FALL 2003 RAPTOR MIGRATION STUDIES IN THE GRAND CANYON OF ARIZONA

HawkWatch International, Inc.
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INTRODUCTION

The Grand Canyon Raptor Migration Project in Arizona is an ongoing effort to monitor long-term trends in populations of raptors using the southern portion of the Intermountain Flyway (Hoffman et al. 2002, Hoffman and Smith 2003). The flight through this region is one of the largest concentrations of migrating raptors known in the western U.S. and Canada. To date, observers have recorded 19 species of migratory raptors at two count sites along the south rim of the canyon, with combined counts typically ranging between 10,000 and 12,000 migrants per season. Chuck LaRue discovered the flyway in 1987 and Christie Van Cleve conducted exploratory counts at points along the south rim in 1989 and 1990. HawkWatch International (HWI) initiated standardized counts of the autumn raptor migration through this region at Lipan Point in 1991, and began standardized monitoring at Yaki Point in 1997. The 2003 season marked the 13th consecutive count at Lipan Point and the 7th consecutive full-season count at Yaki Point. This report summarizes the 2003 count results for both sites.

The Grand Canyon projects comprised 2 of 15 long-term, annual migration counts conducted or co-sponsored by HWI in North America during 2003. The primary objective of these efforts is to track long-term population trends of diurnal raptors throughout primarily western North America (Smith and Hoffman 2000, Hoffman and Smith 2003). Raptors feed atop food pyramids, inhabit most ecosystems, occupy large home ranges, and are sensitive to environmental contamination and other human disturbances. For these reasons they serve as important biological indicators of ecosystem health (Bildstein 2001), and standardized migration counts represent one of the most efficient means of monitoring populations of multiple species at regional and larger scales (Zalles and Bildstein 2000, Hoffman and Smith 2003).

These migration studies also offer unique opportunities for the public to learn about raptors and the natural environment, and providing such opportunities is another important component of HWI's mission. Accordingly, since 1995 the Grand Canyon field crew has included trained educators dedicated to conducting environmental education programs at the sites and facilitating interactions between visitors and the field biologists. With about 5 million people visiting the park each year and easy accessibility, the Grand Canyon sites offer excellent opportunities for public outreach and education about the ecology and conservation needs of raptors and the Grand Canyon ecosystem.

STUDY SITES

Lipan Pt. is located in Coconino County, Arizona (36° 01′ 59.2″ N, 111° 51′ 11.5″ W) along the south rim of the Grand Canyon (Figure 1) at an elevation of about 2,125 m. The site is an established lookout for visitors to Grand Canyon National Park, which can be accessed by driving 3.2 km southwest on Hwy 64 from the east entrance to the park. The observation point is located about 170 m south of the parking lot at the edge of the canyon rim, directly above an Anasazi granary. The spot provides nearly a 360^{o} view of the surrounding landscape, with excellent visibility along the canyon to the north, south, and west. The predominant vegetation consists of big sagebrush (*Artemisia tridentata*), cliffrose (*Cowania mexicana*), Utah juniper (*Juniperus osteosperma*), and two-needle pinyon (*Pinus edulis*).

Yaki Pt. is located in Coconino County, Arizona (36° 03′ 31.0″ N, 112° 05′ 01.7″ W) along the south rim of the Grand Canyon (Figure 1) at an elevation of about 2,025 m. This site also is a popular canyon lookout, which visitors can access from Hwy 64 about 11.2 km northeast of the south entrance to the park. The predominant vegetation is similar to that found at Lipan Pt. The view at Yaki Pt. is superb for sheer grandeur, providing views of the canyon to the west and north; however, thick vegetation obscures the view to the east from the point.

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 to many southbound migrants because most raptors tend to avoid such sparse and inhospitable habitats, although the region produces excellent thermal lift. Conversely, the heavily forested North Kaibab Plateau, which lies immediately west of the desert, provides an accessible pathway toward the canyon. However, because there are no distinct ridges to serve as leading lines for migrating raptors (*sensu* Geyr von Schweppenburg 1963) and provide a concentrated, stable source of lift, the migrants probably approach the canyon along a relatively broad front. Accordingly, monitoring at multiple points will ultimately provide valuable information about variation in daily and seasonal concentrations and a better index to the migration volume through the region. We also believe that Yaki Pt. and Lipan Pt. represent particularly good monitoring locations because they lie immediately across from "peninsulas" of plateau land that jut out into the canyon from the north rim. This arrangement produces especially narrow gaps between the two canyon rims, which we believe the migrants seek out, much as migrating raptors often seek the narrowest passage across large bodies of water (Kerlinger 1989).

METHODS

Four official or designated observers, occasionally assisted by long-time, local volunteer Christi Van Cleve and frequently by on-site educators Eric Dinkle and Melanie Keithley, conducted standardized daily counts of migrant raptors from traditional count sites at Yaki and Lipan points. The four official observers rotated between sites and observation partners to minimize potential observer bias. This arrangement ensured that at least two counters were present most of the time at both sites. Official observer Jody Bartz had two previous seasons of raptor migration counting experience, Mark Leavens one season, Ken Babcock two partial seasons, and Grant Merrill was new to migration counting but had worked on raptor studies in the Grand Canyon region for the previous year (see Appendix A for a complete history of observation participation). All of the official observers also attended preseason training. Other visitors to the sites also occasionally assisted in spotting migrants. The on-site educators routinely facilitated interactions with visitors, including coordinating with personnel from Grand Canyon National Park to conduct educational programs with organized groups of park visitors.

Weather permitting, observations typically began by 0900 hrs Mountain Standard Time (MST) and ended by 1700 hrs 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 hrs 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 follows Hoffman and Smith (2003). In this report, I compare regression analyses of Lipan Point data alone from 1991–2003 and combined-site data from 1997–2003. In comparing 2003 annual statistics against means and 95% confidence intervals for previous seasons, I equate significance ($P \leq 0.05$) with a 2003 value falling outside the bounds of the confidence interval for the associated mean.

RESULTS AND DISCUSSION

WEATHER SUMMARY

In 2003, the average daily temperatures recorded at both sites (average of daily values, which in turn were averages of hourly readings) were the warmest recorded since 1997 (21.6°C at Lipan Pt. and 21.0°C at Yaki Pt. versus averages of 18.1° and 16.6°C, respectively; see Appendixes C and D for daily weather records from the two sites). The numbers of observation days hampered by inclement weather also were below average at both sites: one full day precluded at both sites and one other day reduced to <4 hours observation at Yaki Point, compared to 1997–2002 averages of 4 days fully or severely precluded at each site. Similarly, 60% of the active observation days at Lipan Point and 55% of the active days at Yaki Point featured predominantly fair skies during 2003, compared to 1997–2002 averages at both sites of 52%. Similar to 2002, the main difference in overall sky conditions compared to previous years was the high prevalence of haze due to wildfires that burned throughout the season on the Kaibab Plateau to the north of the count sites. At Lipan Point, 62% of the active observation days featured appreciable visibility reducing fog and especially haze, compared to the 1997–2002 average of 24%. At Yaki Point, the comparative proportions were 58% and 21%.

In terms of wind speeds, in 2003 Lipan Point featured an average proportion of days where light winds (<12 kph) prevailed (80% vs. 1997–2002 average of 81%), a below average proportion of days where moderate winds prevailed (7% vs. average of 15%), and an above average proportion of days where strong winds (>29 kph) prevailed (13% vs. average of 4%). However, in 2003 24% of the active observation days featured primarily calm or variable-direction light winds, compared to the 1997–2002 average of 15%, and an additional 23% of days featured calm/variable winds for a significant portion of the day. Thus, in terms of wind strength, 2003 appeared to feature both extremes more often than usual. In general, the distribution of wind directions at Lipan Point has varied quite a bit from year to year, but southwesterly to northwesterly winds tend to predominate. In 2003, southwest to westerly winds prevailed on 31% of the active observation days, compared to the 1997–2002 average of 14%, whereas more variable southwest to northwesterly winds prevailed on only 3% of days compared to an average of 17%.

In 2003, the proportion of days at Yaki Point where light winds prevailed was above average (82% vs. 1997–2002 average of 76%), whereas the proportions of days where moderate and strong winds prevailed were both below average (14% and 4% vs. 19% and 5%, respectively). In contrast to the scene at Lipan Point, the wind direction pattern at Yaki Point in 2003 was very similar to the average pattern; however, similar to Lipan Point, one appreciable difference was a higher than average prevalence of days where calm/variable winds prevailed during at least a significant portion of the day. Such winds prevailed

throughout 19% of the active observation days and during a significant portion of an additional 31% of the active days, compared to averages of 15% and 26%.

At Lipan Point, 47% of the active observation days received a median (of hourly ratings) thermal-lift rating of good to excellent, while 50% of days received that rating at Yaki Point. The Lipan Point value is slightly below the 1997–2002 average for that site (56%), whereas the Yaki Point value matches the average for that site.

In summary, compared to the last six seasons, 2003 featured relatively mild, warmer weather; a high prevalence of hazy conditions due to wildfires in the area; a higher prevalence of calm and/or light/variable winds at both sites, but also a higher prevalence of strong winds at Lipan Point; a higher prevalence of less variable southwest to westerly winds as opposed to more variable southwest to northwest winds at Lipan Point; and overall poorer thermal-lift conditions at Lipan Point.

OBSERVATION EFFORT

Counts occurred at both sites on 70 of 71 possible days between 27 August and 5 November 2003 (see Appendices E and F for daily count records for each site). Both the number of observation days and total observation hours (566.5; i.e., the total number of hours during which counts occurred at one or both sites) closely matched the 1997–2002 averages for the project (70 ± 95% CI of 1.1 days and 565.5 ± 25.00 hours; see Appendices G and H for annual effort and count summaries for each site). The 2003 average of 4.1 observers/hour spread across the two count sites (including official and guest observers; value is mean of daily values, which are in turn means of hourly values) was 4% above the 1997–2002 average of 4.0 ± 95% CI of 0.10 observers/hour.

MIGRATION SUMMARY

The observers tallied 12,280 migrant raptors of 16 species at the two count sites in 2003 (Table 1), with 45% recorded at Lipan Point and 55% at Yaki Point. Prior to 2002, counts at Lipan Point had always exceeded those at Yaki Point. The combined-site flight was composed of 51% accipiters, 28% buteos, 19% falcons, and about 1% each of Ospreys, harriers, eagles, and unidentified raptors, with Yaki Point attracting proportionately more accipiters (62% of the site total) and fewer buteos (22%) and falcons (14%) than Lipan Point (38%, 35%, 24%; Figure 2). At the combined-site level, the relative abundances of accipiters and harriers were significantly below average, whereas the relative abundance of buteos was significantly above average in 2003. The pattern of compositional differences between the two count sites is typical, with Yaki Point consistently attracting a higher proportion of accipiters and fewer buteos than Lipan Point. However, in terms of absolute numbers, the pattern has shifted steadily from roughly 60% of the combined-site total accipiter count at Lipan Point in 1997 and 1998 to only 34% of the total at Lipan in 2003. The relative migration-composition differences likely reflect topographic variation around the two sites, which effect local thermal production and therefore vary the attractiveness of each site for soaring species. However, the shift in the absolute abundance of accipiters at the two sites in the past seven years does not correspond to any distinct pattern of change in estimated thermal lift conditions, suggesting that some other factor is affecting a change in the migration paths followed by accipiters across the canyon. One possibility is that habitat change on the Kaibab Plateau caused by extensive wildfires is causing the forest-dwelling accipiters to alter their pathways across this landscape. However, there also has been a fairly steady shift over the past seven years at Lipan Point towards increasing prevalence of relatively steady southwest to westerly winds as opposed to more variable southwest to northwest winds. It is unclear how this change in wind conditions might translate to accipiters preferring to cross at Yaki Point rather than Lipan Point, but one possibility is that northwest winds may tend to push birds more towards the east, whereas southwesterly winds may enable easier

quartering along the preferred south to southwesterly orientation of the overall regional flyway (see Hoffman et al. 2003).

As usual, Sharp-shinned Hawks, Cooper's Hawks, Red-tailed Hawks, and American Kestrels were the four most abundant species at both sites (Table 1, Appendices G and H). At Lipan Point, 2003 was the first year since the project began in 1991 that the observers recorded no migrating Northern Goshawks. In contrast, the count of 108 Swainson's Hawks established a new record high count for this species at this site (Appendix G). At Yaki Point, no new record lows occurred, but the counts of both Sharp-shinned and Cooper's Hawks rose to record highs for the site (Appendix H). At the combined-site level, the count of Northern Goshawks fell to a record low and the count of Prairie Falcons matched the previous low count for 1997–2002. In contrast, the combined-site counts rose to record highs for Sharp-shinned, Red-tailed, and Swainson's Hawks.

At the combined-site level comparing 2003 values against 1997–2002 means, adjusted passage rates were significantly below average for Northern Harriers, Northern Goshawks, and Prairie Falcons; significantly above average for Sharp-shinned Hawks, Swainson's Hawks, Red-tailed Hawks, and American Kestrels; and not significantly different from average for eight additional, commonly observed species (Table 1).

Seven years is generally too short a period from which to derive robust assessments of long-term trends; however, comparison of trends at the two count sites and comparison of Lipan Point and combined-site counts patterns during the past seven years is instructive. Regression analyses of adjusted passage rates at Lipan Point from 1991–2003 indicated at least marginally significant ($P \leq 0.10$) linear or quadratic trends for 9 of 15 commonly encountered species (Osprey, Northern Harrier, Cooper's Hawk, Broad-winged Hawk, Swainson's Hawk, Red-tailed Hawk, Ferruginous Hawk, Golden Eagle, and Peregrine Falcon). Regression analyses of adjusted, combined-site passage rates from 1997–2003 indicated at least marginally significant trends for five of the same species, plus Sharp-shinned Hawks.

Marginally to highly ($P \leq 0.01$) significant quadratic trends, tracking stable to increasing patterns through the 1997/1998 and declines thereafter, were indicated for Ospreys, Northern Harriers, and Cooper's Hawks at Lipan Point. The 1997–2003 combined-site data also indicated a significant ($P \leq 0.05$) quadratic trend for Ospreys, but in this case tracking a declining pattern between 1997 and 2002 that stabilized with a slightly higher count in 2003 (Figure 2). For Northern Harriers, the combined-site data confirmed a significant decline since 1997 (Figure 2).

For Sharp-shinned Hawks, the Lipan Point data show a distinct downward trend since 1992, accentuated by a particularly low count in 2003, whereas the Yaki Point data alone and the combined-site data show a distinct increasing trend since 1997, accentuated by a high count in 2003 (Figure 4). Thus, for Sharp-shinned Hawks, counts at multiple sites may be of particular importance for achieving effective monitoring of flights across the canyon. For Cooper's Hawks, data from both sites track patterns that are more similar, except that, like for Sharp-shinned Hawks, the Yaki Point count jumped up sharply in 2003 while the Lipan Point count did not (Figure 4). Both Sharp-shinned and Cooper's Hawks have shown mostly stable to increasing, long-term patterns across HWI's western monitoring network, although both species have shown recent downward trends at most sites, likely in response to widespread drought (Hoffman and Smith 2003). Only slight variations are evident among the datasets for Northern Goshawks, with a substantial rise and fall in activity during the 1992–1993 invasion episode (Hoffman and Smith 2003), followed by an unsteady increasing pattern through 2000, and finally a three-year decline to record low activity in 2003 (Figure 4).

For Broad-winged Hawks, the Lipan and Yaki data show somewhat the opposite pattern between 1999 and 2003; nevertheless, the overall pattern clearly reflects a significant, long-term increase dampened slightly by a modest count in 2003 (Figure 5; see also Smith et al. 2001). The Lipan Point data also show a significant, long-term increasing trend for Swainson's Hawks, which though largely flat during the previous six years was greatly accentuated by a sharp rise in numbers at both sites in 2003 (Figure 5).

The sharp rise in 2003 resulted in a marginally significant quadratic trend in the combined site data. Swainson's Hawks have shown mostly increasing trends across HWI's western monitoring network during the past two decades (Hoffman and Smith 2003). The Lipan Point data show a marginally significant long-term decline for Red-tailed Hawks; however, the combined-site data show a largely flat pattern since 1997 and a recent two-year upswing. Red-tailed Hawks have shown mostly gradual, long-term increasing patterns across much of the West (Hoffman and Smith 2003).

The Lipan Point data show a highly significant, long-term decline for Ferruginous Hawks but with a fairly stable pattern since 1995; however, the combined-site data suggest a continuing decline since 1997 with a slight rebound in 2003 (Figure 5). Long-term data from the Manzano Mountains, New Mexico (1985–2003) show a similar overall pattern as the Lipan Point data: a strong declining pattern through the mid-1990s followed by a comparatively stable pattern thereafter (Hoffman and Smith 2003, Smith 2004a). In contrast, data from farther north in the Goshute Mountains, Nevada show an increasing pattern between the early 1980s and early 1990s, followed by a comparatively stable pattern thereafter (Hoffman and Smith 2003, Smith 2004b).

The Lipan Point data indicate a significant long-term decline in Golden Eagle passage rates, moderated by an above-average rate in 2002 that involved a high immature/subadult : adult ratio (Figure 6). The Lipan and Yaki data followed divergent patterns between 1997 and 2000, but tracked similar patterns the past three years. With Golden Eagles, it is important to recognize that increasing migration counts at lower latitudes where regional residents, especially adults, tend to be relatively sedentary may indicate heightened fall/winter movement activity due to poor habitat conditions rather than increasing populations (Hoffman and Smith 2003). Each of the Bald Eagle datasets shows similar patterns (Figure 6). The overall long-term pattern is similar to that shown for Golden Eagles: a sharp rise in activity in the early 1990s, followed by a decreasing pattern through the remainder of the 1990s, a sharp rise again in 2002, and a moderate decline in 2003 (Figure 6).

The Lipan and Yaki datasets for American Kestrels show similar patterns (Figure 7). Kestrels had been showing a significant long-term decline at Lipan Point, but an above-average passage rate in 2003 moderated that pattern. The American Kestrel is a species for which HWI's long-term western migration data indicate decidedly mixed trends, with long-term declines at some sites but increasing trends at others (Hoffman and Smith 2003). The Lipan and Yaki datasets for Merlins follow similar patterns as for kestrels, except that two sharp jumps in activity at Yaki Point in 2001 and 2003 were not matched at Lipan Point (Figure 7). The Lipan Point data show no significant, overall long-term trend; however, passage rates remained fairly stable through 1996, jumped to a record high in 1997, then declined steadily through 2000, and finally rebounded slightly in 2003. Merlins have shown mostly long-term increasing patterns across HWI's network of western migration sites, but recent, possibly drought-related declines in migration activity also have been common since 1997/1998 (Hoffman and Smith 2003, Smith 2004a, b).

For Prairie Falcons, the Lipan and Yaki datasets show largely divergent patterns; however, all datasets ultimately suggest the same conclusion: no long-term trend (Figure 7). Across HWI's western monitoring network, Prairie Falcons have shown mostly stable to occasionally increasing patterns (Hoffman and Smith 2003). A marginally significant long-term increasing trend is evident for Peregrine Falcons at Lipan Point (Figure 7). In comparison, counts at Yaki Point have been more variable and show no overall trend. In combination, data for the two sites also show no long-term trend, except for a possible 4-year cyclical pattern of ups and downs. As reflected in the recent removal of the Peregrine Falcon from the federal Endangered Species List, peregrines have shown mostly strong increasing patterns across much of the continent since the early-to-mid 1980s (Hoffman and Smith 2003). The comparatively flat pattern in the Grand Canyon therefore stands somewhat at odds with trends at most other western migration sites; perhaps this difference reflects in part the negative influence of a very large, local and territorial breeding population on travel routes of migrants through the region.

At the combined-site level in 2003, 8 of 10 species with readily distinguishable age classes showed significant variation in immature : adult ratios compared to 1997–2002 averages, with five species showing above average ratios and three below average ratios (Table 2). For Peregrine Falcons and Sharp-shinned, Cooper's, and Ferruginous Hawks, elevated age ratios reflected a combination of increases in the abundance of immature birds and at least slight reductions in the abundance of adults. These statistics suggest that productivity may have been decent for these species in 2003 in source areas for Grand Canyon migrants. For Bald Eagles, counts of both adults and immatures/subadults dropped in 2003, with the higher than average age ratio due to a proportionally greater reduction in the count of adults. In contrast, for each of the three species that showed below average age ratios in 2003 (Northern Goshawk, Broad-winged Hawk, and Golden Eagle), the drop was due to a proportional reduction in the abundance of immature birds.

Based on combined-site data, the overall combined-species median passage date in 2003 of 27 September was a significant four days earlier than the 1997–2002 average, largely reflecting a much higher than average spike in relative flight volume during one five-day period in late September and much lower than average flight volume during one five-day period in early October, as opposed to an obvious wholesale shift in the seasonal activity pattern (Table 3). Moreover, at the species level, four species showed significantly early passage, four species showed significantly late passage, and the five remaining species with sufficient data for comparison showed timing that did not differ significantly from average (Table 3). There was some consistency within major species groups, in that all three accipiters showed earlier than average timing (including two immature goshawks that passed through in mid-September nearly three weeks earlier than the early October average median passage date for immature birds of this species) and both eagles and three of four buteos also showed at least slightly early timing. A tendency towards early timing in the fall often reflects either poor prey/habitat conditions on summer ranges or along migration routes, or a particularly early and harsh onset of winter. The latter generally did not apply in 2003, but widespread drought has compromised habitat and prey conditions across wide swaths of the interior West since 1998.

Age-specific median passage dates highlighted additional details for selected species, including indications that both adult and immature Northern Harriers were in fact significantly as opposed to only slightly late in 2003 (Table 4). Otherwise, the age-specific data showed a consistent pattern of at least slightly early passage for adults of all species except harriers, but a mixed pattern for immatures of these species. For Sharp-shinned Hawks, the age-specific data confirmed significantly early passage for both adults and immatures, whereas for Cooper's Hawks the age-specific data indicated only slightly early timing for both adults and immatures, as opposed to the significantly early timing indicated at the species level. For Broad-winged Hawks, age-specific data showed a similar pattern for adults as the species-level data, but indicated significantly late timing for immatures. For Red-tailed Hawks and Golden Eagles, age-specific data revealed patterns for both age classes that matched the species level result. In contrast, contrary to the species-level indicator of no significant variation, age-specific data for Bald Eagles revealed significantly early timing for adults and significantly late timing for immatures/subadults. Similarly, the species-level data indicated significantly late timing for Peregrine Falcons, whereas age-specific data indicated a median passage date for adults that was 10 days earlier than average (albeit a non-significant difference).

RESIDENT RAPTORS

This season a family group of Zone-tailed Hawks, including one immature bird, that are known to have nested in their standard location below Yaki Point were seen regularly at both Lipan and Yaki Points and near Grand Canyon Village through late September.

Otherwise, at Lipan Point resident birds included a family group of light-morph Red-tailed Hawks, including one immature bird, seen throughout the season; a family group of Golden Eagles, including one immature bird, seen throughout the season; two adult Peregrine Falcons seen throughout the season; at least 15 Turkey Vultures routinely seen in the area through 5 October; at least one immature Cooper's Hawks seen regularly throughout much of the season and at least one adult bird seen infrequently; scattered sightings of at least one immature Sharp-shinned Hawk in late August and one adult in mid-October; occasional sightings of a male American Kestrel; and a few distant sightings of California Condors.

At Yaki Point, other resident birds included a family group of light morph Red-tailed Hawks, including one immature bird, seen throughout the season. In addition, in mid-October another 6 Red-tailed Hawks were seen hawking flying insects just above the canyon rim southeast of the watchsite; it appeared that these birds were probably local birds with territories in other parts of the canyon that collected to take advantage of a particular insect hatch. Scattered sightings of apparently resident immature and adult Golden Eagles also occurred at Yaki, but these may have been the same birds seen more regularly at Lipan Point. A pair of adult Peregrine Falcons were active around Yaki Point throughout the season, with an immature bird also seen once early in the season. At least one immature Cooper's Hawk was seen regularly through 7 October. A communal roost of ~70 resident Turkey Vultures was active near Grand Canyon Village and visible from the Yaki Point watchsite through 4 October. California Condors also were seen regularly from the Yaki Point lookout.

These resident assemblages are fairly typical for the sites, except for the absence of immature Northern Goshawks often seen around Yaki Point.

VISITOR PARTICIPATION

A total of 2,092 park visitors signed the HWI visitor logs during the 2003 season, which is among the highest visitation levels of the past decade. The majority of guests visited Yaki Point this season because Lipan Point access was under construction much of the season and therefore all organized park education events (two per day between 2 September and 25 October) were scheduled for Yaki Point. Besides daily, organized park education events, one school group also visited the projects during the season. Visitors originated from many states and a variety of foreign countries, including for example Germany, Ireland, Iceland, United Kingdom, Japan, and India.

In 2003 at Lipan Point, 559 hourly assessments of visitor disturbance resulted in the following ratings: 95% none, 5% low, 0% moderate, and 0% high. At Yaki Point, 577 hourly assessments of visitor disturbance resulted in the following ratings: 82% none, 17% low, 2% moderate, and <1% high. This low level of visitor-related disturbance of the official observers is solid testimony to the benefits of staffing on-site education specialists to ensure both a high-quality experience for visitors and a high-quality monitoring effort.

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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 (Lipan Point and Yaki Point data combined): 1997–2002 versus 2003.

SPECIES	COUNTS			RAPTORS / 100 HOURS		
	1997–2002[1]	2003	% CHANGE	1997–2002[1]	2003	% CHANGE
Osprey	134 ± 25.3	125	-7	31.3 ± 6.99	27.8	-11
Northern Harrier	127 ± 32.2	91	-28	25.4 ± 6.70	18.2	-28
Sharp-shinned Hawk	3156 ± 258.6	3586	+14	734.7 ± 45.86	803.3	+9
Cooper's Hawk	2316 ± 383.0	2438	+5	632.8 ± 112.67	650.1	+3
Northern Goshawk	13 ± 4.6	2	-85	2.4 ± 0.82	0.4	-85
Unknown small accipiter	292.5 ± 240.1	83	–	–	–	–
Unknown large accipiter	3.0 ± 3.9	5	–	–	–	–
Unknown accipiter	256 ± 150.3	150	–	–	–	–
TOTAL ACCIPITERS	5840 ± 283.2	6264	0	–	–	–
Red-shouldered Hawk	0.2 ± 0.33	0	-100	–	–	–
Broad-winged Hawk	30 ± 10.8	20	-33	16.6 ± 6.26	11.8	-29
Swainson's Hawk	50 ± 10.6	255	+408	16.7 ± 3.54	85.2	+411
Red-tailed Hawk	2448 ± 87.3	3055	+25	515.0 ± 19.23	637.4	+24
Ferruginous Hawk	13 ± 3.2	12	-9	2.8 ± 0.75	2.3	-16
Rough-legged Hawk	0.8 ± 0.94	0	-100	–	–	–
Zone-tailed Hawk	1 ± 0.5	2	+100	–	–	–
Unidentified buteo	43 ± 18.9	62	0	–	–	–
TOTAL BUTEOS	2586 ± 86.8	3406	0	–	–	–
Golden Eagle	32 ± 14.5	28	-13	6.1 ± 2.86	5.0	-18
Bald Eagle	40 ± 14.4	26	-34	9.1 ± 3.35	6.3	-31
Unidentified eagle	2 ± 1.7	0	0	–	–	–
TOTAL EAGLES	73 ± 29.3	54	0	–	–	–
American Kestrel	2017 ± 257.3	2243	+11	534.5 ± 63.35	599.9	+12
Merlin	24 ± 8.5	26	+10	5.1 ± 1.99	5.5	+8
Prairie Falcon	11 ± 1.9	8	-25	2.2 ± 0.42	1.8	-19
Peregrine Falcon	18 ± 6.5	15	-14	3.7 ± 1.42	3.2	-14
Unknown small falcon	3 ± 2.0	0	–	–	–	–
Unknown large falcon	4 ± 1.0	1	–	–	–	–
Unknown falcon	7 ± 2.3	1	–	–	–	–
TOTAL FALCONS	2078 ± 254.7	2294	0	–	–	–
Unidentified Raptor	112 ± 27.8	46	-59	–	–	–
GRAND TOTAL	10951 ± 372.3	12280	+12	–	–	–

[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 (Lipan Point and Yaki Point data combined): 1997–2002 versus 2003.

	Total and Age-classified Counts								Immature : Adult	
	1997–2002 Average			2003			% Unknown Age		Ratio	
Species	Total	Imm.	Adult	Total	Imm.	Adult	1997–2002[1]	2003	1997–2002[1]	2003
Northern Harrier	127	34	33	91	23	23	49 ± 4.4	49	1.0 ± 0.15	1.0
Sharp-shinned Hawk	3156	607	1230	3586	804	1080	42 ± 5.6	47	0.5 ± 0.07	0.7
Cooper's Hawk	2316	506	763	2438	663	477	46 ± 4.5	53	0.7 ± 0.11	1.4
Northern Goshawk	13	6	4	2	1	0	24 ± 7.4	50	2.1 ± 0.89	1.0
Broad-winged Hawk	30	8	11	20	7	11	31 ± 7.7	10	0.8 ± 0.16	0.6
Red-tailed Hawk	2448	293	1498	3055	341	1690	27 ± 3.2	34	0.2 ± 0.04	0.2
Ferruginous Hawk	13	3	5	12	5	4	42 ± 9.3	25	0.5 ± 0.15	1.3
Golden Eagle	32	9	12	28	7	12	34 ± 5.0	32	0.9 ± 0.22	0.6
Bald Eagle	40	8	27	26	6	17	11 ± 3.0	12	0.3 ± 0.02	0.4
Peregrine Falcon	18	2	7	15	3	6	47 ± 9.6	40	0.3 ± 0.16	0.5

[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 2003 and 1997–2002 average median passage dates (Lipan Point and Yaki Point data combined).

	2003				1997–2002
Species	First Observed	Last Observed	Bulk Passage Dates [1]	Median Passage Date [2]	Median Passage Date [3]
Osprey	27-Aug	4-Nov	10-Sep – 10-Oct	23-Sep	18-Sep ± 2.5
Northern Harrier	28-Aug	5-Nov	16-Sep – 23-Oct	8-Oct	5-Oct ± 2.9
Sharp-shinned Hawk	27-Aug	5-Nov	14-Sep – 20-Oct	29-Sep	2-Oct ± 1.4
Cooper's Hawk	27-Aug	5-Nov	19-Sep – 11-Oct	26-Sep	29-Sep ± 3.1
Northern Goshawk	11-Sep	17-Sep	11-Sep – 17-Sep	–	7-Oct ± 6.7
Broad-winged Hawk	19-Sep	6-Oct	23-Sep – 6-Oct	24-Sep	25-Sep ± 1.9
Swainson's Hawk	28-Aug	23-Oct	19-Sep – 6-Oct	4-Oct	20-Sep ± 5.4
Red-tailed Hawk	27-Aug	5-Nov	18-Sep – 23-Oct	7-Oct	8-Oct ± 3.0
Ferruginous Hawk	30-Aug	5-Nov	19-Sep – 29-Oct	6-Oct	12-Oct ± 6.7
Zone-tailed Hawk	29-Aug	18-Sep	29-Aug – 18-Sep	–	□
Golden Eagle	30-Aug	4-Nov	2-Sep – 26-Oct	24-Sep	18-Oct ± 4.9
Bald Eagle	15-Sep	5-Nov	16-Oct – 5-Nov	21-Oct	24-Oct ± 4.1
American Kestrel	28-Aug	25-Oct	13-Sep – 7-Oct	23-Sep	23-Sep ± 2.5
Merlin	31-Aug	23-Oct	20-Sep – 23-Oct	9-Oct	5-Oct ± 2.2
Prairie Falcon	10-Sep	15-Oct	10-Sep – 15-Oct	14-Sep	27-Sep ± 6.5
Peregrine Falcon	6-Sep	19-Oct	11-Sep – 19-Oct	4-Oct	24-Sep ± 7.6
All species	27-Aug	5-Nov	15-Sep – 19-Oct	27-Sep	1-Oct ± 2.0

[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 (Lipan Point and Yaki Point data combined): 1997–2002 versus 2003.

	ADULT		IMMATURE / SUBADULT	
SPECIES	1992–2000[1]	2001	1992–2000[1]	2001
Northern Harrier	8-Oct ± 2.9	17-Oct	3-Oct ± 5.3	13-Oct
Sharp-shinned Hawk	8-Oct ± 0.7	7-Oct	25-Sep ± 2.2	23-Sep
Cooper's Hawk	2-Oct ± 3.2	30-Sep	25-Sep ± 2.6	24-Sep
Northern Goshawk	25-Oct ± 11.8[2]	–	8-Oct ± 7.7	–
Broad-winged Hawk	24-Sep ± 2.4	22-Sep	25-Sep ± 3.1	29-Sep
Red-tailed Hawk	8-Oct ± 2.4	6-Oct	2-Oct ± 4.8	29-Sep
Ferruginous Hawk	23-Oct ± 9.9	–	□	25-Sep
Golden Eagle	19-Oct ± 6.1	22-Sep	17-Oct ± 7.3	6-Oct
Bald Eagle	24-Oct ± 4.1	20-Oct	21-Oct ± 5.6	28-Oct
Peregrine Falcon	29-Sep ± 11.9	19-Sep	24-Sep [3]	–

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.

[2] Value based on data for 2000 and 2001 only.

[3] Value is for 1998 only.

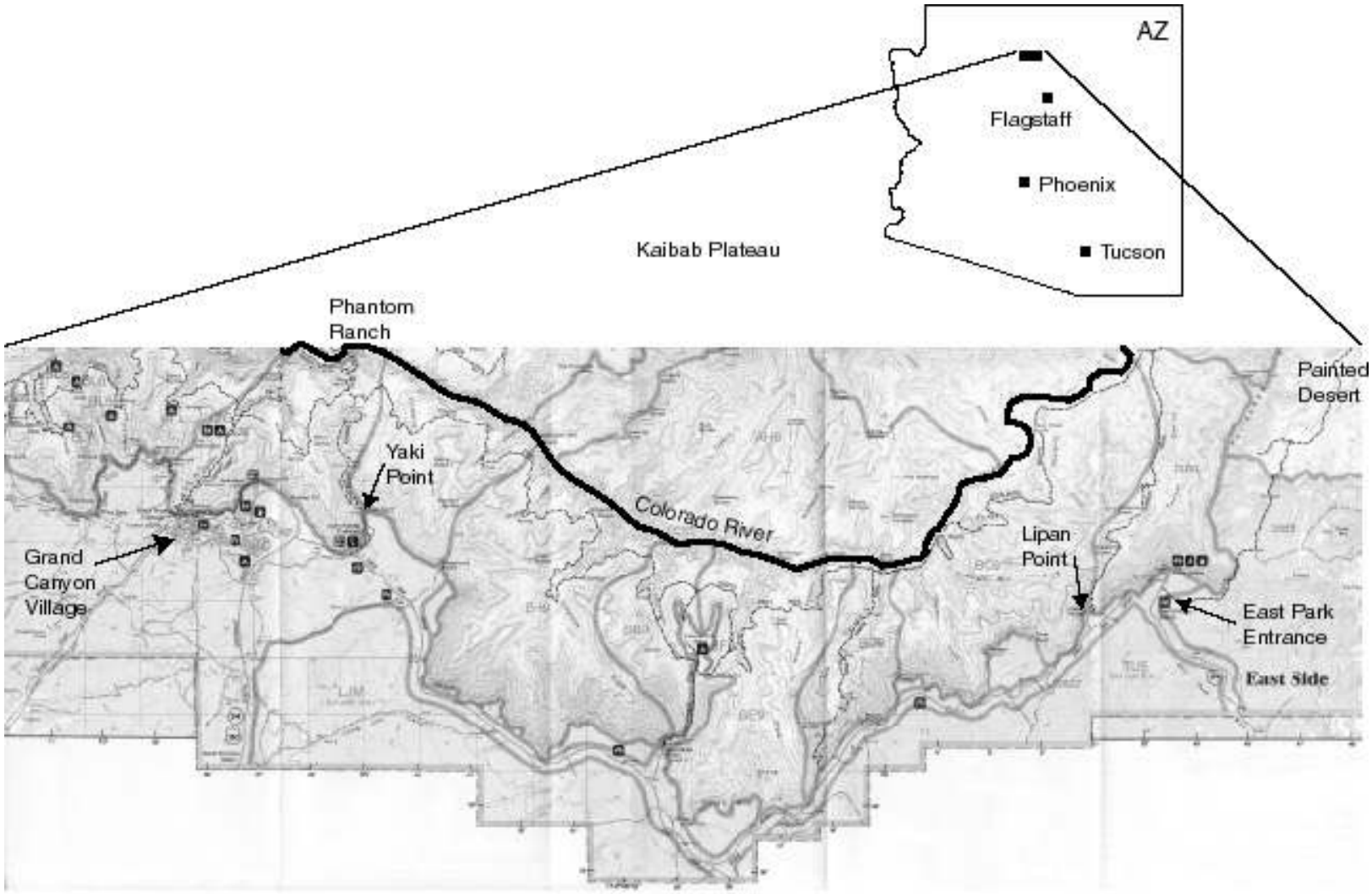

Figure 1. Map showing the Lipan Point and Yaki Point raptor-migration study sites in the Grand Canyon, Arizona.

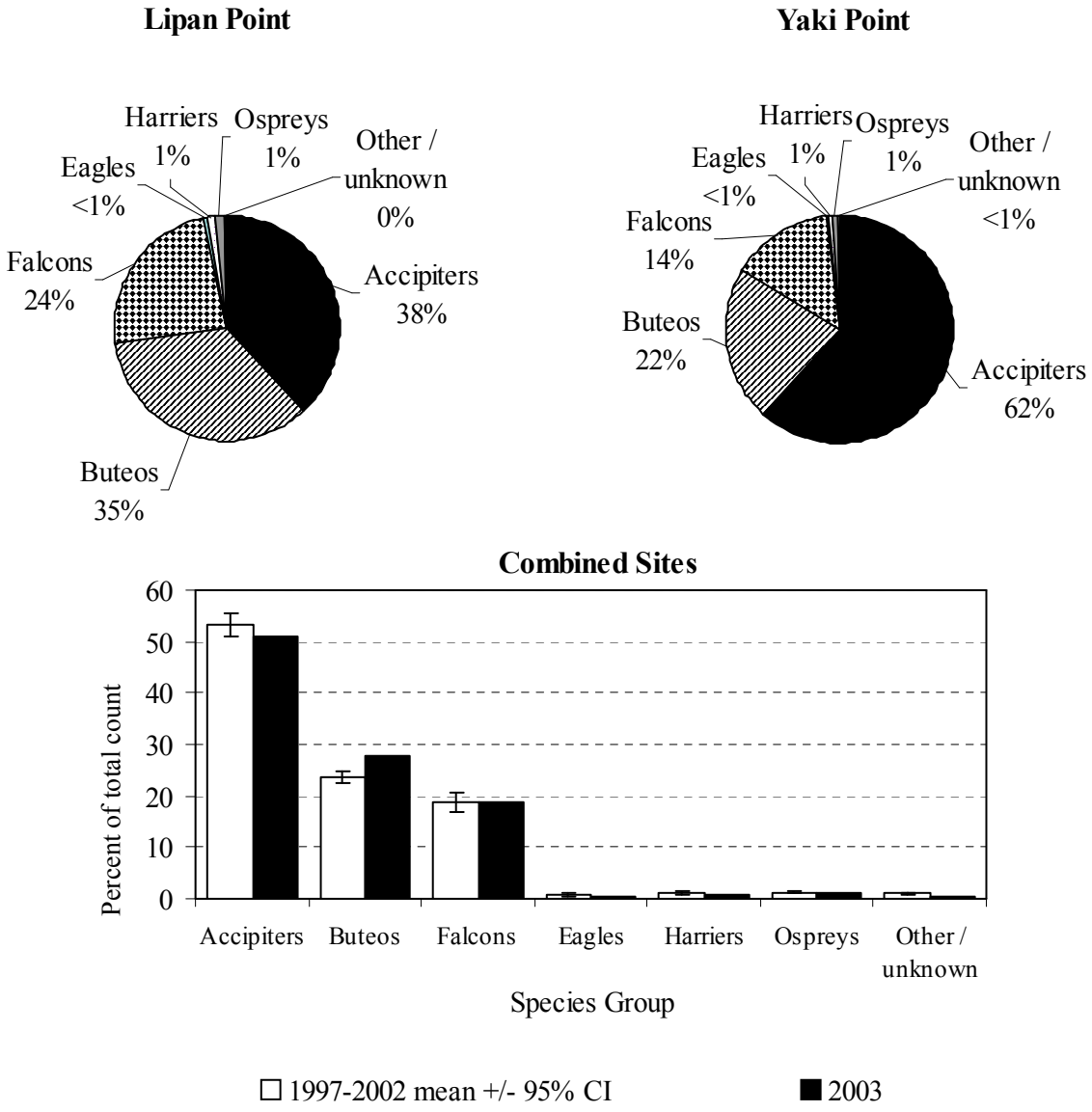

Figure 2. Fall raptor-migration flight composition by major species groups in the Grand Canyon, AZ: 1997–2002 versus 2003.

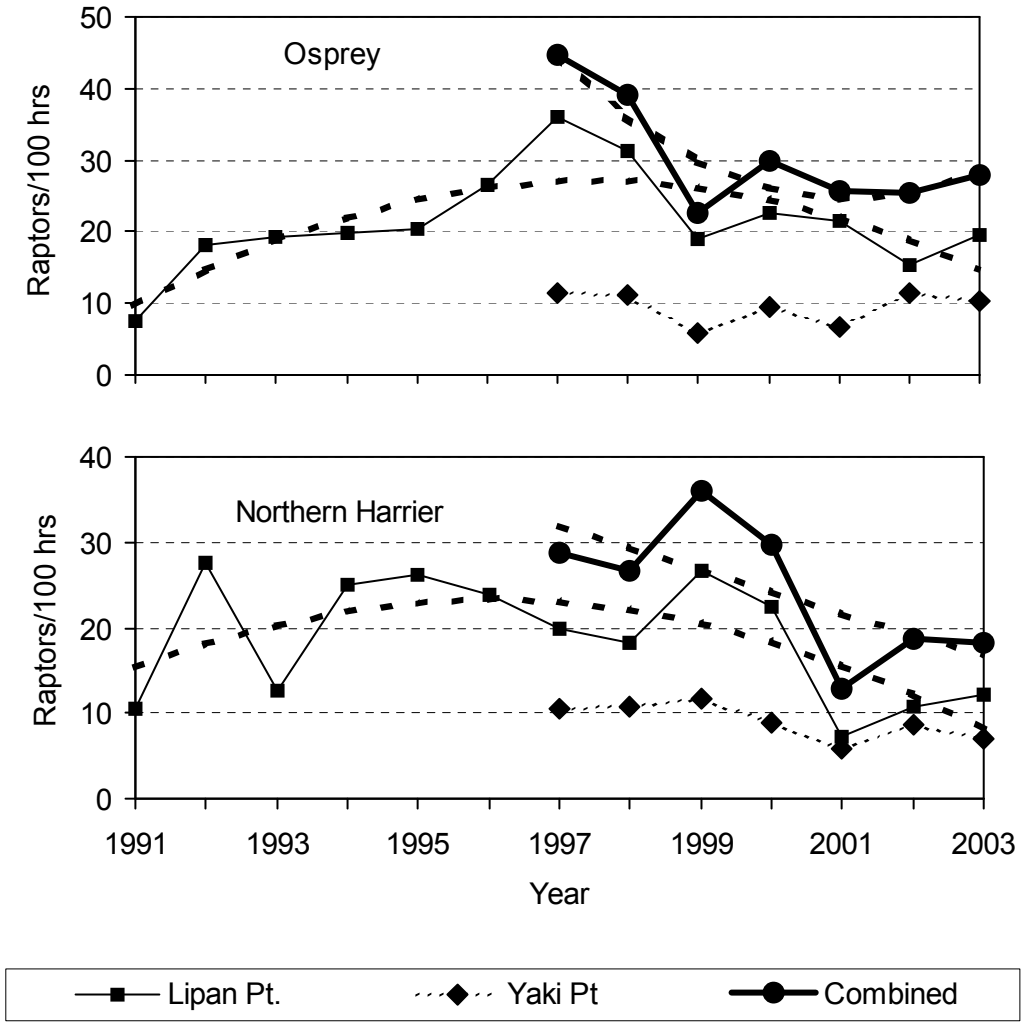

Figure 3. Adjusted (truncated to standardized annual sampling periods and adjusted for incompletely identified birds) fall-migration passage rates for Ospreys and Northern Harriers in the Grand Canyon, AZ: 1991–2003. Dashed lines indicate significant ($P \leq 0.10$) linear or quadratic regressions.

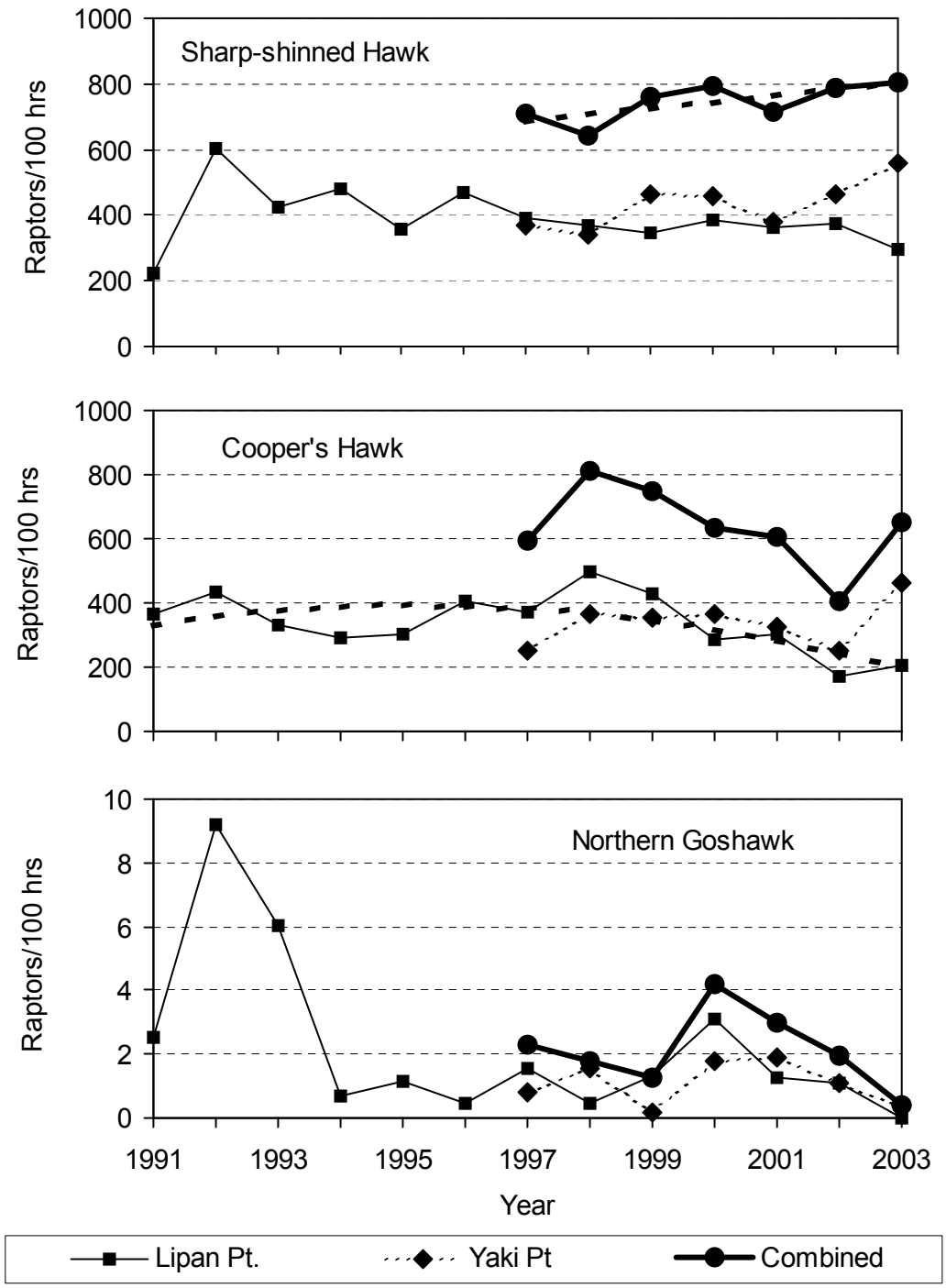

Figure 4. Adjusted (truncated to standardized annual sampling periods and adjusted for incompletely identified birds) fall-migration passage rates for Sharp-shinned Hawks, Cooper's Hawks, and Northern Goshawks in the Grand Canyon, AZ: 1991–2003. Dashed lines indicate significant ($P \leq 0.10$) linear or quadratic regressions.

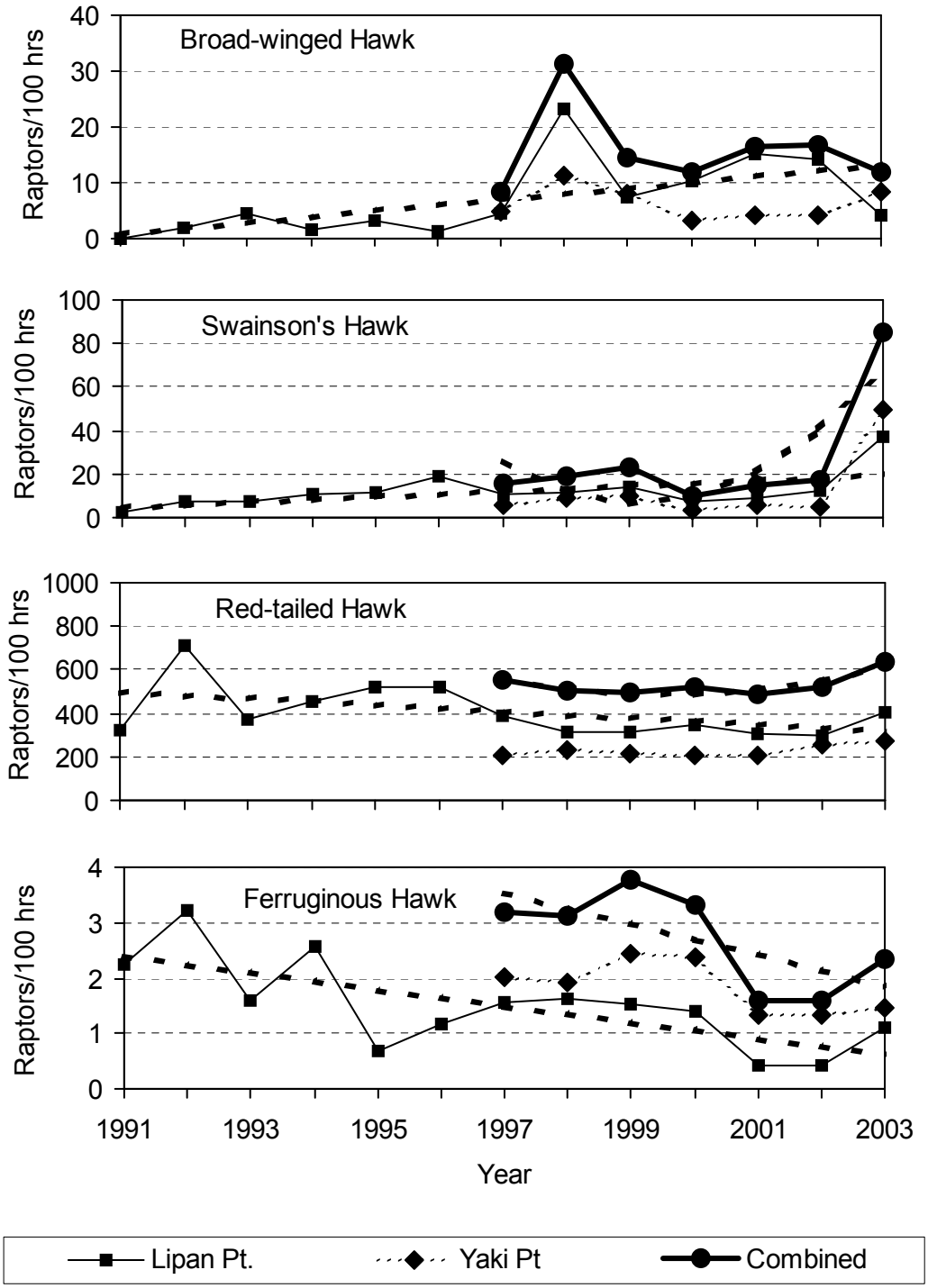

Figure 5. Adjusted (truncated to standardized annual sampling periods and adjusted for incompletely identified birds) fall-migration passage rates for Broad-winged, Swainson's, Red-tailed, and Ferruginous Hawks in the Grand Canyon, AZ: 1991–2003. Dashed lines indicate significant ($P \leq 0.10$) linear or quadratic regressions.

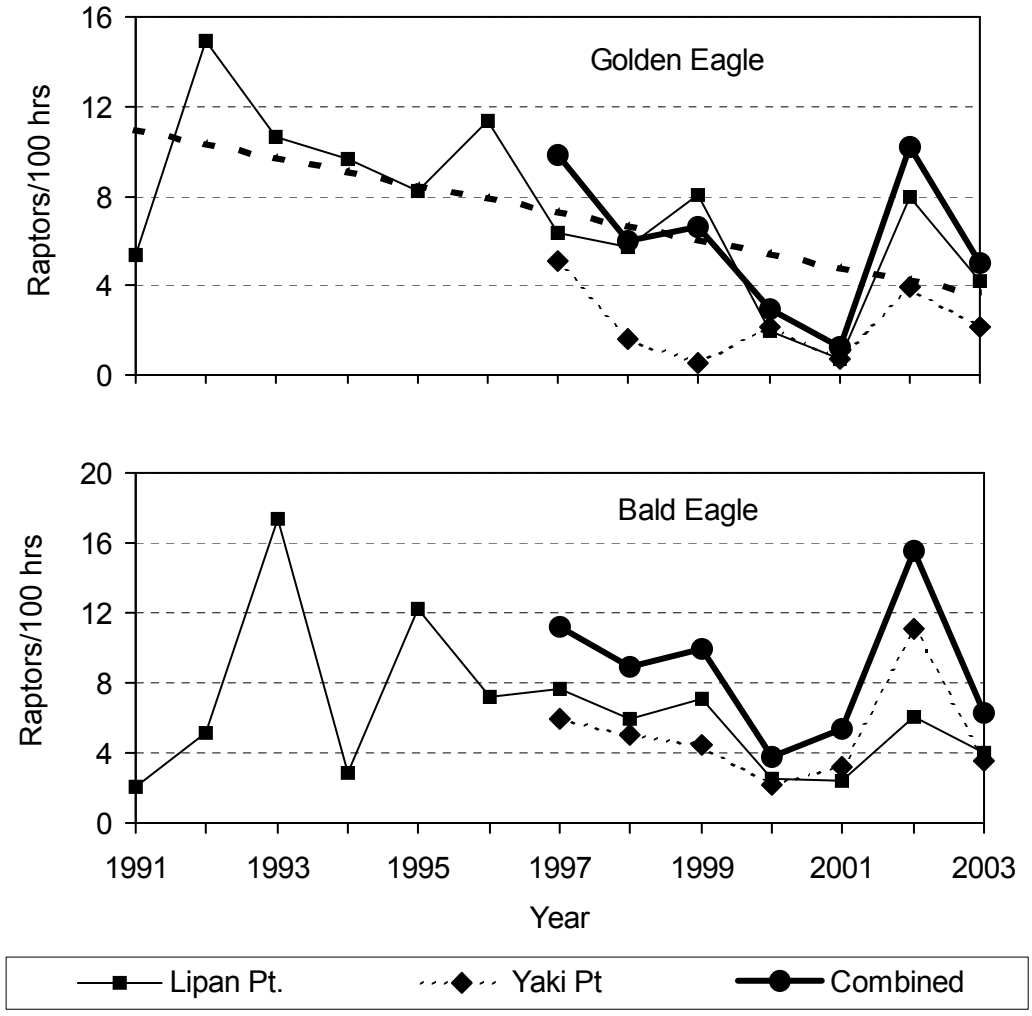

Figure 6. Adjusted (truncated to standardized annual sampling periods and adjusted for incompletely identified birds) fall-migration passage rates for Golden and Bald Eagles in the Grand Canyon, AZ: 1991–2003. Dashed lines indicate significant ($P \leq 0.10$) linear or quadratic regressions.

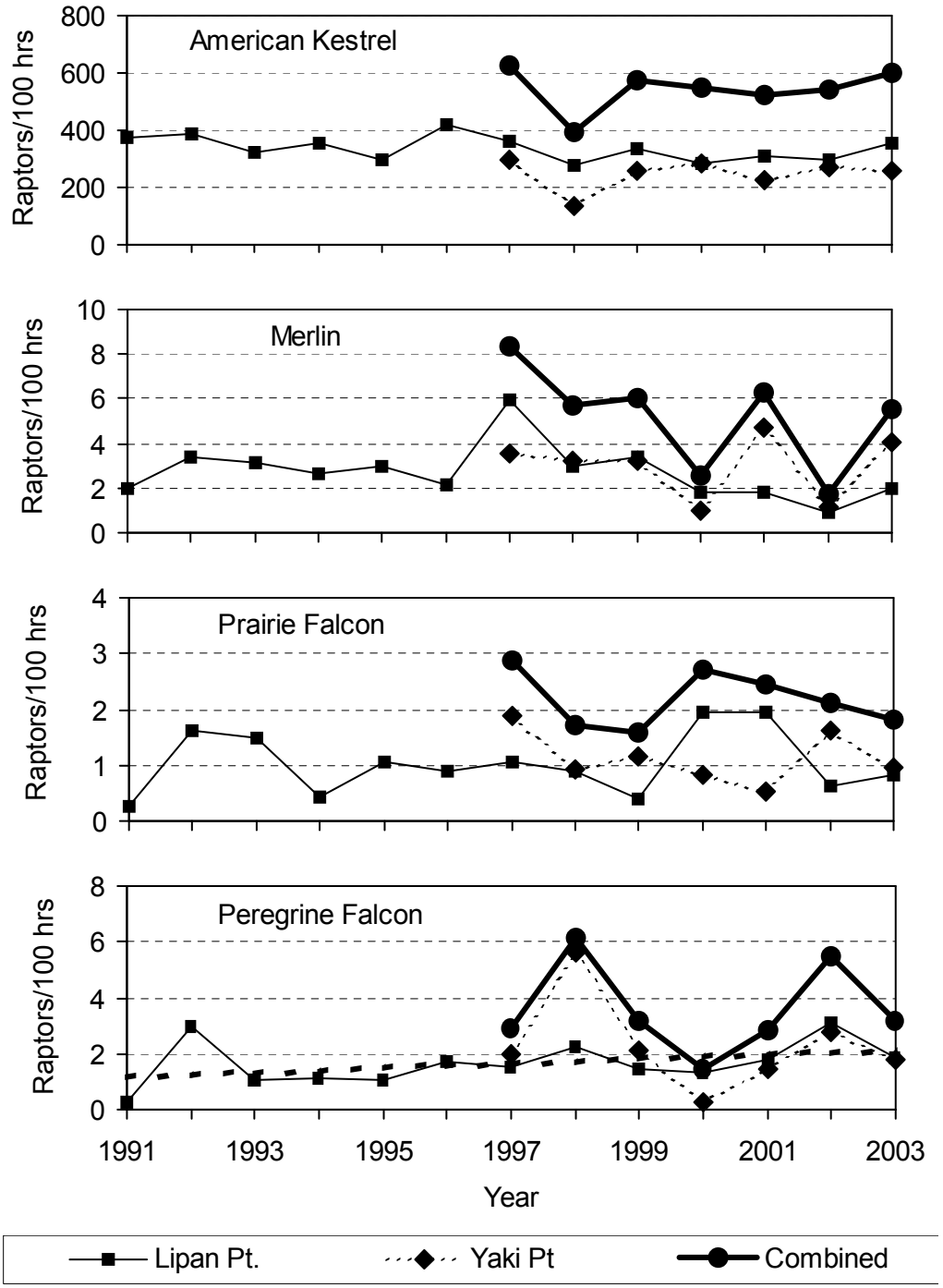

Figure 7. Adjusted (truncated to standardized annual sampling periods and adjusted for incompletely identified birds) fall-migration passage rates for American Kestrels, Merlins, Prairie Falcons, and Peregrine Falcons in the Grand Canyon, AZ: 1991–2003. Dashed lines indicate significant ($P \leq 0.10$) linear or quadratic regressions.

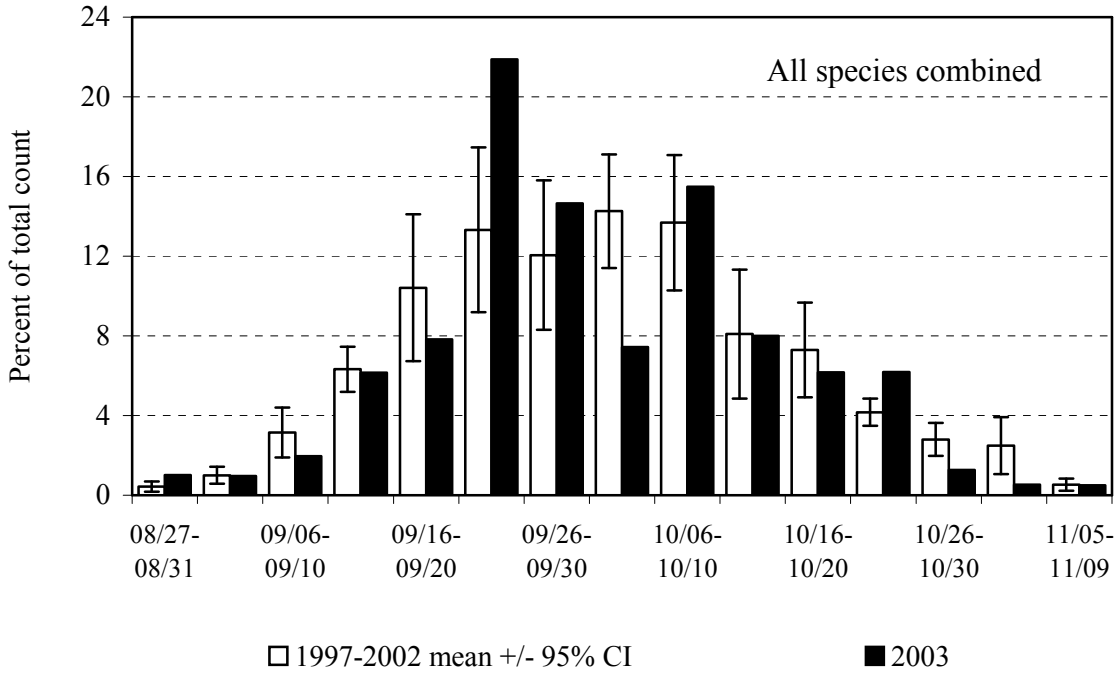

Figure 8. Combined-species, fall-migration passage volume by five-day periods for raptors in the Grand Canyon: 1997–2002 versus 2003 (Lipan Point and Yaki Point data combined).

Appendix A. History of official observer participation in the Grand Canyon raptor migration studies: 1991–2003.

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), Don Rosie (0)

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

1993 Rotating team with at least two observers throughout at Lipan Pt.: Daniel Perry (4), Frank LaSorte (1), 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), Christie van Cleve (3)

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

1996 Rotating team with at least two observers throughout at Lipan Pt.: Amy Adams (2), Elliot Swarthout (1), 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), 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), 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), 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), 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), 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 (partial), 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).

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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 Lipan Point, Grand Canyon, AZ: 2003.

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	8.00	2.2	0	pc	3.5	w	25.4	29.12	4	66	82	3	0.8
28-Aug	8.00	2.5	0	pc-mc	2.1	w	25.2	29.12	4	80	87	2	2.3
29-Aug	8.00	2.0	0	clr-mc, haze	5.3	n, nw	28.0	29.07	2	78	76	2	1.9
30-Aug	8.00	2.0	0	clr-pc, AM haze	3.9	wsw-w	29.4	28.22	1	85	91	3	2.1
31-Aug	8.25	2.6	0	clr-pc	3.2	n/calm, wnw	27.3	28.32	2	80	80	3	1.7
1-Sep	7.50	2.4	0	clr-ovc, haze, PM ts/rain	5.3	sw-wsw	27.7	28.05	4	83	92	2	1.3
2-Sep	4.75	2.0	0	ovc, ts	0.0	calm	27.3	28.05	3	74	100	3	2.3
3-Sep	7.83	2.0	0	clr-ovc, PM ts/rain	2.3	calm/var	26.8	28.06	4	82	79	2	0.6
4-Sep	7.18	2.0	0	clr-mc, PM haze	3.3	nw, ene, wsw-wnw	26.8	28.09	3	70	74	3	1.4
5-Sep	8.00	2.0	0	pc, haze, scat ts/rain	1.0	var	25.7	28.07	2	87	91	2	1.3
6-Sep	5.33	2.0	0	clr-mc, haze	9.6	w	21.6	28.16	3	66	61	3	8.3
7-Sep	8.00	2.0	0	clr-mc, PM haze	10.0	wsw	24.2	27.99	2	80	69	3	5.0
8-Sep	7.83	2.0	0	ovc, AM haze	20.0	wsw-nnw	22.0	27.83	4	50	78	2	0.6
9-Sep	6.83	2.0	0	mc-ovc, ts/rain	32.5	w-wnw	18.8	27.77	4	66	63	1	1.3
10-Sep	8.58	2.0	0	clr, haze	4.8	w	19.5	27.89	2	66	53	2	5.4
11-Sep	8.00	2.0	0	clr	1.3	w/calm	20.7	28.04	2	100	91	2	4.4
12-Sep	8.00	2.0	0	clr	13.7	w	24.3	27.93	2	87	86	3	7.6
13-Sep	8.25	2.0	0	clr	5.8	w-nw	23.6	27.96	4	95	90	3	14.9
14-Sep	8.00	2.0	0	clr	3.0	e, w	23.1	28.04	2	90	78	2	14.9
15-Sep	7.75	2.0	0	clr, haze	6.2	wsw-w	24.8	28.13	2	63	85	2	10.7
16-Sep	7.75	2.0	0	clr, AM haze	28.6	sw-w	24.4	28.02	3	76	80	2	2.5
17-Sep	8.25	2.0	0	clr, haze	10.4	w	24.2	27.81	3	76	70	3	2.8
18-Sep	8.92	1.9	0	clr, haze	0.5	var	18.5	28.00	2	94	80	2	6.5
19-Sep	8.50	2.0	0	clr		calm	23.2	27.95	3	80	80	2	19.1
20-Sep	8.50	2.0	0	clr, haze		calm	24.3	27.94	2	87	79	2	14.7
21-Sep	8.00	2.7	0	clr		calm	23.2	28.01	4	88	85	3	22.8
22-Sep	8.50	2.0	0	clr, AM haze	6.0	e-se/calm	24.1	28.03	3	84	85	2	13.5
23-Sep	9.00	2.0	0	pc-ovc, haze	0.6	calm/var	25.7	27.96	2	80	69	2	34.6
24-Sep	9.00	2.0	0	ovc, haze	1.0	calm/var	25.8	27.95	3	55	55	3	18.1
25-Sep	9.00	1.9	0	clr	0.8	calm/var	23.5	27.98	2	93	68	2	32.2
26-Sep	8.25	2.0	0	clr, haze	1.1	wnw	24.1	27.99	2	84	63	3	13.8
27-Sep	8.75	2.0	0	clr, haze	2.9	calm/var	26.6	28.02	2	73	33	2	44.8
28-Sep	8.00	2.0	0	clr, haze	5.6	w	27.8	27.99	3	44	30	2	17.5
29-Sep	7.75	2.0	0	clr		calm			4	86	86	3	8.9
30-Sep	8.42	2.0	0	clr-pc, haze	7.0	w	27.4	28.08	2	81	70	3	15.0
1-Oct	8.25	2.0	0	pc-ovc, ts/rain	8.1	var, w	24.4	28.03	4	60	60	3	9.7
2-Oct	5.75	2.0	0	pc-ovc, PM ts/rain	5.1	w/calm	23.6	27.87	3	78	89	3	16.9
3-Oct	0.00			fog/rain									
4-Oct	8.25	2.0	0	mc-ovc, AM fog	0.3	ne-calm/var	16.3	27.94	3	45	47	2	10.3
5-Oct	8.83	2.0	0	clr, AM haze	2.1	n-ne	20.4	27.97	2	79	82	2	12.9
6-Oct	8.25	2.0	1	mc-ovc	0.8	calm/var	18.9	27.92	3	98	89	2	21.6
7-Oct	8.00	1.9	0	mc	3.0	calm/var	20.2	27.87	3	91	90	2	33.0
8-Oct	8.00	2.0	0	ovc, haze	0.8	var, ne	21.6	27.95	1	81	83	2	18.3
9-Oct	8.00	2.0	0	clr-ovc	5.0	ne-se	20.6	27.87	3	97	88	2	9.6
10-Oct	8.50	2.0	0	mc-ovc, haze, rain	12.9	w	19.8	27.79	4	52	50	3	5.1
11-Oct	8.00	2.0	0	clr, haze	0.8	ese, w/calm/var	18.9	27.95	2	82	80	3	15.4
12-Oct	8.67	2.0	0	clr	8.8	w	21.3	28.03	2	84	84	3	27.8
13-Oct	8.00	2.0	0	clr, haze	1.0	calm/var	19.7	27.99	2	94	85	2	10.1
14-Oct	8.00	2.0	0	clr	10.6	wsw-w	18.7	27.99	4	0	90	2	5.8
15-Oct	8.00	3.0	0	clr	11.2	w	22.0	27.96	4	86	80	2	8.6

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
16-Oct	8.25	3.0	0	clr	6.0	w	20.0	28.06	3	80	80	3	21.3
17-Oct	8.00	2.0	0	clr, AM haze	4.1	e-se, var	21.8	28.16	2	85	76	2	4.1
18-Oct	8.00	2.0	0	clr	1.9	nne-se/calm	23.2	28.12	1	83	79	2	2.6
19-Oct	8.00	2.0	0	clr-pc	2.7	ne-ese, calm/var	24.1	28.13	2	85	81	2	10.8
20-Oct	8.00	2.0	0	clr	0.9	e	23.8	28.17	2	87	83	2	4.4
21-Oct	8.00	2.0	0	clr	1.5	ne/calm	21.8	28.20	3	75	75	2	2.6
22-Oct	8.00	3.0	0	clr, AM haze	5.7	calm, e	21.9	28.13	1	77	83	2	11.3
23-Oct	8.00	2.0	0	clr, haze	3.1	ne-e/calm, w-nw	22.6	27.97	2	44	15	2	31.1
24-Oct	8.17	1.9	0	clr, PM haze	0.8	var	22.5	28.01	2	88	74	3	2.3
25-Oct	7.75	2.0	0	clr, PM haze	3.0	sw/var	16.5	28.06	2	91	80	3	4.1
26-Oct	8.00	1.9	0	clr-pc, haze	2.9	calm/var	13.1	28.11	3	99	79	2	4.4
27-Oct	7.83	2.0	0	ovc, haze	1.4	w, n-ne/calm, w	16.8	28.02	4	83	39	2	3.8
28-Oct	7.58	2.0	0	ovc, haze	7.4	w	18.2	27.85	3	80	52	3	4.6
29-Oct	6.00	2.0	0	pc-ovc, dust/haze	27.5	wsw, var	17.9	27.70	4	56	52	1	1.2
30-Oct	4.25	2.0	0	pc, dust/haze	38.3	sw, var	15.3	28.60	4	23	24	-	0.0
31-Oct	4.00	2.0	0	pc-mc, dust/haze	39.3	s-sw	13.3	28.48	4	2	20	1	0.3
1-Nov	6.00	2.0	0	mc-ovc, haze	40.1	sw-w	14.0	28.70	4	66	67	2	0.5
2-Nov	5.50	2.0	0	ovc, haze, PM snow	30.3	se-sw	12.4	28.62	4	53	49	3	0.4
3-Nov	4.00	2.0	0	mc-ovc, PM snow	5.7	w	8.2	29.43	4	100	87	3	0.3
4-Nov	6.00	2.0	0	mc-clr	2.8	sw-wnw	9.4	29.94	4	100	88	2	3.0
5-Nov	5.00	2.0	0	clr, haze	4.7	sw-w	9.0	30.01	2	89	74	2	7.8

[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 observation effort, visitor disturbance ratings, weather records, and raptor-migration flight summaries at Yaki Point, Grand Canyon, AZ: 2003.

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]	Median Flight Distance[5]	Birds / Hour
27-Aug	7.25	2.0	0	pc-ovc	2.0	var/calm	27.2	29.15	2	100	2	0.4
28-Aug	8.50	3.5	0	pc-ovc, AM haze/ts	3.8	e/calm, sw PM	25.5	29.20	2	81	1	1.9
29-Aug	8.50	2.7	0	clr-mc	3.4	nw-n	25.0	29.15	2	75	3	1.8
30-Aug	8.00	2.6	0	clr-pc	4.7	nw	26.2	29.19	3	70	3	0.8
31-Aug	8.00	3.0	0	clr, AM haze	5.0	var/calm	26.8	29.16	1	94	2	1.8
1-Sep	8.00	2.0	0	clr-ovc	3.0	calm AM, nw	28.4	29.17	3	100	3	1.0
2-Sep	6.00	2.9	0	pc-ovc	1.6	e-var/calm	25.9	29.21	3	81	3	2.2
3-Sep	6.25	3.6	0	pc-mc, AM haze, PM ts/rain	4.8	ne-ese	26.6	29.21	2	98	2	1.8
4-Sep	8.00	2.4	0	clr-mc	7.1	wnw-nw	27.4	29.21	2	83	1	2.1
5-Sep	7.33	2.5	0	pc-mc, scat ts	3.6	w-wnw/calm	26.4	29.19	2	87	3	3.1
6-Sep	7.00	2.9	0	ovc-clr, fog/haze/rain	5.8	se, wnw-n	21.6	29.17	2	54	2	3.7
7-Sep	8.00	2.6	0	pc-mc, haze	4.7	var	22.7	29.12	3	49	1	1.3
8-Sep	8.00	2.6	0	mc-ovc, AM haze	15.0	var	21.6	29.01	4	49	2	1.9
9-Sep	6.30	2.1	1	ms-ovc, scat ts/rain	28.9	s-sw	20.1	28.93	4	45	2	1.3
10-Sep	9.00	2.4	1	clr, haze	11.5	w-nnw	21.5	28.13	3	52	2	4.1
11-Sep	8.75	2.8	1	clr	1.0	var/calm	19.3	28.20	1	89	2	5.7
12-Sep	8.60	2.3	0	clr	10.6	var/calm	23.5	28.09	3	100	3	7.6
13-Sep	9.00	2.6	0	clr, AM/PM haze	6.9	var	22.2	28.09	3	79	2	13.4
14-Sep	8.25	3.3	0	clr, haze	7.3	e, nw-ne	21.1	28.18	3	59	2	8.4
15-Sep	8.00	2.4	0	clr	10.0	sw-wnw	24.1	29.15	3	89	2	3.6
16-Sep	8.00	2.6	0	clr-pc	18.2	w-nw	23.9	29.04	3	90	2	4.5
17-Sep	9.00	2.5	0	clr, midday haze	17.5	w-nw	23.2	28.95	3	58	2	6.1
18-Sep	8.50	2.6	0	clr, haze	7.1	ene-e, w	17.6	29.15	3	54	2	14.1
19-Sep	9.50	2.5	1	clr, haze	1.5	sw-nw	22.5	29.10	2	70	3	12.6
20-Sep	9.50	2.1	1	clr, haze	3.1	w-nw	22.4	29.09	1	64	2	25.5
21-Sep	9.50	2.4	0	clr	4.5	nne-e/calm	23.2	29.11	2	81	2	26.9
22-Sep	8.75	2.0	0	clr	3.4	e-se-var/calm	25.8	29.15	3	77	2	22.7
23-Sep	9.25	2.6	1	clr-ovc, haze	0.5	nw-ne/calm	26.3	29.12	1	61	3	31.4
24-Sep	8.25	3.5	0	mc-ovc, haze	1.9	e-var/calm	24.6	29.00	4	41	3	35.0
25-Sep	9.25	3.1	0	clr, haze	1.3	n-ene/calm/var	24.3	29.14	2	43	2	64.0
26-Sep	9.25	2.6	0	clr, haze	3.1	var	24.8	29.12	2	32	2	46.2
27-Sep	9.17	2.3	0	clr, haze	3.5	ne-e, nw	25.1	29.13	2	20	2	23.9
28-Sep	9.50	3.0	1.5	clr, AM haze	4.5	nw	26.1	29.16	2	76	2	14.6
29-Sep	8.67	2.8	0	clr, AM haze	8.8	nw-ne	24.6	29.15	3	89	3	7.5
30-Sep	8.75	2.0	0	clr-pc	6.5	nne, w-nw	25.4	29.20	3	80	2	12.5
1-Oct	5.25	3.3	1.5	clr-ovc, haze, ts	6.0	var	26.1	29.19	1	57	3	15.2
2-Oct	5.92	2.5	0	clr-ovc, ts	14.7	sw-nw, var	23.4	28.99	4	65	3	6.3
3-Oct	0.00			ovc, fog/ts								
4-Oct	8.08	2.4	0	clr-mc, AM fog/haze	5.3	ene-se	16.4	29.04	3	74	2	12.0
5-Oct	8.75	2.6	0	clr-pc	6.9	ne-se	19.2	29.09	3	77	3	36.9
6-Oct	8.58	3.3	0	ovc	6.3	ene-se	20.8	29.07	2	82	3	24.7
7-Oct	9.00	2.0	0	mc-pc	6.5	calm, e	21.1	29.01	2	82	3	40.9
8-Oct	9.00	1.9	0	clr-pc	5.3	nne-e	18.0	29.05	2	85	2	45.7
9-Oct	8.25	2.7	0	clr-pc, AM haze	4.8	ene-e	18.8	29.05	3	79	3	14.2
10-Oct	8.25	2.0	0	mc-ovc, AM haze, scat ts	12.3	sw-wnw	18.0	28.93	4	33	2	10.4
11-Oct	8.75	1.9	0	clr, haze	3.4	ne-se, calm	17.2	28.30	2	50	2	27.5
12-Oct	8.25	2.7	0	clr, AM haze	4.7	var	19.9	28.13	2	79	2	7.5
13-Oct	8.00	2.0	0	clr, AM haze	2.3	wnw	21.4	28.17	2	88	3	6.5
14-Oct	8.00	2.1	0	clr	13.2	sw-wnw	19.2	28.13	3	90	2	5.3
15-Oct	8.00	3.7	0	clr	8.9	var	19.1	28.11	3	57	2	3.3

Appendix D. 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]	Median Flight Distance[5]	Birds / Hour
16-Oct	9.00	2.0	0	clr	5.2	w-nnw	19.7	28.22	3	82	2	15.8
17-Oct	8.25	2.3	1	clr, AM haze	10.0	nne-ene	21.7	28.32	3	81	2	5.8
18-Oct	8.00	2.0	0	clr	8.0	e	20.2	28.28	4	80	2	6.6
19-Oct	8.00	2.3	0	clr-mc, haze	1.6	sw/calm	22.0	28.27	2	63	2	6.6
20-Oct	8.17	1.9	0	clr-pc, haze	3.1	e-ese, var/calm	23.0	28.30	3	58	2	13.6
21-Oct	8.25	2.0	0	clr, haze	4.9	ne-se, nnw-ne	21.7	28.28	3	73	2	7.5
22-Oct	8.00	2.0	0	clr	1.1	var	24.4	28.27	2	81	3	6.6
23-Oct	8.25	2.4	0	clr-pc, haze	7.9	e, calm, w-nw	22.3	28.14	3	32	2	8.6
24-Oct	8.25	2.6	0	clr-mc, haze	4.5	ene-e, nnw-nne	19.5	28.14	3	33	3	13.3
25-Oct	7.75	2.3	0	clr-pc, haze	3.5	n-e	14.3	28.22	3	38	2	6.7
26-Oct	8.00	2.0	0	clr-pc	3.8	nw-ne	15.4	28.30	2	62	3	2.4
27-Oct	6.00	2.0	0	ovc, haze	1.9	wnw-nw	17.8	28.21	4	22	2	0.7
28-Oct	7.75	1.0	0	ovc, haze	4.5	wnw-nw	19.2	28.01	3	48	2	2.6
29-Oct	5.00	2.0	0	clr-ovc, dust/haze	34.7	ssw	16.1	27.84	4	61	2	1.0
30-Oct	3.00	2.0	0	mc, dust/haze	39.4	sw	13.0	27.68	4	39	-	0.0
31-Oct	5.00	2.0	0	mc-ovc, haze	36.6	s-sw	12.0	27.84	4	44	3	0.2
1-Nov	7.00	1.9	0	pc-ovc, haze	16.1	s-ssw	10.6	27.92	4	66	2	3.3
2-Nov	5.00	2.0	0	ovc, rain/snow	19.6	s-sw	10.6	27.85	4	60	2	0.6
3-Nov	4.00	2.0	0	ovc	23.7	ssw-sw	5.3	27.84	4	100	2	1.0
4-Nov	6.50	2.0	0	ovc-clr	5.8	w/var	7.8	27.94	2	93	3	1.4
5-Nov	5.00	2.0	0	clr, haze	7.0	calm-sw, nw	10.0	27.98	2	93	2	4.4

[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 E. Daily raptor migration counts by species at Lipan Point, Grand Canyon, AZ: 2003.

	Observ.	Species[1]																										Birds
Date	Hours	OS	NH	SS	CH	NG	SA	LA	UA	RS	BW	SW	RT	FH	ZT	UB	GE	BE	UE	AK	ML	PR	PG	SF	LF	UF	UU	Total	/ Hour
27-Aug	8.00	1	0	2	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
28-Aug	8.00	0	0	1	2	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	18
29-Aug	8.00	0	0	6	0	0	0	0	0	0	0	2	2	0	0	1	0	0	0	0	4	0	0	0	0	0	0	0	15
30-Aug	8.00	2	1	7	0	0	0	0	0	0	0	0	3	1	0	0	0	0	0	0	3	0	0	0	0	0	0	0	17
31-Aug	8.25	0	0	2	2	0	0	0	1	0	0	0	1	0	0	0	2	0	0	0	4	1	0	0	0	0	0	1	14
01-Sep	7.50	0	0	3	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	10
02-Sep	4.75	0	0	2	3	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	11
03-Sep	7.83	0	0	0	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	5
04-Sep	7.18	2	0	3	1	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	10
05-Sep	8.00	0	0	2	1	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	10
06-Sep	5.33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
07-Sep	8.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
08-Sep	7.83	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	5
09-Sep	6.83	2	0	1	0	0	0	0	0	0	0	2	1	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	9
10-Sep	8.58	2	0	16	5	0	0	0	1	0	0	0	6	0	0	0	0	0	0	0	16	0	0	0	0	0	0	0	46
11-Sep	8.00	3	0	15	3	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	11	0	0	1	0	0	0	0	35
12-Sep	8.00	0	1	19	4	0	2	0	1	0	0	0	11	0	0	0	2	1	0	0	19	0	0	0	0	0	0	1	61
13-Sep	8.25	4	2	25	15	0	0	1	1	0	0	0	38	0	0	0	0	0	0	0	36	0	1	0	0	0	0	0	123
14-Sep	8.00	5	1	32	13	0	0	0	0	0	0	2	26	0	0	0	0	0	0	0	40	0	0	0	0	0	0	0	119
15-Sep	7.75	0	1	22	11	0	0	0	1	0	0	1	28	0	0	0	1	0	0	0	16	0	0	1	0	0	0	1	83
16-Sep	7.75	3	0	2	3	0	0	0	0	0	0	1	3	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	19
17-Sep	8.25	2	0	5	2	0	0	0	0	0	0	0	6	0	0	0	1	0	0	0	6	0	0	0	0	0	0	1	23
18-Sep	8.92	2	0	18	9	0	1	0	0	0	0	1	12	0	0	1	0	2	0	0	12	0	0	0	0	0	0	0	58
19-Sep	8.50	2	0	36	26	0	0	0	0	0	1	3	40	1	0	0	0	2	0	0	50	0	0	1	0	0	0	0	162
20-Sep	8.50	1	0	26	22	0	1	0	0	0	0	1	40	0	0	0	0	0	0	0	34	0	0	0	0	0	0	0	125
21-Sep	8.00	2	2	47	30	0	0	1	7	0	0	1	42	0	0	0	0	0	0	0	49	0	0	0	0	0	0	1	182
22-Sep	8.50	1	1	14	7	0	0	0	0	0	0	0	21	0	0	0	0	0	0	0	71	0	0	0	0	0	0	0	115
23-Sep	9.00	6	2	37	36	0	3	0	0	0	3	8	55	0	0	0	0	0	0	0	160	1	0	0	0	0	0	0	311
24-Sep	9.00	4	0	30	28	0	2	0	0	0	0	0	36	0	0	0	0	0	0	0	62	0	0	1	0	0	0	0	163
25-Sep	9.00	3	0	34	58	0	5	0	0	0	0	2	51	0	0	0	1	1	0	0	135	0	0	0	0	0	0	0	290
26-Sep	8.25	0	1	21	17	0	2	0	7	0	0	0	29	0	0	0	1	0	0	0	34	0	0	0	0	0	0	2	114
27-Sep	8.75	4	2	73	72	0	0	0	3	0	1	23	81	0	0	0	2	0	0	0	129	1	0	0	0	0	0	1	392
28-Sep	8.00	1	0	36	31	0	0	0	3	0	0	2	24	0	0	0	1	0	0	0	40	0	1	1	0	0	0	0	140
29-Sep	7.75	3	1	15	18	0	0	0	6	0	0	0	8	0	0	0	2	0	0	0	14	0	0	0	0	1	0	1	69
30-Sep	8.42	1	1	37	34	0	0	0	0	0	1	3	27	0	0	0	0	0	0	0	22	0	0	0	0	0	0	0	126
01-Oct	8.25	1	2	10	15	0	0	0	4	0	0	2	19	0	0	0	1	0	0	0	26	0	0	0	0	0	0	0	80
02-Oct	5.75	2	1	26	14	0	0	0	0	0	0	2	29	0	0	0	0	0	0	0	23	0	0	0	0	0	0	0	97
03-Oct	0.00																												
04-Oct	8.25	1	1	35	10	0	1	0	0	0	0	0	14	0	0	0	1	0	0	0	19	1	0	0	0	0	0	2	85

Appendix E. continued

Date	Observ. Hours	Species[1]																										Total	Birds / Hour
		OS	NH	SS	CH	NG	SA	LA	UA	RS	BW	SW	RT	FH	ZT	UB	GE	BE	UE	AK	ML	PR	PG	SF	LF	UF	UU		
05-Oct	8.83	1	0	33	18	0	0	0	0	0	0	4	26	0	0	0	0	0	0	0	32	0	0	0	0	0	0	0	114
06-Oct	8.25	3	4	41	35	0	0	0	0	0	0	33	35	0	0	0	0	0	0	0	26	0	0	1	0	0	0	0	178
07-Oct	8.00	1	2	48	37	0	2	0	0	0	0	6	117	0	0	0	0	1	0	0	48	0	0	0	0	0	0	2	264
08-Oct	8.00	2	3	67	31	0	0	0	1	0	0	2	10	0	0	0	0	0	0	0	29	0	0	0	0	0	0	1	146
09-Oct	8.00	0	0	27	6	0	0	0	2	0	0	0	29	1	0	0	1	0	0	0	11	0	0	0	0	0	0	0	77
10-Oct	8.50	0	1	9	13	0	2	0	0	0	0	4	11	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	43
11-Oct	8.00	2	2	30	22	0	0	0	1	0	0	1	40	0	0	0	0	0	0	0	25	0	0	0	0	0	0	0	123
12-Oct	8.67	2	2	49	23	0	0	0	0	0	0	1	154	1	0	0	0	0	0	0	9	0	0	0	0	0	0	0	241
13-Oct	8.00	0	0	24	11	0	0	0	0	0	0	0	42	0	0	0	0	0	0	0	3	0	0	1	0	0	0	0	81
14-Oct	8.00	0	4	5	6	0	0	0	0	0	0	0	27	0	0	0	0	0	0	0	2	1	0	1	0	0	0	0	46
15-Oct	8.00	1	0	12	16	0	0	0	1	0	0	0	28	0	0	0	0	1	1	0	8	0	1	0	0	0	0	0	69
16-Oct	8.25	1	2	22	13	0	7	1	3	0	0	0	111	0	0	0	1	3	2	0	3	0	0	0	0	0	0	7	176
17-Oct	8.00	0	1	20	5	0	0	0	0	0	0	0	5	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	33
18-Oct	8.00	0	2	11	4	0	0	0	0	0	0	0	2	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	21
19-Oct	8.00	0	4	16	2	0	0	0	0	0	0	0	61	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	86
20-Oct	8.00	0	0	18	3	0	1	0	0	0	0	0	11	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	35
21-Oct	8.00	0	1	14	1	0	0	0	1	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21
22-Oct	8.00	0	2	19	4	0	0	1	0	0	0	0	55	0	0	0	1	1	0	0	6	1	0	0	0	0	0	0	90
23-Oct	8.00	0	1	33	5	0	1	0	3	0	0	0	204	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	249
24-Oct	8.17	0	1	8	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	19
25-Oct	7.75	0	0	5	2	0	0	0	0	0	0	0	21	0	0	0	0	1	3	0	0	0	0	0	0	0	0	0	32
26-Oct	8.00	0	0	4	1	0	0	0	0	0	0	0	29	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	35
27-Oct	7.83	0	1	8	0	0	0	0	0	0	0	0	20	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	30
28-Oct	7.58	0	1	17	1	0	0	0	0	0	0	0	15	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	35
29-Oct	6.00	0	0	2	1	0	0	0	0	0	0	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
30-Oct	4.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31-Oct	4.00	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	0	0	1
01-Nov	6.00	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
02-Nov	5.50	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
03-Nov	4.00	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
04-Nov	6.00	1	0	11	1	0	0	0	0	0	0	0	4	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	18
05-Nov	5.00	0	0	6	1	0	1	0	0	0	0	0	25	1	0	0	1	0	2	0	0	0	0	0	0	0	0	2	39
Total	535.5	74	56	1223	758	0	31	4	47	0	6	107	1778	6	0	2	20	17	12	0	1278	9	3	8	0	1	0	23	5463

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

Appendix F. Daily raptor migration counts by species at Yaki Point, Grand Canyon, AZ: 2003.

	Observ.	Species[1]																										Birds
Date	Hours	OS	NH	SS	CH	NG	SA	LA	UA	RS	BW	SW	RT	FH	ZT	UB	GE	BE	UE	AK	ML	PR	PG	SF	LF	UF	UU	Total	/ Hour
27-Aug	7.25	0	0	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
28-Aug	8.50	0	1	1	1	0	0	0	0	0	0	2	8	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	16
29-Aug	8.50	0	0	2	2	0	0	1	0	0	0	1	7	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	15
30-Aug	8.00	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	6
31-Aug	8.00	0	0	6	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	14
01-Sep	8.00	2	0	2	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	8
02-Sep	6.00	1	0	4	0	0	0	0	0	0	0	0	3	0	0	0	0	3	0	0	2	0	0	0	0	0	0	0	13
03-Sep	6.25	0	0	1	1	0	0	0	0	0	0	1	3	0	0	0	2	1	0	0	2	0	0	0	0	0	0	0	11
04-Sep	8.00	0	0	3	4	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	17
05-Sep	7.33	0	0	10	1	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	23
06-Sep	7.00	0	0	15	3	0	0	0	0	0	0	1	4	0	0	0	0	0	0	0	2	0	0	1	0	0	0	0	26
07-Sep	8.00	0	0	4	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	10
08-Sep	8.00	0	0	3	2	0	0	0	0	0	0	1	3	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	15
09-Sep	6.30	0	0	2	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	8
10-Sep	9.00	0	0	5	5	0	0	0	1	0	0	0	3	0	0	0	1	0	0	0	21	0	1	0	0	0	0	0	37
11-Sep	8.75	0	0	24	7	1	0	0	0	0	0	1	3	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	50
12-Sep	8.60	0	0	36	8	0	0	0	0	0	0	1	10	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	65
13-Sep	9.00	3	1	47	19	0	3	0	1	0	0	1	10	0	0	0	0	0	0	0	36	0	0	0	0	0	0	0	121
14-Sep	8.25	1	1	16	19	0	1	0	2	0	0	1	16	0	0	0	0	0	0	0	9	0	1	1	0	0	0	1	69
15-Sep	8.00	0	0	11	8	0	0	0	0	0	0	0	5	0	0	0	1	0	1	0	2	0	1	0	0	0	0	0	29
16-Sep	8.00	2	1	9	5	0	2	0	0	0	0	0	6	0	0	0	0	0	0	0	10	0	0	0	0	0	0	1	36
17-Sep	9.00	1	0	4	6	1	0	0	0	0	0	1	9	0	0	0	1	0	0	0	32	0	0	0	0	0	0	0	55
18-Sep	8.50	0	0	31	41	0	3	0	1	0	0	1	15	0	0	0	1	0	0	0	26	0	0	0	0	0	0	1	120
19-Sep	9.50	2	0	49	17	0	1	0	14	0	0	0	15	0	0	0	0	0	0	0	20	0	0	0	0	0	0	2	120
20-Sep	9.50	0	0	110	48	0	9	0	14	0	0	1	17	0	0	0	0	0	0	0	41	2	0	0	0	0	0	0	242
21-Sep	9.50	1	1	61	72	0	0	0	2	0	0	6	55	0	0	0	0	0	0	0	58	0	0	0	0	0	0	0	256
22-Sep	8.75	2	0	54	45	0	5	0	1	0	0	0	33	0	0	0	0	0	0	0	59	0	0	0	0	0	0	0	199
23-Sep	9.25	2	0	66	113	0	1	0	6	0	4	5	29	0	0	0	0	2	0	0	62	0	0	0	0	0	0	0	290
24-Sep	8.25	7	2	70	93	0	2	0	4	0	1	6	51	2	0	0	5	0	0	0	43	0	0	0	0	0	1	2	289
25-Sep	9.25	5	2	184	237	0	11	0	10	0	1	4	39	0	0	0	2	0	0	0	89	1	1	0	0	0	0	6	592
26-Sep	9.25	3	1	175	148	0	1	0	14	0	2	11	24	1	0	0	3	0	0	0	37	3	0	0	0	0	0	4	427
27-Sep	9.17	0	0	97	58	0	1	0	1	0	0	0	13	0	0	0	0	0	0	0	49	0	0	0	0	0	0	0	219
28-Sep	9.50	0	1	39	49	0	0	0	0	0	1	1	25	0	0	0	0	0	0	0	23	0	0	0	0	0	0	0	139
29-Sep	8.67	0	0	21	17	0	1	0	0	0	1	2	11	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	65
30-Sep	8.75	0	0	30	40	0	0	0	6	0	0	0	14	0	0	0	0	0	0	0	19	0	0	0	0	0	0	0	109
01-Oct	5.25	1	0	35	22	0	1	0	2	0	1	0	8	0	0	0	0	0	0	0	9	0	0	0	0	0	0	1	80
02-Oct	5.92	2	0	15	4	0	0	0	6	0	0	0	6	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	37
03-Oct	0.00																												
04-Oct	8.08	1	0	43	33	0	0	0	2	0	0	0	10	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	97

Appendix F. continued

Date	Observ. Hours	Species[1]																										Total	Birds / Hour
		OS	NH	SS	CH	NG	SA	LA	UA	RS	BW	SW	RT	FH	ZT	UB	GE	BE	UE	AK	ML	PR	PG	SF	LF	UF	UU		
05-Oct	8.75	1	1	62	77	0	0	0	1	0	1	77	42	0	0	0	2	0	0	0	58	0	0	1	0	0	0	0	323
06-Oct	8.58	1	2	75	41	0	0	0	1	0	2	11	45	0	0	0	16	0	0	0	17	1	0	0	0	0	0	0	212
07-Oct	9.00	0	1	150	99	0	0	0	0	0	0	6	78	1	0	0	1	0	0	0	31	1	0	0	0	0	0	0	368
08-Oct	9.00	4	1	160	94	0	0	0	0	0	0	2	108	0	0	0	0	0	0	0	42	0	0	0	0	0	0	0	411
09-Oct	8.25	2	1	44	38	0	2	0	0	0	0	1	22	0	0	0	0	0	0	0	6	0	0	0	0	0	0	1	117
10-Oct	8.25	2	0	23	14	0	0	0	2	0	0	0	17	0	0	0	0	0	0	0	26	1	0	0	0	0	0	1	86
11-Oct	8.75	0	2	92	59	0	0	0	5	0	0	0	69	1	0	0	0	0	0	0	10	0	1	1	0	0	0	1	241
12-Oct	8.25	0	2	31	11	0	0	0	1	0	0	0	11	0	0	0	1	0	0	0	2	2	0	1	0	0	0	0	62
13-Oct	8.00	0	3	21	13	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	52
14-Oct	8.00	0	0	23	5	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	42
15-Oct	8.00	1	0	10	2	0	0	0	1	0	0	0	11	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	26
16-Oct	9.00	0	1	44	12	0	0	0	1	0	0	0	73	0	0	0	0	1	2	0	6	2	0	0	0	0	0	0	142
17-Oct	8.25	0	0	28	7	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	48
18-Oct	8.00	0	1	31	6	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	53
19-Oct	8.00	0	1	23	6	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	1	0	0	2	0	0	0	0	53
20-Oct	8.17	0	1	57	17	0	0	0	0	0	0	0	33	1	0	0	0	0	2	0	0	0	0	0	0	0	0	0	111
21-Oct	8.25	0	1	33	7	0	0	0	0	0	0	0	13	0	0	0	0	0	2	0	5	1	0	0	0	0	0	0	62
22-Oct	8.00	0	0	28	4	0	0	0	0	0	0	0	19	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	53
23-Oct	8.25	1	2	13	8	0	0	0	3	0	0	1	39	0	0	0	1	1	0	0	0	2	0	0	0	0	0	0	71
24-Oct	8.25	0	3	33	14	0	4	0	0	0	0	0	51	0	0	0	1	0	1	0	3	0	0	0	0	0	0	0	110
25-Oct	7.75	0	0	24	7	0	3	0	0	0	0	0	14	0	0	0	0	0	1	0	1	0	0	0	0	0	0	2	52
26-Oct	8.00	0	0	8	0	0	0	0	0	0	0	0	10	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	19
27-Oct	6.00	0	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
28-Oct	7.75	0	0	4	1	0	0	0	0	0	0	0	14	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	20
29-Oct	5.00	0	0	0	0	0	0	0	1	0	0	0	3	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	5
30-Oct	3.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31-Oct	5.00	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	0	0	1
01-Nov	7.00	1	0	3	0	0	0	0	0	0	0	0	17	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	23
02-Nov	5.00	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	3
03-Nov	4.00	0	0	0	1	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
04-Nov	6.50	0	0	3	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
05-Nov	5.00	0	1	10	0	0	0	0	0	0	0	0	10	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	22
Total	547.82	50	35	2323	1673	2	52	1	103	0	14	147	1264	6	0	0	42	11	14	0	943	17	5	7	0	0	1	23	6733

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

Appendix G. Annual observation effort and fall raptor migration counts by species at Lipan Point, Grand Canyon, AZ: 1991–2003.

YEAR	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	MEAN
Start date	8-Sep	1-Sep	31-Aug	1-Sep	1-Sep	27-Aug	27-Aug	27-Aug	27-Aug	27-Aug	27-Aug	27-Aug	27-Aug	28-Aug
End date	5-Nov	5-Nov	5-Nov	5-Nov	5-Nov	5-Nov	5-Nov	5-Nov	5-Nov	5-Nov	5-Nov	5-Nov	5-Nov	4-Nov
Days of observation	57	65	66	64	65	69	70	68	71	67	71	69	70	67
Hours of observation	399.66	513.50	504.50	482.92	492.54	508.84	522.19	505.18	546.70	511.54	575.08	557.72	535.58	512.00
Raptors / 100 hours	1231	1957	1249	1372	1369	1574	1331	1283	1152	1107	1008	901	1036	1275
SPECIES	RAPTOR COUNTS													
Osprey	26	72	73	73	77	99	135	115	72	88	83	58	75	80
Northern Harrier	43	131	64	111	121	111	93	81	130	99	39	51	56	87
Sharp-shinned Hawk	698	2472	1643	1802	1441	1680	1566	1366	1427	1449	1609	1455	1263	1529
Cooper's Hawk	1077	1673	1243	974	1052	1322	1332	1715	1515	968	1158	599	765	1184
Northern Goshawk	10	42	26	4	5	3	8	2	6	13	7	5	0	10
Unknown small accipiter[1]	-	-	-	-	-	-	-	-	-	-	98	197	31	109
Unknown large accipiter[1]	-	-	-	-	-	-	-	-	-	-	1	2	4	2
Unknown accipiter	360	337	199	200	243	423	213	243	185	252	0	46	47	211
TOTAL ACCIPITERS	2145	4524	3111	2980	2741	3428	3119	3326	3133	2682	2873	2304	2110	2960
Red-shouldered Hawk	0	1	0	0	0	1	0	0	0	0	0	0	0	<1
Broad-winged Hawk	0	3	7	2	7	2	7	35	11	15	25	20	6	11
Swainson's Hawk	6	24	25	33	34	57	32	31	40	22	26	33	108	36
Red-tailed Hawk	1194	3229	1613	1898	2299	2275	1704	1390	1401	1498	1458	1302	1791	1773
Ferruginous Hawk	8	15	7	11	3	6	7	6	7	6	3	2	6	7
Rough-legged Hawk	0	0	0	0	0	0	0	0	0	0	0	1	0	<1
Zone-tailed Hawk	0	0	0	0	0	0	1	1	0	0	0	1	2	0
Unidentified buteo	55	19	2	8	11	16	33	40	17	15	8	33	20	21
TOTAL BUTEOS	1263	3291	1654	1952	2354	2357	1784	1503	1476	1556	1520	1392	1933	1849
Golden Eagle	18	62	37	36	32	47	26	22	29	9	3	32	17	28
Bald Eagle	5	20	49	8	38	23	25	18	24	11	9	20	12	20
Unidentified eagle	0	0	3	0	0	0	0	1	4	0	0	3	0	1
TOTAL EAGLES	23	82	89	44	70	70	51	41	57	20	12	55	29	49
American Kestrel	1156	1508	1209	1273	1096	1631	1340	978	1218	1045	1180	1057	1300	1230
Merlin	7	14	12	10	12	8	24	12	13	9	8	4	9	11
Prairie Falcon	1	8	8	2	5	4	5	5	2	9	8	1	3	5
Peregrine Falcon	2	14	5	5	5	8	8	10	8	6	6	14	8	8
Unknown small falcon[1]	-	-	-	-	-	-	-	-	-	-	2	1	0	1
Unknown large falcon[1]	-	-	-	-	-	-	-	-	-	-	3	3	1	2
Unknown falcon	0	4	4	1	1	0	6	8	6	5	3	0	0	3
TOTAL FALCONS	1166	1548	1238	1291	1119	1651	1383	1013	1247	1074	1210	1080	1321	1257
Unknown raptor	106	124	24	66	48	60	97	96	107	48	60	83	23	72
GRAND TOTAL	4920	10048	6301	6625	6745	8008	6952	6479	6297	5664	5797	5023	5547	6493

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

Appendix H. Annual observation effort and fall raptor migration counts by species at Yaki Point, Grand Canyon, AZ: 1997–2003.

YEAR	1997	1998	1999	2000	2001	2002	2003	MEAN
Start date	27-Aug	28-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
Days of observation	71	66	71	66	71	71	70	69
Hours of observation	504.97	455.41	543.20	513.10	595.59	585.70	547.90	535.12
Raptors / 100 hours	938.3	907.5	997.8	1054.2	880.6	967.6	1228.9	986.3
SPECIES	RAPTOR COUNTS							
Osprey	50	43	28	43	34	57	50	44
Northern Harrier	50	44	56	41	31	45	35	43
Sharp-shinned Hawk	1474	1190	1906	1772	1792	1932	2323	1770
Cooper's Hawk	856	1109	1204	1256	1293	891	1673	1183
Northern Goshawk	4	7	1	9	11	6	2	6
Unknown small accipiter[1]	–	–	–	–	72	218	52	114
Unknown large accipiter[1]	–	–	–	–	0	3	1	1
Unknown accipiter	94	140	109	236	0	18	103	100
TOTAL ACCIPITERS	2428	2446	3220	3273	3168	3068	4154	3108
Red-shouldered Hawk	1	0	0	0	0	0	0	0
Broad-winged Hawk	9	19	14	6	11	8	14	12
Swainson's Hawk	15	25	32	10	19	16	147	38
Red-tailed Hawk	899	916	985	892	1008	1234	1264	1028
Ferruginous Hawk	8	7	11	10	6	6	6	8
Rough-legged Hawk	0	0	0	1	1	2	0	1
Zone-tailed Hawk	0	0	1	0	1	1	0	0
Unidentified buteo	20	20	13	8	8	43	42	22
TOTAL BUTEOS	952	987	1056	927	1054	1310	1473	1109
Golden Eagle	24	7	2	11	4	23	11	12
Bald Eagle	23	18	17	9	14	49	14	21
Unidentified eagle	1	0	1	0	0	1	0	0
TOTAL EAGLES	48	25	20	20	18	73	25	35
American Kestrel	1016	423	918	1035	881	1011	943	890
Merlin	14	12	14	5	22	5	17	13
Prairie Falcon	9	4	6	4	3	8	5	6
Peregrine Falcon	7	19	8	1	7	11	7	9
Unknown small falcon[1]	–	–	–	–	0	3	0	1
Unknown large falcon[1]	–	–	–	–	0	1	0	0
Unknown falcon	0	4	2	3	2	4	1	2
TOTAL FALCONS	1046	462	948	1048	915	1043	973	919
Unidentified raptor	20	38	16	10	25	71	23	29
GRAND TOTAL	4594	4045	5344	5362	5245	5667	6733	5284

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