The Condor 93:469–472
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COMMENTARY

POPULATION ESTIMATES OF THE BLACK-CAPPED VIREO

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Recently, Benson and Benson (1990) estimated the population size of the endangered Black-capped Vireo (*V. atricapillus*) in Mexico to be 24 times the previous estimate. While making conservative assumptions in most instances, they used a seriously flawed survey design and failed to incorporate appropriate components into their variance calculations. Their estimate may be biased and is too imprecise to be useful.

The first element of any survey design is the selection of sample units by an established sampling scheme known to produce unbiased estimates. Sampling schemes applied to bird censuses commonly include simple random, stratified random, systematic, and cluster sampling (Scheaffer et al. 1986). Benson and Benson (1990) seemingly did not use any recognized sampling scheme, but selected study sites for convenience or for accessibility. Their data, therefore, provide no valid basis for an estimate of a population of Black-capped Vireos in Northern Coahuila. A more defensible approach to estimating the numbers of Black-capped Vireos would have been to take a randomly selected sample of points in the Black-capped Vireos favored habitats within the Coahuila range. Selecting sample points at random would provide a firm basis for making inferences to the population size of Black-capped Vireos in the Coahuila range. Ideally, the sample size should be set such that there is a high expectation of counting 100 birds. In Hawaii in 1975, when the Palila (*Loxioides bailleui*) varied in numbers from 1,500–1,700 (Van Riper et al. 1978), researchers counted 100–300 birds along about 500 km of randomly distributed transects. In this same area from 1980–1984, when the mean population estimate ranged from 2,000 to 6,400 birds, 325 five-minute count periods resulted in counts of 96–243 Palilas. The confidence intervals (95%) for the counts were ±21–33% of the mean population estimates (Scott et al. 1984, 1986). In the case of the Black-capped Vireo, previous estimates of the species abundance (Marshall et al. 1985) would lead researchers to sample far more than the four sites visited by Benson and Benson (1990).

Benson and Benson (1990) assumed they could detect all singing male Black-capped Vireos to a distance of 166.5 m. They provided no evidence for this assumption, although it directly affects the population estimate. How many birds were missed in this area? Our experience with detection distances suggests that an effective detection distance as long as 160 m exists for very few species and, therefore, the assumption results in a conservative estimate. This conservative approach is the appropriate strategy for an endangered species, but Benson and Benson (1990) should have presented evidence for this assumption. Merely recording detection distances for all singing males would have provided support for their assumption. This is particularly important in light of comments by Marshall et al. (1985:8) that this species is unusually conspicuous because its "long distinctive song is uttered at most times of day, rain or shine." Because the detection distances affect the population estimate directly, they should be estimated during the survey, and their variance incorporated into the variance of the final population estimate (Burnham et al. 1980:51). In the same way, the authors' assumption that 87% of the males were paired must be supported and the variance associated with it incorporated into the variance of the population estimate.

To demonstrate the importance of incorporating all variances associated with the estimate, we took the liberty of analyzing again the numbers presented by Benson and Benson (1990). Benson and Benson (1990) sampled 100 points and estimated that a proportion equal to 0.4 of the census zone is similar to the four studied canyons. Thus $P = 0.4$ is an estimate based on a sample size of 100. The variance of this estimate is easily calculated $\mathrm{Var}(P) = 0.0242$ (Scheaffer et al. 1986: 57). The error in this estimate can be included by treating the population estimate as follows:

$$N = Apd$$

where

- N = Estimated population size
- A = Area of census zone
- p = Estimated proportion of census zone which is classified as potential habitat
- d = Estimated mean density

Using the delta method (Seber 1982), the variance of this estimate is calculated by:

$$\mathrm{Var}(N) = A^2[d^2\mathrm{Var}(p) + p^2\mathrm{Var}(d) + \mathrm{Var}(p)\mathrm{Var}(d)]$$

This gives a standard error for Benson and Benson's (1990) estimate as 1,755. A 90% confidence interval for their population estimate is 6,328 ± 4,130. If the other sources of variation were incorporated into this estimate, the confidence interval would be even wider. At best, Benson and Benson's (1990) data allow them to say that they heard or saw 28 singing males. Future researchers will have to determine the actual population size of the species.

Because of the extreme sensitivity and legal status of endangered species, population estimates must be calculated with extreme scientific rigor. Otherwise, agencies may act to list, down-list, or delist a species based on inaccurate information. This risk of misclas-

sification is real for the Black-capped Vireo. The 24-fold increase postulated by Benson and Benson (1990) is not substantiated by the data presented and methods used.

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REPLY TO SCOTT AND GARTON

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We commend Scott and Garton for their analysis of our recent article in which we estimated the population of Black-capped Vireos (*V. atricapillus*) in a region of northern Coahuila, Mexico. We welcome the opportunity to expand and clarify elements of the paper.

Scott and Garton suggest that our results may be biased owing to a flawed survey design. They also suggest that we failed to consider appropriate components in our variance calculation that resulted in an estimate too imprecise to be useful. They reanalyzed our data and close with an admonishment that population estimates for endangered species must be calculated with extreme scientific rigor. We agree with the need for rigor. However, Scott and Garton have made several unfortunate errors in their calculations that exaggerated the size of the standard error.

Our motivation for attempting an estimate of the Black-capped Vireo population stemmed from several reconnaissance trips to this region. In contrast to reports by Marshall et al. (1985), we were struck by vast areas of apparently suitable habitat for Black-capped Vireos and surprised by the frequency with which we encountered singing males. Marshall's estimate of a maximum population of 131 pairs in all of northern Mexico seemed incredible, since by surveying only 0.077% of this species' suspected breeding range in Mexico, we had discovered more than 21% of Marshall's estimate of the maximum population. With detailed field notes and good maps of the region we planned the paper to which Scott and Garton refer. Clearly, our sampling scheme leaves much to be desired, however, we feel that the approach yielded an estimate with controlled bias and is sufficiently precise to be useful.

We agree with Scott and Garton that any one of the sampling designs suggested by Scheaffer et al. (1990) would have been more desirable. Methods other than strict random sampling are defensible as an alternative, if potential sampling bias is evaluated and avoided as much as possible. For example, Scott and Garton suggest systematic sampling as one appropriate method. But systematic sampling suffers from possible bias associated with unsuspected periodicity in the data (Cochran 1977). Consequently, investigators must carefully examine the samples to assure that no systematic bias has been introduced. In general, it is incumbent upon investigators to uncover and address any bias introduced by the sampling design.

Many factors work to prevent the application of "textbook" designs in areas like backcountry Mexico. Permission to be on the property was the major controlling factor in the selection of transects in our design. However, we feel that our design is not likely to suffer from excessive bias because: (1) we searched for indications of habitat dissimilarity by overflying large sections in a small airplane, (2) we examined the foothills with binoculars from a vehicle, and (3) we studied aerial photos and topographical maps of the region. We could not find any evidence that the transect areas differed from the other canyon habitat subsequently included in our study. Both of us are familiar with Black-capped Vireos and their habitat in Texas. Additionally, we sought advice on the transect selection from two other biologists regularly involved in Black-capped Vireo work and familiar with the geology associated with the birds in Texas. Our conclusion is that, although the sampling scheme was not one of those mentioned by Scott and Garton, any bias associated with the selection of transects had a minor effect on the value of our estimate.

Our sampling method was that of a strip transect (Seber 1982, Burnham et al. 1980). We chose this method because we had not precisely measured distances to singing males from the transect centerline. All of the vireos encountered along the four transects were within 100 m of the transect center. This estimated distance was judged from parallax as we continued along the transect. For a margin of safety, we arbitrarily chose the maximum detection distance to be 166.5 m (transect width of ⅓ km). This overly long