RELATIVE ABUNDANCE ANALYSIS: A TECHNIQUE FOR ASSESSING BIRD COUNT DATA

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One of the enduring pleasures of birding is the intellectual stimulation derived from the effort to comprehend the patterns of bird distributions as they shift with the seasons or change over the years. This is one reason why many birders are meticulous note-takers who possess field journals that run back for years. The Massachusetts Audubon Society - Bird Observer statistical network receives regular reports from dozens of active birders who obviously hope that their data will be of interest to others, and that it has some value beyond the mere personal satisfaction. Insofar as such data can contribute to our knowledge of species distribution and population trends, a convenient and efficient method of quantitative analysis would be assessing actual changes in this era of massive habitat alteration.

But the bulk of such data, except for noteworthy rarities, is never compiled or published in a manner that provides a meaningful permanent record. In part, this situation is due to the problems encountered in attempting to compare observations made at different sites by different observers. A meaningful comparison requires that those extraneous factors which affect the count data (such as time afield, type of habitat, and extent of coverage) be taken into account in order to provide a valid basis for comparison. Often the form of the data or the lack of supporting information precludes this.

Consider, for instance, the supporting data which is required for normalization. Leif Robinson (1) has encouraged the use of birds per hour (BPH) as a normalizing measure of abundance. His suggestion that all records include an estimate of time afield is certainly pertinent. However, BPH can remove only the effect of the time afield. This may be the only adjustment required if all data to be analyzed were collected by a single individual at a specific place. But the comparison of data gathered in various habitats by a variety of persons may require further adjustment to account for the number of observers, area covered, and other factors.

Anyone who has participated in a Christmas Bird Count has probably been asked to provide normalizing "level of effort" data (such as number of party hours or party miles) to accompany the observations. But, in a study of CBC results, Raynor (2) concludes that this data alone is not sufficient for proper normalization. Raynor discusses a hypothetical upland count area in which a single lake provides the only waterfowl habitat. One year the count records 100 Mallards on this lake. Ten years later the count was again 100. But over the intervening decade the number of party-hours for the count as a whole rose from 10 to 100. An analyst, unfamiliar with this situation but attempting to normalize the Mallard count according to level of effort, might conclude that a disastrous decline from 10 BPPH (birds per party hour) to 1 BPPH had occurred! In order to avoid such misleading normalization, Raynor concludes that the compiler must provide additional hard-to-come-by information, such as the percentage of each type of habitat that was covered and the degree of thoroughness.

If such difficulties are encountered with CBC data, is there any hope for the retrieval of meaningful information from monthly lists submitted by an ever-changing corps of observers without any normalization information? Perhaps there is, if we focus not on the problem of normalization, which yields absolute abundances, but derive instead relative abundances. The latter type of analysis would merely ask what percentage of the total number of individuals seen was of a particular species. Relative abundance has many self-normalizing properties: the extent of the habitat covered, the number of observers, and the speed at which the party moves do not directly impact the final results.

At first glance, relative abundance may seem to be a less concrete concept than absolute abundance, but many fundamental questions concerning avian populations can be answered from a knowledge of relative abundance alone. For instance, it can be determined which species are increasing relative to others. It can also be determined how the composition of species varies from one site to another.

The determination of relative abundance is not irrelevant to the determination of absolute numbers. Once the proportions are known, it is then necessary only to postulate a number for the total population in order to compute the absolute populations of any given species. For example, if radar observations were to provide estimates of the total number of migrants in a given "wave," and if field observers were to determine the proportion of each species in that wave, then the absolute numbers of each species could be computed. In fact, though far from ideal, it is necessary to know only the absolute numbers of any one species in order to estimate the absolute numbers of all others from the relative abundance data.

A close analogy to this technique is the method used to estimate whale populations. A known number of whales is tagged. Relative abundance of the tagged subpopulation is then determined by collecting tags found on whales killed. The total whale population can then be estimated by dividing the number of tagged individuals by their relative abundance.

Occasionally one encounters studies which compare the relative abundances of two species, for example, Sharp-shinned and Cooper's Hawk, or Hairy and Downy Woodpecker. Such comparisons are generally directed toward answering a specific question that the analyst has posed. The general applicability of the pairwise technique is limited by the fact that only two species are simultaneously analyzed. This approach can be extended to accommodate a variety of species by designating one as the reference species and using its abundance to normalize the others. However, the validity of this type of normalization is highly sensitive to the characteristics of the reference species and the others may influence the results.

A less sensitive approach would be to choose several species that can plausibly be referenced to each other, and to express the abundance of each species as a percentage of the group total. Each species, therefore, contributes to the normalization of all the others. This is the most general utilization of the data and produces results which can easily be re-examined at a later date if some of the more specialized normalization techniques are desired.

The group which is chosen for analysis should consist of species which, <u>in a given habitat</u>, are encountered in rough proportion to their respective populations at large. Birds which tend to be found in quite different habitats should not be grouped, since the observed relative abundance would depend more on the type of habitat visited than upon the size of the populations. For example, it would be highly questionable to compare the winter abundances of Common Loon and Red-breasted Nuthatch, since the ratio of their counted numbers should be more dependent upon the ratio of sea-surface to coniferous forest habitat than upon their actual populations.

To demonstrate how a general-purpose relative-abundance analysis can be carried out, I have applied this technique to 1974 Christmas Bird Count data for four eastern Massachusetts counts. Selected for this analysis are 13 species found primarily in woodlands (woodpeckers through Brown Creeper).

The analysis requires preparation of a table (see Table 1), which contains the actual number of each species counted in each count area and the relative abundance expressed as a decimal fraction of each count; the final column gives similar data for four counts combined. In the absence of additional information, we proceed upon the hypothesis that the data reported from each site are random samples from populations with uniform species distributions. If this were the case, then the relative abundance of each species at each site would approximate the relative abundance of all sites, differing only by variations in the sampling procedures. The best estimate of the true relative abundance of species would then be obtained by combining data from all sites, as in the final column of Table 1.

At this point it is worthwhile to consider the extent to which the data are consistent with the hypothesis of uniform species distribution. By comparing the relative abundances for each count area with the average in the final column, instances can be found in which the differences between individual sites and the combined average are too great to be attributed to sampling error alone. An effective way of examining such differences is to plot the data for individual sites against the combined data, as in Figure 1. A logarithmic scale is used to accommodate the wide range of relative abundance, and the diagonal line indicates where site data must lie in order to coincide perfectly with the combined data.

The tendency of the site data to cluster most near this line is striking, indicating that there <u>is</u> a great similarity between most species distributions for the four sets of data. Nevertheless, there are some notable deviations from the trend--such as the overabundance of Red-breasted Nuthatches reported from Millis, and the underabundance of Common Crows from Worcester. Are these due to normal statistical variation in the samples, or should we look for other explanations? How much variation is significant?

Fortunately there exists a simple statistical measure which indicates the amount of variation to be expected. Let RA be the relative abundance observed at a particular site for a certain species. The amount of variation in RA to be expected due to sampling error can be expressed in terms of the standard deviation of RA, which is derived from observations of all birds at that site. This standard deviation is given by:

$$sd = \sqrt{\frac{RA \quad (1 - RA)}{\text{total count of all species at the site}}}$$

EXAMPLE: For the Millis count of Tufted Titmouse,

$$sd = \sqrt{\frac{0.123 \quad (1 - 0.123)}{893}} = 0.011 \text{ or } 1.1\%$$

In other words, the Millis estimate of the relative abundance of the Tufted Titmouse is .123 with an uncertainty of .011=1.1% (one standard deviation).

Note that the more birds one counts, the smaller is the standard deviation, hence the more accurate the estimate of the relative abundance.

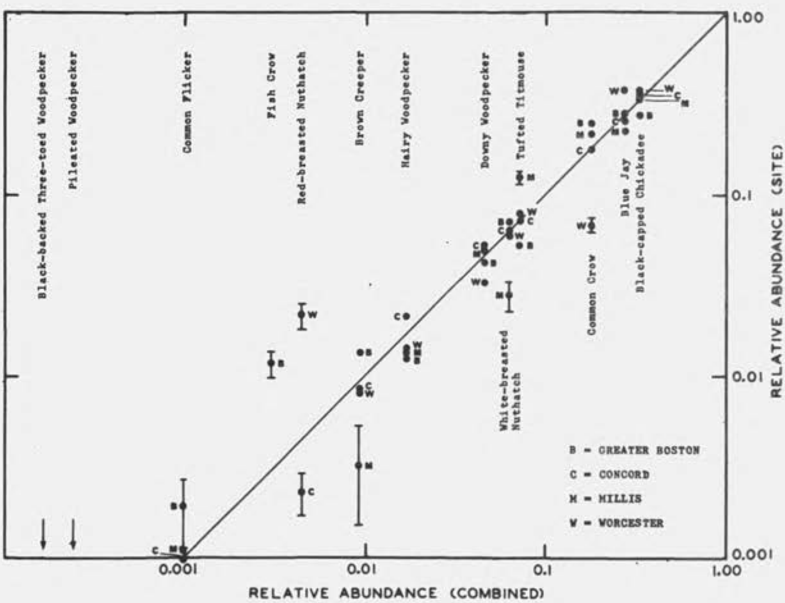

FIGURE 1: Plot of relative abundance at various sites versus combined relative abundance.

TABLE 1: Relative Abundance Data for Four Eastern Massachusetts Christmas Bird Counts (13 selected species)

	CONCORD		GREATER BOSTON		MILLIS		WORCESTER		COMBINED	
	count	RA	count	RA	count	RA	count	RA	count	RA
Common Flicker	5	.0009	6	.0019	1	.0011	0	.0000	12	.0010
Pileated Woodpecker	2	.0004	0	.0000	0	.0000	1	.0006	3	.0003
Hairy Woodpecker	120	.0210	39	.0126	12	.0134	25	.0138	196	.0170
Downy Woodpecker	293	.0513	130	.0419	44	.0493	59	.0325	526	.0457
B-b. 3-toed Wdpckr.	2	.0004	0	.0000	0	.0000	0	.0000	2	.0002
Blue Jay	1,443	.2528	838	.2699	195	.2184	657	.3622	3,133	.2720
Common Crow	997	.1747	772	.2486	193	.2161	122	.0673	2,084	.1809
Fish Crow	0	.0000	36	.0116	0	.0000	0	.0000	36	.0031
B-c. Chickadee	1,994	.3493	856	.2757	310	.3471	646	.3561	3,806	.3304
Tufted Titmouse	409	.0717	165	.0531	110	.1232	138	.0761	822	.0714
W-b. Nuthatch	382	.0669	221	.0712	25	.0280	112	.0617	740	.0642
R-b. Nuthatch	13	.0023	0	.0000	0	.0000	39	.0215	52	.0045
Brown Creeper	48	.0084	42	.0135	3	.0034	15	.0083	108	.0094
INDIVIDUALS	5,708		3,105		893		1,814		11,520	
PARTY HOURS	191		143		48		77		459	
BIRDS/PARTY HOURS	29.9		21.7		18.6		23.6		25.1	

As a rule of thumb, if the observed relative abundance is more than two standard deviations from the value of the combined data, then there is a strong indication that something other than normal statistical variation is at work. In Figure 1 vertical bars are drawn around certain data points to indicate plus and minus one standard deviation for those points. Note that the plot indicates that the high count of Common Flicker at Boston could easily be due to normal sampling error, but that the high count of Tufted Titmouse at Millis is almost certainly not due to sampling error. (In support of the latter conclusion, see Robinson's analysis of the relative abundance of Cardinals and Titmice (3).)

In Table 1 it can be seen that the Concord count had a total birds-per-party-hour that was 61% greater than that for Millis (29.9 to 18.6). Nevertheless, the relative abundances reported from Millis are reasonably consistent with those from Concord. In such cases the differences in the absolute abundances may be due to less extensive habitat or less concentrated effort. The count of Tufted Titmouse at Millis, for example, probably deserves to be called a "high" count on the basis of its relative abundance, even though on an absolute scale it is about equal to the count at Concord. Also, despite the fact that Concord has traditionally reported the highest CBC counts of Blue Jay, albeit not in 1974, in relative abundance Concord ranked below the Worcester and Greater Boston counts!

Any observer who has kept careful records can readily compute relative abundances for his data and compare it with the results of others. In some cases a few minutes with a hand calculator is all that is required to turn a list of incomprehensible numbers into a meaningful statement. We should all strive to put the birding data we are producing to better use. I think relative abundance analysis can help us in this effort - why not give it a try?

REFERENCES:

1. Robinson, L.J., "Some Thoughts About Counting Birds," Bird Observer of Eastern Massachusetts, Vol. 5, No. 4, July-August, 1977.

2. Raynor, G.S., "Techniques for Evaluating and Analyzing Christmas Bird Count Data," American Birds, Vol. 29, No. 2, April, 1975.

3. Robinson, L.J., "Cardinals and Titmice," Bird Observer of Eastern Massachusetts, Vol. 2, No. 1, January-February, 1974.