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More on the need to get the basics right: population indices

By Richard M. Engeman

On the grounds of "the need to get the basics right in wildlife field studies," Anderson (2001:1294–1297) recently included a general condemnation of the use of population indices. My purpose in this brief note is to add a few paragraphs of my thoughts to the comments by Anderson (2001) with respect to indexing animal populations. In general, I agree with the quantitative concepts described by Anderson (2001); however, I would like to place his comments into a broader perspective of general statistical rigor, without condemning the use of population indices if they are appropriately constructed.

The factors cited by Anderson (2001) that impair inferences when using indexing procedures also would, if present, bias any wildlife data collection procedure. In particular, Anderson (2001) cited observer effects, environmental effects, and effects due to characteristics of the target species as sources of bias that could undermine the inferences from population indices. I contend that these influences could undermine the value of virtually any wildlife data, and controlling the influence of such factors is basic to rigorously designing wildlife studies in general, whether or not they involve producing a population index. Consider that most population estimation procedures tend to be highly sensitive to the assumptions upon which they are based. The same influences decried by Anderson (2001) as invalidating indexing methods also could destroy the validity of the assumptions for population estimation procedures. In fact, the tenuous nature of the foundational assumptions for population estimation led Caughley and Sinclair (1994) to go so far as to describe population estimation procedures as requiring a "leap of faith" (Caughley and Sinclair 1994: 214) by the investigator, and to further suggest that appropriately formulated indexing procedures provided practical alternatives for many, if not most, population monitoring situations. Avoiding such potentially confounding effects in data collection resulting from the observers, the environment, or characteristics of the target species should be a fundamental design concept, no matter the method or objective. As such, the general topic of confounding usually is introduced in elementary statistics courses.

Anderson (2001) also emphasized the importance of having a measure of precision accompany a population statistic, and criticized indices in general for their lack of a measure of precision. Unfortunately, wildlife literature is rife with examples of indices (especially raw counts) without appropriate measures of precision. This, I believe, should be considered a characteristic of poor design concepts rather than a censure of the utility of indices. An appropriately designed indexing procedure would have an associated and inherent measure of precision (e.g., Engeman et al. 1998). Perhaps even more insidious than a population value without a measure of precision is a population value (index or estimate) with an inappropriate measure of precision. At least when no measure of precision is available, it is plainly obvious the value has no utility. A population value with an inappropriate estimate of precision provides a false measure of its quality and occurs in many ways. Sometimes data are subjectively subdivided *post hoc*, thus producing an appearance of a design compatible with estimating precision, while other times underlying assumptions may be violated to produce a biased estimate of precision. Just because a measure of precision has been calculated does not imply it is appropriate. Whatever the context, an inappropriate estimate of precision can ultimately result in misleading research findings and tainted management decisions.

Anderson (2001) also pointed out that indices do not directly estimate wildlife population parameters, stating that "common sense might suggest that

one should estimate parameters of interest," and citing population density or abundance as examples of the parameters to be estimated (Anderson 2001: 1295). Taking a little different position, I believe common sense would dictate that the most efficient data relevant and valid for management objectives would be collected. Anderson's contributions to wildlife density estimation are well-known and include the fundamental reference publications in line transect (e.g., Burnham et al. 1980) and mark-recapture (e.g., Otis et al. 1978). However, it is not a universal point of view that population parameters always need to be estimated directly to provide the necessary information upon which to base inferences. Changes in population, or population activity, may be successfully monitored if sufficiently rigorous, but less labor-intensive observational and analytical procedures are available to provide an index reflective of the population (e.g., Caughley 1977, Caughley and Sinclair 1994). This is especially true when the larger volumes of data often needed for population estimation procedures are not, or cannot be, collected. Reinforcing this point, McKelvey and Pearson (2001) found in a 5-year literature review of small-mammal studies that population indices were used twice as often as population estimation and that 98% of the studies resulted in too little data for valid mark-recapture population estimation.

An investigator must be clear on the monitoring objectives when deciding whether to estimate the numerical size or density of the population or whether to produce an index to detect population change. This must be decided in advance because to attempt to estimate abundance or density from an index would require additional study where known densities (not density estimates) are related to index values with a statistical model, and each set of environmental and temporal circumstances would require validation of the functional relationship. Attempting to define a relationship between an index and true population numbers by establishing a relationship between an index and an estimate of density would be inappropriate, yielding only an indication of correspondence among methods, with the benchmark still only an estimate, of unknown quality (e.g., Caughley and Sinclair 1994). If a population estimate is mandatory, it is more sensible to initially devote the additional resources necessary for density or abundance estimation. As White (2001: 383) cautioned, "Don't even start the project if you can't do it right." In such a case, a density estimation procedure such as mark-recapture or line transect should be applied, and the investigator should be prepared to do all that is necessary in terms of resources and information to design a study that ensures that adequate numbers are observed or captured and data are appropriately modeled without violating the underlying assumptions for calculating the density estimate. To do otherwise would likely result in the population estimate itself being a labor-intensive but low-quality index.

In summary, the application of an index does not automatically imply an inappropriate procedure. Rather, an index could well be the most efficient means to address population monitoring objectives. I do not view indexing versus population estimation as an issue. I view the issue as selecting appropriate versus inappropriate experimental design and data analyses to efficiently achieve the investigator's objectives. Application of a poor experimental design or production of a value without an appropriate measure of precision is poor inferential technique that can undermine management decisions. This applies equally to population indices, population estimates, and virtually all other data collection procedures.

Acknowledgments. I thank K. Fagerstone, M. Fall, T. Mathies, J. Shivik, H. Smith, R. Sterner, K. VerCauteren, and an anonymous referee for their helpful comments on earlier drafts of this commentary.

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Key words: experimental design, statistical rigor, study objectives, validity

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