FALL 2006 RAPTOR MIGRATION STUDIES IN THE GRAND CANYON OF ARIZONA

HawkWatch International, Inc.
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Report prepared by:

Jeff P. Smith and Mike C. Neal

Counts conducted by:

Sean Wolfe, Sumit Gurung, Thuy-Vy Bui, and Geni Gellhaus

On-site education by:

Emily Nelson and Kimberly Cullen

Project coordinated by:

HawkWatch International, Inc.

Principal Investigator: Dr. Jeff P. Smith

1800 South West Temple, Suite 226, Salt Lake City, Utah 84115

(801) 484-6808

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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 ranging from ~6,100–12,300 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 2006 season marked the 16th consecutive count at Lipan Point and the 10th consecutive full-season count at Yaki Point. This report summarizes the 2006 count results for both sites.

The Grand Canyon projects comprised 2 of 14 long-term, annual migration counts conducted or co-sponsored by HWI in North America during 2006. The primary objective of these efforts is to track long-term population trends of diurnal raptors in western North America and around the Gulf Coast (Smith et al. 2001, Hoffman and Smith 2003, Ruelas 2005, Lott 2006). 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 (Dunn and Hussell 1995, Zalles and Bildstein 2000, Hoffman and Smith 2003, Bildstein 2006, Farmer et al. 2007).

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 along the south rim of the Grand Canyon at an elevation of 2,243 m (36° 01′ 59.2″ N, 111° 51′ 11.5″ W; Figure 1). 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 along the south rim of the Grand Canyon ~22 km west of Lipan Point at an elevation of 2,213 m (36° 03′ 31.0″ N, 112° 05′ 01.7″ W; Figure 1). 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 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, Bildstein 2006).

METHODS

Four official or designated observers, assisted occasionally by other local volunteers and frequently by on-site educators Emily Nelson and Kimberly Cullen, 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. Lead Observer Sean Wolfe had one previous season of migration counting experience with HWI in Oregon (see Appendix A for a complete history of observation participation). Official observer Sumit Gurung received pre-season training and had previously conducted migration counts in his home country of Nepal. Neither of the other official observers had previously conducted raptor migration counts, but Thuy-Vy Bui and both on-site educators attended pre-season training at HWI's headquarters. 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, we compare regression analyses of long-term (1991–2006) Lipan Point data, and of Yaki Point and combined-site data from 1997–2006. In comparing 2006 annual statistics against means and 95% confidence intervals for previous seasons, we equate significance ($P \leq 0.05$) with a 2006 value falling outside the bounds of the confidence interval for the associated mean.

RESULTS AND DISCUSSION

WEATHER SUMMARY

In 2006, the numbers of observation days entirely precluded or severely hampered (i.e., reduced to ≤4 hours observation) by inclement weather were near average at both sites: 2 days affected at Lipan Point and 0 days at Yaki Point, compared to 1997–2005 averages of 1.8 and 1.9 days, respectively (see Appendixes C and D for daily weather records from the two sites). Both sites featured slightly below-average proportions of active observation days where predominantly fair skies prevailed (47% at Lipan Point and 45% at Yaki Point, compared to 1997–2005 averages of 53% and 52%, respectively), slightly above average proportions of days where transitional skies prevailed (i.e., cloud cover changed during the day from fair skies to mostly cloudy or overcast skies, or vice versa; 34% vs. average of 29% at Lipan, 34% vs. average of 28% at Yaki), and near average proportions of days where mostly cloudy to overcast skies prevailed (20% vs. average of 17% at Lipan, 20% vs. average of 19% at Yaki). Unlike last year, visibility reducing fog and haze, primarily from smoke and dust, hampered observations more than usual at both sites. At Lipan Point, 68% of the active observation days featured appreciable visibility reducing fog and haze, compared to the 1997–2005 average of 28%. At Yaki Point, the comparative proportions were 70% and 25%. In contrast, rain and snow showers occurred about as often as usual. At Lipan Point, 17% of the active observation days featured some rain or snow (average 18%), at Yaki Point 20% (average 16%).

The 2006 temperature regimes at both sites also nearly matched the long-term averages. The average daily temperature (average of daily values, which in turn were averages of hourly readings) at Lipan Point during active observation periods was 18.0°C (1997–2005 average of 18.8°C). At Yaki Point, the 2006 value was 17.3°C (average 17.6°C). At both sites the daily-average minimums were in the range of normal variability, while the maximums ranked near record high values.

At Lipan Point there was a shift toward moderate winds in 2006 (the opposite of last year), with light winds (<12 kph) prevailing on 75%, moderate winds on 24%, and stronger winds (>29 kph) on 1% of the active observation days (1997–2005 averages of 82%, 14%, and 4% of days, respectively). A slightly different pattern applied at Yaki Point, however. There the number of days where light winds prevailed was above average, matching the previous high of 86% (average 75%); the proportion of days where moderate winds prevailed dropped to 14% (average 21%); and, similar to last year, no days featured predominantly strong winds (average 6%).

In terms of wind directions, the pattern at Lipan Point differed slightly from the average pattern. Winds arising from the N–SE sectors were less common than usual: NE–SE winds 7% versus average of 18% of

the active days; no days where northerly winds predominated, average 4%. In contrast, winds arising from the S–NW sector and days where highly variable or a mix of calm/variable winds prevailed were more common than usual: SW–NW winds 30% of the active days, average 26%; S–W winds 25%, average 20%, variable winds 20%, average 10%; calm/variable winds 10%, average 7%. Periods of calm/variable winds also were much more commonly interspersed with otherwise predominant wind directions than usual. Somewhat the opposite pattern applied at Yaki Point, however, with NE–SE winds prevailing on an above-average 31% of the active observation days (average 23%) and northerly winds also slightly more common than usual. These kinds of differences clearly testify to the fact that local wind patterns can be highly variable along the canyon rim.

At both sites, the proportions of active observation days that received a median (of hourly ratings) thermal-lift rating of good to excellent were above average (68% vs. 58% at Lipan, 70% vs. 51% at Yaki).

In summary, compared to the last nine seasons, 2006 featured relatively more transitional or mixed skies; moderate winds at Lipan Point and but lighter than usual winds at Yaki Point; a shift in favor of more south to westerly and variable winds at Lipan Point, but a shift in favor of north to southeasterly winds at Yaki Point; average to slightly above average temperatures; and above-average thermal-lift conditions at both sites. In addition, contrasting markedly with last year but similar to several previous years in the past several, visibility reducing haze from dust and smoke were more common than usual.

OBSERVATION EFFORT

Counts occurred at both sites on all 71 possible days between 27 August and 5 November 2006 (see Appendices E and F for daily count records for each site). The number of observation days and hours (560.62; the hours during which counts occurred at one or both sites) were both within 2% of the respective 1997–2005 averages (70 ± 95% CI of 1.0 days and 568.68 ± 16.62 hours; see Appendices G and H for annual effort and count summaries for each site). The 2006 average of 4.4 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 8% above the 1997–2005 average of 4.1 ± 0.17 observers/hour.

MIGRATION SUMMARY

The observers tallied 7,735 migrant raptors of 16 species at the two count sites in 2006 (Table 1), with 47% recorded at Lipan Point and 53% at Yaki Point. The total combined-site count was 25% below the 1997–2005 average. The three lowest counts recorded at Lipan Point since 1991 occurred in the last three years, while the 2005 and 2006 counts at Yaki Point ranked first and third lowest, respectively, for that site since 1997 (Appendix G). The 2006 Lipan Point count was 40% below the 1997–2005 average and 39% below the 1991–2005 average for that site, whereas the 2006 Yaki Point count was only 17% below the 1997–2005 average for that site. Before 2002, counts at Lipan Point had always exceeded those at Yaki Point, but a distinct shift in relative abundance at the two sites has occurred since simultaneous counts began in 1997. Moreover, this was third time (the first in 2005) that the combined-site count was substantially below average, suggesting that the east-to-west flight line shift that has been developing since 1997 may have finally shifted farther west than either of our two count sites. Reasons for this pattern are yet uncertain, but may reflect some combination of increased fire prevalence in the past several years on the Kaibab Plateau north of the canyon and shifting dynamics due to the widespread drought that plagued much of the interior west after 1998. Counts also have been well below average for five years in a row farther north in the Intermountain Flyway at the Goshute Mountains, Nevada (Hoffman and Smith 2003, Smith and Neal 2007).

Compositional Patterns

The combined-site flight was composed of 52% accipiters, 25% buteos, 10% falcons, and ~1% or less each of ospreys, harriers, eagles, and unidentified raptors. The proportions of accipiters and buteos were significantly above average, while the proportions of falcons and Ospreys were significantly below average. Yaki Point attracted proportionately more accipiters (60% vs. 50%), Lipan Point attracted more buteos (37% vs. 22%), and the relative abundance of all other species was similar at the two sites (Figure 2). This is a typical pattern; however, in 2006, although the proportional representation of falcons declined similarly at both sites, the relative abundance of Ospreys was below average only at Lipan Point. In addition, the relative abundance of accipiters shifted steadily from roughly 60% of the combined-site total at Lipan Point in 1997/1998 to only 33% in 2004, but then bounced back a bit in 2005 and again 2006 (42%). The typical compositional 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 abundance of accipiters at the two sites over the past 10 years suggests that other factors are influencing the flight paths of migrating accipiters across the canyon.

One possibility is that habitat change on the Kaibab Plateau caused by extensive wildfires has caused the forest-dwelling accipiters to alter their pathways across this landscape. However, between the late 1990s and 2004 at Lipan Point, a distinct shift towards increasing prevalence of relatively steady SW–W winds, as opposed to more variable SW–NW, occurred. 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. 2002). Future detailed analyses of count trends at both sites in relation to weather and other landscape variables should clarify the situation.

The second possibility is that widespread drought extending throughout much of the Intermountain region, especially from 1999–2004, caused many Intermountain migrants to shift their migration routes away from the already xeric Great Basin in favor of passage along the relatively mesic Sierra–Cascade range to the west or Rocky Mountains to the east.

Count and Passage Rate Trends

As usual, Sharp-shinned Hawks, Cooper's Hawks, Red-tailed Hawks, and American Kestrels were by far the most abundant species at both sites (Table 1, Appendices G and H). Combined-site counts fell to record lows for Ospreys (70, second year in a row), Golden Eagles (6), and American Kestrels (692, second year in a row), and ranked as the second lowest for Cooper's Hawks (1121). No record-high counts occurred in 2006. Combined-site, adjusted passage rates were significantly below average for 8 of 15 commonly encountered species, and were significantly above average only for Northern Goshawks and Prairie and Peregrine Falcons (Table 1).

Ten years is a minimal period from which to derive robust assessments of long-term, combined-site trends; however, examination of 16-year trends at Lipan Point in comparison to shorter-term combined-site and Yaki Point trends is instructive. Regression analyses of adjusted passage rates at Lipan Point from 1991–2006 indicated at least marginally significant ($P \leq 0.10$) linear or quadratic (second-order) trends for 10 of 15 commonly encountered species, with long-term or at least post mid-1990s declines indicated for 7 species and long-term increase indicated for 3 species (Figures 3–7). Regression analyses for the period 1997–2006 indicated similar, at least marginally significant, combined-site trends for six of these species, in all cases reflecting declining trends since the late 1990s (Ospreys, Northern Harriers, Cooper's Hawks, Ferruginous Hawks, Golden Eagles, and American Kestrels; Figures 3–7).

The lowest passage rate to date for Sharp-shinned Hawks at Lipan Point occurred in 1991, but that was followed by the highest passage rate to date in 1992 (Figure 4). Between 1992 and 2005, passage rates

for this species at Lipan Point declined steadily, dropping to the second and third lowest rates in 2004 and 2005, respectively, before bouncing back up to moderate levels in 2006. In contrast, Sharp-shinned Hawk passage rates increased significantly at Yaki Point between 1997 and 2003, but then also dropped to a record low level there by 2005 before again bouncing back up to moderate levels in 2006. The combined-site data for 1997–2006 showed essentially the same pattern as at Yaki Point, which with the modest rebound in 2006 resulted in no significant overall trend for the past decade. A similar scenario applies to Red-tailed Hawks (Figure 5), which also showed a long-term (1991–2006) decline at Lipan Point alone, but a relatively stable combined-site pattern and no significant trend from 1997–2006. Ospreys, Cooper's Hawks, Golden Eagles, and American Kestrels also showed at least post-1998 declines at Lipan Point alone but no significant trend at Yaki Point alone; however, for these species the combined-site trend mimicked the indication of significant declines at Lipan Point (Figure 3, 4, 6, and 7). For Northern Harriers and Ferruginous Hawks, all three datasets showed significant declines at least since the late 1990s (Figures 5 and 7). For Merlins, neither of the single-site datasets showed a significant trend, but the combined-site dataset indicated a marginally significant decline since 1997 (Figure 7). In contrast, Broad-winged and Swainson's Hawks (Figure 5) and Peregrine Falcons (Figure 7) showed significant long-term increases at Lipan Point alone, but neither the Yaki Point nor combined-site datasets showed significant trends. Conversely, no significant trends were shown in the two single-site datasets for Prairie Falcons, whereas a marginally significant quadratic trend fit the combined-site data, tracking a mostly stable to slight declining pattern through 2003, then an increasing pattern for the next three years culminating in a record-high passage rate in 2006 (Figure 7). Finally, the only two species that showed no significant trends based on any of the three datasets were the Northern Goshawk (Figure 4) and Bald Eagle (Figure 6).

Age Ratios

At the combined-site level, 6 of 10 species with readily distinguishable age classes, and for which the 2006 counts were high enough to warrant some attention to age ratios, showed significant variation in immature: adult ratios compared to 1997–2005 averages (Table 2). The age ratios for all three relevant buteos (Broad-winged, Red-tailed, and Ferruginous Hawks) were significantly below average, whereas ratios were significantly above average for Northern Harriers, Northern Goshawks, and Peregrine Falcons. The low age ratios for Broad-winged and Ferruginous Hawks were primarily due to relative reductions in the abundance of immature birds, suggesting possible productivity declines; however, small sample sizes confound this comparison. For Red-tailed Hawks, the low age ratio was driven primarily by a substantial increase in the abundance of identified adults, although the abundance of immatures also was slightly below average. Similarly, the high age ratios indicated for harriers, goshawks, and peregrines primarily reflected proportional reductions in the abundance of adults rather than noteworthy increases in immature birds. Note also that significant variation in proportions of unaged birds compared to the long-term averages confounds these comparisons for several species.

Seasonal Timing

Based on combined-site data, the overall combined-species median passage date of 30 September 2006 matched the 1997–2005 average (Table 3). Examination of the seasonal distribution of activity revealed several five-day periods in which relative flight volume differed significantly from the average pattern, but no clear overall early or late shift in the activity pattern was apparent (Figure 8). At the species level, however, 5 of 15 species with data sufficient for comparisons showed significantly later than average median passage dates (Northern Harrier, Red-tailed Hawk, Ferruginous Hawk, Bald Eagle, and American Kestrel) and three species showed significantly early timing (Northern Goshawk, Golden Eagle and Merlin; Table 3). In all cases except for Red-tailed Hawks, the significant variations in median dates reflected unusually large spikes in relative activity levels during one or two five-day periods, rather than distinct overall early or late shifts in the seasonal activity patterns. Median passage dates for both adult and immature Red-tailed Hawks indicated an overall late shift in seasonal activity patterns (Table 3).

Age-specific median passage dates for other species revealed additional detail, but generally reflected the same basic patterns as the species-level data (Table 4).

RESIDENT RAPTORS

Local Turkey Vultures were observed at Lipan Point regularly through mid-October, usually in groups of 3–10 individuals. Through mid-September they were routinely the first and last birds observed for the day. Groups were often composed of both adults and immatures. California Condors were rarely spotted from Lipan Point, with only four sightings, usually at midday and overhead.

Resident Cooper's Hawks at Lipan Point included an unknown-age individual seen several times hunting and perching in the nearby canyon and woods, which was last seen on 28 September. An unknown-age Sharp-shinned Hawk also was observed on several occasions and was last seen on 25 September.

Local Red-tailed Hawks were observed at Lipan Point on most days until the end of the season. These included three light-morph adults and one light-morph immature bird, likely comprising one family group and a floater. The immature bird was last spotted on 28 September. At least one adult and one unknown-age Zone-tailed Hawk resided around Lipan Point. Often, the adult was observed in the morning calling above Navajo Point, and was observed capturing a small mammal on one occasion. On another occasion, the two individuals were observed talon grappling. They were last seen on 21 September.

At least one pair of American Kestrels resided around Lipan Point, last spotted in mid-September. At least one unknown age Peregrine Falcon resided near Lipan Point, and was often seen flying north through the canyon or overhead. The last sighting of a local peregrine was on 27 September.

At Yaki Point, local Turkey Vultures were seen regularly, with large groups seen in early September circling above both Yaki and Mather Points. The group sightings became less common as the season progressed and the last individual was seen on 11 October. California Condors were seen nearly every day early in the season and may have roosted south of the observation point on a few occasions. Sightings were less common late in the season, but some birds were occasionally spotted in early November. Most of the individuals were tagged with wing markers; # 19 was the most commonly sighted individual, but others sighted include: 16, 8, 23, 97, 87, 41, 75, 0, 37, A9, 36, 50, A3, 6, 4, 72, 34, 80, and 22.

At least one immature Cooper's Hawk was seen regularly displaying resident behavior around Yaki Point until 10 October. One adult and one immature Sharp-shinned Hawk also were frequently seen in the area, flying north or circling over the trees west of observation until mid-September.

Like at Lipan Point, light-morph Red-tailed Hawks were seen almost daily throughout the season at Yaki Point. An apparent family group was occasionally observed together, most likely consisting of two adults and one immature bird. The immature bird was spotted infrequently at the beginning of the season and was last observed on 12 September. The adults were commonly seen circling to the north, hunting over the trees to the south, or escorting migrants. At least one adult was still in the area at the end of the season. Zone-tailed Hawks apparently nested in the same site as previous years, just below Yaki Point. Adults and an immature bird were seen regularly at the point until 19 September. A possible local, immature Golden Eagle was seen on 10 October flying north past Yaki Point and down into the canyon.

Local Peregrine Falcons were seen regularly around Yaki Point, often flying around the bowl west of the count site for as much as an hour and then going back into the canyon. Two adults were seen at different times, with the adults seen together only a few times. Occasionally these birds were observed harassing migrants and were in the area until the end of the season.

These resident assemblages are fairly typical for the sites, except that before 2003 immature Northern Goshawks were often seen around Yaki Point.

VISITOR PARTICIPATION

HWI educators conducted 103 organized education programs most days at both Lipan and Yaki Points in close coordination with personnel of Grand Canyon National Park. These programs reached 1,373 people, with 1,207 individuals formally recorded on HWI visitor logs during the season. Visitors originated in 45 states and Washington, DC, several Canadian provinces, and 29 other foreign countries: Spain, England, Scotland, Wales, Germany, Israel, Holland, Japan, Ireland, Poland, Italy, Russia, Costa Rica, Austria, Belgium, Australia, Mexico, Switzerland, Brazil, Argentina, Ukraine, Indonesia, New Zealand, India, Denmark, South Africa, France, China, Vietnam. Six organized groups visited the sites in 2006, from Grand Canyon Middle School, Prescott Audubon, Northern Arizona Audubon, Rocky Ridge School, and the elder hostel of Yavapai Community College.

In 2006 at Lipan Point, 543 hourly assessments of visitor disturbance resulted in the following ratings: 97% none, 2% low, <1% moderate, and 0% high. At Yaki Point, 542 hourly assessments of visitor disturbance resulted in the following ratings: 96% none, 4% low, <1% moderate, and 0% 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): 1997–2005 versus 2006.

SPECIES	COUNTS			RAPTORS / 100 HOURS		
	1997–2005[1]	2006	% CHANGE	1997–2005[1]	2006	% CHANGE
Osprey	124 ± 20.3	70	-44	29.1 ± 3.15	17.3	-41
Northern Harrier	111 ± 25.8	94	-16	22.0 ± 3.09	18.5	-16
Sharp-shinned Hawk	3012 ± 351.9	2782	-8	702.3 ± 40.37	682.7	-3
Cooper's Hawk	2045 ± 451.9	1121	-45	558.8 ± 71.03	324.8	-42
Northern Goshawk	11 ± 4.0	18	+71	1.9 ± 0.39	3.6	+87
Unknown small accipiter	217.4 ± 106.9	254	+17	–	–	–
Unknown large accipiter	3.6 ± 2.1	13	+261	–	–	–
Unknown accipiter	210 ± 109.0	98	-53	–	–	–
TOTAL ACCIPITERS	5401 ± 706.4	4286	-21	–	–	–
Red-shouldered Hawk	0.1 ± 0.22	0	-100	–	–	–
Broad-winged Hawk	25 ± 8.7	27	+7	13.5 ± 2.73	16.2	+20
Swainson's Hawk	93 ± 48.6	52	-44	28.4 ± 8.58	15.7	-45
Red-tailed Hawk	2358 ± 296.6	2202	-7	487.9 ± 35.67	482.1	-1
Ferruginous Hawk	11 ± 3.3	8	-28	2.3 ± 0.42	1.7	-26
Rough-legged Hawk	0.6 ± 0.66	1	+80	–	–	–
Zone-tailed Hawk	1 ± 0.5	0	-100	–	–	–
Unidentified buteo	45 ± 14.1	141	+213	–	–	–
TOTAL BUTEOS	2534 ± 314.3	2431	-4	–	–	–
Golden Eagle	27 ± 11.1	6	-78	5.1 ± 1.25	1.2	-77
Bald Eagle	36 ± 10.1	33	-8	8.3 ± 1.34	9.1	+10
Unidentified eagle	1 ± 1.3	0	-100	–	–	
TOTAL EAGLES	64 ± 21.2	39	-39	–	–	
American Kestrel	1906 ± 262.7	692	-64	493.1 ± 40.40	196.4	-60
Merlin	23 ± 6.2	11	-53	4.8 ± 0.77	2.6	-46
Prairie Falcon	11 ± 1.6	13	+21	2.0 ± 0.17	3.8	+87
Peregrine Falcon	17 ± 4.4	25	+46	3.4 ± 0.56	7.0	+105
Unknown small falcon	2 ± 1.4	34	+1600	–	–	–
Unknown large falcon	3 ± 1.8	18	+592	–	–	–
Unknown falcon	6 ± 2.1	9	+53	–	–	–
TOTAL FALCONS	1966 ± 261.5	802	-59	–	–	–
Unidentified Raptor	90 ± 28.3	13	-86	–	–	–
GRAND TOTAL	10290 ± 1229.4	7735	-25	–	–	–

[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): 1997–2005 versus 2006.

	Total and Age-classified Counts								Immature : Adult	
	1997–2005 Average			2006			% Unknown Age		Ratio	
Species	Total	Imm.	Adult	Total	Imm.	Adult	1997–2005[1]	2006	1997–2005[1]	2006
Northern Harrier	111	28	29	94	24	20	51 ± 6.0	53	1.0 ± 0.19	1.2
Sharp-shinned Hawk	3012	625	1099	2782	498	843	42 ± 9.6	52	0.6 ± 0.16	0.6
Cooper's Hawk	2045	471	618	1121	206	312	47 ± 8.7	54	0.8 ± 0.22	0.7
Northern Goshawk	11	5	3	18	3	0	25 ± 11.9	83	1.8 ± 1.11	3.0
Broad-winged Hawk	25	7	10	27	1	3	25 ± 10.6	85	0.8 ± 0.22	0.3
Red-tailed Hawk	2358	318	1399	2202	290	1723	27 ± 4.2	9	0.2 ± 0.07	0.2
Ferruginous Hawk	11	3	4	8	1	3	39 ± 11.8	50	0.7 ± 0.31	0.3
Golden Eagle	27	8	10	6	4	2	34 ± 7.0	0	1.6 ± 1.16	2.0
Bald Eagle	36	7	25	33	8	25	9 ± 4.7	0	0.3 ± 0.03	0.3
Peregrine Falcon	17	3	8	25	4	4	42 ± 12.9	68	0.3 ± 0.19	1.0

[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 2006 and 1997–2005 average median passage dates (Lipan Point and Yaki Point data combined).

	2006				1997–2005
Species	First Observed	Last Observed	Bulk Passage Dates [1]	Median Passage Date [2]	Median Passage Date [3]
Osprey	27-Aug	7-Oct	15-Sep – 4-Oct	19-Sep	19-Sep ± 1.9
Northern Harrier	27-Aug	5-Nov	17-Sep – 27-Oct	10-Oct	6-Oct ± 2.1
Sharp-shinned Hawk	29-Aug	5-Nov	17-Sep – 19-Oct	2-Oct	1-Oct ± 1.3
Cooper's Hawk	27-Aug	3-Nov	17-Sep – 12-Oct	28-Sep	28-Sep ± 2.2
Northern Goshawk	7-Sep	26-Oct	8-Sep – 15-Oct	15-Sep	3-Oct ± 7.3
Broad-winged Hawk	17-Sep	9-Oct	17-Sep – 7-Oct	25-Sep	25-Sep ± 1.3
Swainson's Hawk	8-Sep	4-Nov	16-Sep – 7-Oct	26-Sep	23-Sep ± 4.9
Red-tailed Hawk	27-Aug	5-Nov	21-Sep – 26-Oct	11-Oct	8-Oct ± 2.1
Ferruginous Hawk	26-Sep	4-Nov	26-Sep – 4-Nov	21-Oct	10-Oct ± 5.5
Rough-legged Hawk	26-Oct	26-Oct	–	–	–
Golden Eagle	28-Sep	30-Oct	28-Sep – 30-Oct	10-Oct	16-Oct ± 6.4
Bald Eagle	18-Sep	4-Nov	13-Oct – 4-Nov	28-Oct	23-Oct ± 2.7
American Kestrel	27-Aug	30-Oct	14-Sep – 11-Oct	27-Sep	23-Sep ± 1.8
Merlin	16-Sep	4-Nov	16-Sep – 7-Oct	21-Sep	4-Oct ± 3.4
Prairie Falcon	30-Aug	4-Nov	2-Sep – 15-Oct	19-Sep	24-Sep ± 5.9
Peregrine Falcon	29-Aug	4-Nov	8-Sep – 7-Oct	20-Sep	25-Sep ± 6.0
All species	27-Aug	5-Nov	17-Sep – 20-Oct	30-Sep	30-Sep ± 1.7

[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): 1997–2005 versus 2006.

	ADULT		IMMATURE / SUBADULT	
SPECIES	1997–2005[1]	2006	1997–2005[1]	2006
Northern Harrier	11-Oct ± 3.5	10-Oct	4-Oct ± 4.3	10-Oct
Sharp-shinned Hawk	7-Oct ± 0.8	6-Oct	25-Sep ± 1.6	27-Sep
Cooper's Hawk	1-Oct ± 2.3	28-Sep	25-Sep ± 1.7	27-Sep
Red-tailed Hawk	8-Oct ± 1.7	11-Oct	1-Oct ± 3.3	8-Oct
Bald Eagle	23-Oct ± 2.8	29-Oct	22-Oct ± 3.8	21-Oct

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.

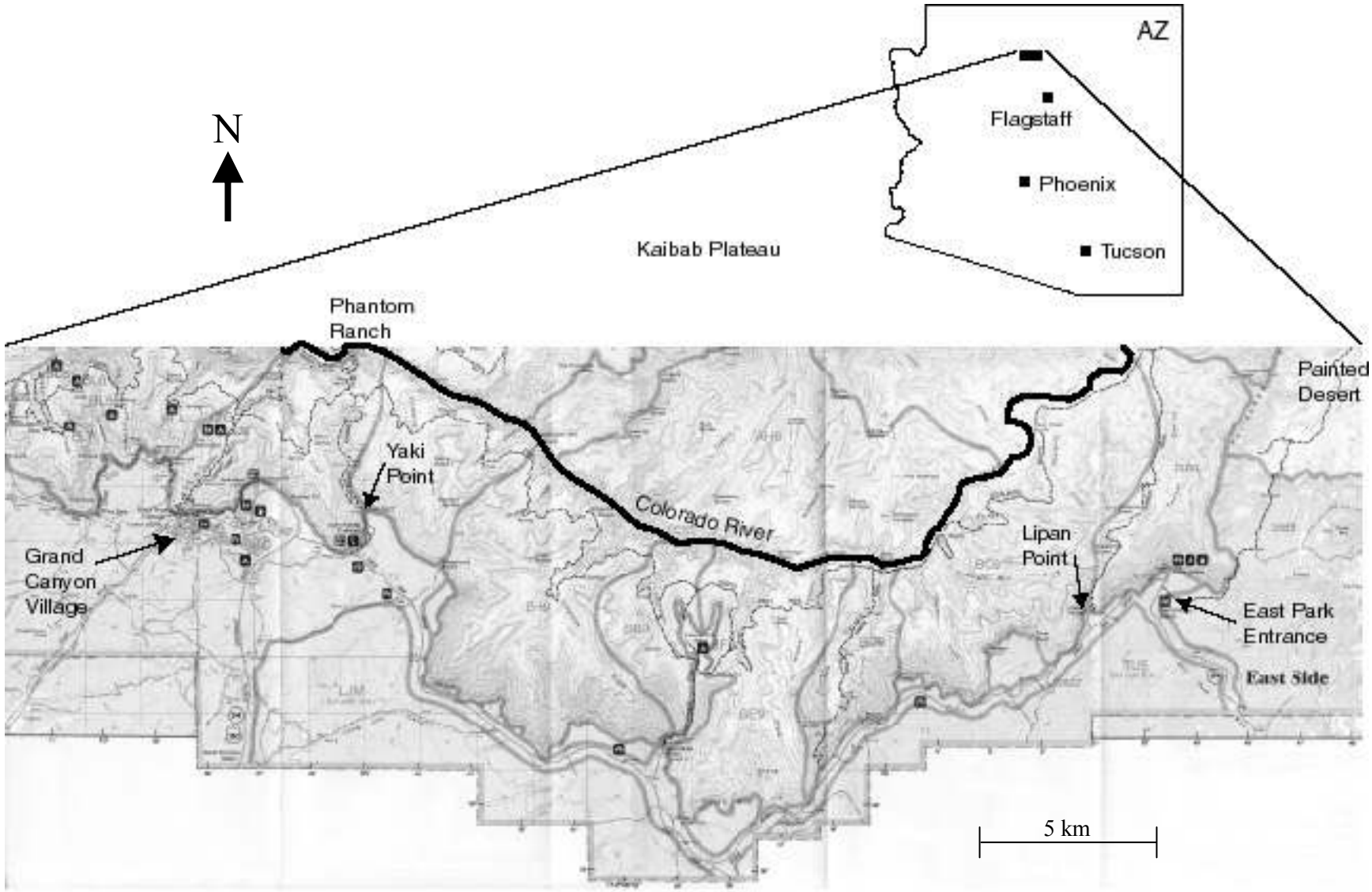

Figure 1. Map showing the Lipan Point and Yaki Point raptor-migration study sites in the Grand Canyon, Arizona.

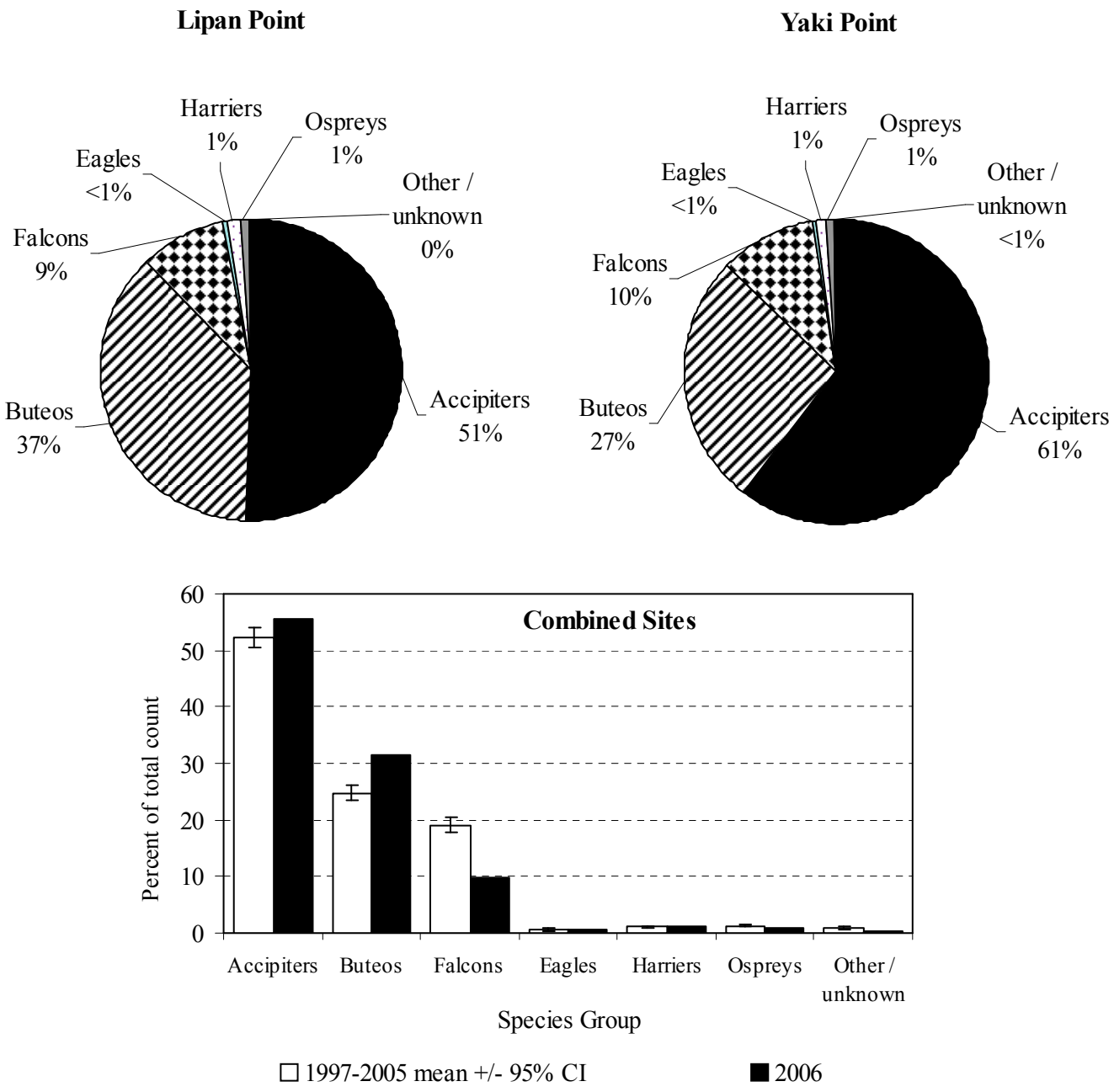

Figure 2. Fall raptor-migration flight composition by major species groups in the Grand Canyon, AZ: 1997–2005 versus 2006.

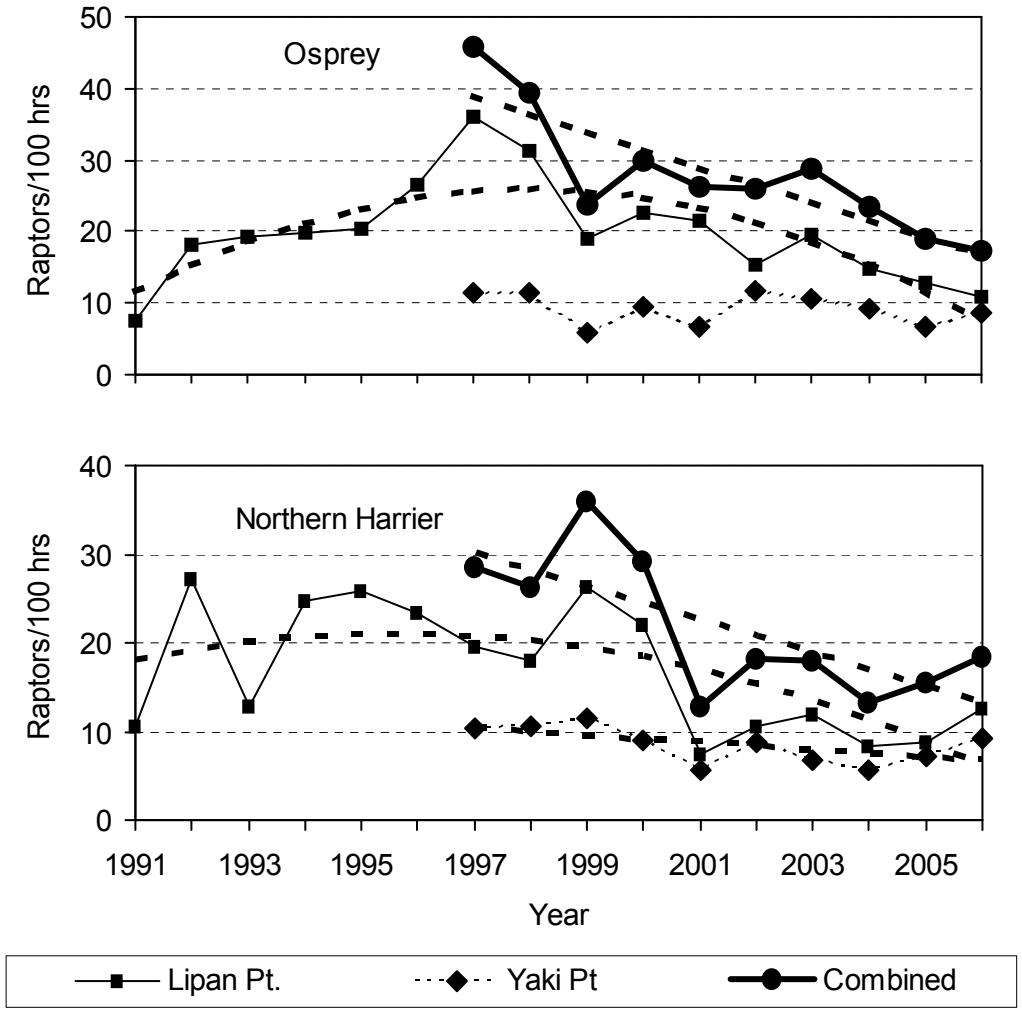

Figure 3. Adjusted (truncated to standardized annual sampling periods and adjusted for incompletely identified birds) fall-migration passage rates for Ospreys and Northern Harriers in the Grand Canyon, AZ: 1991–2006. Dashed lines indicate significant ($P \leq 0.10$) linear or quadratic regressions.

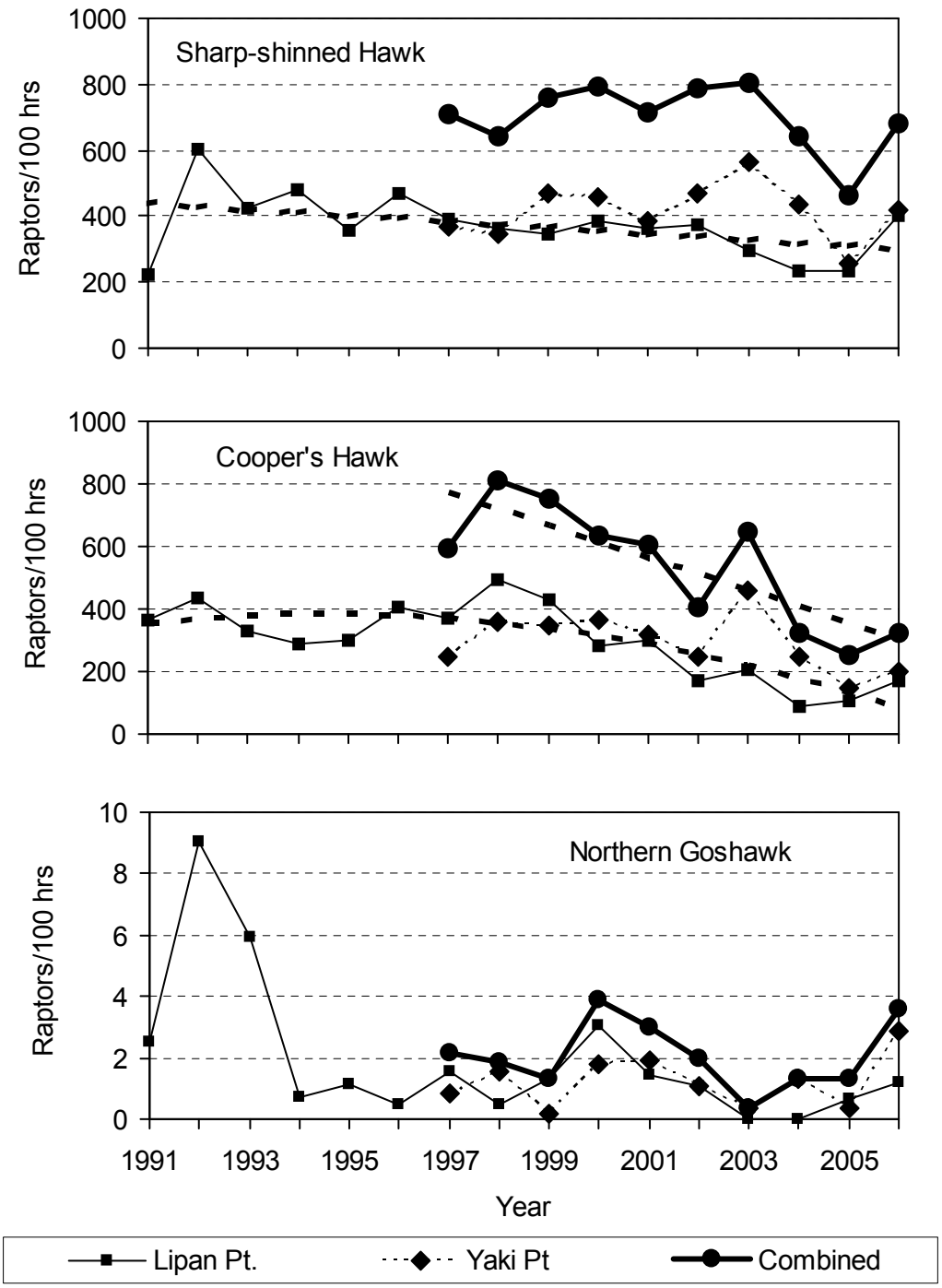

Figure 4. Adjusted (truncated to standardized annual sampling periods and adjusted for incompletely identified birds) fall-migration passage rates for Sharp-shinned Hawks, Cooper's Hawks, and Northern Goshawks in the Grand Canyon, AZ: 1991–2006. Dashed lines indicate significant ($P \leq 0.10$) linear or quadratic regressions.

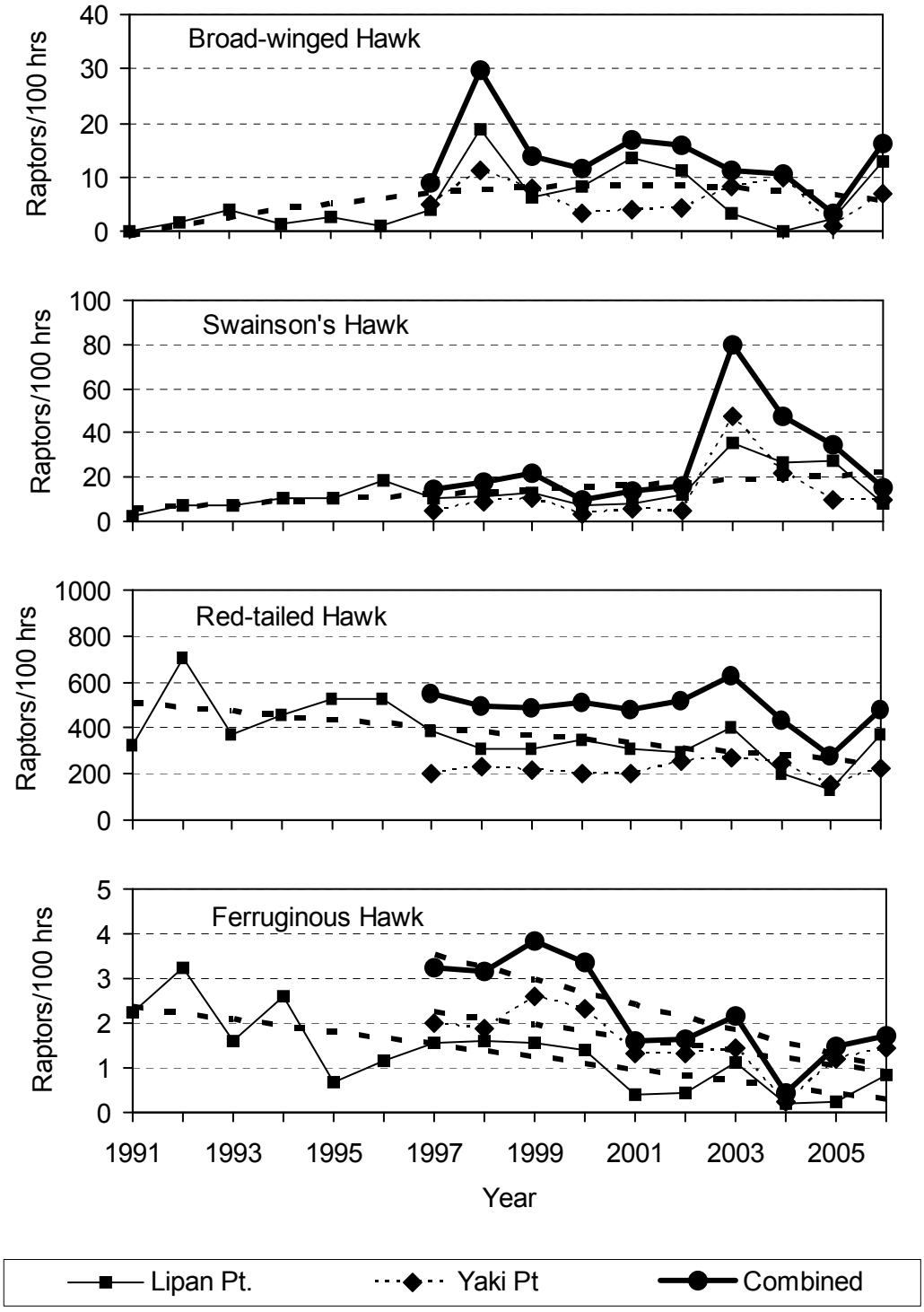

Figure 5. Adjusted (truncated to standardized annual sampling periods and adjusted for incompletely identified birds) fall-migration passage rates for Broad-winged, Swainson's, Red-tailed, and Ferruginous Hawks in the Grand Canyon, AZ: 1991–2006. Dashed lines indicate significant ($P \leq 0.10$) linear or quadratic regressions.

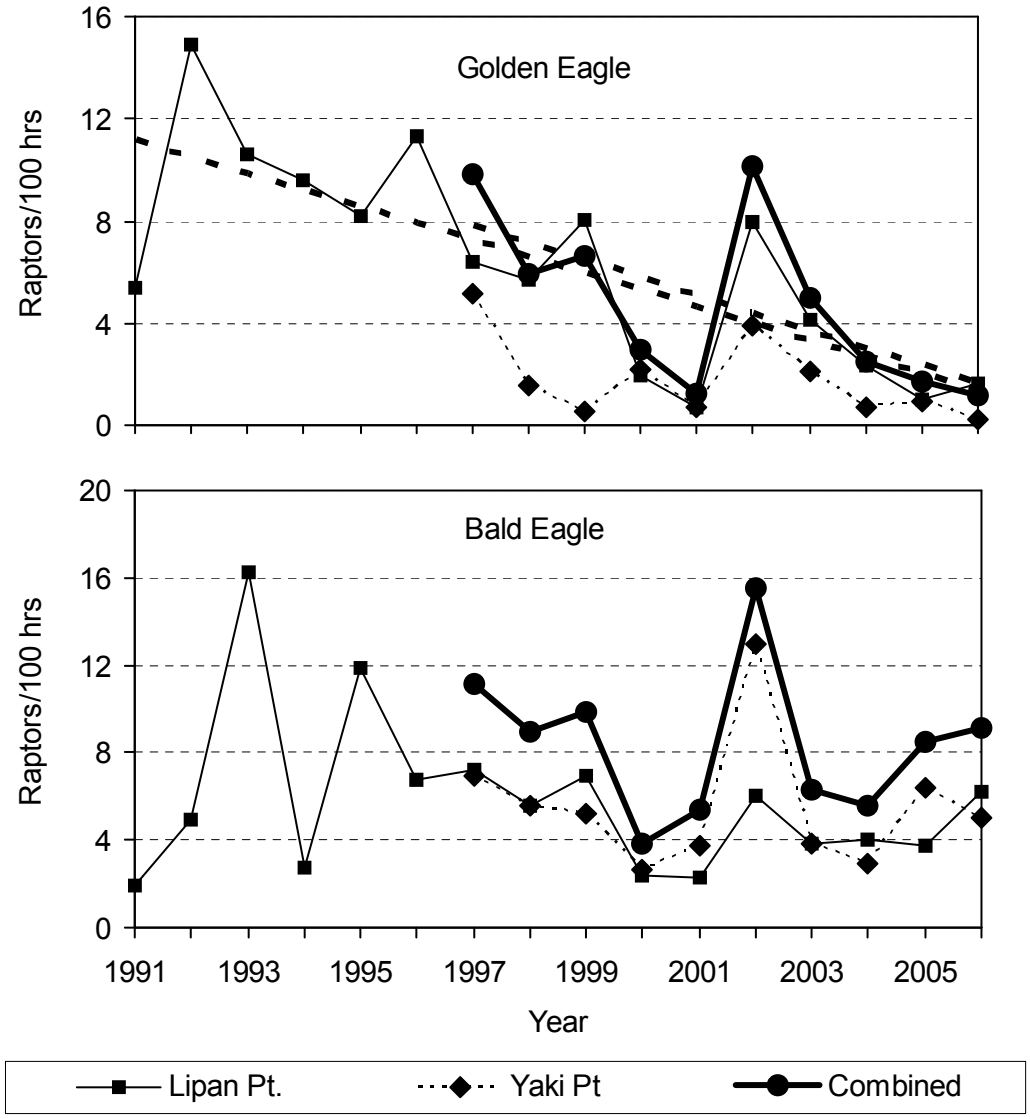

Figure 6. Adjusted (truncated to standardized annual sampling periods and adjusted for incompletely identified birds) fall-migration passage rates for Golden and Bald Eagles in the Grand Canyon, AZ: 1991–2006. Dashed lines indicate significant ($P \leq 0.10$) linear or quadratic regressions.

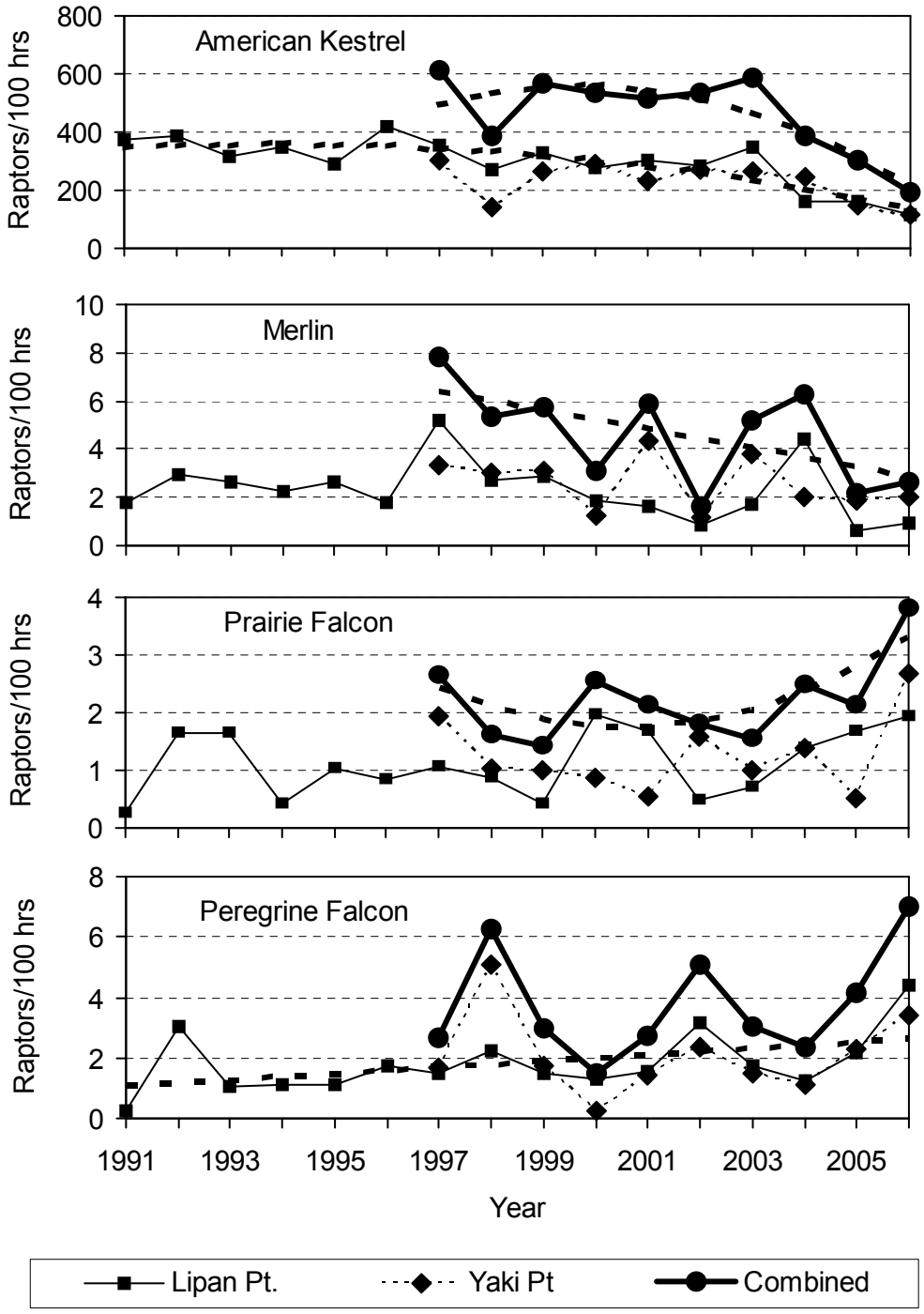

Figure 7. Adjusted (truncated to standardized annual sampling periods and adjusted for incompletely identified birds) fall-migration passage rates for American Kestrels, Merlins, Prairie Falcons, and Peregrine Falcons in the Grand Canyon, AZ: 1991–2006. Dashed lines indicate significant ($P \leq 0.10$) linear or quadratic regressions.

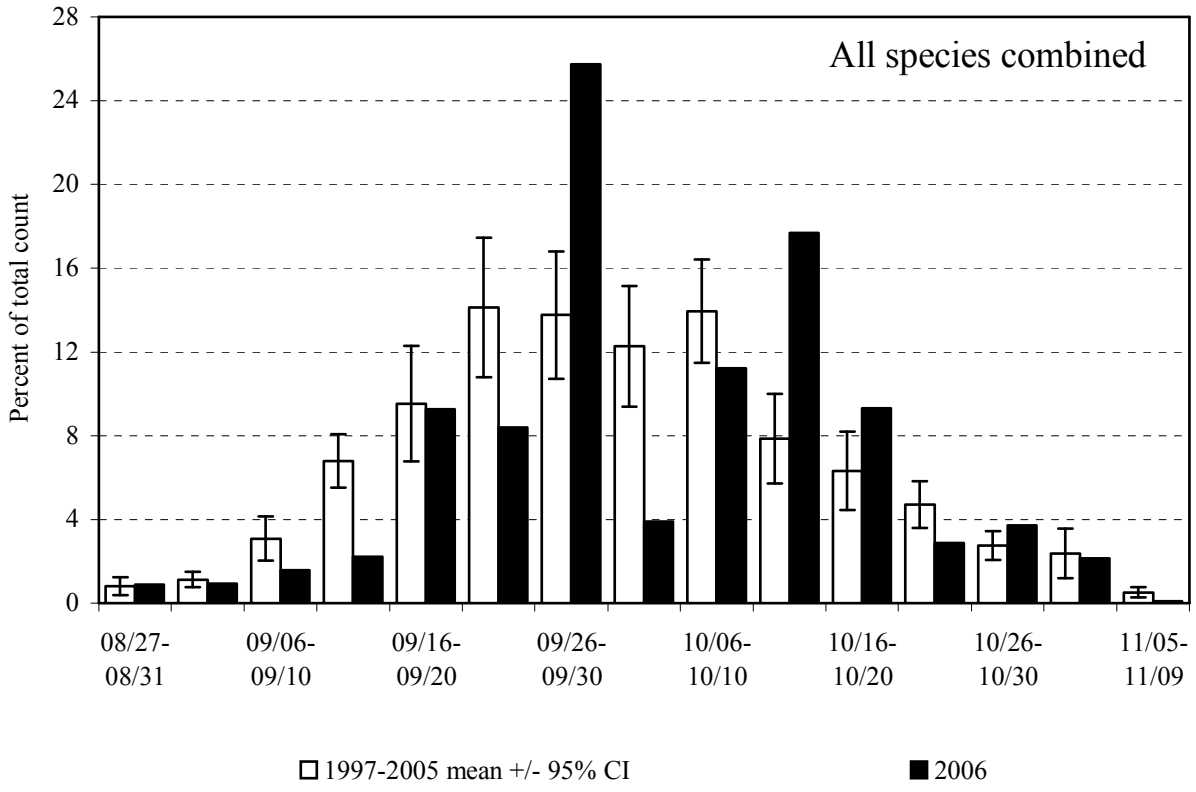

Figure 8. Combined-species, fall-migration passage volume by five-day periods for raptors in the Grand Canyon, AZ: 1997–2005 versus 2006 (Lipan Point and Yaki Point data combined).

Appendix A. History of official observer participation in the Grand Canyon raptor migration studies: 1991–2006.

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 (+).

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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: 2006.

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	7.00	2.0	0	clr, haze	4.1	e, w	32.0		1	90	92	3	1.7
28-Aug	6.50	2.0	0	clr, haze	3.0	e, s	24.1		1	30	30	2	0.6
29-Aug	6.75	2.0	0	clr-pc, PM haze	1.5	calm, wnw	25.5		1	90	98	2	1.0
30-Aug	7.50	2.0	0	pc, PM haze	4.1	w	24.7		2	30	30	3	0.8
31-Aug	2.50	2.0	0	pc-mc, ts	1.3	w	26.0		3	50	50	3	0.8
01-Sep	7.50	2.0	0	pc-mc, haze	2.0	ne, wsw	27.4	30.36	2	85	86	2	3.1
02-Sep	8.00	2.0	0	clr-mc, scat ts/rain	1.6	calm/var	26.6	30.35	1	90	96	2	1.0
03-Sep	8.00	2.5	0	clr-pc	1.6	calm, se, w	23.1	30.34	1	90	96	1	0.3
04-Sep	8.00	2.5	0	clr, haze	3.4	var	24.9	30.43	1	90	90	3	0.1
05-Sep	7.00	2.0	0	clr-pc	3.3	calm/var	24.9	30.53	1	50	50	2	0.7
06-Sep	6.25	1.0	0	clr-ovc, PM ts/rain	6.8	e, w	23.5	30.44	3	50	50	3	0.5
07-Sep	5.00	1.3	0	mc-ovc, haze, scat ts	2.0	var	20.4	29.93	3	80	80	2	0.4
08-Sep	7.50	2.3	0	clr-pc	11.2	w	20.4	30.20	2	50	50	2	1.9
09-Sep	8.00	2.8	0	pc-ovc, haze/scat rain	22.8	w	19.4	30.28	3	50	32	2	2.6
10-Sep	8.00	2.0	0	clr-mc, PM haze	1.6	calm, wsw, wnw	21.2	30.34	1	90	87	1	1.5
11-Sep	8.00	2.0	0	clr-pc	1.0	calm/var	23.7	30.41	1	50	50	3	1.9
12-Sep	8.00	1.5	0	clr, haze	2.7	calm/var	25.0	30.42	1	20	20	3	2.1
13-Sep	8.00	2.0	0	pc-ovc	2.5	var	24.8	30.27	2	30	29	3	3.1
14-Sep	3.75	2.8	0	pc-ovc, ts/rain	13.3	w	20.3	30.01	4	74	71	2	1.1
15-Sep	6.75	2.0	0	pc-mc	49.0	wsw	18.0	29.93	3	90	90	2	0.3
16-Sep	8.00	3.3	0	clr, haze	12.7	w	16.3	30.16	2	90	82	2	11.6
17-Sep	8.00	3.0	0	clr	4.2	calm, ne, w	19.7	30.28	1	90	82	2	4.9
18-Sep	8.00	2.0	0	clr	1.4	calm, e, w	21.7	30.34	1	90	87	2	3.8
19-Sep	8.00	2.7	0	clr	6.1	ne, w	22.0	30.30	1	90	85	3	3.6
20-Sep	8.00	3.0	0	clr-ovc	21.0	ne, w	17.4	30.02	3	90	81	2	3.1
21-Sep	8.00	3.9	0	pc-ovc, haze	20.0	sw, wsw	15.2	30.01	2	90	90	2	14.6
22-Sep	8.00	3.0	0	pc-ovc, haze	12.3	w	17.1	29.93	3	90	80	2	14.8
23-Sep	7.50	3.1	0	clr, haze	2.6	var	12.9	30.30	1	90	86	3	1.5
24-Sep	8.00	3.3	0	clr, PM haze	2.1	e, s	15.6	30.42	1	50	42	2	0.6
25-Sep	8.00	2.0	0	clr-pc	2.4	calm/var	20.2	30.42	1	90	88	3	9.6
26-Sep	9.00	2.8	0	clr-ovc, haze	4.9	ene, s, wsw	19.4	30.44	2	90	90	3	20.4
27-Sep	8.00	2.0	0	clr-mc, haze	6.4	s, w	23.0	30.45	2	27	42	2	12.0
28-Sep	8.00	2.9	0	clr-pc, haze	4.4	wnw	22.2	30.45	1	90	83	2	17.5
29-Sep	9.50	2.1	0	clr-pc	4.2	ne, w	25.7	30.37	1	90	87	2	17.8
30-Sep	8.28	3.1	0	clr-ovc	7.7	calm, wnw	25.9	30.33	1	90	86	3	22.3
01-Oct	8.00	3.0	0	mc-ovc	11.1	w	26.0	30.30	2	90	79	3	8.9
02-Oct	8.00	2.0	0	mc, haze	22.4	se, wnw	21.4	30.29	3	90	76	1	0.5
03-Oct	8.00	2.8	0	mc-ovc	4.2	w	23.3	30.36	2	90	88	2	4.1
04-Oct	8.00	2.0	0	ovc, PM haze	20.5	e, s, w	22.1	30.34	4	47	28	3	4.3
05-Oct	6.50	2.6	0	ovc, fog/rain/ts	8.1	ese, nw	17.6	30.28	4	90	71	1	0.6
06-Oct	6.00	2.0	0	mc-ovc, haze	25.1	sse	14.4	30.14	4	90	90	1	0.3

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
07-Oct	8.50	1.9	0	clr, haze	4.5	e, w	14.8		2	50	37	3	25.1
08-Oct	7.00	2.0	0	clr-mc, PM haze	0.9	calm, e, w	17.2	30.25	2	37	50	3	8.6
09-Oct	8.00	2.0	0	pc-ovc, scat rain	9.2	s, w	13.5	30.10	3	50	36	2	5.6
10-Oct	8.00	1.7	0	mc-ovc, haze	16.6	wsw	13.7	30.21	4	90	80	1	2.5
11-Oct	8.50	2.3	0	clr, haze	3.6	e, w	17.7	30.28	1	50	50	3	33.5
12-Oct	8.00	2.6	0	clr, haze	2.6	var	17.2	30.24	1	90	90	3	47.8
13-Oct	8.00	2.2	0	clr-ovc, PM rain	12.7	var	16.6	30.16	2	50	42	2	24.8
14-Oct	5.00	2.0	0	ovc, fog/rain	1.0	ese	10.7	29.92	4	0	0	-	0.2
15-Oct	8.00	2.8	0	pc-ovc, AM fog, PM haze	1.0	calm/var	10.3	29.95	3	90	79	2	11.4
16-Oct	8.00	2.9	0	clr-mc, PM haze	20.5	w	12.0	29.85	3	90	85	2	8.4
17-Oct	8.00	2.5	0	pc-ovc, AM fog/snow, PM haze	17.6	wnw	8.9	29.84	4	90	80	2	2.5
18-Oct	8.00	2.0	0	clr-pc, PM haze	2.6	var	9.4	30.21	2	50	49	2	4.6
19-Oct	8.00	1.9	0	clr, haze	2.3	n	8.7	30.29	1	90	90	3	17.1
20-Oct	8.00	2.2	0	clr, PM haze	13.4	w	12.3	30.09	2	90	85	2	18.3
21-Oct	8.00	2.5	0	clr, PM haze	2.1	var	11.9	30.28	1	50	50	2	4.0
22-Oct	7.00	2.0	0	clr, PM haze	2.3	var	12.9	30.37	1	50	40	2	1.9
23-Oct	8.00	2.0	0	clr, haze	5.0	ne, se	12.2	30.35	2	90	90	2	2.0
24-Oct	5.00	1.8	0	ovc, haze, rain	4.5	var	13.0	30.18	4	13	13	1	0.2
25-Oct	5.75	2.0	0	ovc, haze, rain	13.3	sw, nw	10.0	30.05	4	50	50	3	1.4
26-Oct	8.00	1.6	0	clr, PM haze	1.2	calm, w	5.8	30.40	2	90	85	1	2.5
27-Oct	7.50	2.0	0	clr, PM haze	7.0	var	12.3	30.59	1	50	50	2	1.5
28-Oct	8.00	2.6	0	pc-ovc	7.7	e, s	13.5	30.46	2	50	47	2	0.6
29-Oct	8.00	2.0	0	clr, PM haze	14.5	calm, w	13.6	30.13	2	90	85	2	2.1
30-Oct	8.00	2.0	0	clr, haze	21.9	w	12.6	30.08	3	90	85	2	8.8
31-Oct	8.00	1.7	0	pc-mc, haze	14.4	w	11.5	30.12	3	90	82	2	2.5
01-Nov	7.00	1.4	0	mc-ovc	0.0	calm, w	14.8	30.31	3	90	68	2	1.0
02-Nov	8.00	2.0	0	mc-ovc, haze	1.2	e, s, wsw	12.5	30.32	2	80	67	4	0.5
03-Nov	8.00	2.0	0	pc-ovc, haze	5.4	wsw, nw	13.9	30.33	2	90	90	3	2.0
04-Nov	8.00	2.9	0	clr-pc, haze	4.1	calm, w	12.0	30.26	1	90	85	1	2.8
05-Nov	4.50	2.0	0	ovc, haze	0.0	calm	14.3	30.37	2	50	50	2	1.6

[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: 2006.

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	7.75	1.9	0	clr	2.0	calm, sse, nnw	23.3	–	1	5	100	100	2
28-Aug	7.00	2.0	0	clr, haze	6.9	var	32.2	–	1	5	90	90	2
29-Aug	7.00	2.0	0	clr, PM haze	3.6	e, s	24.8	–	1	30	30	30	3
30-Aug	8.00	2.0	0	pc-mc, PM haze	2.0	calm/var	26.3	–	2	5	92	92	2
31-Aug	6.75	2.0	0	clr-ovc, AM haze, PM ts/rain	7.6	var	24.8	29.81	3	5	81	81	2
1-Sep	7.50	2.0	0	pc-mc, scat ts	2.6	calm, ese	26.1	29.93	1	5	95	95	2
2-Sep	7.50	2.4	0	clr-mc, haze	2.5	e, ese	26.2	29.91	1	5	90	90	–
3-Sep	7.50	2.5	0	clr-pc	3.6	calm, e, s	25.4	29.87	1	30	30	30	3
4-Sep	8.00	2.0	0	clr-pc	3.2	e, s	24.2	29.97	1	50	50	50	2
5-Sep	7.33	1.8	0	clr-mc	0.7	ene-se/var	29.0	30.06	1	1	89	89	2
6-Sep	8.00	1.9	0	mc-ovc	4.3	ne, nw	24.8	30.01	2	5	78	78	2
7-Sep	6.00	2.9	0	ovc, ts/rains	1.3	calm, se	20.6	29.79	3	5	87	87	2
8-Sep	8.00	3.5	0	clr-pc, PM haze	4.7	calm, se, nw	21.0	29.76	1	5	88	88	2
9-Sep	6.42	2.6	0	mc-ovc, haze	6.2	s, sw, nw	20.3	29.84	2	5	73	73	–
10-Sep	8.00	2.9	0	pc-mc	1.8	s	25.9	–	2	30	30	30	3
11-Sep	8.00	2.3	0	clr, PM haze	2.0	se, nw	22.2	29.96	1	5	90	90	2
12-Sep	8.00	2.5	0	clr, haze	3.2	ne, e, wsw	24.9	29.95	1	5	90	90	2
13-Sep	8.75	2.1	0	pc-ovc, PM haze/ts	2.9	calm, nw	22.7	29.81	2	5	80	80	2
14-Sep	4.50	2.0	0	pc-ovc, haze/PM rain	22.6	ssw	20.1	29.60	3	5	80	80	2
15-Sep	7.50	2.7	0	pc-mc	23.8	se	18.9	29.52	4	5	77	77	2
16-Sep	9.00	4.4	0	clr, haze	7.6	wsw	16.5	29.72	1	5	90	90	2
17-Sep	9.00	3.8	0	clr	3.1	s, wnw	16.8	29.84	1	50	50	50	2
18-Sep	8.00	3.3	0	clr, haze	4.7	var	19.2	29.90	2	50	50	50	2
19-Sep	8.00	2.4	0	clr, haze	9.2	s-w	20.1	29.83	2	5	90	90	2
20-Sep	8.00	2.7	0	pc-mc, haze	21.3	sw, nw	16.3	29.58	3	5	72	72	2
21-Sep	8.00	2.8	0	pc-mc	4.8	s, w, n	20.7	–	2	50	50	50	2
22-Sep	8.00	3.2	0	pc-mc	8.5	ne, e, sse	16.2	29.49	2	90	89	89	2
23-Sep	8.00	1.9	0	clr	3.3	e, n	13.9	29.84	1	50	50	50	3
24-Sep	8.00	4.3	0	clr, haze	7.7	nnw-ene	14.3	29.96	2	5	85	85	2
25-Sep	8.25	3.2	0	clr-pc, PM haze	6.7	e, n	20.1	29.96	1	50	50	50	2
26-Sep	8.50	2.5	0	clr-ovc	4.3	calm, nw	20.8	29.98	2	5	83	83	2
27-Sep	9.00	2.7	0	clr, haze	5.8	ne	21.0	29.99	2	5	90	90	3
28-Sep	9.00	2.6	0	clr-pc, haze	5.5	sw, w	20.1	29.99	1	5	90	90	2
29-Sep	9.00	3.0	0	pc	5.2	calm, wnw	21.2	29.92	2	5	84	84	2
30-Sep	8.00	4.1	0	clr-ovc, haze	5.2	var	20.5	29.88	2	5	90	90	–
1-Oct	8.00	2.7	0	mc-ovc, haze	9.6	ne, s	21.3	29.77	2	5	90	90	3
2-Oct	8.00	2.7	0	pc-ovc, haze	12.2	ssw	20.5	29.70	3	5	90	90	3
3-Oct	8.00	2.3	0	mc-ovc, PM rain	6.0	wnw	19.8	29.72	3	5	83	83	2
4-Oct	8.00	2.7	0	ovc	9.8	sse	23.3	29.71	3	90	90	90	2
5-Oct	4.00	2.0	0	ovc, fog/ts	1.0	sse	20.0	29.63	4	78	56	56	–
6-Oct	4.58	1.5	0	mc-ovc, scat fog/rain	10.3	sse, ssw	15.4	29.48	3	61	5	5	1
7-Oct	9.00	3.7	0	clr, haze	2.8	sse	12.5	29.59	1	5	90	90	2
8-Oct	8.00	3.8	0	clr-ovc, PM fog/rain/ts	3.1	ese, s	13.6	29.62	4	5	85	85	3
9-Oct	8.00	1.8	0	pc-ovc, rain	5.2	calm, sse, wnw	12.3	29.48	4	5	87	87	2
10-Oct	8.00	1.8	0	ovc, haze	8.3	s, sw	13.3	29.56	3	5	90	90	3
11-Oct	8.50	1.9	0	clr, haze	1.5	calm, wsw	13.2	29.65	1	5	85	85	2
12-Oct	8.00	2.2	0	clr, PM haze	1.2	calm, w	13.6	29.57	1	5	85	85	2
13-Oct	6.50	2.6	0	clr-ovc	2.8	calm, e, ssw	14.0	29.54	3	5	80	80	2
14-Oct	4.00	2.0	0	ovc, rain/PM fog	7.4	s	13.1	29.33	4	3	8	8	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]	Visib. West (km)[1]	Median Flight Distance[5]	Birds / Hour
15-Oct	7.50	1.6	0	clr-ovc, AM fog, PM haze	3.0	s	11.7	29.32	3	32	25	25	2
16-Oct	8.25	2.6	0	clr-pc, PM haze	19.5	var	11.6	29.23	3	50	39	39	2
17-Oct	7.00	2.0	0	ovc, haze/snow	16.0	ne, s	8.1	29.22	3	5	90	90	3
18-Oct	7.50	1.9	0	clr-pc, haze	2.6	ne	8.8	29.59	2	5	90	90	3
19-Oct	8.00	2.0	0	clr, PM haze	1.1	calm, se	7.4	29.65	1	5	87	87	2
20-Oct	8.50	1.7	0	clr, PM haze	13.9	w, n	11.1	29.47	2	50	49	49	2
21-Oct	8.00	2.0	0	clr, PM haze	4.6	calm, se	9.1	29.63	1	5	85	85	2
22-Oct	8.00	3.0	0	clr, haze	7.8	e, ese	9.9	29.72	2	5	90	90	2
23-Oct	8.00	1.6	0	clr-ovc	7.9	e, ese	12.9	29.70	2	59	33	33	2
24-Oct	4.50	2.0	0	ovc, rain/PM fog	2.2	calm, w	12.8	29.57	4	5	68	68	1
25-Oct	6.25	1.4	0	clr-ovc, fog/rain	15.9	s, w	9.6	29.42	4	4	29	29	2
26-Oct	8.25	2.4	0	clr, haze	2.4	ne, ese	5.3	29.71	1	5	82	82	3
27-Oct	8.00	2.1	0	clr, PM haze	9.0	e	8.4	29.92	2	5	85	85	2
28-Oct	8.00	3.4	0	clr-mc, PM haze	9.2	e	11.9	29.81	3	5	85	85	2
29-Oct	8.00	3.0	0	clr, haze	15.4	s	13.0	29.60	2	5	81	81	3
30-Oct	7.00	1.5	0	clr, haze	14.9	w	12.3	29.47	2	20	20	20	2
31-Oct	8.00	2.0	0	pc-mc, haze	13.5	se, s	9.8	29.51	2	5	80	80	3
1-Nov	7.50	1.9	0	mc-ovc, haze	0.6	calm	11.8	29.65	2	5	84	84	1
2-Nov	8.00	1.0	0	ovc, haze	0.0	calm	11.0	29.68	3	5	82	82	2
3-Nov	8.00	2.4	0	pc-ovc, PM haze	2.4	w	11.3	29.63	2	5	81	81	2
4-Nov	7.25	1.8	0	clr, PM haze	8.3	w	13.6	29.62	1	5	90	90	2

[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: 2006.

	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	7.00	2	1	0	1	0	1	0	0	0	0	0	5	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	12	1.7
28-Aug	6.50	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	4	0.6
29-Aug	6.75	0	0	1	0	0	0	0	0	0	0	0	3	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	7	1.0
30-Aug	7.50	0	1	1	2	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0.8
31-Aug	2.50	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0.8
1-Sep	7.50	1	0	2	0	0	1	0	3	0	0	0	4	0	0	0	3	0	0	0	8	0	0	0	0	0	1	0	23	3.1
2-Sep	8.00	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	1	0	0	0	0	0	1	0	0	0	0	2	8	1.0
3-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
4-Sep	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
5-Sep	7.00	0	1	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	5	0.7
6-Sep	6.25	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	3	0.5
7-Sep	5.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2	0.4
8-Sep	7.50	0	0	4	5	0	0	0	0	0	0	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	1.9
9-Sep	8.00	0	0	12	2	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	21	2.6
10-Sep	8.00	0	0	3	3	0	2	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	12	1.5
11-Sep	8.00	1	0	5	2	0	0	1	2	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	15	1.9
12-Sep	8.00	2	1	5	2	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	1	0	2	0	0	0	0	0	17	2.1
13-Sep	8.00	0	0	8	5	1	0	2	0	0	0	0	2	0	0	0	1	0	0	0	5	0	0	0	1	0	0	0	25	3.1
14-Sep	3.75	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	4	1.1
15-Sep	6.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2	0.3
16-Sep	8.00	4	1	37	10	0	11	0	0	0	0	1	7	0	0	0	3	0	0	0	18	0	0	0	1	0	0	0	93	11.6
17-Sep	8.00	0	1	8	6	0	3	0	2	0	1	1	4	0	0	0	1	0	0	0	11	0	0	0	1	0	0	0	39	4.9
18-Sep	8.00	0	1	9	5	0	2	1	0	0	0	0	2	0	0	0	0	0	0	0	8	0	0	0	2	0	0	0	30	3.8
19-Sep	8.00	6	0	9	3	0	1	0	1	0	1	1	4	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	29	3.6
20-Sep	8.00	2	0	12	1	0	0	0	1	0	0	0	6	0	0	0	0	0	0	0	2	0	0	0	0	1	0	0	25	3.1
21-Sep	8.00	0	0	51	35	0	4	1	0	0	0	0	18	0	0	0	3	0	0	0	2	0	0	3	0	0	0	0	117	14.6
22-Sep	8.00	2	1	49	35	0	6	0	1	0	0	2	12	0	0	0	0	0	0	0	5	1	0	1	3	0	0	0	118	14.8
23-Sep	7.50	0	0	2	2	0	0	0	0	0	0	1	4	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	11	1.5
24-Sep	8.00	0	0	3	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	5	0.6
25-Sep	8.00	4	0	9	9	0	0	1	4	0	0	1	24	0	0	0	2	0	0	0	20	0	0	1	0	0	2	0	77	9.6
26-Sep	9.00	1	0	52	33	2	6	0	2	0	8	1	39	1	0	0	18	0	0	0	11	0	0	0	5	1	1	3	184	20.4
27-Sep	8.00	0	0	43	11	0	8	1	8	0	2	2	13	0	0	0	2	0	0	0	4	0	0	0	0	1	1	0	96	12.0
28-Sep	8.00	0	3	52	21	0	15	0	0	0	0	1	22	0	0	0	3	1	0	0	22	0	0	0	0	0	0	0	140	17.5
29-Sep	9.50	1	0	40	16	0	4	0	1	0	1	1	34	0	0	0	6	0	0	0	61	0	0	3	1	0	0	0	169	17.8
30-Sep	8.28	0	1	45	39	0	6	1	18	0	1	2	40	0	0	0	4	0	0	0	27	0	0	1	0	0	0	0	185	22.3
1-Oct	8.00	0	0	37	9	0	0	0	1	0	0	0	7	0	0	0	2	0	1	0	13	1	0	0	0	0	0	0	71	8.9
2-Oct	8.00	0	0	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0.5

Appendix E. 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		
3-Oct	8.00	2	0	14	8	0	2	0	1	0	0	0	2	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	33	4.1
4-Oct	8.00	1	2	18	1	0	1	0	0	0	0	0	1	0	0	0	2	0	0	0	7	0	0	0	1	0	0	0	34	4.3
5-Oct	6.50	1	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0.6
6-Oct	6.00	0	0	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	2	0.3
7-Oct	8.50	3	0	95	54	0	5	0	5	0	0	1	35	0	0	0	4	0	0	0	9	0	0	1	0	1	0	0	213	25.1
8-Oct	7.00	0	2	38	4	0	3	0	0	0	0	0	8	0	0	0	0	0	0	0	4	0	1	0	0	0	0	0	60	8.6
9-Oct	8.00	0	3	16	3	0	1	0	1	0	1	0	17	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	45	5.6
10-Oct	8.00	0	0	8	5	0	3	0	0	0	0	0	2	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	20	2.5
11-Oct	8.50	0	4	75	28	0	4	1	27	0	0	0	111	0	0	0	12	1	0	0	21	0	0	0	0	0	1	0	285	33.5
12-Oct	8.00	0	0	109	28	0	16	0	0	0	0	3	214	0	0	0	6	0	1	0	5	0	0	0	0	0	0	0	382	47.8
13-Oct	8.00	0	5	48	11	0	10	0	5	0	0	0	105	0	0	0	3	0	1	0	7	0	0	0	1	1	1	0	198	24.8
14-Oct	5.00	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	0.2
15-Oct	8.00	0	1	25	8	0	3	0	0	0	0	0	50	0	0	0	2	0	0	0	1	0	0	0	0	1	0	0	91	11.4
16-Oct	8.00	0	1	33	3	0	3	0	0	0	0	0	26	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	67	8.4
17-Oct	8.00	0	0	10	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	20	2.5
18-Oct	8.00	0	0	12	6	0	0	0	0	0	0	0	15	0	0	0	3	0	0	0	1	0	0	0	0	0	0	0	37	4.6
19-Oct	8.00	0	3	51	2	0	6	0	0	0	0	0	73	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	137	17.1
20-Oct	8.00	0	1	31	2	0	2	0	0	0	0	0	107	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	146	18.3
21-Oct	8.00	0	1	4	2	0	1	0	0	0	0	0	23	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	32	4.0
22-Oct	7.00	0	3	5	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	1.9
23-Oct	8.00	0	3	8	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	2.0
24-Oct	5.00	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	0	1	0.2
25-Oct	5.75	0	1	2	0	0	1	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	8	1.4
26-Oct	8.00	0	1	0	0	1	0	0	0	0	0	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	20	2.5
27-Oct	7.50	0	2	6	0	0	1	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	1.5
28-Oct	8.00	0	0	1	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0.6
29-Oct	8.00	0	0	2	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	2.1
30-Oct	8.00	0	2	4	2	0	1	0	0	0	0	0	49	0	0	0	1	3	7	0	1	0	0	0	0	0	0	0	70	8.8
31-Oct	8.00	0	1	7	0	0	1	0	0	0	0	0	10	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	20	2.5
1-Nov	7.00	0	0	5	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	1.0
2-Nov	8.00	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0.5
3-Nov	8.00	0	0	7	1	0	0	0	0	0	0	0	3	1	0	0	2	0	2	0	0	0	0	0	0	0	0	0	16	2.0
4-Nov	8.00	0	0	9	0	0	0	0	0	0	0	0	9	0	0	0	2	0	2	0	0	0	0	0	0	0	0	0	22	2.8
5-Nov	4.50	0	1	1	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	1.6
Total	530.53	33	49	1155	426	4	136	9	84	0	15	22	1207	2	0	0	93	5	15	0	308	2	4	12	19	8	7	7	3622	6.8

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

Appendix F. Daily raptor migration counts by species at Yaki Point, Grand Canyon, AZ: 2006.

	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	7.75	0	0	0	1	0	2	0	2	0	0	0	5	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	13	1.7
28-Aug	7.00	0	0	0	1	0	1	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0.9
29-Aug	7.00	0	0	0	0	0	1	0	0	0	0	0	7	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	11	1.6
30-Aug	8.00	0	0	1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	4	0.5
31-Aug	6.75	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	3	0.4
1-Sep	7.50	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0.4
2-Sep	7.50	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	8	0	0	1	0	0	0	0	12	1.6
3-Sep	7.50	0	0	3	2	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	8	1.1
4-Sep	8.00	0	0	4	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	6	0.8
5-Sep	7.33	0	1	2	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	0.5
6-Sep	8.00	0	0	3	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	0.8
7-Sep	6.00	0	0	0	3	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	1.0
8-Sep	8.00	0	0	3	6	1	1	0	0	0	0	0	8	0	0	0	0	0	0	0	4	0	0	1	0	1	0	0	25	3.1
9-Sep	6.42	0	0	3	2	0	1	0	0	0	0	0	2	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	13	2.0
10-Sep	8.00	0	0	2	5	0	2	0	0	0	0	0	4	0	0	0	3	0	0	0	3	0	0	2	0	0	0	0	21	2.6
11-Sep	8.00	0	0	9	4	0	4	0	0	0	0	0	4	0	0	0	0	0	0	0	6	0	0	1	0	0	0	0	28	3.5
12-Sep	8.00	0	0	5	2	0	5	0	1	0	0	0	1	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	20	2.5
13-Sep	8.75	0	1	3	6	0	1	0	0	0	0	0	2	0	0	0	2	0	0	0	3	0	1	0	1	2	0	0	22	2.5
14-Sep	4.50	0	0	4	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2	0	0	0	0	1	0	0	10	2.2
15-Sep	7.50	10	0	3	4	0	0	0	0	0	0	2	6	0	0	0	0	0	0	0	2	0	0	0	1	1	0	0	29	3.9
16-Sep	9.00	6	2	53	37	10	2	3	1	0	0	2	51	0	0	0	1	0	0	0	35	4	1	1	3	0	0	0	212	23.6
17-Sep	9.00	2	2	108	27	0	3	0	4	0	2	2	32	0	0	0	0	0	0	0	19	0	0	1	0	0	0	0	202	22.4
18-Sep	8.00	0	1	18	4	0	4	0	0	0	0	0	15	0	0	0	0	0	1	0	15	0	0	0	0	0	1	0	59	7.4
19-Sep	8.00	0	0	11	2	0	1	0	0	0	0	0	3	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	18	2.3
20-Sep	8.00	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	3	0	1	0	2	1	0	0	10	1.3
21-Sep	8.00	1	0	19	11	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	2	0	0	1	0	0	0	0	41	5.1
22-Sep	8.00	3	0	15	6	0	0	0	3	0	1	1	7	0	0	0	0	0	0	0	6	1	0	0	2	1	0	0	46	5.8
23-Sep	8.00	1	0	6	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	1.1
24-Sep	8.00	4	1	16	25	0	5	0	0	0	2	2	24	0	0	0	1	0	0	0	23	0	0	1	0	0	0	0	104	13.0
25-Sep	8.25	2	0	59	22	0	1	1	1	0	1	2	16	0	0	0	0	0	0	0	15	1	0	0	0	0	0	0	121	14.7
26-Sep	8.50	2	1	21	7	0	3	0	0	0	0	0	12	0	0	0	0	0	0	0	8	0	0	0	0	1	0	0	55	6.5
27-Sep	9.00	1	1	103	54	0	8	0	0	0	1	1	25	0	0	0	0	0	0	0	29	1	0	1	2	0	0	0	227	25.2
28-Sep	9.00	1	4	151	129	0	10	0	0	0	2	7	58	0	0	0	0	0	0	0	41	0	0	0	0	0	0	1	404	44.9
29-Sep	9.00	0	1	187	96	0	5	0	1	0	1	5	58	1	0	0	1	0	0	0	61	0	0	0	1	0	0	0	418	46.4
30-Sep	8.00	0	0	39	32	0	5	0	0	0	0	0	19	0	0	0	2	0	0	0	14	0	1	0	0	0	0	0	112	14.0
1-Oct	8.00	1	0	15	13	0	0	0	0	0	0	0	9	1	0	0	1	0	0	0	5	0	0	0	2	0	0	0	47	5.9
2-Oct	8.00	1	0	10	3	1	1	0	0	0	0	0	3	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	21	2.6

Appendix F. 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		
3-Oct	8.00	0	0	14	8	0	5	0	1	0	0	0	3	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	35	4.4
4-Oct	8.00	0	0	21	5	0	8	0	0	0	0	1	5	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	44	5.5
5-Oct	4.00	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	2.3
6-Oct	4.58	0	2	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	5	1.1
7-Oct	9.00	2	3	186	53	0	6	0	0	0	2	2	54	0	0	0	3	0	0	0	12	1	0	0	0	0	0	1	325	36.1
8-Oct	8.00	0	0	63	31	0	14	0	0	0	0	1	12	0	0	0	10	0	0	0	3	0	0	0	0	0	0	3	137	17.1
9-Oct	8.00	0	4	21	7	0	1	0	0	0	0	0	8	0	0	0	1	0	0	0	11	0	0	0	0	0	0	0	53	6.6
10-Oct	8.00	0	1	4	1	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	9	1.1
11-Oct	8.50	0	4	119	28	0	2	0	0	0	0	0	57	0	0	0	0	1	0	0	15	0	1	0	0	0	0	0	227	26.7
12-Oct	8.00	0	2	58	14	0	2	0	0	0	0	0	41	0	0	0	0	0	0	0	7	0	1	0	0	0	0	0	125	15.6
13-Oct	6.50	0	0	6	1	0	1	0	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	11	1.7
14-Oct	4.00	0	0	5	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	3.0
15-Oct	7.50	0	0	15	2	1	1	0	0	0	0	0	17	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	37	4.9
16-Oct	8.25	0	1	34	5	0	1	0	0	0	0	0	33	0	0	0	2	0	2	0	1	0	0	0	0	0	0	0	79	9.6
17-Oct	7.00	0	0	3	0	0	0	0	0	0	0	0	5	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	9	1.3
18-Oct	7.50	0	2	17	1	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	23	3.1
19-Oct	8.00	0	2	40	0	0	1	0	0	0	0	0	72	0	0	0	6	0	1	0	0	0	0	0	0	0	0	0	122	15.3
20-Oct	8.50	0	0	22	5	0	2	0	0	0	0	0	49	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	81	9.5
21-Oct	8.00	0	0	16	0	0	0	0	0	0	0	0	11	0	0	0	2	0	2	0	0	0	0	0	0	0	0	0	31	3.9
22-Oct	8.00	0	4	17	1	0	0	0	0	0	0	0	24	1	0	0	1	0	1	0	1	0	0	0	0	0	0	0	50	6.3
23-Oct	8.00	0	0	12	3	0	0	0	0	0	0	0	11	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	27	3.4
24-Oct	4.50	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	0.2
25-Oct	6.25	0	1	8	2	0	0	0	0	0	0	0	31	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	44	7.0
26-Oct	8.25	0	0	23	12	0	2	0	0	0	0	0	46	2	1	0	1	0	0	0	0	0	0	0	0	0	0	1	88	10.7
27-Oct	8.00	0	0	10	1	0	0	0	0	0	0	0	9	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	23	2.9
28-Oct	8.00	0	1	5	0	0	1	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	1.3
29-Oct	8.00	0	0	1	2	0	0	0	0	0	0	0	8	0	0	0	0	0	4	0	1	0	0	0	0	0	0	0	16	2.0
30-Oct	7.00	0	0	4	0	0	0	0	0	0	0	0	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28	4.0
31-Oct	8.00	0	1	4	1	0	0	0	0	0	0	0	13	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	21	2.6
1-Nov	7.50	0	0	5	2	0	0	0	0	0	0	0	6	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	16	2.1
2-Nov	8.00	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	1.1
3-Nov	8.00	0	1	3	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	1.4
4-Nov	7.25	0	1	6	0	0	1	0	0	0	0	1	22	1	0	0	1	0	2	0	0	1	1	1	0	0	1	0	39	5.4
5-Nov	0.00																													
Total	533.33	37	45	1627	695	14	118	4	14	0	12	30	995	6	1	0	48	1	18	0	384	9	9	13	15	10	2	6	4113	7.7

[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: 1991–2006

YEAR	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	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	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	5-Nov	5-Nov	5-Nov	5-Nov
Days of observation	57	65	66	64	65	69	70	68	71	67	71	69	70	68	70	70	68
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	554.98	554.38	530.53	518.49
Raptors / 100 hours	1231	1957	1249	1372	1369	1574	1331	1283	1152	1107	1008	901	1036	597	528	683	1149
SPECIES	RAPTOR COUNTS																
Osprey	26	72	73	73	77	99	135	115	72	88	83	58	75	61	52	33	75
Northern Harrier	43	131	64	111	121	111	93	81	130	99	39	51	56	41	44	49	79
Sharp-shinned Hawk	698	2472	1643	1802	1441	1680	1566	1366	1427	1449	1609	1455	1263	945	891	1155	1429
Cooper's Hawk	1077	1673	1243	974	1052	1322	1332	1715	1515	968	1158	599	765	319	377	426	1032
Northern Goshawk	10	42	26	4	5	3	8	2	6	13	7	5	0	0	5	4	9
Unknown small accipiter[1]	–	–	–	–	–	–	–	–	–	–	98	197	31	85	104	136	109
Unknown large accipiter[1]	–	–	–	–	–	–	–	–	–	–	1	2	4	0	2	9	3
Unknown accipiter	360	337	199	200	243	423	213	243	185	252	0	46	47	39	28	84	181
TOTAL ACCIPITERS	2145	4524	3111	2980	2741	3428	3119	3326	3133	2682	2873	2304	2110	1388	1407	1814	2693
Red-shouldered Hawk	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Broad-winged Hawk	0	3	7	2	7	2	7	35	11	15	25	20	6	0	6	15	10
Swainson's Hawk	6	24	25	33	34	57	32	31	40	22	26	33	108	89	80	22	41
Red-tailed Hawk	1194	3229	1613	1898	2299	2275	1704	1390	1401	1498	1458	1302	1791	951	594	1207	1613
Ferruginous Hawk	8	15	7	11	3	6	7	6	7	6	3	2	6	1	1	2	6
Rough-legged Hawk	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Zone-tailed Hawk	0	0	0	0	0	0	1	1	0	0	0	1	2	0	0	0	0
Unidentified buteo	55	19	2	8	11	16	33	40	17	15	8	33	20	8	36	93	26
TOTAL BUTEOS	1263	3291	1654	1952	2354	2357	1784	1503	1476	1556	1520	1392	1933	1049	717	1339	1696
Golden Eagle	18	62	37	36	32	47	26	22	29	9	3	32	17	9	4	5	24
Bald Eagle	5	20	49	8	38	23	25	18	24	11	9	20	12	14	14	15	19
Unidentified eagle	0	0	3	0	0	0	0	1	4	0	0	3	0	0	0	0	1
TOTAL EAGLES	23	82	89	44	70	70	51	41	57	20	12	55	29	23	18	20	44
American Kestrel	1156	1508	1209	1273	1096	1631	1340	978	1218	1045	1180	1057	1300	689	639	308	1102
Merlin	7	14	12	10	12	8	24	12	13	9	8	4	9	21	4	2	11
Prairie Falcon	1	8	8	2	5	4	5	5	2	9	8	1	3	7	9	4	5
Peregrine Falcon	2	14	5	5	5	8	8	10	8	6	6	14	8	7	10	12	8
Unknown small falcon[1]	–	–	–	–	–	–	–	–	–	–	2	1	0	1	2	19	4
Unknown large falcon[1]	–	–	–	–	–	–	–	–	–	–	3	3	1	0	3	8	3
Unknown falcon	0	4	4	1	1	0	6	8	6	5	3	0	0	1	1	7	3
TOTAL FALCONS	1166	1548	1238	1291	1119	1651	1383	1013	1247	1074	1210	1080	1321	726	668	360	1131
Unknown raptor	106	124	24	66	48	60	97	96	107	48	60	83	23	25	20	7	62
GRAND TOTAL	4920	10048	6301	6625	6745	8008	6952	6479	6297	5664	5797	5023	5547	3313	2926	3622	5892

[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: 1997–2006.

YEAR	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	MEAN
Start date	27-Aug	28-Aug	27-Aug	27-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	4-Nov	5-Nov
Days of observation	71	66	71	66	71	71	70	68	70	70	69
Hours of observation	504.97	455.41	543.20	513.10	595.59	585.70	547.90	559.40	570.48	533.33	540.90
Raptors / 100 hours	938	908	998	1054	881	968	1229	932	556	771	916
SPECIES	RAPTOR COUNTS										
Osprey	50	43	28	43	34	57	50	42	31	37	42
Northern Harrier	50	44	56	41	31	45	35	29	38	45	41
Sharp-shinned Hawk	1474	1190	1906	1772	1792	1932	2323	1743	1008	1627	1677
Cooper's Hawk	856	1109	1204	1256	1293	891	1673	855	516	695	1035
Northern Goshawk	4	7	1	9	11	6	2	7	2	14	6
Unknown small accipiter[1]	–	–	–	–	72	218	52	122	108	118	115
Unknown large accipiter[1]	–	–	–	–	0	3	1	1	4	4	2
Unknown accipiter	94	140	109	236	0	18	103	125	15	14	85
TOTAL ACCIPITERS	2428	2446	3220	3273	3168	3068	4154	2853	1653	2472	2874
Red-shouldered Hawk	1	0	0	0	0	0	0	0	0	0	0
Broad-winged Hawk	9	19	14	6	11	8	14	19	2	12	11
Swainson's Hawk	15	25	32	10	19	16	147	80	32	30	41
Red-tailed Hawk	899	916	985	892	1008	1234	1264	1169	765	995	1013
Ferruginous Hawk	8	7	11	10	6	6	6	1	6	6	7
Rough-legged Hawk	0	0	0	1	1	2	0	0	0	1	1
Zone-tailed Hawk	0	0	1	0	1	1	0	0	0	0	0
Unidentified buteo	20	20	13	8	8	43	42	17	24	48	24
TOTAL BUTEOS	952	987	1056	927	1054	1310	1473	1286	829	1092	1097
Golden Eagle	24	7	2	11	4	23	11	4	5	1	9
Bald Eagle	23	18	17	9	14	49	14	10	22	18	19
Unidentified eagle	1	0	1	0	0	1	0	0	0	0	0
TOTAL EAGLES	48	25	20	20	18	73	25	14	27	19	30
American Kestrel	1016	423	918	1035	881	1011	943	930	555	384	810
Merlin	14	12	14	5	22	5	17	9	9	9	12
Prairie Falcon	9	4	6	4	3	8	5	7	2	9	6
Peregrine Falcon	7	19	8	1	7	11	7	6	11	13	9
Unknown small falcon[1]	–	–	–	–	0	3	0	0	1	15	3
Unknown large falcon[1]	–	–	–	–	0	1	0	0	2	10	2
Unknown falcon	0	4	2	3	2	4	1	4	3	2	3
TOTAL FALCONS	1046	462	948	1048	915	1043	973	956	583	442	842
Unidentified raptor	20	38	16	10	25	71	23	36	12	6	26
GRAND TOTAL	4594	4045	5344	5362	5245	5667	6733	5216	3173	4113	4949

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