

# A Temporal Field Guide to Autumn Raptor Migration at Hawk Mountain Sanctuary, Pennsylvania

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Hawk Mountain Sanctuary was established in 1934 by conservationist Rosalie Edge to prevent the slaughter of hawks and eagles migrating along the Kittatinny Ridge in southern Schuylkill and northern Berks counties, eastern Pennsylvania. Each year, tens of thousands of raptors representing 16 species traverse the Sanctuary's rocky promontories en route to wintering areas as near as southern Pennsylvania, and as far away as Chile and Argentina in southern South America (Broun 1949, Brett and Nagy 1973, Brett 1991, Allen et al. 1995).

As a result of migration counts begun in 1934, the Sanctuary maintains the longest and most complete record of raptor migration in the world (Broun 1949, Brett 1991). The Sanctuary counted its millionth raptor on 8 October 1992 (Allen et al. 1995). Typically, one or two experienced counters record each day's flight. Counters use binoculars and, occasionally, telescopes to locate and identify passing migrants. Except when curtailed by rain, counts usually begin at 0800 EST and conclude at 1700, or later. In recent years, birds have been counted during approximately 880 hrs during 110 days between 15 August and 15 December (Viverette et al. 1996). Additional details regarding count procedures and the Sanctuary's database are in Bednarz et al. (1990) and Allen et al. (1996).

The Sanctuary's annual counts of migrating raptors have helped assess long-term trends in raptor populations throughout northeastern

North America (Bednarz et al. 1990). The Sanctuary's extensive raptor-migration database played a key role in exposing first-generation organochlorine pesticides, including DDT, as causative agents for precipitous declines in numbers of several species of birds of prey earlier this century (Carson 1962), as well as in their subsequent rebounds more recently (Bednarz et al. 1990). Sanctuary counts also have been used to address many questions regarding the migration ecology of raptors (cf. Allen et al. 1996, and Viverette et al. 1996).

In addition to its value in science and conservation, Hawk Mountain's long-term database also is of considerable interest to birdwatchers. A detailed analysis of the Sanctuary's migration database summarizing several temporal aspects of raptor migration at the site was published recently in *BIRDING* magazine (Allen et al. 1995). Earlier accounts of general aspects of raptor migration at the site include those of Sanctuary curators Maurice Broun (1948), Alex Nagy, and Jim Brett (1973, 1986, 1991). In each of the latter accounts, the timing of raptor migration at Hawk Mountain was depicted graphically, in one or more illustrations that have come to be known among migration aficionados as the "bubble" diagrams. Except in Brett and Nagy (1973), where the figure documents changes in the pulse of each species migration as a function of the changes in shading of a horizontal bar of fixed width (Brett and Nagy 1973), the diagram documents changes in migration intensity as a function of the width

of a horizontal line (Broun 1948; Brett 1986, 1991) over the course of autumn migration. The expanded line at the peak of each species migration period is what gives the bubble diagram its name.

All previous bubble diagrams, including those appearing in the Sanctuary's numerous brochures, appear to be based on general impressions of data collected to-date. Here, for the first time ever, we present bubble diagrams depicting the timing of raptor migration at the Sanctuary that are based on an actual analysis of the Sanctuary's migration database (Figure 1). Specifically, we present bubble diagrams for each of the Sanctuary's 16 species of regular migrants (the two eagle species are broken-down by age), in which the thickness of the bar is a function of the daily percentage of the total number of that species passing on that date. All of the diagrams are represented at the same scale. Thus, the areas of all species "bubbles" are the same, although the shape can differ substantially. The bubbles presented in Figure 1 were smoothed somewhat by taking 5-day running means of each species daily counts. All analysis were done on PC SAS (SAS Institute 1988), Microsoft Excel (Microsoft Corporation 1995), and Sigma Plot (Jandel Scientific 1994) software.

The resulting figures offer several insights into raptor migration at the Sanctuary. First, and foremost, they confirm that previous bubble diagrams were reasonable impressions of the Sanctuary's autumn raptor migration. Second, they suggest that

previous representations tended to flatten periods of peak migration for most species, making the migrations of these species appear to be more protracted and less punctuated than they actually are. Our analysis, for example, indicates that the middle 50% of all Broad-winged Hawks sighted at the Sanctuary passes within a 6-day period centered around 15-16 September, and that 50% of all Sharp-shinned Hawks sighted at the Sanctuary passed within a 13-day period centered around 7 October. Third, our results suggest that the current official count period of 15 August through 15 December fails to include the start of a significant autumn migration in Bald Eagles and American Kestrels. (Further evidence for this comes in the form of the first dates of appearance for these two species. Although the Sanctuary began officially counting raptors on a regular basis as early as 15 August only in the early 1960s, Bald Eagles and American Kestrels were first counted on this date in 8 and 14 years of autumn counts, respectively. Other species with 15 August appearances in 5 or more years, include Northern Harriers [7], Sharp-shinned Hawks [5], Broad-winged Hawks [17], and Red-tailed Hawks [9]).

As a whole, our observations indicate that, although some fine-tuning of the Sanctuary's bubble diagram is needed, general perceptions of the timing of raptor migration at Hawk Mountain Sanctuary have been correct for some time.

A thorough analysis of the Sanctuary's long-term database is currently underway. As additional information regarding raptor migration at the site becomes available, we plan to publish it in *Pa. Birds* and other ornithological

journals. In the interim, please stop by the Sanctuary's office for an update on our progress during your next visit.

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Figure 1. Timing of autumn migration of 16 species of diurnal raptors at Hawk Mountain Sanctuary, eastern Pennsylvania, based on observations made between 15 August and 15 December, 1934-1942 and 1946-1995 (see Allen 1996 for additional details regarding data collection). Data are presented as five-day running means of the daily percentages for each day. Percentages can be read directly from the mirror-image scale on either side of the x axis, without adding the two scales. Because all images are based on percentages of each species flight, rather than on actual numbers involved, all images have the same area.



