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Next we determine if the calculated Tau differs significantly from zero. Use the critical Tau values in Table 5, where α is the probability associated with the critical Kendall's Tau value for a sample size of n. Here the computed Tau (0.72) is larger than the tabulated Tau (0.556) for a sample size of 9 and a probability (α) of 0.05, so the mix of birds is statistically the same for Usual and Observed data, and we are 95% confident that the mix of species is statistically usual.

Using statistical techniques, you will make some mistakes with initial attempts to analyze your data. Do not be discouraged by these initial mistakes. Only when the hawkwatcher is intimately involved with data analysis will the full implications of his or her observations become apparent. Mark Twain noted, "There are three kinds of lies — lies, damn lies, and statistics," and even today there are many critics of statistical analysis. Be careful with statistics *and* don't underestimate the power of statistical analysis.

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A Technique for Evaluating Observer Efficiency in Raptor Migration Counts

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ABSTRACT: A technique is described for sampling sections of the sky individually during a raptor migration count to obtain an unbiased estimate of the true number of raptors passing. This allows an estimate to be made of the efficiency of raptor detection by an observer counting at the same location and time. Practical and statistical issues are addressed that must be understood for efficient use of the technique.

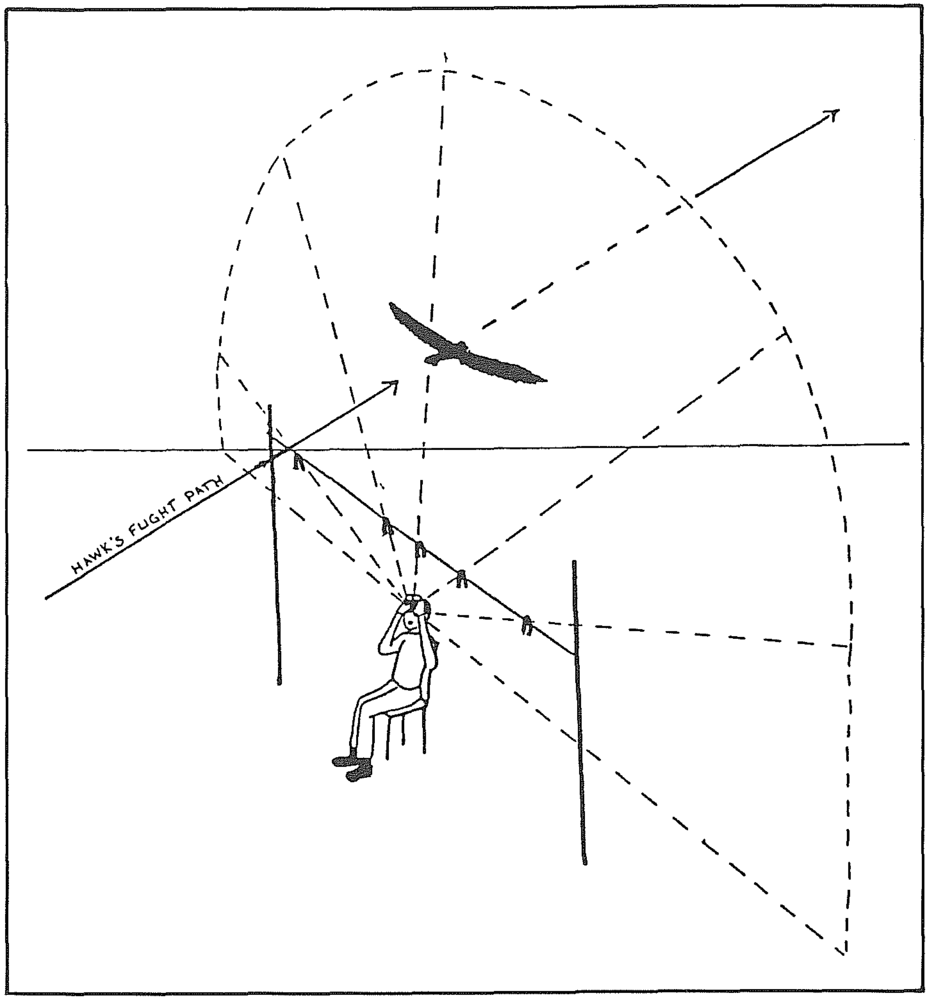
In most visual surveys, it is recognized that observers do not record all of the individuals that pass within their view. Caughley (1977), for example, summarized estimates of the proportion of wild animals of several species seen by observers flying strip transects in Africa; the proportions detected (referred to in our article as observer efficiency) varied from 0.3 to 0.8, despite the fact that these were all large animals in open habitats. Efficiencies well below 100% have also been reported in other big-game surveys as well as in aerial surveys of waterfowl. Similarly, it is widely acknowledged that on singing-bird surveys, field workers do not record all the audible birds. It appears that even the best surveyors have efficiencies of less than 70% (Bart and Schoultz, in prep.).

It is important for 2 reasons to estimate observer efficiency and to understand what factors determine it. First, if efficiency changes, a corresponding change will be produced in the survey results even if population density does not change. Second, it is often of interest to compare different species or one species at two different places, but such comparisons are difficult unless some assurance can be gained that observer efficiencies are comparable.

This study describes a technique for estimating observer efficiency at raptor-migration lookouts. The method was first described at a meeting of Ontario ornithologists in 1978; in 1982 it was field-tested at the Derby Hill lookout in New York. Here, we describe the method in detail, explaining the practical and statistical issues that must be understood for efficient use of the technique. The estimates of observer efficiency obtained in the 1982 study will be reported elsewhere.

The method. During the evaluation, one of us sat underneath a rope divided into 6 sections by poles and flagging (Figure 1). Data were collected in 30-minute periods during which the arc of sky above each segment of the rope was observed in turn for 5 minutes. The order in which the segments were sampled was random within each 30-minute observation period. All raptors crossing the

FIGURE 1. Sampling method used to obtain unbiased estimates of numbers of raptors passing Derby Hill, New York. During each half-hour observation period each sector of the sky was observed for 5 minutes. The observer was able to detect virtually all birds passing within this restricted field of view.



segment of rope under observation were counted. The official observer worked directly in front of us and far enough away that he was unaffected by our observations. He too recorded data by half-hour periods, and in addition to the number of individuals of each species passing, he recorded weather information, mean altitude of the passing raptors, number of visitors, and other information. Fatigue was a serious problem during the study, so we sampled half-hour periods rather than attempting to collect data continuously. The decrease in

sample size increased the variance of our estimates of observer efficiency for each species — that is, their closeness to the true observer efficiencies — but it left them unbiased by fatigue factors.

Our estimate of the total number of birds of each species passing during a single half-hour was obtained as follows: we multiplied the sum of all birds counted in each of the 6 sections by 6. For example, if 2 Sharp-shinned Hawks *(Accipiter striatus)* were counted in each of the 6 sections during sampling, then that sum of 12 birds would be multiplied by 6 for a total estimate of 72 birds passing during the half-hour. This follows from sampling theory. If 2 birds pass through a given section during 5 minutes, then an average of 12 should pass in 30 minutes. Of course hawks rarely pass in such a precise manner. But as our sample of half-hour periods increases we can be sure that our estimate of observer efficiency, which is drawn from these estimates of the actual number of hawks passing, will approach the true observer efficiency.

Although our sky segments were all of equal length, there is no need for this to be the case. A simple example illustrates this. Suppose the sky is divided into only 2 segments of equal size. Each section will thus be sampled for half of the 30-minute period. If 10 sharpshins pass through each section during sampling, we estimate that twice 20, or 40, passed during the half-hour. Now suppose that we continue to use only 2 sections but that one of them covers one-quarter of the sky and the other covers three-quarters of the sky. Under the previous conditions only 5 sharpshins might be counted in the small section, 15 in the large section. Again, however, the estimate of the total number passing during the 30 minutes will be twice this sum, or 40 birds. An investigator might vary the size of sections if the hawks' flight path is concentrated in an "alley" that requires careful monitoring for the detection of all the hawks passing in that alley. We, however, did not find such a strategy necessary when using 6 sections for sampling.

Implicit in this method of estimating the true total number of hawks passing, which number we will use to estimate the observer's efficiency in detecting these hawks, is the assumption that when sampling a section of the sky we are detecting virtually all of the hawks passing there at that time. Because we have to monitor only a fraction of the sky, as opposed to searching the entire sky as the observer must, we can give much greater attention to the detection of hawks. There is little opportunity for one hawk to distract our attention from the detection of another. The only exception might occur when the high altitude of the passing hawks necessitates the use of binoculars to detect them. At Derby Hill this was not a major problem. Only Broad-winged Hawks *(Buteo platypterus)*, and rarely other species, flew at such an altitude that regular use of binoculars was necessary to detect the birds when they were passing directly overhead. Even under those conditions, we found that one-sixth of the sky could be swept carefully with binoculars to prevent many from slipping by. The same was true of birds a great lateral distance from the lookout. Although it is certain that we did not detect every single bird, we feel that our ability to monitor a small segflight conditions and fatigue of the observer. If our periods had come from adverse times, the estimate of overall efficiency would have been far too low, and the converse is also true. Investigators unfamiliar with sampling techniques are strongly urged to seek the advice of a statistician before embarking on the study.

We have stressed the possible problems with the method in this paper as an aid to avoiding them. In practice, the method was easy to use and produced interesting results that both we and the observer at Derby Hill feel are reliable; it seems likely the method could be employed with equal ease at certain other lookouts.

Acknowledgments

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The Effects of Varying Observer Numbers on Raptor Count Totals at Cape May, New Jersey

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ABSTRACT: A study was conducted using 3 observation points, none farther than 472 meters from either of the others. Teams of 1, 2, and 3 observers recorded migrating raptors from 25 September to 17 October 1982, the peak migration period. Resulting data were used to determine the effects of different numbers of observers on the total numbers of hawks observed and on the species of hawks observed. We also studied the effects of the size of a day's flight on the counts recorded by the several teams. There were significant differences in counts of 9 species of raptors. The greatest differences involved the most numerous species. A positive correlation was found between the increase in the size of a day's flight and the degree of variation between counts of the most common species recorded by the various teams. Positioning of the observation teams proved to have greater impact on the results than expected.

The Expanded Hawk Watch project at Cape May Point was developed in an effort to determine the effects of different observer numbers on data gathered. It was conducted at Cape May Point State Park, New Jersey (38°56′ N, 74°57′ W; see Figures 1 and 2), from 25 September to 17 October 1982.

Methods

Each of 3 observation sites was set up within 198-259 meters of the Official Count (OC) station, in expectation of assuring that all observers would see the same flight but be far enough apart that they did not influence each other's counts (Figure 2).

Sites A, B, and C were staffed by teams of 1, 2, and 3 observers, respectively. Site A, where a single observer was stationed, was called the Tower. It was a wooden platform 20 feet high and 15 feet square, located along the tree line. Site B, where 2 observers were stationed, was located along the beach. It was known as the Bunker – a reinforced-concrete remnant of a World War II coastal-defense structure. The observers there were about 40 feet above sea level and had an unobstructed view in all directions. Site C, where 3 observers watched, was a ground-level station about 20 meters south of the Cape May Point lighthouse and was referred to as the Lighthouse. The view to the north there was somewhat hampered by a combination of vegetation and the lack of elevation. Visibility to the east and south – generally the direction from which the birds approached – was uninterrupted.

The observers (D. Ward, Jr. – leader, M. Gustafson, D. Kreuger, M. Maurer, L. Metcalfe, V. Truan) were rotated through the different stations to eliminate