-Heron
YEJU	Yellow-eyed Junco
YFGR	Yellow-faced Grassquit
YFGU	Yellow-footed Gull
YFCA	Yellow-fronted Canary
YGVI	Yellow-green Vireo
YHBL	Yellow-headed Blackbird
YNAL	Yellow-nosed Albatross
YSFL	Yellow-shafted Flicker
YSBL	Yellow-shouldered Blackbird
YSGR	Yellow-shouldered Grassquit
YTVI	Yellow-throated Vireo
YTWA	Yellow-throated Warbler
ZEBD	Zebra Dove
ZEND	Zenaida Dove
ZTHA	Zone-tailed Hawk

APPENDIX D. Proposed structure of computer files for point count data.

VARIABLE	COLUMNS	DESCRIPTION OF VARIABLE
STATE	1–2	State
REGION	3–12	Regional description of area (e.g., STFRANNF = St. Francis National Forest or WRNWR = White River National Wildlife Refuge)
STATION	13–16	Station, compartment, or study area within region (e.g., CMP1=compartment 1)
POINT NUMBER	17–19	Number of point within the station 1–999
VISIT NUMBER	20	Visits to same point within the same year (1) 1–9
YEAR	21–24	Year (19xx)
MONTH	25–26	Month (01–12)
DAY	27–28	Day (01–31)
TIME	29–32	Time of day; 2400 hour clock (e.g., 0732), in standard, not daylight time
OBSERVER	33–35	Observer identification (e.g., initials)
TEMPERATURE	36–37	Temperature °C
WIND	38	Beaufort scale (Appendix B)
SKY CONDITION	39	Sky condition, combining cloud cover and precipitation (Appendix B)
HABITAT	40	General habitat characterization (A=agriculture, F=forest, G=grasslands, U=urban/suburban)
FOREST TYPE	41–43	Society of American Foresters Forest Cover Type (001–999)
TIMBER TYPE	44	B=brush/scrub–shrub, C=cut/clear, P=poletimber, S=sawtimber, M=mature/old growth, D=disease/dead/damaged
GEO–CODING SYSTEM	45–46	0 if in lat–long; UTM zone if in UTM (e.g., 15 or 16 within the Mississippi Valley)
N–S COORDINATES	47–53	UTM (Northing – 7 digits) or latitude (DDMMSS) = (30°42′33")
E–W COORDINATES	54–60	UTM (Easting – 6 digits) or longitude (DDDMMSS) = (089°14′59")
SPECIES	61–64	Alpha code – from Appendix C (e.g., NOCA, WOTH)
0–3min/<25m	65–66	Number of birds counted within 25 m (82 ft) during the first 3 minutes
4–5min/<25m	67–68	Number of birds counted within 25 m (82 ft) during minutes 4–5
6–10min/<25m	69–70	Number of birds counted within 25 m (82 ft) during minutes 6–10
0–3min/25–50m	71–72	Number of birds counted between 25–50 m (82–164 ft) during the first 3 minutes
4–5min/25–50m	73–74	Number of birds counted between 25–50 m (82–164 ft) during minutes 4–5
6–10min/25–50m	75–76	Number of birds counted between 25–50 m (82–164 ft) during minutes 6–10
0–3min/>50m	77–78	Number of birds counted beyond 50 m (164 ft) during the first 3 minutes
4–5min/>50m	79–80	Number of birds counted beyond 50 m (164 ft) during minutes 4–5
6–10min/>50m	81–82	Number of birds counted beyond 50 m (164 ft) during minutes 6–10
0–3min/fly–overs	83–84	Number of fly–overs counted during the first 3 minutes
4–5min/fly–overs	85–86	Number of fly–overs counted during minutes 4–5
6–10min/fly–overs	87–88	Number of fly–overs counted during minutes 6–10
0–3 min/<50m	89–90	Number of birds counted within 50 m (164 ft) during the first 3 minutes
4–5min/<50m	91–92	Number of birds counted within 50 m (164 ft) during minutes 4–5
6–10min/<50m	93–94	Number of birds counted within 50 m (164 ft) during minutes 6–10
0–3 min/total	95–96	Total number of birds counted during the first 3 minutes
4–5min/total	97–98	Total number of birds counted during minutes 4–5
6–10min/total	99–100	Total number of birds counted during minutes 6–10
SUBMITTER	101–105	Initials of the person or entity submitting the data
REMARKS	106–150	Notes and observations

Appendix E. Determining sample size by the power method.

The power method (Neter and Wasserman 1974) can be used to determine the desired sample size for a particular application. Unfortunately, it requires some math, some previous data, and some reference tables. The following is an example of the use of this method. The math is outlined below, the previous data come from Smith and others (1993), and the reference tables appear at the end of this appendix.

Neter and Wasserman (1974) propose to determine the sample size required to decide whether mean numbers of birds recorded for a particular species from counts in different habitats are equal. Suppose there are four habitats of interest for a particular situation. Suppose the species is red-eyed vireo (*Vireo olivaceus*). What is needed is to find a sample size with which to test the working hypothesis that numbers of red-eyed vireos are similar among the four habitats being examined:

Case 1: All four means are equal, $\mu_1 = \mu_2 = \mu_3 = \mu_4$.

Case 2: All four means are not equal.

For this test, it is necessary to determine a particular amount of difference that is meaningful to detect and then to select appropriate α and β values. For the example, $\alpha = 0.05$ and $\beta = 0.10$ have been selected. The power of the test is given by $1-\beta$, in this case 0.90. For this calculation, it is necessary to compute ϕ, called the noncentrality parameter, which reflects how evenly dispersed the means for individual habitats are relative to the overall mean. For this example, it is assumed that the mean numbers of birds in the various habitats are uniformly dispersed and symmetrical about the overall mean. This approach is used because it minimizes the value of ϕ. and thus provides the most conservative (i.e., maximizes) estimates of minimum sample size (Neter and Wasserman 1974).

The formula for ϕ', a suitable approximation of ϕ, is

$$\phi' = \frac{1}{MSE}\sqrt{\frac{\sum(\mu_i-\mu)^2}{r}},$$

where:
ϕ' = estimate of the noncentrality parameter ϕ,
MSE = mean square error from analysis of variance,
μ_i = mean number of birds in habitat i,
μ = overall mean, and
r = number of habitats, also called factor levels (four, in this case).

Once ϕ' has been calculated, the minimum sample size for each factor level can be obtained for a specifed α and β from tables E-1 through E-5. The values for red-eyed vireo for the example come from Smith and others (1993), as follows: $\mu = 0.524$ birds per count, $MSE = 0.44$ birds per count. Habitats to be compared are $r = 4$. The only remaining need is for a manager's decision as to how different the means need to be; i.e., $\mu_i - \mu$.

Suppose the manager chooses 25 percent of the mean, 0.131 birds per count. Then the calculation of minimum sample size is as follows:

$$\phi' = \frac{1}{0.44}\sqrt{\frac{4*(0.131)^2}{4}}$$

$$\phi' = 0.33$$

Looking up the value of $\phi' = 0.33$, with $\alpha = 0.05$, $\beta = 0.1$, and $r = 4$ habitats in table E-4 yields an estimate of 33 counts per habitat. Thus, in order to distinguish differences in relative abundance of 25 percent of the mean of red-eyed vireos in 4 different habitats in bottomland forests of the Mississippi Alluvial Valley, according to the pilot data of Smith and others (1993), at least 33 separate point counts from each habitat will be necessary.

Table E-1.—*Minimum sample sizes calculated by Smith and others (1993) according to the power method for several bird species and community measures; these sample sizes are the number of point counts for each factor level necessary to detect the listed differences in mean values with $\alpha = 0.05$ and $\beta = 0.10$, as based on the observed variation among the three regions in the Mississippi Alluvial Valley*

	Sample size required to dectect a difference equivalent to		
Variable	Actual difference*	±0.25 birds†	±25% of mean
Yellow-billed cuckoo (*Coccyzus americanus*)	80	44	100
Red-bellied woodpecker (*Melanerpes carolinus*)	>200	90	53
Acadian flycatcher (*Empidonax virescens*)	53	65	80
Carolina chickadee (*Parus carolinensis*)	85	>200	>200
Tufted titmouse (*Parus bicolor*)	58	53	80
Carolina wren (*Thryothorus ludovicianus*)	>200	85	44
Blue-gray gnatcatcher (*Polioptila caerulea*)	9	58	100
Wood thrush (*Hylocichla mustelina*)	>200	27	>200
Yellow-throated vireo (*Vireo flavifrons*)	100	9	>200
Red-eyed vireo (*Vireo olivaceus*)	15	37	>200
Northern parula (*Parula americana*)	27	23	>200
American redstart (*Setophaga ruticilla*)	>200	9	>200
Prothonotary warbler (*Protonotaria citrea*)	9	58	70
Kentucky warbler (*Oporornis formosus*)	80	9	>200
Hooded warbler (*Wilsonia citrina*)	65	9	>200
Summer tanager (*Piranga rubra*)	53	27	>200
Northern cardinal (*Cardinalis cardinalis*)	>200	>200	53
Indigo bunting (*Passerina cyanea*)	50	19	>200
Rufous-sided towhee (*Pipilo erythrophthalmus*)	>200	9	>200
Brown-headed cowbird (*Molothrus ater*)	23	44	>200
Total species	41	>500	5
Total individuals	20	>500	5

*Actual difference is the difference observed by Smith and others (1993) among mean values in the various regions of the Mississippi Alluvial Valley in which their counts were conducted.

†Absolute difference between mean values for the various regions in the Mississippi Alluvial Valley.

Table E-2.—*Critical values of Student's t**

Table E-2a.—*Critical value for power of test (1-β)*

	Desired power of test (1-β)					
df	0.60	0.70	0.80	0.90	0.95	0.99
1	1.376	1.963	3.078	6.314	12.706	63.657

Table E-2b.—*Critical value for statistical significance α*

	Desired statistical significance α					
df	0.40	0.30	0.20	0.10	0.0	0.01
10	0.879	1.093	1.372	1.812	2.228	3.169
15	0.866	1.074	1.341	1.753	2.131	2.947
20	0.860	1.064	1.325	1.725	2.086	2.845
25	0.856	1.058	1.316	1.708	2.060	2.787
30	0.854	1.055	1.310	1.697	2.042	2.750
40	0.851	1.050	1.303	1.684	2.021	2.704
60	0.848	1.046	1.296	1.671	2.000	2.660
120	0.845	1.041	1.289	1.658	1.980	2.617
∞	0.842	1.036	1.282	1.645	1.960	2.576

*Adapted from table 2 of Freese (1967).

Table E-3.—*Determination of sample size for point counts with α = 0.10**

		ϕ'											
Number of factor levels	β	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.50	0.60	0.70	0.80
r = 2	0.05	2165	542	241	136	87	61	45	35	22	16	12	9
	0.10	1713	429	191	108	69	48	36	27	18	13	10	8
	0.20	1237	310	138	78	50	35	26	20	13	9	7	6
	0.30	942	236	105	60	38	27	20	15	10	7	6	5
r = 3	0.05	1738	435	194	109	70	49	36	28	18	13	10	8
	0.10	1395	349	156	88	57	40	29	23	15	11	8	6
	0.20	1029	258	115	65	41	29	22	17	11	8	6	5
	0.30	797	200	89	50	32	23	17	13	9	6	5	4
r = 4	0.05	1458	365	163	92	59	41	30	24	15	11	8	7
	0.10	1180	296	132	74	48	34	25	19	13	9	7	5
	0.20	883	221	99	56	36	25	19	15	10	7	5	4
	0.30	690	173	77	43	28	20	15	11	8	6	4	4
r = 5	0.05	1267	317	141	80	51	36	27	21	13	10	7	6
	0.10	1031	258	115	65	42	29	22	17	11	8	6	5
	0.20	773	193	87	49	32	22	17	13	9	6	5	4
	0.30	612	154	68	38	25	18	13	10	7	5	4	3
r = 9	0.05	765	192	86	49	31	22	16	13	8	6	5	4
	0.10	633	159	71	40	26	18	14	11	7	5	4	3
	0.20	482	121	54	31	20	14	11	8	6	4	3	3
	0.30	390	98	44	25	16	11	9	7	5	4	3	2
r = 13	0.05	688	173	77	44	28	20	15	11	8	5	4	4
	0.10	571	143	64	36	24	17	12	10	6	5	4	3
	0.20	437	110	49	28	18	13	10	8	5	4	3	3
	0.30	355	89	40	23	15	11	8	6	4	3	3	2
r = 25	0.05	456	114	52	30	19	13	10	8	5	4	3	3
	0.10	382	96	43	25	16	11	8	7	5	3	3	2
	0.20	298	75	34	19	12	9	7	5	4	3	2	2
	0.30	246	62	27	16	10	7	6	5	3	2	2	2

*Adapted from table 8.4 of Cohen (1977).

Table E-4.—*Determination of sample size for point counts with α = 0.05***

Number of factor levels	β	φ' 0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.50	0.60	0.70	0.80
r = 2	0.05	2600	651	290	163	105	73	54	42	27	19	14	11
	0.10	2102	526	234	132	85	59	44	34	22	16	12	9
	0.20	1571	393	175	99	64	45	33	26	17	12	9	7
	0.30	1235	310	138	78	50	35	26	20	13	10	7	6
r = 3	0.05	2060	515	230	130	83	58	43	33	22	15	12	9
	0.10	1682	421	188	106	68	48	35	27	18	13	10	8
	0.20	1286	322	144	81	52	36	27	21	14	10	8	6
	0.30	1028	258	115	65	42	29	22	17	11	8	6	5
r = 4	0.05	1718	430	192	108	70	49	36	28	18	13	10	8
	0.10	1415	354	158	89	58	40	30	23	15	11	8	7
	0.20	1096	274	123	69	45	31	23	18	12	9	7	5
	0.30	881	221	99	56	36	25	19	15	10	7	6	5
r = 5	0.05	1486	372	166	94	60	42	31	24	16	11	9	7
	0.10	1231	309	138	78	50	35	26	20	13	10	7	6
	0.20	956	240	107	61	39	27	20	16	10	8	6	5
	0.30	776	195	87	49	32	22	17	13	9	6	5	4
r = 9	0.05	1012	254	113	64	41	29	22	17	11	8	6	5
	0.10	848	213	95	54	35	24	18	14	9	7	5	4
	0.20	669	168	75	42	27	19	14	11	8	6	4	4
	0.30	548	138	61	35	23	16	12	9	6	5	4	3
r = 13	0.05	796	200	89	51	33	23	17	13	9	6	5	4
	0.10	673	169	75	43	28	20	15	11	8	6	4	4
	0.20	534	134	60	34	22	16	12	9	6	5	4	3
	0.30	443	111	50	28	18	13	10	8	5	4	3	3
r = 25	0.05	525	132	59	34	22	15	11	9	6	4	4	3
	0.10	457	115	51	29	19	13	10	8	5	4	3	3
	0.20	363	91	41	23	15	11	8	6	4	3	3	2
	0.30	303	76	34	20	13	9	7	5	4	3	2	2

*Adapted from table 8.4 of Cohen (1977).

Table E-5.—*Determination of sample size for point counts with α = 0.01* *

Number of factor levels	β	ϕ'											
		0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.50	0.60	0.70	0.80
$r = 2$	0.05	3564	892	398	224	144	101	74	57	37	26	20	16
	0.10	2978	746	332	188	120	84	62	48	31	22	17	13
	0.20	2338	586	259	148	95	67	49	38	25	18	14	11
	0.30	1924	482	215	122	79	55	41	32	21	15	12	9
$r = 3$	0.05	2756	690	308	174	112	78	58	45	29	21	16	12
	0.10	2325	582	260	147	95	66	49	38	25	18	14	11
	0.20	1851	464	207	117	76	53	39	30	20	14	11	9
	0.30	1543	387	173	98	63	44	33	26	17	12	10	8
$r = 4$	0.05	2270	568	253	143	92	64	48	37	24	17	13	10
	0.10	1927	483	215	122	78	55	41	31	21	15	11	9
	0.20	1548	388	175	98	63	44	33	25	17	12	9	8
	0.30	1299	326	146	83	53	37	28	22	14	10	8	7
$r = 5$	0.05	1948	488	218	123	79	55	41	32	21	15	11	9
	0.10	1661	416	186	105	68	47	35	27	18	13	10	8
	0.20	1341	336	150	85	55	38	29	22	15	11	8	7
	0.30	1128	283	127	72	46	33	24	19	13	9	7	6
$r = 9$	0.05	1303	324	146	83	53	37	28	22	14	10	8	6
	0.10	1122	251	126	71	46	32	24	19	12	9	7	6
	0.20	918	230	103	58	38	27	20	15	10	8	6	5
	0.30	785	197	88	50	32	23	17	13	9	7	5	4
$r = 13$	0.05	1017	255	114	65	42	29	22	17	11	8	6	5
	0.10	881	221	99	56	36	25	19	15	10	7	6	5
	0.20	726	182	82	46	30	21	16	12	8	6	5	4
	0.30	623	157	70	40	26	18	14	11	7	5	4	3
$r = 25$	0.05	662	166	74	42	27	19	14	11	8	6	4	4
	0.10	578	145	65	37	24	17	13	10	7	5	4	3
	0.20	485	121	55	31	20	15	11	8	6	4	3	3
	0.30	417	105	47	27	17	12	9	7	5	4	3	3

*Adapted from table 8.4 of Cohen (1977).

Appendix F. Sample vegetation measurements.

I. Level Two scheme

Habitat variables, incorporated into the Migratory and Resident Landbird Conservation Strategy of the Forest Service, Southern Region, National Forests (USDA FS 1995), will be measured at each of the point counting stations employed by the National Forest System in monitoring landbirds in the South.

Nonvegetative variables include:

Elevation (in feet [1 ft = 0.3049 m])

Aspect (0 to 360 degrees)

Slope (0 to 90 percent)

Water (present, absent, standing, flowing, fresh, brackish, salt, within point, nearer than 328 ft [100 m] to point)

Variables of the dominant and codominant canopy include:

1. Forest cover (using the Forest Service's Continuous Inventory of Stand Conditions [CISC; Compartment Prescription Fieldbook (USDA FS no date)] codes that will describe the makeup of the major tree species in the overstory).

2. Dominant age (using a dominant tree characteristic of the point or CISC data for the stand if these are thought to be a reliable representation of age at the point.)
3. Dominant tree height (using a clinometer estimate of the average height (in feet [1 ft = 0.3049 m]) of the dominant tree canopy for the point).
4. Total basal area (using a prism to determine total square feet per acre ([1 m^2/ha = 4.36 ft^2/acre] of dominant tree species measured from point center; the basal area will be tallied and recorded separately according to the categories of conifer and hardwood).
5. Percentage of canopy cover (using an ocular estimate from point center to determine percentage of cover by the dominant and codominant canopy according to the following categories: 0 percent, 1 to 25 percent, 26 to 50 percent, 51 to 75 percent, 76 to 100 percent).

Variables of the midstory layer include:

1. Dominant vegetation (general vegetation categories based on ocular observations from point center that include deciduous [i.e., dogwood/maple, oak/hickory, gum/poplar, other], coniferous [i.e., pine, hemlock, cypress, other], evergreen [i.e., rhododendron, mountain laurel, titi, bays, other]).
2. Percentage of canopy cover (an ocular estimate from point center of percentage of cover by the midstory canopy according to the following categories: 0 percent, 1 to 25 percent, 26 to 50 percent, 51 to 75 percent, 76 to 100 percent).

Variables of the shrub layer include:

1. Dominant vegetation (general vegetation categories based on ocular observations from point center that include deciduous trees, deciduous shrubs, vines, coniferous [i.e., pine, hemlock, cypress, other], and evergreen [i.e., rhododendron, mountain laurel, bays, switchcane, other]).
2. Percentage of canopy cover (an ocular estimate from point center of percentage of cover by the shrub layer according to the following categories: 0 percent, 1 to 25 percent, 26 to 50 percent, 51 to 75 percent, 76 to 100 percent).

Variables of the herbaceous layer include:

1. Dominant vegetation (general vegetation categories based on ocular observations from point center that include woody plants, forbs/sedges, and grasses).
2. Percentage of canopy cover (an ocular estimate from point center of percentage of cover by the herbaceous layer according to the following categories: 0 percent, 1 to 25 percent, 26 to 50 percent, 51 to 75 percent, 76 to 100 percent).
3. Groundcover description (an ocular estimate from point center of the following groundcover categories: litter, open glade, bare ground, moist, standing water).

Other key habitat components include:

1. Standing snags (an ocular estimate from point center of the following categories: number of snags greater than 25 cm [12 inches] in d.b.h., number of snags greater than 50 cm [20 inches] in d.b.h.).
2. Live cavity trees (an ocular estimate from point center of the following categories: number of cavity trees greater than 25 cm [12 inches] in d.b.h., number of cavity trees greater than 50 cm [20 inches] in d.b.h.).

II. Level Three scheme

The standard set of measurements follows:

Elevation to the nearest meter (1 m = 3.28 ft), measured with an altimeter or from a topographic map

Slope in percent, measured with a clinometer

Aspect of the slope (the compass direction from plot center downslope) to the nearest degree, measured with a compass

Presence or absence of significant water within 50 m (164 ft) of plot center

Canopy closure, in percent, is measured with an ocular tube, a 3- or 6-cm (1.5- or 2-inch) diameter cylinder of polyvinylchloride or other material, with cross-hairs attached to one end. The tube is held vertically, and the presence or absence of living vegetation at the cross-hairs recorded; 20 readings are taken at each point count station, at 2-m (6.5-ft) intervals along 10-m (33-ft) transects in the cardinal directions. The number of "vegetation present" readings multiplied by 5 equals the percentage of canopy closure.

Groundcover is measured at the same points as canopy closure. The ocular tube is pointed down in a randomly selected direction, and the observer's eyes are closed. The eyes are then opened and if green vegetation is present at the cross-hairs, the point is counted as "groundcover present." The number of "groundcover present" readings multiplied by 5 is the estimate of the percentage of groundcover. The three most common plant species in the groundcover layer are recorded.

Shrub cover: If the station at which canopy closure is measured is in a shrub, a positive reading of "shrub present" occurs. The number of "shrub present" readings multiplied by 5 is the estimate of the percentage of shrub cover. Shrub density per hectare can be estimated as the number of shrubs within a circular plot centered on the point with a radius of 5.64 m (18.5 ft) multiplied by 100. Density of the three most numerous shrub species is also recorded.

Species composition, basal area, stem density, and canopy height of the overstory are measured in the following way: From the center point counting station, use an angle gauge or prism to determine the sample of trees 10 cm (4 inches) in d.b.h. or larger. Use a basal-area factor prism or gauge that includes approximately 10 trees in the sample (e.g., 5x or 7x m^2/ha [20x or 30x ft^2/acre] in dense forests, 2.5x or 1.3x m^2/ha [10x or 5x ft^2/acre] in sparse forests). Measure and record the species and diameter of each of the trees included in the prism sample. Basal area for each species is the number of stems of that species counted, multiplied by the basal-area factor. Stem density is a function calculated from the diameter and basal-area factor for each tree (stem density = basal area factor/basal area of the tree, in the appropriate units; thus, if basal area is in m^2, the basal area of the tree is: (d.b.h. in cm/200)^2 multiplied by π (for basal area in ft^2, the basal area of the tree is: [d.b.h. in inches/24]^2 multiplied by π). Stem density for the species is the sum of the stem densities for each of the trees of that species. Dead trees are recorded in the same way as live ones, but assigned to the species "SNAG." Canopy height is measured with a clinometer and is the average of the heights of the four tallest trees in the prism sample.

Additional measurements that have been found useful:

Vegetation profile (or midstory density)—
Measure with a 0.5- by 0.5-m (20- by 20-inch) density board gridded into a checkerboard of 25 equal squares, read from the center of the point count station, and set up at a distance of 10 m (33 ft) in each of the cardinal directions. The board is read at 0, 2.5, and 5 m (0, 8.2, and 16.4 ft). The number of squares more than 50 percent obscured by vegetation is the measure of vegetation density. When all four measures in each direction are summed, a percentage of cover in that layer is obtained. As a practical matter in the field, the number of open squares is usually tallied, and that number is subtracted from 25 to determine the number of squares that are obscured by vegetation.

Percentage of cover of vines in the canopy and of Spanish moss—
Measure in the same way as canopy closure, except that presence of these features anywhere in the view of the tube, rather than only at the cross-hairs, counts as a "present." Because the entire field of the ocular tube is examined, standardization of the diameter of the tube at 3 to 5 cm (1.5 to 2 inches) is necessary to ensure comparability of data among observers.

Presence or absence of snags and water—
Measure in two bands, representing the 25-m and 25- to 50-m (82-ft and 82- to 164-ft) bands around the counting station. If water (e.g., creek, pond, temporary pool) is present in either of these bands, it is recorded as "present." If standing dead trees are present in either of these bands, then that fact is recorded as well. Note that the presence of snags may also be recorded by the canopy tree sample.

APPENDIX G. List and descriptions of computer files and suggested coding standards for Level Three vegetation variables. List follows a general sequence from more general to more specific data items.

Table G-1.—***File One: Description of suggested coding standards for level three vegetation variables associated with point counts of birds.***

Variable	Description of variable
STATE	Two-letter State code (U.S. Postal Service code).
REGION	A description of the region or geographic locality where points are conducted. Regions could be such entities as national forests, national parks, river basins, counties, etc.
STATION	Smaller area within the region. Stations could be forest compartments, study areas, townships, or any subdivision of the regional description. Stations should be small enough to allow for no more than 999 point count locations.
POINT NUMBER	Number assigned to a point count location within the station (between 1 and 999).
YEAR	Year (4 digits).
MONTH	Month (01 to 12).
DAY	Day (01 to 31).
OBSERVER	Any observer identification unique within the station, generally observer's initials.
GEO-CODING SYSTEM	Enter 0 if geo-coordinates are recorded in latitude and longitude; enter UTM zone if UTM coordinates are being used.
N-S COORDINATES	If data are in UTM coordinates, enter the Northing (7 digits); if latitude is used, enter the degrees, minutes, seconds as (DDMMSS) for DD°MM'SS".
E-W COORDINATES	If data are in UTM coordinates, enter the Easting (6 digits); if longitude is used, enter the degrees, minutes, seconds as (DDDMMSS) for DDD°MM'SS".
ELEVATION	Elevation in meters (1 m = 3.28 ft).
ASPECT	Aspect (0° to 360°).
SLOPE	Percent slope (0 to 99).
WATER within 25 m	Presence or absence (+/-) of significant water within 25 m (82 ft).
WATER within 25 to 50 m	Presence or absence (+/-) of significant water within 25 to 50 m (82 to 164 ft).
TREE LAYER*	Canopy layer of vegetation; generally trees >10 cm (4 inches) in d.b.h.
COVER	Percentage of plot occupied by tree layer (i.e., canopy cover) (0 to 99).
BASAL AREA	Total basal area (m^2) per hectare (1 m^2/ha = 4.36 ft^2/acre) of all trees (trees > 10 cm [4 inches] in d.b.h.).
TOTAL SNAGS WITHIN 25m	Total number of dead trees (> 10 cm [4 inches] in d.b.h.) within 25 m (82 ft) of counting station.
TOTAL SNAGS WITHIN 25 to 50 m	Total number of dead trees (> 10 cm [4 inches] in d.b.h.) within 25 to 50 m (82 to 164 ft) of counting station.
SPSx	Four-letter code for tree species "x", where x = 1, 2, . . . in order of importance value.
SPSx-HT	Average height (m [1 m = 3.28 ft]) of tree species "x" (canopy height).
SPSx-#	Number of trees per hectare (1 tree/ha = 2.47 trees/acre) of tree species "x" (trees > 10 cm [4 inches] in d.b.h.).
SPSx-BA	Basal area (m^2) per hectare (1 m^2/ha = 4.36 ft^2/acre) of tree species "x" (trees > 10 cm [4 inches] in d.b.h.).
SHRUB LAYER	Shrubs and small trees; generally between 0.5 and 2.5 m (1.5 and 8 ft).
COVER	Percentage of plot occupied by all shrubs (shrubs and trees < 10 cm [4 inches] in d.b.h.).

Variable	Description of variable
DENSITY	Total number of shrubs measured on a 0.01-ha (0.04-acre) circular plot centered on the counting station.
SPSx	Four-letter code for shrub species "x", where x = 1, 2, . . ., in decreasing order of percentage of cover.
SPSx-HT	Average height (dm) of shrub species "x" (e.g., 12 = 1.2 m; 1 dm = 4 inches)
SPSx-#	Number of indviduals of shrub species "x".
HERB LAYER	Ground-story vegetation; generally < 0.5 m (20 inches).
COVER	Percentage of plot occupied by herbaceous cover.
SPSx	Four-letter code for herb species "x," where x = 1, 2, 3 for first, second, third most abundant herb species.
VEGETATION PROFILE	Vegetation coverage 0 to 5 m (0 to 16 ft)
COVER at 0 m	Percentage of cover by vegetation at 0 m (0 ft), measured with density board.
COVER at 2.5 m	Percentage of cover by vegetation at 2.5 m (8 ft), measured with density board.
COVER at 5 m	Percentage of cover by vegetation at 5 m (16 ft), measured with density board.
COVER OF VINES IN CANOPY	Percentage of cover by vines in the canopy, measured with ocular tube.
COVER OF SPANISH MOSS IN CANOPY	Percentage of cover by Spanish moss in the canopy, measured with ocular tube.
SUBMITTER	Five-letter code to identify person or group submitting data (required to relate species codes to region if multiple groups are monitoring within same region).
NOTES	Comments and notes.

*Basal area and number of stems are all standardized on a per-hectare basis. This method allows for the use of sampling plots of varying size and also for plotless sampling methods.

Table G-2.—*File Two: Description of suggested mechanism for standardizing computer coding of species nomenclature.*

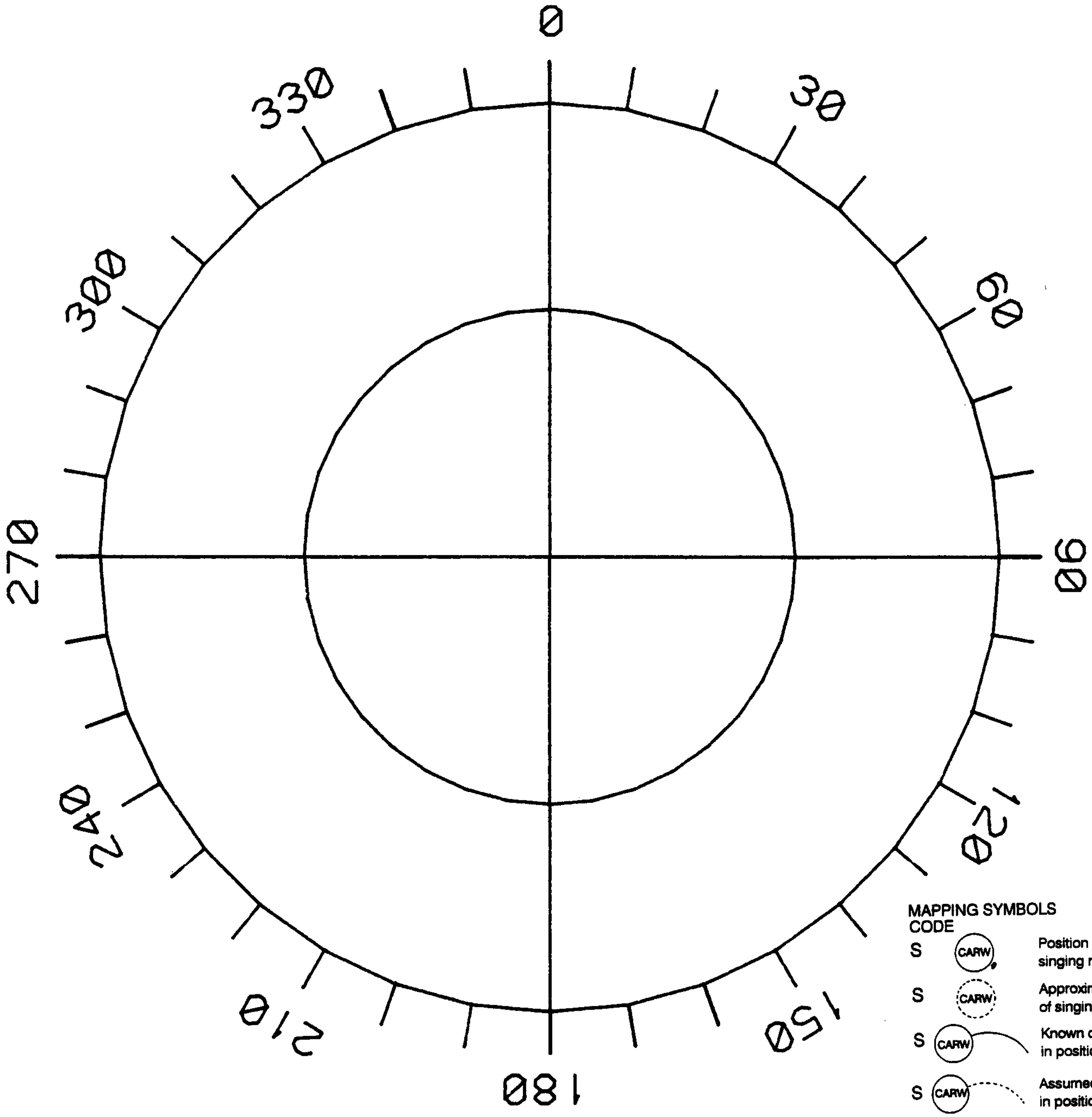
Variable*	Description of variable
Species Code	Four-Letter Codes Used for Trees, Shrubs, and Herbs.
Species Name	Scientific name of species

*The species codes and species names are required because no universally accepted standard species codes are available for plants. All data should entered using the four-letter codes suggested by Ralph and others (1993); i.e., the first two letters of the genus name and the first two letters of the species epithet. For example, American beech (*Fagus grandifolia*) would be coded as FAGR. Standardization using this system will minimize (although not eliminate) species identification conflicts. Nevertheless, the use of alternate nomenclature is accommodated by the use of this identification file. Ideally, this file need only be submitted with the initial submission of data from a region and updated (verified by year) periodically as additional species are added.

State Region ______________ Station ____ Point # ____ Visit # ____ Year ____ Month ____ Day ____ Time ____

Observer ____ Temp °C ____ Wind ____ Sky ____ Habitat ____ Forest type ____ Stage ____ Zone ____ N-S coordinates ____ E-W coordinates ____

Geographic coding: Zone=0 for lat-long, else UTM Zone



MAPPING SYMBOLS

CODE		
S	CARW	Position of singing male
S	CARW	Approximate position of singing male
S	CARW	Known change in position
S	CARW	Assumed change in position
S	CARW CARW	Simultaneous song, two males
N	CARW*	Nest
M	CARW	Male observed
F	CARW	Female observed
C	CARW	Calling, sex unknown
P	CARW	Pair together assumed mated
O	CARW	Observed, sex unknown

Flyovers:

Remarks

____

____

____

State Region Station Point # Visit # Year Month Day Time

Observer Temp °C Wind Sky Habitat Forest type Stage Zone N-S coordinates E-W coordinates

Geographic coding: Zone=0 for lat-long, else UTM Zone

Species Alpha Code	Count < 25 m			25-50 m			> 50 m			Flyovers		
	0-3 min	4-5 min	6-10 min	0-3 min	4-5 min	6-10 min	0-3 min	4-5 min	6-10 min	0-3 min	4-5 min	6-10 min

Submitter Remarks

Hamel, Paul B.; Smith, Winston Paul; Twedt, Daniel J. [and others]. 1996. A land manager's guide to point counts of birds in the Southeast. Gen. Tech. Rep. SO-120. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Research Station. 39 p.

A strategy for monitoring birds using point counts is outlined and developed. Techniques for conducting point counts, recording data, and computer coding are presented. Means for determining sample sizes of point counts to answer specific questions are explained. Blank data forms are included. A standard protocol for point counts of birds in the Southeast is suggested.

Keywords: Bird sampling, bird sampling data forms, inventory, land management, monitoring, Partners in Flight, sample size determination, Southeastern United States, vegetation sampling.

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