Fall 1984

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JOURNAL OF FIELD ORNITHOLOGY
Formerly BIRD-BANDING
A Journal of Ornithological Investigation

VOL. 55, NO. 4 AUTUMN 1984 PAGES 415–537

J. Field Ornithol., 55(4):415–423

RELIABILITY OF COUNTS OF MIGRATING RAPTORS: AN EXPERIMENTAL ANALYSIS

BY GENE SATTLER AND JONATHAN BART

Counts of migrating raptors are becoming a valuable method for monitoring population levels. Records from Hawk Mountain Sanctuary, where daily counts have been taken nearly every fall since 1934, reveal trends for many species, such as declines in eagles between 1950 and 1975, which are consistent with data from other sources (Nagy 1975). Numerous raptor counting groups have been organized in the past decade, and their efforts are being coordinated and reported by the Hawk Migration Association of North America, organized in 1974. With the cooperation of the Migratory Bird and Habitat Research Laboratory of the U.S. Fish and Wildlife Service, a standardized report form has been designed (Fuller and Robbins 1979). The Fish and Wildlife Service has also funded daily, standardized raptor counts at 6 migration sites.

Several factors determine what proportion of the migrants passing a lookout are recorded by the survey. Wind speed and direction are known to have an impact on how concentrated the raptor flight is at lookouts in the Great Lakes region (Mueller and Berger 1961, 1967; Richardson 1974), on the Atlantic coast (Stone 1922, Allen and Peterson 1936), in the Appalachian Mountains (Broun 1935, 1939), and elsewhere. Precipitation, humidity, temperature, and cloud cover are also sometimes important (see Haugh 1972).

Less attention has been given to observer success in detecting raptors that pass within view. Reports of migration counts assume that all visible birds are tallied, but evaluations of other visual counts, such as aerial surveys, usually have produced surprisingly low observer efficiencies. Caughley (1977), for example, reports that trained observers flying under good survey conditions often missed more than 50% of the individuals in big game surveys in Africa.

This study was conducted to investigate the detection rates achieved by a trained individual (designated the "official" observer) at a raptor count site. The goals were to estimate and compare efficiencies for different species, determine how much efficiency varies under different conditions, and identify some of the causes of variation. The results are used to discuss how reliable migration counts are and how their value as a method of monitoring population levels might be increased. Efficiency is defined as the proportion of the visible raptors detected by the official observer. Efficiency and detectability are used interchangeably.

STUDY SITE AND METHODS

Derby Hill is located near the southeast corner of Lake Ontario. It is on the south shore less than 1 km from where the shore abruptly turns north. During spring migration, raptors that encounter lakes Erie or Ontario usually move east along the shores of these lakes rather than crossing the open water. Some birds flying along Lake Erie pass between the Lakes near Buffalo, but most continue along Lake Ontario. This flight line reaches its highest density at the southeast corner of Lake Ontario where Derby Hill is located. The flight begins in February when Northern Goshawks (*Accipiter gentilis*) appear and continues into June with the last of the immature Broad-winged Hawks (*Buteo platypterus*). On favorable days, several thousand raptors of more than a dozen species may be observed.

Two lookouts are used at Derby Hill. With south winds, warm air moving north encounters a dome of cooler air over the Lake and is deflected upwards. Under these conditions migrating birds are concentrated in a narrow zone along the shoreline, and the North Lookout, which is within 50 m of the Lake, provides an excellent viewing site. With east, north, or west winds the dome of cooler air and the updrafts move somewhat inland. Under these conditions the flight line also moves inland, becomes wider, and is harder to monitor. Observers usually move to the South Lookout, 1 km inland, for these flights.

In 1980 the Onondaga Audubon Society, in cooperation with the U.S. Fish and Wildlife Service, began a daily count of migrating raptors at Derby Hill from 1 March until 31 May. The same observer has been employed each year since then and had several years experience counting hawks at Derby Hill and elsewhere prior to accepting this position.

The official observer attempts to detect all birds passing within view. His success rate was estimated by a second observer who sat underneath a rope to which flags were tied dividing the sky into 6 sections of 30° each. The rope was oriented perpendicular to the flightline (Fig. 1). Data were collected in 30-min periods during which the second observer counted raptors for 5 min in each of the 6 sections. He only counted those birds which passed by the rope in the sector being observed. His count was multiplied by 6 to obtain an estimate of the total number of raptors passing. He was positioned behind the official observer to avoid influencing his counts.

A preliminary investigation during April 1981 indicated that restricting the second observer's view to one-sixth of the flightline would permit him to record virtually all passing raptors, even under heavy flight conditions. This estimate was thus unbiased. It had high variance because only one-sixth of the sky at a time was sampled, but by combining numerous periods we were able to obtain accurate estimates of the official observer's average efficiency (Table 1).

During each 30-min period, we recorded the identity of each raptor

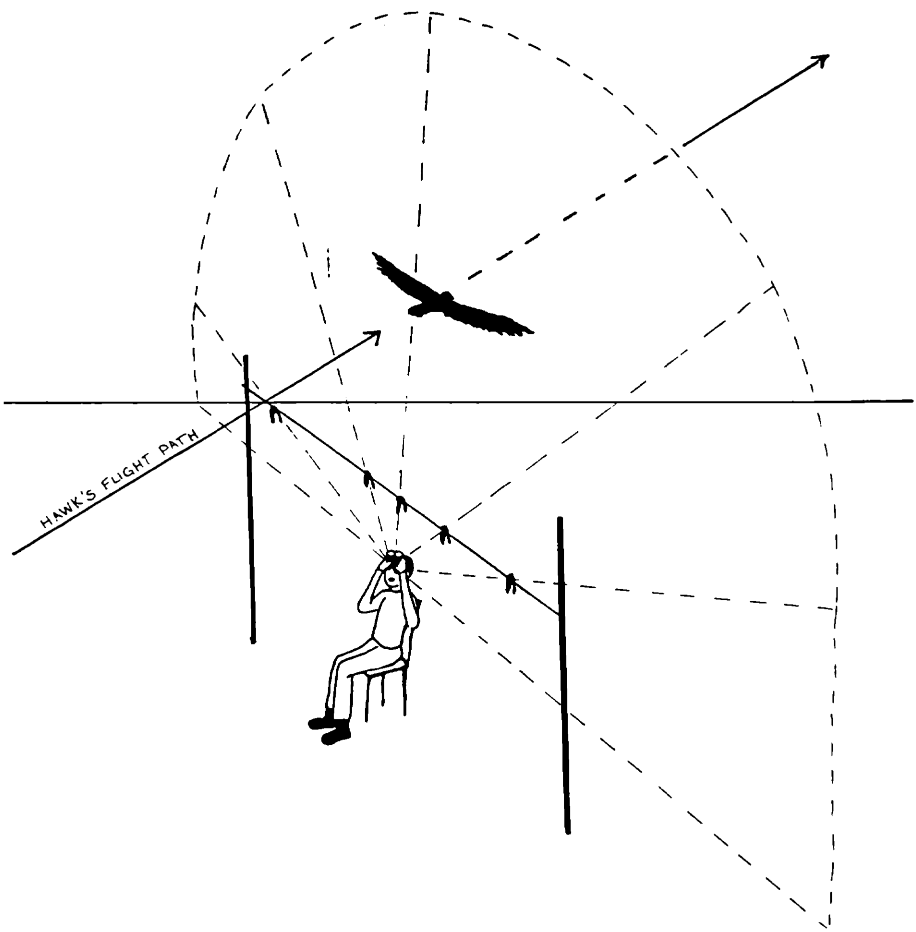

FIGURE 1. Method used to partition the sky for sampling migrating raptors at Derby Hill, New York.

(except Sharp-shinned Hawks, *Accipter striatus,* and Cooper's Hawks, *A. cooperii,* which were combined), the number of other observers present, and a "visibility index" describing how easy the flight was to monitor. Poor, medium, and good viewing conditions were assigned visibility ratings of 1, 2, and 3, respectively. The rating was determined primarily by how high the flight line was. Other factors included sky cover (birds in high flights are much easier to detect against clouds than against blue sky), how quickly the birds passed the lookout, and how widely dispersed the flight line was. The purpose of assigning visibility ratings was to determine whether factors other than species and flight density had a substantial impact on the observer's efficiency. Number of raptors passing, therefore, did not influence the visibility rating.

TABLE 1. Proportion of raptors detected by the official observer at Derby Hill, New York in Spring 1982.[a] Species are arranged in decreasing order of their use of soaring flight while passing Derby Hill, as estimated by the authors and the official observer.

Species	Proportion detected ± 1 SE (no. individuals)	Comments
Soarers		
Broad-winged Hawk	.73 ± .08 (15,816)	Uses thermals extensively, usually in conspicuous intraspecific flocks
Red-tailed Hawk	.78 ± .04 (6250)	Soars frequently, sometimes with other individuals
Red-shouldered Hawk	.72 ± .10 (590)	Uses flapping flight more than Red-tail
Non-Soarers		
Osprey	.47 ± .09 (273)	Soars when thermals available but moves without them
Rough-legged Hawk	.53 ± .10 (365)	Many pass in late afternoon when thermals are weak
Sharp-shinned and Cooper's hawks	.53 ± .03 (7338)	Move primarily by flapping and gliding at low altitude
Northern Harrier	.47 ± .08 (701)	Uses flapping flight primarily
American Kestrel	.41 ± .06 (442)	Passes quickly in low, rapid flapping flight

[a] Two 30-min periods were omitted due to large numbers (1795, 1192) passing in a small area during a short time span.

The official observer sometimes suffered from fatigue. To measure the effect of this fatigue on efficiency, we categorized the observer's attentiveness during a selection of 30-min periods as either high or low intensity. The assignments were made solely on the basis of the observer's behavior, not on the basis of flight density or visibility conditions.

During 21 March to 30 May 1982, 216 30-min periods were monitored. Observations were made at both North and South lookouts. Sampling intensity at the 2 lookouts was proportional to their coverage by the official observer.

TABLE 2. Example of hypothetical calculations to determine the effect on raptor surveys of a change in flight density between years.[a]

	Actually passing in density class				No. detected in density class			
Year	a	b	c	Total	a	b	c	Total
1	2000	10,000	18,000	30,000	720	6400	17,280	24,400
2	2000	18,000	10,000	30,000	720	11,520	9600	21,840
		Actual change: .0%				Estimated change: +12%		

[a] Observer efficiencies (see Fig. 2): density class a—.36; b—.64; c—.96.

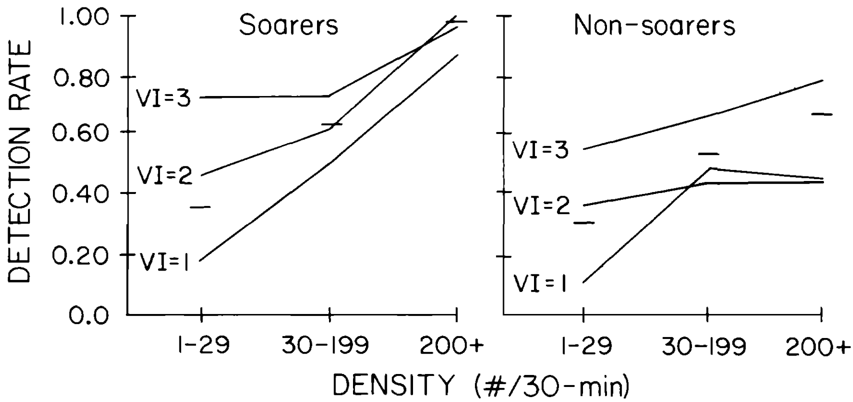

FIGURE 2. Variation in observer efficiency with flight density and visibility index (VI) during the 1982 raptor flight at Derby Hill, New York. Horizontal lines indicate the means for each density class. SE's of these means varied from .03 to .06.

The official observer estimated his efficiency prior to our showing him any results of the study. The level of significance in all statistical tests was .05.

RESULTS

Observer efficiencies were significantly lower than 1.0 for every species monitored. The 9 species studied had efficiencies varying from .41 to .78, and several of the differences between species were significant (Table 1). Tendency to soar seemed to be the strongest determinant of a species' detectability. Broad-winged, Red-tailed (*Buteo jamaicensis*), and Red-Shouldered hawks (*B. lineatus*) usually passed when thermals were strong, made extensive use of them, and were detected with the highest efficiency (.72–.78). Ospreys (*Pandion haliaetus*), Rough-legged (*B. lagopus*), Sharp-shinned, and Cooper's hawks, Northern Harriers (*Circus cyaneus*), and American Kestrels (*Falco sparverius*) often passed when thermals were weak or absent and sometimes did not use thermals even if they were present. These species had significantly lower detectabilities (.41–.53). We refer to these 2 groups as soarers and non-soarers. Species' size did not show any consistent relationship with detectability.

Flight density had a significant effect on efficiency. For both soarers and non-soarers, in all 3 visibility classes, there was a clear increase in efficiency with increasing density (Fig. 2). The change was especially drastic for soarers in poor visibility flights. Under these conditions, efficiency varied from less than 20% when density was low to more than 80% when density was high.

Within density classes, efficiency varied with how difficult the flight was to monitor. For both soarers and non-soarers, there was a substantial increase in efficiency with increasing visibility (Fig. 2). The change was especially great for soarers passing at low density. Under poor visibility conditions, the observer detected fewer than 20% of the individuals whereas under good viewing conditions, he detected about 70%. At high density, there was little difference in efficiency with visibility for soarers but a considerable difference for non-soarers.

The official observer's efficiencies (± 1 SE) were .56 (.04) with no other observers present, .52 (.05) with 1–3 other observers present, and .66 (.07) with 4–8 other observers present. These estimates exclude all Broad-winged Hawk data because our sample of periods during heavy broad-winged flights with no additional observers present was too small for us to obtain meaningful estimates of efficiency. We thus have no basis for estimating the effect of additional observers during heavy broad-winged flights, but it appears that at other times, additional observers had little impact on the official observer's efficiency.

Observer attentiveness had a marked effect on efficiency. For soarers, efficiency during low intensity periods was .43 (.08) whereas it was .82 (.07) during high intensity periods. For non-soarers the comparable figures were .32 (.05) and .57 (.04).

The official observer estimated that under good viewing conditions he detected 95–100% of the individuals and that under poor conditions he detected 60–90% of the individuals. There were no consistent relationships between his estimates and ours for different species. Study of his estimates would not lead one to distinguish soarers from non-soarers.

DISCUSSION

Factors affecting efficiency.—We believe efficiency was higher during high density flights primarily because the observer was more attentive at these times. It is impossible to maintain maximum alertness 8–10 h per day, week after week, and so observers tend to pace themselves, working most intensively when doing so produces the greatest increase in number of hawks detected. That, of course, is during the high density flights.

With high intensity effort, the observer can detect most (80–100%) of the soarers, even under poor viewing conditions. Non-soarers are harder to detect. Under good viewing conditions most (80+%) are detected, but under medium and poor conditions, the detection rate is 40–50%. Soarers are easier to detect because they remain in view for longer and tend to pass in groups or "kettles." If one individual of such a group is seen, the observer's attention is usually drawn to the rest of the members of the group.

During low density flights, the observer's level of effort is lower. Under good viewing conditions, about 50–75% of the birds are detected; under poor conditions fewer than 20% are recorded. The detection rates are slightly lower for non-soarers than soarers, presumably reflecting ease of detection.

Reliability of the counts.—In considering the reliability of counts used to monitor raptor populations, it is useful to distinguish 2 questions: does the proportion of migrants passing in view of the lookout remain fairly constant from year-to-year and does the observer record a constant proportion of the visible hawks. This study deals with only the second question; 3 issues merit consideration.

The first issue is whether there are any factors which would prevent the survey from detecting long-term population trends. One reason for conducting our study was the concern that as density increased observer efficiency might decrease due to "overloading." This would cause changes in density to be underestimated. In our study, efficiency did change with density—though in the opposite direction from what we expected—but a several-fold change in density was required before efficiency changed appreciably. Population trends rarely exceed 10% per year, and our results indicate that there would be no detectable change in efficiency over such small changes in density (Fig. 2).

We were also concerned that additional observers would affect the official observer's efficiency. If this were true, then an increase in attendance at hawk watching stations might alone be sufficient to produce a change in migration counts. Fortunately, little effect of the additional observers could be detected. The official observer attempted to eliminate the influences of others. If he had actively enlisted their aid in sighting hawks, there is little doubt that his count would have been strongly affected by the number of other observers present.

One other factor that might affect the survey's ability to detect long term trends deserves mention. The number of official observers is small enough that if a few of them were replaced by new observers differing in skill and attentiveness, there could be a severe effect on count totals. The cause of the change could presumably be detected, but it would complicate subsequent analysis of the data. Any steps taken to increase and standardize observer efficiency would help alleviate this problem.

The second issue concerning reliability of the counts arises when it is desirable to make tentative judgements about differences in counts based on only two years of data. The question that arises is, "What factors should be scrutinized most closely to determine whether they alone might have produced the sample difference?" If a single species is being studied (the usual case), then this investigation suggests that daily flight density is the most important factor to compare between years. Determining whether visibility conditions varied strongly between years may also be worthwhile, though the effect on efficiency will depend on whether the species in question is a soarer or non-soarer. This type of analysis, while hypothetical, is quite easy to carry out. Table 2 shows the impact of a hypothetical change in the frequency of 3 flight densities. In each year, 30,000 birds pass the lookout. In the first year 10,000 pass in medium-density flights and 18,000 in high-density flights. In the second year weather conditions are different causing 18,000 to pass in medium-density flights and 10,000 to pass in high-density. Using the detection rates from this study, it turns out that the change in weather would cause an increase in numbers reported of 12% despite the fact that the actual densities in each year are the same. This type of analysis indicates that changes of 10–15% might occur frequently solely in response to changes in weather or other factors that affect observer efficiency.

The third issue is how the counts might be made more reliable. As noted above, it is desirable that efficiency be as high and as constant as possible. This study revealed that observer fatigue is a major cause of variation in observer efficiency. There is little reason for counts to be made continuously. A sampling scheme could be devised under which all high-density, most medium-density, and only some low-density periods would be monitored. The scheme would require advance prediction of which category a given period would fall into, and the decision about whether to monitor the period would have to be determined under some random plan. Such a system might decrease the variation in efficiency by as much as 50% and could hardly help but improve the reliability of the survey.

SUMMARY

An observer at the Derby Hill hawk lookout in New York sampled small portions of the sky to determine what fraction of the visible raptors was counted by an official observer. The study showed that: (1) the proportion of raptors detected varied among species from approximately 40% to 80%; (2) soarers were detected at a higher rate than nonsoarers; (3) the intensity of effort exerted by the observer had a major influence on his efficiency and effort was greatest during high density flights; (4) visibility of the flight, which was determined mainly by its height, also affected efficiency; and (5) the number of other observers present had little influence on the official observer's efficiency. The evaluation provided reassurance that the raptor monitoring program should be able to detect long-term trends in abundance. When data from only a few years are being evaluated, the distribution of flight densities during the seasons and the frequency of days with poor viewing conditions should be compared. Consideration should be given to developing a sampling scheme under which the official observer would not have to survey continuously as the fatigue this causes sharply depresses efficiency. Throughout the study, we stress that observers do not, and cannot, detect all visible raptors, and that the counts should thus be viewed as sampling surveys not as censuses.

ACKNOWLEDGMENTS

We are indebted to Gerald Smith for cooperation and assistance in the field as well as for his many insights about hawk migration. The manuscript was reviewed by T. A. Bookhout, T. Grubb, J. Harder, J. Heinen, R. S. Kennedy, J. Ruos, S. Sheriff, and G. Smith. M. Grigore helped prepare the figures. We thank the Board of Managers of the Derby Hill Bird Observatory for providing lodging.

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