FALL 2010 RAPTOR MIGRATION STUDIES IN THE GRAND CANYON OF ARIZONA

HawkWatch International, Inc.
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INTRODUCTION

The Grand Canyon Raptor Migration Project in northern Arizona has been an ongoing effort to monitor long-term population trends of migratory raptors using the southern portion of the Intermountain Flyway (Hoffman et al. 2002, Hoffman and Smith 2003, Smith et al. 2008a). HawkWatch International (HWI) initiated standardized counts at Lipan Point in 1991, and later in 1997 began simultaneous standardized monitoring at Yaki Point. These sites were picked based on exploratory counts conducted by Chuck LaRue in 1987 and Christie Van Cleve during the 1989 and 1990 autumn migration seasons. Marking the 18th consecutive count at Lipan Point and the 12th consecutive full-season count at Yaki Point, 2008 was the last year both counts were able to be conducted simultaneously. No counts were conducted in 2009 due to budgetary issues, but for the 2010 season, HWI was able to procure enough funding to resume counts at Yaki Point only. Thus, this report summarizes the 2010 count results from that site.

The Yaki Point Grand Canyon project was 1of 9 long-term, annual migration counts conducted or co-sponsored by HWI in North America during 2010. The primary objective of these efforts is to track long-term population trends of diurnal raptors moving through western North America and around the Texas Gulf Coast (Hoffman and Smith 2003, Smith et al. 2008a, b). Raptors serve as important biological indicators of ecosystem health (Bildstein 2001), and standardized long-term migration counts represent one of the most efficient and cost effective means of monitoring raptor populations at regional and larger scales (Zalles and Bildstein 2000, Hoffman and Smith 2003, Bildstein 2006, Bildstein et al. 2008).

These migration studies also offer opportunities for the public to learn about raptors and the natural environment, and providing such opportunities is another important component of HWI's mission. With about 5 million people visiting the park each year and easy accessibility, the Grand Canyon sites offer excellent opportunities for public outreach and educating folks about the ecology and conservation needs of raptors and the Grand Canyon ecosystem.

STUDY SITES

The migration over the Grand Canyon is unique among HWI's western sites because migrating raptors are not guided to the region by mountain ridges and must rely on thermal lift rather than ridge updrafts to carry them over the broad North Kaibab Plateau toward the canyon. The Painted Desert along the eastern boundary of the park (Figure 1) may serve as a barrier because most raptors tend to avoid habitat communities with sparse vegetation, although the region does produce excellent thermal lift. The edge habitat where the forested Kaibab Plateau juxtaposes the desert, nevertheless, may provide for a more hospitable migratory pathway southbound as birds migrate towards the canyon. However, because there are no distinct ridges to serve as "leading lines" to provide a stable source of lift to concentrate migrating raptors (Bildstein 2006), migrants probably approach the canyon along a relatively broad front. Thus, monitoring at multiple points has ultimately provided valuable information about variation with daily and seasonal concentrations, as well as a better index of migration volume through the region. Yaki and Lipan Points particularly provide good monitoring locations because they lie immediately across from "peninsulas" of plateau land that jut out into the canyon from the north rim. These peninsulas produce narrow gaps between the two canyon rims that allow raptors to seemingly concentrate, akin to locations where raptors seek narrow passages to cross large bodies of water (Kerlinger 1989, Bildstein 2006).

Yaki and Lipan Points are both popular canyon lookouts located in Coconino County, Arizona along the south rim of the Grand Canyon. Yaki Point can be accessed from Hwy 64, about 11.2 km northeast of the south entrance of the park. The observation site sits at an elevation of 2,213 m (36° 03′ 31.0″ N, 112° 05′ 01.7″ W; Figure 1), and provides superb views of the canyon to the west and north, but thick vegetation obscures the view towards the east. The Lipan Point observation site can be accessed by driving southwest 3.2 km on Hwy 64 from the east entrance of the park, and is located about 170 m south of the parking lot at the edge the canyon rim, directly above an Anasazi granary at an elevation of 2,243 m (36°

01′ 59.2″ N, 111° 51′ 11.5″ W; Figure 1). This spot provides for a nearly 360° view of the surrounding landscape, with excellent visibility along the canyon to the north, south, and west. The predominant vegetation for both sites consists of big sagebrush (*Artemisia tridentata*), cliffrose (*Cowania mexicana*), Utah juniper (*Juniperus osteosperma*), and two-needle pinyon (*Pinus edulis*).

METHODS

As already stated above, counts were only conducted at Yaki Point during 2010. Two official or designated observers, assisted occasionally by other local volunteers and HWI staff, conducted standardized daily counts of migrating raptors from that traditional site. Lead Observer Kimberly Cullen had two previous seasons of migration counting, and one was as a Lead Observer at HWI's Manzano Mountain migration site in New Mexico. Other official observers Christine Duffy and Felipe Guerrero, who also acted as Interpreter, had no prior migration counting experience (see Appendix A for a complete history of observation participation). HWI and Grand Canyon National Park Service staff also sometimes assisted with counts and interpretation as well.

Weather permitting, observations typically began by 0900 H Mountain Standard Time (MST) and ended by 1700 H MST. 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 1000–1059 H MST.
3. Wind speed and direction, air temperature, percent cloud cover, predominant cloud type(s), presence or of 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 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 (high, moderate, low, none) for each hour, recorded on the hour.
7. Daily start and end times for each official observer.

Calculation of "adjusted" (to standardize sampling periods and adjust for incompletely identified birds) annual passage rates (migrants counted per 100 hours of observation) and analysis of trends updated through 2010 follows Farmer et al. (2007). Previous analyses compare long-term regression results between both the Lipan and Yaki Point sites separately, as well as results by combining sites together. For this report, we will only report on the trends from Yaki Point since that was the only site observational counts were conducted at. In comparing 2010 annual statistics against means and 95% confidence intervals for previous seasons, we equate significance with a 2010 value falling outside the bounds of the confidence interval for the associated mean.

RESULTS AND DISCUSSION

WEATHER SUMMARY

During 2010, there were no lost nor severly hampered days due to weather (i.e., reduced to ≤4 hours observation, Appendix C). In comparison (i.e.,1997–2008), severe weather, on average has shown to preclude 1.3, and severely hamper 1.6 days in a given season at this site.

Sky conditions were recorded predominantly clear to partly cloudy or fair 54% of the time, 31% as transitional (i.e., cloud cover changing from clear or partly cloudy to mostly cloudy or overcast during the day, or vice versa), and 15% as mostly cloudy or overcast. The averages for the site were 53% fair, 28% transitional, and 19% as mostly cloudy or overcast, suggesting that weather during the 2010 season brought a slight influx of mostly cloudy or overcast skies with less transitional cloud cover, and clear conditions. The increased clouds may have caused a greater than average increase in mean daily temperatures (20.8°C vs. on average of 18.1°C), which in turn may have also contributed to a good to excellent ranking of the thermal lift being significantly higher than average as well (i.e., 73% of days in 2010 vs. 46% on average). Thus, with thermal lift being high, raptors may have migrated so high through or above the cloud cover to escape detectibility. In addition, the season's visibility was also affected by dust and haze, as well as fog, to a lesser extent (66% of active observation days vs. on average of 33%). Rain and snow also occurred but was comparably no different from the norm (occurring on 16% of active observation days vs. 16% on average). Despite the effect of dust and haze, however, the observers ranked the season's visibility as the highest on record, both looking towards the east (95.9 km vs. 52.2 km on average) and west (91.0 km vs. 66.7 km on average).

The prevalent winds for the season were primarily light (<12 kph), occurring 87% of active observation days (vs. 77% on average), but also moderate (12-29 kph, occurring 13% of the active observation days, vs. 19% on average). On average, strong winds (≥ 29 kph) do occure but only at approximately 4% of active observational days in a given season. During 2010, no strong winds were recorded. The seasons wind directions primarily blew from the SE-SW (27%), NE-SE/Calm and Variable (25%), NE-SE (10%), Calm/Variable (10%), SW-NW/Calm and Variable (6%), and N-E (6%). Winds were also recorded from the NW-NE/Calm and Variable (4%), N-E/Calm and Variable (3%), S-W (3%), SW-NW/NE-SE (3%), W-N/Calm and Variable (3%), and Variable (1%). In comparison, winds, on average (1997-2008) blow primarily from the SW-NW (17%), NE-SE (16%), SE-SW (13%), recorded as Variable (10%), NE-SE/Calm and Variable (8%), SW-NW/Calm and Variable (7%), and NW-NE (6%).

In summary, during the 2010 season winds blew from a more consistent NE-SE, as well as SE-SW variable directions, and unlike most years, no winds were recorded to come from a SW-NW direction. Light and variable winds were also predominant. Thus, raptors could have migrated more broadly; thereby, having a less concentration of raptors moving through the point to count. And although the observers recorded a large percentage of days where dust and/or haze may have influenced visibility, they also ranked the visibility as being the highest on record. It is unknown, therefore, if raptors were not being detected, and if so, why.

Observation Effort

Counts occurred on 71 of 71 possible days between 27 August and 5 November (Appendix E). The 2010 average of 2.7 observers per hour (including official and guest observers; value is mean of daily values, which are in turn means of hourly values) was significantly above average (i.e., 2.2 ± 0.39 observers per hour). And of even greater significance, the season's total of 572.42 hours of observation was at an all time high (Appedix E).

MIGRATION SUMMARY

Observers at Yaki Point counted 5,442 migrant raptors of 15 species, which was a significant 14% above the long-term average (Table 1). Counts for Osprey, Northern Harriers, Swainson's Hawks, and Peregrine Falcons were above average and the season's totals for Sharp-shinned Hawks were significantly above average (Table 1). In contrast, ten (i.e., Cooper's Hawks, Northern Goshawks, Broad-winged Hawks, Red-tailed Hawks, Ferruginous Hawks, Golden and Bald Eagles, American Kestrels, Merlins, and Prairie Falcons) out of the 15 species were counted below average. Six of those were counted significantly below average (i.e., Northern Goshawks, Ferruginous Hawks, Golden and Bald Eagles, American Kestrels and Prairie Falcons; Table 1).

The flight consisted of 67.4% accipiters, 20.4% buteos, 9.4% falcons, 0.8% harriers, 0.8% Ospreys, 0.2% eagles, and 0.4% unidentified raptors. The proportions of accipiters were above average; buteos, falcons, eagles, and harriers were below average; and Ospreys showed no difference (Fig. 2). As per normal, Sharp-shinned Hawks were the most commonly observed species (38% of the total), followed by Red-tailed and Cooper's Hawks (each at 17%), then American Kestrels (9%). The remainder of species only comprised of 1%, or less (Table 1).

Passage Rate and Long-term Trends

Regression analyses of the adujusted passage rates through 2010 show significant linear declines for Ferruginous Hawks (Fig. 5), Golden Eagles (Fig. 6), and American Kestrels (Fig. 7). Northern Harriers are also showing a marginal (P-value = 0.0530) quadratic decline (Fig. 3), but not significantly linear (slope = -0.217, $r^2 = 0.212$, P-value = 0.114). Whether Northern Harriers continue to show declining trends, remains to be seen. With Ferruginous Hawks and Golden Eagles, annual counts at this site are often low, especially for Ferruginous Hawks (Appendix E). Nevertheless, results for Ferruginous Hawks show a strong significant decline (slope = -0.143, $r^2 = 0.622$, P-value = 0.001), and likewise, the observed Golden Eagle (slope = -0.207, $r^2 = 0.326$, P-value = 0.042) and American Kestrel (slope = -12.244, $r^2 = 0.471$, P-value = 0.010) declines at this site are similar to what is going on throughout the North American West for Golden Eagles (cf. Farmer et al. (2008)) and continentally for American Kestrels (cf. Farmer et al. (2008) and Farmer and Smith (2009)).

Age Ratios

When counting raptors, our observers try to identify and separate species' ages (adults vs. immature) and gender as best as possible. This, however, is often difficult with many raptor species, especially at a distance and during poor lighting (see, for example, Table 2 "% Unknown Age" column). Nevertheless, accurate age and gender identification allows for better understanding of flight volumes, passage dates, and trends in a more detailed context. Table 2 allows for annual comparison of flight volume based on comparing the ratio of immature to adults that are passing through in a given season, compared to long-term seasonal averages. At Yaki Point, normally adult Sharp-shinned Hawks, Cooper's Hawks, Broad-winged Hawks, Red-tailed Hawks, and Bald Eagles come through at higher numbers than immature birds (Table 2). During 2010, only Broad-winged Hawks came through in equal proportions of immature to adult birds. Amazingly, all birds from this species were able to be aged! The ratio of immature to adult Red-tailed Hawks showed no change, compared to the long-term average, even though the season's totals came down slightly (Table 2). Thus, based on the low percentages of birds that weren't able to be correctly aged, the proportions of adults to young still came through relatively consistently but the 2010 counts tallied slightly less adults and more immatures than normal (Table 2). With these data, it is equivocal to say anything about a change in productivity, as well as survival. For Sharp-shinned Hawks, Cooper's Hawks, and Bald Eagles the immature to adult ratios were below average (Table 2), suggesting fewer immatures came through. Lastly, with Northern Harriers, typically immature birds come through, on average, at a higher proportion than adults (Table 2). Interestingly, during the 2010 season, observers

tallied only a slight increase in the total number of harriers, as well as the percentage of birds that they were able to age. The major descrepency came from the significant increase in adults and decrease in immatures that were tallied (Table 2). Whether this has to do with low reproductive success and an increase in adults coming through because, of perhaps, low food availability, or some other reason entirely, is difficult to say because sample sizes are low.

Seasonal Timing

The combined-species median passage date of 4 October was a significant three days later than the 1997–2008 long-term average (Table 3). On average, the combined-species seasonal distribution illustrates that migration peaks during the last week in September, then experiences a lull during the first 5-day period in October, peaks again during the second 5-day period in October, then steadily drops off to end out the season (Fig. 8). In contrast, migration during the 2010 season started out slow, picked up in a major way around 20 September to surpass the normal September peak, then following previous trends, experienced a major lull way below average during the next 5-day period, peaked again above average during the second 5-day period in October, then declined but numbers remained above average until about the last week in October (Fig. 8). At the species level, five species (i.e., the Northern Harrier, Cooper's Hawk, Broad-winged Hawk, Swainson's Hawk, and Red-tailed Hawk) arrived, on average, two to fourteen days later than normal; whereas, five others (i.e., Osprey, Sharp-shinned Hawk, Bald Eagle, Merlin, Peregrine Falcon) arrived, on average, one to four days early (Table 3). The American Kestrel was the only species that did not shift from average (Table 3). The age-specifice median dates generally followed the same pattern except that both adult and immature Sharp-shinned arrived, on average, two and three days later, respectively, and that adult Cooper's Hawks, on average, arrived one day early (Table 4). The arrival of both Sharp-shinned Hawk age groups arriving later initially contrasts counterintuitively compared to the overall timing of Sharp-shinns arriving one day early (Table 3) but the contrast dates aren't really that wide and the discrepancy does not factor in the percentage of Sharp-shinned Hawks that were unable to be aged (Table 2).

RESIDENT RAPTORS

At least one adult Red-tail light morph was seen on numerous days from the beginning of the count through the last day (i.e., 27 August through 05 November). On two separate days, 30 August and 03 September, two adult light morphs were observerd. An immature light morph was also seen through the season. Thus, a family group of two adult and one immature light morphs was probably present through most of the season, but one of the adults could have departed by early September since there were no other observations of multiple adult light morphs being recorded on the same day. In addition, on two separate days, 17 October and 05 November, observers identified an adult dark morph Red-tailed Hawk as being a resident as well.

From 27 August through 16 September, Zone-tailed Hawks were observed on twelve separate days. Observers started out recording a presumable family group of two adults and one immature, but the immature was last seen on 29 August and after that observers only recorded one adult so it is unknown if one of the adults departed that day as well.

A presumable family of Peregrine Falcons (including both adults and one immature) were also recorded. This is based on all three birds being recorded on two separate days, 09 and 11 September. Beyond 11 September, however, the adult pair was often seen up to 27 September. After that date, only one Peregrine was observed, an adult on 29 September, and an unknown Peregrine on 02 October.

A number of resident accipiters were also recorded throughout the season. Immature Sharp-shinns were recorded on two separate days, 27 August and 10 September (on this day observers recorded the bird as being an immature female). Adult Sharp-shinns were recorded on three separate occations later in the season on 14 and 16 October, as well as on 01 November; an unknown aged female Sharp-shinned was recorded on 11 September and unknown resident Sharp-shinns were recorded on 16 September, as well as

17 October. An adult Cooper's Hawk was recorded on three separate occasions on 02, 10, and 25 September, and one unknown Northern Goshawk was recorded on 02 October. In addition, four unidentified resident accipiters were also recorded on four separate occasions; on 01 September and 04 October (as unidentified accipiters), a large accipiter on 15 September, and a small accipiter on 01 November (see Appendix B for definitions on large and small accipiters).

Lastly, in August and through early September, observers recorded a number of Turkey Vultures. Specifically, 12, up to 30 birds were recorded on 03 September.

VISITOR PARTICIPATION

During the season, approximately 512 individuals visited the site from 36 states, 5 Canadian provinces, and 11 foreign countries: Netherlands, U.K., Australia, Spain, Czech Republic, Ireland, Italy, Belgium, Brazil, Germany, France; and one foreign territory: Bermuda. In addition, HWI staff member Mike Neal led a group attended by the Prescott chapter of Arizona Audubon.

Every hour observers assess the disturbance level of visitors to quantify how visitation may affect detectibility. During the 2010 season, a total of 610 hourly assessments of visitor disturbance resulted in the following ratings: 92.1% as not being disturbed, 5.9% as low, 1.6% moderate, and 0.3% as high visitor disturbance

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Table 1. Annual raptor migration counts and adjusted (truncated to standardized annual sampling periods and adjusted for incompletely identified birds) annual passage rates by species in the Grand Canyon, AZ (Yaki Point data only): 1997–2008 versus 2010.

SPECIES	COUNTS			RAPTORS / 100 HOURS		
	1997–2008[1]	2010	% CHANGE	1997–2008[1]	2010	% CHANGE
Osprey	40 ± 5.4	42	+6	9.3 ± 0.77	9.2	-1
Northern Harrier	41 ± 4.4	45	+11	8.3 ± 0.65	9.0	+8
Sharp-shinned Hawk	1,633 ± 202.0	2,065	+26	409.2 ± 25.88	579.8	+42
Cooper's Hawk	961 ± 203.1	911	-5	277.2 ± 31.64	304.4	+10
Northern Goshawk	8 ± 3.0	4	-48	1.6 ± 0.38	0.9	-44
Unknown small accipiter	138 ± 56.2	582	+323	–	–	–
Unknown large accipiter	15 ± 19.1	19	+26	–	–	–
Unknown accipiter	83 ± 38.6	87	+5	–	–	–
TOTAL ACCIPITERS	2,786 ± 370.7	3,668	+32	–	–	–
Red-shouldered Hawk	0.1 ± 0.2	0	-100	–	–	–
Broad-winged Hawk	11 ± 3.3	8	-29	4.5 ± 0.81	2.8	-39
Swainson's Hawk	35 ± 22.7	51	+44	9.2 ± 3.41	13.9	+51
Red-tailed Hawk	973 ± 103.3	934	-4	211.3 ± 12.54	211.7	0
Ferruginous Hawk	6 ± 1.6	2	-67	1.4 ± 0.24	0.5	-67
Rough-legged Hawk	0 ± 0.4	0	-100	–	–	–
Zone-tailed Hawk	0.7 ± 0.8	0	-100	–	–	–
Unidentified buteo	26 ± 7.9	116	+343	–	–	–
TOTAL BUTEOS	1,053 ± 122.2	1,111	+6	–	–	–
Golden Eagle	8 ± 4.3	2	-76	1.6 ± 0.50	0.5	-66
Bald Eagle	20 ± 6.1	10	-51	5.8 ± 0.93	3.1	-46
Unidentified eagle	0.5 ± 0.5	1	+100	–	–	
TOTAL EAGLES	30 ± 10.2	13	-57	–	–	
American Kestrel	747 ± 154.1	485	-35	207.3 ± 23.35	131.3	-37
Merlin	12 ± 2.9	10	-18	2.5 ± 0.35	2.1	-17
Prairie Falcon	6 ± 1.5	3	-46	1.3 ± 0.23	0.9	-30
Peregrine Falcon	10 ± 3.0	11	+9	2.1 ± 0.40	2.5	+18
Unknown small falcon	5 ± 4.8	21	+367	–	–	–
Unknown large falcon	2.4 ± 2.3	5	+111	–	–	–
Unknown falcon	3 ± 0.9	5	+94	–	–	–
TOTAL FALCONS	782 ± 148.3	540	-31	–	–	–
Unidentified Raptor	25 ± 10.2	23	-6	–	–	–
GRAND TOTAL	4,755 ± 583.0	5,442	+14	–	–	–

[1] Mean of annual values ± 95% confidence interval.

Table 2. Fall migration counts by age classes and immature : adult ratios for selected raptor species in the Grand Canyon, AZ (Yaki Point data only): 1997–2008 versus 2010.

	Total and Age-classified Counts								Immature : Adult	
	1997–2008 Average			2010			% Unknown Age		Ratio	
Species	Total	Imm.	Adult	Total	Imm.	Adult	1997–2008[1]	2010	1997–2008[1]	2010
Northern Harrier	41	13	11	45	5	20	42 ± 8.3	44	1.2 ± 0.18	0.3
Sharp-shinned Hawk	1,633	347	663	2,065	265	708	37 ± 7.6	53	0.6 ± 0.12	0.4
Cooper's Hawk	961	248	304	911	124	227	41 ± 7.4	61	0.9 ± 0.19	0.5
Northern Goshawk	8	3	2	4	2	0	23 ± 17.1	50	2.1 ± 0.83	-
Broad-winged Hawk	11	3	5	8	4	4	28 ± 16.0	0	0.7 ± 0.45	1.0
Red-tailed Hawk	973	163	639	934	177	594	17 ± 4.6	17	0.3 ± 0.07	0.3
Ferruginous Hawk	6	2	2	2	0	0	37 ± 17.0	100	1.1 ± 0.75	-
Golden Eagle	8	3	3	2	1	0	29 ± 8.8	50	1.1 ± 0.44	-
Bald Eagle	20	5	14	10	2	7	9 ± 7.0	10	0.4 ± 0.15	0.3
Peregrine Falcon	10	2	4	11	0	6	47 ± 17.4	45	0.5 ± 0.19	0.0

[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 dates of observation, bulk passage dates, and median passage dates by species for migrating raptors in the Grand Canyon, AZ, with comparisons of 2010 and 1997–2008 average median passage dates (Yaki Point data only).

	2010				1997–2008
Species	First Observed	Last Observed	Bulk Passage Dates [1]	Median Passage Date [2]	Median Passage Date [3]
Osprey	28-Aug	15-Oct	1-Sep – 8-Oct	21-Sep	22-Sep ± 2.2
Northern Harrier	13-Sep	5-Nov	26-Sep – 3-Nov	21-Oct	7-Oct ± 3.1
Sharp-shinned Hawk	27-Aug	5-Nov	20-Sep – 17-Oct	2-Oct	3-Oct ± 1.8
Cooper's Hawk	31-Aug	5-Nov	20-Sep – 14-Oct	1-Oct	29-Sep ± 2.0
Northern Goshawk	28-Sep	10-Oct	–	–	5-Oct ± 9.4
Broad-winged Hawk	17-Sep	10-Oct	17-Sep – 10-Oct	30-Sep	25-Sep ± 1.8
Swainson's Hawk	27-Aug	20-Oct	10-Sep – 20-Oct	28-Sep	23-Sep ± 4.7
Red-tailed Hawk	27-Aug	5-Nov	26-Sep – 31-Oct	19-Oct	10-Oct ± 2.3
Ferruginous Hawk	11-Oct	4-Nov	–	–	11-Oct ± 10.2
Zone-tailed Hawk	–	–	–	–	–
Golden Eagle	10-Sep	8-Oct	–	–	17-Oct ± 3.9
Bald Eagle	12-Oct	5-Nov	12-Oct – 26-Oct	22-Oct	26-Oct ± 3.9
American Kestrel	29-Aug	25-Oct	6-Sep – 10-Oct	25-Sep	25-Sep ± 2.0
Merlin	30-Aug	25-Oct	16-Sep – 25-Oct	3-Oct	6-Oct ± 4.9
Prairie Falcon	1-Sep	30-Sep	–	–	23-Sep ± 5.0
Peregrine Falcon	28-Aug	2-Nov	5-Sep – 12-Oct	24-Sep	28-Sep ± 8.1
All species	27-Aug	5-Nov	18-Sep – 20-Oct	4-Oct	1-Oct ± 1.5

[1] Dates between which the central 80% of the flight passed.

[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 classes for selected species of migrating raptors in the Grand Canyon, AZ (Yaki Point data only): 1997–2008 versus 2010.

	ADULT		IMMATURE / SUBADULT	
SPECIES	1997–2008[1]	2010	1997–2008[1]	2010
Northern Harrier	9-Oct ± 5.6	26-Oct	6-Oct ± 4.3	14-Oct
Sharp-shinned Hawk	9-Oct ± 1.5	11-Oct	27-Sep ± 1.4	30-Sep
Cooper's Hawk	3-Oct ± 1.7	2-Oct	27-Sep ± 1.8	30-Sep
Northern Goshawk	– ± –	–	– ± –	–
Broad-winged Hawk	24-Sep ± 2.5	–	25-Sep ± 6.5	–
Red-tailed Hawk	10-Oct ± 2.1	21-Oct	2-Oct ± 3.5	13-Oct
Golden Eagle	8-Oct ± 15.0	–	18-Oct ± 0.0	–
Bald Eagle	25-Oct ± 3.9	22-Oct	26-Oct ± 5.4	–
Peregrine Falcon	1-Oct ± 30.1	15-Sep	– ± –	–

Note: Median passage dates are dates by which 50% of the flight had passed the lookout; values were calculated based only on counts of ≥5 birds per year.

[1] Mean ± 95% confidence interval in days; unless otherwise indicated, values were calculated only for species with ≥3 years of counts ≥5 birds per year.

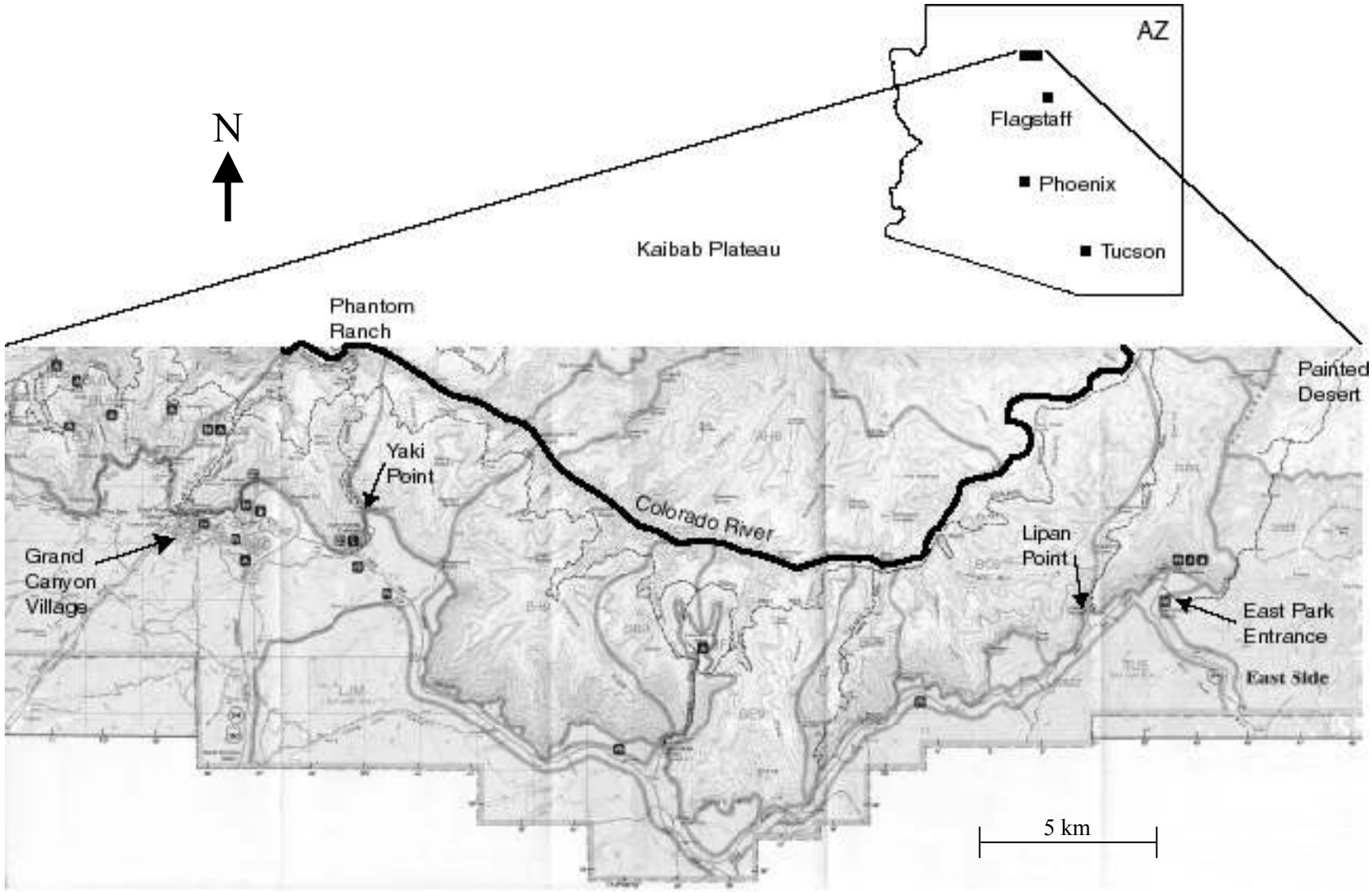

Figure 1. Map showing the Lipan Point and Yaki Point raptor-migration study sites in the Grand Canyon, Arizona.

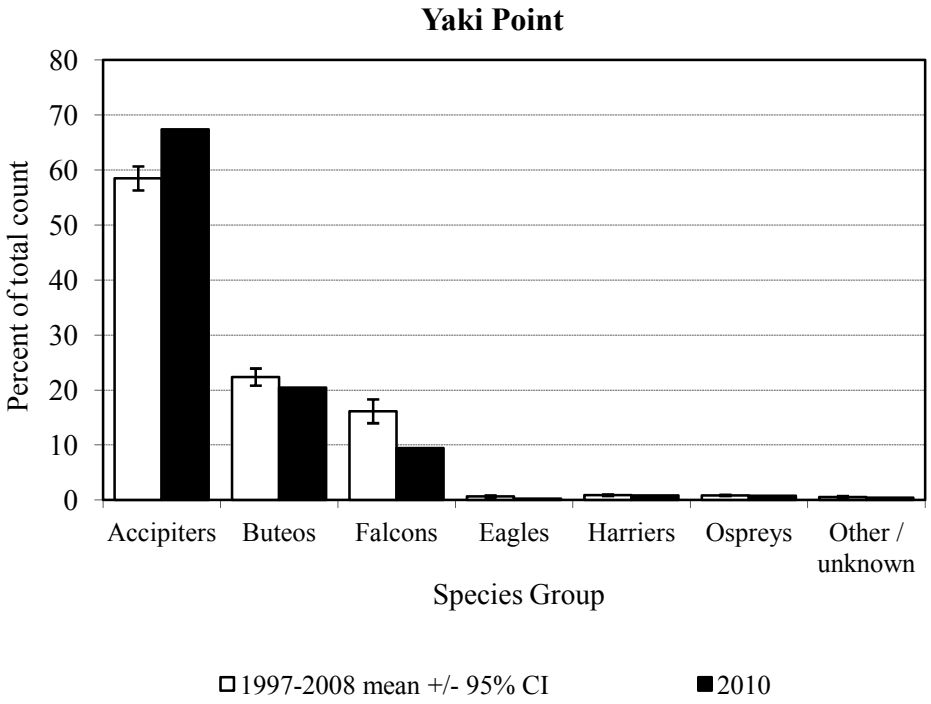

Figure 2. Fall raptor-migration flight composition by major species groups at Yaki Point in the Grand Canyon, AZ: 1997–2008 versus 2010.

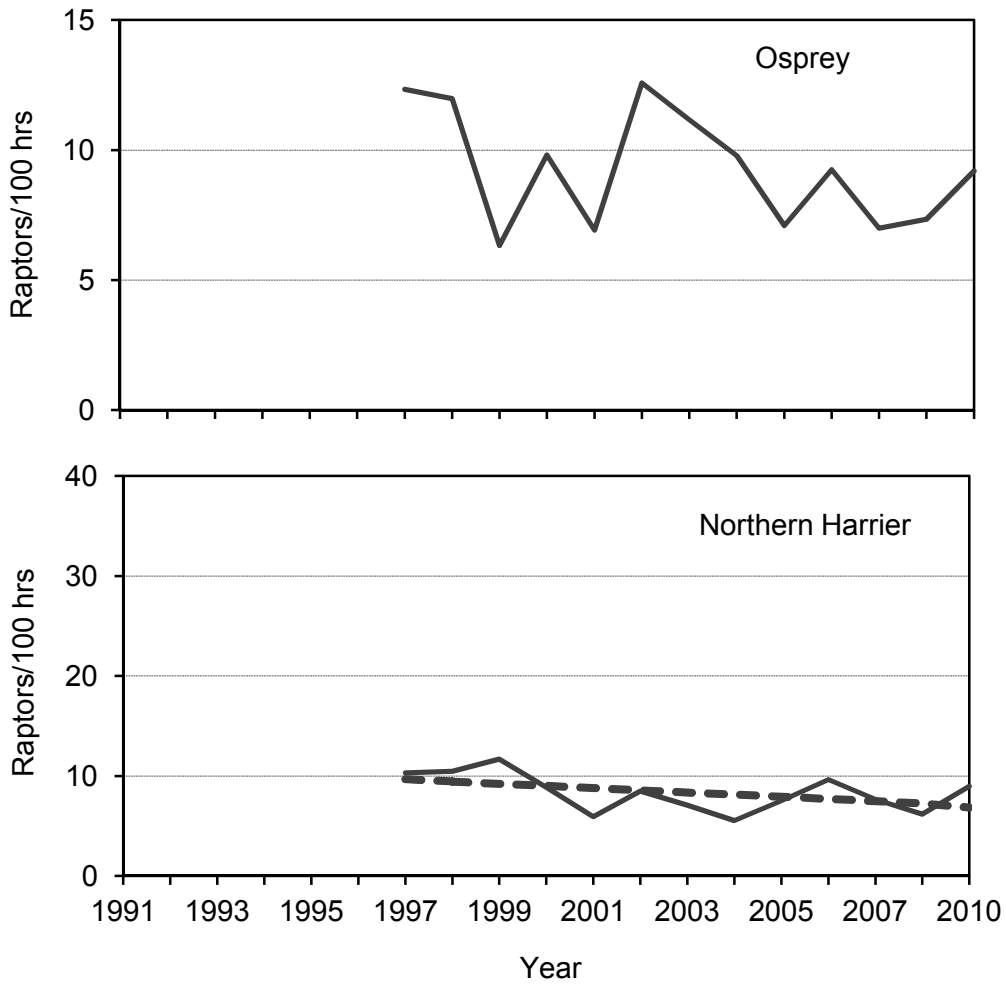

Figure 3. Adjusted (truncated to standardized annual sampling periods and adjusted for incompletely identified birds) fall-migration passage rates for Ospreys and Northern Harriers at Yaki Pt. in the Grand Canyon, AZ: 1991–2010. Dashed lines indicate significant ($P \leq 0.10$) linear or quadratic regressions.

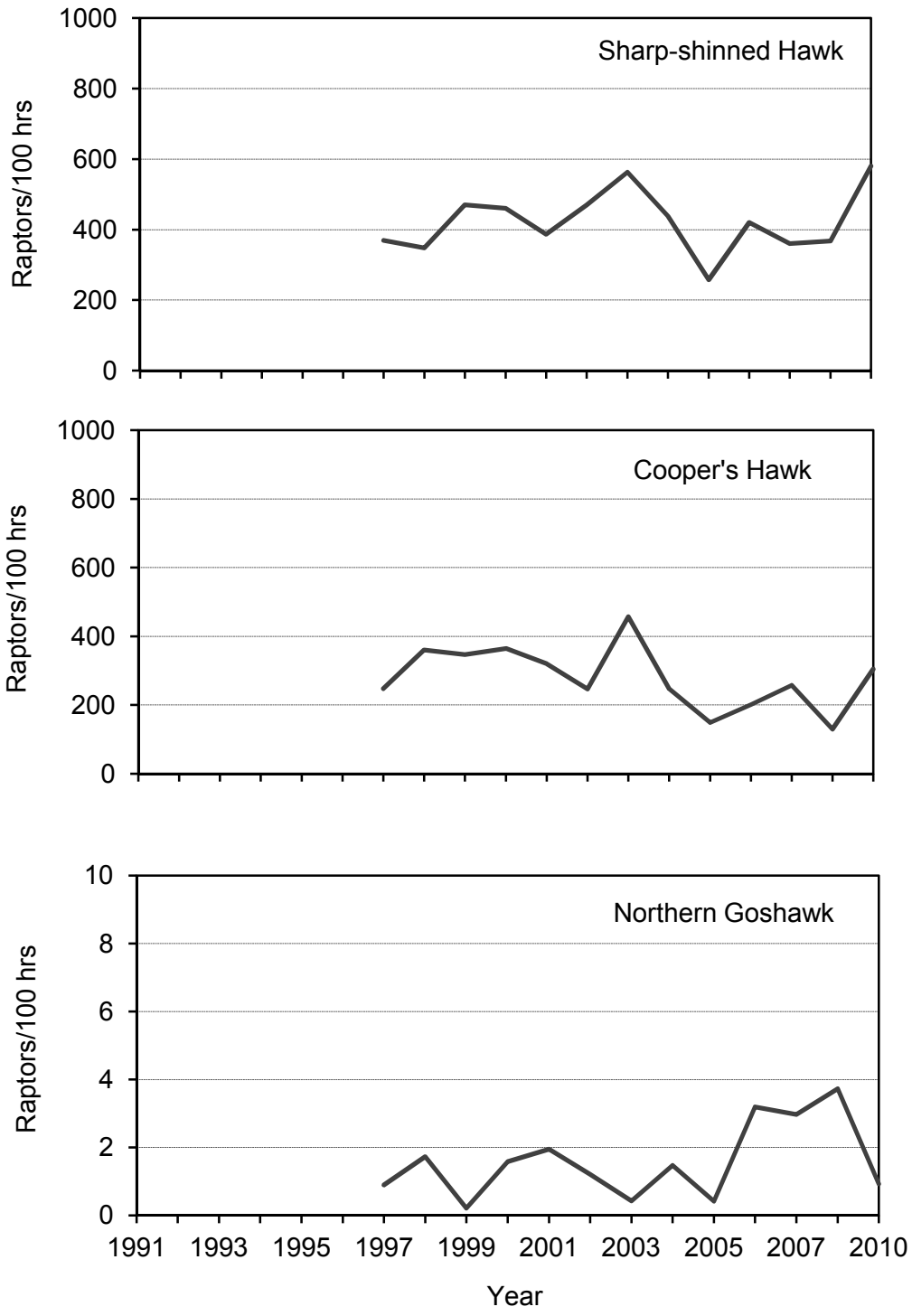

Figure 4. Adjusted (truncated to standardized annual sampling periods and adjusted for incompletely identified birds) fall-migration passage rates for Sharp-shinned Hawks, Cooper's Hawks, and Northern Goshawks at Yaki Pt. in the Grand Canyon, AZ: 1991–2010. Dashed lines indicate significant ($P \leq 0.10$) linear or quadratic regressions.

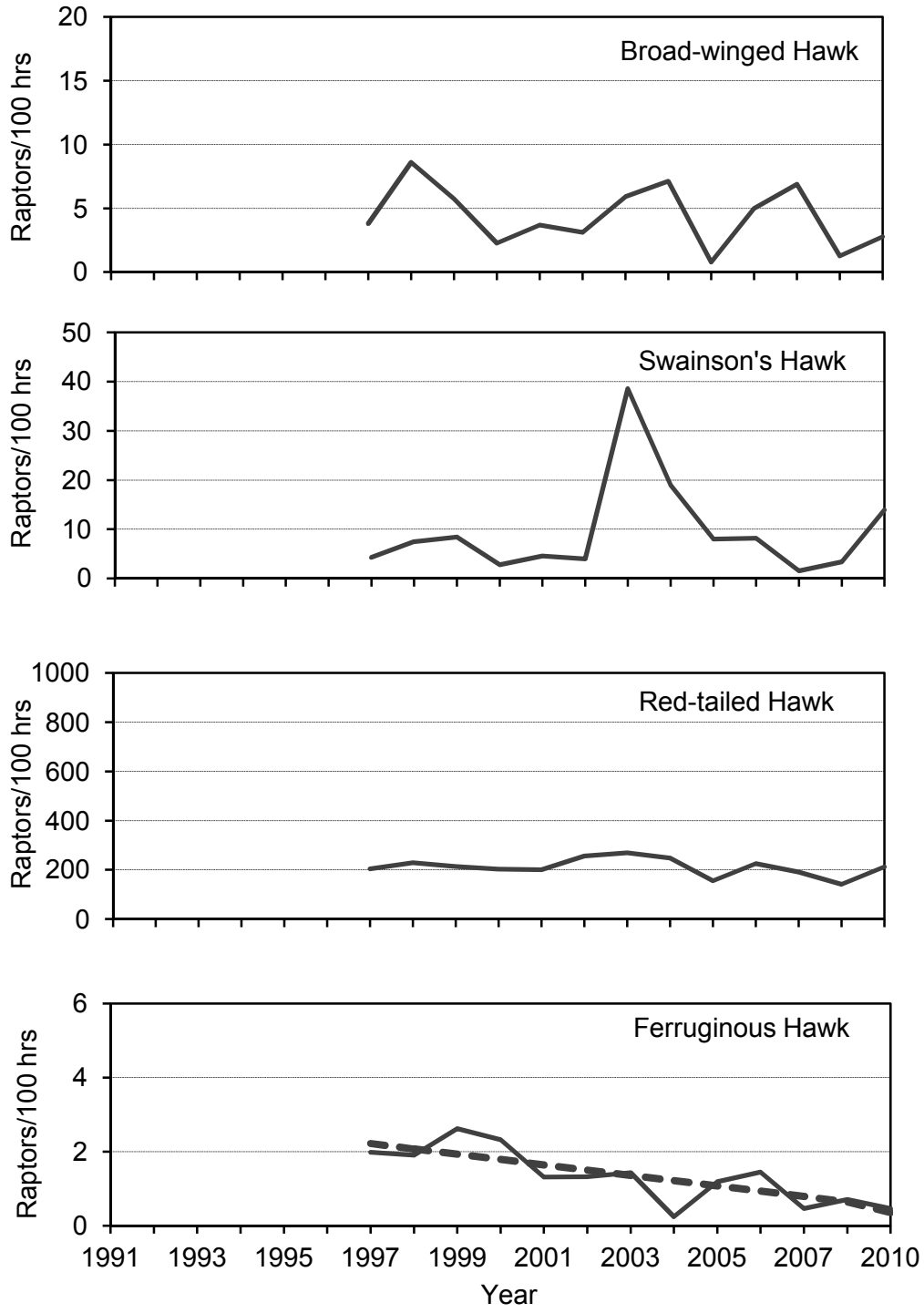

Figure 5. Adjusted (truncated to standardized annual sampling periods and adjusted for incompletely identified birds) fall-migration passage rates for Broad-winged, Swainson's, Red-tailed, and Ferruginous Hawks at Yaki Pt. in the Grand Canyon, AZ: 1991–2010. Dashed lines indicate significant ($P \leq 0.10$) linear or quadratic regressions.

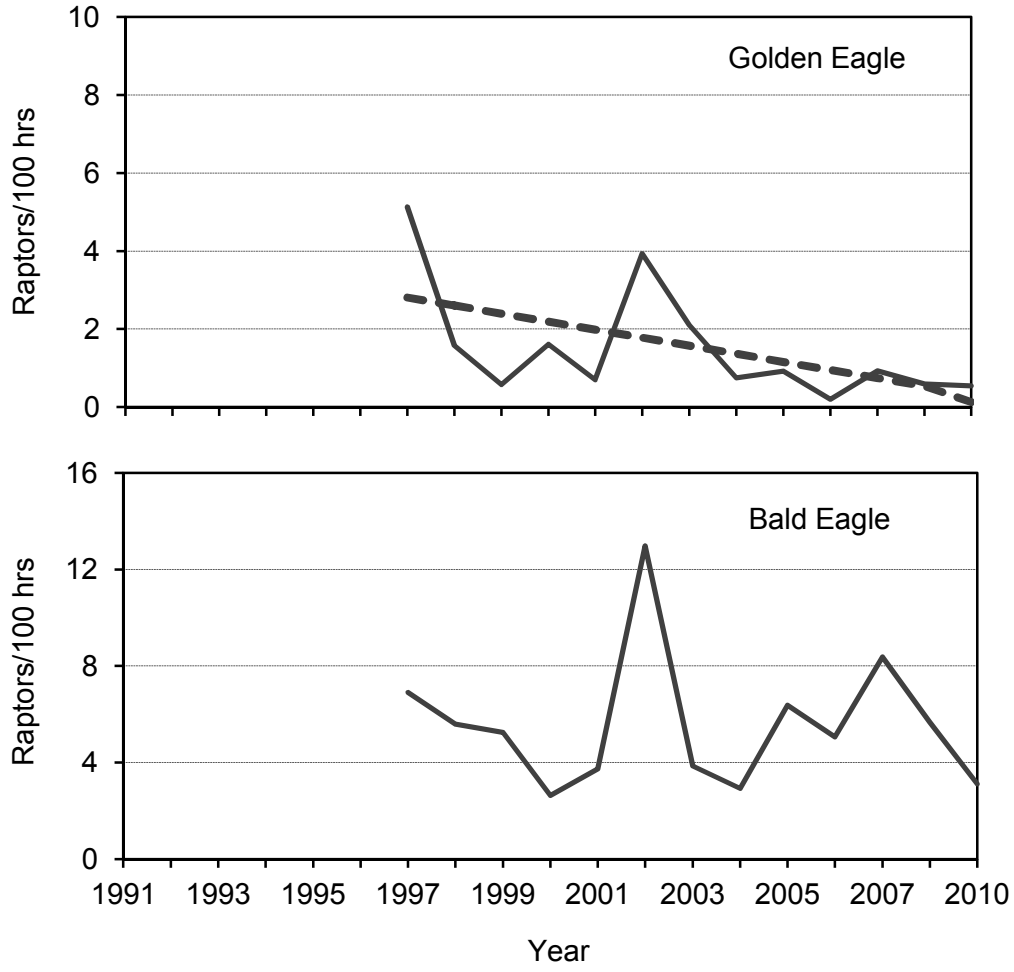

Figure 6. Adjusted (truncated to standardized annual sampling periods and adjusted for incompletely identified birds) fall-migration passage rates for Golden and Bald Eagles at Yaki Pt. in the Grand Canyon, AZ: 1991–2010. Dashed lines indicate significant ($P \leq 0.10$) linear or quadratic regressions.

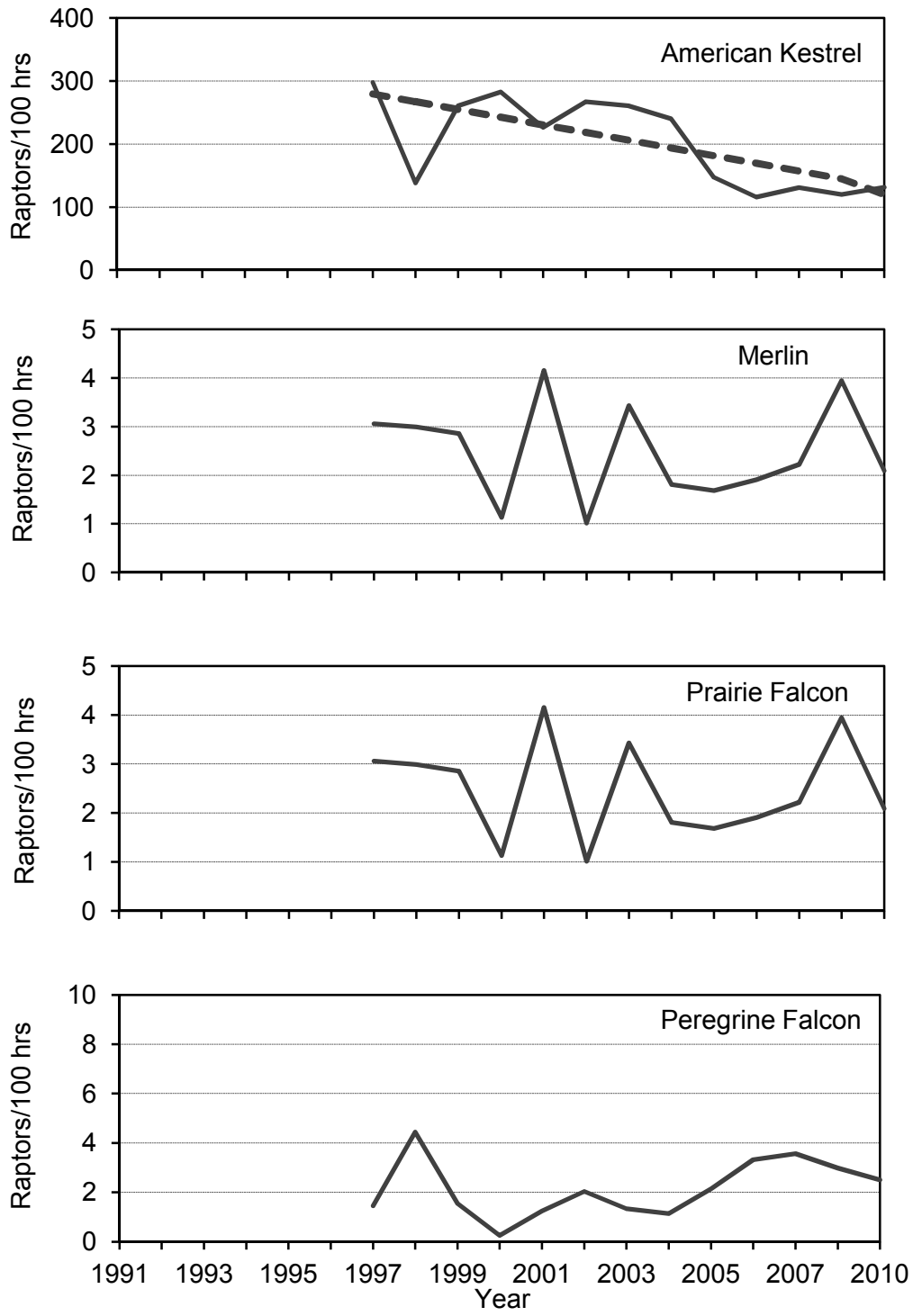

Figure 7. Adjusted (truncated to standardized annual sampling periods and adjusted for incompletely identified birds) fall-migration passage rates for American Kestrels, Merlins, Prairie Falcons, and Peregrine Falcons at Yaki Pt. in the Grand Canyon, AZ: 1991–2010. Dashed lines indicate significant ($P \leq 0.10$) linear or quadratic regressions.

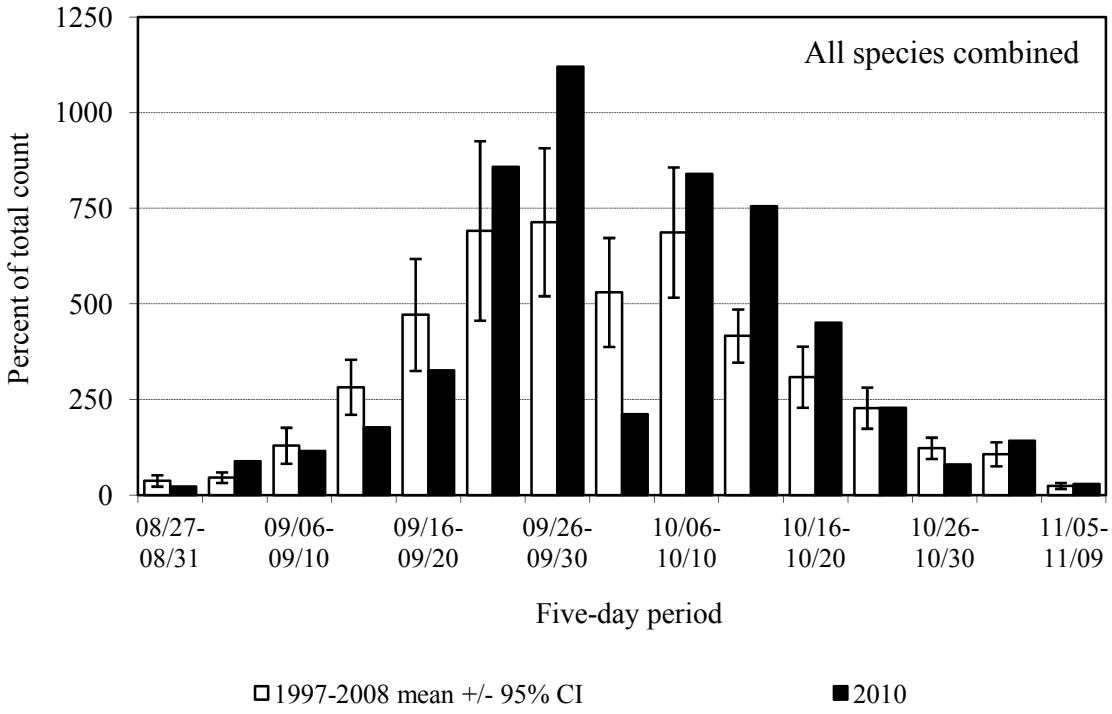

Figure 8. Combined-species, fall-migration passage volume by five-day periods for raptors at Yaki Point in Grand Canyon, AZ: 1997–2008 versus 2010.

Appendix A. History of official observer participation in the Grand Canyon raptor migration studies: 1991–2010.

1991 Rotating team with at least two observers throughout at Lipan Pt.: Mark Cantrell (1), Phil West (0), Vickie O'Brien (0), Christie Van Cleve (0), and Don Rosie (0)

1992 Rotating team with at least two observers throughout at Lipan Pt.: Mark Cantrell (2), Daniel Perry (3), and Christie Van Cleve (1)

1993 Rotating team with at least two observers throughout at Lipan Pt.: Daniel Perry (4), Frank LaSorte (1), and Christie Van Cleve (2)

1994 Rotating team with at least two observers throughout at Lipan Pt. and 1–2 observers at Yaki Pt. for limited season: Daniel Perry (5), Justin Silcox (0), Amy Adams (0), Rod Adams (0), and Christie Van Cleve (3)

1995 Rotating team with at least two observers throughout at Lipan Pt.: Amy Adams (1), Elliot Swarthout (0), and Christie Van Cleve (4)

1996 Rotating team with at least two observers throughout at Lipan Pt.: Amy Adams (2), Elliot Swarthout (1), and Christie Van Cleve (5)

1997 Rotating team with at least two observers throughout at Yaki and Lipan Pts.: Sue Thomas (2), Scott Harris (2), Rusty Namitz (1), Annie Touliatos (0), and Christie Van Cleve (6)

1998 Rotating team with at least two observers throughout at Yaki and Lipan Pts.: Josh Lipton (4), Jackie Speicher (2), Stacy Prosser (1), Karen McDonald (0), and Christie Van Cleve (7)

1999 Rotating team with at least two observers throughout at Lipan Pt. and at least 1 and usually 2 observers throughout at Yaki Pt.: Scott Rush (1), Adam Hutchins (1), Steve Seibel (1), Christie Van Cleve (8), and Kate James (0).

2000 Rotating team with at least two observers throughout at Lipan Pt. and Yaki Pt.: Adam Hutchins (2), Steve Seibel (2), Geoff Evans (0), Jody Bartz (0), Christie Van Cleve (9), and Kate James (1).

2001 Rotating team with at least two observers throughout at Lipan Pt. and Yaki Pt.: Adam Hutchins (3), Jody Bartz (1), Paula Shannon (1), Tom Magarian (0), and Christie Van Cleve (10).

2002 Rotating team with at least two observers throughout at Lipan Pt. and Yaki Pt.: Allison Cebula (2), Corrie Borgman (1), Erin McEldowney (+), Toni Appleby (0), and Christi Van Cleve (11)

2003 Rotating team with at least two observers throughout at Lipan Pt. and Yaki Pt.: Jody Bartz (2), Mark Leavens (1), Ken Babcock (2 partial), and Grant Merrill (0).

2004 Rotating team with at least two observers throughout at Lipan Pt. and Yaki Pt.: Ken Babcock (2 + 2 partial), Kirsten McDonnell (4), Chadette Pfaff (1), and Scott Olmstead (0).

2005 Rotating team with at least two observers throughout at Lipan Pt. and Yaki Pt.: Surya Bahadur Gurung (1+), Brad Alexander (0), Alyson Webber (0), and Sarah Keller (0).

2006 Rotating team with at least two observers throughout at Lipan Pt. and Yaki Pt.: Sean Wolfe (1), Sumit Gurung (1+), Thuy-Vy Bui (0), and Geni Gellhaus (+).

2007 Rotating team with at least two observers throughout at Lipan Pt. and Yaki Pt.: Jennifer Good (2+), Graeme Davis (1), Tyler Hallman (0), and Jenny Aleman-Zometa (0).

2008 Rotating team with at least two observers throughout at Lipan Pt. and Yaki Pt.: Lyndia Hammer (2+), Lainie LaHaye (0), Shannon Longoria (0), Stephanie Newton (0), Kris Schuller (0), Mike Neal (10+).

2009 No counts

2010 Two observers throughout at Yaki Pt. only: Kimberly Cullen (2), Christine Duffy (0), Felipe Guerrero (0)

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[1] Numbers in parentheses indicate previous full seasons of observation experience.

Appendix B. Common and scientific names, species codes, and regularly applied age, sex, and color-morph classifications for all diurnal raptor species observed during fall migration in the Grand Canyon, AZ.

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
Zone-tailed Hawk	*Buteo albonotus*	ZT	A I U	U	NA
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 raptor-migration flight summaries at Yaki Point, Grand Canyon, AZ: 2010.

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. East (km)[1]	Visib. West (km)[1]	Median Flight Distance[5]	Birds / Hour
27-Aug	6.42	3.7	0	pc-mc-ovc, rain, t-storms	2.9	sw-nw, calm/var	26.6	30.01	3	98	93	0	0.9
28-Aug	8.00	2.5	0	mc-ovc-mc, blowing dust	11.1	se-sw	22.8	29.78	4	100	95	0	0.3
29-Aug	8.08	2.8	0	ovc-mc, blowing dust	17.2	se-sw	22.3	29.75	3	100	93	0	0.1
30-Aug	8.00	2.0	0	clr	9.7	ne-se, calm/var	21.2	29.85	3	100	96	1	0.8
31-Aug	8.00	2.1	0	clr	7.3	ne-se	23.4	30.03	2	100	97	1	0.9
1-Sep	8.00	2.2	0	clr	1.8	nw-ne, calm/var	27.7	30.13	2	100	96	3	2.6
2-Sep	8.08	2.3	0	clr, haze	1.7	ne-se, calm/var	28.6	30.10	2	100	88	2	2.6
3-Sep	8.50	2.0	0	clr-pc, haze	2.4	n-e, calm/var	30.2	30.16	3	100	90	3	2.4
4-Sep	8.00	3.0	0	clr-pc, haze	5.3	sw-nw, ne-se	28.7	30.10	2	100	93	2	1.3
5-Sep	8.33	2.0	0	clr, haze-blowing dust	10.3	se-sw	26.4	29.89	3	100	95	2	1.9
6-Sep	9.00	2.0	0	clr, haze	2.0	nw-ne, calm/var	28.0	29.91	2	100	90	2	2.2
7-Sep	8.00	2.5	0	ovc-pc, rain	2.2	ne-se, calm/var	20.6	29.97	4	93	83	0	0.3
8-Sep	8.00	2.0	0	ovc-mc-pc-clr	11.1	se-sw	25.2	29.85	3	98	94	3	1.5
9-Sep	8.42	3.8	0	clr, haze-blowing dust	12.4	se-sw	20.0	29.80	4	100	96	2	3.7
10-Sep	8.75	3.2	0	clr, haze	3.5	w-n, calm/var	21.5	29.99	3	99	94	2	5.7
11-Sep	9.25	2.7	0	clr-pc, haze	2.2	calm/var	24.5	30.09	2	100	91	2	4.5
12-Sep	8.50	4.5	1.5	ovc-pc	0.9	calm/var	27.3	30.10	3	100	95	2	6.1
13-Sep	8.00	3.1	0	clr	3.0	calm/var	27.1	30.08	2	100	97	3	3.6
14-Sep	8.42	2.6	0	clr-mc-pc, haze	10.4	se-sw	26.1	30.03	3	100	94	2	2.7
15-Sep	8.00	2.0	0	clr-pc	7.0	var	26.9	30.06	2	100	95	3	3.9
16-Sep	9.33	2.8	0	clr-pc-clr	4.3	sw-nw, calm/var	27.3	30.06	3	100	94	2	6.5
17-Sep	9.25	2.0	0	clr, haze	10.0	se-sw	26.8	30.02	3	96	94	2	6.3
18-Sep	8.33	2.5	0	clr	8.4	se-sw	27.7	30.06	2	100	98	3	9.6
19-Sep	8.33	2.7	0	clr-pc, haze	13.8	s-w	27.3	29.98	2	100	98	2	7.4
20-Sep	9.75	2.0	0	pc-mc-pc-clr, blowing dust, haze	8.2	se-sw	26.3	29.84	3	98	88	1	6.7
21-Sep	9.58	2.7	0	clr-pc-mc, blowing dust	12.5	s-w	25.3	29.83	2	100	94	2	6.8
22-Sep	7.50	2.0	0	pc-mc	9.9	se-sw	21.8	29.69	4	100	90	3	7.1
23-Sep	9.92	3.1	0	clr, haze	1.8	ne-se, calm/var	22.8	29.95	3	98	90	2	34.4
24-Sep	9.08	2.1	0	clr, haze	4.1	ne-se, calm/var	23.5	30.18	2	100	90	2	25.0
25-Sep	8.92	2.8	0	clr, haze	6.4	ne-se	25.1	30.19	3	100	89	3	19.3
26-Sep	9.33	2.6	0	clr	4.8	ne-se	27.0	30.13	2	100	93	3	22.0
27-Sep	9.25	1.8	0	clr	0.8	ne-se, calm/var	26.9	30.11	2	100	96	2	28.6
28-Sep	9.00	2.9	0	clr, haze	4.0	n-e	29.6	30.08	3	100	94	2	20.7
29-Sep	9.00	3.3	0	clr, haze	0.7	calm/var	27.5	29.99	2	100	82	2	27.3
30-Sep	8.00	4.4	1	ovc-mc, haze	5.9	n-e	28.8	30.02	3	100	90	2	27.3
1-Oct	5.92	3.0	0	mc-ovc, t-storms, haze	5.4	sw-nw, ne-se	25.8	30.15	3	96	90	3	12.7
2-Oct	5.75	3.7	0	pc-ovc, haze	4.3	ne-se, calm/var	24.0	30.13	3	98	95	3	5.9
3-Oct	8.00	4.0	0	pc-mc-ovc, haze, rain, t-storms	8.4	se-sw	21.3	30.07	4	92	91	3	11.3
4-Oct	4.75	2.0	0	pc-ovc, rain, t-storms	20.1	se-sw	17.8	29.98	4	91	84	1	2.1
5-Oct	6.75	2.5	0	ovc, fog, rain	12.5	se-sw	11.1	29.91	4	53	39	0	0.3
6-Oct	4.33	2.0	0	ovc-mc, rain, t-storms, fog	16.3	se-sw	14.6	29.96	4	75	68	0	0.9
7-Oct	8.00	3.4	0	pc-ovc	18.0	se-sw	16.0	29.99	4	100	100	2	4.0
8-Oct	9.25	2.0	0	clr, haze	2.4	sw-nw, calm/var	15.8	30.08	3	100	92	3	22.4
9-Oct	9.00	2.8	0	clr-mc-pc, haze	3.0	ne-se, calm/var	16.8	30.14	3	100	95	3	36.7
10-Oct	8.92	4.9	0	clr, haze	3.7	ne-se, calm/var	17.3	30.05	3	100	95	3	29.9
11-Oct	8.58	3.0	0	clr	0.0	calm/var	20.8	30.04	2	100	95	3	31.3
12-Oct	8.50	3.5	0	clr-pc, haze	3.5	ne-se, calm/var	19.9	30.13	3	100	99	2	28.5
13-Oct	8.08	3.5	0	clr, haze	4.9	ne-se, calm/var	20.0	30.24	3	100	96	2	9.3

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. East (km)[1]	Visib. West (km)[1]	Median Flight Distance[5]	Birds / Hour
14-Oct	8.50	3.3	0	clr-pc-clr, haze	2.1	n-e, calm/var	21.1	30.21	2	100	94	2	10.8
15-Oct	8.25	2.1	0	clr-pc, haze	1.0	calm/var	21.3	30.11	3	99	94	2	9.3
16-Oct	8.25	3.4	0	clr-mc-pc, haze	3.2	sw-nw, calm/var	21.0	30.08	3	100	94	2	14.5
17-Oct	6.83	4.6	1	ovc, haze, rain	7.0	se-sw	18.8	29.99	3	88	87	3	10.8
18-Oct	7.92	2.1	0	pc-mc-ovc, haze	0.9	calm/var	15.8	29.94	3	94	91	1	5.1
19-Oct	8.00	3.5	0	clr-pc, haze	7.2	ne-se, calm/var	16.6	29.95	3	100	95	2	2.1
20-Oct	6.17	2.8	0	ovc-mc-ovc, rain	4.2	ne-se, calm/var	15.0	29.89	4	88	88	1	32.4
21-Oct	6.50	2.3	0	pc-ovc-mc, fog, rain	4.0	ne-se, calm/var	11.2	29.85	3	91	80	2	7.4
22-Oct	8.00	3.6	0	ovc, fog, rain	8.2	se-sw	8.2	29.78	4	76	83	2	2.9
23-Oct	8.58	2.6	0	ovc-mc, fog	10.5	se-sw	9.3	29.88	4	63	74	2	4.5
24-Oct	8.00	3.0	0	ovc-mc, fog	5.7	ne-se, calm/var	11.6	29.88	4	64	70	2	8.1
25-Oct	5.42	1.9	0	ovc-pc, fog, rain	10.4	ne-se	10.0	29.60	4	63	71	1	9.8
26-Oct	8.00	3.5	0	clr-pc-clr	5.2	w-n, calm/var	9.7	29.68	3	100	98	2	7.3
27-Oct	8.00	3.0	0	clr-pc	6.9	nw-ne, calm/var	7.4	30.06	3	100	98	1	1.4
28-Oct	8.00	2.8	0	clr-pc-mc	12.2	ne-se	9.6	30.17	3	100	97	0	0.1
29-Oct	7.75	2.0	0	pc-mc-ovc	8.0	se-sw	18.6	30.07	4	100	95	0	0.6
30-Oct	8.00	2.3	0	clr-mc, blowing snow/dust	22.0	ne-se	13.5	29.82	4	100	95	1	0.6
31-Oct	8.33	2.0	0	mc-pc-clr	1.8	ne-se, calm/var	12.8	30.02	3	100	96	1	5.8
01-Nov	8.00	1.9	0	clr, haze	8.2	n-e	14.3	30.23	3	100	98	2	2.4
02-Nov	8.00	2.3	0	clr, haze	9.1	ne-se	16.1	30.30	3	100	98	2	2.0
03-Nov	8.00	2.2	0	clr, haze	7.8	n-e	17.3	30.29	3	100	97	2	3.4
04-Nov	8.00	2.0	0	pc-mc	0.8	ne-se, calm/var	19.0	30.19	2	100	99	2	4.0
05-Nov	7.75	2.4	0	pc, haze	2.0	ne-se, calm/var	20.0	30.08	3	100	96	2	3.7

[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. Daily raptor migration counts by species at Yaki Point, Grand Canyon, AZ: 2010.

	Observ.	Species[1]																											Birds
Date	Hours	OS	NH	SS	CH	NG	SA	LA	UA	RS	BW	SW	RT	FH	RL	ZT	UB	GE	BE	UE	AK	ML	PR	PG	SF	LF	UF	UU	Total	/ Hour
27-Aug	6.42	0	0	1	0	0	1	0	0	0	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0.9
28-Aug	8.00	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0.3
29-Aug	8.08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0.1
30-Aug	8.00	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	6	0.8
31-Aug	8.00	0	0	0	2	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	7	0.9
1-Sep	8.00	1	0	0	5	0	0	0	1	0	0	1	2	0	0	0	3	0	0	0	5	0	1	0	2	0	0	0	21	2.6
2-Sep	8.08	0	0	4	3	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	21	2.6
3-Sep	8.50	0	0	7	1	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	1	1	0	20	2.4
4-Sep	8.00	0	0	4	2	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	10	1.3
5-Sep	8.33	0	0	2	0	0	3	0	0	0	0	2	1	0	0	0	0	0	0	0	7	0	0	1	0	0	0	0	16	1.9
6-Sep	9.00	1	0	4	3	0	3	0	0	0	0	0	2	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	20	2.2
7-Sep	8.00	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0.3
8-Sep	8.00	1	0	1	0	0	0	0	3	0	0	0	0	0	0	0	1	0	0	0	5	0	0	0	1	0	0	0	12	1.5
9-Sep	8.42	1	0	3	1	0	2	0	0	0	0	0	7	0	0	0	0	0	0	0	16	0	0	0	1	0	0	0	31	3.7
10-Sep	8.75	1	0	15	11	0	2	1	1	0	0	2	4	0	0	0	0	1	0	0	12	0	0	0	0	0	0	0	50	5.7
11-Sep	9.25	2	0	12	7	0	9	0	3	0	0	0	1	0	0	0	0	0	0	0	7	0	0	0	1	0	0	0	42	4.5
12-Sep	8.50	1	0	13	9	0	10	1	1	0	0	2	3	0	0	0	0	0	0	1	11	0	0	0	0	0	0	0	52	6.1
13-Sep	8.00	0	1	9	9	0	2	0	0	0	0	2	1	0	0	0	1	0	0	0	2	0	0	1	0	0	0	1	29	3.6
14-Sep	8.42	4	1	6	3	0	0	0	0	0	0	1	0	0	0	0	2	0	0	0	4	0	1	1	0	0	0	0	23	2.7
15-Sep	8.00	1	0	7	0	0	3	1	3	0	0	0	4	0	0	0	2	0	0	0	8	0	0	0	0	0	2	0	31	3.9
16-Sep	9.33	0	0	29	4	0	0	1	3	0	0	2	3	0	0	0	2	0	0	0	15	1	0	0	0	0	0	1	61	6.5
17-Sep	9.25	1	1	13	4	0	7	0	2	0	1	0	13	0	0	0	0	0	0	0	12	2	0	0	1	1	0	0	58	6.3
18-Sep	8.33	0	0	33	14	0	10	0	0	0	0	0	8	0	0	0	0	0	0	0	11	0	0	1	0	0	1	2	80	9.6
19-Sep	8.33	1	0	30	9	0	7	0	1	0	0	0	7	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	62	7.4
20-Sep	9.75	3	0	21	8	0	5	0	0	0	0	3	3	0	0	0	1	0	0	0	21	0	0	0	0	0	0	0	65	6.7
21-Sep	9.58	0	0	18	13	0	6	0	0	0	0	1	5	0	0	0	0	0	0	0	20	0	0	0	1	0	0	1	65	6.8
22-Sep	7.50	1	0	10	4	0	16	2	6	0	0	0	6	0	0	0	0	0	0	0	7	0	0	0	0	0	0	1	53	7.1
23-Sep	9.92	4	0	113	83	0	74	0	9	0	0	1	16	0	0	0	6	0	0	0	30	0	0	1	1	2	0	1	341	34.4
24-Sep	9.08	0	1	123	37	0	26	2	0	0	0	0	7	0	0	0	0	0	0	0	27	0	0	0	3	0	0	1	227	25.0
25-Sep	8.92	1	0	62	36	0	20	1	3	0	0	1	2	0	0	0	1	0	0	0	45	0	0	0	0	0	0	0	172	19.3
26-Sep	9.33	0	2	103	43	0	16	0	0	0	0	6	19	0	0	0	1	0	0	0	13	0	0	1	1	0	0	0	205	22.0
27-Sep	9.25	3	0	131	56	0	22	0	1	0	1	6	20	0	0	0	1	0	0	0	22	0	0	1	0	0	0	1	265	28.6
28-Sep	9.00	0	0	98	45	1	27	0	4	0	0	0	7	0	0	0	2	0	0	0	1	1	0	0	0	0	0	0	186	20.7
29-Sep	9.00	1	0	94	54	1	36	0	9	0	3	3	34	0	0	0	3	0	0	0	7	1	0	0	0	0	0	0	246	27.3
30-Sep	8.00	0	0	99	58	0	35	0	1	0	1	0	12	0	0	0	0	0	0	0	10	0	1	0	0	0	1	0	218	27.3
1-Oct	5.92	0	0	33	15	0	9	0	5	0	0	1	8	0	0	0	3	0	0	0	0	0	0	0	0	1	0	0	75	12.7
2-Oct	5.75	0	1	12	5	0	8	0	0	0	0	0	4	0	0	0	2	0	0	0	1	1	0	0	0	0	0	0	34	5.9
3-Oct	8.00	2	0	18	12	1	14	1	6	0	1	2	12	0	0	0	4	0	0	0	15	0	0	0	1	0	0	1	90	11.3

Appendix D. continued

Date	Observ. Hours	Species[1]																											Total	Birds / Hour
		OS	NH	SS	CH	NG	SA	LA	UA	RS	BW	SW	RT	FH	RL	ZT	UB	GE	BE	UE	AK	ML	PR	PG	SF	LF	UF	UU		
4-Oct	4.75	0	0	8	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	10	2.1
5-Oct	6.75	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0.3
6-Oct	4.33	0	0	2	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0.9
7-Oct	8.00	3	0	12	7	0	4	0	1	0	0	0	3	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	32	4.0
8-Oct	9.25	2	0	125	20	0	13	1	3	0	0	0	18	0	0	0	3	1	0	0	19	0	0	0	0	0	0	2	207	22.4
9-Oct	9.00	1	2	98	74	0	93	3	7	0	0	5	23	0	0	0	6	0	0	0	16	0	0	0	2	0	0	0	330	36.7
10-Oct	8.92	1	4	94	41	1	34	0	7	0	1	3	36	0	0	0	5	0	0	0	37	1	0	0	1	0	0	1	267	29.9
11-Oct	8.58	0	4	116	65	0	9	1	1	0	0	0	62	1	0	0	0	0	0	0	8	0	0	0	1	0	0	1	269	31.3
12-Oct	8.50	0	2	101	57	0	20	2	1	0	0	0	39	0	0	0	12	0	2	0	5	0	0	1	0	0	0	0	242	28.5
13-Oct	8.08	1	2	26	6	0	10	0	3	0	0	1	10	0	0	0	6	0	0	0	9	0	0	0	1	0	0	0	75	9.3
14-Oct	8.50	0	0	56	17	0	1	0	0	0	0	0	15	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	92	10.8
15-Oct	8.25	1	0	35	10	0	1	0	0	0	0	0	23	0	0	0	4	0	0	0	3	0	0	0	0	0	0	0	77	9.3
16-Oct	8.25	0	0	66	18	0	5	0	0	0	0	0	24	0	0	0	3	0	0	0	4	0	0	0	0	0	0	0	120	14.5
17-Oct	6.83	0	0	24	11	0	3	2	0	0	0	0	27	0	0	0	4	0	0	0	0	0	0	0	0	0	0	3	74	10.8
18-Oct	7.92	0	0	18	4	0	2	0	0	0	0	0	15	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	40	5.1
19-Oct	8.00	0	0	14	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	2.1
20-Oct	6.17	0	2	21	3	0	3	0	0	0	0	4	145	0	0	0	15	0	1	0	5	0	0	0	0	0	0	1	200	32.4
21-Oct	6.50	0	2	13	0	0	2	0	0	0	0	0	19	0	0	0	9	0	3	0	0	0	0	0	0	0	0	0	48	7.4
22-Oct	8.00	0	2	4	0	0	0	0	0	0	0	0	16	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	23	2.9
23-Oct	8.58	0	0	9	2	0	0	0	0	0	0	0	27	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	39	4.5
24-Oct	8.00	0	1	13	3	0	0	0	0	0	0	0	47	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	65	8.1
25-Oct	5.42	0	3	17	2	0	0	0	1	0	0	0	26	0	0	0	0	0	1	0	1	1	0	0	1	0	0	0	53	9.8
26-Oct	8.00	0	0	23	3	0	1	0	0	0	0	0	28	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1	58	7.3
27-Oct	8.00	0	1	0	3	0	0	0	0	0	0	0	6	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	11	1.4
28-Oct	8.00	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.1
29-Oct	7.75	0	0	2	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0.6
30-Oct	8.00	0	0	3	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	0.6
31-Oct	8.33	0	0	12	1	0	0	0	0	0	0	0	32	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	48	5.8
1-Nov	8.00	0	0	6	1	0	2	0	0	0	0	0	6	0	0	0	3	0	0	0	0	0	0	0	0	0	0	1	19	2.4
2-Nov	8.00	0	5	4	1	0	0	0	0	0	0	0	4	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	16	2.0
3-Nov	8.00	0	5	6	0	0	1	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27	3.4
4-Nov	8.00	0	1	1	3	0	0	0	0	0	0	0	23	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0	32	4.0
5-Nov	7.75	0	1	6	1	0	0	0	0	0	0	0	18	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1	29	3.7
Total	572.42	42	45	2065	911	4	582	19	87	0	8	51	934	2	0	0	116	2	10	1	485	10	3	11	21	5	5	23	5442	9.5

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

Appendix E. Annual observation effort and fall raptor migration counts by species at Yaki Point, Grand Canyon, AZ: 1997–2010.

YEAR	1997	1998	1999	2000	2001	2002	2003	2004	2005
Start date	27-Aug	28-Aug	27-Aug	27-Aug	27-Aug	27-Aug	27-Aug	27-Aug	27-Aug
End date	5-Nov	5-Nov	5-Nov	5-Nov	5-Nov	5-Nov	5-Nov	5-Nov	5-Nov
Days of observation	71	66	71	66	71	71	70	68	70
Hours of observation	504.97	455.41	543.20	513.10	595.59	585.70	547.90	559.40	570.48
Raptors / 100 hours	938	908	998	1054	881	968	1229	932	556
SPECIES	RAPTOR COUNTS								
Osprey	50	43	28	43	34	57	50	42	31
Northern Harrier	50	44	56	41	31	45	35	29	38
Sharp-shinned Hawk	1,474	1,190	1,906	1,772	1,792	1,932	2,323	1,743	1,008
Cooper's Hawk	856	1,109	1,204	1,256	1,293	891	1,673	855	516
Northern Goshawk	4	7	1	9	11	6	2	7	2
Unknown small accipiter[1]	–	–	–	–	72	218	52	122	108
Unknown large accipiter[1]	–	–	–	–	0	3	1	1	4
Unknown accipiter	94	140	109	236	0	18	103	125	15
TOTAL ACCIPITERS	2,428	2,446	3,220	3,273	3,168	3,068	4,154	2,853	1,653
Red-shouldered Hawk	1	0	0	0	0	0	0	0	0
Broad-winged Hawk	9	19	14	6	11	8	14	19	2
Swainson's Hawk	15	25	32	10	19	16	147	80	32
Red-tailed Hawk	899	916	985	892	1,008	1,234	1,264	1,169	765
Ferruginous Hawk	8	7	11	10	6	6	6	1	6
Rough-legged Hawk	0	0	0	1	1	2	0	0	0
Zone-tailed Hawk	0	0	1	0	1	1	0	0	0
Unidentified buteo	20	20	13	8	8	43	42	17	24
TOTAL BUTEOS	952	987	1,056	927	1,054	1,310	1,473	1,286	829
Golden Eagle	24	7	2	11	4	23	11	4	5
Bald Eagle	23	18	17	9	14	49	14	10	22
Unidentified eagle	1	0	1	0	0	1	0	0	0
TOTAL EAGLES	48	25	20	20	18	73	25	14	27
American Kestrel	1,016	423	918	1,035	881	1,011	943	930	555
Merlin	14	12	14	5	22	5	17	9	9
Prairie Falcon	9	4	6	4	3	8	5	7	2
Peregrine Falcon	7	19	8	1	7	11	7	6	11
Unknown small falcon[1]	–	–	–	–	0	3	0	0	1
Unknown large falcon[1]	–	–	–	–	0	1	0	0	2
Unknown falcon	0	4	2	3	2	4	1	4	3
TOTAL FALCONS	1,046	462	948	1,048	915	1,043	973	956	583
Unidentified raptor	20	38	16	10	25	71	23	36	12
GRAND TOTAL	4,594	4,045	5,344	5,362	5,245	5,667	6,733	5,216	3,173

[1] New designations used regularly beginning in 2001 (see Appendix B).

Appendix E. continued

YEAR	2006	2007	2008	2010	MEAN
Start date	27-Aug	27-Aug	1-Sep	27-Aug	26-Aug
End date	4-Nov	5-Nov	5-Nov	5-Nov	4-Nov
Days of observation	70	71	66	71	69
Hours of observation	533.33	566.76	514.09	572.42	540.80
Raptors / 100 hours	771	750	645	951	880
SPECIES			RAPTOR COUNTS		
Osprey	37	29	30	42	40
Northern Harrier	45	38	35	45	41
Sharp-shinned Hawk	1,627	1,417	1,417	2,065	1,633
Cooper's Hawk	695	761	417	911	961
Northern Goshawk	14	12	18	4	8
Unknown small accipiter[1]	118	298	112	582	138
Unknown large accipiter[1]	4	79	29	19	15
Unknown accipiter	14	88	51	87	83
TOTAL ACCIPITERS	2,472	2,655	2,044	3,668	2,786
Red-shouldered Hawk	0	0	0	0	0
Broad-winged Hawk	12	18	3	8	11
Swainson's Hawk	30	9	10	51	35
Red-tailed Hawk	995	903	641	934	973
Ferruginous Hawk	6	3	3	2	6
Rough-legged Hawk	1	0	0	0	0
Zone-tailed Hawk	0	0	5	0	1
Unidentified buteo	48	36	34	116	26
TOTAL BUTEOS	1,092	969	696	1,111	1,053
Golden Eagle	1	5	4	2	8
Bald Eagle	18	30	20	10	20
Unidentified eagle	0	3	0	1	1
TOTAL EAGLES	19	38	24	13	30
American Kestrel	384	475	395	485	747
Merlin	9	12	18	10	12
Prairie Falcon	9	2	8	3	6
Peregrine Falcon	13	19	12	11	10
Unknown small falcon[1]	15	1	16	21	5
Unknown large falcon[1]	10	2	4	5	2
Unknown falcon	2	1	5	5	3
TOTAL FALCONS	442	512	458	540	782
Unidentified raptor	6	8	31	23	25
GRAND TOTAL	4,113	4,249	3,318	5,442	4,755

[1] New designations used regularly beginning in 2001 (see Appendix B).