1999

# Fall 1998 Raptor Migrations Study in the Wellsville Mountains of Northern Utah

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# INTRODUCTION

The Wellsville Mountains raptor migration study in northern Utah is an ongoing effort to monitor long-term trends in populations of raptors using this northern Rocky Mountain migratory flyway. Raptors feed atop food pyramids, inhabit most ecosystems, occupy large home ranges, and are sensitive to environmental contamination and other human disturbances. Therefore, they serve as important biological indicators of ecosystem health (Cade et al. 1988; Bednarz et al. 1990a; Bildstein and Zalles 1995). For example, long-term migration counts in the eastern United States documented declines in several raptor species and helped us understand the deleterious effects of organochlorine pesticides (Spofford 1969, Mueller et al. 1988, Bednarz et al. 1990b). Migration counts, in particular, may also represent the most cost-effective and efficient method for monitoring the regional status and trends of multiple raptor species (Bednarz and Kerlinger 1989, Titus et al. 1989, Bildstein and Zalles 1995, Bildstein et al. 1995, Dunn and Hussell 1995, Dixon et al. 1998, Hoffman et al. in review).

Steve Hoffman and Wayne Potts discovered the Wellsville fall flyway in 1976 and conducted season-long counts from 1977 through 1979 (Hoffman and Potts 1985). The migration count was suspended from 1980 to 1986, then reestablished by HawkWatch International (HWI) in 1987. The 22-year span of this effort is a longer period than for any other similar monitoring project in the western United States. To date, 17 species of raptors have been observed migrating along the Wellsville flyway. Migrants concentrate along the Wellsville range to glide upon ridge updrafts created by consistent southwest winds.

The primary objective of HWI migration studies is to document long-term trends in raptor populations that migrate through western North America. Additional objectives include the following:

1) Document seasonal flight patterns and determine the species, age, and sex composition of migrating raptors.
2) Evaluate how weather affects the visible migratory flights.
3) Compare data collected at the Wellsville site with data collected at other North American migration monitoring sites.
4) Educate the public about the conservation needs of raptor species, their ecological roles in healthy ecosystems, and their value as biological indicators.

This report summarizes the fall 1998 observation season at the Wellsville lookout. The 1998 season marked the 12th consecutive and 15th overall standardized full-season count of migratory raptors at the site. We report on aspects of seasonal and daily timing, passage rates, and the species, age, sex, and color-morph composition of the flight. We also compare statistics from 1998 with means for previous years and discuss long-term trends in annual passage rates.

# STUDY SITE

The Wellsville Mountains are situated northeast of the Great Salt Lake, 16 km west of Logan, Utah (41°25' N, 122°02' W; Fig. 1). The single observation point is located at 2,637 m (8,650 ft) near the northern end of the Wellsville range (Fig. 2) and provides a panoramic view in all directions. The lookout is reached by a 5.6 km (3.5 mi) hike up Deep Canyon Trail and then another 1 km (0.6 mi) hike to the north along the ridgetop. The trailhead begins just west of Mendon at the end of 300 North Street.

The Wellsvilles are an exceptionally steep, isolated ridge oriented in a north-south direction. Agriculture is the dominant land use in the expansive valleys below. The Great Salt Lake lies 31 km to the southwest. The predominant vegetation on the slopes of the ridge are subalpine fir (*Abies lasiocarpa*), quaking aspen (*Populus tremuloides*), Douglas-fir (*Pseudotsuga menziesii*), bigtooth maple (*Acer grandidentatum*), Rocky Mountain maple (*Acer glabrum*), and Sitka Mountain-ash (*Sorbus sitchensis*). The ridgetop supports few trees; primary vegetation along the ridgetop includes grasses and sagebrush (*Artemisia tridentata*). Consequently, the lookout affords exceptional unobstructed views in all directions.

Many factors make the Wellsville lookout ideal for observing consistent fall flights of migrating raptors. Several ridges to the north serve as "leading lines" (Mueller and Berger 1967), funneling migrating raptors into the Wellsvilles (Fig. 1). In addition, the Great Salt Lake and Great Salt Desert probably serve as barriers to migration. Most species of raptors probably prefer not to fly over this large expanse of water and inhospitable habitat (Kerlinger 1989) and therefore divert their migratory flight around either side of the Bonneville Basin (Hoffman 1985). The Wellsville range is the first ridge northeast of the lake. Migrating raptors find consistent updrafts along steep slopes such as those in the Wellsvilles because ridges deflect winds upward. These updrafts, combined with rising thermals, provide lift that the raptors use to reduce the need for powered flight. By reducing the amount of flapping flight, birds may migrate great distances while minimizing energetic output (Haugh 1972).

# METHODS

Two official observers, David Tidhar and Wendy Peacock, conducted standardized daily counts of migrating raptors from a single, traditional observation site for an average of 6.6 hours per day on 54 days between 23 August and 25 October 1998. Neither observer had previous experience counting migrating hawks, however, both received extensive training at the HWI Goshute site prior to the beginning of the 1998 season (see Appendix B for a complete history of observer participation). Visitors occasionally assisted with spotting migrants (see Smith and Hoffman [in review] for a discussion of visitor effects).

The observers routinely recorded the following data:

1. Species, age, sex, and color morph of each migrant raptor, whenever possible and applicable (Appendix A lists common and scientific names for all species, information about the applicability of age, sex, and color morph distinctions, and two-letter codes used to identify species in some tables and figures).
2. Hour of passage for each migrant; e.g., the 1000 hour, always using Mountain Standard Time.
3. Wind speed and direction, air temperature, percent cloud cover, predominant cloud type(s), precipitation, visibility, and an assessment of thermal lift conditions, recorded for each hour of observation on the half hour.
4. Predominant direction, altitude, and distance from the lookout of the flight during each hour.
5. Total minutes observed and mean number of observers (official observers plus other visitors who actively scanned for migrants) and visitors present during each hour.
6. Daily start and end times for each official or experienced observer.

The observers used high quality 8x and 10x binoculars to assist in spotting and identifying birds. Clark and Wheeler (1987), Dunne et al. (1988), and Wheeler and Clark (1995) served as primary identification references. Assessments of wind speed, cloud type, cloud cover, and flight altitude followed guidelines published by the Hawk Migration Association of North America (HMANA). Assessments of thermal lift conditions as poor, fair, good, or excellent involved subjective evaluations of solar intensity, wind speed, and migrant behavior.

For purposes of examining long-term variation in annual counts, we manipulated the count data to standardize sampling periods and adjust for daily variation in observation effort and observer numbers. The seasonal and daily duration of observation effort can greatly affect count statistics (Hussell 1985, Kerlinger 1989, Bednarz et al. 1990b), and both varied considerably in the Wellsvilles during the first several years of observations. To standardize daily sampling effort, we eliminated counts collected outside the period 1000–1559 hrs Mountain Standard Time (MST). To standardize seasonal sampling effort, we defined a consistent annual sample period following conventions proposed by Bednarz and Kerlinger (1989) and Bednarz et al. (1990b). Specifically, we converted counts to passage rates on a daily basis (raptors/10 hours of observation), summed daily rates by Julian date across all years, and defined standardized passage periods for each species by eliminating approximately 2.5% from each extreme of the cumulative passage-rate distributions. Because entire count days must be either included or excluded, the defined sample period for a given species included between 95–100% of the detected number of migrants. For some species, the sample periods defined in this way encompassed dates earlier or later than periods of continuous observations. In these cases, we further restricted the adjusted sample periods to between mean starting and ending dates of continuous observations: 27 August – 21 October. The final standardized sample periods for each species are shown in Table 1.

Smith and Hoffman (in review) recently demonstrated that passage rates documented at this site through 1997 increased significantly when the daily-average number of observers increased to 2 or more (observers included official, designated counters plus guests that actively participated for more than 10 minutes in a given hour). Before 1991, a single official observer conducted all counts; thereafter, a standard system of 2 official observers was implemented. Guest observers have participated in the counts throughout the study. Smith and Hoffman (in review) provided correction factors to adjust daily counts to standardize for a 2-observer system. We applied the recommended correction factors before examining patterns in the data.

After standardizing sample periods and adjusting daily counts for observer numbers, we calculated annual passage rates (total raptors counted / total hours of observation for a given year * 100 = raptors/100 hrs) for each species. Using passage rates rather than counts as the index of interest avoids potential biases caused by variation in sampling effort due to inclement weather and other unforeseeable events.

Hoffman et al. (in review) recently completed a comprehensive analysis of long-term trends in counts from four HWI migration sites, including the Wellsvilles. We do not repeat the results of these analyses in detail here, but we do cite specific results to provide context for consideration of 1998 observations. For the Wellsvilles, the analyses included 2 basic components: *t*-tests comparing mean annual passage rates for 1977–1979 and 1981–1997, and linear regressions examining trends in annual passage rates between 1987 and 1997. In this context, we refer to results as highly statistically significant ($P \leq 0.01$), significant ($0.01 < P \leq 0.05$), marginally significant ($0.05 < P \leq 0.10$) or not significant ($P > 0.10$).

We also compare 1998 annual statistics (i.e., passage rates, passage dates, age ratios, sex ratios, and color-morph ratios) against means and 95% confidence intervals for previous seasons. Here, we equate significance with a 1998 value falling outside of the 95% confidence interval for the associated mean. Most comparisons of age, sex, and color morph statistics are limited to 1998 versus means for 1992–1997, because older class data are not yet fully computerized.

# RESULTS

## WEATHER

In 1998, several monsoon weather systems and cold fronts passed over the Wellsville Mountains during the fall migration season. Inclement weather prevented observations on 10 days (5 days each in September and October), and rain or snow impaired visibility on 13 other days (9 days in September, 4 days in October; see Appendix C for daily weather summaries). Rain canceled 5 days of observation during September and impaired an additional 9 days. Precipitation canceled 5 days of observation in October and impaired another 4 days. Overall, weather limited observations on 41% of the possible count days. Strong winds (>20kph) prevailed on less than 1% of the observation days, reflecting typical light-wind conditions for the site.

## OBSERVATION EFFORT

This season's 53 observation days is only 1% higher than the 1977–1997 average of 52 ± 95% CI of 4.1 days. Similarly, this season's 358.75 observation hours is only 3% higher than the long-term average of 348.02 ± 32.290 hours. Accordingly, this season's daily average observation effort of 6.77 hours per day is only 1.5% higher than the long-term average of 6.67 ± 0.409 hours/day. The 1998 average of 1.9 observers per hour (includes official and guest observers; value is mean of daily values, which are in turn means of hourly values) matches the 1977–1997 mean of 1.9 ± 0.32. This means that the degree to which we adjusted the 1998 raw counts was average.

## FLIGHT SUMMARY

The observers tallied 4,069 migrant raptors of 16 species during 358.75 hours on 54 days between 23 August and 25 October (Table 2; see Appendix D for 1998 unadjusted daily count records and Appendix E for unadjusted count summaries by species for each year of the project). The hours of observation were 3% higher than average and the days of observation were 1% higher than average, with neither difference significant. The adjusted combined-species count of 3,743 is 6% lower than average, but the difference is not significant (Table 2). In contrast, the adjusted annual passage rate of 1,831 raptors / 100 hrs is significantly higher (34%) than average (Table 2), which reverses a 3-year decline in this statistic (Fig. 3).

The season's tally included no new species and the Bald Eagle, which is seen in most years, was absent from the count (Appendix E). The most numerous species were Sharp-shinned Hawks (25% of the total count), American Kestrels (18%), Red-tailed Hawks (15%), Cooper's Hawks (14%), and Northern Harriers (11%). Based on adjusted numbers, the flight was comprised of 44% accipiters, 21% buteos, 19% falcons, 10% Northern Harriers, 4% eagles, 1% Ospreys, <1% Turkey Vultures, and <1% unidentified raptors (Fig. 4). Eagles and falcons were less abundant than usual, whereas buteos and harriers were more abundant than usual. Unadjusted counts of Northern Harriers (443) and Peregrine Falcons (19) reached record highs (Appendix E). Based on adjusted numbers, 4 species showed significantly higher than average counts, 7 species showed significantly lower than average counts, and 6 species showed counts that fell within the bounds of 95% confidence intervals for the long-term means (Table 2). However, adjusted passage rates revealed a different picture: 10 species showed significantly higher than average rates, 2 species showed significantly lower than average rates, and 4 species showed average rates (Table 2).

For 10 species with routinely distinguishable age classes, adjusted immature : adult ratios were 2–164% higher than average for 6 species (significantly higher for 4 species), 32–100% lower than average for 3 species (no significant differences), and no comparison was possible for Bald Eagles (Table 3). Unusually low or high proportions of unknown-age birds may confound 4 of the 9 possible comparisons. Adjusted female : male ratios were 16% lower than average for American Kestrels and 60% higher than average for Northern Harriers (Table 4). Unusually high proportions of unknown-sex birds may confound both comparisons.

The 1998 combined-species daily flight rhythm was similar to the long-term average pattern, with activity increasing steadily from 0900 hrs until reaching a peak during the 1300 hour, then declining steadily through the remainder of the day (Fig. 5).

The 1998 combined-species median passage date of 23 September matches the long-term mean (Table 5); however, the seasonal activity pattern showed two distinct delays of about 5 days during mid-September and early October (Fig. 6). Peak activity occurred between 13 September and 9 October in 1998, with more than 100 birds counted on 15 of those 23 days. Counts exceeded 200 birds on 4 days: 14 September (224 birds, 26.4 birds/hr), 18 September (203 birds, 22.6 birds/hr), 28 September (225 birds, birds/hr), and 2 October (220 birds, 29.3 birds/hr) (Appendix D). Among the 14 species with comparative data, 3 species showed significantly earlier than average median passage dates, 2 species showed significantly later than average median dates, and 9 species showed average median dates (Table 5). However, age- and sex-specific median dates revealed additional variation. All of 5 species with sufficient data showed significantly later than average median passage dates for adults (Table 6), but sex-specific data for adult Northern Harriers revealed that this was true only for adult males (Table 7). In contrast, only 2 of 6 species showed significantly later than average dates for immatures (only marginally later for Cooper's Hawks); the remainder showed average dates (Table 6). American Kestrels also showed average dates for both females and males (Table 7).

## SPECIES ACCOUNTS

The observers counted 17 **Turkey Vultures** during 7 days of observation between 31 August and 23 September (Table 5, Appendix E). The 1998 adjusted count of 16 birds and adjusted passage rate of 10.9 raptors/100 hrs are 12% and 68% higher than average, respectively, but the difference is significant only for passage rates (Table 2). The *t*-test analysis of adjusted annual passage rates indicated a marginally significant increase between 1977–1979 and 1987–1997, and the 1987–1997 regression also indicated a marginally significant increasing trend. The 1998 adjusted passage rate extends an oscillating pattern that has occurred since 1989, and in so doing also extends the increasing trend (Fig. 7). The 1998 median passage date of 4 September is 14 days earlier than average, which is a highly significant difference (Table 5) that is clearly illustrated in a plot of seasonal activity (Fig. 8).

The observers counted 39 **Ospreys** during 15 days between 6 September and 2 October (Table 5, Appendix E). The adjusted count of 38 birds and adjusted passage rate of 28 raptors/100 hrs are both significantly higher than average (58% and 139% higher, respectively; Table 2). The 1987–1997 mean annual passage rate was significantly higher than the 1977–1979 mean, and the 1987–1997 regression indicated a marginally significant increasing trend. The 1998 adjusted passage rate accelerates the increasing trend (Fig. 7). The median passage date of 16 September is 2 days later than average, but the difference is not significant (Table 5). However, the seasonal activity pattern differed from the long-term average pattern in being constrained to between early September and early October (Fig. 8).

The observers counted a record high 443 **Northern Harriers** during 50 days between 23 August and 25 October (Table 5, Appendix E). This was the fifth most common species, comprising 11% of the total unadjusted count. The adjusted count of 383 birds and adjusted passage rate of 187 raptors/100 hrs are both significantly higher than average (56% and 124% higher, respectively; Table 2). The mean annual passage rates for 1977–1979 and 1987–1997 did not differ significantly, and the 1987–1997 regression also indicated no trend. The high 1998 adjusted passage rate reverses a 3-year decline in this statistic, but does not establish a distinct increasing trend (Fig. 7). Based on adjusted numbers, the 1998 flight consisted of 5% adult males, 6% adult females, 62% immatures, and 23% unidentifiable brown birds (indistinguishable immatures or adult females), and 5% birds of unknown age or sex. The adjusted immature : adult ratio of 6.9 is significantly higher than average (164% higher; Table 3). The adult female : adult male ratio of 1.4 also is significantly higher than average (60% higher; Table 4). The 1998 median passage date for the species of 24 September is only 1 day earlier than average (Table 5). The 1998 seasonal activity pattern also is similar to the average pattern, except for showing atypical concentration of activity during 3 periods: 11–15 September, 21–30 September, and 6–10 October (Fig. 8). The largest single-day count of 33 harriers occurred on 28 September (Appendix D). Age- and sex-specific median passage dates provide additional insight. Adult males were significantly later than average (10 days), whereas adult females were only 1 day later than average and the 1998 median date for immatures exactly matched the long-term mean (Tables 6 and 7). Within 1998, immatures were 3 days earlier than adult females, and adult females were 5 days earlier than adult males (Tables 6 and 7).

The observers counted 1,005 **Sharp-shinned Hawks** during 51 days between 24 August and 25 October (Table 5, Appendix E). This was the most common species, comprising 25% of the total unadjusted count. The adjusted count of 995 birds is 4% lower than average, but the difference is not significant (Table 2). In contrast, the 1998 adjusted passage rate of 495 raptors/100 hrs is significantly higher than average (40% higher; Table 2). The mean annual passage rates for 1977–1979 and 1987–1997 did not differ significantly; however, the 1987–1997 regression indicated a significant decreasing trend. The high 1998 adjusted passage rate counters the apparent decreasing trend and supports the conclusion of no long-term trend. Based on adjusted numbers, the 1998 flight consisted of 24% adults, 42% immatures, and 34% birds of unknown age. The adjusted immature : adult ratio of 1.8 is significantly higher than average (57% higher); however, a higher than average proportion of unknown-age birds may confound this comparison (Table 3, Fig. 10). The 1998 median passage date for the species of 27 September is only 2 days later than average (Table 5); however, age-specific dates indicated that both adults and immatures were significantly later than average (both 8 days later; Table 6). Within 1998, immatures preceded adults by 14 days (Table 6). The 1998 seasonal activity pattern for the species is similar to the average pattern, except for showing an unusually large peak in activity during 6–10 October (Fig. 11).

The observers counted 587 **Cooper's Hawks** during 50 days between 23 August and 24 October (Table 5, Appendix E). This was the fourth most common species, comprising 14% of the total unadjusted count. The adjusted count of 600 birds is 4% lower than average, but the difference is not significant (Table 2). In contrast, the 1998 adjusted passage rate of 298 raptors/100 hrs is significantly higher than average (38% higher; Table 2). The mean annual passage rates for 1977–1979 and 1987–1997 did not differ significantly, and the 1987–1997 regression also indicated no trend. The 1998 adjusted passage rate does not alter this conclusion (Fig. 9). Based on adjusted numbers, the 1998 flight consisted of 17% adults, 48% immatures, and 35% birds of unknown age. The adjusted immature : adult ratio of 2.8 is significantly higher than average (153% higher); again however, a higher than average proportion of unknown-age birds may confound this comparison (Table 3, Fig. 10). The 1998 median passage date for the species of 24 September is only 1 day later than average (Table 5); age-specific dates indicated that both adults and immatures were significantly later than average (7 and 6 days later, respectively; Table 6). Within 1998, immatures preceded adults by 12 days (Table 6). The 1998 seasonal activity pattern for the species is similar to the average pattern (Fig. 11).

The observers counted 14 **Northern Goshawks** during 11 days between 3 September and 17 October (Table 5, Appendix E). This is second lowest count recorded during the project for this species (Appendix E). The adjusted count of 14 birds is significantly lower than average (42% lower) and the adjusted passage rate of 6.8 raptors/100 hrs is 20% lower than average, but the difference is not significant (Table 2). A drop in the mean annual passage rate between 1977–1979 and 1987–1997 was highly significant, reflecting primarily a drop in detections of immature hawks, but the 1987–1997 species-level regression indicated no trend. The 1998 adjusted passage rate extends the recent pattern of no trend (Fig. 9). Based on adjusted numbers, the 1998 flight consisted of 7% adults, 43% immatures, and 50% birds of unknown age. The immature : adult ratio of 6.0 is nearly identical to the long-term average; again however, a higher than average proportion of unknown-age birds may confound this comparison (Table 3, Fig. 10). The 1998 median passage date for the species of 2 October is 3 days later than average, but the difference is not significant (Table 5) and the 1998 seasonal activity pattern is similar to the average pattern (Fig. 11). The 1998 median passage date for immatures of 29 September matches the long-term average; too few adults were counted in 1998 to calculate a meaningful median passage date (Table 6).

The observers counted 1 adult, light-morph **Broad-winged Hawk** on 24 September (Table 5, Appendix E). This is the second lowest count recorded during the project for this species (Appendix E). The adjusted count of 1 bird and adjusted passage rate of 1.1 raptors/100 hrs are both significantly lower than average (72% and 58% lower, respectively; Table 2). An increase in the mean annual passage rate between 1977–1979 and 1987–1997 was highly significant, but the 1987–1997 regression indicated no trend. Although low, the 1998 count maintains the recent pattern of high annual variability but no overall trend (Fig. 12).

The observers counted 309 **Swainson's Hawks** during 23 days between 28 August and 2 October (Table 5, Appendix E). The adjusted count of 261 birds and adjusted passage rate of 197 raptors/100 hrs are both significantly higher than average (87% and 176% higher, respectively; Table 2). An increase in the mean annual passage rate between 1977–1979 and 1987–1997 was highly significant, and the 1987–1997 regression indicated a marginally significant increasing trend. High annual variability has been the rule. The high 1998 passage rate follows a low rate in 1997, and supports the conclusion of an unsteady increasing trend. Based on unadjusted numbers, the 1998 flight consisted of 56% light-morph birds, 17% dark morphs, and 28% birds of unknown color morph. The light : dark morph ratio of 3.4 is 30% lower than average, but the difference is not significant (Table 8). The 1998 median passage date of 14 September is 2 days earlier than average, but the difference is not significant (Table 5). However, the 1998 seasonal activity pattern shows an unusual concentration of activity during the 11–15 September 5-day period (Fig. 14). The observers tallied 72 Swainson's Hawks on 13 September and a kettle of 18 the following day.

The observers counted 609 **Red-tailed Hawks** during 49 days between 23 August and 24 October (Table 5, Appendix E). This was the third most common species, comprising 15% of the unadjusted total count. The adjusted count of 488 birds is 5% lower than average, but the difference is not significant (Table 2). In contrast, the adjusted passage rate of 239 raptors/100 hrs is significantly higher than average (37% higher; Table 2). An increase in the mean annual passage rate between 1977–1979 and 1987–1997 was highly significant, but the 1987–1997 regression indicated no trend. Addition of the high 1998 adjusted passage rate suggests a possible increasing trend (Fig. 13). Based on adjusted numbers, the 1998 flight consisted of 43% adults, 46% immatures, and 11% birds of unknown age. The adjusted immature : adult ratio of 1.1 is significantly higher than average (77% higher; Table 3, Fig. 15). Based on unadjusted numbers, the flight consisted of 71% light morphs, 10% dark morphs, and 19% birds of unknown color morph. The light : dark ratio of 6.9 is 4% lower than average, but the difference is not significant (Table 8). The 1998 median passage date for the species of 20 September is 3 days earlier than average and falls just outside of the 95% confidence interval for the long-term mean (Table 5). Age-specific median dates indicated that adults were 3 days later than average and immatures were 2 days later than average, but the difference is significant only for adults (Table 6). Within 1998, immatures preceded adults by 11 days. The 1998 seasonal activity pattern showed lower than average activity during 6–10 September and 26 September through 5 October, and higher than average activity during 11–25 September (Fig. 14). Migrating immature Red-tailed Hawks frequently soared or were chased by resident adult Red-tailed Hawks.

The observers counted 14 **Ferruginous Hawks** during 11 days between 26 August and 24 October (Table 5, Appendix E). The adjusted count of 12 birds and adjusted passage rate of 5.6 raptors/100 hrs are 21% and 76% higher than average, respectively, but the difference is significant only for passage rates (Table 2). An increase in the mean annual passage rate between 1977–1979 and 1987–1997 was highly significant, but the 1987–1997 regression indicated no trend. The 1998 adjusted passage rate reverses a 3-year decline and reestablishes a possible increasing trend (Fig. 12). Based on unadjusted numbers, the 1998 flight consisted of 4 light-morph immatures, 4 light-morph adults, and 6 unknown-age light-morphs. The adjusted immature : adult ratio of 0.9 is 55% higher than average, but the difference is not significant owing to small annual counts (Table 3). The light : dark morph ratio of 14 is significantly higher than average (102% higher; Table 8). The median passage date for the species of 24 September is only 1 day later than average (Table 5). The overall extent of seasonal activity in 1998 is similar to the average pattern, but activity is more concentrated during select periods than usual (Fig. 14).

The observers counted 1 dark-morph **Rough-legged Hawk** on 15 September (Table 5, Appendix E). The adjusted count of 1 bird and adjusted passage rate of 0.4 raptors/100 hrs are 45% and 23% lower than average, respectively; however, the difference is not significant for passage rates and is only marginally significant for counts (Table 2, Fig. 12). No long-term trend analyses were conducted for this species because of consistently low annual counts.

The observers counted 154 **Golden Eagles** during 43 days between 25 August and 24 October (Table 5, Appendix E). The adjusted count of 137 birds is significantly lower than average (27% lower), whereas the adjusted passage rate of 67 raptors/100 hrs is 1% higher than average (Table 2). The mean annual passage rate decreased significantly between 1977–1979 and 1987–1997, but the 1987–1997 species-level regression indicated no trend and the 1998 passage rate does not clearly alter this conclusion (Fig. 16). Age-specific analyses revealed that the decline in passage rates between the late 1970s and late 1980s was entirely attributable to a decline in detections of immature/subadult birds. In addition, although immatures/subadults showed no trend for 1987–1997, adults showed a significant increasing trend. The 1998 adult and immature/subadult adjusted passage rates do not alter these conclusions (Fig. 16). Based on adjusted numbers, the 1998 flight consisted of 41% adults, 49% immatures and subadults, and 10% birds of unknown age. The immature/subadult : adult ratio of 1.2 is 36% lower than average, but the difference is not significant (Table 3, Fig. 17). The 1998 median passage date for the species of 2 October is only 1 day later than average (Table 5); however, age-specific median dates showed that adults were significantly later than average (7 days later), whereas immature/subadults were only 1 day later than average (Fig. 18). Within 1998, immatures/subadults preceded adults by 4 days (Table 6).

The observers counted no **Bald Eagles** this season, compared to a long-term average count of 5 birds. Another zero count occurred in 1989, but based on adjusted numbers a zero count and a zero passage rate both fall below the 95% confidence interval for the respective long-term means. The 1987–1997 regression and comparison of 1977–1979 and 1987–1997 mean annual passage rates showed no trends. The low 1998 adjusted passage rate appears to emphasize a possible declining trend (Fig. 19); however, low annual counts, high annual variability, and incomplete coverage of this late-season migrant all preclude attaching much significance to these results.

The observers counted 727 **American Kestrels** during 46 days between 23 August and 24 October (Table 5, Appendix E). This was the second most common species, comprising 18% of the total unadjusted count. The adjusted annual of 672 birds and adjusted passage rate of 355 raptors/100 hrs are 35% and 5% lower than average, but the difference is significant only for the counts (Table 2). The mean annual passage rates for 1977–1979 and 1987–1997 did not differ significantly; however, the 1987–1997 regression indicated a significant declining trend. The 1998 adjusted passage rate lessens but does not eliminate evidence of a possible declining trend (Fig. 20). Based on adjusted numbers, the 1998 flight consisted of 35% males, 26% females, and 39% birds of unknown sex. The female : male ratio of 0.75 is 16% lower than average, but the difference is at best marginally significant (Table 3). The 1998 median passage date for the species of 19 September is only 1 day earlier than average (Table 5). Sex-specific median dates showed average timing for both sexes of adults (Table 7). Within 1998, adult females preceded adult males by 9 days. The 1998 species-level, seasonal activity pattern is similar to the average pattern (Fig. 21). The largest single-day count of 66 kestrels occurred on 18 September; however, numbers declined sharply after the beginning of October.

The observers counted 11 **Merlins** during 8 days between 14 September and 13 October (Table 5, Appendix E). The adjusted count of 11 birds and adjusted passage rate of 5.5 raptors/100 hrs are 9% and 63% higher than the long-term means, but only the passage rate difference is significant (Table 2). The mean annual passage rate increased significantly between 1977–1979 and 1987–1997, but the 1987–1997 regression indicated no trend. The 1998 adjusted passage rate does not alter this conclusion (Fig. 20). Based on adjusted numbers, the 1998 flight consisted of 18% adult males, 18% brown birds (indistinguishable adult females or immatures of unknown sex), and 64% birds of unknown age and sex. The 1998 median passage date for the species of 6 October is significantly later than average (8 days later; Table 5). The 1998 seasonal activity pattern conforms to the average pattern except for showing an unusually large concentration of activity during 6–10 October (Fig. 21).

The observers counted 13 **Prairie Falcons** during 9 days between 23 August and 13 October (Table 5, Appendix E). The adjusted count of 8 birds and adjusted passage rate of 3.9 raptors/100 hrs are 40% and 17% lower than average, but only the count difference is significant (Table 2). The 1987–1997 regression and comparison of 1977–1979 and 1987–1997 mean annual passage rates showed no trends. The 1998 adjusted passage rate does not alter this conclusion (Fig. 22). The 1998 median passage date for the species of 2 October is significantly later than average (11 days later; Table 5). The 1998 seasonal activity pattern differs from the average pattern in showing greater concentration of activity, especially during the first five days of September and October (Fig. 23).

The observers counted a record high 19 **Peregrine Falcons** during 15 days between 29 August and 17 October (Table 5, Appendix E). The adjusted count of 17 birds and adjusted passage rate of 8.7 raptors/100 hrs are both significantly higher than average (222% and 392% higher, respectively; Table 2). An increase in the mean annual passage rate between 1977–1979 and 1987–1997 was highly significant, but the 1987–1997 regression indicated no trend. The high 1998 adjusted passage rate stands in stark contrast against the relatively constant rates of the previous 11 years (Fig. 22). Based on adjusted numbers, the 1998 flight consisted of 24% adults, 18% immatures, and 59% birds of unknown age. The adjusted immature : adult ratio of 0.8 is 27% lower than average, but the difference is not significant (Table 3, Fig. 24). The 1998 median passage date for the species of 9 September is significantly earlier than average (6 days earlier; Table 5). The 1998 seasonal activity pattern is similar to the average pattern except for showing an unusually large concentration of activity during 6–10 October (Fig. 23). The observers frequently saw a resident immature peregrine harassing and escorting migrating peregrines and other raptors through the area. They also saw a group of 3 peregrines migrating during a thunderstorm on 9 September.

In addition to identified migrants, the observers recorded 106 migrants (3% of the total count) that they could not identify to species (Appendix E). This group included 55 unidentified accipiters, 19 unidentified buteos, 2 unidentified falcons, and 30 unidentified raptors.

## RESIDENT AND NORTHBOUND RAPTORS

Migrant raptors tend to have a direct flight pattern. Therefore, the observers typically classified all birds observed perching, hunting, or performing territorial displays as residents and excluded them from the count. A consistent number of resident individuals have been present throughout the 14-year study. This season, residents included 1 immature and 1 pair of adult Golden Eagles, 2 immatures and 1 pair of adult Red-tailed Hawks, 2 male and 2 female American Kestrels, 1 adult Cooper's Hawk, 1 immature

Peregrine Falcon, and 1 immature and 1 adult female Northern Harrier. The adult Red-tailed Hawks, the immature Northern Harrier, and the adult Golden Eagles were present throughout the entire observation period.

The observers recorded as northbound migrants all raptors seen heading north past the Wellsville lookout that did not appear to stop or change direction while in view. We assume that northbound birds were dispersing juveniles or non-migratory adults searching for more productive wintering grounds in the local region (i.e., within 100 km of their usual territory). This season, the observers classified 3 raptors as northbound migrants: 1 Turkey Vulture, 1 dark-morph Swainson's Hawk, and 1 unknown-age, light-morph Ferruginous Hawk.

# DISCUSSION

## WEATHER

The timing and magnitude of raptor migrations may vary from year to year depending on the availability and abundance of prey species (Newton 1979). Local and regional weather patterns also influence the number of migrants observed passing a monitoring site, but analysts commonly assume that the effects of weather on migration counts are random from year to year (Fuller and Mosher 1981, Bednarz et al. 1990b, Hoffman et al. in review). We believe, however, that weather systems contributed to drastic surges in the 1998 migration count. Conversely, we believe that weather patterns during the final weeks of observation contributed to a declining count.

Several studies have examined the relationships among weather variables and raptor migration (Kerlinger 1989, Hall et al. 1992, Allen et al. 1996, Niles et al. 1996, Maransky et al. 1997). Weather can effect the number of birds counted by restricting raptor movements during inclement conditions, by producing low clouds or fog that reduce visibility for observers, or by producing wind or thermal patterns that effect migrant flight paths and travel speeds. Wind direction clearly plays a significant role in migration counts conducted on ridgetops. Strong northeasterly and easterly winds resulted in poor counts this season. Such winds predominated during the last week of observation and counts were consistently low. In contrast, when southwest winds predominated, the flight was close to the ridge and numbers were often high. For example, on the morning of 18 September, a south wind prevailed and the passage rate was low; however, when the wind shifted to the southwest in the late-morning, the passage rate increased from 7 birds per hour to 50 birds per hour, resulting in one of the highest daily counts of the season (203 birds).

Peak flights often occurred immediately following passage of a cold front. For example, on 11 September the tally included only 51 birds. A storm system then developed and suspended the count until 13 September when the tally increased to 157 birds. High flight activity continued until another front passed through between 19 and 21 September, and resumed on 22 September once the storm had passed.

## DAILY FLIGHT RHYTHM

Several factors determine what time of day a particular species chooses to migrate. Feeding behavior and wing-loading are probably most important (Mueller 1973; Hoffman 1985; Kerlinger 1985, 1989); however, topography and weather also influence daily timing. Species with lighter wing-loading, such as harriers and accipiters, often begin migrating earlier in the day than species with heavier wing-loading, such as buteos and eagles. This is a result of the latter species reliance on strong thermals and ridge updrafts to facilitate soaring and gliding migratory flight. Lift-generating thermals and updrafts are driven primarily by solar heating from the sun, and therefore usually do not occur until later in the day.

Falcons, especially American Kestrels are a notable exception to this relationship between wing-loading and daily flight timing (Hoffman 1985). They have light to moderate wing loading, but often do not begin migrating until later in the day. Lighter wing-loading facilitates the typically high-powered and maneuverable flight style of falcons, and most species use primarily powered flight during migration. Most migratory falcons are therefore less constrained by the availability of favorable lift, wind, or weather conditions and are able to rapidly move long distances through a variety of climatic and surface conditions (Kerlinger 1989). The delay in migratory passage until later in the day may result from a strategy of hunting early in the day and then rapidly moving south in the afternoon.

Therefore, the daily flight rhythm in the Wellsvilles this season followed an expected pattern. Accipiters and harriers began moving early in the morning. Activity increased sharply as the day warmed up and buteos, eagles, and falcons joined the flight. Activity then decreased steadily through the afternoon; however, late-flying American Kestrels and Sharp-shinned Hawks using powered flight frequently passed through during early evening.

### SEASONAL TIMING

All 5 species with sufficient age-specific data showed median dates for adults that were significantly later than average, whereas immatures more typically showed average dates. At the species level, Merlins and Prairie Falcons also showed later than average median passage dates. The pattern of late adults but immatures on an average schedule also occurred at several other HWI sites during fall 1998 (e.g., Neal 1999, Lanzone 1999, Rossman 1999). We speculate that favorable winter/spring weather followed by mild fall weather combined to enable prolonged, high prey productivity over vast areas of temperate, western North America. In turn, these conditions enabled high raptor nesting success and delayed onset of migration among adults (especially males) reluctant to abandon high quality, productive nesting territories. In contrast, when growth rates and health are high because of high prey availability, recent fledglings probably depart on average, sometimes early, schedules because of competitive displacement by tenacious adults and instinct acting more strongly to motivate immatures to migrate as soon as they are physiologically ready.

Species with distinguishable age or sex classes followed typical patterns of immatures moving through before adults and females moving through before males (Kerlinger 1989).

### FLIGHT COMPOSITION, PASSAGE RATES AND LONG-TERM TRENDS

Evidence of increasing passage rates for **Turkey Vultures** and **Ospreys** mirrors similar increasing trends evident at other HWI migration sites and elsewhere in western North America (Hoffman et al. in review). Ospreys were negatively impacted by heavy use of organochlorine pesticides in the 1950s and 1960s; however, subsequent banning of DDT for agricultural use allowed populations of these species to rebound in many areas (Henny and Anthony 1989). Increasing availability of artificial nesting platforms and artificial reservoirs also has helped increase the breeding range and nesting densities of Ospreys (Swenson 1981, Henny 1983, Henny and Kaiser 1995). Long-term increases in the number of Turkey Vultures may reflect northward expansion of the species' range in response to global warming (Kiff in press) and general increases in population density in response to greater availability of carrion on roadways, around domestic livestock operations, and in other human-altered environments (Wilbur 1983, Hoffman et al. in review).

Most HWI sites in western North America showed record or near-record high counts and high immature : adult ratios for **Northern Harriers** in 1998 (e.g., Lanzone 1999, Neal 1999, Rossman 1999). This suggests that 1998 nesting success and juvenile recruitment were high across a broad area of western North America. We speculate that favorable spring/summer weather resulted in high productivity among small open-country rodents, which are the mainstay of harrier diets, and produced especially healthy ground vegetation, which harriers rely on for concealing their ground nests.

**Sharp-shinned** and **Cooper's Hawks** are two other examples of species that appear to have experienced high nesting success and juvenile recruitment in 1998. Both showed high passage rates and high immature : adult ratios in the Wellsvilles and at other HWI sites (e.g., Lanzone 1999, Neal 1999, Rossman 1999). For all four of HWI's longest-term sites, regressions typically indicated no distinct long-term trends for either of these species; the one exception was a significant increasing trend for Cooper's Hawks in the Goshute Mountains, Nevada (Hoffman et al in review). In the Wellsvilles, passage rates of both species have fluctuated considerably but show no long-term trend. Regardless, it appears that for both species 1998 was an outstanding year for juvenile recruitment throughout much of the Rocky Mountain and Intermountain regions.

As at other long-term HWI migration monitoring sites, the Wellsville data show high annual variability in counts of **Northern Goshawks**. Two factors appear to contribute to this pattern: (1) otherwise non-migratory adult Northern Goshawks that breed in boreal forest regions periodically undergo irruptive southward invasions during winter in response to crashes in the boreal prey base (Mueller et al. 1977); and (2) annual variability in recruitment of juveniles that disperse and/or migrate is high. The very high count in 1992 at the Wellsvilles, and elsewhere, clearly reflects occurrence of an invasion year. A modest 1998 count and average immature : adult ratio is consistent with data from HWI's Goshute and Manzano sites (Lanzone 1999, Rossman 1999). In contrast, nesting studies of Northern Goshawks in western Montana indicated that the species experienced good productivity in 1998 in that region (J. Kirkley personal communication), and 1998 counts and immature : adult ratios of goshawks were correspondingly high at the HWI site in the Bridger Mountains, Montana (Neal 1999). Thus, the status of the species appears to vary from region to region, with some positive trends indicated. Nevertheless, although the USDI Fish and Wildlife Service (1998) recently determined that listing under the Endangered Species Act was not warranted for western populations, reasons for concern also remain (Hoffman et al. in review).

High 1998 adjusted passage rates emphasized possible increasing trends for both **Swainson's Hawks** and **Red-tailed Hawks**. The same patterns applied to 1998 data from HWI's Manzano Mountains site in central New Mexico (Rossman 1999). Other long-term HWI migration counts show mostly stable or at best slightly increasing trends for Red-tailed Hawks; however, it is generally believed that this species is benefiting from continued, widespread forest clearing, which creates a mosaic of forested and open habitat (Preston and Beane 1993, Hoffman et al. in review). Reasons for concern about Swainson's Hawks exist, such as the recent discovery of extensive mortality from exposure to pesticides on wintering grounds in Argentina (Woodbridge et al. 1995) and widespread declines in productivity in Saskatchewan and Alberta (Houston and Schmutz 1995). However, the Swainson's Hawk has adapted successfully to irrigated agricultural habitats in many areas of the West (e.g., Woodbridge et al. 1995) and is currently considered common and stable in most western states (Harlow and Bloom 1989, England et al. 1997). Migration count data from all 4 of HWI's longest-term sites provide some indication of recent increases for Swainson's Hawks (Hoffman et al. in review). At each site, either the background activity level or the magnitude of peaks has increased through the course of each study. Such increases are consistent with evidence of expanding grassland habitats in many parts of the Intermountain West (e.g., Knick and Dryer 1997). Moreover, indications of the strongest increases at 2 of 3 Rocky Mountain sites is consistent with Breeding Bird Survey data showing significant increases from 1980–1996 in Montana, Wyoming, and New Mexico (Sauer et al. 1997).

Throughout much of the interior West, the reproductive success of **Golden Eagles** is tightly coupled with the abundance of black-tailed jackrabbits (*Lepus californicus*; Beecham and Kochert 1975, Steenhof and Kochert 1988, Steenhof et al. 1997). Jackrabbit densities were relatively high during the late 1970's and early 1980's, crashed in 1983-1985, recovered by the early 1990's, and then crashed again during 1993-

1994. The rabbits naturally undergo these cyclic population fluctuations; however, the current low-abundance period is more severe and prolonged than normal. Furthermore, peak abundances of jackrabbits in the early 1990s were substantially lower than during previous high years (Steenhof et al. 1997). The probable ultimate cause of these trends is habitat degradation resulting from poor management of livestock grazing and fire, excessive habitat conversion for agriculture, and especially invasions of exotic grasses (primarily cheatgrass, *Bromus tectorum*). In the Great Basin, jackrabbits occupy shrub habitats and avoid thick grassland habitats (Knick and Dyer 1997). Widespread degradation and conversion of native sagebrush habitats may be negatively effecting populations in many areas (United States Department of Interior 1996, Steenhof et al. 1997, Marzluff et al 1997). The Wellsville migration data indicate that the passage rate of immatures/subadults dropped significantly between the late 1970s and late 1980s and has not recovered. This information suggests a need for more intensive Golden Eagle population monitoring and more aggressive efforts to restore shrub-steppe ecosystems throughout the Great Basin and Intermountain West (Hoffman et al. in review).

Data from numerous sources, including most HWI migration sites indicate long-term increases in populations of the once endangered **Peregrine Falcon** and the **Merlin** (Hoffman et al. in review). Like Ospreys, these species were negatively impacted by heavy use of organochlorine pesticides in the 1950s and 1960s, but have rebounded strongly since DDT was banned for agricultural use in 1972 (Cade et al. 1988, Sodhi et al. 1993). For this and other reasons the U.S. Fish and Wildlife Service is currently de-listing the Peregrine Falcon. In the Wellsvilles, no Peregrine Falcons were seen during 1977–1979, whereas between 5 and 19 birds have been seen every year since 1987. However, the lack of a distinct increasing trend between 1987 and 1997 differs from other long-term HWI sites. Perhaps the high 1998 count is an indication that this discrepancy will disappear in the future. The average count of Merlins also was significantly lower during 1977–1979 (4 birds) than during 1987–1997 (10 birds), but again the lack of a distinct increasing trend between 1987 and 1997 differs from the picture at other long-term HWI sites. Moreover, in this case the 1998 count does not alter the conclusion of no recent trend. Reasons for the difference between patterns shown in the Wellsvilles and at other HWI sites in Nevada and New Mexico are unclear.

# RECOMMENDATIONS

The Wellsville hawkwatch offers great views of migrating raptors as well as stunning vistas and serene privacy. However, the Wellsville Mountains are steep and adequate preparation for adverse weather and backcountry emergencies is essential. Exposure to strong winds and lightning is common; severe cold and snow are possible. Sheltered campsites are lacking, therefore, during severe weather, observers are advised to abandon the ridge altogether and head down to shelter. A wonderful support base exists in Cache Valley. Observers should contact Bryan Dixon and Jean Lown, the generous hawkwatcher host family located in Logan, before the beginning of the observation season. Randy and Julie Stacey live at the bottom of Deep Canyon and provide additional refuge. Another contact in Logan is Keith Archibald, long-time supporter of HawkWatch International. Caroline Barcus will horsepack all needed water up to the saddle for the season and she can always be contacted through Randy Stacey. Mike Vanhorn of the USDA Forest Service, Logan Ranger District can provide a radio for receiving national weather service broadcasts and reaching Logan dispatch.

Observations should begin by 0900 hrs every day of the season. When bad weather strikes or a day off is needed, consider the logistics necessary for the return trip. The combined drive/hike time to the hawkwatch from Logan is at least 3 hours.

Observers should develop a sound scanning strategy with each other during the first week of observations. A map of prominent landmarks is a valuable resource to aid in tracking flight lines.

Observers are advised to scan with both the naked eye and binoculars. The birds do not always follow the west side of the ridge within easy view of the observation point; therefore, observers must employ a flexible scanning strategy to accommodate changing flight patterns. On east-wind mornings, the raptor flight can sometimes extend across the Cache Valley. During periods of variable winds or strong southerly winds, birds will often hug the west side of the ridge at very low altitudes. In order to sight many of these birds, we recommend that one observer walk 10 m south and slightly west, where better observations of such birds are possible. It is important to emphasize that the migration is variable. Observers must develop a variable and comprehensive strategy in order to sight the maximum number of birds.

The observers felt that simple promotional efforts could increase awareness of and visitation to the Wellsville project. For example, currently there is no sign at the Deep Canyon trailhead to inform potential visitors about the project. Perhaps HawkWatch and the USFS, Logan District can cooperate to produce a trailhead sign that describes the trail as well as the seasonal location of the hawkwatch site and it's importance. If this is not possible, perhaps HawkWatch could produce simple posters to fit in the windshields of observer cars, which would show a map to the site and provide a phone number for obtaining additional information. The latter method worked during 1998 to draw some day hikers to the observation site.

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**Table 1. Species-specific standardized sample periods.**

| SPECIES | SAMPLING PERIOD |
|---|---|
| Turkey Vulture | 02-Sep – 05-Oct* |
| Osprey | 02-Sep – 03-Oct* |
| Northern Harrier | 02-Sep – 19-Oct* |
| Sharp-shinned Hawk | 02-Sep – 19-Oct* |
| Cooper's Hawk | 02-Sep – 19-Oct* |
| Northern Goshawk | 02-Sep – 19-Oct* |
| Broad-winged Hawk | 02-Sep – 18-Oct |
| Swainson's Hawk | 02-Sep – 18-Oct* |
| Red-tailed Hawk | 02-Sep – 19-Oct* |
| Ferruginous Hawk | 05-Sep – 28-Sep |
| Golden Eagle | 02-Sep – 02-Oct* |
| Bald Eagle | 02-Sep – 19-Oct* |
| American Kestrel | 02-Sep – 16-Oct* |
| Merlin | 02-Sep – 19-Oct* |
| Prairie Falcon | 02-Sep – 19-Oct* |
| Peregrine Falcon | 02-Sep – 17-Oct* |

*Note*: Sample periods include approximately 95% of the cumulative, study-wide count rate for a given species unless noted with an * next to the ending date, in which case the sample period is further constrained to between mean starting and ending dates of continuous observations.

**Table 2. Adjusted annual counts and passage rates by species: 1977–1997 versus 1998.**

| | COUNTS | | | RAPTORS / 100 HRS | | |
|---|---|---|---|---|---|---|
| SPECIES | 1977–1997[1] | 1998 | % CHANGE | 1977–1997[1] | 1998 | % CHANGE |
| Turkey Vulture | 14 ± 4.9 | 16 | 12 | 6.5 ± 2.00 | 10.9 | 68 |
| Osprey | 24 ± 6.2 | 38 | 58 | 11.7 ± 3.09 | 27.9 | 139 |
| Northern Harrier | 245 ± 41.0 | 383 | 56 | 83.7 ± 12.45 | 187.3 | 124 |
| Sharp-shinned Hawk | 1033 ± 207.8 | 995 | -4 | 354.3 ± 52.35 | 494.8 | 40 |
| Cooper's Hawk | 622 ± 106.4 | 600 | -4 | 215.8 ± 31.30 | 298.1 | 38 |
| Northern Goshawk | 24 ± 7.0 | 14 | -42 | 8.6 ± 2.50 | 6.8 | -20 |
| Unidentified accipiter | 67 ± 17.1 | 52 | -22 | 23.9 ± 6.63 | 25.8 | 8 |
| TOTAL ACCIPITERS | 1746 ± 293.8 | 1661 | -5 | 593.1 ± 72.60 | 812.5 | 37 |
| Broad-winged Hawk | 4 ± 1.9 | 1 | -72 | 2.7 ± 1.19 | 1.1 | -58 |
| Swainson's Hawk | 139 ± 84.4 | 261 | 87 | 71.5 ± 45.60 | 197.1 | 176 |
| Red-tailed Hawk | 515 ± 103.2 | 488 | -5 | 174.7 ± 32.96 | 238.8 | 37 |
| Ferruginous Hawk | 10 ± 3.0 | 12 | 21 | 3.2 ± 1.09 | 5.6 | 76 |
| Rough-legged Hawk | 2 ± 0.9 | 1 | -45 | 0.5 ± 0.27 | 0.4 | -23 |
| Unidentified buteo | 16 ± 5.3 | 16 | -2 | 5.6 ± 1.75 | 7.8 | 39 |
| TOTAL BUTEOS | 686 ± 173.2 | 779 | 14 | 209.0 ± 49.43 | 329.4 | 58 |
| Golden Eagle | 188 ± 43.6 | 137 | -27 | 66.3 ± 16.70 | 67.1 | 1 |
| Bald Eagle | 4 ± 1.5 | 0 | -100 | 1.4 ± 0.44 | 0.0 | -100 |
| TOTAL EAGLES | 192 ± 43.8 | 137 | -29 | 67.7 ± 16.74 | 67.1 | -1 |
| American Kestrel | 1039 ± 188.0 | 672 | -35 | 374.8 ± 57.46 | 355.3 | -5 |
| Merlin | 10 ± 3.2 | 11 | 9 | 3.4 ± 0.89 | 5.5 | 63 |
| Prairie Falcon | 13 ± 3.0 | 8 | -40 | 4.7 ± 1.33 | 3.9 | -17 |
| Peregrine Falcon | 5 ± 1.8 | 17 | 222 | 1.8 ± 0.57 | 8.7 | 392 |
| Unidentified falcon | 2 ± 0.6 | 1 | -36 | 0.5 ± 0.22 | 0.5 | -5 |
| TOTAL FALCONS | 1070 ± 189.2 | 709 | -34 | 365.5 ± 54.04 | 347.0 | -5 |
| Unidentified raptor | 25 ± 13.6 | 21 | -17 | 9.2 ± 4.92 | 10.3 | 12 |
| GRAND TOTAL | 4001 ± 545.8 | 3743 | -6 | 1366.2 ± 142.75 | 1831.2 | 34 |

[1] Mean ± 95% confidence interval.

**Table 3. Adjusted counts by age class and immature : adult ratios for selected species: 1992–1997 versus 1998.**

| | Total and Age-Classified Counts | | | | | | % Unknown Age | | Immature : Adult Ratio | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1992–1997 Average | | | 1998 | | | | | | |
| | Total | Imm. | Adult | Total | Imm. | Adult | 1992–1997[1] | 1998 | 1992–1997[1] | 1998 |
| Northern Harrier | 250 | 140 | 58 | 383 | 244 | 36 | 21 ± 5.7 | 27 | 2.6 ± 1.08 | 6.9 |
| Sharp-shinned Hawk | 939 | 369 | 391 | 995 | 420 | 236 | 18 ± 5.7 | 34 | 1.1 ± 0.64 | 1.8 |
| Cooper's Hawk | 630 | 231 | 255 | 600 | 290 | 102 | 22 ± 8.7 | 35 | 1.1 ± 0.56 | 2.8 |
| Northern Goshawk[2] | 24 | 15 | 4 | 14 | 6 | 1 | 21 ± 7.6 | 50 | 5.9 ± 3.09 | 6.0 |
| Broad-winged Hawk | 5 | 2 | 2 | 1 | 0 | 1 | 38 ± 31.6 | 0 | 0.9 ± 1.55 | 0.0 |
| Red-tailed Hawk | 599 | 194 | 326 | 488 | 226 | 209 | 13 ± 4.1 | 11 | 0.6 ± 0.19 | 1.1 |
| Ferruginous Hawk | 13 | 2 | 3 | 12 | 3 | 3 | 63 ± 21.3 | 46 | 0.6 ± 0.41 | 0.9 |
| Golden Eagle[2] | 188 | 92 | 65 | 137 | 67 | 56 | 8 ± 3.2 | 10 | 1.8 ± 1.15 | 1.2 |
| Bald Eagle | 4 | 2 | 1 | 0 | 0 | 0 | 20 ± 21.1 | – | 1.0 ± 0.98 | – |
| Peregrine Falcon | 6 | 1 | 1 | 17 | 3 | 4 | 63 ± 16.9 | 59 | 1.1 ± 0.78 | 0.8 |

[1] Mean ± 95% confidence interval. For age ratios, note that the long-term mean immature : adult ratio is an average of annual ratios and may differ from the value obtained by dividing long-term average numbers of immatures and adults. Discrepancies in the two values reflect high annual variability in the observed age ratio.

[2] Long-term means are for 1977–1997.

**Table 4. Adjusted counts by sex and female : male ratios for selected species: 1992–1997 versus 1998.**

| | Total and Sex-Classified Counts | | | | | | % Unknown Sex | | Female : Male Ratio | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1992–1997 Average | | | 1998 | | | | | | |
| | Total | Female | Male | Total | Female | Male | 1992–1997[1] | 1998 | 1992–1997[1] | 1998 |
| Adult | | | | | | | | | | |
| Northern Harrier | 250 | 24 | 33 | 383 | 21 | 15 | 1 ± 1.4 | 4 | 0.88 ± 0.424 | 1.41 |
| American Kestrel | 864 | 347 | 381 | 672 | 177 | 236 | 16 ± 7.1 | 39 | 0.89 ± 0.113 | 0.75 |

[1] Mean ± 95% confidence interval. For sex ratios, note that the long-term mean female : male ratio is an average of annual ratios and may differ from the value obtained by dividing the long-term average numbers of females and males. Discrepancies in the two values reflect high annual variability in the observed sex ratio.

**Table 5. Observation-range, bulk-passage, and median passage dates by species for 1998, with a comparison of 1998 and 1977–1997 average median passage dates.**

| | 1998 | | | | 1977–1997 |
|---|---|---|---|---|---|
| SPECIES | FIRST DATE OBSERVED | LAST DATE OBSERVED | BULK PASSAGE DATES[1] | MEDIAN PASSAGE DATE[2] | MEDIAN PASSAGE DATE[3] |
| Turkey Vulture | 31-Aug | 23-Sep | 3-Sep – 15-Sep | 4-Sep | 18-Sep ± 3.9 |
| Osprey | 6-Sep | 2-Oct | 7-Sep – 28-Sep | 16-Sep | 14-Sep ± 3.2 |
| Northern Harrier | 23-Aug | 25-Oct | 8-Sep – 10-Oct | 24-Sep | 25-Sep ± 2.1 |
| Sharp-shinned Hawk | 24-Aug | 25-Oct | 8-Sep – 8-Oct | 27-Sep | 25-Sep ± 2.1 |
| Cooper's Hawk | 23-Aug | 24-Oct | 9-Sep – 9-Oct | 24-Sep | 23-Sep ± 2.3 |
| Northern Goshawk | 3-Sep | 17-Oct | 13-Sep – 17-Oct | 2-Oct | 29-Sep ± 4.8 |
| Broad-winged Hawk | 24-Sep | 24-Sep | – | – | 20-Sep ± 4.1 |
| Swainson's Hawk | 28-Aug | 2-Oct | 30-Aug – 24-Sep | 14-Sep | 16-Sep ± 4.6 |
| Red-tailed Hawk | 23-Aug | 24-Oct | 1-Sep – 8-Oct | 20-Sep | 23-Sep ± 2.1 |
| Ferruginous Hawk | 26-Aug | 24-Oct | 14-Sep – 14-Oct | 24-Sep | 23-Sep ± 6.0 |
| Rough-legged Hawk | 15-Sep | 15-Sep | – | – | – |
| Golden Eagle | 25-Aug | 24-Oct | 8-Sep – 14-Oct | 2-Oct | 1-Oct ± 1.7 |
| American Kestrel | 23-Aug | 24-Oct | 4-Sep – 7-Oct | 19-Sep | 20-Sep ± 2.7 |
| Merlin | 14-Sep | 13-Oct | 16-Sep – 10-Oct | 6-Oct | 28-Sep ± 3.6 |
| Prairie Falcon | 23-Aug | 13-Oct | 3-Sep – 13-Oct | 2-Oct | 21-Sep ± 5.4 |
| Peregrine Falcon | 29-Aug | 17-Oct | 1-Sep – 8-Oct | 9-Sep | 15-Sep ± 4.6 |
| Total | 23-Aug | 25-Oct | 4-Sep – 8-Oct | 23-Sep | 23-Sep ± 1.6 |

[1] Dates between which the central 80% of the flight passed; values are given only for species with annual counts ≥ 5 birds.

[2] Date by which 50% of the flight had passed; values are given only for species with annual counts ≥ 5 birds.

[3] Mean of annual values ± 95% confidence interval in days; calculated only for species with annual counts ≥5 birds for ≥3 years.

**Table 6. Median passage dates by age for selected species: 1992–1997 versus 1998.[1]**

| | Adult | | Immature | |
|---|---|---|---|---|
| Species | 1992–1997[2] | 1998 | 1992–1997[2] | 1998 |
| Northern Harrier | 28-Sep ± 3.1 | 9-Oct | 23-Sep ± 3.0 | 23-Sep |
| Sharp-shinned Hawk | 29-Sep ± 3.4 | 7-Oct | 15-Sep ± 4.1 | 23-Sep |
| Cooper's Hawk | 29-Sep ± 4.6 | 6-Oct | 17-Sep ± 5.4 | 23-Sep |
| Northern Goshawk | 27-Sep ± 12.4 | – | 29-Sep ± 5.4 | 29-Sep |
| Red-tailed Hawk | 24-Sep ± 2.0 | 27-Sep | 13-Sep ± 2.6 | 15-Sep |
| Golden Eagle | 29-Sep ± 3.1 | 6-Oct | 1-Oct ± 2.2 | 2-Oct |

[1] Dates by which 50% of the flight had passed; 1998 values are given only for species with annual counts of at least 5 birds, and long-term means were calculated only from annual values based on counts of at least 5 birds.

[2] Mean ± 95% confidence interval in days.

**Table 7. Median passage dates by sex for selected species: 1992–1997 versus 1998.[1]**

| | Female | | Male | |
|---|---|---|---|---|
| Species | 1992–1997[2] | 1998 | 1992–1997[2] | 1998 |
| Adult Northern Harrier | 26-Sep ± 4.2 | 27-Sep | 1-Oct ± 2.8 | 11-Oct |
| American Kestrel | 13-Sep ± 4.2 | 15-Sep | 22-Sep ± 2.9 | 22-Sep |

[1] Dates by which 50% of the flight had passed.

[2] Mean ± 95% confidence interval in days; calculated only from annual counts ≥5 birds.

**Table 8. Color morph-specific unadjusted counts and light : dark morph ratios for selected buteos: 1992–1997 versus 1998.**

| | Total and Morph-classified Counts | | | | | | % Unknown Morph | | Light : Dark Ratio | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1992–1966 Average | | | 1998 | | | | | | |
| | Total | Light | Dark | Total | Light | Dark | 1992–1997[1] | 1998 | 1992–1997[1] | 1998 |
| Broad-winged Hawk | 6 | 4 | <1 | 1 | 1 | 0 | 50 ± 24.7 | 0 | 7.3 ± 3.28 | 1.0 |
| Swainson's Hawk | 278 | 128 | 47 | 309 | 173 | 51 | 33 ± 14.4 | 28 | 4.9 ± 2.72 | 3.4 |
| Red-tailed Hawk | 718 | 545 | 83 | 609 | 433 | 63 | 12 ± 2.0 | 19 | 7.2 ± 1.50 | 6.9 |
| Ferruginous Hawk | 15 | 8 | 1 | 14 | 14 | 0 | 38 ± 33.3 | 0 | 6.9 ± 5.43 | 14.0 |
| Rough-legged Hawk | 2 | 1 | <1 | 1 | 0 | 1 | 60 ± 48.0 | 0 | 4.0 ± 1.96 | 0.0 |

[1] Mean ± 95% CI (confidence interval). For morph ratios, note that the long-term mean light : dark ratio is an average of annual ratios and may differ from the value obtained by dividing average numbers of light and dark morphs. Discrepancies in the two values reflect high annual variability in the observed morph ratio.

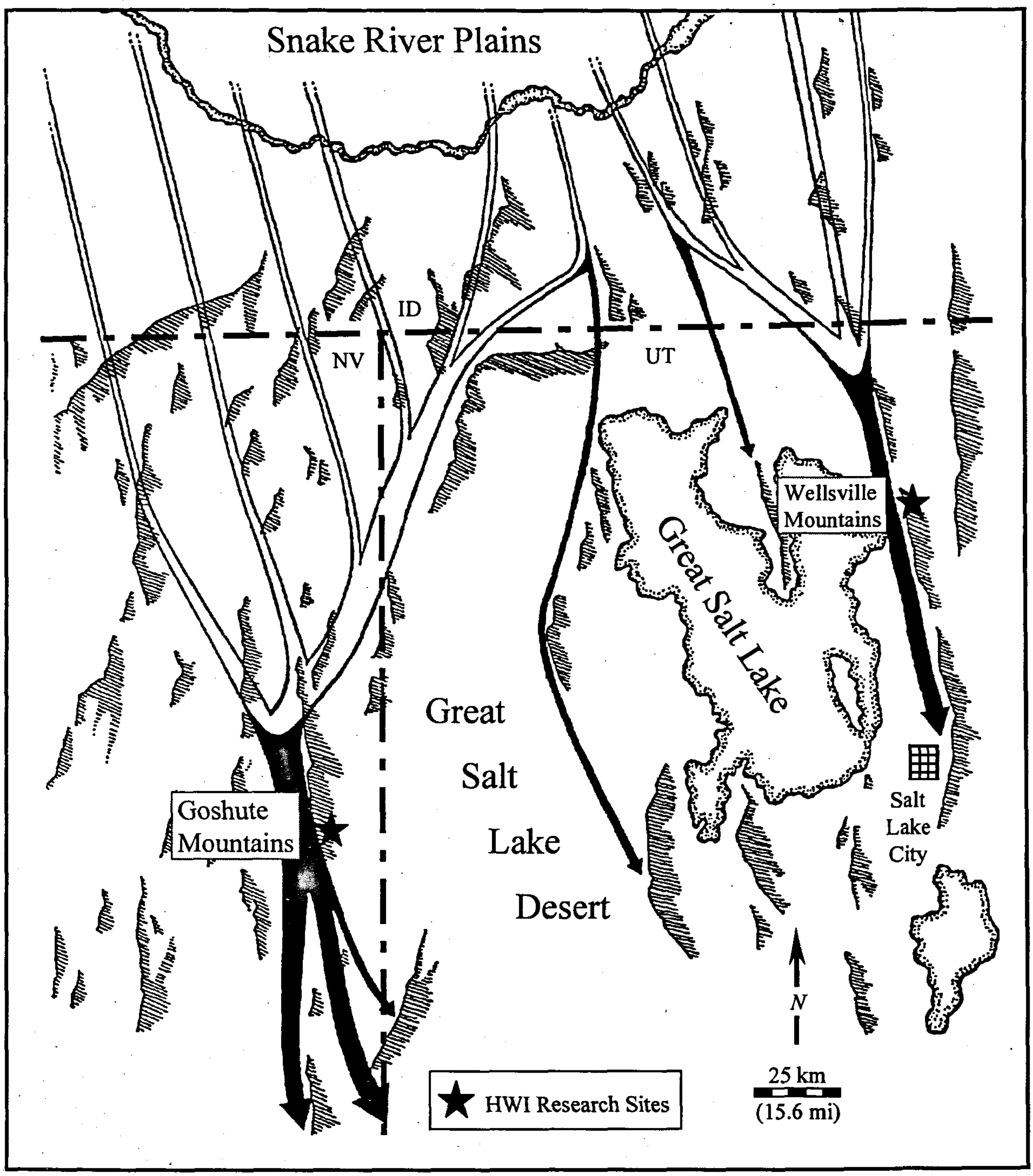


**Figure 1. Map showing the location of the Wellsville Mountains migration study site in relation to regional raptor flyways.**

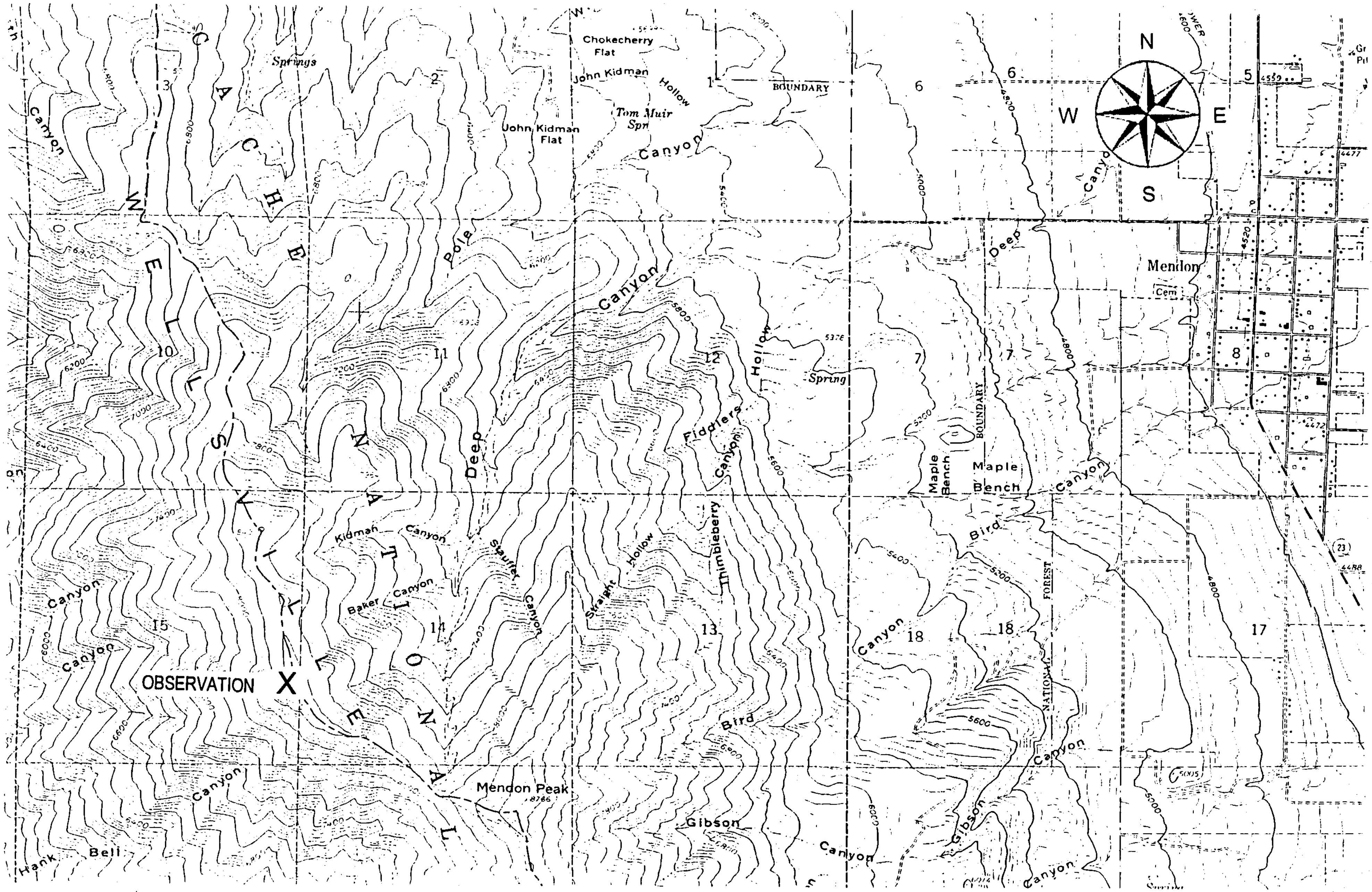


**Figure 2. Topographic map showing the location of the Wellsville raptor migration count site.**

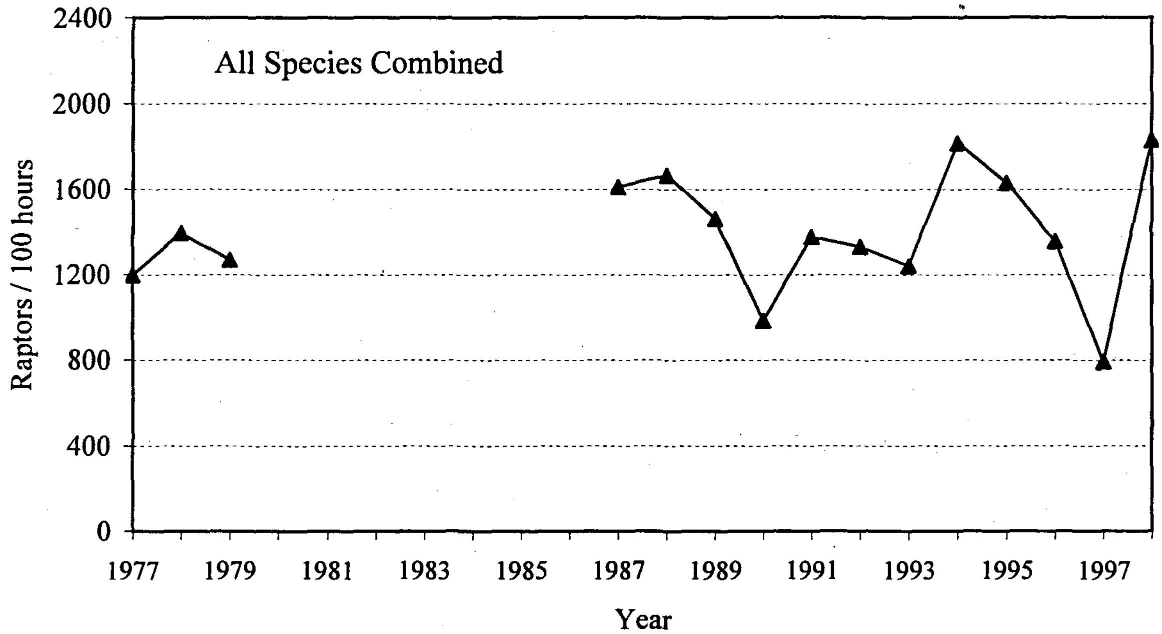


**Figure 3. Combined-species, adjusted annual passage rates: 1977–1998.**

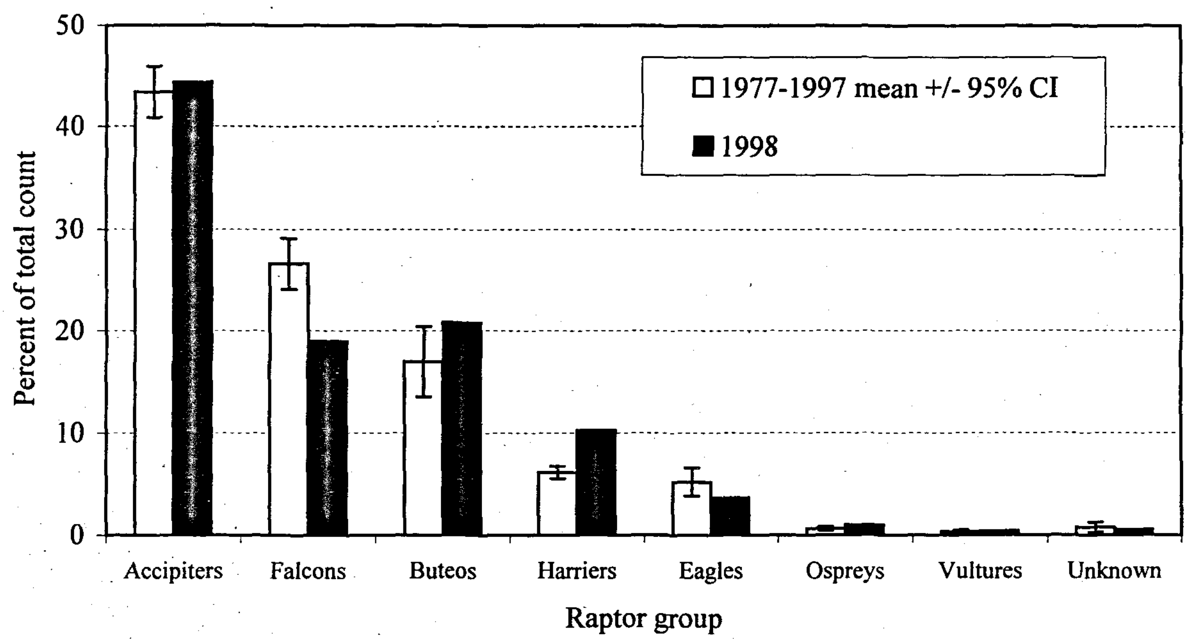


**Figure 4. Group composition of annual flights: 1977–1997 versus 1998.**

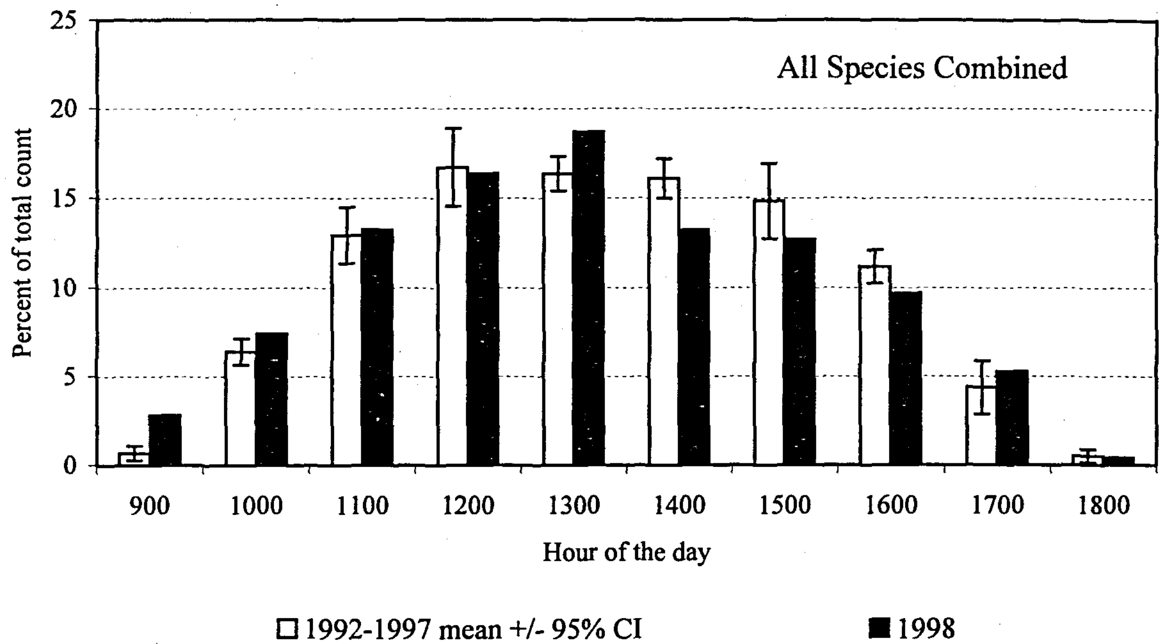


**Figure 5. Combined-species passage volume by hourly periods of the day: 1992–1997 versus 1998.**

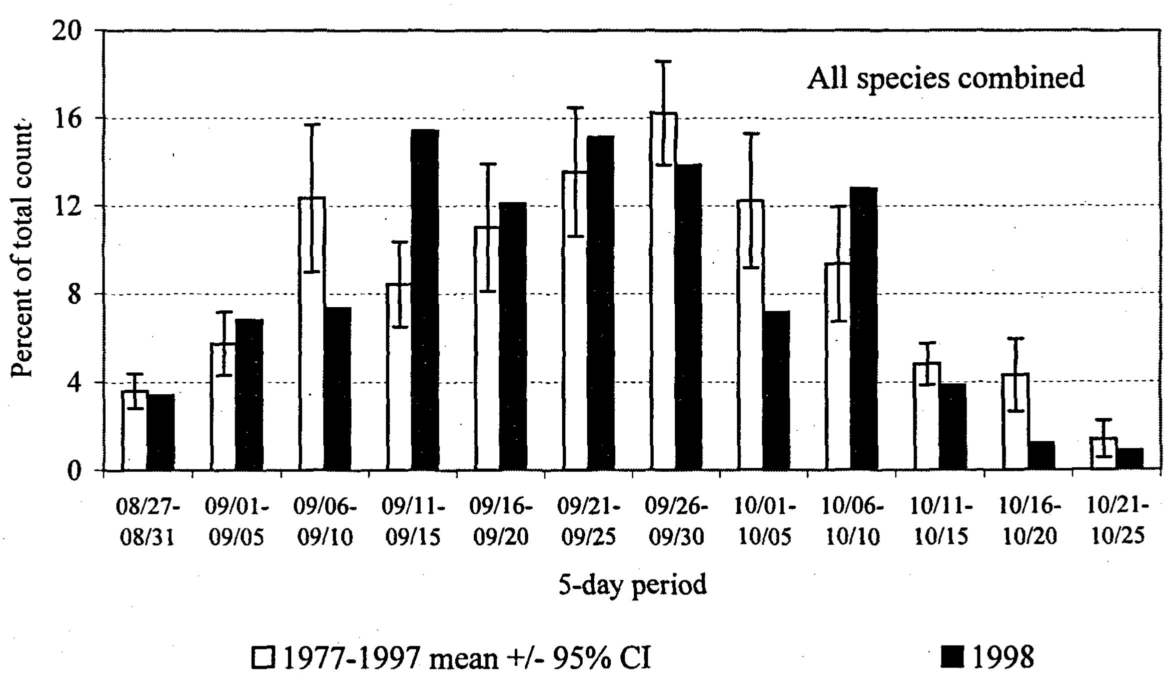


**Figure 6. Combined-species passage volume by five-day periods: 1977–1997 versus 1998.**

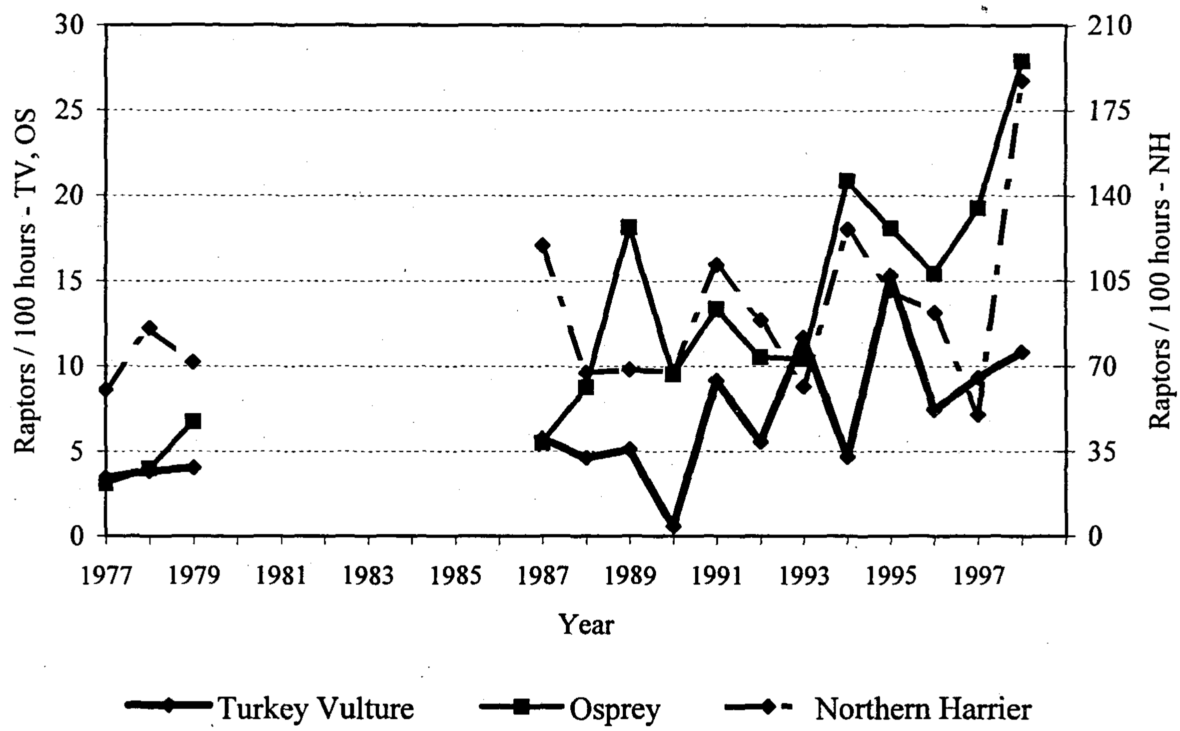


**Figure 7. Adjusted annual passage rates for Turkey Vultures, Ospreys, and Northern Harriers: 1977–1998.**

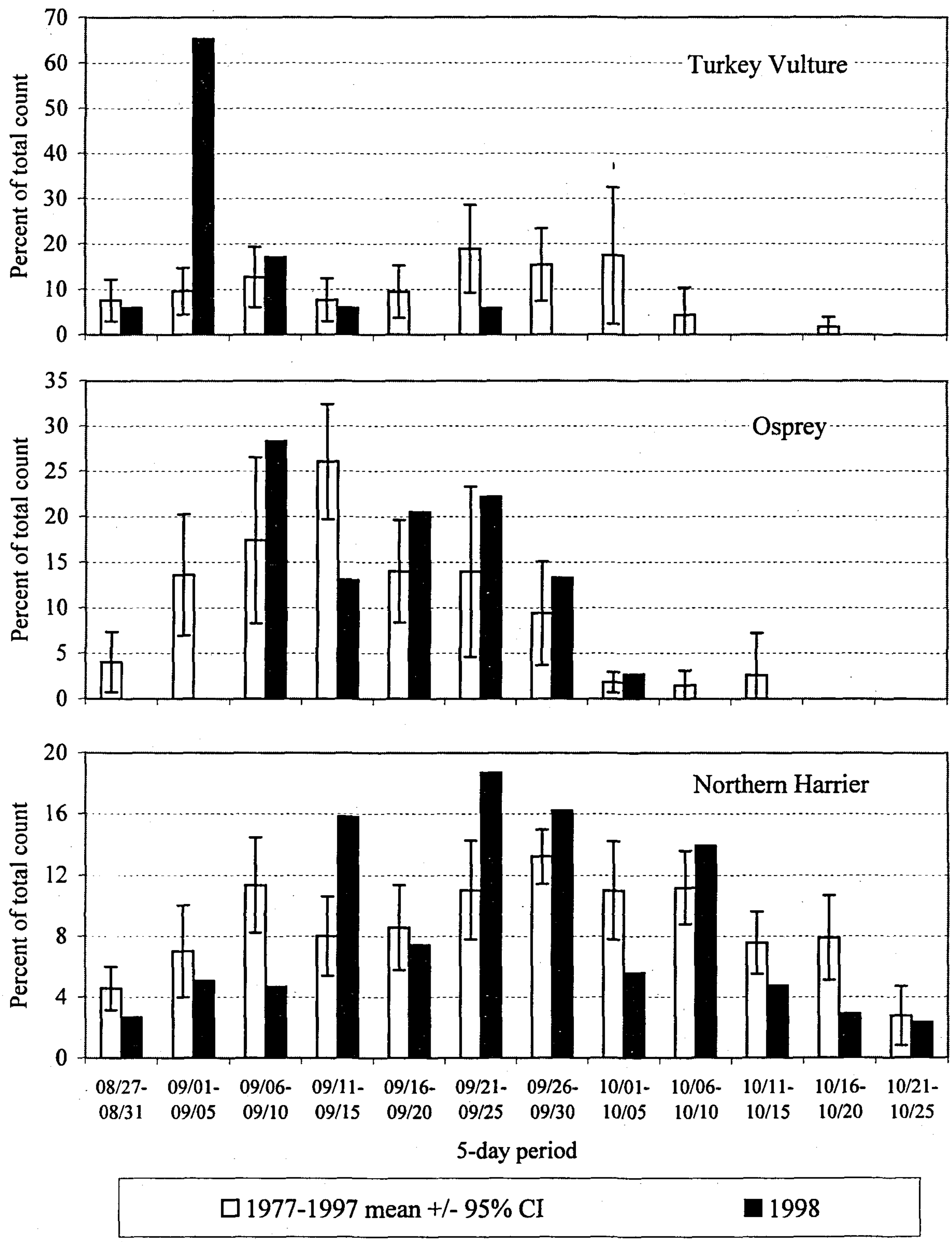


**Figure 8. Passage volume by five-day periods for Turkey Vultures, Ospreys, and Northern Harriers: 1977–1997 versus 1998.**

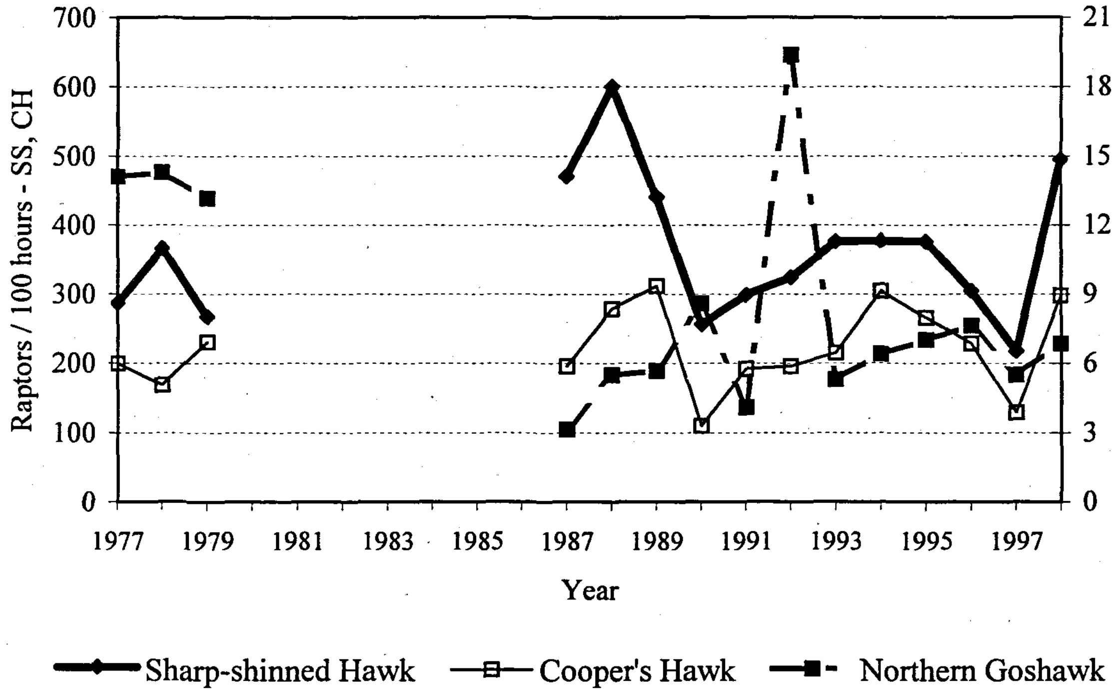


**Figure 9. Adjusted annual passage rates for Sharp-shinned Hawks, Cooper's Hawks, and Northern Goshawks: 1977–1998.**

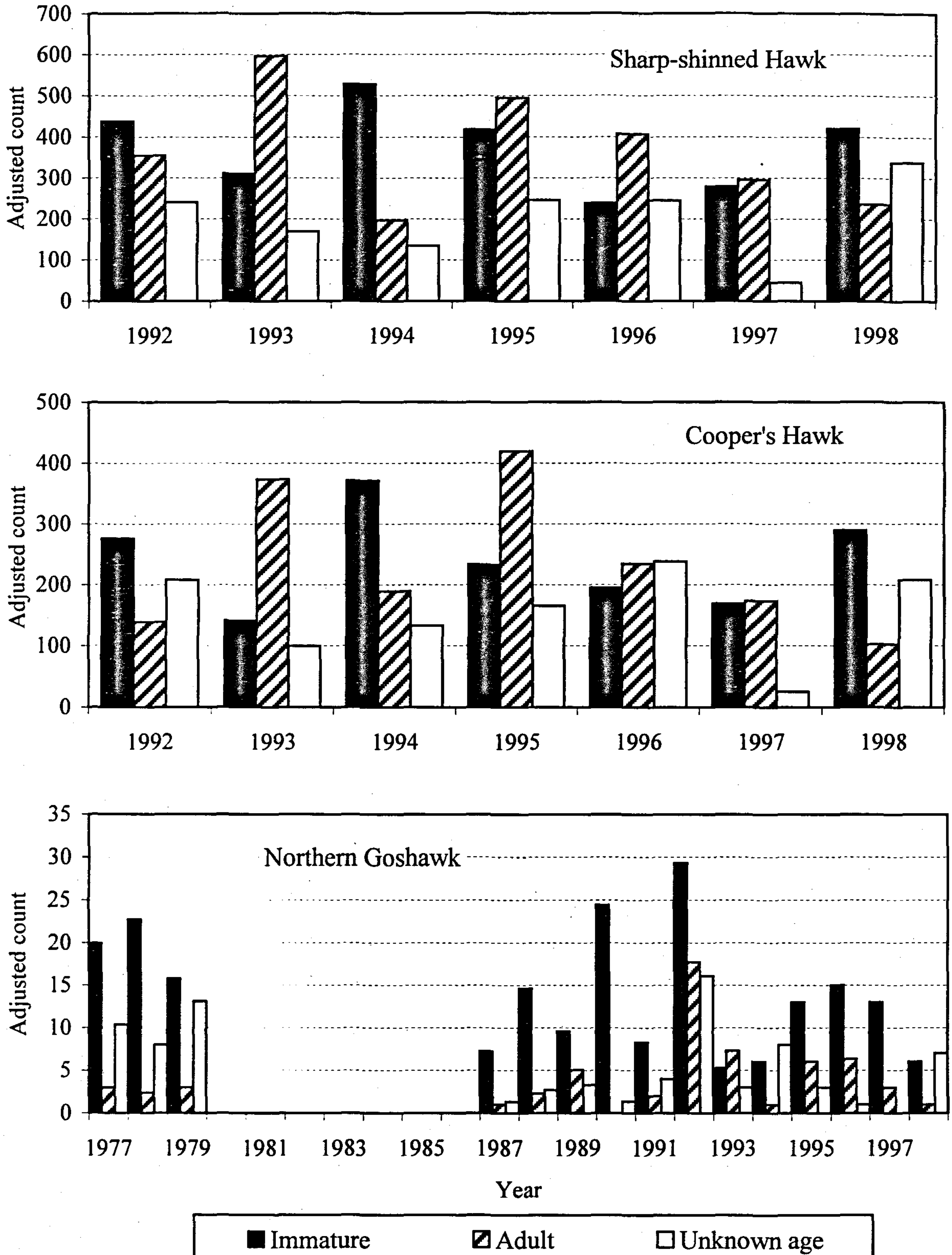


**Figure 10. Age composition of annual flights of Sharp-shinned Hawks, Cooper's Hawks, and Northern Goshawks: 1992–1998.**

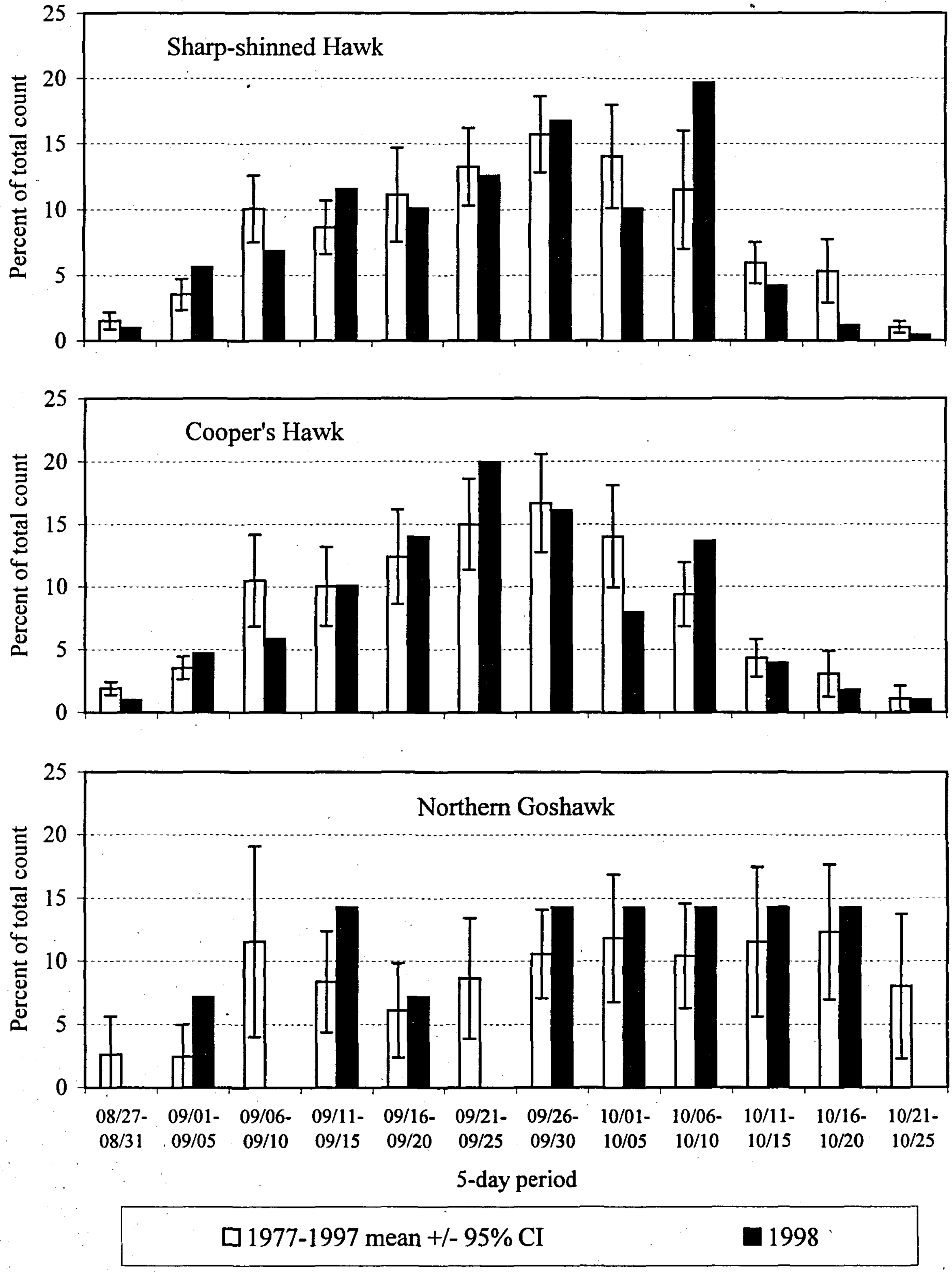


**Figure 11. Passage volume by five-day periods for Sharp-shinned Hawks, Cooper's Hawks, and Northern Goshawks: 1977–1997 versus 1998.**

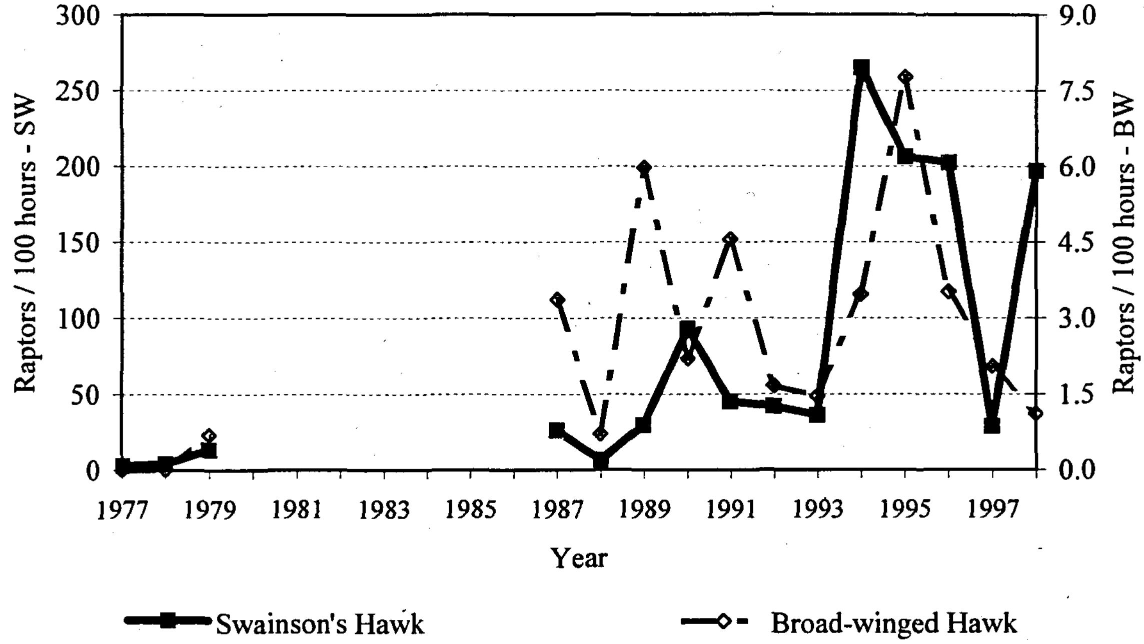


**Figure 12. Adjusted annual passage rates for Broad-winged Hawks, Ferruginous Hawks, and Rough-legged Hawks: 1977–1998.**

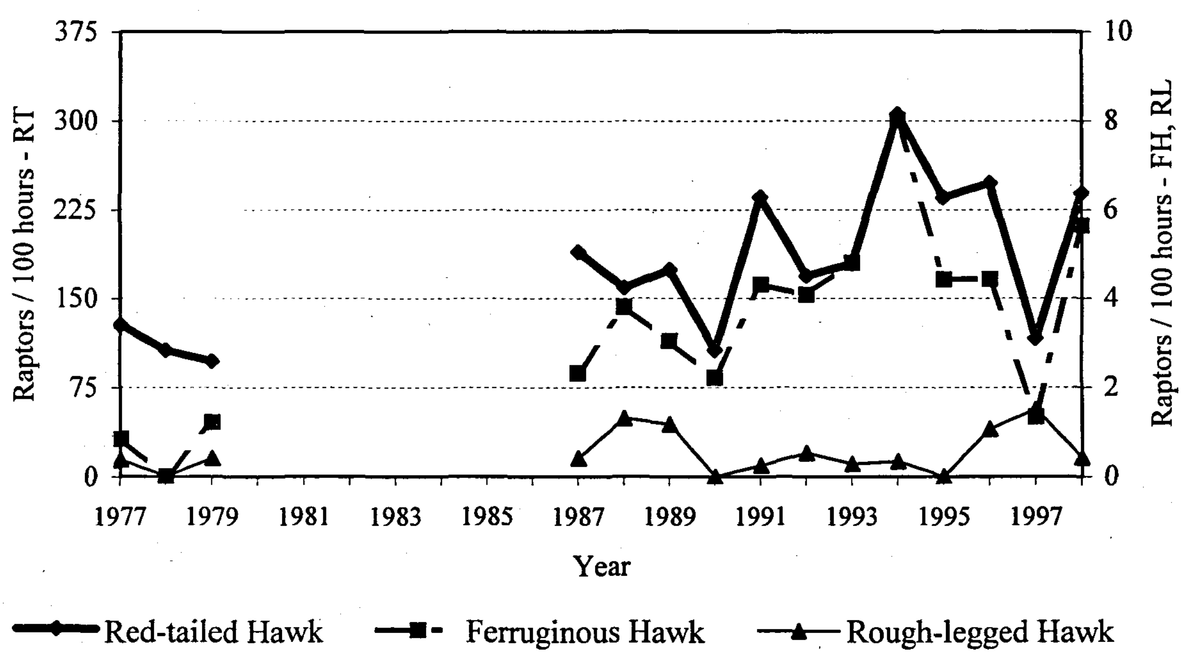


**Figure 13. Adjusted annual passage rates for Swainson's Hawks and Red-tailed Hawks: 1977–1998.**

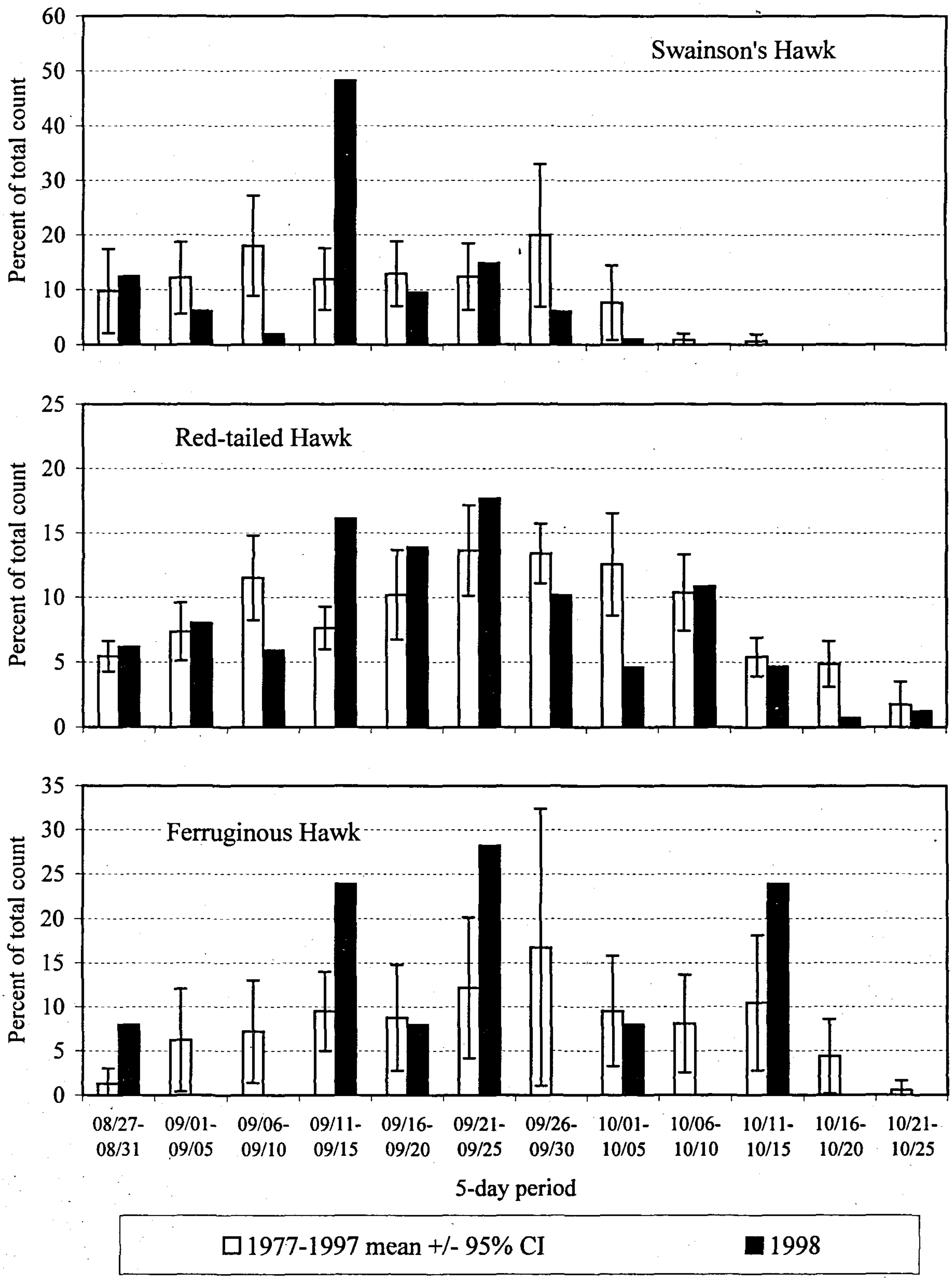


**Figure 14. Passage volume by five-day periods for Swainson's Hawks, Red-tailed Hawks, and Ferruginous Hawks: 1977–1997 versus 1998.**

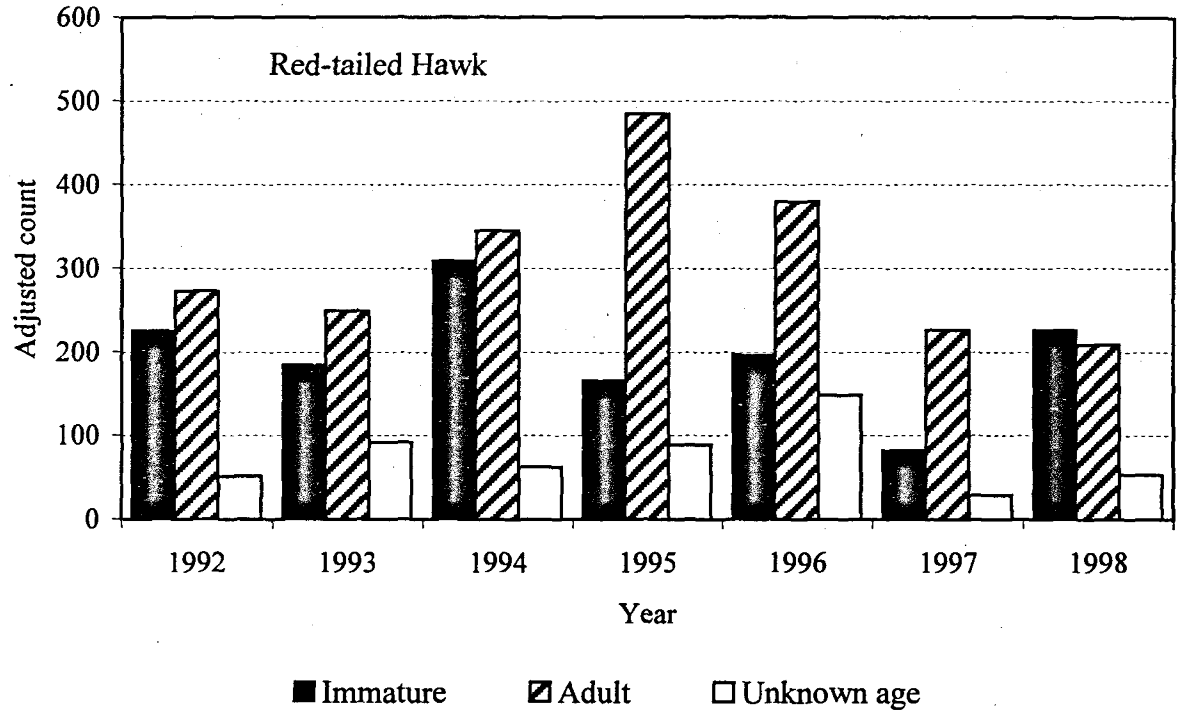


**Figure 15. Age composition of annual flights of Red-tailed Hawks: 1992–1998.**

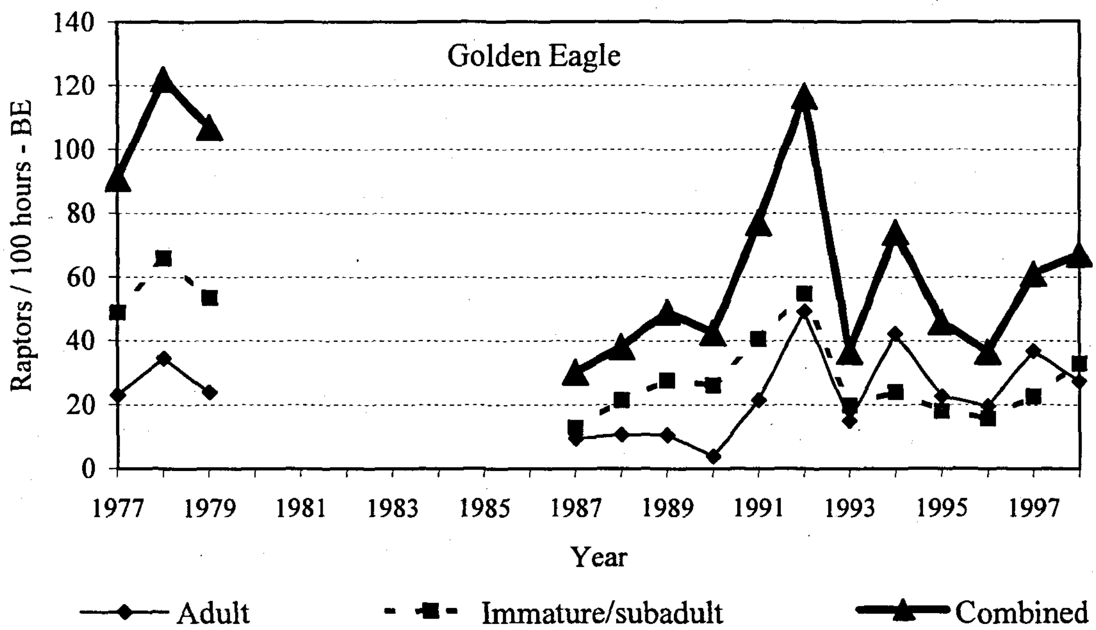


**Figure 16. Species-level and age-specific adjusted annual passage rates for Golden Eagles: 1977–1998.**

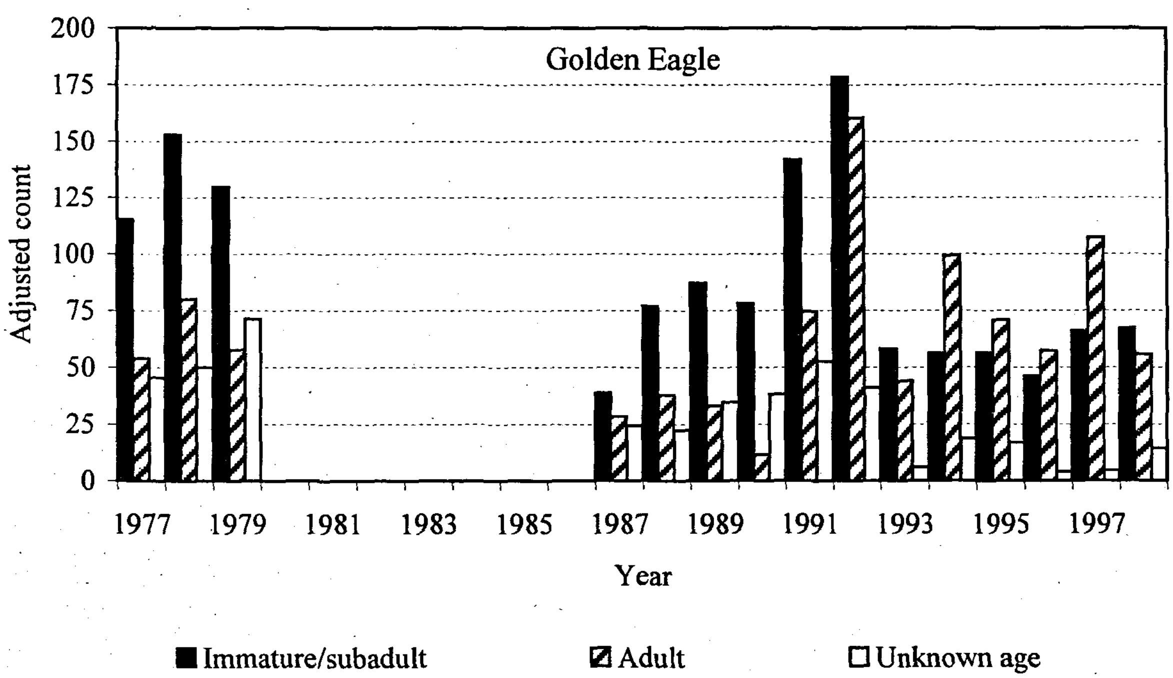


**Figure 17. Age composition of annual flights of Golden Eagles: 1992–1998.**

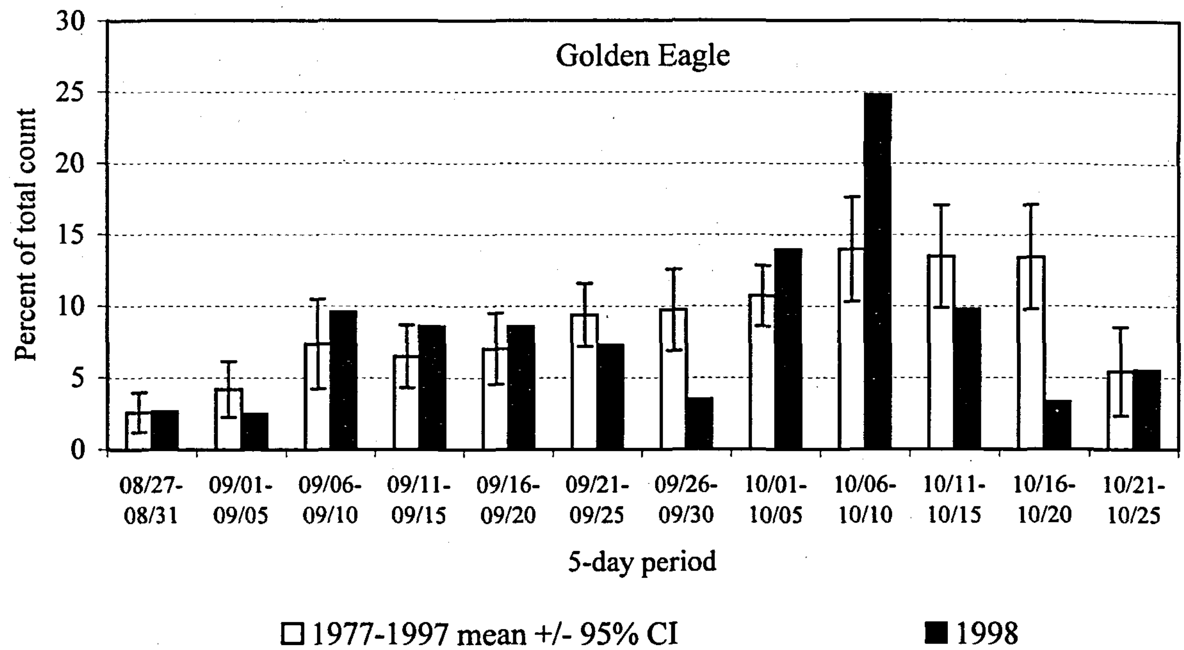


**Figure 18. Passage volume by five-day periods for Golden Eagles: 1977–1997 versus 1998.**

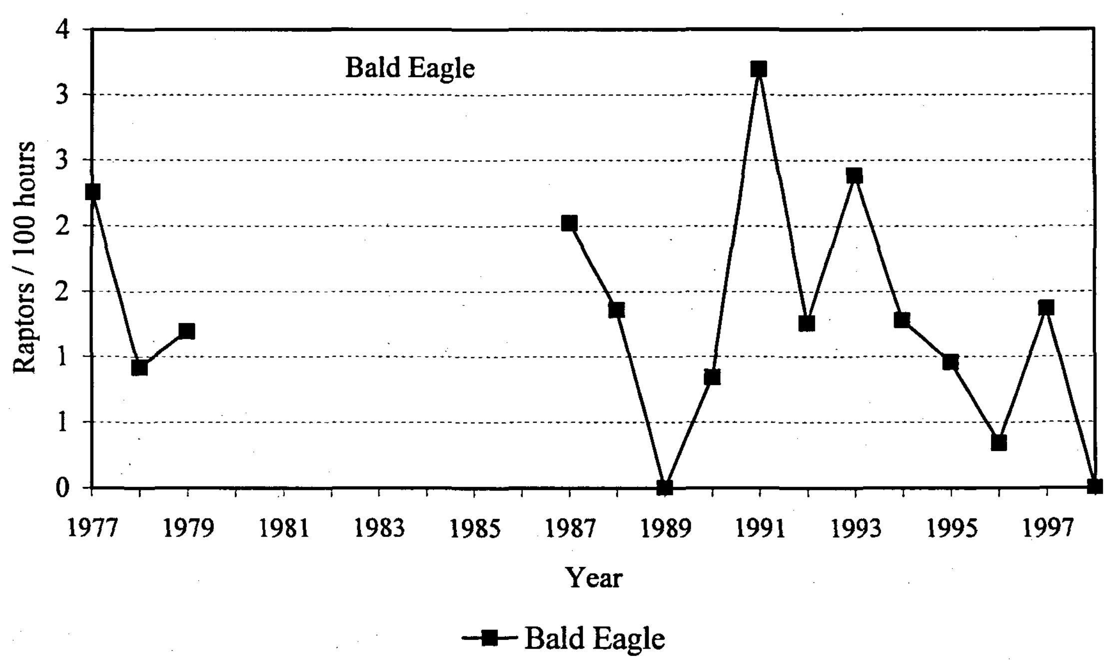


**Figure 19. Adjusted annual passage rates for Bald Eagles: 1977–1998.**

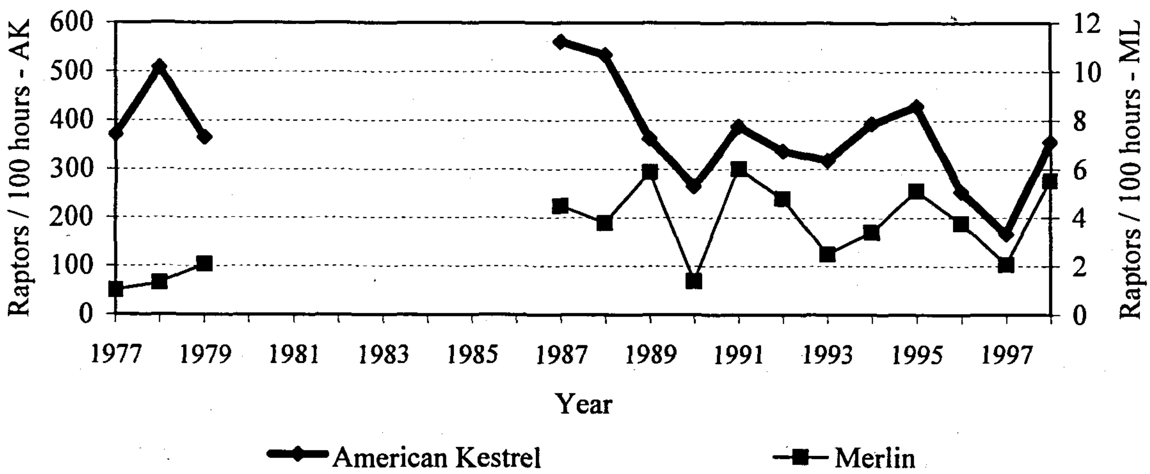


**Figure 20. Adjusted annual passage rates for American Kestrels and Merlins: 1977–1998.**

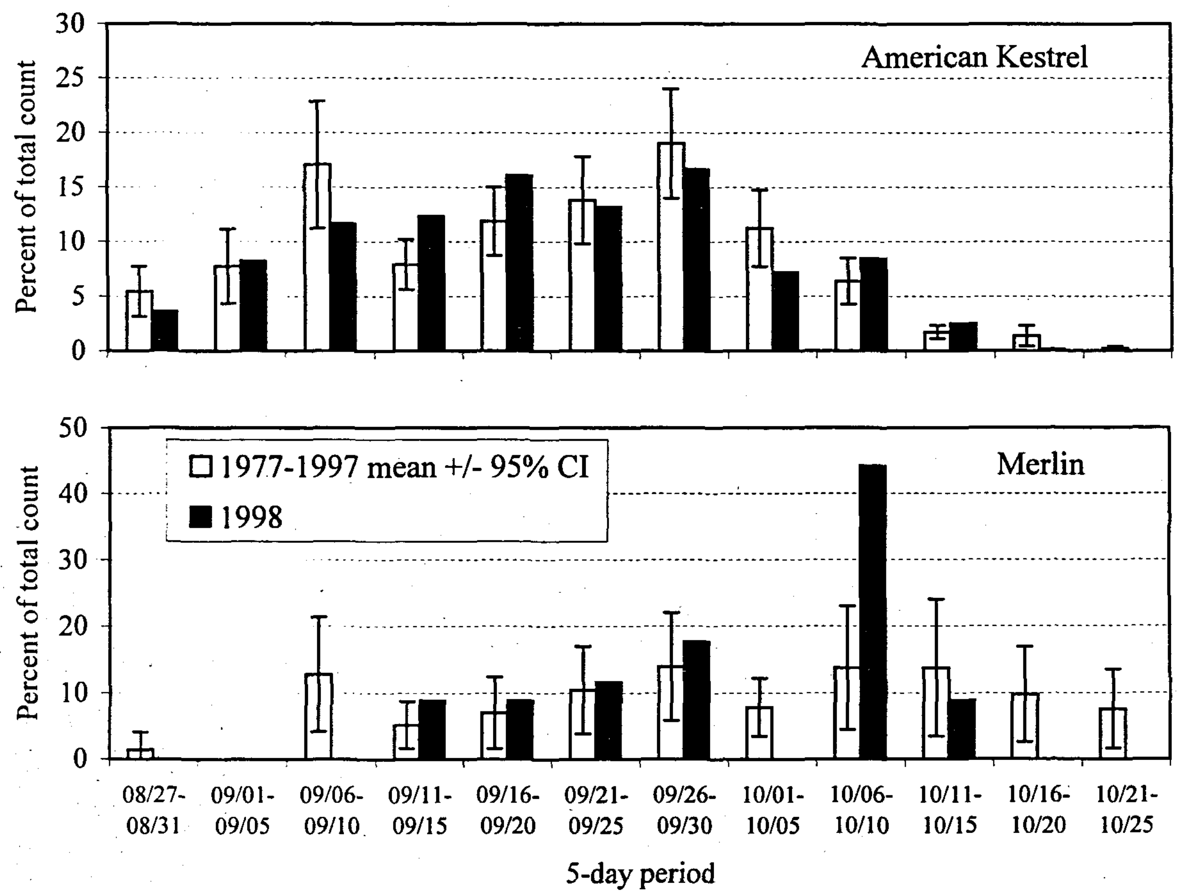


**Figure 21. Passage volume by five-day periods for American Kestrels and Merlins: 1977–1997 versus 1998.**

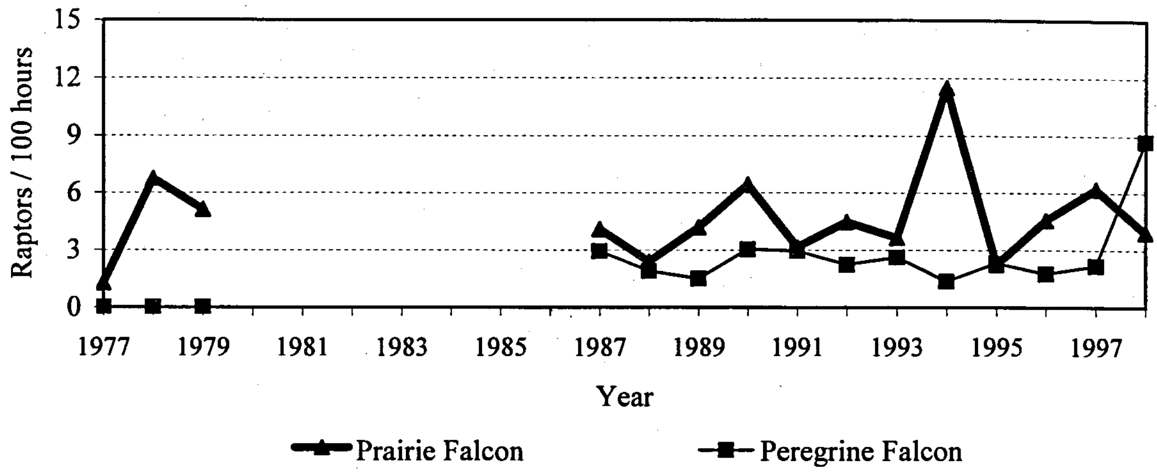


**Figure 22. Adjusted annual passage rates for Prairie Falcons and Peregrine Falcons: 1977–1998.**

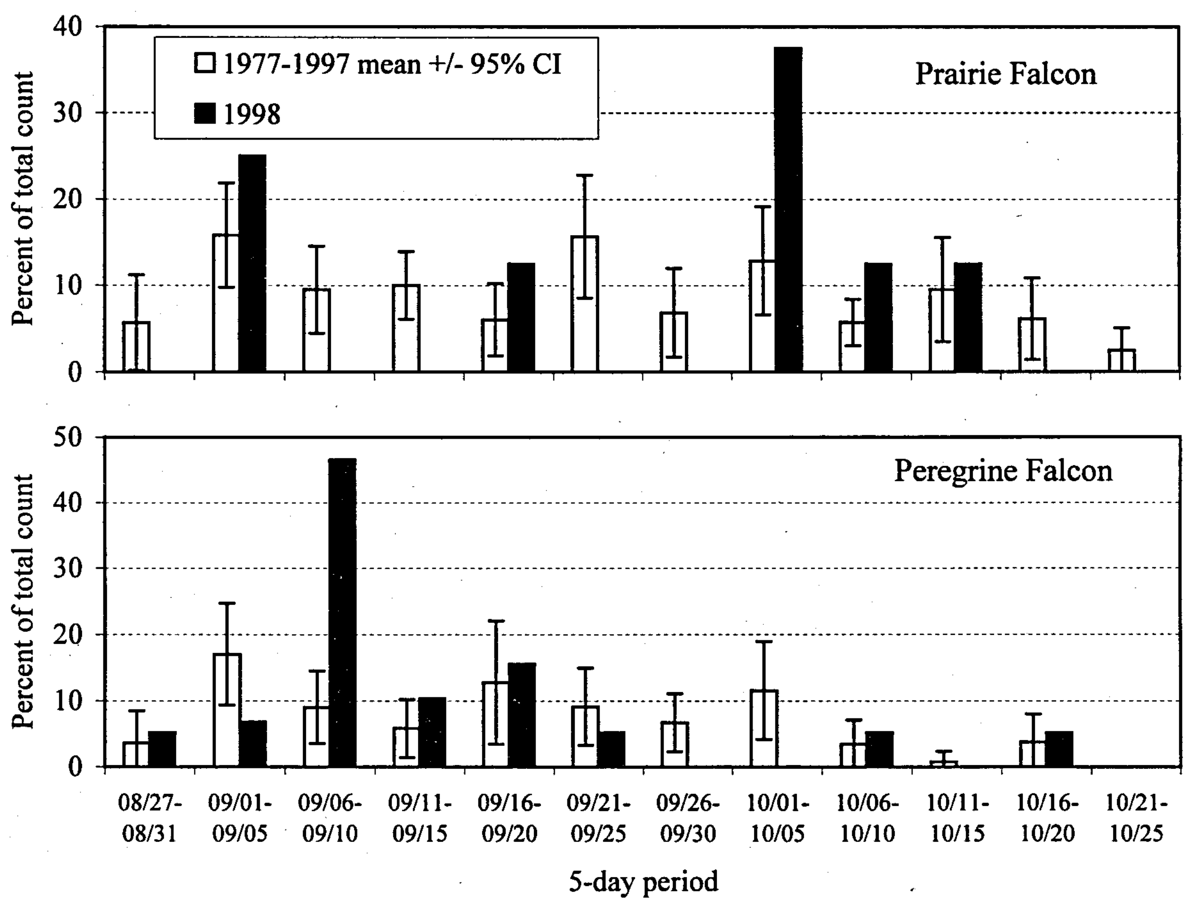


**Figure 23. Passage volume by five-day periods for Prairie Falcons and Peregrine Falcons: 1991–1997 versus 1998.**

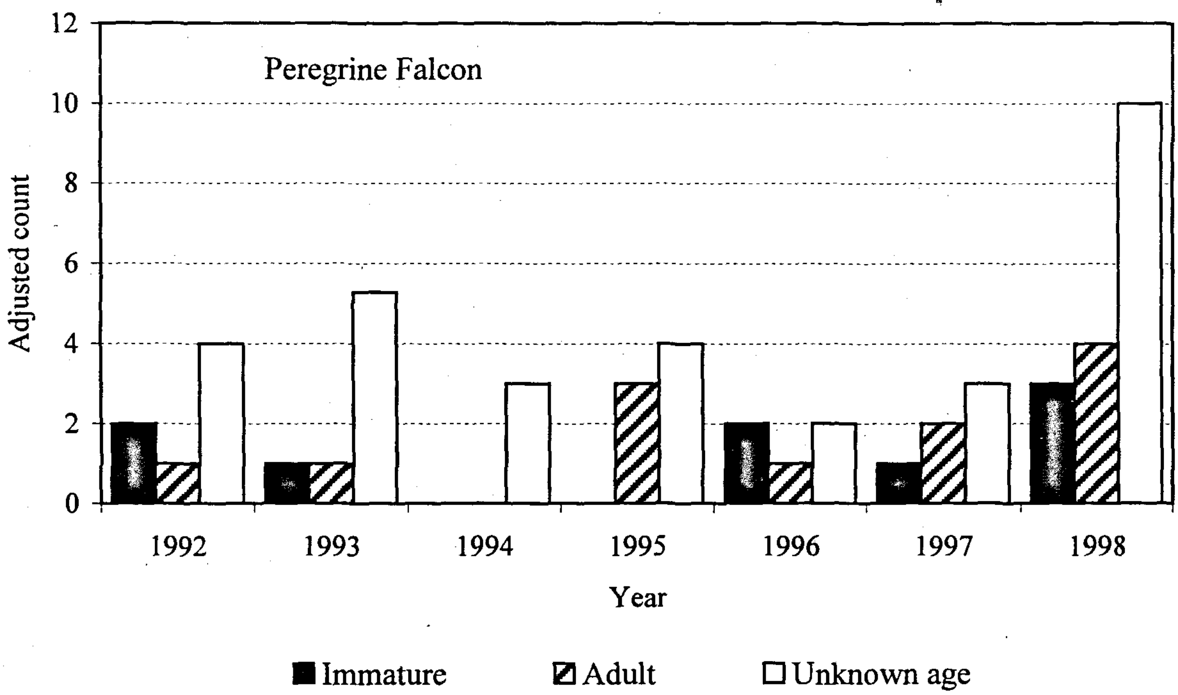


**Figure 24. Age composition of annual flights of Peregrine Falcons: 1992–1998.**

**Appendix A. Common and scientific names, species codes, and regularly applied age, sex, and color morph classifications for all raptor species observed during migration in the Wellsville Mountains.**

| Common Name | Scientific Name | Species Code | Age[1] | Sex[2] | Color Morph[3] |
|---|---|---|---|---|---|
| Turkey Vulture | *Cathartes aura* | TV | U | U | NA |
| Osprey | *Pandion haliaetus* | OS | U | U | NA |
| Northern Harrier | *Circus cyaneus* | NH | A I Br U | M F U | NA |
| Sharp-shinned Hawk | *Accipiter striatus* | SS | A I U | U | NA |
| Cooper's Hawk | *Accipiter cooperii* | CH | A I U | U | NA |
| Northern Goshawk | *Accipiter gentilis* | NG | A I U | U | NA |
| Unknown accipiter | *Accipiter* spp. | UA | U | U | NA |
| Broad-winged Hawk | *Buteo platypterus* | BW | A I U | U | D L U |
| Swanson's Hawk | *Buteo swainsoni* | SW | U | U | D L U |
| Red-tailed Hawk | *Buteo jamaicensis* | RT | A I U | U | D L U |
| Ferruginous Hawk | *Buteo regalis* | FH | A I U | U | D L U |
| Rough-legged Hawk | *Buteo lagopus* | RL | U | U | D L U |
| Unknown buteo | *Buteo* spp. | UB | U | U | D L U |
| Golden Eagle | *Aquila chrysaetos* | GE | A 2 1 I/S U[4] | U | NA |
| Bald Eagle | *Haliaeetus leucocephalus* | BE | A 3 2 1 I/S U[5] | U | NA |
| Unknown eagle | *Aquila* or *Haliaeetus spp.* | UE | U | U | NA |
| American Kestrel | *Falco sparverius* | AK | U | M F U | NA |
| Merlin | *Falco columbarius* | ML | AM Br | M U | NA |
| Prairie Falcon | *Falco mexicanus* | PR | U | U | NA |
| Peregrine Falcon | *Falco peregrinus* | PG | U | U | NA |
| Unknown falcon | *Falco* spp. | UF | U | U | NA |
| Unknown raptor | Falconiformes | UU | U | U | NA |

[1] Age classification codes: A = adult, I = immature (HY), Br = brown (adult female or immature), U – unknown age.

[2] Sex classification codes: M = male, F = female, U = unknown.

[3] Color morph classification codes: D = dark or rufous, L = light, U – unknown, NA = not applicable.

[4] Golden Eagle age codes: A = adult — no white in wings or tail; 2 = plumage class 2 — no white patch in wings, obvious white in tail; 1 = plumage class 1 — white wing patch visible below, small wing patch may be visible above, bold white in tail; I/S = unknown age immature or subadult — obvious white in tail, wings not adequately observed

[5] Bald Eagle age codes: A = adult — completely white head and tail; 3 = plumage class 3 — head mostly white, with osprey-like dark eyeline; 2 = plumage class 2 — dark head, light belly, and/or upside-down white triangle on back; 1 = plumage class 1 — dark head, breast, and belly; I/S = unknown age immature or subadult — dark or mottled head, other plumage features not adequately observed.

**Appendix B. History of observer participation in the Wellsville Raptor Migration Study: 1977–1998.**

**1977:** Single observer throughout: Wayne Potts (0)[1]

**1978:** Single observer throughout: 5–6 rotating observers (0)

**1979:** Single observer throughout: 5–6 rotating observers (0)

**1987:** Single observer throughout: Joe DiDonato (1), Fred Tilly (16), and Allen Hale (2)

**1988:** Single observer throughout: Scott Stoleson (0)

**1989:** Single observer throughout: LisaBeth Daly (1)

**1990:** Single observer throughout: Jane Kidd (0)

**1991:** Two observers throughout: Jim Daly (4), and Bernd Rindermann (0)

**1992:** Two observers throughout: Shawn Farry (0), and Frank A. LaSorte (0)

**1993:** Two observers throughout: Rob Clemens (1), Chris Berger—1st half (0), Andy Day—2nd half (0)

**1994:** Two observers throughout: Susan Salafsky (1), and Mari Remsberg (0)

**1995:** Two observers throughout: Sean O'Connor (1), and Paul Archibald (0)

**1996:** Two observers throughout: Susan Thomas (1), Scott Harris (1)

**1997:** Two observers throughout: Julie Heath (0), Doug Cooper (0), and Rob Wilson (1)

**1998:** Two observers throughout: David Tidhar (0), and Wendy Peacock (0)

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[1] Numbers in parentheses indicate the number of previous full-seasons of experience conducting migratory raptor counts.

**Appendix C. Daily observation effort, visitation, and weather records: 1998.**

| Date | Obs. Hours | Average Observers / Hour | Average Visitors / Hour | Sky Condition[1] | Thermal Lift[2] | Wind Speed[3] | Wind Direct. | Avg. Temp. (°C) | Avg. Visib. E (km) | Avg. Visib. W (km) | Flight Dist.[4] | Raptors / Hour |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 23-Aug | 5.08 | 1.3 | 0.0 | clr | 2 | 3 | sw-w | 23.0 | 29.2 | 38.3 | 2 | 2.8 |
| 24-Aug | 7.00 | 2.0 | 0.3 | clr, hz | 1 | 1 | var | 18.3 | 25.0 | 26.3 | 2 | 4.0 |
| 25-Aug | 2.50 | 1.5 | 0.0 | ovc, hz | 3 | 4 | sw-s | 18.0 | 20.0 | 16.7 | 2 | 4.4 |
| 26-Aug | 5.00 | 1.7 | 0.0 | pc-ovc, fog/hz | 3 | 3 | var | 17.5 | 8.3 | 11.7 | 2 | 5.0 |
| 27-Aug | 8.50 | 1.8 | 0.0 | clr, hz | 1 | 1 | sw, var | 16.0 | 30.6 | 23.9 | 2 | 2.9 |
| 28-Aug | 8.00 | 1.8 | 0.0 | clr-pc, hz | 1 | 1 | sw | 20.8 | 12.2 | 25.6 | 2 | 5.9 |
| 29-Aug | 8.00 | 1.6 | 0.0 | clr-mc, hz | 2 | 2 | sw-s, var | 23.1 | 9.4 | 8.8 | 2 | 5.8 |
| 30-Aug | 9.00 | 1.8 | 0.9 | cl-ovc, hz | 3 | 2 | sw-s, var | 22.1 | 17.0 | 18.0 | 2 | 5.8 |
| 31-Aug | 8.50 | 2.0 | 0.0 | pc-ovc, hz | 3 | 3 | ne-e | 19.2 | 15.5 | 16.0 | 2 | 4.6 |
| 1-Sep | 8.00 | 0.8 | 0.0 | clr, hz | 2 | 2 | ne-e, var | 18.1 | 22.5 | 21.3 | 2 | 7.9 |
| 2-Sep | 0.00 | | | ovc, rain | | | | | | | | |
| 3-Sep | 5.00 | 1.7 | 0.0 | clr, hz | 1 | 1 | sw-w | 25.2 | 17.5 | 10.0 | 2 | 14.6 |
| 4-Sep | 8.75 | 1.6 | 0.0 | pc-ovc, hz | 3 | 1 | w, var | 25.7 | 18.9 | 25.6 | 2 | 11.2 |
| 5-Sep | 1.08 | 0.7 | 0.0 | ovc, rain | 4 | 3 | w, var | 16.0 | 27.5 | 25.0 | 2 | 1.8 |
| 6-Sep | 6.50 | 3.5 | 0.0 | pc-ovc, rain | 3 | 1 | w, var, sw | 20.0 | 29.4 | 26.3 | 2 | 5.8 |
| 7-Sep | 6.75 | 2.5 | 0.0 | pc-ovc, hz, rain | 3 | 2 | s-w | 21.6 | 20.0 | 12.5 | 2 | 9.8 |
| 8-Sep | 8.50 | 1.6 | 0.0 | clr-pc, hz | 2 | 2 | s-w | 19.9 | 26.1 | 24.4 | 1 | 10.6 |
| 9-Sep | 7.50 | 1.8 | 0.0 | pc-ovc, hz/rain/ts | 4 | 3 | s-sw, var | 16.9 | 16.3 | 31.9 | 2 | 5.6 |
| 10-Sep | 7.00 | 1.8 | 0.0 | pc-ovc, rain/ts | 3 | 2 | var | 18.3 | 31.9 | 19.4 | 2 | 8.9 |
| 11-Sep | 7.75 | 1.3 | 0.0 | pc-ovc, hz, rain | 4 | 2 | s-sw | 21.9 | 23.1 | 41.3 | 2 | 6.6 |
| 12-Sep | 0.00 | | | ovc, rain | | | | | | | | |
| 13-Sep | 6.00 | 2.9 | 0.0 | clr-ovc, fog | 3 | 1 | var | 18.1 | 25.0 | 15.0 | 2 | 26.2 |
| 14-Sep | 8.50 | 1.8 | 0.0 | clr, hz | 1 | 1 | var | 24.4 | 20.0 | 23.3 | 2 | 26.4 |
| 15-Sep | 9.00 | 1.8 | 0.0 | clr, hz | 1 | 1 | sw-se | 23.7 | 28.0 | 19.5 | 2 | 21.4 |
| 16-Sep | 8.50 | 2.6 | 0.0 | clr-pc, hz | 1 | 2 | s-w | 24.9 | 30.0 | 19.0 | 2 | 18.8 |
| 17-Sep | 8.75 | 1.8 | 0.0 | clr-pc, hz | 2 | 2 | s-sw | 27.6 | 28.5 | 29.0 | 2 | 8.6 |
| 18-Sep | 9.00 | 1.8 | 0.0 | clr-mc | 3 | 6 | n, s-sw | 23.5 | 26.0 | 35.0 | 2 | 22.6 |
| 19-Sep | 3.25 | 1.8 | 0.0 | clr-ovc, hz | 4 | 1 | sw | 11.3 | 32.5 | 45.0 | 1 | 4.6 |
| 20-Sep | 3.00 | 2.2 | 0.8 | ovc, fog/rain/snow | 4 | 1 | s-sw | 8.3 | 26.7 | 35.0 | 1 | 12.3 |
| 21-Sep | 0.00 | | | ovc, rain | | | | | | | | |
| 22-Sep | 7.50 | 1.9 | 0.0 | clr-ovc, hz | 3 | 2 | s-w | 11.9 | 23.8 | 23.8 | 1 | 19.6 |
| 23-Sep | 8.50 | 2.1 | 0.0 | pc, hz/rain | 2 | 2 | s-w | 15.0 | 14.4 | 22.8 | 2 | 18.8 |
| 24-Sep | 8.75 | 1.0 | 0.0 | cl,pc,mc,hz | 2 | 2 | s-w | 15.9 | 23.9 | 23.9 | 2 | 18.9 |
| 25-Sep | 0.00 | | | ovc, rain | | | | | | | | |
| 26-Sep | 0.00 | | | ovc, rain | | | | | | | | |
| 27-Sep | 7.50 | 4.3 | 0.0 | clr | 1 | 2 | s-sw, var | 16.6 | 26.9 | 28.1 | 1 | 25.7 |
| 28-Sep | 8.75 | 4.8 | 0.0 | clr, hz | 2 | 2 | s-w | 18.1 | 31.1 | 28.3 | 1 | 25.7 |
| 29-Sep | 7.75 | 1.6 | 0.0 | clr | 1 | 2 | var | 18.6 | 32.5 | 30.6 | 2 | 12.9 |
| 30-Sep | 4.50 | 4.2 | 0.0 | mc-ovc, rain/ts | 3 | 2 | var | 16.4 | 22.0 | 37.0 | 2 | 16.9 |
| 1-Oct | 0.00 | | | ovc, rain | | | | | | | | |
| 2-Oct | 7.50 | 1.7 | 0.0 | ovc, hz/rain | 4 | 4 | var | 10.0 | 20.6 | 18.8 | 2 | 29.3 |
| 3-Oct | 4.25 | 1.7 | 1.3 | ovc, fog/snow/ts | 4 | 0 | n, var | 9.2 | 6.4 | 0.0 | 2 | 2.8 |
| 4-Oct | 2.33 | 1.3 | 0.0 | ovc, fog/snow | 4 | 1 | n-e, var | -0.7 | 5.0 | 3.3 | 2 | 4.3 |
| 5-Oct | 7.00 | 1.8 | 0.0 | clr-mc, fog | 2 | 2 | n, s-w | -0.5 | 30.6 | 29.4 | 2 | 6.6 |
| 6-Oct | 8.00 | 1.9 | 0.9 | clr, hz | 1 | 2 | n-ne, var | 3.4 | 35.0 | 21.1 | 2 | 9.9 |

Appendix B. continued

| Date | Obs. Hours | Average Observers / Hour | Average Visitors / Hour | Sky Condition[1] | Thermal Lift[2] | Wind Speed[3] | Wind Direct. | Avg. Temp. (°C) | Avg. Visib. E (km) | Avg. Visib. W (km) | Flight Dist.[4] | Raptors / Hour |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7-Oct | 8.25 | 1.8 | 7.2 | clr-pc, hz | 2 | 5 | s-sw | 11.0 | 28.9 | 23.9 | 1 | 14.1 |
| 8-Oct | 8.50 | 1.6 | 0.0 | clr, hz | 1 | 3 | s-sw | 12.0 | 25.6 | 23.3 | 1 | 25.2 |
| 9-Oct | 7.50 | 1.3 | 0.0 | clr-mc, hz | 2 | 2 | var, s-sw | 11.5 | 20.6 | 22.5 | 2 | 15.3 |
| 10-Oct | 6.50 | 3.3 | 0.5 | clr-ovc | 2 | 2 | sw-nw, var | 7.1 | 16.4 | 31.4 | 2 | 6.2 |
| 11-Oct | 6.50 | 3.1 | 0.4 | clr-pc | 2 | 3 | s-sw | 9.9 | 32.1 | 30.0 | 1 | 4.8 |
| 12-Oct | 0.00 | | | ovc, rain | | | | | | | | |
| 13-Oct | 6.50 | 1.9 | 0.0 | clr-mc, hz | 1 | 3 | s-sw | 13.7 | 31.4 | 24.3 | 2 | 13.4 |
| 14-Oct | 6.50 | 1.8 | 0.0 | clr-ovc, hz | 3 | 2 | s-w | 11.0 | 27.1 | 30.0 | 2 | 7.8 |
| 15-Oct | 0.00 | | | fog, snow | | | | | | | | |
| 16-Oct | 0.00 | | | fog, snow | | | | | | | | |
| 17-Oct | 4.50 | 1.5 | 0.0 | clr-pc | 2 | 2 | sw | -0.6 | 26.0 | 30.0 | 2 | 7.6 |
| 18-Oct | 8.00 | 2.0 | 0.0 | pc-ovc | 3 | 2 | var | 3.1 | 34.4 | 37.8 | 1 | 0.9 |
| 19-Oct | 8.50 | 1.8 | 0.0 | clr-pc | 2 | 2 | n-e | 4.3 | 31.7 | 32.2 | 1 | 2.0 |
| 20-Oct | 3.50 | 2.0 | 0.0 | clr | 4 | 7 | e | 5.2 | 35.0 | 48.0 | | 0.0 |
| 21-Oct | 5.50 | 0.9 | 0.0 | clr-pc, hz | 2 | 2 | e-s | 7.8 | 35.0 | 37.5 | 2 | 2.0 |
| 22-Oct | 0.00 | | | snow | | | | | | | | |
| 23-Oct | 4.25 | 0.8 | 0.0 | pc-ovc, fog/snow | 4 | 2 | s-sw | 3.8 | 9.0 | 8.0 | 1 | 4.9 |
| 24-Oct | 5.00 | 0.7 | 0.6 | mc-ovc, hz | 4 | 2 | var, s-sw | 10.6 | 12.0 | 13.0 | 2 | 6.8 |
| 25-Oct | 2.50 | 1.5 | 0.0 | ovc, fog | 4 | 3 | n-ne | 6.3 | 11.7 | 3.3 | 1 | 1.2 |

[1] Predominant sky condition during day: clr = clear (0-15% cloud cover); pc = partly cloudy (16-50% cover); mc = mostly cloudy (51-75% cover); ovc = overcast (76-100% cover); hz = haze; ts = thunder storms; others are self-explanatory.

[2] Average of hourly ratings concerning prevalence of lift-generating thermals, based on subjective assessments of solar intensity, wind speeds, and migrant behavior: 1 = excellent, 2 = good, 3 = fair, 4 = poor.

[3] Average of hourly categorical ratings: 0 = less than 1 km/h; 1 = 1–5 km/h; 2 = 6–11 km/h; 3 = 12–19 km/h; 4 = 20–28 km/h; 5 = 29–38 km/h; 6 = 39–49 kph; 7 = 50–61 kph.

[4] Average of hourly line-of-sight ratings concerning distance of flight from observation site: 1 = close, detection and identification possible with naked eye; 2 = moderate, detection possible with naked eye, but binoculars needed for identification; 3 = far, binoculars needed for both detection and identification; 4 = distant, birds detected and identified only with excellent binoculars or spotting scope and by experienced observers.

**Appendix D. Observation hours and daily count totals (complete, unadjusted data) by species: 1998.**

| Date | Hours | TV | OS | NH | SS | CH | NG | UA | BW | SW | RT | FH | RL | UB | GE | BE | AK | ML | PR | PG | UF | UU | Total | Birds / hr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 23-Aug | 5.08 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 3 | 0 | 2 | 0 | 0 | 1 | 0 | 1 | 14 | 2.8 |
| 24-Aug | 7.00 | 0 | 0 | 3 | 3 | 1 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 9 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 28 | 4.0 |
| 25-Aug | 2.50 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 7 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 11 | 4.4 |
| 26-Aug | 5.00 | 0 | 0 | 4 | 4 | 4 | 0 | 0 | 0 | 4 | 1 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 25 | 5.0 |
| 27-Aug | 8.50 | 0 | 0 | 2 | 4 | 1 | 0 | 0 | 0 | 7 | 0 | 0 | 1 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 25 | 2.9 |
| 28-Aug | 8.00 | 0 | 0 | 5 | 4 | 3 | 0 | 0 | 6 | 14 | 0 | 0 | 1 | 0 | 10 | 0 | 2 | 0 | 0 | 0 | 1 | 1 | 47 | 5.9 |
| 29-Aug | 8.00 | 0 | 0 | 2 | 2 | 2 | 0 | 0 | 13 | 12 | 1 | 0 | 2 | 0 | 10 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 46 | 5.8 |
| 30-Aug | 9.00 | 0 | 0 | 6 | 6 | 2 | 0 | 0 | 21 | 9 | 0 | 0 | 1 | 0 | 6 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 52 | 5.8 |
| 31-Aug | 8.50 | 1 | 0 | 3 | 2 | 2 | 0 | 0 | 4 | 14 | 0 | 0 | 1 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 39 | 4.6 |
| 1-Sep | 8.00 | 0 | 0 | 7 | 7 | 2 | 0 | 0 | 5 | 22 | 0 | 0 | 1 | 0 | 13 | 0 | 0 | 1 | 3 | 1 | 0 | 1 | 63 | 7.9 |
| 2-Sep | 0.00 | | | | | | | | | | | | | | | | | | | | | | | |
| 3-Sep | 5.00 | 6 | 0 | 2 | 19 | 18 | 1 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 18 | 0 | 1 | 0 | 3 | 0 | 1 | 1 | 73 | 14.6 |
| 4-Sep | 8.75 | 5 | 0 | 9 | 27 | 8 | 0 | 0 | 11 | 8 | 0 | 0 | 1 | 0 | 18 | 0 | 1 | 0 | 3 | 3 | 0 | 4 | 98 | 11.2 |
| 5-Sep | 1.08 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 1.8 |
| 6-Sep | 6.50 | 1 | 1 | 3 | 6 | 4 | 0 | 0 | 0 | 2 | 0 | 0 | 3 | 0 | 16 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 38 | 5.8 |
| 7-Sep | 6.75 | 0 | 7 | 6 | 14 | 8 | 0 | 0 | 2 | 6 | 0 | 0 | 3 | 0 | 17 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 66 | 9.8 |
| 8-Sep | 8.50 | 0 | 2 | 4 | 20 | 14 | 0 | 0 | 0 | 8 | 0 | 0 | 6 | 0 | 30 | 0 | 0 | 3 | 2 | 0 | 0 | 1 | 90 | 10.6 |
| 9-Sep | 7.50 | 2 | 1 | 0 | 15 | 1 | 0 | 0 | 2 | 6 | 0 | 0 | 2 | 0 | 9 | 0 | 0 | 3 | 0 | 1 | 0 | 0 | 42 | 5.6 |
| 10-Sep | 7.00 | 0 | 0 | 7 | 15 | 9 | 0 | 0 | 2 | 12 | 0 | 0 | 1 | 0 | 12 | 0 | 0 | 1 | 2 | 1 | 0 | 0 | 62 | 8.9 |
| 11-Sep | 7.75 | 0 | 0 | 6 | 12 | 6 | 0 | 0 | 0 | 8 | 0 | 0 | 1 | 0 | 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 51 | 6.6 |
| 12-Sep | 0.00 | | | | | | | | | | | | | | | | | | | | | | | |
| 13-Sep | 6.00 | 0 | 3 | 13 | 19 | 6 | 1 | 0 | 72 | 19 | 0 | 0 | 2 | 0 | 18 | 0 | 0 | 1 | 1 | 0 | 0 | 2 | 157 | 26.2 |
| 14-Sep | 8.50 | 0 | 2 | 24 | 38 | 33 | 1 | 0 | 51 | 35 | 1 | 0 | 4 | 0 | 24 | 1 | 0 | 1 | 6 | 1 | 0 | 2 | 224 | 26.4 |
| 15-Sep | 9.00 | 1 | 0 | 23 | 49 | 17 | 0 | 0 | 29 | 30 | 2 | 1 | 6 | 0 | 29 | 0 | 0 | 0 | 3 | 2 | 0 | 1 | 193 | 21.4 |
| 16-Sep | 8.50 | 0 | 5 | 18 | 40 | 36 | 0 | 0 | 2 | 29 | 0 | 0 | 4 | 0 | 22 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 160 | 18.8 |
| 17-Sep | 8.75 | 0 | 1 | 5 | 23 | 13 | 0 | 0 | 5 | 10 | 0 | 0 | 5 | 0 | 12 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 75 | 8.6 |
| 18-Sep | 9.00 | 0 | 0 | 5 | 31 | 23 | 0 | 0 | 22 | 35 | 1 | 0 | 4 | 0 | 67 | 0 | 0 | 1 | 4 | 5 | 0 | 5 | 203 | 22.6 |
| 19-Sep | 3.25 | 0 | 1 | 1 | 1 | 4 | 1 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 15 | 4.6 |
| 20-Sep | 3.00 | 0 | 1 | 3 | 8 | 10 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 37 | 12.3 |
| 21-Sep | 0.00 | | | | | | | | | | | | | | | | | | | | | | | |
| 22-Sep | 7.50 | 0 | 0 | 31 | 28 | 27 | 0 | 0 | 10 | 25 | 1 | 0 | 7 | 0 | 14 | 0 | 0 | 1 | 2 | 0 | 0 | 1 | 147 | 19.6 |
| 23-Sep | 8.50 | 1 | 6 | 17 | 38 | 26 | 0 | 0 | 9 | 34 | 0 | 0 | 0 | 0 | 26 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 160 | 18.8 |
| 24-Sep | 8.75 | 0 | 2 | 19 | 30 | 33 | 0 | 1 | 17 | 26 | 2 | 0 | 3 | 0 | 27 | 1 | 0 | 0 | 4 | 0 | 0 | 0 | 165 | 18.9 |
| 25-Sep | 0.00 | | | | | | | | | | | | | | | | | | | | | | | |
| 26-Sep | 0.00 | | | | | | | | | | | | | | | | | | | | | | | |

Appendix D. continued.

| Date | Hours | TV | OS | NH | SS | CH | NG | UA | BW | SW | RT | FH | RL | UB | GE | BE | AK | ML | PR | PG | UF | UU | Total | Birds / hr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 27-Sep | 7.50 | 0 | 1 | 22 | 44 | 32 | 0 | 0 | 4 | 25 | 0 | 0 | 2 | 0 | 57 | 2 | 0 | 0 | 3 | 1 | 0 | 0 | 193 | 25.7 |
| 28-Sep | 8.75 | 0 | 5 | 33 | 69 | 39 | 0 | 0 | 13 | 19 | 0 | 0 | 1 | 0 | 46 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 225 | 25.7 |
| 29-Sep | 7.75 | 0 | 0 | 19 | 30 | 13 | 2 | 0 | 5 | 13 | 0 | 0 | 1 | 0 | 12 | 0 | 0 | 0 | 4 | 0 | 0 | 1 | 100 | 12.9 |
| 30-Sep | 4.50 | 0 | 0 | 10 | 28 | 15 | 0 | 0 | 0 | 16 | 0 | 0 | 2 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 76 | 16.9 |
| 1-Oct | 0.00 | | | | | | | | | | | | | | | | | | | | | | | |
| 2-Oct | 7.50 | 0 | 1 | 6 | 82 | 43 | 2 | 0 | 3 | 18 | 1 | 0 | 12 | 0 | 46 | 0 | 3 | 0 | 2 | 1 | 0 | 0 | 220 | 29.3 |
| 3-Oct | 4.25 | 0 | 0 | 1 | 7 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 2.8 |
| 4-Oct | 2.33 | 0 | 0 | 3 | 3 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 4.3 |
| 5-Oct | 7.00 | 0 | 0 | 13 | 11 | 3 | 0 | 0 | 0 | 6 | 0 | 0 | 8 | 0 | 4 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 46 | 6.6 |
| 6-Oct | 8.00 | 0 | 0 | 15 | 25 | 16 | 0 | 0 | 0 | 6 | 0 | 0 | 11 | 0 | 4 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 79 | 9.9 |
| 7-Oct | 8.25 | 0 | 0 | 8 | 52 | 18 | 1 | 0 | 0 | 7 | 0 | 0 | 8 | 0 | 13 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 108 | 13.1 |
| 8-Oct | 8.50 | 0 | 0 | 10 | 85 | 21 | 1 | 0 | 0 | 37 | 0 | 0 | 9 | 0 | 23 | 3 | 0 | 1 | 1 | 0 | 0 | 0 | 191 | 22.5 |
| 9-Oct | 7.50 | 0 | 0 | 13 | 32 | 23 | 0 | 0 | 0 | 8 | 0 | 0 | 6 | 0 | 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 101 | 13.5 |
| 10-Oct | 6.50 | 0 | 0 | 15 | 7 | 6 | 0 | 0 | 0 | 4 | 0 | 0 | 4 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 39 | 6.0 |
| 11-Oct | 6.50 | 0 | 0 | 7 | 7 | 1 | 1 | 0 | 0 | 8 | 0 | 0 | 2 | 0 | 3 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 30 | 4.6 |
| 12-Oct | 0.00 | | | | | | | | | | | | | | | | | | | | | | | |
| 13-Oct | 6.50 | 0 | 0 | 8 | 31 | 14 | 0 | 0 | 0 | 5 | 1 | 0 | 11 | 0 | 10 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 82 | 12.6 |
| 14-Oct | 6.50 | 0 | 0 | 6 | 5 | 9 | 1 | 0 | 0 | 15 | 2 | 0 | 2 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 46 | 7.1 |
| 15-Oct | 0.00 | | | | | | | | | | | | | | | | | | | | | | | |
| 16-Oct | 0.00 | | | | | | | | | | | | | | | | | | | | | | | |
| 17-Oct | 4.50 | 0 | 0 | 4 | 7 | 4 | 2 | 0 | 0 | 3 | 0 | 0 | 4 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 27 | 6.0 |
| 18-Oct | 8.00 | 0 | 0 | 3 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 0.9 |
| 19-Oct | 8.50 | 0 | 0 | 5 | 3 | 5 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 15 | 1.8 |
| 20-Oct | 3.50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| 21-Oct | 5.50 | 0 | 0 | 3 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 2.0 |
| 22-Oct | 0.00 | | | | | | | | | | | | | | | | | | | | | | | |
| 23-Oct | 4.25 | 0 | 0 | 4 | 2 | 3 | 0 | 0 | 0 | 4 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 14 | 3.3 |
| 24-Oct | 5.00 | 0 | 0 | 5 | 5 | 2 | 0 | 0 | 0 | 11 | 1 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 27 | 5.4 |
| 25-Oct | 2.50 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0.8 |
| Total | 358.75 | 17 | 39 | 443 | 1005 | 587 | 14 | 1 | 309 | 609 | 14 | 1 | 154 | 0 | 727 | 11 | 13 | 19 | 55 | 19 | 2 | 30 | 4069 | 11.3 |

**Appendix E. Observation effort and raptor counts (complete, unadjusted data) by year and species: 1977-1979, 1987-1998.**

| | 1977 | 1978 | 1979 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Start date | 6-Aug | 4-Sep | 6-Sep | 7-Sep | 3-Sep | 3-Sep | 28-Aug | 25-Aug | 23-Aug | 24-Aug | 26-Aug | 22-Aug | 23-Aug | 22-Aug | 23-Aug | 26-Aug |
| End date | 26-Nov | 1-Nov | 17-Oct | 20-Oct | 20-Oct | 20-Oct | 20-Oct | 24-Oct | 25-Oct | 26-Oct | 26-Oct | 25-Oct | 25-Oct | 25-Oct | 25-Oct | 25-Oct |
| Observation days | 62 | 43 | 41 | 42 | 45 | 47 | 52 | 59 | 63 | 55 | 49 | 62 | 55 | 57 | 53 | 52 |
| Observation hours | 317.17 | 234.83 | 242.25 | 303.50 | 366.42 | 315.92 | 339.00 | 417.75 | 428.00 | 414.25 | 333.25 | 407.75 | 374.25 | 377.92 | 358.75 | 348.73 |
| Raptors / 100 hours | 885.0 | 1257.5 | 1160.4 | 968.7 | 899.8 | 981.6 | 707.1 | 1189.9 | 1048.1 | 908.6 | 1461.7 | 1389.8 | 1222.4 | 712.3 | 1134.2 | 1061.8 |
| SPECIES | RAPTOR COUNTS | | | | | | | | | | | | | | | |
| Turkey Vulture | 6 | 7 | 8 | 11 | 10 | 9 | 1 | 39 | 15 | 28 | 16 | 43 | 33 | 47 | 17 | 19 |
| Osprey | 5 | 8 | 13 | 11 | 17 | 30 | 19 | 34 | 29 | 25 | 44 | 41 | 35 | 39 | 39 | 26 |
| Northern Harrier | 159 | 200 | 173 | 278 | 181 | 172 | 196 | 430 | 330 | 208 | 363 | 362 | 315 | 171 | 443 | 265 |
| Sharp-shinned Hawk | 618 | 737 | 570 | 793 | 1073 | 832 | 546 | 997 | 989 | 1000 | 901 | 1217 | 928 | 652 | 1005 | 857 |
| Cooper's Hawk | 457 | 333 | 495 | 362 | 549 | 603 | 260 | 621 | 601 | 596 | 778 | 874 | 701 | 388 | 587 | 547 |
| Northern Goshawk | 35 | 32 | 30 | 8 | 15 | 15 | 20 | 18 | 74 | 26 | 16 | 23 | 27 | 17 | 14 | 25 |
| Unidentified accipiter | 86 | 53 | 122 | 64 | 25 | 43 | 47 | 59 | 124 | 44 | 70 | 66 | 73 | 22 | 55 | 64 |
| TOTAL ACCIPITERS | 1196 | 1155 | 1217 | 1227 | 1662 | 1493 | 873 | 1695 | 1788 | 1666 | 1765 | 2180 | 1729 | 1079 | 1661 | 1492 |
| Broad-winged Hawk | 0 | 0 | 2 | 5 | 1 | 9 | 4 | 10 | 3 | 2 | 5 | 13 | 7 | 3 | 1 | 4 |
| Swainson's Hawk | 19 | 5 | 21 | 44 | 12 | 47 | 188 | 129 | 97 | 91 | 487 | 468 | 419 | 106 | 309 | 163 |
| Red-tailed Hawk | 311 | 258 | 238 | 409 | 401 | 413 | 298 | 908 | 566 | 621 | 891 | 926 | 876 | 430 | 609 | 544 |
| Ferruginous Hawk | 2 | 0 | 3 | 6 | 11 | 8 | 6 | 16 | 13 | 15 | 23 | 18 | 15 | 8 | 14 | 11 |
| Rough-legged Hawk | 2 | 0 | 1 | 1 | 4 | 3 | 0 | 1 | 2 | 1 | 2 | 0 | 3 | 6 | 1 | 2 |
| Unidentified buteo | 10 | 13 | 21 | 12 | 5 | 5 | 34 | 17 | 38 | 26 | 14 | 24 | 33 | 9 | 19 | 19 |
| TOTAL BUTEOS | 344 | 276 | 286 | 477 | 434 | 485 | 530 | 1081 | 719 | 756 | 1422 | 1449 | 1353 | 562 | 953 | 742 |
| Golden Eagle | 236 | 285 | 237 | 73 | 106 | 119 | 108 | 292 | 423 | 133 | 224 | 163 | 127 | 212 | 154 | 193 |
| Bald Eagle | 5 | 3 | 3 | 5 | 4 | 0 | 2 | 13 | 10 | 10 | 4 | 3 | 2 | 7 | 0 | 5 |
| TOTAL EAGLES | 241 | 288 | 240 | 78 | 110 | 119 | 110 | 305 | 433 | 143 | 228 | 166 | 129 | 219 | 154 | 198 |
| American Kestrel | 808 | 970 | 799 | 817 | 857 | 744 | 557 | 1307 | 1118 | 888 | 975 | 1371 | 922 | 524 | 727 | 892 |
| Merlin | 2 | 3 | 5 | 10 | 11 | 15 | 3 | 21 | 17 | 8 | 11 | 17 | 12 | 8 | 11 | 10 |
| Prairie Falcon | 4 | 15 | 11 | 10 | 7 | 11 | 16 | 13 | 17 | 14 | 33 | 18 | 17 | 23 | 13 | 15 |
| Peregrine Falcon | 0 | 0 | 0 | 7 | 5 | 5 | 9 | 10 | 7 | 7 | 6 | 11 | 8 | 9 | 19 | 7 |
| Unidentified falcon | 0 | 0 | 2 | 2 | 1 | 2 | 4 | 2 | 3 | 3 | 0 | 1 | 1 | 3 | 2 | 2 |
| TOTAL FALCONS | 814 | 988 | 817 | 846 | 881 | 777 | 589 | 1353 | 1162 | 920 | 1025 | 1418 | 960 | 567 | 772 | 926 |
| Unidentified raptors | 42 | 31 | 57 | 12 | 2 | 16 | 79 | 34 | 10 | 18 | 8 | 8 | 21 | 8 | 30 | 25 |
| GRAND TOTAL | 2807 | 2953 | 2811 | 2940 | 3297 | 3101 | 2397 | 4971 | 4486 | 3764 | 4871 | 5667 | 4575 | 2692 | 4069 | 3693 |