J. Field Ornithol., 69(3):450–456

INCREASING POINT-COUNT DURATION INCREASES STANDARD ERROR

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Abstract.—We examined data from point counts of varying duration in bottomland forests of west Tennessee and the Mississippi Alluvial Valley to determine if counting interval influenced sampling precision. Estimates of standard error increased as point-count duration increased for cumulative number of both individuals and species in both locations. Although point counts appear to yield data with standard errors proportional to means, a square root transformation of the data may stabilize the variance. Using long (>10 min) point counts may reduce sample size and increase sampling error, both of which diminish statistical power and thereby the ability to detect meaningful changes in avian populations.

EL INCREMENTO EN LA DURACIÓN DE CONTEO DE PUNTOS, INCREMENTA EL ERROR ESTÁNDAR

Sinopsis.—Examinamos los datos de conteos de puntos, cuya duración varió, en bosques del oeste de Tennessee y el valle aluvial del Mississippi, para determinar si el intérvalo de conteo influía en la presición de la muestra. Los estimados del error estándar aumentaron en ambas

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localidades de trabajo, conforme al incremento en la duración del conteo de punto para números acumulativos tanto para individuos como de especies. Aunque los conteos de punto parecen ofrecer datos con errores estándares proporcional a la media, la transformación de la data a raíz cuadrada pude estabilizar la varianza. Utilizando puntos de conteos largos (>10 min) se puede reducir el tamaño de la muestra e incrementar el error de muestreo. No obstante, ambos disminuyen el poder estadístico de la prueba y por tanto la habilidad para detectar cambios significativos en las poblaciones de aves.

The efficacy of methods used to inventory or monitor land birds has received considerable attention (Gutzwiller 1991, 1993a,b; Hamel et al. 1996; Petit et al. 1995; Ralph et al. 1993, 1995a; Smith et al. 1993; Verner 1988). A growing concern over the conservation of Neotropical migratory birds has provided the impetus for refining avian sampling techniques. Although it is generally recognized that no single approach will provide information suitable to answer all the questions of researchers or land managers (Ralph et al. 1993), the fixed-radius point-count method (Hutto et al. 1986) is quickly becoming the monitoring method of choice for many agencies faced with monitoring bird populations over large areas (e.g., Hamel et al. 1996, Manley et al. 1993, Ralph et al. 1995b). In addition, there has been much support and effort toward standardizing point-count protocols (Hamel et al. 1996, Ralph et al. 1995b) and some investigators argue that standardization should be the primary factor of consideration in survey design (Thompson and Schwalbach 1995).

Implementing a comprehensive monitoring scheme that can reliably detect meaningful changes in species composition or abundance may be beyond the capabilities of many land managers because of the sampling effort required to achieve even modest statistical power (Gutzwiller 1991, Hamel et al. 1996, Smith et al. 1993, Thompson and Schwalbach 1995). Time of day, number of point stations, number of visits to a point station, or duration of point counts can influence sampling efficiency (i.e., number of new species recorded per unit effort; Smith et al. 1993), precision, and the ability to detect meaningful variation (Gutzwiller 1991, 1993a,b; Hamel et al. 1996; Rollfinke and Yahner 1990, Ralph et al. 1995b, Smith et al. 1993, 1995; Thompson and Schwalbach 1995; Verner and Ritter 1986). To overcome these deficiencies, researchers continue to investigate ways to improve point-count sampling (Gutzwiller 1991, 1993a,b; Ralph et al. 1995a; Smith et al. 1993).

Despite progress (Ralph et al. 1995a), disagreement remains regarding the "optimal" counting interval. Longer point counts provide more information at a single location than do shorter counts because more species are usually detected (Fuller and Langslow 1984, Verner 1988, Gutzwiller 1991, Smith et al. 1993, Dawson et al. 1995, Lynch 1995, Petit et al. 1995), but evidence suggests that there exists an interval beyond which expending more time is inefficient. When Smith et al. (1993) compared results of point counts of varying duration (i.e., 5, 10, 15, or 20 min), they observed that efficiency declined substantially after 10 min. Gutzwiller (1991) and Lynch (1995) reported similar declines in efficiency after 10 min of sampling with unlimited radius point counts in the winter.

Fuller and Langslow (1984:198) noted variation in efficiency among habitats, but concluded that fixed-radius point "counts of 15 or 20 min are a poor investment of time . . . ."

An important consideration in developing a protocol for surveying birds is not only identifying an appropriate counting interval that is most efficient, but also one that "reduces variability in the probability of detecting the birds present at points" (Dawson et al. 1995:35). Based on our data from the Mississippi Alluvial Valley (MAV) and west Tennessee bottomlands (Smith et al. 1993), there emerged a consistent pattern that could potentially impose additional limitations on the use of long (>10 min) point counts. The purpose of this paper is to describe these findings and provide a brief discussion of their implications for designing sampling schemes to monitor bird populations.

STUDY AREA AND METHODS

In our original analysis (Smith et al. 1993), we included 132 fixed-radius point counts from a 3-yr study (1985–1987) in west Tennessee bottomland forests stratified among seven major drainages between the Tennessee River and the Mississippi River (Ford 1990), and 81 point counts distributed among regions (southern, central, northern) of the Mississippi Alluvial Valley. West Tennessee point counts consisted of four, consecutive 5-min periods whereas MAV counts consisted of an initial 3-min count, a cumulative 5-min count (i.e., two additional min), and a cumulative 10-min count (Smith et al. 1993).

We used resampling iterations to generate mean number of cumulative individuals and mean number of cumulative species for all possible 5-min period combinations of 5-, 10-, 15-, and 20-min duration at each count in west Tennessee (see Smith et al. 1993). For the MAV, we computed mean cumulative number of individuals and cumulative number of species for all localities during the first 3 min and for each additional minute thereafter.

RESULTS AND DISCUSSION

For both MAV and west Tennessee data sets, our estimates of standard error increased as point-count duration increased (Table 1). This pattern was consistent for cumulative number of individuals and species in both locations and for all years in west Tennessee. Whether this result is typical of point-count data remains unclear. That we obtained similar results from two independent data sets collected by different individuals in different locations suggests that this pattern was not the result of observer bias, nor was it unique to a locality. Still, variation among observers may be exacerbated by longer point counts because of differences in skill level, experience, ability to concentrate, or fatigue.

Few studies have examined variability among point counts relative to counting interval. Gutzwiller (1991) reported significant variation in standard error for winter point-count estimates of species richness with significant interaction between point count duration and period (i.e., time of day). Generally, standard error increased as the day progressed, with the most evident increases in standard error occurring with 10- and 15-min counts (Gutzwiller 1991).

Also, Fuller and Langslow (1984) obtained results comparable to ours in three of six habitats; remaining habitats showed no obvious variation in standard error. The means and variances from four consecutive 5-min counts were not presented, but there was an apparent increase in the length of standard error bars with increasing point-count duration for cumulative plots of species and breeding pairs (Fuller and Langslow 1984: 197). Verner (1988:3) depicted a similar increase in standard error in a plot of cumulative counts obtained at 1-min intervals during 10-min point counts.

In contrast, the standard errors of 3-, 6-, and 10-min point counts reported by Buskirk and McDonald (1995) appeared indistinguishable. Also, Welsh (1995) reported results from 3-, 5-, and 10-min point counts that had similar standard errors, except where variability actually may have declined as duration increased. Although our MAV estimates and Verner's (1988:3) estimates of variability appeared to increase over minute intervals, it may be that differences in standard error become apparent only in point counts that differ by more than just a few minutes.

Counting interval *per se* may not be responsible for variation in standard error, but may be only a covariate. Cumulative number of individuals and species, for example, almost invariably increases with increasing point-count duration. In studies we examined, cumulative number of birds and number of species increased as counting interval increased. If an increase in mean is the primary factor determining an increase in standard error, or variability, then one should observe concomitant increases in these two statistics even when point-count duration remains constant. In our study, mean estimates of individual birds and species in west Tennessee bottomlands increased annually from 1985 to 1987 across all time intervals (Table 1). Corresponding estimates of standard error increased incrementally each year during that same period.

Point counts appear to yield data with standard errors proportional to means. Thus, point counts are probably not unlike other biological counting data in that these counts are samples from a distribution that approximates Poisson distributions in which the mean and variance are equal (Zar 1996:279). The variances of observations from Poisson distributions therefore increase with increases in the mean (Zar 1996). Thus, researchers and land managers may want to consider using a transformation of their point-count data to reduce the likelihood that variances and means will vary proportionally. A square root transformation of our data from the MAV resulted in standard errors which were no longer proportional to the mean.

Regardless of the cause, there appears to be sufficient empirical evidence to caution researchers and land managers against using long (>10 min) point counts in surveys designed to monitor bird populations. Not only are long point counts less efficient since monitoring schemes using

TABLE 1. Mean and standard error (SE) of individual birds and species recorded in point counts of 5-, 10-, 15-, and 20-min duration in west Tennessee, 1985–1987, and in point counts of 3-, 5-, and 10-min duration in 1992 across the Mississippi Alluvial Valley (MAV) (adapted from Smith et al. 1993). A hyphen denotes no data.

	Duration of point count									
	3 min		5 min		10 min		15 min		20 min	
Location/year	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
			Number of Individuals							
West Tennessee										
1985	—	—	12.9	0.28	18.7	0.33	23.4	0.38	28.7	0.41
1986	—	—	17.2	0.44	24.9	0.59	30.3	0.68	36.4	0.79
1987	—	—	19.2	0.64	26.8	0.83	32.2	1.02	36.1	1.14
MAV	11.4	0.27	15.0	0.37	19.8	0.44	—	—	—	—
			Number of Species							
West Tennessee										
1985	—	—	10.1	0.18	13.4	0.20	15.9	0.21	18.2	0.21
1986	—	—	12.7	0.24	16.2	0.33	18.1	0.37	20.3	0.42
1987	—	—	12.5	0.41	15.8	0.48	17.9	0.48	19.1	0.48
MAV	8.5	0.21	10.3	0.22	12.8	0.26	—	—	—	—

long point counts will necessarily include fewer point counts (everything else being equal), but variability of their estimates of species richness and relative abundance may increase. A reduction in sample size with a concomitant increase in sampling error when attempting to detect meaningful changes in avian populations using point counts will result in severely diminished statistical power.

In conclusion, point counts of long duration (>10 min) may be useful or even recommended in some circumstances such as when logistic constraints are paramount. However, we strongly caution researchers and land managers against using point counts that are longer than 10 min because of detrimental effects on sample size, standard error, and ultimately the statistical power of subsequent analyses. We further recommend that when using point counts with duration >10 min consider transformation of their data to stabilize variances.

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Received 1 May 1997; accepted 15 Oct. 1997.