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REVISIT SCHEDULE DOES NOT AFFECT RESULTS OF POINT COUNTS

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Abstract.—We compared two fixed-radius point count sampling regimes using two abundant breeding species, the Dark-eyed Junco (*Junco hyemalis*) and the Chestnut-sided Warbler (*Dendroica pensylvanica*), in a forested landscape in the southern Appalachian mountains of Virginia. The same 20 points were counted three times under each of two revisiting schedules, either hourly or weekly, and the maximum and mean number of males recorded. Revisit schedule had no detectable effect on numbers of either species recorded, regardless of whether the fixed radius was 50 or 100 m or whether count duration was 5 or 10 min. For juncos, the maximum number of birds detected using an hourly revisit schedule with a 100-m fixed-radius count circle and a 5-min or 10-min count duration provided close matches to the density estimated by intensive territory mapping of this color-banded population (0.398 males/ha or 0.298 males/ha respectively, versus 0.325 known breeding males/ha). When revisiting count stations is desirable, the use of a 1-h revisit schedule provides an economical way to increase number of visits, with no apparent reduction in precision or accuracy of the estimate.

ITINERARIO DE VISITAS NO AFECTA LOS RESULTADOS DE CENSOS POR CONTEO DE PUNTOS

Sinopsis.—Comparamos dos regímenes de muestreo de conteo de muestras en áreas de radio fijo usando dos especies abundantes que se reproducen en un paisaje boscoso en el sur de las Montañas Apalaches en Virginia: *Junco hyemalis* y *Dendroica pensylvanica*. Se llevaron a cabo conteos en los mismos 20 puntos tres veces durante cada uno de dos itinerarios de revisitación, ya fuera por hora o por semana, y se registraron el número máximo y el promedio de machos cantando. El itinerario de revisitas no tuvo ningún efecto detectado en el número registrado de ninguna especie, independientemente de que el radio fijado fuese de 50 o de 100 metros, o si la duración de conteo fue de 5 o de 10 minutos. El mayor número de *Junco hyemalis* detectados usando un itinerario de revisitas cada hora en círculos de radio fijo de 100 m y con duración ya fuera de 5 o 10 minutos produjeron similitudes en la densidad estimada al producir un mapa detallado de esta población marcada con bandas de colores (0.398 machos/ha o 0.298 machos/ha contra 0.325 machos que se saben reproducirse por ha). Cuando se desea revisitar las estaciones de conteo, el uso de un itinerario de 1 hora entre visitas provee una forma económica para aumentar el número de visitas, sin aparente reducción en la precisión o adecuación del estimado.

Researchers frequently estimate avian population densities for the purpose of assessing local population sizes, geographic and temporal trends, and habitat preferences (Ralph et al. 1995). Of the various survey methods commonly used, territory mapping has the potential for the greatest accuracy, but is also time consuming and therefore not a practical method for surveying large areas (Bibby et al. 1992). Consequently, sampling techniques such as line transects, spot-mapping and point counts are more often used for censusing populations (Bibby et al. 1992; Dobkin and Rich 1998). Because short-duration circular-plot point counts conducted at predetermined sites produce reasonably good density estimates while remaining time and cost effective (Verner 1985), they are rapidly becoming the method of choice for wildlife professionals (Smith et al. 1998)

Although point-count techniques are considered to generate efficient density estimates for breeding birds, they still require much effort. This is particularly the case if count stations are revisited several times over the course of the breeding season. The case has been made that revisiting count stations is inefficient because it reduces the number of sites that can be censused and could reduce statistical power (Smith et al. 1998). However, some experimental designs require revisits because they increase precision and/or accuracy (Smith et al. 1995). Our survey of the methods sections of all papers that report breeding bird census results in volume 69 (1998) of this journal indicated that 10 of 12 studies involved repeated visits to the same stations (range: 2–28 visits repeated every 3–30 d). Five of seven studies involving point counts reported 3–8 visits on a 1–30 d revisit schedule. Given that most researchers currently find it desirable to revisit their count stations, our objective was to determine if revisiting a specified site hourly during the same day would produce breeding bird abundance estimates indistinguishable from counts repeated over a longer period of time. We chose one-week as the longer interval of time between counts. In doing so, our test of the null hypothesis that short and long revisit schedules do not produce different density estimates was made reasonably conservative, since a weekly revisit schedule is as short as or shorter than most found in our survey (revisit schedule median = 7 d, mean = 10.3 d). Because we had an independent density estimate for one of our study species, we were able to compare results of the different census methodologies to a highly accurate population density estimate based on color-banding, nest-finding and territory mapping of the entire study area. To increase the generality of our results, we also examined the interactions between any effect of revisit schedule and different count durations and circular-plot radii.

METHODS

Our study area was located in a mesic, oak-dominated forest interspersed with regenerating clear-cuts in Giles County, Virginia (37°22′30″N: 80°37′30″W elevation 1000–1200 m). We chose to census Dark-eyed Juncos (*Junco hyemalis*) and Chestnut-sided Warblers (*Dendroica pensylvanica*) because (1) they were detectable by song and were not easily confusable with any other species on the study site; and (2) they were both relatively abundant in the study area. This combination should produce more reliable estimates of density because it satisfies several key assumptions of the sampling method and produces numerous detections (Bibby et al. 1992). To determine the effect of revisit schedule on the accuracy of point counts, we performed counts at 20 stations and then revisited each one twice, either hourly or weekly. The mean and maximum number of males detected on these three counts were then compared across revisit schedules, and, for juncos, to the population density as estimated using territory mapping via audio playbacks, mist-netting, nest-finding, and color-banding.

The study area was a 6-km stretch of gravel road with low traffic (0.48 vehicles/h) that was only 3-m wide and covered by closed forest canopy in many places. The entire road was marked with flagging tape at 50-m intervals. We performed point counts at 20 of the 117 flagged sites, chosen randomly with the constraint that points be spaced between 200 and 300 m apart to avoid overlap yet ensure thorough coverage. Observers noted the time (up to 10 min) that each bird was first seen or heard and recorded its initial location. The distance to each bird was estimated as being <50 m, <100 m, or >100 m from the center point. There was always flagging 50 m and 100 m from each point in two directions to help with distance estimation, and each observer had a partner who did not participate in locating or identifying birds but stood 100 m away to serve as an additional distance marker. To ensure that point counts were conducted accurately, each observer received a week of intense field training on local bird songs and distance estimation. We made no effort to adjust for observer error other than the random assignment of observers to points. A recent study using more bird species and less intensive training suggests that novice observers can provide credible data for a carefully selected subset of species (McLaren and Cadman 1999). To prevent observer bias, points were never revisited by the same observer.

To determine whether the time between visits affected the accuracy of point counts, two sets of data were generated for the same set of 20 points: one using an hourly revisit schedule and another using a weekly (7-d) revisit schedule. Each hourly and weekly data set consisted of three repetitions at each point. The maximum or mean number of males detected on the three revisits to each point under each regime was the dependent variable used for analyses. Hourly counts for all points were completed on 15–16 June 1999, the first between 0700 and 0740 h, the second between 0800 and 0840 h, and the third between 0900 and 0940 h, with each point recounted 55 to 65 min apart. One count from each point in the hourly schedule was chosen at random to serve as the first data point in the weekly schedule. To complete the weekly schedule, a subsequent count was carried out at each site 7 d and 14 d later. To eliminate any time-of-day effects, these counts were conducted in such a way that each point in the weekly data set was counted once beginning 0700–0740 h, once beginning 0800–0840 h, and once beginning 0900–0940 h, just as in the hourly data set.

Territory mapping was carried out during and after the census period to determine more accurately the population densities of juncos in the study area. We played audio-recordings every 50 m along the entire study area (using Stokes' Field Guide to Bird Songs compact disk audible by humans for <150 m) and recorded all responding juncos. Because mist netting and trapping of Dark-eyed Juncos had been carried out during the previous two years for another study, 90% of the 39 male juncos detected during territory mapping were uniquely color banded, allowing for better discrimination between neighbors. Additional visits, netting, and nest searches were used when necessary to clarify territory occupation. Although the fieldwork for mapping and point counting essentially overlapped in time, territory maps were not assembled until after the point counts were completed. The majority of territory mapping was carried out by one observer (DAC), and all other observers were restricted from doing point counts in areas that they had previously mapped. Finally, observers were strictly forbidden from discussing specific points or bird territories with others throughout the study.

To examine whether our results were robust we considered not only time between revisits, but also possible interactions with count duration and radius. All males detected were classified as either <5 min or <10 min. In addition, all detections were classified as being <50, <100, or >100 m from the center of the count circle. Data for >100 m were not used further in our analysis. For each study species, we calculated the maximum and mean number of males detected for the first 5 min and the entire 10 min for both the 50-m and 100-m radii count circles. To test whether there was an effect of revisit schedule on the mean or maximum number of juncos or warblers detected we used a four-way ANOVA with revisit schedule, count-circle radius, and count duration as fixed effects and point as a random effect. The following four interactions were also included in the model: point × schedule, duration × radius, schedule × duration, and schedule × radius. To verify the lack of significant revisit schedule effect using a more powerful, and perhaps more intuitive analysis, we alternatively used a paired *t*-test to examine whether schedule affected the mean or maximum number of males detected for warblers or juncos for the <5-min, 100-m radius counts. Data were tested for normality and homogeneity of variances. While the mean values were normally distributed, the maximum values were not and transformations did not improve their fit. Because ANOVA and *t*-tests are generally robust to violations of the assumption of normality when sample sizes are equal and >20 (Cohen 1988), these data were analyzed using parametric tests. Thus, conclusions based on statistical hypothesis tests about the maximum values should perhaps be interpreted with caution.

Because our main conclusions were based on interpretation of the negative results of statistical tests, it was important to determine the statistical power for each nonsignificant comparison (Cohen 1988). Power was calculated for each relevant ANOVA result. This was to determine the likelihood of detecting a hypothesized 10% difference in the number of males. When power was low, we also calculated the power for a moderate difference of 25%, and showed both values in the tables. The effect sizes used in our power calculations bracketed the ''small'' effect size of d = 0.2 described by Cohen (1988). For paired *t*-tests, we determined power by using a hypothesized effect size of 0.5, which corresponds to ''medi-

TABLE 1. ANOVA results for detections of Chestnut-sided Warblers using point counts on hourly and weekly schedules.

						Power	
Estimate	Effect	MS	df	F	P	10%	25%
Mean	Point	3.46	19	5.41	<0.001		
	Schedule	<0.01	1	<0.01	0.98	0.30	0.94
	Radius	15.80	1	110.7	<0.0001		
	Duration	1.42	1	9.96	<0.01		
	Point × schedule	0.64	19	4.49	<0.0001		
	Schedule × radius	<0.01	1	<0.01	0.94	>0.99	
	Radius × duration	0.25	1	1.77	0.19		
	Schedule × duration	<0.01	1	<0.01	0.94	>0.99	
Maximum	Point	5.31	19	6.57	<0.0001		
	Schedule	0.90	1	1.11	0.30	0.33	0.97
	Radius	25.60	1	88.61	<0.0001		
	Duration	1.23	1	4.24	0.04		
	Point × schedule	0.81	19	2.8	<0.001		
	Schedule × radius	0.40	1	1.38	0.24	0.98	
	Radius × duration	0.02	1	0.09	0.77		
	Schedule × duration	0.02	1	0.09	0.77	0.98	

um'' in Cohen (1988). Because the members of each matched pair were the same point count station censused at different times, a high correlation certainly existed between them. Thus, we calculated power for these tests using moderate (0.5) or high (0.75) Pearson product-moment correlation coefficients.

RESULTS

We found that revisit schedule had no effect on the numbers of juncos or warblers detected across all points (Tables 1, 2). This was true whether the maximum or average counts at each site were compared. In some cases, the power of our statistical tests was low for detecting a small difference between the two samples, but the power was higher for detecting a moderate difference between treatments (Tables 1, 2). Count radius and duration both had significant effects on the numbers of birds detected, but of more relevance to the hypothesis, there were no significant interactions between count radius or duration and schedule (Tables 1, 2). A consistently significant interaction between point and revisit schedule (Tables 1, 2) resulted from changes in the detections of birds over time at particular points, such that at some points there was a difference in the results generated by hourly and weekly schedules. Because counts were apparently as likely to go up as to go down, there was no overall effect of revisit schedule on the mean or maximum numbers of birds counted. The alternative paired analysis also indicated that there was no difference in number of warblers or juncos detected by the hourly versus weekly revisit schedules (Table 3).

For the 5-min counts of juncos, density estimates closely bracketed the

TABLE 2. ANOVA results for detections of Dark-eyed Juncos using point counts on hourly and weekly schedules.

Estimate	Effect	MS	df	F	P	Power 10%	Power 25%
Mean	Point	1.67	19	3.18	0.008		
	Schedule	0.02	1	0.03	0.86	0.25	0.88
	Radius	5.75	1	99.63	<0.001		
	Duration	1.28	1	22.20	<0.001		
	Point × schedule	0.52	19	9.07	<0.001		
	Schedule × radius	0.03	1	0.60	0.44	>0.99	
	Radius × duration	0.31	1	5.30	0.02		
	Schedule × duration	<0.01	1	0.31	0.58	>0.99	
Maximum	Point	4.18	19	2.33	0.04		
	Schedule	0.16	1	0.09	0.77	0.10	0.40
	Radius	12.65	1	57.71	<0.0001		
	Duration	3.31	1	15.08	<0.001		
	Point × schedule	1.79	19	8.15	<0.0001		
	Schedule × size	<0.01	1	0.03	0.87	0.90	
	Size × duration	0.51	1	2.31	0.13		
	Schedule × duration	0.51	1	0.26	0.61	0.90	

estimate based on territory mapping (0.32 males/ha), with means providing an underestimate (hourly = 0.24 males/ha; weekly = 0.22 males/ha) and maxima, an overestimate (hourly = 0.40 males/ha; weekly = 0.41 males/ha). For the 10-min counts, the density estimates calculated from mean number of birds detected were very close to those based on territory mapping (hourly or weekly = 0.30 males/ha). Estimates based on maximum number of detections on the 10-min counts provided an overestimate (hourly or weekly = 0.54 males/ha). Revisit schedule made no difference in the density estimate from 10-min counts.

TABLE 3. Paired t-test results for detections of Chestnut-sided Warblers and Dark-eyed Juncos using point counts on hourly and weekly schedules.

Species	Estimate	Schedule	Mean	SD	t	P[a]
Chestnut-sided Warbler	Mean	Hourly	1.3	0.74	<0.01	0.997
		Weekly	1.3	1.0		
	Maximum	Hourly	2.15	0.99	0.30	0.19
		Weekly	1.85	1.18		
Dark-eyed Junco	Mean	Hourly	0.77	0.65	0.08	0.54
		Weekly	0.68	0.56		
	Maximum	Hourly	1.25	1.07	0.05	0.84
		Weekly	1.3	1.03		

[a] Power was 60% for all comparisons if effect size (d) and Pearson product-moment correlation coefficient (r) were hypothesized to be 0.5. Using the same d, but r = 0.75, indicates a power of 87%.

DISCUSSION

We found that repeating all three samples of a fixed-radius point count during a single two-hour period produced an estimate of breeding bird numbers that was not statistically different from that produced by sampling the same point over a two-week period. This was true for two species of breeding birds using either a 5-min or 10-min count duration, and a 50-m or 100-m count circle radius. We are aware of only one other test of the effect of same-day revisits (Buskirk and McDonald 1995). That study also found no statistically detectable effect of revisiting three times, two hours apart as compared to revisiting over 2–3 d; however, statistical power was not reported, and the published data show a consistent pattern of same-day revisits producing slightly lower counts. Our results suggest that researchers should seriously consider the possibility that multiple revisits to point count stations may be made on the same morning, thereby greatly reducing effort involved in revisiting count stations. For Dark-eyed Juncos, repeating replicates hourly and using the maximum number of males detected on any of the three 5-min replicates, or the mean number on the three 10-min replicates, produced estimates close to that generated by intensive territory mapping of a color-banded population. Thus, in this case, the most economical census was also the most accurate. There are certainly some reasons to consider spreading revisits over a longer time period, such as to detect species with different breeding phenologies, or to eliminate the influence of nonbreeding floaters or migrants early in the season. However, researchers designing breeding bird censuses that include revisits should carefully consider whether they are necessary and the reason they are including them. If stations are to be revisited solely to increase the likelihood of detecting all breeding individuals during short-duration point counts, then our results suggest that economical revisits as close as one hour apart should not affect results.

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