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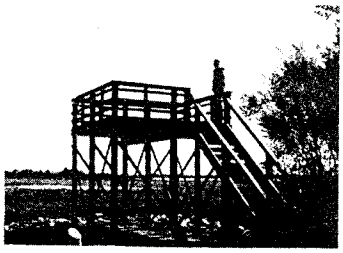

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# AVIAN PLOT METHODS

## Section 6.3.3, US ARMY CORPS OF ENGINEERS WILDLIFE RESOURCES MANAGEMENT MANUAL


by

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This report on avian plot methods is provided as Section 6.3.3 of the US Army Corps of Engineers Wildlife Resources Management Manual. The report is designed to assist the District or project biologist in the application of plot methods to estimate the density and diversity of bird populations for planning, management, and research purposes.

Plot sampling is performed by a stationary observer who stands at each sampling point and records detections of birds in all directions during a fixed sampling period. The method is particularly suited to small or irregular study areas or where terrain is too rough for the use of transects. Plot methods can be used at any time of year. The report provides guidelines concerning plot establishment, sample size, survey timing and procedures, and interpretation of results, including an explanation and comparison of fixed plots and variable circular plots.


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## NOTE TO READER

This report is designated as Section 6.3.3 in Chapter 6 -- CENSUS AND SAMPLING TECHNIQUES, Part 6.3 -- BIRD SURVEY/CENSUS TECHNIQUES, of the US ARMY CORPS OF ENGINEERS WILDLIFE RESOURCES MANAGEMENT MANUAL. Each section of the manual is published as a separate Technical Report but is designed for use as a unit of the manual. For best retrieval, this report should be filed according to section number within Chapter 6.

# AVIAN PLOT METHODS

Section 6.3.3, US ARMY CORPS OF ENGINEERS
WILDLIFE RESOURCES MANAGEMENT MANUAL


BACKGROUND . . . . . 3
ASSUMPTIONS . . . . . 4
STUDY DESIGN . . . . . 5
Plot Establishment . . . . . 5
Sample Size . . . . . 5
Timing . . . . . 7
FIXED PLOTS . . . . . 8
Procedure . . . . . 8
Analysis . . . . . 10
VARIABLE CIRCULAR PLOTS . . . . . 10
Procedure . . . . . 10
Analysis . . . . . 13
CAUTIONS AND LIMITATIONS . . . . . 15
LITERATURE CITED . . . . . 16


Plot sampling methods offer an alternative to line-transect techniques (see Section 6.3.2) for estimating the density of a bird population. Like transects, plot methods can be used at any time of year and can be applied to a single species of interest or to an entire avian community. They are useful in areas of almost any size or in any type of vegetative cover. Although plot methods can be used anywhere that transects would be appropriate, they are particularly applicable where study areas are small, fragmented, or irregularly shaped, or where terrain is rough, making transects difficult to establish and follow. An important advantage of plot sampling in thick cover is that no transect lines need to be cleared or maintained. Plot methods may also be more efficient because the observer's attention is not divided between searching for birds and watching the path (Reynolds et al. 1980).

## BACKGROUND

The basic approach to plot sampling is essentially the same as transect sampling, except that the transect line has been reduced to a single point or series of points. Each point is the center of a circular plot where a stationary observer records sightings of birds in all directions during a fixed sampling period. The plot radius may be selected in advance of sampling

(fixed plots) or determined later by estimating the effective detection distance for each species of interest (variable circular plots).

Several investigators have compared plot sampling with other avian sampling methods under field conditions. Edwards et al. (1981) performed monthly songbird surveys with fixed plots, variable circular plots, and Emlen's line-transect method in a variety of habitats. Density estimates generally were not significantly different among methods, but the variable circular plot method consistently detected more bird species. DeSante (1981) used variable circular plots to estimate the densities of 8 species on an area of coastal scrub where bird abundance and distribution had previously been determined by territory mapping and by observing color-banded individuals. The plot method underestimated overall bird density by 18%. Furthermore, dense populations tended to be underestimated whereas sparse populations were somewhat overestimated. Anderson and Ohmart (1981) preferred the transect method over variable circular plots in fairly level terrain because they could sample a larger fraction of their study area with the same amount of time and effort spent moving around the tract.

## ASSUMPTIONS

The underlying assumptions of plot sampling are similar to those of line-transect methods. They are as follows:

(1) Plots are located at random with respect to the distribution of birds being counted.

(2) All birds located near the observer are detected and counted.

(3) Birds do not move into or out of the plot either as the observer approaches a sampling point or during the sampling period.

(4) Individual birds are counted only once.

(5) The distance from the plot center to the point at which a bird was first detected is measured accurately.

(6) Sightings of birds are independent events.

As in any bird sampling method, each assumption is likely to be violated to some degree. Assumption 3 is particularly troublesome in plot sampling because some birds are probably disturbed as the observer approaches the sampling point and may leave the plot undetected. Birds may also enter the plot in their normal movements during the several minutes that the count is being made (Verner 1985). This can result in an overestimate of density because

birds have the opportunity to move toward the observer from a wide area surrounding the plot. Furthermore, the magnitude of the error varies according to the mobility of the species (Scott and Ramsey 1981).

## STUDY DESIGN

### Plot Establishment

Sampling points (plot centers) must be established so as to minimize the probability of detecting the same bird at different points. Sampling points are often located at intervals along transects. One simple procedure uses parallel transect lines that are either equally or randomly spaced, and plot centers are established along each transect at constant or random intervals. An alternative procedure is to superimpose a grid over a map of the study area and randomly select numbered grid intersections (Fig. 1).

The distance between sampling points is a compromise between statistical concerns and the demands of field sampling (DeSante 1981). To be truly independent, sampling points should be spaced at least twice the maximum distance at which the bird species of interest can be seen or heard. However, this may result in considerable travel time between points and can reduce the number of points that can be placed within a restricted cover type. The minimum spacing between sampling points is equal to twice the predetermined plot radius (fixed plots) or twice the distance within which all birds are detectable (variable circular plots). This provides the closest packing of sampling points in a small area but undoubtedly results in the counting of the same individuals from adjacent points.

Plot spacing also depends upon topography and vegetation density; therefore, it is best determined by doing some preliminary sampling in the intended study area and estimating the distance at which the species of interest can be seen or heard. For species occupying forested and brushy areas, plot spacing mentioned in the literature ranges from 100 m (330 ft) to more than 350 m (1150 ft) (e.g., Anderson and Ohmart 1981, DeSante 1981, Skirvin 1981).

### Sample Size

The appropriate number of plots to sample depends upon (1) the abundance and conspicuousness of the birds to be counted, and (2) the degree of confidence needed in the density estimate. For line-transect sampling, Burnham et al. (1980) suggested that at least 40 detections of a species were needed

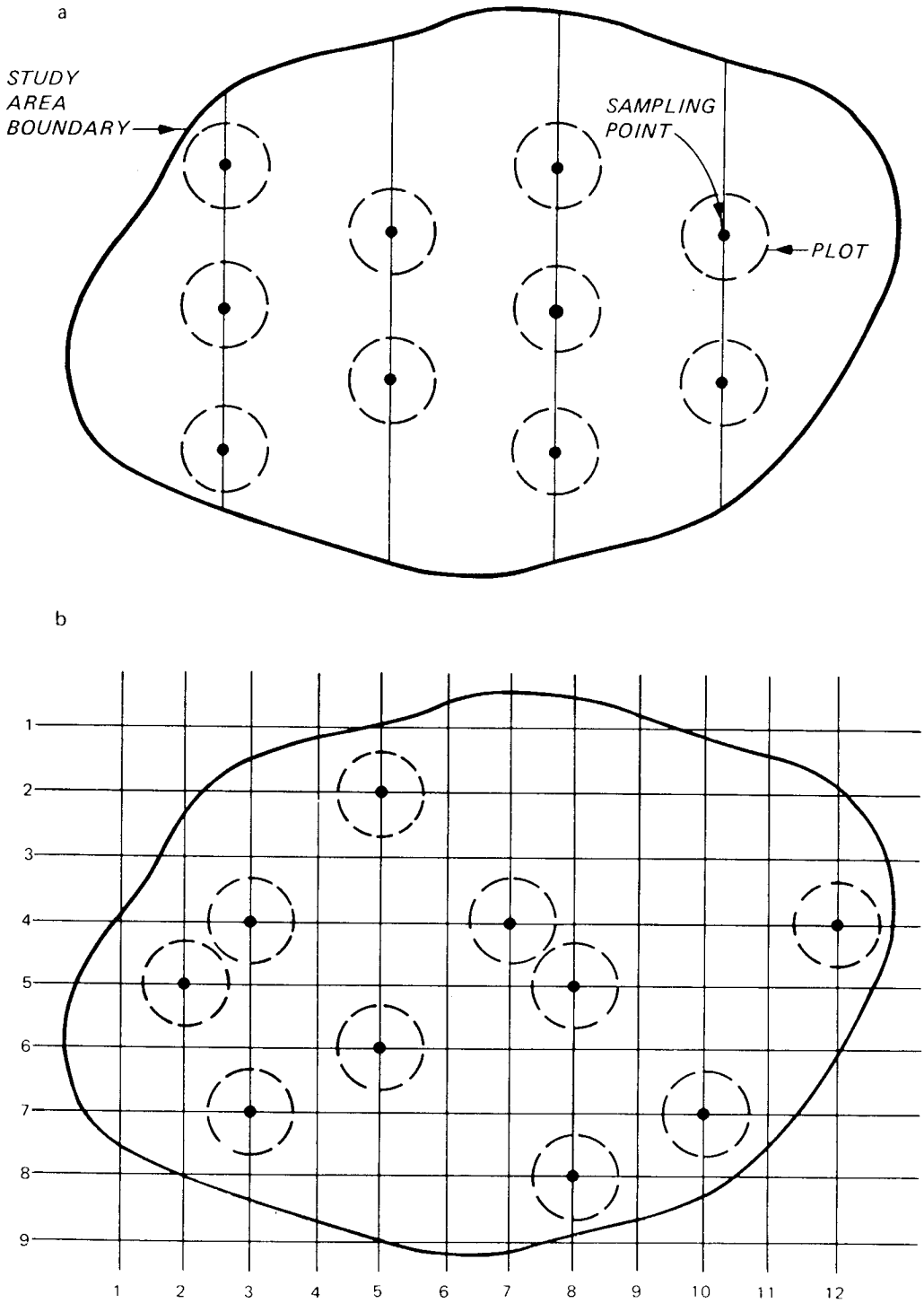


Figure 1. Two methods for locating bird sampling plots: (a) spacing plots at intervals along transect lines, and (b) randomly selecting grid intersections

to estimate its density reliably; this guideline applies equally well to plot sampling. A small pilot study involving 10 to 20 plots should be done to estimate the number of plots needed to accumulate at least 40 sightings of each species in the study area.

The number of plots required to estimate the density of a species depends upon its abundance, distribution, and detectability. For example, Reynolds et al. (1980) used a large number of plots to estimate average densities of 5 Hawaiian bird species. They then calculated the number of plots needed to estimate within 20% of the overall means. They found that 37 plots were sufficient for an abundant but variably distributed species; 31 to 84 plots were needed for common species that were uniformly to variably distributed; and more than 600 plots were needed for a very rare and variably distributed species. To estimate within 50% of the mean required 6, 5 to 14, and 107 plots, respectively. Reynolds et al. (1980) suggested that estimates within 20% were sufficient for common species and estimates within 50% were adequate for rare ones.

Repeat sampling of the same plots increases precision without increasing the number of plots required. Morrison et al. (1981) found that estimates of the combined density of all birds on forested sites could be reliably made with data from only 6 to 8 plots if each was sampled 5 times; however, more plots would be needed to estimate the density of each species separately.

Timing

As with line-transect surveys, plot sampling for breeding birds is usually done from 1/2 hour before to 3 to 4 hours after sunrise. Evening counts (beginning approximately 3 hours before sunset) may be used to supplement, but should not replace, morning counts. Sampling for winter birds should begin later in the morning after temperatures have risen and the birds have become more active.

Sampling dates depend on the objectives of the study, that is, whether breeding, wintering, or migrant populations are the primary interest. Local chapters of the National Audubon Society should be consulted if the investigator is not already familiar with the seasonal timing of activities of bird populations in the study area. Bird surveys must often be repeated several times over a period of days or weeks to obtain reliable density estimates for all species, particularly during the breeding season. This is because

different species breed at different times, and there is no one time when all species are fully active or conspicuous. It is typical for breeding bird surveys to be repeated 5 to 10 times over a period of 4 to 6 weeks to ensure that all species in the study area are counted accurately.

## FIXED PLOTS

### Procedure

For fixed-radius plots, the investigator assumes that all birds located within a designated distance from the plot center are detected. Therefore, the plot radius must be small enough to permit a complete census. This depends on the conspicuousness of the species and density of the cover. Plot radius might range from 25 m (82 ft) or less in thick brush or second-growth forest to 250 m (820 ft) or more in an open marsh or grassland. It is not necessary to measure the distance to each bird seen, only to record its presence within the boundaries of the plot.

Each plot is sampled for a fixed period of time; the period should be long enough to give the observer time to find all birds that are present, yet short enough to reduce the movement of birds into or out of the plot. Sampling periods from 5 to 10 minutes are frequently used, with the shorter periods used in the more open habitats. A 1-minute delay is sometimes allowed for birds to resume their normal activities after the arrival of the observer. Birds that are flushed as the observer approaches a sampling point are counted if they were within the plot. Field data are recorded on a form such as that provided in Figure 2.

All birds that are considered to be users or potential users of the study site are counted. Thus, a hawk flying over a forested sampling plot may be hunting within the plot and should be counted; a gull flying over the same plot should not (Reynolds et al. 1980). During the breeding season, males of many species are conspicuous and easily detected, whereas females are not. Therefore, a more accurate estimate of breeding bird density might be made by multiplying the count of males by 2.

PLOT SURVEY FORM

PLOT NUMBER: _____ OBSERVER: _____

SURVEY NUMBER: _____ DATE: _____

VEGETATION: _____ START TIME: _____

WEATHER: _____ FINISH TIME: _____

| SIGHTING NUMBER | SPECIES | NO. OF BIRDS | DISTANCE | COMMENTS |
|---|---|---|---|---|
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Figure 2. Field data form for avian plot surveys

## Analysis

The density, D , of birds on a single sample plot is calculated as follows:

$$D = n/\pi r^2 \tag{1}$$

where:

n = number of birds counted on that plot

r = plot radius

The density is usually converted to some convenient unit, such as birds/ 100 ha.

Plots should be sampled several times each, perhaps on successive days, to improve the precision of the density estimates. For each plot the count for a species should be averaged (not totaled) over the number of sampling days before using equation 1 to calculate the density of birds on that plot. Then the average density, $\bar{D}$ , in the entire study area is equal to the average density across all plots:

$$\bar{D} = (\Sigma\ D)/p \tag{2}$$

where:

D = bird density on an individual plot

p = number of plots

A 95% confidence interval is calculated as follows:

$$95\%\ \text{confidence interval} = \bar{D} \pm 1.96s \tag{3}$$

where:

$\bar{D}$ = average density in the study area

s = standard error of the mean

Example 1 illustrates the use of fixed-radius plots to estimate the density of a towhee population.

# VARIABLE CIRCULAR PLOTS

## Procedure

The procedure for determining the density of birds sampled with variable circular plots (Reynolds et al. 1980) is similar to that described by Emlen (1971) for variable-width line transects. The observer stands at the sampling point for the predetermined sampling period (usually about 8 minutes) and

Example 1

Use of Fixed Plots to Estimate Bird Density

Fixed-radius circular plots were used to estimate the density of breeding birds occupying rugged chaparral habitats in the Coast Range of California. Sampling points were located by superimposing a 100-m grid over aerial photographs of the study area and selecting 75 grid intersections at random. A pilot study in the same habitat indicated that a fixed radius of 25 m was sufficient to detect all birds present. Each point was sampled for 8 minutes, following a 1-minute delay, on 6 randomly selected mornings in April. The following data are for brown towhees (*Pipilo fuscus*).

The density of birds on each plot was first calculated by equation 1 using the average number of detections within 25 m of the sampling point over the 6 sampling dates. If the 6 counts on plot 1 were 2, 1, 1, 0, 3, and 2 (for a mean of 1.50 birds), the density was

$$D = 1.50/(3.14 \times 25^2)$$

$$D = 0.000764 \text{ bird/m}^2 \text{ or } 764 \text{ birds/100 ha}$$

In the same way, bird density at each sampling point was calculated, giving the following results:

| Plot Number | Birds/100 ha |
|---|---|
| 1 | 764 |
| 2 | 255 |
| 3 | 301 |
| 4 | 128 |
| . | . |
| . | . |
| . | . |
| 74 | 220 |
| 75 | 412 |

Mean = 328 birds/100 ha

The estimated density of towhees in the entire study area is the same as the average density on the sample plots, or 328 birds/100 ha.

(Continued)

Example 1 (Concluded)

A 95% confidence interval is calculated from the standard error, s , of the density estimates on the plots. The standard error is estimated by the following formula:

$$s = \sqrt{\frac{\Sigma(x - \bar{x})^2/(n - 1)}{n}}$$

where:

s = standard error

x = density on a given plot

$\bar{x}$ = mean density across all plots

n = number of plots

For the above example, s = 44.8 .

Therefore, a 95% confidence interval around the overall density estimate is calculated by equation 3 as follows:

95% confidence interval = 328 ± (1.96 × 44.8)

= 328 ± 88 birds/100 ha

records the distance to each bird seen or heard on a standard field data form (Fig. 2). Detection distances are measured from the plot center to a point on the ground immediately below the bird when it was first detected. Distances are usually estimated visually or with a range finder; this procedure is less accurate than pacing or using a tape but avoids disruption of the birds during a count. Any birds that are flushed as the observer approaches the sampling point are counted, and the detection distance is measured from the flush site to the plot center.

Analysis

To facilitate analysis of the data, detection distances are categorized into zones that form concentric rings around the plot center. The zones are arbitrary and should be chosen after experience with conditions on the study site. The width of each zone should be determined by the observer's ability to estimate the distance to a bird in a particular habitat. Zones need not be of equal width, and those closer to the plot center should be narrower than those at greater distances, reflecting the relative reliability of distance estimates. Vegetation structure and openness will affect the choice of zone widths. For example, Anderson and Ohmart (1981) used the following zones to estimate bird density in riparian habitats along the lower Colorado River: 5-m (16.4-ft) widths for the 3 zones closest to the observer; 15-m (49.2-ft) widths for zones 4, 5, and 6; and 30-m (98.4-ft) widths for zones 7 and 8. In contrast, DeSante (1981) used 20 inner zones each 9.1 m (30 ft) wide and 10 outer zones 18.3 m (60 ft) wide.

The effective plot radius is determined by developing a histogram of bird density versus distance from the plot center (Fig. 3). Densities are calculated separately for each zone using the following formula to determine the area of a zone:

$$A = \pi(r_o^2 - r_i^2) \tag{4}$$

where:

$A$ = area of the zone

$r_o$ = outer radius

$r_i$ = inner radius

Densities, rather than raw counts, are used in the histogram to correct for the fact that zones are of unequal area.

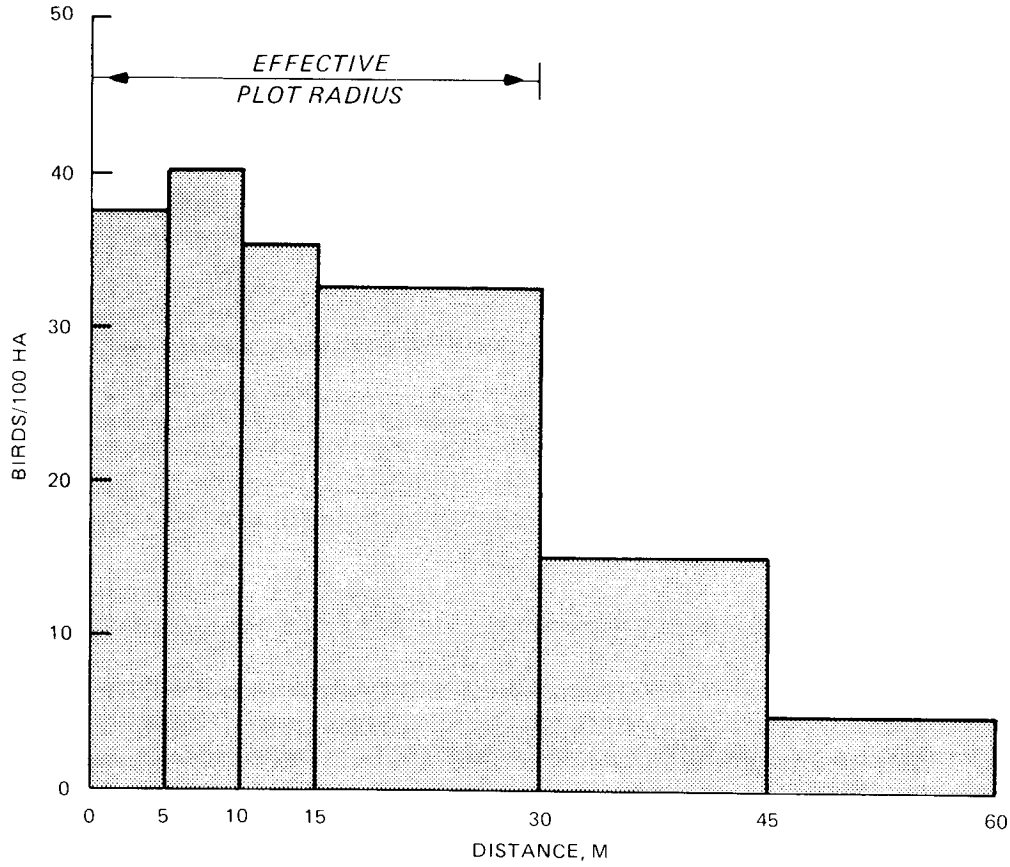


Figure 3. Hypothetical histogram of observed bird densities at increasing distances from the center of a variable circular sampling plot. The effective plot radius is indicated by the distance at which observed density declines

If all birds were detected and were not clumped in their distribution, each zone would be expected to contain the same density of birds. Therefore, the effective plot radius is indicated where the histogram drops off and birds start to be missed (Fig. 3). Plot radius should be determined for each species separately by combining data from all plots and all replications within a cover type. Because vegetation structure affects detection distances, and therefore effective plot radius, different cover types should be sampled and analyzed separately.

Often there are too few observations of an uncommon species to estimate the effective plot radius. In those cases it is appropriate to use the plot radius for a more abundant species that is similar in detectability (Reynolds et al. 1980, Anderson and Ohmart 1981).

When the plot radius has been determined for a species, observations of birds outside that distance are ignored, and density is estimated in the same way as for fixed-radius plots. If repeated samples are made at each plot, bird density, D , at a single plot is calculated as follows:

$$D = n'/\pi d^2 \tag{5}$$

where:

$n'$ = number of birds counted within the effective plot radius (average of repeated samples)

$d$ = effective plot radius

Equation 2 is then used to calculate the density of birds over all plots, and a 95% confidence interval is estimated by equation 3.

An alternative procedure for the analysis of data derived from a variable-circular plot survey is to determine the Effective Area Surveyed for each species; all detections of that species are then used to estimate bird density (Ramsey and Scott 1981). This technique is described in more detail in the section on line-transect methods.

## CAUTIONS AND LIMITATIONS

Plot sampling methods are well suited for use in small study areas or in rough terrain, but probably should be avoided in favor of line-transect methods in larger or more level areas. One reason is that transect methods allow the investigator to sample a greater area in the same amount of time; in plot sampling, considerable time is wasted in traveling between sampling points. Another limitation of plot sampling is that the approach of the observer to a sampling point may disturb birds, causing them to move before the count begins. Birds also have the opportunity to move into the plot from adjoining areas during the lengthy sampling period. Line-transect methods and plot methods are based on the same underlying assumptions, but these are more likely to be violated in plot sampling.

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