FALL 2008 RAPTOR MIGRATION STUDY IN THE WELLSVILLE MOUNTAINS OF NORTHERN UTAH

HawkWatch International, Inc.
Salt Lake City, Utah

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The Wellsville Mountains Raptor Migration Project in northern Utah is an ongoing effort to monitor long-term population trends of raptors that migrate through the Wasatch Mountains along the western margin of the Rocky Mountain Flyway (Hoffman and Smith 2003, Smith et al. in press). Steve Hoffman and Wayne Potts discovered the Wellsville fall site in 1976 and conducted season-long counts from 1977 through 1979 (Hoffman and Potts 1985). The migration count was suspended from 1980 to 1986, and then reestablished by HawkWatch International (HWI) in 1987. Annual counts have occurred at the site since then, except during 2002 and 2005. To date, 17 species of raptors have been observed migrating along the Wellsville Mountains, with annual counts typically ranging between 2,500 and 5,000 migrants. This report summarizes count results from the 2008 season, which marked the 22nd full-season autumn count of migrating raptors at the site.

The Wellsvilles project was 1 of 14 long-term, annual migration counts conducted or co-sponsored by HWI in North America during 2008. The primary objective of these efforts is to track long-term population trends of diurnal raptors in western North America and around the Gulf Coast region (Hoffman and Smith 2003; Smith et al. 2001, 2008 a, b). Raptors serve as important biological indicators of ecosystem health (Bildstein 2001) and long-term migration counts are one of the most cost effective and efficient methods for monitoring the regional status and trends of multiple raptor species (Zalles and Bildstein 2000).

STUDY SITE

The Wellsville Mountains are situated northeast of the Great Salt Lake, 16 km west of Logan, Utah (41°41'18" N, 112°02'54" W; Figure 1). The single, traditional observation point is located at 2,617 m (8,585 ft) near the northern end of the Wellsville range (Figure 1) 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.

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 types 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, with primary vegetation along the ridgetop consisting of 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" (see Bildstein 2006) funneling migrating raptors into the Wellsvilles. In addition, the Great Salt Lake and Great Salt Desert to the west likely serve as barriers to migration for many raptors. Most species of raptors prefer not to fly over large expanses of water and inhospitable habitat (Kerlinger 1989). If this holds true for raptors navigating the Great Salt Lake, they would most likely divert their migratory flight around either side of the Bonneville Basin (Hoffman 1985), and 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 from the plains below, 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

Weather permitting, two official or designated observers conducted standardized daily counts of migrating raptors at the site from late August through October. Observations typically began between 0830 and 0930 H Mountain Standard Time (MST) and ended between 1630 and 1730 H MST. Official observer Josh Lawrey had three previous seasons of migration counting experience and attended pre-season protocol and field training. This was the first season of migration counting for official observer Ethan Peters, who began late, but received on-site training (see Appendix A for a complete history of official observer participation). Experienced visitors, previous official observers, and HWI staff occasionally assisted with spotting and identifying migrants.

Data gathering and recording followed standardized protocols used at all HWI migration sites (Hoffman and Smith 2003). The observers routinely recorded the following data:

1. Species, age, sex, and color morph of each migrant raptor, whenever possible and applicable (Appendix B 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, barometric pressure, percent cloud cover, predominant cloud type(s), presence of precipitation, visibility estimates, 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 the mean number of observers present during each hour (included designated observers plus volunteers/visitors who actively contributed to the count [active scanning, pointing out birds, recording data, etc.] for more than 10 minutes in a given hour), recorded on the hour.
6. A subjective visitor-disturbance rating for each hour, recorded on the hour.
7. Daily start and end times for each official or experienced observer.

We limited some data comparisons to the years 1991–2008; 1991 was the first year that a standardized two-observer system was instituted at the site (see Appendix A). Calculation of "adjusted" (to standardize sampling periods and adjust for incompletely identified birds) passage rates (migrants counted per 100 hours of observation) and analysis of trends updated through 2008 follows Hoffman and Smith (2003). In comparing 2008 annual statistics against means and 95% confidence intervals for previous seasons, we equate significance with a 2008 value falling outside the bounds of the confidence interval for the associated mean.

RESULTS AND DISCUSSION

WEATHER

Inclement weather fully precluded seven full days of potential observations between the targeted survey period of 27 August through 31 October, and reduced observation time to ≤4 hours on only one other day (see Appendix C for daily weather records). The 1997–2007 averages (the period for which detailed comparative data have been compiled) calculated across variable annual observation periods are 9.0 full and 3.3 partial days (see Appendix D for annual effort and count summaries). Thus, unlike especially

2006, when stormy weather and low-hanging clouds hindered the count to a record-setting degree, conditions were much milder for the site in 2008.

Based on hourly weather records collected during actual observation periods, the array of sky conditions documented in 2008 differed markedly from the average pattern for the last decade. Fair skies prevailed on a record-high 78% of the active observation days (1997–2007 average of 57%), transitional skies (i.e., skies changed from primarily fair to mostly cloudy or overcast during the day, or vice versa) on a below average 12% (average 25%), and mostly cloudy to overcast skies on an below average 10% of the active days (average of 17%). Visibility reducing fog and/or haze occurred on a significantly below average 24% of the active days (average 42%), and scattered rain and/or snow showers occurred on a significantly below average 2% of the active days (average 10%). These characteristics appeared to contribute to above-average visibility, with the 2008 averages of 78 km visibility to the east and west markedly higher than the 1997–2007 averages of 60–61 km.

The 2008 season was consistently windier than average, but without any gusty or strong winds that are typical for the site. Light winds (<12 kph) prevailed on 36%, moderate winds (12–28 kph) on 64%, and strong winds (>28 kph) on 0% of the active observation days. The comparative 1997–2007 averages are 43% light, 48% moderate, and 9% strong winds. Typically the most common wind pattern, S–SW winds, prevailed on a record-low 38% of the active days (average 53%). Several other more-variable patterns also were less common than usual in 2008, including SE–SW winds (0% vs. average of 5% of the active days), S–W winds (3% vs. average of 7%), and Variable winds (0% vs. average of 5%). In contrast, SW–W winds were much more prevalent than usual (36% vs. average of 7% of the active observation days).

The daily-average (mean of hourly readings) temperature averaged 13.3°C, ranging from 0.4 to 26.4°C. The average is significantly lower than the 1997–2007 mean of 14.6°C and ranks as second lowest since 1997; however, the minimum and maximum daily-averages fell well within the range of normal variability. The daily-average (mean of hourly readings) barometric pressure averaged 30.34 in Hg, ranging from 29.73 to 30.60 in Hg. The average is the highest recorded since 2001 (when we started recording such data) and the maximum is the second highest recorded to date. The proportion of days rated as good to excellent for thermal lift (53%) was above average (average 47%), which is consistent with a lack of strong winds in 2008.

In summary, fair skies prevailed more often than usual in 2008, rain/snow showers and fog/haze were less prevalent than usual, and the barometric pressure during active observation periods averaged higher than usual; however, the temperature regime was a bit cooler than usual and, although strong winds were largely absent this season, the winds averaged stronger than usual. In addition, SW–W winds were much more prevalent than usual, whereas several other more-variable patterns and the most common pattern, SW–W winds, were less common than usual. The reduction in cloudy conditions and fog/haze appeared to result in above-average visibility and, combined with the absence of strong winds, also appeared to increase the prevalence of days where thermal lift was rated as good to excellent.

OBSERVATION EFFORT

The observers worked on 59 of 66 possible observation days between 27 August and 31 October. The number of observation days was a significant 8% higher than the 1977–2007 average of 54 ± 95% CI of 2.8 days, and the number of observation hours (453.08) was a significant 16% higher than the 1977–2007 average of 391.04 ± 23.68 hours. The 2008 average of 1.6 observers per hour (includes official and guest observers; value is the mean of daily values, which are in turn means of hourly values) was a significant 16% lower than the 1977–2007 average of 1.9 ± 0.21 observers/hr, primarily due to our second observer starting two-weeks late.

FLIGHT SUMMARY

The observers tallied 4,372 migrant raptors of 16 species during the 2008 season (Table 1, and see Appendix E for daily count records). The flight was composed of 53% accipiters, 19% buteos, 15% falcons, 9% harriers, 3% eagles, and <1% each of Ospreys, vultures, and unidentified raptors (Figure 2). The proportional representations of accipiters, Ospreys, and vultures were significantly above average, whereas the proportional representations of falcons and buteos were significantly below average. The most numerous species were the Sharp-shinned Hawk (36% of the total count), Cooper's Hawk (15%), Red-tailed Hawk (14%), American Kestrel (14%), Northern Harrier (9%), Swainson's Hawk (4%), and Golden Eagle (3%). All other species each comprised ≤1% of the total count.

The total combined-species count was a significant 21% above the 1991–2007 average (Table 1). Counts of seven species were significantly above average (Osprey, Northern Harrier, Sharp-shinned Hawk, Cooper's Hawk, Swainson's Hawk, Broad-winged Hawk, Rough-legged Hawk, and Bald Eagle), whereas counts of three species (Turkey Vulture, Golden Eagle, and Prairie Falcon) were significantly below average (Table 1). The counts for Sharp-shinned Hawks and Broad-winged Hawks were new record highs for the site, whereas no record-low counts were recorded in 2008 (Appendix D).

Passage Rates and Long-term Trends

Adjusted passage rates were significantly above average in 2008 for Ospreys, Northern Harriers, Sharp-shinned Hawks, Cooper's Hawks, and Broad-winged Hawks, whereas they were significantly below average for Turkey Vultures, Northern Goshawks, Golden Eagles, American Kestrels, Merlins, and Prairie Falcons (Table 1). Updated regression analyses (after Hoffman and Smith 2003) of adjusted passage rates for the period 1987 through 2008 revealed at least marginally significant ($P \leq 0.10$) quadratic trends for four species (Turkey Vulture, Northern Goshawk, Golden Eagle, and Prairie Falcon), generally tracking hill-shaped patterns with increases through the early to mid-1990s followed by recent declines (Figures 3–7). A closer look at Golden Eagles indicated a significant quadratic trend for adult Golden Eagles, whereas a marginally significant linear decline applied to non-adult Golden Eagles (Figure 6). Similar quadratic models also applied previously to Ospreys, Northern Harriers, Cooper's, Swainson's, Red-tailed and Ferruginous Hawks, and American Kestrels; however, recent increases eliminated evidence of any significant long-term, first- or second-order trends for all but the latter two species (Figures 3–7). For both Ferruginous Hawks (Figure 6) and American Kestrels (Figure 7), however, at least marginally significant, linear declines are still indicated for 1987–2008. That said, the recent passage rates of Ferruginous Hawks have remained higher than those seen in the late 1970s, whereas the indication of a long-term decline for American Kestrels is further magnified when significantly higher counts from the late 1970s are considered (*t*-test comparing 1977–1979 vs. 1987–2008 averages, $P = 0.008$). In fact, although still one of North America's most common raptors, currently kestrels appear to be declining across the continent and therefore are of particular conservation concern (Farmer et al. 2008, Farmer and Smith in review). In contrast, the only other significant, species-level regression was a highly significant, long-term increasing trend for Peregrine Falcons, which again is a common pattern across much of North America (Hoffman and Smith 2003, Farmer et al. 2008).

The common pattern of increases through the late 1990s but then declines through at least the mid-2000s, correlates with rising regional moisture levels during the early to mid-1990s due to an *El Nino* weather pattern, followed by the onset of severe and widespread drought throughout much of the interior West beginning in 1999. This pattern of variation in passage rates is also common to other regional datasets, such as in the Goshute Mountains of northeastern Nevada (Smith and Hoffman 2003, Smith et al. 2008a). Moisture levels have improved again in the northern Intermountain and Rocky Mountain regions since 2005, and evidence of recent increases in the Wellsvilles for several species likely reflects this change.

Smith et al. (2008a) present trend analyses of data collected through 2005 for most of the long-term, ongoing, autumn migration studies in western North America, including the Wellsvilles (1987–2004).

These analyses (hereafter called the Raptor Population Index or "RPI" analyses; see http://www.rpi-project.org) are based on a more complex analytical approach (also see Farmer et al. 2007) than that represented in Hoffman and Smith (2003) and used herein to present analyses updated through 2008. Among other refinements, this new approach both fits polynomial trajectories to the complete series of annual count indexes and allows for estimating rates of change between various periods, while also allowing for assessments of trend significance and precision. Note, however, that restrictions related to the mathematical assumptions behind the new approach precluded analyzing data for rare species, which in this case included Bald Eagle, all buteos except Swainson's and Red-tailed Hawks, and all falcons except kestrels.

The overall patterns of change and derived trend estimates suggested by the new modeling technique yielded similar inferences as those derived using the simpler methodology of Hoffman and Smith (2003) and presented herein to provide trend assessments updated through 2008. Differences between the RPI results and those presented herein that clearly relate to addition of three more years of data include: a) a new marginally significant, hill-shaped, second-order model fit to the count indexes for Turkey Vultures reflecting addition of two very low counts in 2006 and 2008; b) elimination of second-order, hill-shaped model fits for Ospreys, Sharp-shinned Hawks, Cooper's Hawks, and Swainson's Hawks reflecting addition of three years of moderate to high counts; c) a newly significant second-order model fit for Northern Goshawks reflecting addition of three years of moderate to low counts; and d) indication of only a marginally significant overall decline for kestrels through 2004 in the RPI analyses, but a highly significant decline through 2008 based on the updated analyses presented here.

Age Ratios

Four of 10 species with data suited to such comparisons showed significantly above-average immature : adult ratios in 2008 (Table 2). For Broad-winged Hawks, Bald Eagles, and Peregrine Falcons, high abundance of immature birds clearly contributed to the increased ratios, suggesting that increased regional productivity may have been responsible for the patterns (Table 2). However, in each of these cases, not only were the overall counts low, but the proportions of unaged birds were well below average in 2008, potentially confounding the comparisons (Table 2). For Golden Eagles, the number of aged non-adults was similar to the long-term average, whereas the number of aged adults was less than half the average, indicating that high non-adult abundance was not the cause of the high age ratio. However, this may be indicative of improving habitat quality and breeding success in the Intermountain and central Rocky Mountain region, because in this region largely sedentary adult eagles may tend to disperse/wander less when conditions are improving (Hoffman and Smith 2003). Northern Harriers, Northern Goshawks, and Red-tailed Hawks were the only species to show significantly below-average age ratios in 2008. For the latter two species, their low age ratios clearly reflected below-average abundances of immature birds, potentially reflecting the influence of low regional productivity. In contrast, the low age ratio for Northern Harriers clearly was due to an abundance of identified adults rather than a decline in the number of immature birds, suggesting instead that productivity was probably good but overwinter survival and adult recruitment were particularly high during the past year. Again, it is important to note, however, that the proportions of unaged birds were very low for all three of these species this year, and this may confound the comparisons.

Seasonal Timing

The combined-species median passage date of 24 September was a non-significant one day later than the 1991–2007 average of 23 September ± 9%% CI of 1.1 days (Table 3). Despite the minimal difference in median dates, the overall seasonal distribution pattern did reveal some significant variations compared to the average pattern; i.e., an unusually high peak in proportional activity levels during the last week of September and low activity levels during three other five-day periods (Figure 8). The late September increase in activity corresponded to a window between two significant cold fronts (Appendix C.) At the species level, 4 of 16 species for which a comparison was possible showed significantly later than average

median passage dates in 2008, and four species showed significantly early timing (Table 3). No obvious commonalities were apparent within major species groups, except that four of five buteo species showed at least slightly later-than-average timing. Age and sex-specific data revealed little additional complexity of note, except for suggesting 1) contrary to the indication of significantly late passage at the species level, significantly early timing for immature Red-tailed Hawks and average timing for adults, and 2) significantly early timing for immature Peregrine Falcons, whereas the species level data suggested only non-significantly early timing (Table 4).

RESIDENT RAPTORS

Resident Northern Harriers were observed almost daily, with at least 4–5 birds present in the area. They routinely investigated and chased away other migrants of all kinds, and hunted throughout the ridgetop. Toward the end of the season, only immature bird remained, which was seen several times per day, often attacking the decoy owl then continuing north.

Several Sharp-shinned Hawks displayed resident behavior during the season, but it was difficult for the observers to determine the number of individuals present. Many times birds would come up from the east, hit the owl, and continue cruising north in pursuit of passerines, but it was difficult to know for sure whether or not these were hungry migrants or true residents. Otherwise, likely locals most often were seen exhibiting resident behavior on the east slope among the heavy foliage there. The observers believed that there were at least three resident Cooper's Hawks that comprised a family group with one juvenile. They often saw at least one bird hunting stands of mountain ash for passerines in the morning as they hiked up the ridge, and thought that Deep Canyon likely was the heart of the family's territory.

Numerous Red-tailed Hawks resided in the area surrounding the observation point and ranged broadly across the ridgetop. At least one adult, light-morph bird often perched in a snag on the slope just east of the observation point, and it appeared that the heart of at least one territory was located between Deep Canyon and the next ridgetop knob north of the observation point. At least one adult bird was seen almost daily throughout the season.

At least four Golden Eagles resided in the area during the season, including two adults, one subadult, and one juvenile. They were observed almost daily flying in all directions around the observation hill, with the adult male often seen displaying over the valley to the west and escort migrating eagles through the area. It was also common to see them flying low above the adjacent valleys and perching on nearby rocks and snags, and one day one of the eagles actually knocked our decoy owl out of its tree! Between 10–15 October, the observers noted the subadult engaged in curious behavior with an adult observing: the sub-adult would fly in and perch, then fly back out and display, and then repeated the same pattern over and over.

A family of American Kestrels, including two adults and two juveniles, resided in the area during the early part of the season and often were observed perching on snags on the west slope and north of the observation point, kiting and hunting all around the ridgetop, and occasionally chasing other migrants and passerines. The crew observed a likely family of Peregrine Falcons, including two adults and two juveniles, on several occasions, mainly at the beginning of the season. They were seen circling and gliding along the ridge incessantly for about two weeks in early September. The observers thought that their central territory was probably located low to the northwest among the cliffs where they were often spotted.

During the last week of September and first week of October, the observers encountered a few Flammulated Owls passing through the field camp in the evenings. On two occasions while at their campfire, they were able to observe resting owls perched close by. This is the second season in a row that such has been observed at this site. Although Flammulated Owls may well breed in the Wellsville Mountains, these also could be migrating birds rather than residents.

Other than the relatively recent observations of Flammulated Owls, this is a typical resident assemblage for the site, except that resident Northern Goshawks often have been included in the past.

VISITATION

Our 2008 visitor logs recorded 84 visitors to the site. All visitors originated in local communities except for one individual from Illinois. This closely matches the visitation level in 2007 (previously unreported: 82 total visitors from Utah, Colorado, and Florida, including a group of local high school students), but is lower than during most other years since 2000 (range 100–139 visitors). Organized groups that visited during the 2008 season included a group of ornithology students from Utah State University, folks from the Utah Newcomers Group in Logan, a group from the Bridgerland Audubon Society, and students from Mountain Crest High School in Hyrum, Utah.

In 2008, 449 hourly assessments of visitor disturbance resulted in the following ratings: 81% none, 15% low, 3% moderate, and 1% high. This is a considerably higher level of disturbance than recorded in the past four years, but similar to 2001, the first year we began recording such data. Unlike at most other HWI sites where on-site Environmental Interpreters facilitate visitor interactions, the Wellsville observers must themselves deal with all aspects of visitor coordination. Achieving positive public outreach is an important aspect of all HWI migration projects; accordingly, a modest level of observer distraction, especially at observer-only sites like the Wellsvilles, is expected.

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Table 1. Unadjusted fall-migration counts and adjusted passage rates by raptor species in the Wellsville Mountains, UT: 1987–2007 versus 2008.

	COUNTS			BIRDS / 100 HRS		
SPECIES	1991–2007[1]	2008	% CHANGE	1991–2007[1]	2008	% CHANGE
Turkey Vulture	23 ± 6.2	3	-87	8.2 ± 1.80	1.0	-87
Osprey	28 ± 4.4	39	+39	11.9 ± 2.24	14.7	+23
Northern Harrier	279 ± 52.1	412	+47	77.8 ± 16.46	94.6	+22
Sharp-shinned Hawk	888 ± 71.0	1,582	+78	295.4 ± 28.00	456.6	+55
Cooper's Hawk	525 ± 75.7	675	+29	174.5 ± 29.95	207.9	+19
Northern Goshawk	21 ± 6.4	9	-57	6.2 ± 2.07	1.9	-69
Unknown small accipiter[2]	69 ± 42.8	37	-47	–	–	–
Unknown large accipiter[2]	4 ± 3.1	1	-74	–	–	–
Unidentified accipiter	40 ± 14.4	3	-92	–	–	–
TOTAL ACCIPITERS	1494 ± 141.5	2,307	+54	–	–	–
Broad-winged Hawk	5 ± 1.6	17	+271	2.4 ± 1.03	8.1	+244
Swainson's Hawk	154 ± 67.9	174	+13	72.2 ± 35.41	65.5	-9
Red-tailed Hawk	599 ± 110.7	628	+5	180.3 ± 33.95	164.7	-9
Ferruginous Hawk	10 ± 2.6	12	+15	3.0 ± 0.94	3.3	+10
Rough-legged Hawk	2 ± 0.7	6	+226	0.7 ± 0.35	0.9	+27
Unidentified buteo	20 ± 5.3	1	-95	–	–	–
TOTAL BUTEOS	790 ± 165.4	838	+6	–	–	–
Golden Eagle	160 ± 40.2	114	-29	45.5 ± 12.26	26.0	-43
Bald Eagle	4 ± 1.8	6	+48	1.0 ± 0.54	1.3	+27
TOTAL EAGLES	164 ± 41.1	120	-27	–	–	–
American Kestrel	776 ± 122.8	624	-20	248.5 ± 47.39	193.9	-22
Merlin	12 ± 2.2	13	+6	3.4 ± 0.69	2.6	-25
Prairie Falcon	16 ± 2.9	5	-70	4.9 ± 0.95	1.3	-73
Peregrine Falcon	12 ± 2.9	11	-7	3.7 ± 0.97	3.0	-19
Unknown small falcon[2]	2 ± 2.0	0	-100	–	–	–
Unknown large falcon[2]	3 ± 2.0	0	-100	–	–	–
Unidentified falcon	3 ± 1.1	0	-100	–	–	–
TOTAL FALCONS	821 ± 122.1	653	-20	–	–	–
Unidentified raptor	18 ± 7.8	0	-100	–	–	–
GRAND TOTAL	3618 ± 443.4	4,372	+21	–	–	–

[1] Mean ± 95% confidence interval.

[2] Designations used for the first time in 2001.

Table 2. Annual counts by age classes and immature : adult ratios for selected species: 1991–2007 versus 2008.

	Total and Age-classified Counts						% Unknown Age		Immature : Adult Ratio	
	1991–2007 Average			2008						
	Total	Imm.	Adult	Total	Imm.	Adult	1991–2007[1]	2008	1991–2007[1]	2008
Northern Harrier	289	150	79	412	165	212	21 ± 5.2	8	2.13 ± 0.83	0.78
Sharp-shinned Hawk	903	343	359	1582	736	792	22 ± 5.9	3	1.04 ± 0.28	0.93
Cooper's Hawk	542	211	189	675	330	305	26 ± 8.0	6	1.36 ± 0.38	1.08
Northern Goshawk	23	12	6	9	3	6	27 ± 11.1	0	2.86 ± 1.04	0.50
Broad-winged Hawk	4	1	2	17	10	4	36 ± 60.6	18	0.84 ± 0.71	2.50
Red-tailed Hawk	642	254	318	628	149	469	11 ± 3.0	2	0.81 ± 0.30	0.32
Ferruginous Hawk	11	3	3	12	6	3	52 ± 16.6	25	1.96 ± 1.61	2.00
Golden Eagle	167	81	72	114	78	33	7 ± 2.1	3	1.38 ± 0.37	2.36
Bald Eagle	4	3	1	6	6	0	7 ± 8.5	0	2.96 ± 1.79	6.00
Peregrine Falcon	13	2	4	11	6	4	58 ± 10.5	9	0.94 ± 0.42	1.50

[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.

Table 3. First and last observed, bulk passage, and median passage dates by species for 2008, with a comparison of 2008 and 1991–2007 average median passage dates.

Species	2008 First Date Observed	2008 Last Date Observed	2008 Bulk Passage Dates[1]	2008 Median Passage Date[2]	1991–2007 Median Passage Date[3]
Turkey Vulture	3-Sep	30-Sep	–	–	10-Sep ± 6.7
Osprey	29-Aug	2-Oct	31-Aug – 29-Sep	12-Sep	14-Sep ± 1.8
Northern Harrier	27-Aug	30-Oct	7-Sep – 21-Oct	29-Sep	25-Sep ± 1.8
Sharp-shinned Hawk	27-Aug	31-Oct	11-Sep – 17-Oct	27-Sep	26-Sep ± 1.7
Cooper's Hawk	28-Aug	26-Oct	11-Sep – 1-Oct	21-Sep	25-Sep ± 1.7
Northern Goshawk	13-Sep	28-Oct	13-Sep – 28-Oct	16-Oct	26-Sep ± 4.7
Broad-winged Hawk	12-Sep	2-Oct	13-Sep – 1-Oct	26-Sep	23-Sep ± 3.4
Swainson's Hawk	27-Aug	8-Oct	2-Sep – 29-Sep	5-Sep	16-Sep ± 4.6
Red-tailed Hawk	27-Aug	31-Oct	4-Sep – 8-Oct	26-Sep	22-Sep ± 1.6
Ferruginous Hawk	28-Aug	9-Oct	31-Aug – 2-Oct	19-Sep	15-Sep ± 5.2
Rough-legged Hawk	21-Oct	31-Oct	21-Oct – 31-Oct	27-Oct	19-Oct ± 0.0
Golden Eagle	31-Aug	30-Oct	7-Sep – 22-Oct	27-Sep	30-Sep ± 2.5
Bald Eagle	21-Sep	29-Oct	21-Sep – 29-Oct	9-Oct	05-Oct ± 11.3
American Kestrel	27-Aug	29-Oct	5-Sep – 1-Oct	19-Sep	20-Sep ± 2.1
Merlin	27-Aug	30-Oct	12-Sep – 28-Oct	29-Sep	01-Oct ± 2.6
Prairie Falcon	8-Sep	18-Oct	8-Sep – 18-Oct	15-Sep	13-Sep ± 3.3
Peregrine Falcon	31-Aug	19-Sep	3-Sep – 18-Sep	8-Sep	11-Sep ± 3.4
Total	27-Aug	31-Oct	6-Sep – 16-Oct	24-Sep	23-Sep ± 1.1

[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 4. Median passage dates by age and sex classes for selected species: 1991–2007 versus 2008.

SPECIES	2008	1991–2007[1]	2008	1991–2007[1]
	ADULT		IMMATURE / SUBADULT	
Northern Harrier	1-Oct	29-Sep ± 2.3	28-Sep	24-Sep ± 2.2
Sharp-shinned Hawk	2-Oct	02-Oct ± 1.9	19-Sep	19-Sep ± 2.5
Cooper's Hawk	27-Sep	30-Sep ± 2.0	16-Sep	18-Sep ± 2.2
Northern Goshawk	16-Oct	29-Sep ± 8.1	–	26-Sep ± 5.9
Broad-winged Hawk	–	23-Sep ± 4.7	27-Sep	22-Sep[2]
Red-tailed Hawk	27-Sep	27-Sep ± 1.9	11-Sep	15-Sep ± 1.8
Ferruginous Hawk	–	22-Sep ± 7.2	15-Sep	16-Sep ± 19.1
Golden Eagle	28-Sep	30-Sep ± 3.5	27-Sep	01-Oct ± 2.4
Bald Eagle	–	–	9-Oct	04-Oct ± 10.4
Peregrine Falcon	–	15-Sep ± 7.0	5-Sep	20-Sep ± 10.8
	MALE		FEMALE	
Adult Northern Harrier	6-Oct	01-Oct ± 2.4	30-Sep	24-Sep ± 5.5
American Kestrel	24-Sep	23-Sep ± 2.0	13-Sep	15-Sep ± 2.3

Note: The median passage date is the date by which 50% of the flight had passed; values are based only on annual counts ≥5 birds.

[1] Mean ± 95% CI (days).

[2] Data for 1995 only.

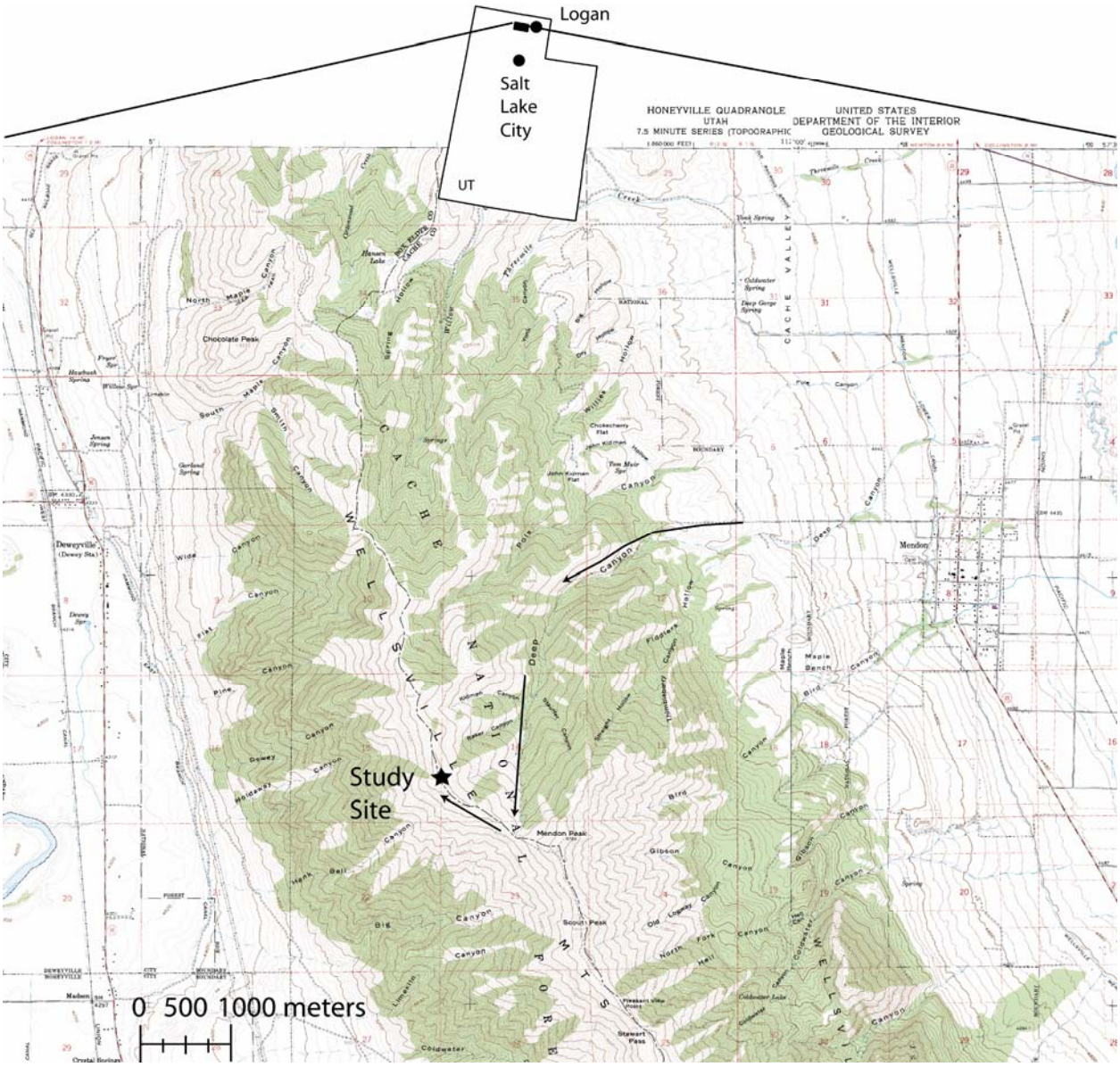

Figure 1. Location of the Wellsville Mountains Raptor Migration Project site in northern Utah.

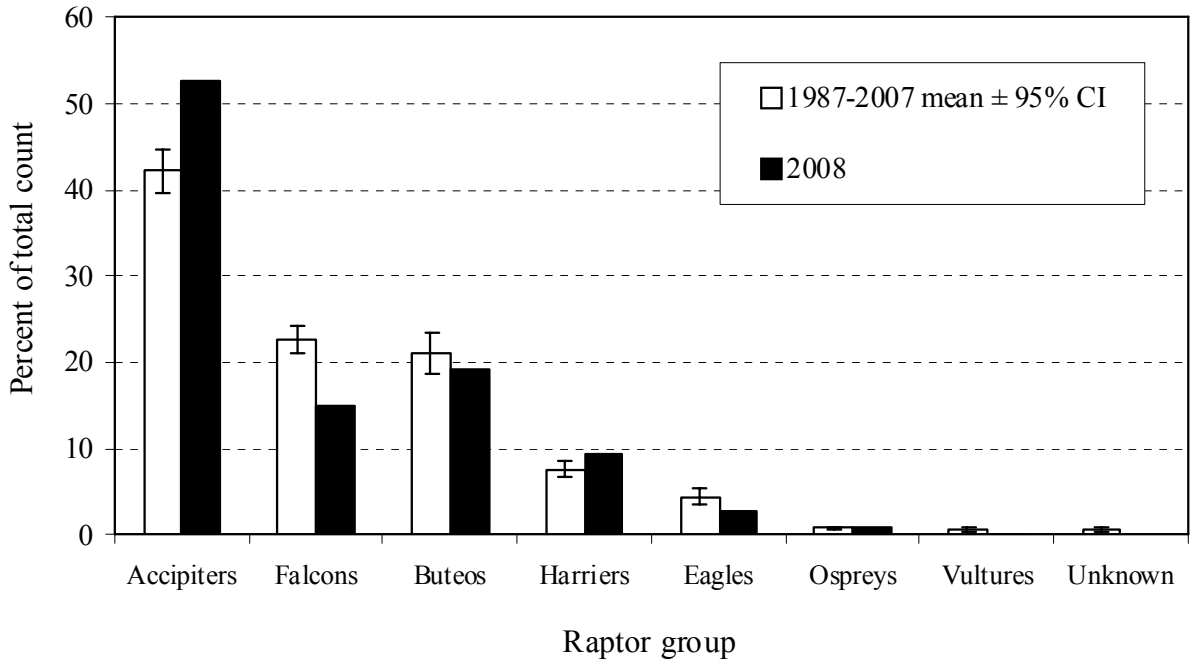

Figure 2. Fall-migration flight composition by major raptor species groups: 1987–2007 versus 2008.

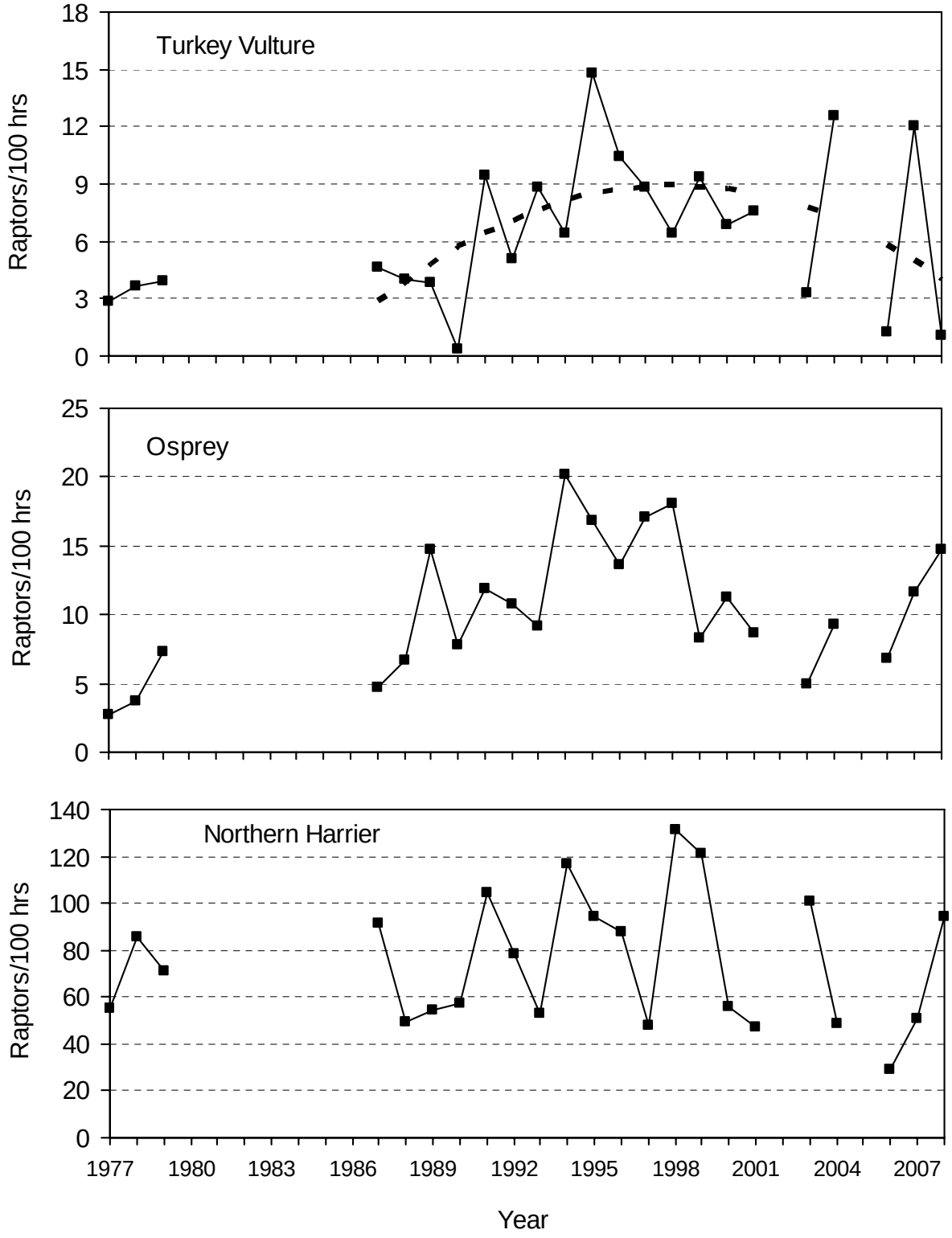

Figure 3. Adjusted fall-migration passage rates for Turkey Vultures, Ospreys, and Northern Harriers: 1977–2008. Dotted lines indicate significant ($P \leq 0.10$) linear or quadratic regressions.

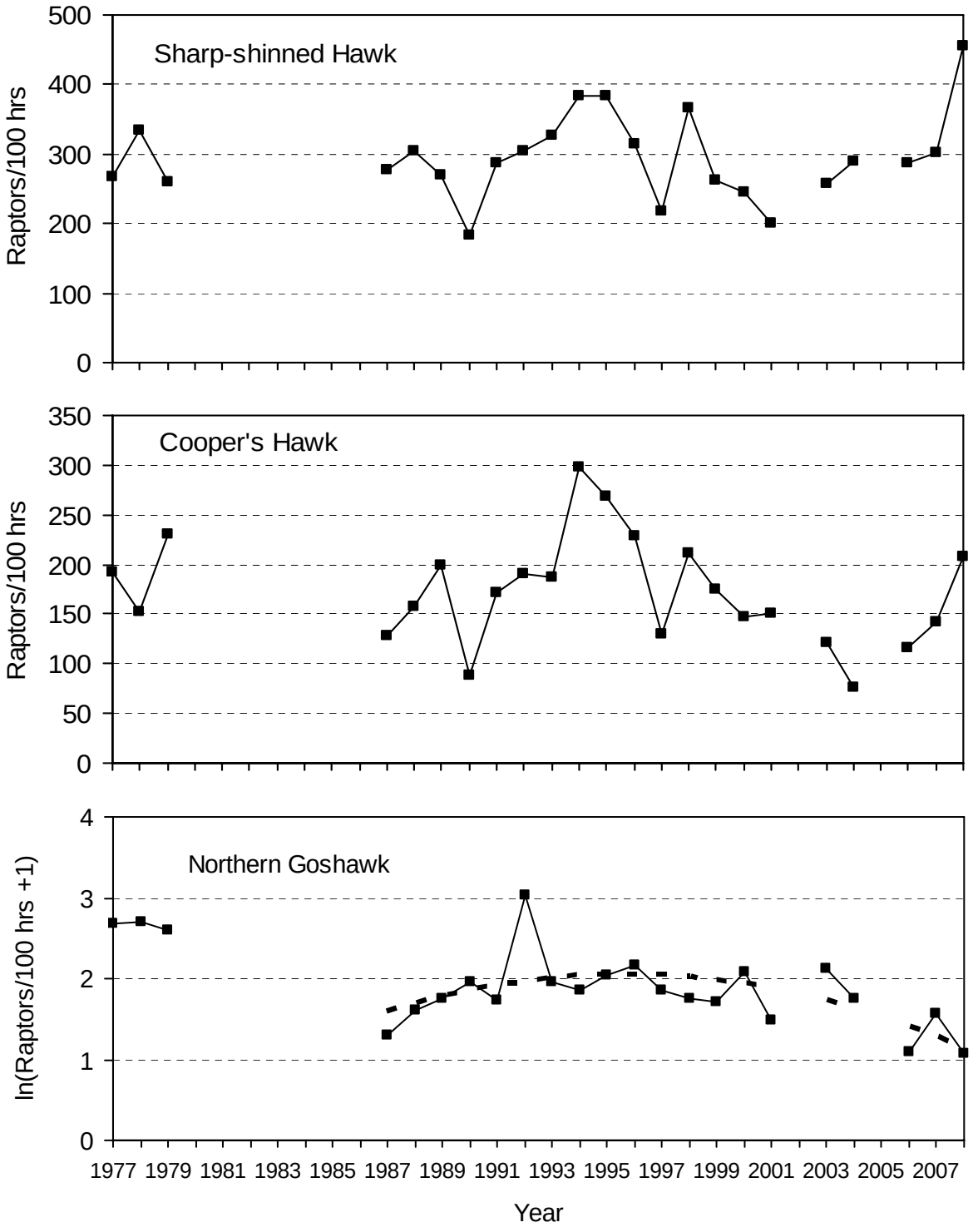

Figure 4. Adjusted fall-migration passage rates for Sharp-shinned Hawks, Cooper's Hawks, and Northern Goshawks: 1977–2008. Dotted lines indicate significant ($P \leq 0.10$) linear or quadratic regressions.

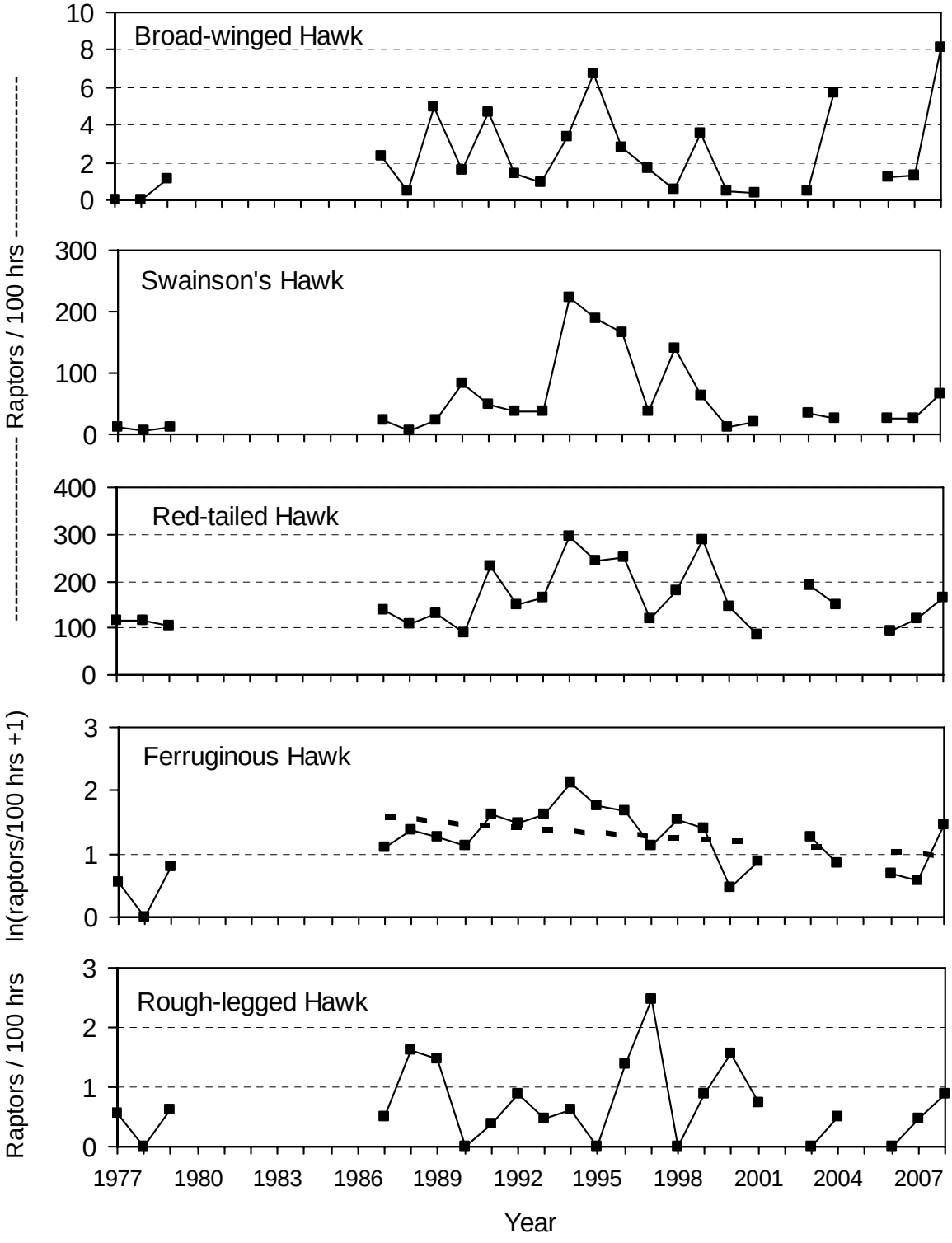

Figure 5. Adjusted fall-migration passage rates for Broad-winged, Swainson's, Red-tailed, Ferruginous, and Rough-legged Hawks: 1977–2008. Dotted lines indicate significant ($P \leq 0.10$) linear or quadratic regressions.

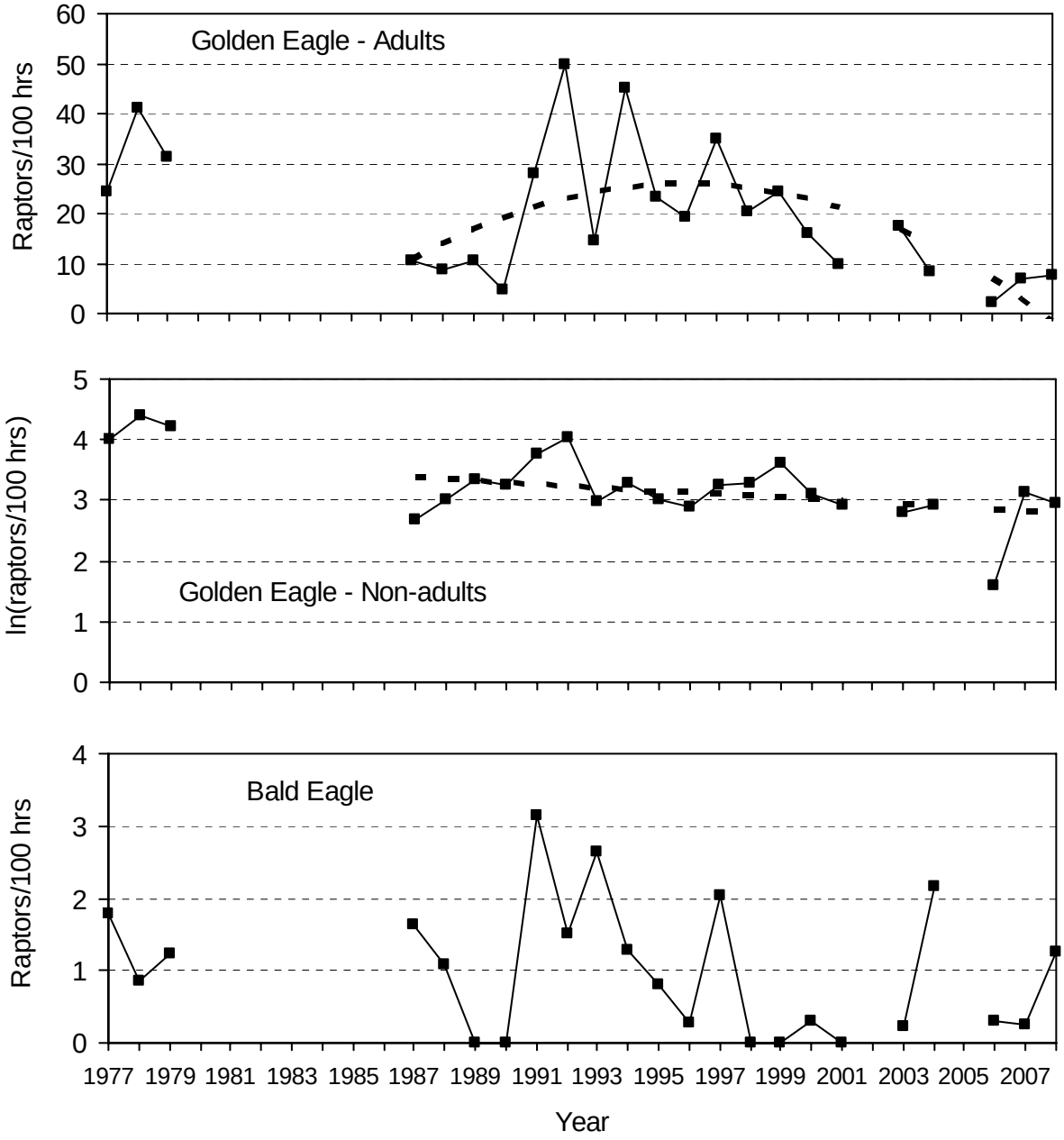

Figure 6. Adjusted fall-migration passage rates for Golden and Bald Eagles: 1977–2008. Dotted lines indicate significant ($P \leq 0.10$) linear or quadratic regressions.

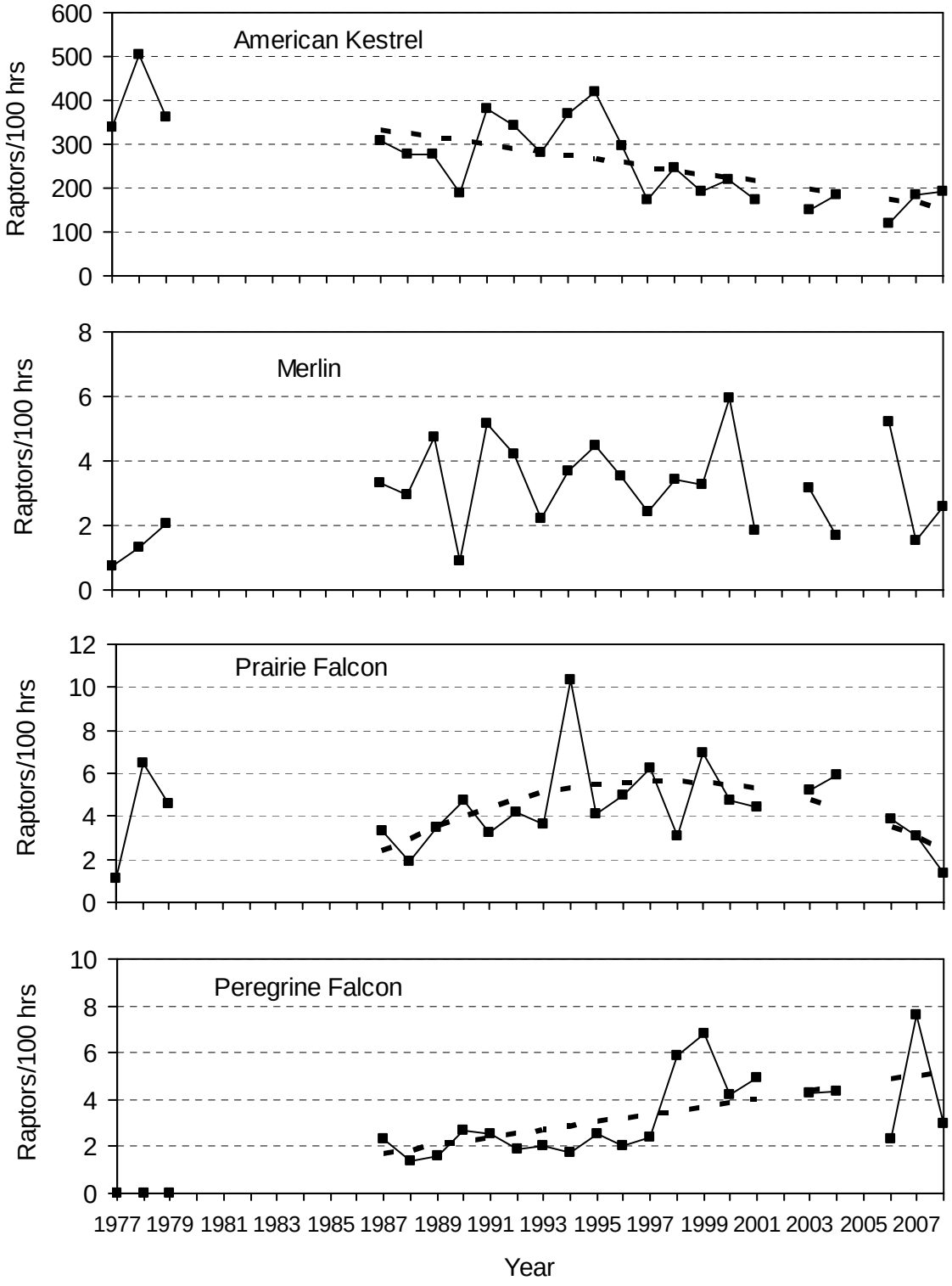

Figure 7. Adjusted fall-migration passage rates for American Kestrels, Merlins, Prairie Falcons, and Peregrine Falcons in the Wellsville Mountains, UT: 1977–2008. Dotted lines indicate significant ($P \leq 0.10$) linear or quadratic regressions.

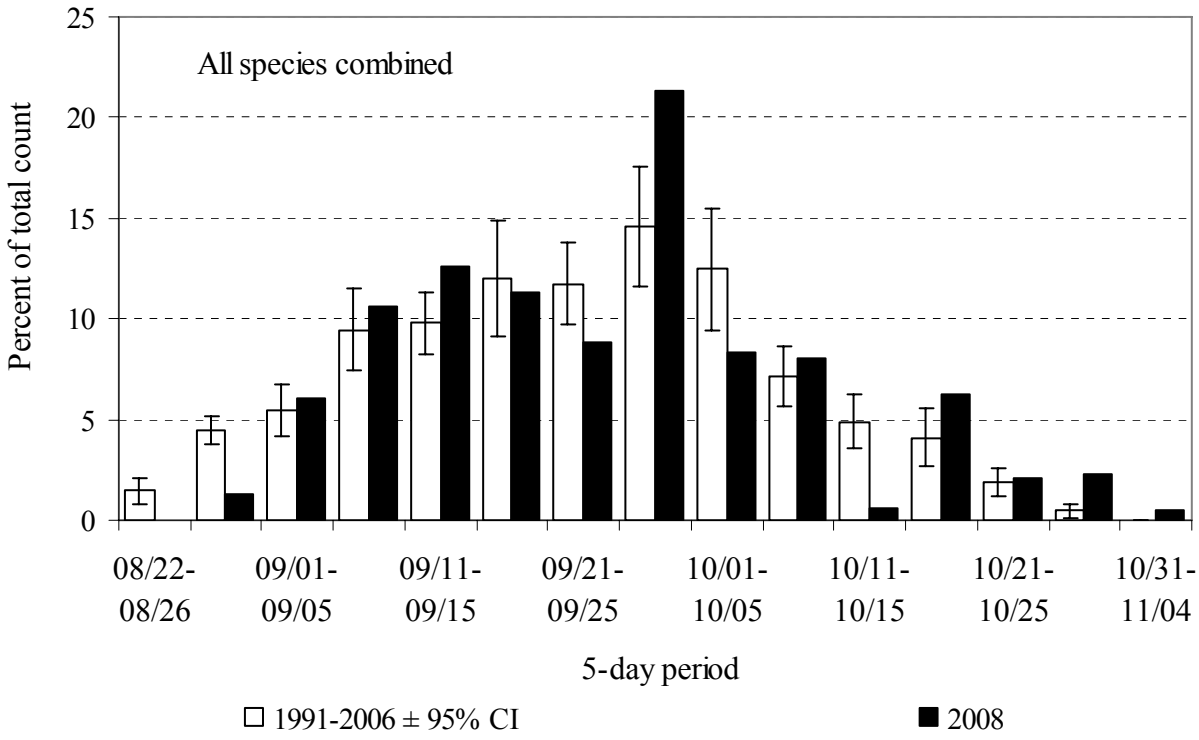

Figure 8. Combined-species, fall-migration passage volume by five-day periods in the Wellsville Mountains, UT: 1991–2007 versus 2008.

Appendix A. History of official observer participation in the Wellsville Mountains Raptor Migration Project.

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)

1999: Two observers throughout: Jorge Canaca (0) and Laura Lutz (0)

2000: Two observers throughout: Darlene Kilpatrick (0) and Paula Shannon (0)

2001: Two observers throughout: Peter Cole (0) and Lisa Sheffield (0)

2003: Two observers throughout: David Tidhar (1), Jason Ferrell (0), Anthony Sandoval (0)

2005: Two observers throughout: Mark Fogg (1 partial), Rob Spaul (0)

2006: Two observers throughout: Adam Remus (0) and Adam Schmidt (0)

2007: Two observers throughout: Laurel Ferreira (0) and Aaron Viducich (0)

2008: Two observers throughout most: Josh Lawrey (3) and Ethan Peters (0)

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

Appendix B. Common and scientific names, species codes, and regularly applied age, sex, and color-morph classifications for migrating raptors observed in the Wellsville Mountains, UT.

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 small accipiter	*A. striatus* or *cooperii*	SA	U	U	NA
Unknown large accipiter	*A. cooperii* or *gentilis*	LA	U	U	NA
Unknown accipiter	*Accipiter* spp.	UA	U	U	NA
Red-shouldered Hawk	*Buteo lineatus*	RS	A I 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	I, S, NA, A, U[4]	U	NA
Bald Eagle	*Haliaeetus leucocephalus*	BE	I, S1, S2, NA, A, 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	AM U	NA
Prairie Falcon	*Falco mexicanus*	PR	U	U	NA
Peregrine Falcon	*Falco peregrinus*	PG	A I U	U	NA
Unknown small falcon	*F. sparverius* or *columbarius*	SF	U	U	NA
Unknown large falcon	*F. mexicanus* or *peregrinus*	LF	U	U	NA
Unknown falcon	*Falco* spp.	UF	U	U	NA
Unknown raptor	Falconiformes	UU	U	U	NA

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

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

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

[4] Golden Eagle age codes: I = Immature: juvenile or first-year bird, bold white wing patch visible below, bold white in tail, no molt; S = Subadult: white wing patch variable or absent, obvious white in tail and molt or tawny bar visible on upper wing; NA = Not adult: unknown age immature/subadult; A = Adult: no white in wings or tail; U = Unknown.

[5] Bald Eagle age codes: I = Immature: juvenile or first-year bird, dark breast and tawny belly; S1 = young Subadult: Basic I and II plumages, light belly, upside-down triangle on back; S2 = older Subadult: Basic III plumage, head mostly white with osprey-like dark eye line and dark band on tail; NA = Not adult: unknown age immature/subadult; A = Adult: includes near adult with dark flecks in head and dark tail tip, and adult with white head and tail; U = Unknown.

Appendix C. Daily observation effort, visitor disturbance ratings, weather records, and fall-migration flight summaries for raptors in the Wellsville Mountains, UT: 2008.

Date	Obs. Hours	Obsrvr / Hour[1]	Median Visitor Disturb[2]	Predominant Weather[3]	Wind Speed (kph)[1]	Wind Direction	Temp (°C)[1]	Barom. Press. (in Hg)[1]	Median Thermal Lift[4]	Visib. West (km)[1]	Visib. East (km)[1]	Median Flight Distance[5]	Birds / Hour
27-Aug	8.50	1.7	0	pc-mc, AM haze	15.6	wsw	18.4	30.34	2	70	64	2	1.1
28-Aug	8.00	1.0	0	clr, haze	6.3	w	20.1	30.37	1	36	63	1	1.6
29-Aug	8.00	1.0	0	clr-pc, PM haze	11.5	sw-wsw	20.1	30.40	1	80	73	2	1.9
30-Aug	8.00	1.0	1	clr-pc	18.8	ssw-sw	26.4	30.18	2	80	80	1	2.6
31-Aug	5.50	1.0	0	clr-pc, PM haze/scat ts	22.3	sw	19.5	29.97	2	80	67	2	2.9
01-Sep	0.00			weather day: rain/snow									
02-Sep	8.00	1.0	0	clr	9.9	sw-wsw	9.8	30.39	2	80	78	1	8.4
03-Sep	9.00	1.0	0	clr, AM fog	17.7	wsw	13.0	30.37	2	77	74	1	10.8
04-Sep	9.00	1.0	0	clr-pc	21.1	wsw	13.4	30.34	2	100	100	1	9.3
05-Sep	8.00	1.9	0	clr	16.1	wsw	11.8	30.30	2	80	80	2.0	11.4
06-Sep	8.00	1.0	1	clr	13.3	wnw	12.3	30.27	2	100	100	-	11.6
07-Sep	8.00	1.0	0	clr	13.3	wsw-w	16.6	30.26	2	100	100	-	15.8
08-Sep	8.50	1.0	0	clr	16.1	s, sw	20.9	30.29	2	100	100	1	12.7
09-Sep	8.00	1.7	0	mc-ovc	20.5	sw	19.8	30.11	4	100	100	1	5.8
10-Sep	0.00			weather day: fog/ts/rain									
11-Sep	8.00	1.8	0	clr, haze	8.4	var, e	13.1	30.18	2	74	75	-	22.9
12-Sep	8.00	2.0	1.5	clr	15.1	s, sw	14.4	30.20	2	80	80	1	7.8
13-Sep	8.00	2.0	2	clr, PM haze	10.4	wsw-w	16.8	30.29	2.5	80	80	1	19.1
14-Sep	8.00	2.0	0	clr	9.3	wsw-w	19.0	30.45	2	80	80	1	18.9
15-Sep	8.00	2.0	0	clr	4.6	var, sw	20.8	30.55	2	80	80	-	9.9
16-Sep	8.00	1.0	0	clr	14.8	s-wsw	20.6	30.51	2	80	80	1	10.0
17-Sep	8.50	2.0	0	clr, haze	19.6	sw	20.3	30.38	2	80	80	1	12.2
18-Sep	8.50	1.0	0	ovc-clr, haze	7.4	ne, sw	19.2	30.38	2	80	80	1	11.9
19-Sep	8.00	2.0	0	clr, haze	11.1	sw	20.9	30.34	2	76	76	1	16.4
20-Sep	4.50	2.0	0	mc-ovc, rain	23.6	ssw-sw	13.2	30.14	4	60	44	-	6.4
21-Sep	8.00	2.5	2	mc-ovc	14.9	sw	14.1	30.15	2.5	65	70	1	19.8
22-Sep	0.00			weather day: fog/rain									
23-Sep	8.00	1.0	0	clr-ovc	11.1	wsw	10.6	30.40	3	80	80	2	11.6
24-Sep	8.00	2.0	0	clr	19.4	ssw-sw	17.0	30.41	3	80	80	1	13.1
25-Sep	8.50	1.0	0	clr-pc	25.0	ssw-sw	16.4	30.35	3	80	80	1	11.5
26-Sep	8.00	2.0	0	clr-pc	9.0	ene, wsw	19.1	30.44	1.5	80	80	1	17.0
27-Sep	8.50	2.0	2	clr	13.9	sw-wsw	20.0	30.46	2	80	80	2	50.7
28-Sep	8.00	1.9	0	clr	5.3	sw-wsw	18.3	30.50	2	80	80	1	13.4
29-Sep	8.50	1.8	0	clr	11.8	ene, sw-wsw	21.1	30.54	2	80	80	1	18.9
30-Sep	8.50	1.0	0	clr-pc	16.5	sw	19.9	30.60	3	80	80	1	21.3
01-Oct	8.00	2.0	0	pc-mc	9.0	var, sw	21.0	30.49	2	80	80	1	11.8
02-Oct	7.08	1.0	1	clr-pc	19.0	ssw-sw	18.4	30.21	3	80	80	1	4.4
03-Oct	3.00	1.0	0	clr-ovc	13.0	ssw	12.3	30.09	3	80	80	1	19.0
04-Oct	0.00			weather day: rain									
05-Oct	0.00			weather day: rain/snow									
06-Oct	8.50	1.7	0	ovc	11.6	w, sw	8.3	30.38	3	36	38	1	11.9
07-Oct	8.00	2.0	1	clr-mc	24.5	sw	8.5	30.42	4	80	80	1	17.1
08-Oct	8.00	1.0	0	clr	10.1	var, wsw-w	11.8	30.33	2	80	80	1	9.5
09-Oct	8.00	2.0	0	mc-ovc, AM haze	15.9	ssw-wsw	9.0	29.81	3	58	60	1	4.9
10-Oct	7.00	1.0	0	pc-mc	10.9	e, sw	0.6	29.73	4	69	80	1	2.7

Appendix C. continued

Date	Obs. Hours	Obsrvr / Hour[1]	Median Visitor Disturb[2]	Predominant Weather[3]	Wind Speed (kph)[1]	Wind Direction	Temp (°C)[1]	Barom. Press. (in Hg)[1]	Median Thermal Lift[4]	Visib. West (km)[1]	Visib. East (km)[1]	Median Flight Distance[5]	Birds / Hour
11-Oct	0.00			weather day: snow									
12-Oct	0.00			weather day: snow									
13-Oct	6.50	2.0	0	pc	8.9	ne-ene	0.4	30.49	3	44	56	1	0.8
14-Oct	7.50	2.0	0	clr, PM haze	9.4	wnw	2.0	30.36	3	93	93	1	0.1
15-Oct	8.00	2.0	0	pc	23.9	sw-wsw	6.3	30.33	3	80	80	1	5.4
16-Oct	7.00	1.0	0	ovc-pc	13.3	sw	9.6	30.42	3	80	80	1	9.1
17-Oct	7.50	2.0	1	clr	17.6	sw	11.3	30.53	2.5	80	80	1	8.3
18-Oct	8.00	2.0	0	clr	23.0	sw	10.8	30.31	3	80	80	1	7.8
19-Oct	8.00	2.0	0	pc-mc	6.4	sw	11.9	30.35	2.5	80	80	1	5.1
20-Oct	8.00	2.0	0	pc	19.9	sw	11.6	30.27	3	80	80	1	7.1
21-Oct	7.50	1.0	0	clr-pc	18.9	wnw-nw	0.9	30.25	3	80	80	1	0.9
22-Oct	7.50	2.0	0	clr	8.9	ne	0.6	30.53	2	80	80	1	0.8
23-Oct	7.50	2.0	0	clr	12.4	wnw, sw	4.3	30.34	3	80	80	1	0.5
24-Oct	7.50	2.0	0	clr-pc, haze	10.9	w-wnw	2.9	30.30	3	70	71	1	2.0
25-Oct	7.00	1.9	1	clr	25.8	wsw	6.6	30.36	3.5	80	80	1	1.9
26-Oct	7.00	2.0	1	pc	7.6	e	6.4	30.56	2.5	80	80	1	2.4
27-Oct	7.00	2.0	0	clr	23.6	ssw-sw	10.3	30.60	3	80	80	1	3.1
28-Oct	7.00	1.0	0	clr	12.1	ssw-sw	11.1	30.60	2	80	80	1	2.4
29-Oct	7.00	2.0	0	clr	14.4	sw	10.3	30.36	3	80	78	1	4.3
30-Oct	7.00	2.0	1	clr	15.3	ssw-sw	11.1	30.48	2	80	80	1	2.9
31-Oct	7.00	2.0	0	mc, rain	27.1	sw	9.1	30.47	4	70	70	1	0.4

[1] Average of hourly records.

[2] Median hourly visitor-disturbance rating (subjective assessment by observers): 0 = none, 1 = low, 2 = moderate, 3 = high.

[3] 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); ts = thunderstorms.

[4] Median hourly rating 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.

[5] Median hourly rating concerning line-of-sight 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. Annual observation effort and unadjusted fall-migration counts by raptor species in the Wellsville Mountains, UT: 1977–2008.

	1977	1978	1979	1987	1988	1989	1990	1991	1992	1993	1994	1995
Start date	6-Aug	6-Sep	6-Sep	7-Sep	2-Sep	3-Sep	28-Aug	25-Aug	23-Aug	24-Aug	26-Aug	22-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
Observation days	67	41	41	43	47	47	52	59	63	55	49	62
Observation hours	317.17	234.83	242.25	303.50	373.92	315.92	339.00	417.75	428.00	414.25	333.25	407.75
Raptors / 100 hours	885.0	1257.5	1160.4	968.7	893.8	981.6	699.7	1189.9	1048.1	908.6	1461.7	1389.8
SPECIES	RAPTOR COUNTS											
Turkey Vulture	6	7	8	11	11	9	1	36	15	28	16	43
Osprey	5	8	13	11	17	30	19	37	29	25	44	41
Northern Harrier	159	200	173	278	185	172	191	443	330	208	363	362
Sharp-shinned Hawk	618	737	570	793	1093	832	526	990	990	1000	901	1217
Cooper's Hawk	457	333	495	362	561	603	253	619	601	596	778	874
Northern Goshawk	35	32	30	8	15	15	19	18	74	26	16	23
Unknown small accipiter[1]	–	–	–	–	–	–	–	–	–	–	–	–
Unknown large accipiter[1]	–	–	–	–	–	–	–	–	–	–	–	–
Unidentified accipiter	86	53	122	64	26	43	41	56	124	44	70	66
TOTAL ACCIPITERS	1196	1155	1217	1227	1695	1493	839	1683	1789	1666	1765	2180
Broad-winged Hawk	0	0	2	5	1	9	4	10	3	2	5	13
Swainson's Hawk	19	5	21	44	12	47	184	128	97	91	487	468
Red-tailed Hawk	311	258	238	409	403	413	281	898	566	621	891	926
Ferruginous Hawk	2	0	3	6	11	8	6	16	13	15	23	18
Rough-legged Hawk	2	0	1	1	4	3	0	1	2	1	2	0
Unidentified buteo	10	13	21	12	5	5	32	15	38	26	14	24
TOTAL BUTEOS	344	276	286	477	436	485	507	1068	719	756	1422	1449
Golden Eagle	236	285	237	73	106	119	113	294	423	133	224	163
Bald Eagle	5	3	3	5	4	0	2	13	10	10	4	3
TOTAL EAGLES	241	288	240	78	110	119	115	307	433	143	228	166
American Kestrel	808	970	799	817	862	744	542	1303	1118	888	975	1371
Merlin	2	3	5	10	11	15	3	21	17	8	11	17
Prairie Falcon	4	15	11	10	7	11	15	12	17	14	33	18
Peregrine Falcon	0	0	0	7	5	5	12	11	7	7	6	11
Unknown small falcon[1]	–	–	–	–	–	–	–	–	–	–	–	–
Unknown large falcon[1]	–	–	–	–	–	–	–	–	–	–	–	–
Unidentified falcon	0	0	2	2	1	2	4	2	3	3	0	1
TOTAL FALCONS	814	988	817	846	886	777	576	1349	1162	920	1025	1418
Unidentified raptors	42	31	57	12	2	16	77	36	10	18	8	8
GRAND TOTAL	2807	2953	2811	2940	3342	3101	2325	4959	4487	3764	4871	5667

Appendix D. continued

	1996	1997	1998	1999	2000	2001	2003	2004	2006	2007	2008	MEAN
Start date	23-Aug	22-Aug	23-Aug	25-Aug	23-Aug	28-Aug	22-Aug	22-Aug	28-Aug	27-Aug	27-Aug	25-Aug
End date	23-Oct	25-Oct	25-Oct	31-Oct	26-Oct	30-Oct	29-Oct	17-Oct	31-Oct	31-Oct	31-Oct	25-Oct
Observation days	55	58	54	59	49	59	65	49	50	59	59	54
Observation hours	374.25	377.92	358.75	407.83	373.84	488.00	495.53	391.59	370.25	458.50	453.08	377.27
Raptors / 100 hours	1222.4	712.3	1134.2	1044.8	796.1	605.7	733.0	747.0	527.2	714.1	965.0	957.4
SPECIES	RAPTOR COUNTS											
Turkey Vulture	32	47	17	28	20	26	18	40	3	39	3	20
Osprey	35	39	39	21	28	27	14	24	18	35	39	26
Northern Harrier	315	171	443	487	198	230	440	183	97	222	412	272
Sharp-shinned Hawk	928	652	1005	901	790	764	871	918	750	958	1582	886
Cooper's Hawk	701	388	587	577	482	545	441	241	312	462	675	519
Northern Goshawk	27	17	14	16	24	15	33	17	8	15	9	22
Unknown small accipiter[1]	–	–	–	–	–	87	64	44	11	141	37	64
Unknown large accipiter[1]	–	–	–	–	–	2	1	9	1	6	1	3
Unidentified accipiter	73	22	55	20	31	0	6	7	1	4	3	44
TOTAL ACCIPITERS	1729	1079	1661	1514	1327	1413	1416	1236	1083	1586	2307	1489
Broad-winged Hawk	7	3	1	7	1	1	1	9	2	3	17	5
Swainson's Hawk	419	106	309	154	29	61	101	63	58	69	174	137
Red-tailed Hawk	872	430	609	1088	508	357	848	536	296	443	628	557
Ferruginous Hawk	15	8	14	13	2	6	12	6	3	3	12	9
Rough-legged Hawk	3	6	1	2	3	2	0	1	0	3	6	2
Unidentified buteo	32	9	19	22	4	19	35	37	2	28	1	18
TOTAL BUTEOS	1348	562	953	1286	547	446	997	652	361	549	838	728
Golden Eagle	127	212	154	245	130	122	155	104	20	128	114	170
Bald Eagle	2	7	0	2	1	0	1	10	1	2	6	4
TOTAL EAGLES	129	219	154	247	131	122	156	114	21	130	120	174
American Kestrel	922	524	727	600	660	623	515	616	328	630	624	781
Merlin	12	8	11	13	20	8	13	6	18	10	13	11
Prairie Falcon	17	23	13	28	14	16	23	20	13	10	5	15
Peregrine Falcon	8	9	19	24	13	16	17	14	7	27	11	10
Unknown small falcon[1]	–	–	–	–	–	6	1	2	0	2	0	2
Unknown large falcon[1]	–	–	–	–	–	6	1	3	1	5	0	3
Unidentified falcon	1	3	2	6	10	2	1	4	1	3	0	2
TOTAL FALCONS	960	567	772	671	717	677	571	665	368	687	653	820
Unidentified raptors	20	8	30	4	7	15	29	16	1	26	0	21
GRAND TOTAL	4568	2692	4069	4258	2975	2956	3641	2930	1952	3274	4372	3551

[1] Designations used for the first time in 2001.

Appendix E. Daily observation hours and unadjusted fall-migration counts by raptor species in the Wellsville Mountains, UT: 2008.

		Species[1]																									Birds
Date	Hours	TV	OS	NH	SS	CH	NG	SA	LA	UA	BW	SW	RT	FH	RL	UB	GE	BE	UE	AK	ML	PR	PG	SF	LF	UF	UU	Total	/ hour
27-Aug	8.50	0	0	1	1	0	0	0	0	0	0	1	2	0	0	0	0	0	0	3	1	0	0	0	0	0	0	9	1.1
28-Aug	8.00	0	0	1	4	2	0	0	0	0	0	0	2	1	0	0	0	0	0	3	0	0	0	0	0	0	0	13	1.6
29-Aug	8.00	0	1	0	1	3	0	0	0	0	0	3	4	0	0	0	0	0	0	3	0	0	0	0	0	0	0	15	1.9
30-Aug	8.00	0	1	1	2	0	0	0	0	0	0	1	8	0	0	0	0	0	0	8	0	0	0	0	0	0	0	21	2.6
31-Aug	5.50	0	4	1	1	0	0	0	0	0	0	1	5	1	0	0	2	0	0	0	0	0	1	0	0	0	0	16	2.9
01-Sep	0.00																												
02-Sep	8.00	0	0	5	5	2	0	0	0	0	0	45	7	0	0	0	0	0	0	3	0	0	0	0	0	0	0	67	8.4
03-Sep	9.00	1	3	9	3	7	0	1	0	1	0	19	26	0	0	0	2	0	0	24	0	0	1	0	0	0	0	97	10.8
04-Sep	9.00	0	1	7	13	9	0	1	0	0	0	9	29	0	0	0	2	0	0	12	0	0	1	0	0	0	0	84	9.3
05-Sep	8.00	0	2	8	16	7	0	1	0	2	0	14	16	0	0	0	3	0	0	20	0	0	2	0	0	0	0	91	11.4
06-Sep	8.00	0	1	8	13	8	0	1	0	0	0	5	21	0	0	0	2	0	0	34	0	0	0	0	0	0	0	93	11.6
07-Sep	8.00	0	1	12	27	14	0	1	0	0	0	14	21	0	0	0	2	0	0	34	0	0	0	0	0	0	0	126	15.8
08-Sep	8.50	0	2	13	25	12	0	0	0	0	0	5	17	0	0	0	1	0	0	31	0	1	1	0	0	0	0	108	12.7
09-Sep	8.00	0	2	2	18	2	0	1	0	0	0	0	8	0	0	1	4	0	0	7	0	0	1	0	0	0	0	46	5.8
10-Sep	0.00																												
11-Sep	8.00	0	1	9	67	51	0	8	0	0	0	7	22	0	0	0	1	0	0	17	0	0	0	0	0	0	0	183	22.9
12-Sep	8.00	0	2	6	20	13	0	0	0	0	1	1	10	0	0	0	1	0	0	7	1	0	0	0	0	0	0	62	7.8
13-Sep	8.00	0	2	13	45	31	1	2	0	0	1	0	11	1	0	0	0	0	0	44	0	1	1	0	0	0	0	153	19.1
14-Sep	8.00	0	4	9	68	39	2	3	1	0	0	3	9	0	0	0	2	0	0	10	1	0	0	0	0	0	0	151	18.9
15-Sep	8.00	0	0	3	27	18	0	1	0	0	1	3	14	2	0	0	5	0	0	4	0	1	0	0	0	0	0	79	9.9
16-Sep	8.00	0	0	7	32	12	0	0	0	0	0	0	12	0	0	0	1	0	0	14	1	0	1	0	0	0	0	80	10.0
17-Sep	8.50	0	0	2	51	19	0	1	0	0	1	3	8	0	0	0	4	0	0	15	0	0	0	0	0	0	0	104	12.2
18-Sep	8.50	0	0	8	26	34	0	0	0	0	1	0	17	0	0	0	1	0	0	12	0	1	1	0	0	0	0	101	11.9
19-Sep	8.00	1	2	7	62	31	0	2	0	0	1	1	6	1	0	0	4	0	0	12	0	0	1	0	0	0	0	131	16.4
20-Sep	4.50	0	1	0	12	4	0	0	0	0	0	5	4	1	0	0	0	0	0	2	0	0	0	0	0	0	0	29	6.4
21-Sep	8.00	0	0	7	65	22	0	2	0	0	1	0	5	0	0	0	1	1	0	54	0	0	0	0	0	0	0	158	19.8
22-Sep	0.00																												
23-Sep	8.00	0	1	3	45	18	0	3	0	0	0	1	10	0	0	0	3	0	0	9	0	0	0	0	0	0	0	93	11.6
24-Sep	8.00	0	0	11	46	18	0	0	0	0	0	1	10	0	0	0	3	0	0	16	0	0	0	0	0	0	0	105	13.1
25-Sep	8.50	0	3	7	39	30	0	0	0	0	1	1	8	1	0	0	2	0	0	6	0	0	0	0	0	0	0	98	11.5
26-Sep	8.00	0	0	10	41	33	0	2	0	0	1	1	13	0	0	0	4	0	0	30	1	0	0	0	0	0	0	136	17.0
27-Sep	8.50	0	1	22	160	77	0	1	0	0	6	9	67	0	0	0	8	0	0	79	1	0	0	0	0	0	0	431	50.7
28-Sep	8.00	0	0	10	24	31	0	4	0	0	0	0	22	0	0	0	3	0	0	13	0	0	0	0	0	0	0	107	13.4
29-Sep	8.50	0	1	17	44	25	0	1	0	0	0	19	34	2	0	0	1	0	0	16	1	0	0	0	0	0	0	161	18.9
30-Sep	8.50	1	0	25	72	31	0	0	0	0	0	1	34	0	0	0	4	0	0	13	0	0	0	0	0	0	0	181	21.3

Appendix E. continued

		Species[1]																										Birds
Date	Hours	TV	OS	NH	SS	CH	NG	SA	LA	UA	BW	SW	RT	FH	RL	UB	GE	BE	UE	AK	ML	PR	PG	SF	LF	UF	UU	Total	/ hour
01-Oct	8.00	0	2	13	42	9	0	0	0	0	1	0	15	0	0	0	3	0	0	9	0	0	0	0	0	0	0	94	11.8
02-Oct	7.08	0	1	3	16	1	0	0	0	0	1	0	0	1	0	0	2	0	0	6	0	0	0	0	0	0	0	31	4.4
03-Oct	3.00	0	0	8	22	4	0	0	0	0	0	0	13	0	0	0	3	1	0	6	0	0	0	0	0	0	0	57	19.0
04-Oct	0.00																												
05-Oct	0.00																												
06-Oct	8.50	0	0	8	40	18	0	0	0	0	0	0	26	0	0	0	1	0	0	7	1	0	0	0	0	0	0	101	11.9
07-Oct	8.00	0	0	14	84	14	1	1	0	0	0	0	11	0	0	0	1	0	0	11	0	0	0	0	0	0	0	137	17.1
08-Oct	8.00	0	0	6	30	5	0	0	0	0	0	1	19	0	0	0	5	0	0	10	0	0	0	0	0	0	0	76	9.5
09-Oct	8.00	0	0	8	10	2	0	0	0	0	0	0	14	1	0	0	0	1	0	3	0	0	0	0	0	0	0	39	4.9
10-Oct	7.00	0	0	1	2	0	0	0	0	0	0	0	12	0	0	0	3	0	0	1	0	0	0	0	0	0	0	19	2.7
11-Oct	0.00																												
12-Oct	0.00																												
13-Oct	6.50	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	5	0.8
14-Oct	7.50	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.1
15-Oct	8.00	0	0	9	22	1	0	0	0	0	0	0	5	0	0	0	2	1	0	2	1	0	0	0	0	0	0	43	5.4
16-Oct	7.00	0	0	9	47	4	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	64	9.1
17-Oct	7.50	0	0	11	37	4	0	0	0	0	0	0	5	0	0	0	4	0	0	1	0	0	0	0	0	0	0	62	8.3
18-Oct	8.00	0	0	16	31	2	0	0	0	0	0	0	4	0	0	0	2	0	0	5	1	1	0	0	0	0	0	62	7.8
19-Oct	8.00	0	0	12	20	2	0	0	0	0	0	0	3	0	0	0	1	1	0	2	0	0	0	0	0	0	0	41	5.1
20-Oct	8.00	0	0	5	34	3	0	0	0	0	0	0	6	0	0	0	6	0	0	2	1	0	0	0	0	0	0	57	7.1
21-Oct	7.50	0	0	4	0	0	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	7	0.9
22-Oct	7.50	0	0	2	2	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	6	0.8
23-Oct	7.50	0	0	2	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0.5
24-Oct	7.50	0	0	3	5	1	0	0	0	0	0	0	1	0	0	0	4	0	0	1	0	0	0	0	0	0	0	15	2.0
25-Oct	7.00	0	0	1	11	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	1.9
26-Oct	7.00	0	0	5	9	1	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	2.4
27-Oct	7.00	0	0	7	12	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	22	3.1
28-Oct	7.00	0	0	5	7	0	1	0	0	0	0	0	1	0	1	0	1	0	0	0	1	0	0	0	0	0	0	17	2.4
29-Oct	7.00	0	0	12	12	0	0	0	0	0	0	0	1	0	0	0	3	1	0	1	0	0	0	0	0	0	0	30	4.3
30-Oct	7.00	0	0	4	9	0	0	0	0	0	0	0	2	0	1	0	3	0	0	0	1	0	0	0	0	0	0	20	2.9
31-Oct	7.00	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	3	0.4
TOTAL	453.08	3	39	412	1582	675	9	37	1	3	17	174	628	12	6	1	114	6	0	624	13	5	11	0	0	0	0	4372	9.6

[1] See Appendix B for explanations of species codes.