FALL 2005 RAPTOR MIGRATION STUDIES IN THE GRAND CANYON OF ARIZONA

HawkWatch International, Inc.
Salt Lake City, Utah

January 2005

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January 2005

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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 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 2005 season marked the 15th consecutive count at Lipan Point and the 9th consecutive full-season count at Yaki Point. This report summarizes the 2005 count results for both sites.

The Grand Canyon projects comprised 2 of 13 long-term, annual migration counts conducted or co-sponsored by HWI in North America during 2005. 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 (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, assisted occasionally by other local volunteers and frequently by on-site educators Deanna Draudt and Rebecca Lohnes, 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 Surya Gurung had received prior training as an intern at Hawk Mountain Sanctuary in Pennsylvania and had previously conducted migration counts in his home country of Nepal. None of the other official observers had previously conducted raptor migration counts, but all attended pre-season training at HWI's headquarters (see Appendix A for a complete history of observation participation). 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 Lipan Point data alone from 1991–2005 and Yaki Point and combined-site data from 1997–2005. In comparing 2005 annual statistics against means and 95% confidence intervals for previous seasons, we equate significance ($P \leq 0.05$) with a 2005 value falling outside the bounds of the confidence interval for the associated mean.

RESULTS AND DISCUSSION

WEATHER SUMMARY

In 2005, the number of observation days entirely precluded or severely hampered (i.e., reduced to ≤4 hours observation) by inclement weather were slightly below average at both sites: 3 days affected at Lipan Point and 2 days at Yaki Point, compared to 1997–2004 averages of 3.6 and 3.9 days, respectively (see Appendixes C and D for daily weather records from the two sites). Both sites also featured above-average proportions of active observation days where predominantly fair skies prevailed (61% at Lipan Point and 56% at Yaki Point, compared to 1997–2004 averages of 53% and 52%, respectively), near 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; 29% vs. average of 29% at Lipan, 31% vs. average of 27% at Yaki), and below average proportions of days where mostly cloudy to overcast skies prevailed (10% vs. average of 18% at Lipan, 13% vs. average of 20% at Yaki). Unlike the last three years, visibility reducing haze, smoke, and dust hampered a below-average number of days at both sites. At Lipan Point, 17% of the active observation days featured appreciable visibility reducing fog and haze, compared to the 1997–2004 average of 29%. At Yaki Point, the comparative proportions were 10% and 27%. Rain and snow showers also were less prevalent than usual. At Lipan Point, 10% of the active observation days featured some rain or snow, compared to the 1997–2004 average of 19%. At Yaki Point, the comparative proportions were 9% and 16%.

The temperature regimes at both sites were warmer than usual in 2005. The average daily temperature (average of daily values, which in turn were averages of hourly readings) at Lipan Point during active observation periods was 21.0°C (1997–2004 average of 18.5°C); at Yaki Point the 2005 value was 20.4°C (long-term average 17.2°C). Moreover, at both sites the daily-average minimums and maximums either tied previous highs or ranked as record high values.

At Lipan Point there was a shift toward lighter winds in 2005 (the opposite of last year), with light winds (<12 kph) prevailing on 89% of the active observation days, moderate winds on 11%, and stronger winds (>29 kph) on no days (1997–2004 averages of 81%, 14%, and 5% of days, respectively). A slightly different pattern applied at Yaki Point, however. There the number of days where light winds prevailed was below average, matching the previous low of 69% (average 76%); the proportion of days where moderate winds prevailed rose to a record high of 31% (average 19%); and, like at Lipan Point, no days featured predominantly strong winds (average 5%).

In terms of wind directions, the pattern at Lipan Point was fairly typical for that site, with variable SW-NW winds prevailing throughout much or all of 52% of the active observation days (average 46%), variable NE-SE winds on 21% (average 21%), and calm/variable winds on 14% of the active days (average 16%). However, days where more northerly winds prevailed were completely absent this year

(average 5% of days) and periods of calm/variable winds were much more commonly interspersed with otherwise predominant wind directions than usual. A similar pattern applied at Yaki Point.

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 (86% vs. 54% at Lipan, 66% vs. 49% at Yaki).

In summary, compared to the last eight seasons, 2005 featured relatively fairer and warmer weather than usual; lighter than usual winds at Lipan Point and both more calm-wind days and moderate-wind days at Yaki Point; fairly typical arrays of wind directions at both sites; and above-average thermal-lift conditions at both sites. Moreover, contrasting markedly with the last three years in particular, visibility reducing dust, smoke, and haze were less common than usual.

OBSERVATION EFFORT

Counts occurred at both sites on 70 of 71 possible days between 27 August and 5 November 2005 (see Appendices E and F for daily count records for each site). Both the number of observation days and total observation hours (581.17; the total number of hours during which counts occurred at one or both sites) were both within 2% of the respective 1997–2004 averages (70 ± 95% CI of 1.0 days and 567.12 ± 18.53 hours; see Appendices G and H for annual effort and count summaries for each site). The 2005 average of 4.0 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 1% below the 1997–2004 average of 4.1 ± 95% CI of 0.11 observers/hour.

MIGRATION SUMMARY

The observers tallied 6,099 migrant raptors of 15 species at the two count sites in 2005 (Table 1), with 48% recorded at Lipan Point and 52% at Yaki Point. For the second year in a row, the total count is the lowest combined-site count yet recorded, 44% below the 1997–2004 average. The drop reflected a 48% below average (1997–2004; 53% below the 1991–2004 average) count at Lipan Point, and for the first time a 40% below-average count at Yaki Point. 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 only the second time (the first in 2004) 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 few years on the Kaibab Plateau north of the canyon and shifting dynamics due to the widespread drought that plagued much of the Great Basin between 1999 and 2004. Counts have been well below average for four years in a row farther north in the Intermountain Flyway at the Goshute Mountains, Nevada (Hoffman and Smith 2003, Smith and Neal 2005).

Compositional Patterns

The combined-site flight was composed of 50% accipiters, 25% buteos, 19% falcons, and ~1% each of ospreys, harriers, eagles, and unidentified raptors. The proportion of harriers was significantly above average and the proportions of accipiters and unknown raptors were significantly below average. Yaki Point attracted proportionately more accipiters (54% of the combined-site total), buteos (54%), and eagles (60%), whereas Lipan Point attracted more Ospreys (63%), harriers (54%), and falcons (53%; Figure 2). This pattern of compositional differences is typical except that until 2004 buteos had always been proportionately more common at Lipan Point. Only the relative abundance of eagles at the two sites has varied regularly from year to year. In addition, the relative abundance of accipiters has shifted steadily from roughly 60% of the combined-site total at Lipan Point in 1997 and 1998 to only 33% in

2004, but then rebounded back to 46% this year. 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 nine 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 is causing the forest-dwelling accipiters to alter their pathways across this landscape. However, although less true in 2004 and 2005 than previously, there also has been a fairly steady shift over the past nine 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. 2002). Future detailed analyses of count trends at both sites in relation to weather and other landscape variables should clarify the situation.

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 (83), Sharp-shined Hawks (1,899), Cooper's Hawks (1,174, second year in a row), Broad-winged Hawks (8), Red-tailed Hawks (1,359, second year in a row), and American Kestrels (1194), and matched or ranked as the second lowest counts for Northern Harriers (82), Northern Goshawks (7), Ferruginous Hawks (7), Golden Eagles (9), and Merlins (13). In contrast, the counts of Swainson's Hawks (112), Prairie Falcons (11), and Peregrine Falcons (21) matched or ranked as the third highest to date. Combined-site, adjusted passage rates were significantly below average for 11 of 15 commonly encountered species, and were significantly above average only for Prairie and Peregrine Falcons (Table 1).

Nine years is still too short a period from which to derive robust assessments of long-term, combined-site trends; however, examination of 15-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 1991–2005 indicated at least marginally significant ($P \leq 0.10$) linear or quadratic trends for 11 of 15 commonly encountered species, in all cases reflecting long-term or at least post mid-1990s declining patterns, except for Swainson's Hawks (Figures 3–7). Regression analyses for the period 1997–2005 indicated similar, at least marginally significant, combined-site trends for six of these species, reflecting declining trends since the late 1990s for Ospreys, Northern Harriers, Cooper's Hawks, and Ferruginous Hawks, a more recent decline for Sharp-shinned Hawks, and an increasing trend for Swainson's Hawks (Figures 3–5). Except for a temporary upswing in 2002, Golden Eagles have shown a pronounced, highly significant ($P < 0.01$) long-term decline at Lipan Point, with a similar though non-significant short-term pattern evident in the combined-site data (Figure 6).

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). Since 1992, passage rates for this species at Lipan Point have declined steadily, dropping to the second and third lowest rates in 2004 and 2005. In contrast, from 1997 through 2003, Sharp-shinned Hawk passage rates increased significantly at Yaki Point and contributed to a significant increasing trend in the combined-site passage rates, reflecting the aforementioned distributional shift from Lipan to Yaki Point. However, passage rates of this species plummeted at both sites in 2004 and 2005 and have now produced a significant quadratic trend in the combined-site passage rates illustrating the recent sharp decline. Similar scenarios apply to Red-tailed Hawks (Figure 5) and American Kestrels (Figure 7), which both show long-term (1991–2005) declines at

Lipan Point alone, but relatively stable combined-site patterns from 1997–2005. Both Broad-winged Hawks (Figure 5) and Peregrine Falcons (Figure 7) previously had been showing long-term increases at Lipan Point alone, but an overall combined-site declining pattern has set in for Broad-winged Hawks since 2001, and a highly variable but overall stable combined-site pattern has applied to Peregrine Falcons since 1997.

Although subtle differences in pattern are evident among the two count datasets for Northern Goshawks (Figure 4; discounting the importance of the large upswing in 1992 which reflects a cyclic invasion of northern birds; Hoffman and Smith 2003), Bald Eagles (Figure 6), Merlins, and Prairie Falcons (Figure 7), in general all datasets point to the same basic conclusion of no distinct long-term trends for these species.

Age Ratios

At the combined-site level, 7 of 10 species with readily distinguishable age classes and for which the 2005 counts were high enough to warrant some attention to age ratios, showed significant variation in immature : adult ratios compared to 1997–2004 averages (Table 2). The age ratio for Northern Harriers was significantly below average, whereas ratios were significantly above average for Sharp-shinned Hawks, Cooper's Hawks, Broad-winged Hawks, Red-tailed Hawks, Ferruginous Hawks, and Golden Eagles (Table 2). The low age ratio for Northern Harriers was clearly due to both an absolute and relative reduction in the abundance of immature birds. In contrast, except for Sharp-shinned Hawks, the high age ratios for the other five species were clearly not due to high absolute abundances of young birds, but rather to reductions in the absolute or relative abundances of adults. Nevertheless, given evidence of a probable flight-line shift to the west and resulting low overall numbers in the past two years, the high abundance of immature Sharp-shinned Hawks in 2005 is particularly conspicuous and almost certainly is a good indicator that productivity was relatively good for Sharp-shinned Hawks in the Intermountain region in 2005. By logical extension, the obvious shifts in the relative abundance of immature and adult Cooper's Hawks and Red-tailed Hawks may well reflect a similar pattern. It is also important to note, however, that most of these age-ratio comparisons are confounded by significant variation in proportions of unaged birds compared to the long-term averages.

Seasonal Timing

Based on combined-site data, the overall combined-species median passage date in 2005 of 29 September was only one day earlier than the 1997–2004 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, 7 of 15 species with data sufficient for comparisons showed significantly earlier than average median passage dates (Sharp-shinned Hawk, Northern Goshawk, Broad-winged Hawk, Ferruginous Hawk, American Kestrel, Merlin, and Prairie Falcon) and three species showed significantly late timing (Northern Harrier, Swainson's Hawk, and Peregrine Falcon; Table 3). In all cases, 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. Age-specific median passage dates 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 12 October, but the observers did not closely track numbers.

Resident Cooper’s Hawks at Lipan Point included an adult seen several other times hunting and perching

in the nearby canyon and woods, and interacting with ravens. It was last seen on 26 September. One immature bird was also seen in similar areas and displaying similar behavior through 27 September. No other local accipiters were noted at Lipan Point.

Local Red-tailed Hawks were observed at Lipan Point on most days until the end of the season. These included a family of light-morphs consisting of two adults and one immature bird, plus other possibles spotted at greater distances over Navajo Point or on the far west side of the canyon bowl west of the observation point. At least one adult and one immature Zone-tailed Hawk resided around Lipan Point. They were first spotted on 28 August and last seen on 19 September. Often, the immature was observed in the morning calling above Navajo point and was observed making hunting attempts on several occasions. On 2 September, one bird made a prey hand-off to another, and on 3 September an adult was seen catching a chipmunk.

At least one pair of American Kestrels resided around Lipan Point, last spotted on 9 September. At least two Peregrine Falcons, one immature and one adult, resided at Lipan and were most often seen near Navajo Point attacking ravens. The last sighting of a local peregrine was of an adult on 26 September. At Yaki Point, local Turkey Vultures were seen regularly through 10 October, with large groups seen in October circling above both Yaki and Mather Points.

At least one adult and one immature Cooper's Hawks were seen regularly displaying resident behavior around Yaki Point until 21 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 two immature birds. A second, likely family of rufous-morph red-tails (two adults and one immature), also was seen infrequently at the point beginning around 15 September. Beginning around 20 October most residents, including an immature and adult light-morph and an adult rufous morph, were seen apparently catching bugs on the wing. This behavior has been witnessed at the site before. Zonetailed Hawks nested in the same site as previous years just below Yaki Point. Adults and an immature bird were seen regularly at the point until 21 September. Occasionally they were observed hunting along the rim and were seen a few times unsuccessfully going after the local rock squirrels.

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 and an immature were seen at different times, with the adults seen together only a few times. On 7 October, the immature bird was observed harassing migrants for about an hour, including actually striking a Sharp-shinned Hawk, which apparently was unharmed and continued on its way. The last sighting of a local peregrine was on 19 October.

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

VISITOR PARTICIPATION

As usual, HWI educators routinely conducted organized education programs most days at both Lipan and Yaki Points in close coordination with personnel of Grand Canyon National Park. A total of 434 people attended these programs at Lipan Point, and 771 people attended programs at Yaki Point closer to Grand

Canyon Village. A total of 1,277 visitors signed the HWI visitor log during the season. Visitors originated in 42 states and Washington, DC, several Canadian provinces, and 15 other foreign countries: Germany, Japan, Israel, Australia, Scotland, Britain, Switzerland, France, Austria, New Zealand, Denmark, Spain, Brazil, Kazakstan, and Holland. Other organized groups that visited the sites included elder hostel groups from Yavapai Community College and a group from Prescott Audubon Society.

In 2005 at Lipan Point, 559 hourly assessments of visitor disturbance resulted in the following ratings: 92% none, 6% low, 2% moderate, and 0% high. At Yaki Point, 562 hourly assessments of visitor disturbance resulted in the following ratings: 78% none, 18% low, 4% 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.

ACKNOWLEDGMENTS

We gratefully acknowledge the financial support of the U.S. Fish and Wildlife Service, Region 2; Grand Canyon Association; New Belgium Brewing Company; Mrs. George W. Perkins Jr., Jennifer and Randy Speers, and HawkWatch International members. The Tusayan Ranger District of the Kaibab National Forest and Grand Canyon National Park provided essential logistical support. Special thanks to park orientation specialists Ron and Pat Brown (both former HWI on-site educators in the park) and park interpretative ranger Marker Marshall for their considerable logistical and educational assistance. We also extend our sincerest appreciation to Brian Gatlin and Christie Van Cleve for their volunteer efforts to assist our full-time observers.

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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): 1997–2004 versus 2005.

SPECIES	COUNTS			RAPTORS / 100 HOURS		
	1997–2004[1]	2005	% CHANGE	1997–2004[1]	2005	% CHANGE
Osprey	129 ± 20.0	83	-36	30.4 ± 3.15	18.9	-38
Northern Harrier	115 ± 28.1	82	-29	22.8 ± 3.32	15.6	-32
Sharp-shinned Hawk	3152 ± 252.1	1899	-40	732.0 ± 25.44	465.3	-36
Cooper's Hawk	2189 ± 400.2	893	-59	596.6 ± 63.84	255.7	-57
Northern Goshawk	11 ± 4.4	7	-36	2.0 ± 0.43	1.3	-35
Unknown small accipiter	218.8 ± 138.0	212	-3	–	–	–
Unknown large accipiter	3.0 ± 2.3	6	+100	–	–	–
Unknown accipiter	231 ± 114.5	43	-81	–	–	–
TOTAL ACCIPITERS	5693 ± 467.8	3060	-46	–	–	–
Red-shouldered Hawk	0.1 ± 0.25	0	-100	–	–	–
Broad-winged Hawk	27 ± 8.6	8	-71	14.8 ± 2.62	3.5	-77
Swainson's Hawk	91 ± 54.9	112	+24	27.6 ± 9.59	35.0	+27
Red-tailed Hawk	2483 ± 189.9	1359	-45	514.1 ± 22.64	278.8	-46
Ferruginous Hawk	12 ± 3.6	7	-40	2.4 ± 0.45	1.5	-39
Rough-legged Hawk	0.6 ± 0.74	0	-100	–	–	–
Zone-tailed Hawk	1 ± 0.5	0	-100	–	–	–
Unidentified buteo	43 ± 15.4	60	+39	–	–	–
TOTAL BUTEOS	2657 ± 227.4	1546	-42	–	–	–
Golden Eagle	29 ± 11.5	9	-69	5.5 ± 1.30	1.7	-69
Bald Eagle	36 ± 11.5	36	+0	8.3 ± 1.51	8.5	+3
Unidentified eagle	1 ± 1.4	0	-100	–	–	
TOTAL EAGLES	66 ± 23.4	45	-32	–	–	
American Kestrel	1996 ± 222.7	1194	-40	526.3 ± 34.67	309.3	-41
Merlin	25 ± 6.4	13	-47	5.2 ± 0.81	2.4	-54
Prairie Falcon	11 ± 1.8	11	+2	2.0 ± 0.18	2.6	+28
Peregrine Falcon	17 ± 4.9	21	+26	3.3 ± 0.60	4.3	+29
Unknown small falcon	2 ± 1.7	3	+71	–	–	–
Unknown large falcon	2 ± 1.8	5	+150	–	–	–
Unknown falcon	6 ± 2.3	4	-35	–	–	–
TOTAL FALCONS	2056 ± 220.1	1251	-39	–	–	–
Unidentified Raptor	97 ± 27.8	32	-67	–	–	–
GRAND TOTAL	10814 ± 766.5	6099	-44	–	–	–

[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): 1997–2004 versus 2005.

	Total and Age-classified Counts								Immature : Adult Ratio	
	1997–2004 Average			2005			% Unknown Age			
Species	Total	Imm.	Adult	Total	Imm.	Adult	1997–2004[1]	2005	1997–2004[1]	2005
Northern Harrier	115	31	30	82	12	18	49 ± 5.8	63	1.0 ± 0.20	0.7
Sharp-shinned Hawk	3152	600	1145	1899	825	733	45 ± 8.7	18	0.5 ± 0.11	1.1
Cooper's Hawk	2189	483	659	893	374	289	49 ± 8.0	26	0.8 ± 0.22	1.3
Northern Goshawk	11	5	3	7	2	5	28 ± 11.6	0	1.9 ± 1.20	1.0
Broad-winged Hawk	27	7	11	8	3	3	25 ± 12.0	25	0.7 ± 0.24	1.0
Red-tailed Hawk	2483	322	1476	1359	289	785	27 ± 4.6	21	0.2 ± 0.07	0.4
Ferruginous Hawk	12	3	5	7	3	2	41 ± 13.1	29	0.7 ± 0.28	1.0
Golden Eagle	29	8	11	9	6	1	35 ± 7.2	22	1.1 ± 0.50	6.0
Bald Eagle	36	7	25	36	8	28	10 ± 4.7	0	0.3 ± 0.03	0.3
Peregrine Falcon	17	2	7	21	5	12	44 ± 13.2	19	0.3 ± 0.22	0.4

[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 2005 and 1997–2004 average median passage dates (Lipan Point and Yaki Point data combined).

	2005				1997–2004
Species	First Observed	Last Observed	Bulk Passage Dates [1]	Median Passage Date [2]	Median Passage Date [3]
Osprey	27-Aug	26-Oct	5-Sep – 1-Oct	19-Sep	19-Sep ± 2.2
Northern Harrier	28-Aug	5-Nov	6-Sep – 23-Oct	9-Oct	6-Oct ± 2.3
Sharp-shinned Hawk	28-Aug	5-Nov	15-Sep – 22-Oct	29-Sep	1-Oct ± 1.3
Cooper's Hawk	27-Aug	5-Nov	14-Sep – 13-Oct	27-Sep	28-Sep ± 2.5
Northern Goshawk	1-Sep	5-Nov	1-Sep – 5-Nov	18-Sep	5-Oct ± 6.8
Broad-winged Hawk	18-Sep	22-Oct	18-Sep – 22-Oct	24-Sep	25-Sep ± 1.5
Swainson's Hawk	2-Sep	11-Oct	14-Sep – 1-Oct	29-Sep	22-Sep ± 5.3
Red-tailed Hawk	27-Aug	5-Nov	16-Sep – 29-Oct	10-Oct	7-Oct ± 2.3
Ferruginous Hawk	11-Sep	13-Oct	11-Sep – 13-Oct	4-Oct	11-Oct ± 6.0
Golden Eagle	30-Sep	24-Oct	30-Sep – 24-Oct	21-Oct	15-Oct ± 7.1
Bald Eagle	3-Sep	5-Nov	1-Oct – 4-Nov	25-Oct	23-Oct ± 3.1
American Kestrel	27-Aug	30-Oct	11-Sep – 7-Oct	20-Sep	23-Sep ± 1.8
Merlin	27-Aug	5-Nov	2-Sep – 29-Oct	23-Sep	6-Oct ± 2.0
Prairie Falcon	27-Aug	9-Oct	28-Aug – 26-Sep	12-Sep	25-Sep ± 5.8
Peregrine Falcon	7-Sep	3-Nov	13-Sep – 29-Oct	2-Oct	24-Sep ± 6.6
All species	27-Aug	5-Nov	14-Sep – 23-Oct	29-Sep	30-Sep ± 1.9

[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): 1997–2004 versus 2005.

	ADULT		IMMATURE / SUBADULT	
SPECIES	1997–2004[1]	2005	1997–2004[1]	2005
Northern Harrier	10-Oct ± 3.1	21-Oct	4-Oct ± 4.9	5-Oct
Sharp-shinned Hawk	7-Oct ± 0.8	6-Oct	25-Sep ± 1.8	25-Sep
Cooper's Hawk	2-Oct ± 2.5	29-Sep	25-Sep ± 1.9	25-Sep
Northern Goshawk	25-Oct ± 11.8	19-Sep	8-Oct ± 7.7	–
Red-tailed Hawk	8-Oct ± 1.8	10-Oct	2-Oct ± 3.7	30-Sep
Golden Eagle	15-Oct ± 10.4	–	16-Oct ± 6.4	6-Oct
Bald Eagle	23-Oct ± 3.1	24-Oct	22-Oct ± 4.3	25-Oct
Peregrine Falcon	24-Sep ± 8.6	30-Sep	24-Sep [2]	7-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.

[2] Value is for 1998 only.

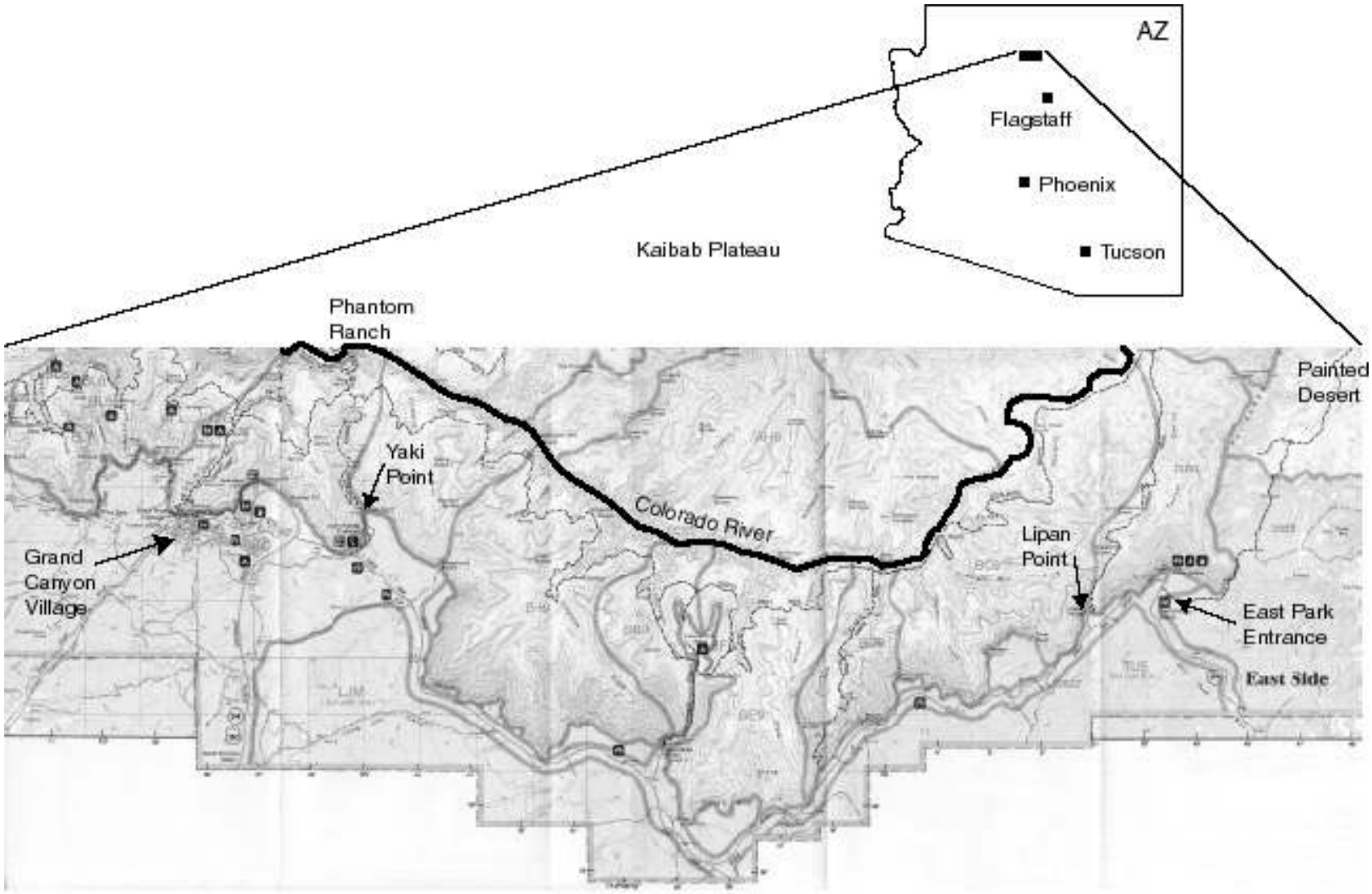

Figure 1. Map showing the Lipan Point and Yaki Point raptor-migration study sites in the Grand Canyon, Arizona.

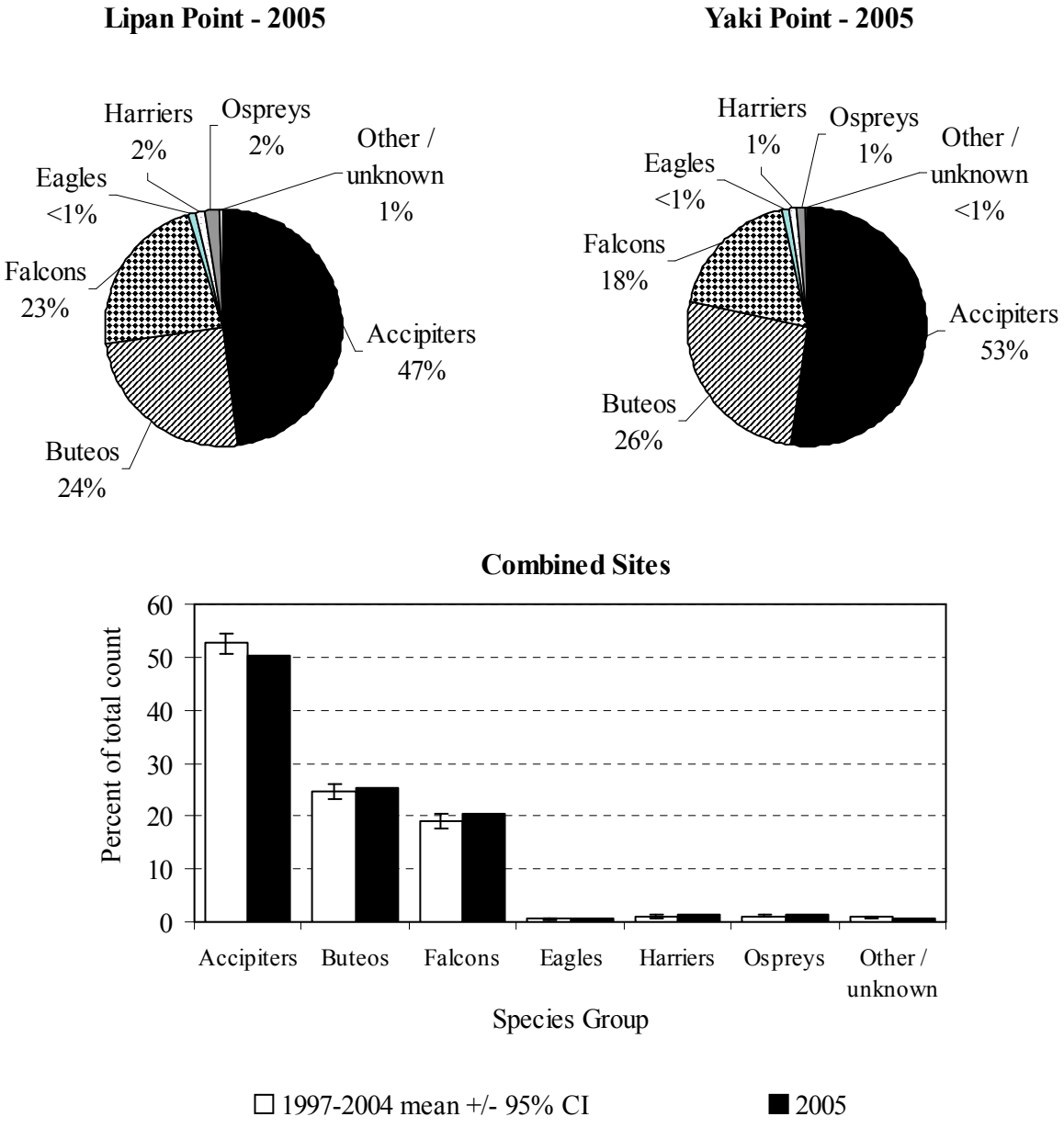

Figure 2. Fall raptor-migration flight composition by major species groups in the Grand Canyon, AZ: 1997–2004 versus 2005.

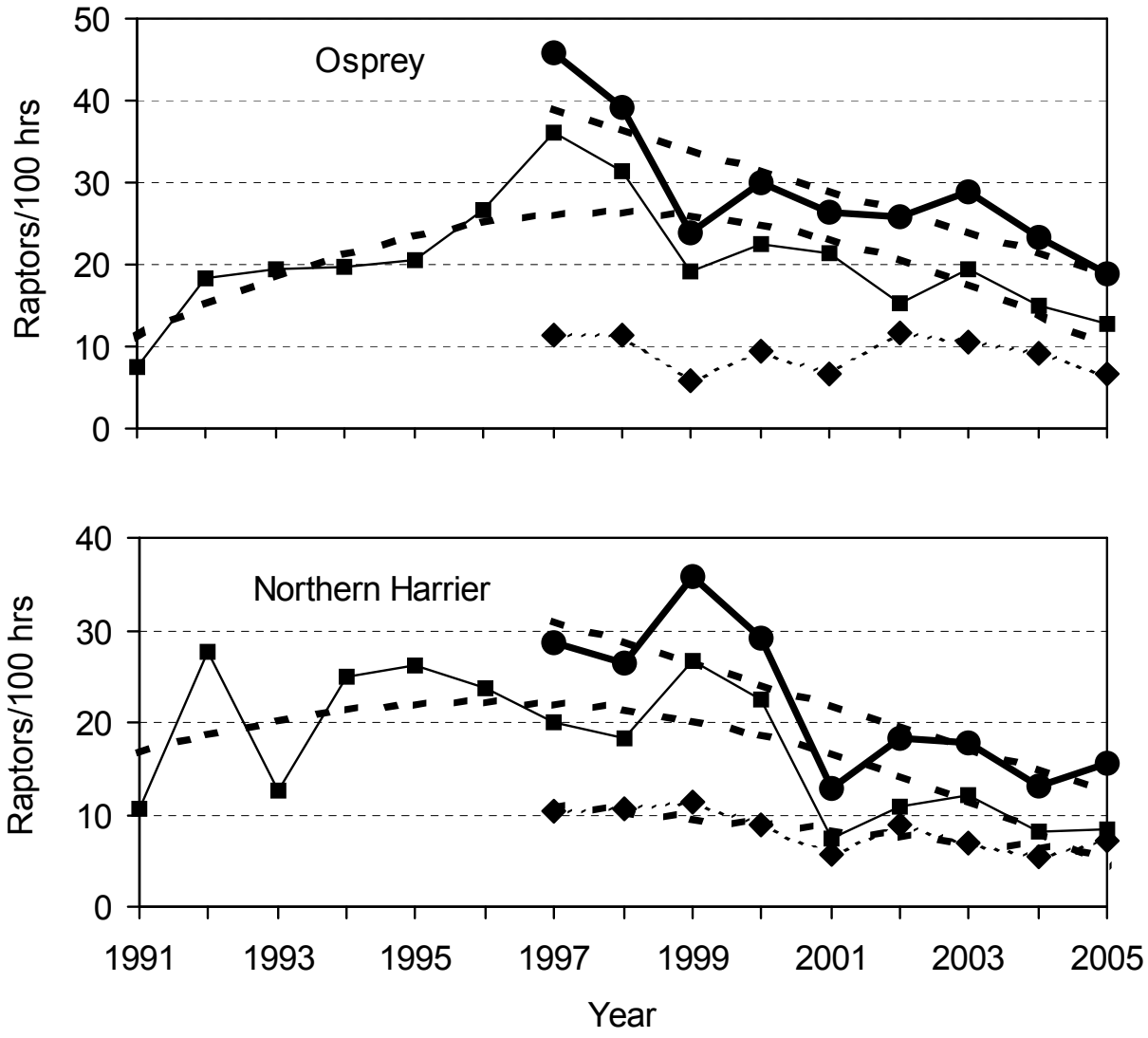

Figure 3. Adjusted (truncated to standardized annual sampling periods and adjusted for incompletely identified birds) fall-migration passage rates for Ospreys and Northern Harriers in the Grand Canyon, AZ: 1991–2005. Dashed lines indicate significant ($P \leq 0.10$) linear or quadratic regressions.

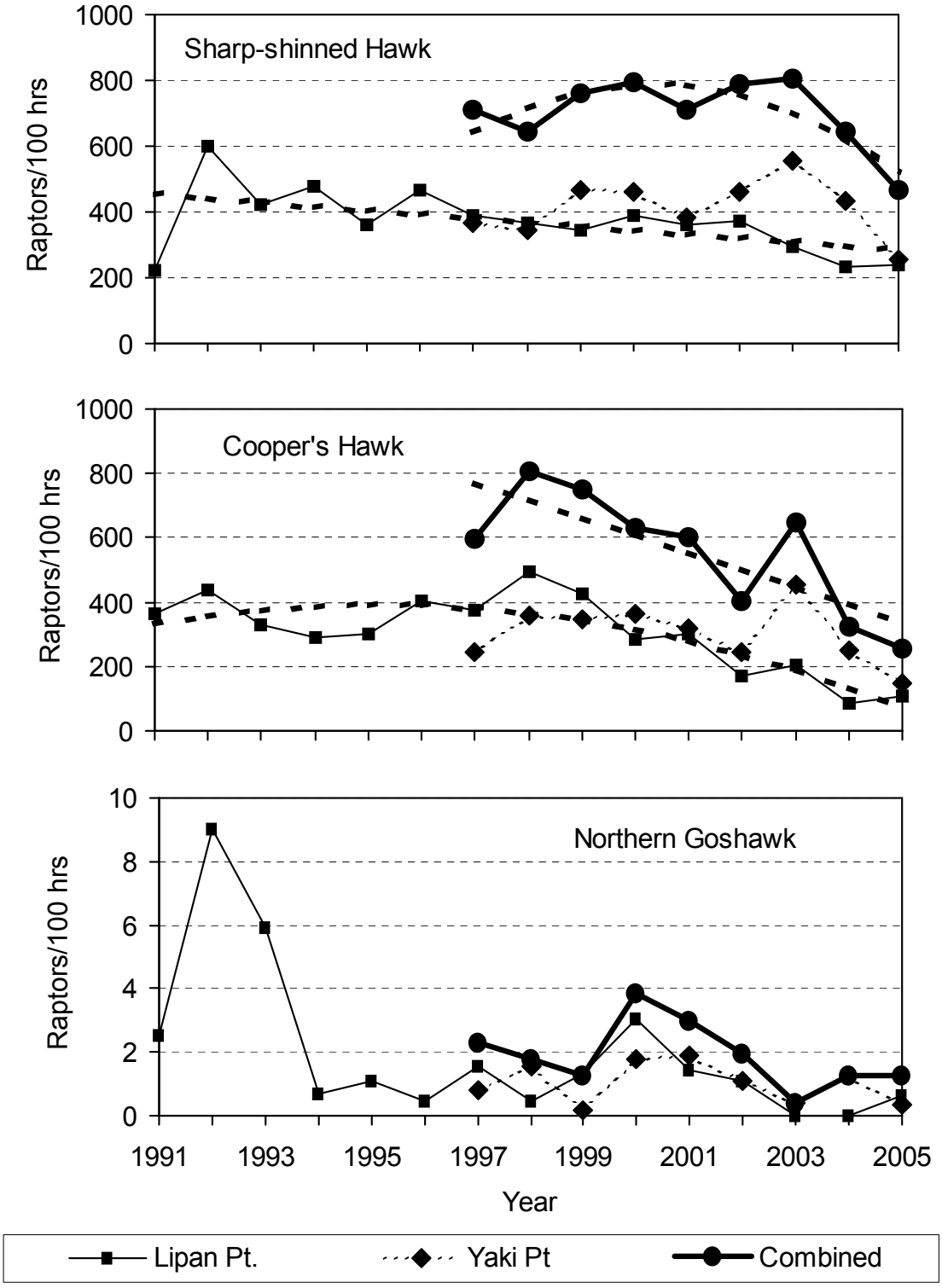

Figure 4. Adjusted (truncated to standardized annual sampling periods and adjusted for incompletely identified birds) fall-migration passage rates for Sharp-shinned Hawks, Cooper's Hawks, and Northern Goshawks in the Grand Canyon, AZ: 1991–2005. Dashed lines indicate significant ($P \leq 0.10$) linear or quadratic regressions.

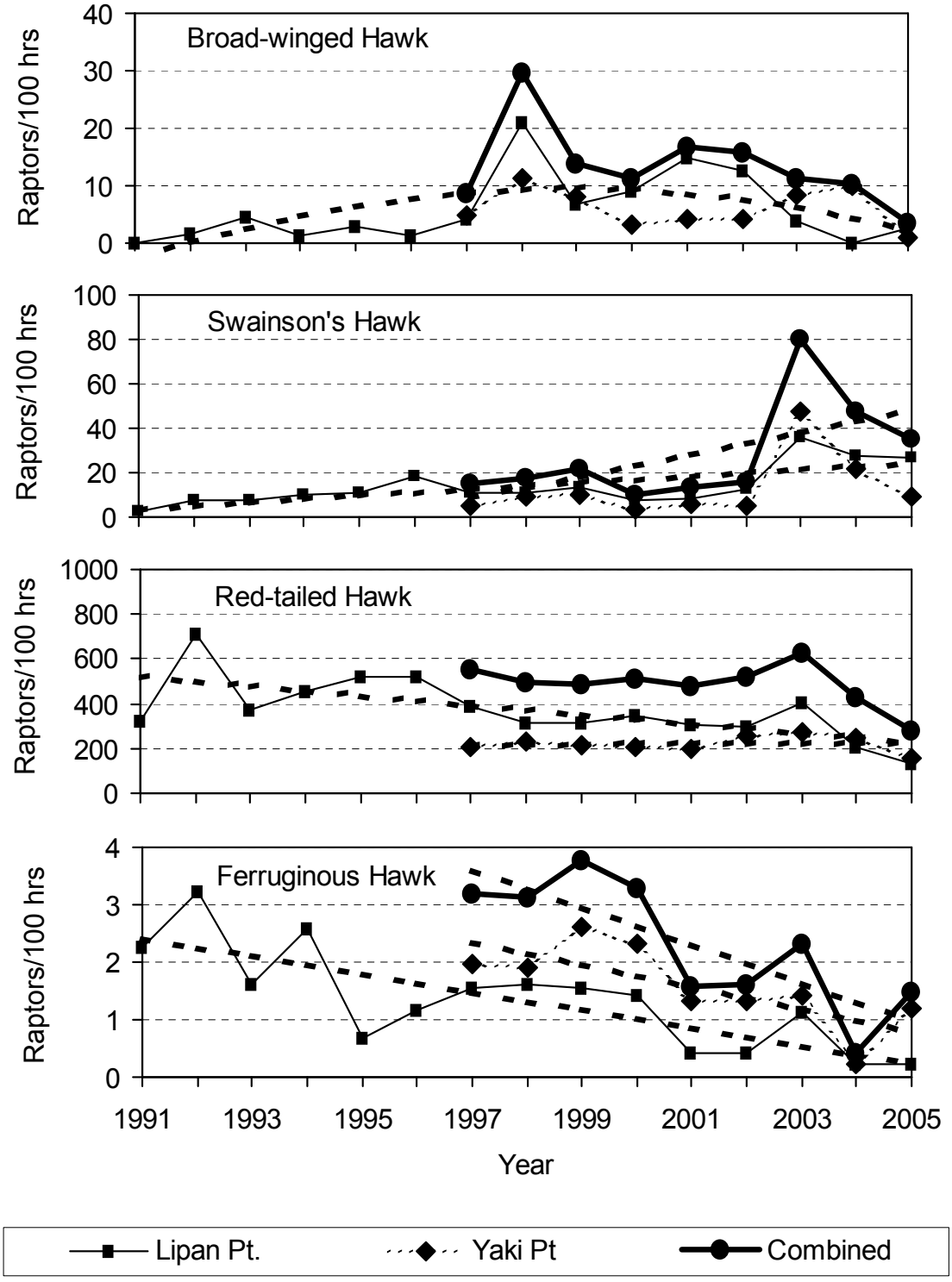

Figure 5. Adjusted (truncated to standardized annual sampling periods and adjusted for incompletely identified birds) fall-migration passage rates for Broad-winged, Swainson's, Red-tailed, and Ferruginous Hawks in the Grand Canyon, AZ: 1991–2005. Dashed lines indicate significant ($P \leq 0.10$) linear or quadratic regressions.

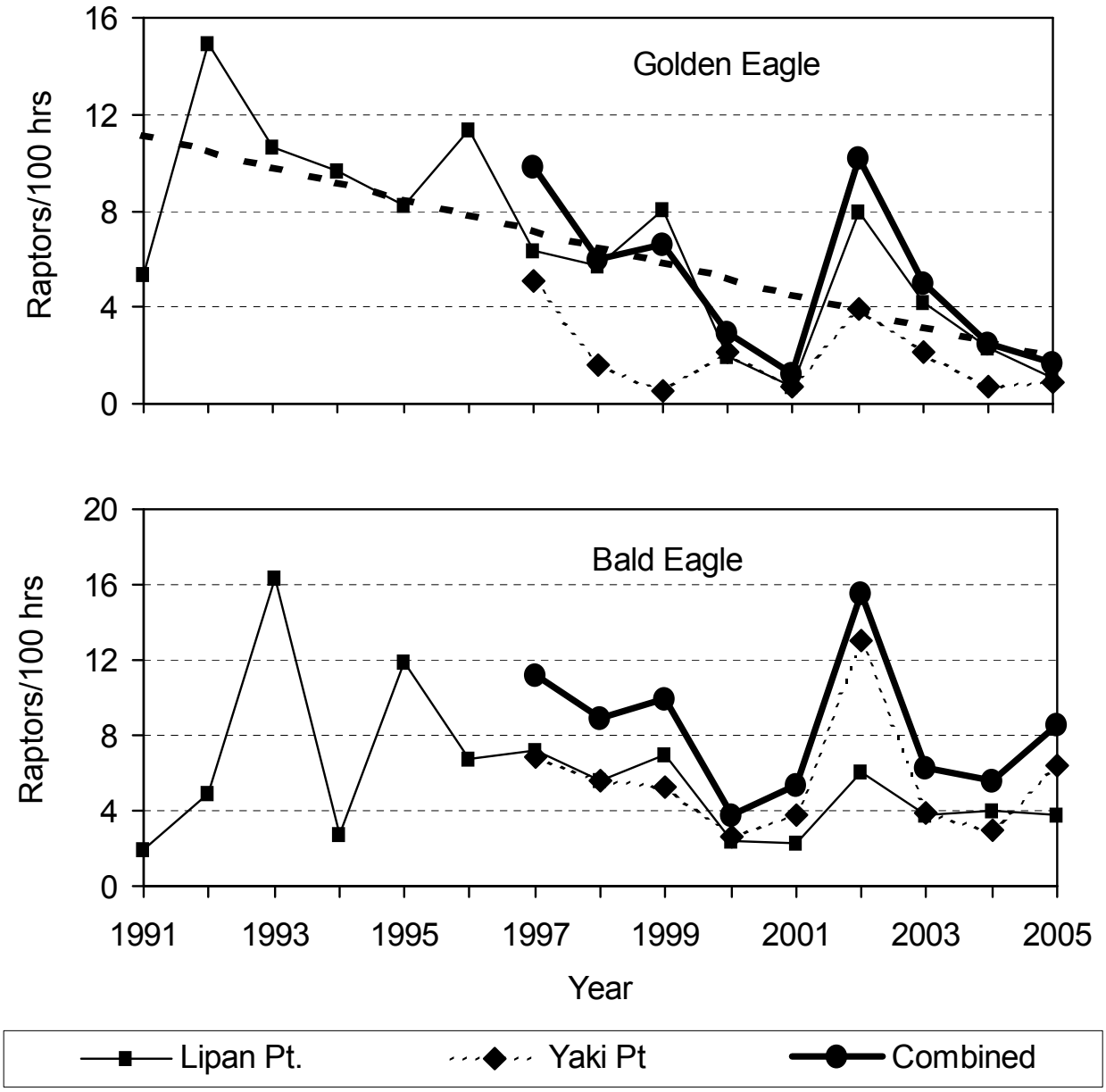

Figure 6. Adjusted (truncated to standardized annual sampling periods and adjusted for incompletely identified birds) fall-migration passage rates for Golden and Bald Eagles in the Grand Canyon, AZ: 1991–2005. Dashed lines indicate significant ($P \leq 0.10$) linear or quadratic regressions.

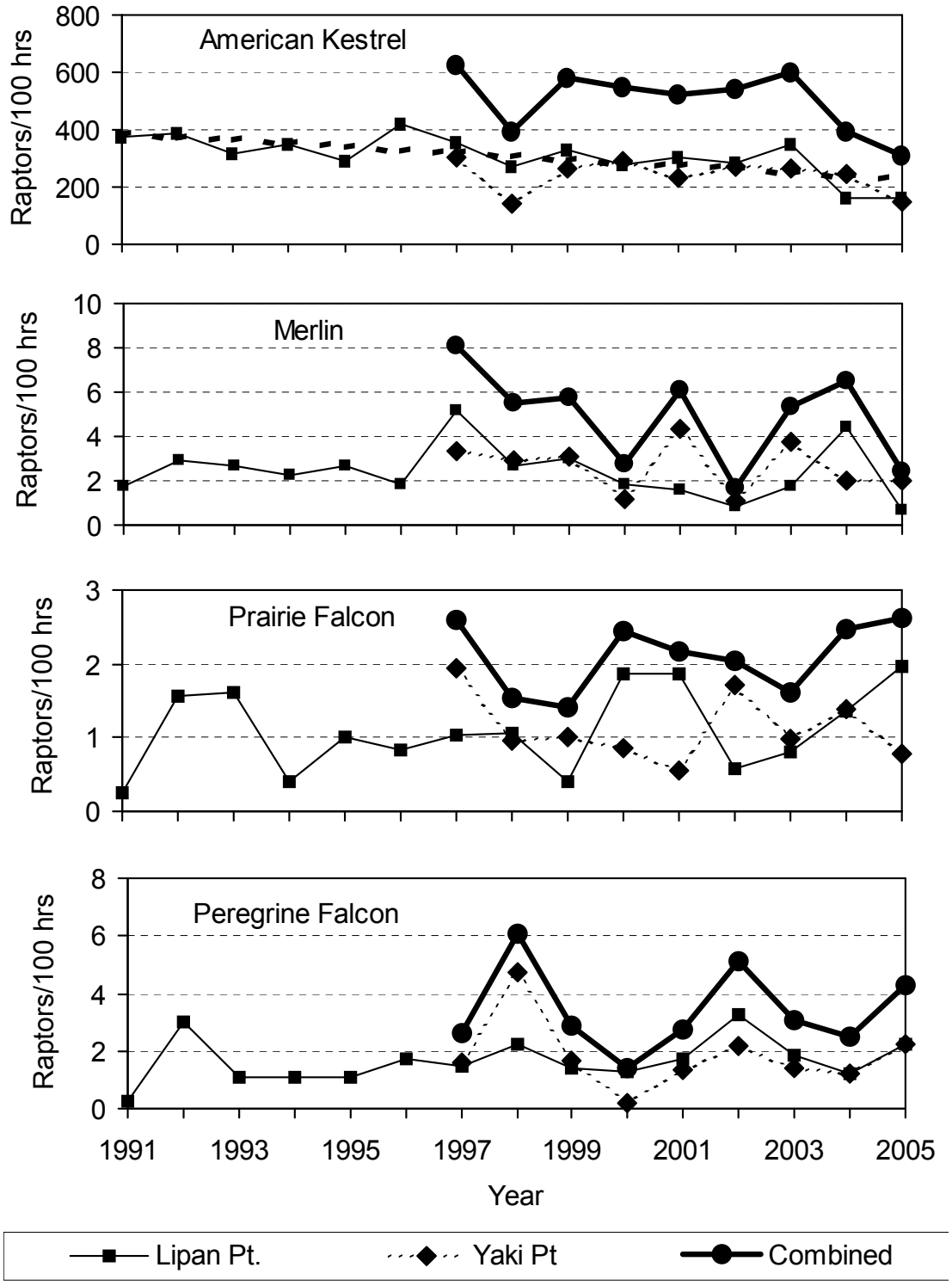

Figure 7. Adjusted (truncated to standardized annual sampling periods and adjusted for incompletely identified birds) fall-migration passage rates for American Kestrels, Merlins, Prairie Falcons, and Peregrine Falcons in the Grand Canyon, AZ: 1991–2005. Dashed lines indicate significant ($P \leq 0.10$) linear or quadratic regressions.

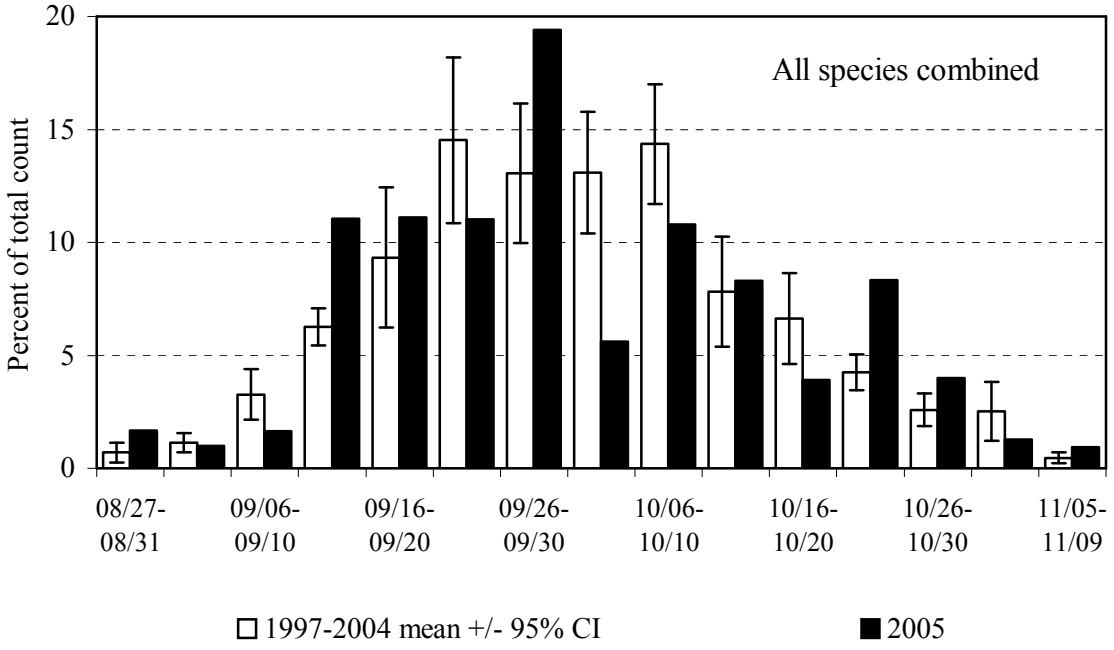

Figure 8. Combined-species, fall-migration passage volume by five-day periods for raptors in the Grand Canyon: 1997–2004 versus 2005 (Lipan Point and Yaki Point data combined).

Appendix A. History of official observer participation in the Grand Canyon raptor migration studies: 1991–2005.

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 (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).

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).

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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: 2005.

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	9.00	2.1	0	clr-pc	8.8	wsw-w	33.4	29.83	1	50	50	1	1.7
28-Aug	9.00	2.1	0	clr-pc	1.9	calm, w	31.0	29.79	1	74	74	1	1.0
29-Aug	9.00	2.1	0	clr	6.8	w, calm	32.4	29.72	1	72	72	1	1.9
30-Aug	9.00	2.1	0	clr	6.7	ene-e	29.8	29.67	2	69	69	1	0.2
31-Aug	9.00	2.2	0	clr-pc	1.0	nw, ssw-w, calm	27.9	29.76	1	35	33	1	0.8
1-Sep	7.40	2.1	0	clr-ovc, scat ts	2.9	calm/var	29.3	29.77	2	41	41	1	1.4
2-Sep	6.08	2.0	0	clr-mc	3.8	calm/var	26.9	29.82	2	63	63	1	1.8
3-Sep	7.50	2.4	0	mc-ovc	1.8	s-w, calm	23.0	29.90	2	56	56	1	0.3
4-Sep	8.08	3.2	0	clr-ovc, scat ts	2.6	calm/var	23.0	29.87	3	3	20	1	0.9
5-Sep	9.00	2.0	0	clr-ovc	2.7	calm, w	24.0	29.89	2	5	24	1	1.2
6-Sep	9.00	2.7	0	pc-mc	4.6	w	24.9	29.89	2	44	44	0	2.0
7-Sep	9.00	3.1	0	pc	2.2	wsw-nw	26.7	29.78	1	75	75	1	1.9
8-Sep	9.00	2.0	0	mc-clr	1.3	calm, w-nw	25.6	29.79	2	65	66	1	1.0
9-Sep	8.92	2.0	0	pc-mc	23.0	s-wsw	23.6	29.62	4	30	30	1	0.6
10-Sep	9.00	2.2	0	clr	23.8	sw-nw	21.7	29.60	4	17	17	0	1.4
11-Sep	9.00	2.2	0	clr	11.6	s-wnw	22.2	29.65	2	17	17	1	2.6
12-Sep	9.08	2.9	0	clr	25.0	w	19.9	29.72	2	62	62	1	1.2
13-Sep	9.00	2.9	0	clr/haze	6.6	ne, w	25.7	29.66	1	40	40	1	6.3
14-Sep	9.00	2.2	0	clr-pc	5.0	w	24.0	29.68	2	21	21	1	8.4
15-Sep	7.92	3.1	1.5	clr	3.8	calm/var	23.6	29.78	1	42	42	4	11.6
16-Sep	8.00	3.1	0	clr	10.1	sw-w	21.4	29.76	1	36	32	1	3.0
17-Sep	8.00	2.5	0	clr	10.4	wnw	21.3	29.71	1	41	49	1	6.5
18-Sep	9.00	2.7	0	clr	7.2	calm/var	22.0	29.70	1	38	36	1	14.2
19-Sep	8.00	2.9	0	clr-pc, AM haze	2.9	calm/var	23.6	29.98	1	53	53	1	12.0
20-Sep	5.50	2.5	0	clr-mc	5.6	ene-ese, calm	24.6	29.93	2	21	23	1	8.9
21-Sep	7.92	2.0	0	mc-ovc, AM haze	8.4	sw	23.7	29.84	4	33	32	1	2.3
22-Sep	8.00	2.3	0	pc	6.4	calm, wsw	27.0	29.71	3	39	39	1	8.3
23-Sep	8.00	3.0	0	clr-pc	9.6	sw-nw	22.8	29.60	2	22	24	0	10.1
24-Sep	8.00	2.1	0	clr-mc	3.7	w	23.3	29.57	2	36	28	2	5.0
25-Sep	9.08	2.0	0	clr	8.0	w-nw	22.1	29.80	1	70	61	1	27.9
26-Sep	7.23	3.8	0	clr-ovc, PM haze/rain	1.3	calm, se	26.2	29.89	1	66	51	4	24.3
27-Sep	8.00	2.3	0	pc-ovc	11.1	sw-w	23.3	29.75	2	47	39	1	5.9
28-Sep	8.00	2.4	0	clr-pc	4.5	calm, w	18.6	29.81	1	64	64	1	5.6
29-Sep	8.25	2.0	0	clr	1.6	w-wnw	19.7	29.75	1	51	51	1	5.9
30-Sep	7.83	2.9	0	clr-pc	0.8	w-nw, calm	22.9	29.78	1	67	57	4	28.1
1-Oct	8.00	2.0	0	clr-pc	12.6	w	23.1	29.72	1	62	62	1	23.5
2-Oct	8.00	2.0	0	clr-pc	9.7	wsw-w	21.6	29.65	2	50	42	1	2.1
3-Oct	8.08	2.0	0	clr	24.4	sw	20.6	29.53	2	49	48	1	1.4
4-Oct	8.00	2.3	0	ovc-pc	12.7	calm, ene, sw	22.2	29.47	4	36	50	0	0.6
5-Oct	8.00	2.4	0	clr	1.0	calm/var	15.2	29.71	1	53	52	0	2.0
6-Oct	8.00	2.1	0	clr/haze	0.4	calm, nne	16.2	29.76	1	90	66	1	5.0

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
7-Oct	8.00	2.7	0	clr	4.4	wsw	22.1	29.64	1	51	36	1	22.5
8-Oct	8.00	2.1	0	clr-ovc	26.0	w	19.2	29.39	2	51	39	0	2.3
9-Oct	8.00	1.9	0	mc-ovc	0.3	calm/var	18.6	29.38	2	70	69	1	3.8
10-Oct	8.00	1.9	0	clr-pc, haze	1.5	calm/var	16.0	29.63	1	73	64	2	2.1
11-Oct	7.92	2.4	0	clr/haze	0.2	calm, s	22.2	29.62	2	50	36	4	17.9
12-Oct	8.00	1.9	0	ovc-pc	1.5	calm, w	16.7	29.77	1	68	66	1	1.5
13-Oct	7.83	2.0	0	clr, PM haze	2.3	calm, ne	19.0	29.90	1	63	63	1	2.9
14-Oct	7.75	2.2	0	clr	2.9	e-ese, calm	21.9	29.88	2	52	49	1	3.7
15-Oct	5.50	2.8	0	clr-ovc, scat rain/ts	3.1	wnw-nw	17.0	29.67	2	47	42	1	5.3
16-Oct	8.00	2.9	0	ovc-pc	1.1	calm, e	16.7	29.78	2	41	43	0	1.3
17-Oct	8.00	2.0	0	ovc	9.3	ese	16.7	29.95	4	23	23	0	0.1
18-Oct	0.00			weather day									
19-Oct	8.08	2.4	0	clr	5.3	wsw-w	11.4	29.77	1	64	54	1	6.7
20-Oct	8.00	2.2	0	clr	0.9	calm, w, e	13.7	29.84	1	65	57	0	4.4
21-Oct	8.00	2.2	0	mc-ovc	0.3	e, calm	20.0	29.89	3	60	60	1	1.0
22-Oct	8.00	2.4	0	clr	0.3	ene, calm	16.6	29.74	1	65	59	1	5.6
23-Oct	7.17	2.0	1.5	pc-mc, scat ts	5.3	calm, s	20.2	29.71	2	60	54	1	4.7
24-Oct	7.50	2.0	0	clr-pc	2.9	ene, calm	16.4	29.96	1	53	53	1	4.7
25-Oct	3.92	2.1	0	clr-ovc, scat rain/ts	5.1	e, calm/var	16.5	29.80	3	66	66	0	0.3
26-Oct	8.00	2.2	0	clr-pc	0.2	calm, ene	19.7	29.76	1	30	25	2	6.8
27-Oct	8.00	2.2	0	pc-ovc, PM haze	8.0	s, calm, w	15.4	29.70	2	59	53	2	6.5
28-Oct	2.00	2.0	0	ovc, scat rain	10.6	ssw-w, calm	11.4	29.74	4	14	6	-	0.0
29-Oct	7.83	1.7	0	pc	1.0	calm, e-ese	19.0	29.82	2	65	65	1	2.4
30-Oct	8.00	2.0	0	clr, haze	10.4	ssw-w	12.7	29.90	1	60	57	1	1.9
31-Oct	8.00	2.0	0	clr, haze	0.2	ssw, calm	13.9	30.12	1	64	46	1	0.9
1-Nov	8.00	2.0	0	clr	6.3	e	14.2	30.02	1	50	42	1	0.5
2-Nov	8.00	2.0	0	mc-ovc	9.4	sw-wsw	16.6	29.80	2	54	43	1	0.1
3-Nov	8.00	2.0	0	ovc-clr	14.3	s-wsw	13.2	29.67	2	54	53	1	0.5
4-Nov	8.00	1.6	0	clr, haze	2.8	ene, s	14.8	29.61	1	65	65	1	2.5
5-Nov	6.00	1.8	0	clr-pc	2.4	var	17.1	29.71	2	60	60	1	2.3

[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: 2005.

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	9.42	2.0	0	clr-pc	3.4	s, w-nnw	32.3	29.61	2	1	8	2
28-Aug	9.00	2.0	0	clr-pc	3.4	calm, sse	31.6	29.57	2	1	8	2
29-Aug	8.83	1.9	0	clr	7.5	calm/var	31.3	29.53	2	1	8	2
30-Aug	9.00	1.4	0	clr	18.4	var	28.3	29.45	3	1	11	2
31-Aug	9.00	1.2	0	clr-pc, haze	4.8	calm, ne-e, s	23.1	29.54	2	1	3	2
1-Sep	9.00	2.0	0	clr-mc	6.4	ne-ese	27.5	29.54	2	0	0	2
2-Sep	9.00	1.8	0	clr-ovc	5.8	calm/var	26.4	29.61	2	49	49	2
3-Sep	6.25	2.0	0	ovc-pc	5.8	calm/var	23.5	29.60	3	1	4	2
4-Sep	9.00	2.2	0	clr-ovc, scat rain, haze	3.0	calm, w	25.1	29.62	2	61	58	2
5-Sep	9.00	1.9	0	pc-ovc	3.3	calm/var	28.5	29.57	2	0	0	2
6-Sep	9.00	2.3	1	mc-clr	4.2	calm/var	25.2	29.60	2	17	17	2
7-Sep	8.92	1.2	0	pc-mc	2.8	calm/var	30.1	29.58	2	22	22	2
8-Sep	9.00	2.9	1	ovc-pc	2.0	calm/var	26.0	29.57	4	39	37	2
9-Sep	9.00	1.0	0	clr-mc	20.9	sse-ssw, sw-nw	24.0	29.32	2	35	46	2
10-Sep	9.00	3.0	0	clr	14.8	ese-s, ssw-nw	21.0	29.37	1	60	60	1
11-Sep	9.08	3.0	1	clr	20.6	s-w	22.0	29.47	2	65	65	2
12-Sep	9.25	1.7	1	clr	17.4	ssw-wnw	21.2	29.43	3	18	18	2
13-Sep	9.00	1.9	0	clr	8.4	sse-w	20.9	29.38	1	18	22	1
14-Sep	9.50	1.7	0	clr	10.0	wnw	20.9	29.48	1	60	60	2
15-Sep	8.92	3.5	0	clr	3.9	e, nnw	23.4	29.56	1	18	18	2
16-Sep	8.25	2.6	1	clr	13.3	sw-nw	24.0	29.54	3	30	30	2
17-Sep	7.50	2.5	1	clr	9.1	var	20.7	29.44	1	27	26	2
18-Sep	8.50	2.9	0	pc	16.3	s-sw	20.9	29.51	1	57	56	2
19-Sep	9.00	1.4	0	clr	5.8	e-ese, wnw	22.6	29.66	1	26	22	2
20-Sep	6.75	1.3	0	pc-ovc, scat rain/ts	12.4	ene-ese	21.7	29.71	3	44	44	2
21-Sep	7.33	1.3	0	ovc	15.9	wsw-w	25.2	29.53	4	42	39	2
22-Sep	8.00	1.9	0	pc	7.3	var	22.3	29.45	2	21	19	2
23-Sep	8.00	1.5	1	ovc-mc	16.6	s-sw, w-nnw	22.1	29.41	3	43	41	2
24-Sep	8.00	2.0	0	pc-ovc	26.3	w	20.9	29.34	2	58	58	1
25-Sep	9.25	2.9	0	clr	9.4	wsw	21.8	29.51	1	17	18	1
26-Sep	8.00	3.3	0	clr-ovc, scat rain	17.7	e, s	22.2	29.63	2	61	61	2
27-Sep	6.50	1.4	0	ovc	8.2	s-sw	24.4	29.51	3	33	33	2
28-Sep	8.00	1.9	1	clr-mc, scat rain	1.0	calm/var	21.9	29.55	1	68	59	3
29-Sep	9.00	2.9	1	clr	2.3	se, nnw, calm	23.4	29.49	3	59	59	2
30-Sep	8.75	2.2	0	clr	4.4	wsw-wnw	21.2	29.46	1	24	26	2
1-Oct	8.75	3.7	0	clr-pc	12.8	sw-wnw	21.7	29.40	2	24	26	2
2-Oct	8.00	2.0	0	clr	27.6	sse-ssw, w	21.6	29.36	2	17	21	1
3-Oct	8.00	2.0	0	clr	25.2	s-ssw, wnw-nnw	21.1	29.32	3	30	15	2
4-Oct	7.75	1.0	0	ovc-clr	29.1	s, nw-n	18.0	29.30	3	56	56	2
5-Oct	8.00	2.0	0	clr	18.6	se, ne	12.7	29.49	2	68	68	2
6-Oct	8.08	2.6	0	clr	6.1	ne-se	20.8	29.47	2	49	49	2

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
7-Oct	8.00	2.2	0	clr/haze	14.8	sw-wnw	21.0	29.44	1	47	42	2
8-Oct	7.83	2.0	0	clr-ovc, haze/dust	26.7	s-sw, nw	18.9	29.19	3	42	35	2
9-Oct	8.00	2.8	0	clr	5.3	calm, w-nw	15.0	29.16	1	49	49	2
10-Oct	8.58	3.1	0	clr	2.2	calm, e-ese, sw-nnw	14.0	29.36	1	43	45	3
11-Oct	7.92	2.7	0	clr, haze	11.7	sw, calm, wnw-n	15.2	29.44	1	60	60	2
12-Oct	8.75	2.0	0	mc-pc	4.8	calm/var	17.2	29.52	3	55	46	3
13-Oct	8.67	3.0	1	clr	3.6	var	16.0	29.65	1	55	47	2
14-Oct	8.00	1.4	0	clr	1.7	e	17.3	29.69	1	48	49	2
15-Oct	7.92	2.3	1	clr-ovc, scat rain	16.1	sw-w	17.2	29.38	3	52	54	2
16-Oct	8.00	1.9	0	mc-ovc	10.6	e-se	16.8	29.57	3	39	38	2
17-Oct	7.42	1.9	0	ovc	8.6	e-se	17.1	29.56	3	51	51	2
18-Oct	0.00			Weather Day								
19-Oct	8.00	1.5	0	mc-ovc	5.9	sw-n	12.5	29.49	3	38	36	2
20-Oct	8.08	1.4	0	clr	5.1	se	17.3	29.52	3	58	60	3
21-Oct	7.90	1.6	0	pc-mc	9.0	nne-e, se	15.1	29.59	2	37	33	3
22-Oct	8.00	3.0	0	clr-mc	7.0	ene-ese, calm	15.3	29.44	1	49	43	3
23-Oct	8.00	2.6	0	clr-pc	3.6	ese, calm	14.6	29.36	1	50	52	2
24-Oct	8.00	1.0	0	clr-pc	3.3	ne	20.6	29.55	2	60	54	2
25-Oct	8.00	1.8	0	clr-mc	16.1	se-s, wsw	14.9	29.41	2	54	53	2
26-Oct	8.00	1.3	0	clr-mc, haze	7.3	calm, nnw	12.3	29.47	1	60	56	2
27-Oct	7.75	2.0	0	mc-ovc	8.0	s-w	14.5	29.42	4	39	38	3
28-Oct	1.00	1.0	0	ovc, fog/rain	11.0	sw-wsw	11.3	29.36	4	9	4	-
29-Oct	8.00	2.0	0	clr	7.8	se, ssw, wnw	11.1	29.44	1	33	37	3
30-Oct	8.00	2.1	0	clr	6.9	wsw-nnw	17.0	29.56	2	50	50	2
31-Oct	7.83	1.0	0	clr	4.9	nne-ese	15.2	29.75	2	49	49	2
1-Nov	8.00	2.0	1.5	clr	8.6	ne-ese	14.6	29.69	3	93	93	2
2-Nov	7.83	1.0	0	mc-ovc	10.7	s-sw, w	18.7	29.48	3	80	80	1
3-Nov	6.83	1.0	0	ovc-pc	20.1	s-sw	15.9	29.33	4	45	45	1
4-Nov	7.83	1.0	0	clr	14.3	s-ssw, ne-e	14.3	29.73	4	45	45	2
5-Nov	6.75	1.5	1	clr	3.4	var			3	99	99	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: 2005.

	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	9.00	1	0	0	1	0	0	1	0	0	0	0	4	0	0	0	0	0	0	0	7	0	1	0	0	0	0	0	15	1.7
28-Aug	9.00	1	1	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	3	0	0	0	0	1	0	0	9	1.0
29-Aug	9.00	2	1	1	1	0	0	0	0	0	0	0	4	0	0	0	1	0	0	0	7	0	0	0	0	0	0	0	17	1.9
30-Aug	9.00	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2	0.2
31-Aug	9.00	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	7	0.8
01-Sep	7.40	0	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	5	0	0	0	1	0	0	0	10	1.4
02-Sep	6.08	0	0	0	0	0	1	0	0	0	0	1	5	0	0	0	0	0	0	0	2	1	1	0	0	0	0	0	11	1.8
03-Sep	7.50	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0.3
04-Sep	8.08	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	1	0	0	0	0	0	7	0.9
05-Sep	9.00	1	3	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	11	1.2
06-Sep	9.00	0	1	3	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	18	2.0
07-Sep	9.00	1	0	4	0	0	0	0	0	0	0	1	3	0	0	0	0	0	0	0	7	0	0	1	0	0	0	0	17	1.9
08-Sep	9.00	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	4	0	0	0	0	0	0	1	9	1.0
09-Sep	8.92	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	5	0.6
10-Sep	9.00	1	0	1	2	0	1	0	0	0	0	2	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	13	1.4
11-Sep	9.00	3	0	4	0	0	1	0	0	0	0	4	3	0	0	0	0	0	0	0	7	0	0	0	1	0	0	0	23	2.6
12-Sep	9.08	0	0	3	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	11	1.2
13-Sep	9.00	1	0	10	6	0	4	0	0	0	0	0	11	0	0	0	1	0	0	0	18	0	5	1	0	0	0	0	57	6.3
14-Sep	9.00	1	0	17	9	0	7	0	6	0	0	0	9	0	0	0	0	0	0	0	26	0	0	0	0	1	0	0	76	8.4
15-Sep	7.92	0	2	30	9	1	6	0	2	0	0	0	10	0	0	0	0	0	0	0	32	0	0	0	0	0	0	0	92	11.6
16-Sep	8.00	2	0	7	2	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	9	0	0	0	0	0	0	1	24	3.0
17-Sep	8.00	1	0	25	3	0	2	0	0	0	0	0	9	0	0	0	0	0	0	0	11	1	0	0	0	0	0	0	52	6.5
18-Sep	9.00	1	2	23	24	1	1	0	0	0	1	0	8	0	0	0	0	0	1	0	65	0	0	0	0	0	1	0	128	14.2
19-Sep	8.00	1	3	19	13	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	49	0	0	0	0	0	0	0	96	12.0
20-Sep	5.50	0	0	7	3	0	1	0	0	0	0	0	7	0	0	0	0	0	0	0	30	0	0	0	0	0	0	1	49	8.9
21-Sep	7.92	1	1	9	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	18	2.3
22-Sep	8.00	1	0	23	10	0	2	0	0	0	0	1	8	0	0	0	4	0	0	0	10	0	0	2	0	0	0	5	66	8.3
23-Sep	8.00	3	0	25	24	0	5	0	0	0	0	1	4	0	0	0	2	0	0	0	17	0	0	0	0	0	0	0	81	10.1
24-Sep	8.00	0	0	18	7	0	5	0	0	0	0	0	6	0	0	0	0	0	0	0	3	0	0	0	0	0	0	1	40	5.0
25-Sep	9.08	12	5	99	36	0	7	0	0	0	2	2	16	0	0	0	3	0	0	0	71	0	0	0	0	0	0	0	253	27.9
26-Sep	7.23	2	1	53	30	0	9	0	1	0	0	2	20	0	0	0	3	0	0	0	53	0	1	1	0	0	0	0	176	24.3
27-Sep	8.00	0	0	18	11	0	0	0	2	0	0	4	2	0	0	0	1	0	0	0	8	0	0	1	0	0	0	0	47	5.9
28-Sep	8.00	2	1	14	17	0	2	0	2	0	0	0	1	0	0	0	1	0	0	0	5	0	0	0	0	0	0	0	45	5.6
29-Sep	8.25	1	0	15	7	0	0	0	3	0	0	0	1	0	0	0	0	0	0	0	22	0	0	0	0	0	0	0	49	5.9
30-Sep	7.83	0	2	66	37	0	17	0	0	0	0	12	47	0	0	0	4	0	0	0	34	0	0	1	0	0	0	0	220	28.1
01-Oct	8.00	4	1	53	23	0	5	0	3	0	0	39	39	0	0	0	4	0	0	0	17	0	0	0	0	0	0	0	188	23.5
02-Oct	8.00	1	0	9	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	2	0	0	1	0	0	0	0	17	2.1

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		
03-Oct	8.08	2	0	5	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2	0	0	1	0	0	0	0	11	1.4
04-Oct	8.00	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	5	0.6
05-Oct	8.00	0	0	8	4	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	2.0
06-Oct	8.00	0	2	14	2	0	0	0	2	0	0	0	14	0	0	0	1	0	1	0	4	0	0	0	0	0	0	0	40	5.0
07-Oct	8.00	0	0	45	31	0	8	0	3	0	0	2	63	0	0	0	2	2	2	0	21	0	0	0	0	0	0	1	180	22.5
08-Oct	8.00	1	0	8	1	0	1	0	0	0	0	0	4	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	18	2.3
09-Oct	8.00	0	0	15	5	0	4	0	0	0	0	0	4	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	30	3.8
10-Oct	8.00	0	1	3	1	0	0	0	1	0	0	0	3	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	17	2.1
11-Oct	7.92	0	2	21	12	0	6	0	0	0	1	4	85	0	0	0	2	0	0	0	9	0	0	0	0	0	0	0	142	17.9
12-Oct	8.00	0	0	7	2	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	12	1.5
13-Oct	7.83	1	0	13	2	0	0	0	0	0	0	0	4	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	23	2.9
14-Oct	7.75	0	0	15	3	0	3	0	0	0	0	0	5	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	29	3.7
15-Oct	5.50	0	1	10	5	0	1	0	0	0	0	0	5	0	0	0	1	0	0	0	3	0	0	0	0	0	0	3	29	5.3
16-Oct	8.00	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	10	1.3
17-Oct	8.00	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	0.1
18-Oct	0.00																													
19-Oct	8.08	0	2	26	4	0	0	0	1	0	0	0	18	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	54	6.7
20-Oct	8.00	0	2	25	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	35	4.4
21-Oct	8.00	0	1	4	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	1.0
22-Oct	8.00	0	0	26	2	1	0	0	0	0	1	0	12	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	45	5.6
23-Oct	7.17	0	3	18	4	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	34	4.7
24-Oct	7.50	1	3	8	2	0	0	1	0	0	0	0	17	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	35	4.7
25-Oct	3.92	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	0	1	0.3
26-Oct	8.00	0	0	19	4	0	0	0	0	0	0	0	26	0	0	0	0	0	2	0	2	0	0	0	0	0	0	1	54	6.8
27-Oct	8.00	0	1	9	0	0	0	0	0	0	0	0	36	0	0	0	1	0	3	0	1	0	0	0	0	0	0	1	52	6.5
28-Oct	2.00	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	0.0
29-Oct	7.83	0	0	8	1	0	1	0	0	0	0	0	5	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	19	2.4
30-Oct	8.00	0	1	5	1	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	15	1.9
31-Oct	8.00	0	0	5	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0.9
01-Nov	8.00	0	0	2	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0.5
02-Nov	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
03-Nov	8.00	0	0	1	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0.5
04-Nov	8.00	0	0	0	0	0	0	0	1	0	0	0	17	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	20	2.5
05-Nov	6.00	0	0	1	0	1	0	0	0	0	0	0	8	0	0	0	1	0	1	0	0	1	0	0	0	1	0	0	14	2.3
Total	554.38	52	44	891	377	5	104	2	28	0	6	80	594	1	0	0	36	4	14	0	639	4	9	10	2	3	1	20	2926	5.3

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

Appendix F. Daily raptor migration counts by species at Yaki Point, Grand Canyon, AZ: 2005.

	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	9.42	0	0	0	1	0	0	0	0	0	0	0	9	0	0	0	2	0	0	0	0	1	0	0	1	1	1	0	16	1.7
28-Aug	9.00	0	1	1	0	0	0	0	0	0	0	0	7	0	0	0	1	0	0	0	7	0	1	0	0	0	1	0	19	2.1
29-Aug	8.83	0	0	0	2	0	1	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0.7
30-Aug	9.00	0	0	0	1	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	3	0	0	0	0	0	0	0	7	0.8
31-Aug	9.00	0	0	1	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0.4
01-Sep	9.00	0	0	2	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	7	0.8
02-Sep	9.00	0	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	3	0.3
03-Sep	6.25	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	0.6
04-Sep	9.00	1	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	3	0.3
05-Sep	9.00	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2	0.2
06-Sep	9.00	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	10	1.1
07-Sep	8.92	0	0	0	0	0	2	0	0	0	0	0	5	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	11	1.2
08-Sep	9.00	1	2	1	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	8	0.9
09-Sep	9.00	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	4	0.4
10-Sep	9.00	3	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	6	0.7
11-Sep	9.08	8	0	10	4	0	0	0	0	0	0	0	6	1	0	0	1	0	0	0	23	1	0	1	0	0	0	0	55	6.1
12-Sep	9.25	0	1	5	2	0	1	0	1	0	0	0	7	0	0	0	1	0	0	0	45	1	0	0	0	1	0	0	65	7.0
13-Sep	9.00	0	0	2	6	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	24	2.7
14-Sep	9.50	1	0	64	47	0	5	0	0	0	0	1	7	2	0	0	1	0	0	0	41	0	0	0	0	0	0	1	170	17.9
15-Sep	8.92	0	0	27	22	0	11	0	6	0	0	0	11	0	0	0	6	0	0	0	17	0	0	0	0	0	0	0	100	11.2
16-Sep	8.25	2	0	10	8	0	6	0	0	0	0	0	9	0	0	0	0	0	0	0	13	0	0	0	0	0	0	1	49	5.9
17-Sep	7.50	2	0	14	11	0	1	0	2	0	0	0	8	0	0	0	0	0	0	0	13	1	0	0	0	0	0	0	52	6.9
18-Sep	8.50	0	0	29	7	0	3	0	0	0	0	1	4	0	0	0	0	0	0	0	40	0	0	0	0	0	0	1	85	10.0
19-Sep	9.00	0	1	42	22	1	0	0	0	0	0	1	6	0	0	0	0	0	0	0	40	0	0	0	0	0	0	0	113	12.6
20-Sep	6.75	2	0	14	5	1	2	0	0	0	1	0	1	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	30	4.4
21-Sep	7.33	0	0	11	1	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	16	2.2
22-Sep	8.00	2	0	17	6	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	31	3.9
23-Sep	8.00	0	0	6	9	0	0	0	0	0	0	0	4	0	0	0	1	0	0	0	3	0	0	0	0	0	0	0	23	2.9
24-Sep	8.00	1	0	6	5	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	12	1	0	0	0	0	0	0	27	3.4
25-Sep	9.25	4	0	23	24	0	8	0	0	0	0	0	9	0	0	0	1	0	0	0	48	0	0	0	0	0	0	0	117	12.6
26-Sep	8.00	1	0	53	33	0	6	1	0	0	1	15	9	0	0	0	0	0	0	0	16	0	0	0	0	0	0	0	135	16.9
27-Sep	6.50	0	0	13	3	0	1	0	0	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	20	3.1
28-Sep	8.00	0	0	27	15	0	10	0	0	0	0	2	4	0	0	0	0	0	0	0	21	0	0	0	0	0	0	1	80	10.0
29-Sep	9.00	0	4	40	19	0	8	0	1	0	0	3	19	0	0	0	1	0	0	0	25	0	0	0	0	0	0	2	122	13.6
30-Sep	8.75	0	0	113	79	0	3	0	3	0	0	5	39	0	0	0	2	1	1	0	43	0	0	0	0	0	0	0	289	33.0
01-Oct	8.75	0	1	28	5	0	1	1	0	0	0	0	11	0	0	0	0	0	1	0	11	0	0	1	0	0	0	0	60	6.9
02-Oct	8.00	0	0	12	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	17	2.1

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		
03-Oct	8.00	0	0	1	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	5	0.6
04-Oct	7.75	0	0	3	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	9	1.2
05-Oct	8.00	0	0	6	3	0	2	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	1.8
06-Oct	8.08	0	1	46	36	0	11	1	0	0	0	2	20	0	0	0	0	0	0	0	17	0	0	1	0	0	0	0	135	16.7
07-Oct	8.00	0	0	16	11	0	1	0	0	0	0	1	15	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	46	5.8
08-Oct	7.83	0	0	3	2	0	2	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	12	1.5
09-Oct	8.00	0	1	40	19	0	4	0	0	0	0	0	22	0	0	0	1	0	0	0	10	0	1	0	0	0	0	0	98	12.3
10-Oct	8.58	0	4	18	8	0	3	0	1	0	0	1	26	1	0	0	0	0	0	0	19	1	0	0	0	0	0	0	82	9.6
11-Oct	7.92	0	1	17	5	0	0	0	0	0	0	0	17	0	0	0	0	0	0	0	4	1	0	0	0	0	0	1	46	5.8
12-Oct	8.75	0	0	17	7	0	1	0	0	0	0	0	21	0	0	0	1	0	0	0	12	0	0	0	0	0	0	0	59	6.7
13-Oct	8.67	0	5	57	22	0	2	0	0	0	0	0	25	1	0	0	1	0	2	0	10	0	0	0	0	0	0	1	126	14.5
14-Oct	8.00	0	0	15	10	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	2	0	0	1	0	0	0	0	31	3.9
15-Oct	7.92	0	0	5	0	0	2	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	9	1.1
16-Oct	8.00	0	0	9	1	0	1	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	1.6
17-Oct	7.42	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
18-Oct	0.00																													
19-Oct	8.00	0	1	25	1	0	0	0	0	0	0	0	11	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	40	5.0
20-Oct	8.08	0	2	27	7	0	2	0	0	0	0	0	36	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	79	9.8
21-Oct	7.90	0	1	3	1	0	0	0	0	0	0	0	14	0	0	0	2	0	0	0	1	1	0	0	0	0	1	1	25	3.2
22-Oct	8.00	0	4	43	10	0	1	0	0	0	0	0	118	0	0	0	0	2	0	0	3	1	0	0	0	0	0	1	183	22.9
23-Oct	8.00	0	4	31	8	0	0	1	1	0	0	0	37	0	0	0	0	1	3	0	0	0	0	0	0	0	0	2	88	11.0
24-Oct	8.00	0	0	14	4	0	2	0	0	0	0	0	41	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	63	7.9
25-Oct	8.00	0	0	2	0	0	0	0	0	0	0	0	23	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	26	3.3
26-Oct	8.00	1	0	7	4	0	1	0	0	0	0	0	25	0	0	0	0	0	2	0	0	0	0	2	0	0	0	0	42	5.3
27-Oct	7.75	0	0	1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0.4
28-Oct	1.00	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	0.0
29-Oct	8.00	0	0	3	1	0	0	0	0	0	0	0	9	0	0	0	0	0	1	0	1	0	0	3	0	0	0	0	18	2.3
30-Oct	8.00	0	0	5	3	0	0	0	0	0	0	0	32	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	41	5.1
31-Oct	7.83	0	0	2	3	0	1	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	1.7
01-Nov	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
02-Nov	7.83	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	7	0.9
03-Nov	6.83	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	3	0.4
04-Nov	7.83	0	0	1	0	0	0	0	0	0	0	0	11	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	16	2.0
05-Nov	6.75	0	2	8	1	0	1	0	0	0	0	0	29	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	43	6.4
Total	570.48	31	38	1008	516	2	108	4	15	0	2	32	765	6	0	0	24	5	22	0	555	9	2	11	1	2	3	12	3173	5.6

[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: 1991–2005

YEAR	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	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	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	4-Nov
Days of observation	57	65	66	64	65	69	70	68	71	67	71	69	70	68	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	554.98	554.38	517.68
Raptors / 100 hours	1231	1957	1249	1372	1369	1574	1331	1283	1152	1107	1008	901	1036	597	528	1180
SPECIES	RAPTOR COUNTS															
Osprey	26	72	73	73	77	99	135	115	72	88	83	58	75	61	52	77
Northern Harrier	43	131	64	111	121	111	93	81	130	99	39	51	56	41	44	81
Sharp-shinned Hawk	698	2472	1643	1802	1441	1680	1566	1366	1427	1449	1609	1455	1263	945	891	1447
Cooper's Hawk	1077	1673	1243	974	1052	1322	1332	1715	1515	968	1158	599	765	319	377	1073
Northern Goshawk	10	42	26	4	5	3	8	2	6	13	7	5	0	0	5	9
Unknown small accipiter[1]	-	-	-	-	-	-	-	-	-	-	98	197	31	85	104	103
Unknown large accipiter[1]	-	-	-	-	-	-	-	-	-	-	1	2	4	0	2	2
Unknown accipiter	360	337	199	200	243	423	213	243	185	252	0	46	47	39	28	188
TOTAL ACCIPITERS	2145	4524	3111	2980	2741	3428	3119	3326	3133	2682	2873	2304	2110	1388	1407	2751
Red-shouldered Hawk	0	1	0	0	0	1	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	10
Swainson's Hawk	6	24	25	33	34	57	32	31	40	22	26	33	108	89	80	43
Red-tailed Hawk	1194	3229	1613	1898	2299	2275	1704	1390	1401	1498	1458	1302	1791	951	594	1640
Ferruginous Hawk	8	15	7	11	3	6	7	6	7	6	3	2	6	1	1	6
Rough-legged Hawk	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Zone-tailed Hawk	0	0	0	0	0	0	1	1	0	0	0	1	2	0	0	0
Unidentified buteo	55	19	2	8	11	16	33	40	17	15	8	33	20	8	36	21
TOTAL BUTEOS	1263	3291	1654	1952	2354	2357	1784	1503	1476	1556	1520	1392	1933	1049	717	1720
Golden Eagle	18	62	37	36	32	47	26	22	29	9	3	32	17	9	4	26
Bald Eagle	5	20	49	8	38	23	25	18	24	11	9	20	12	14	14	19
Unidentified eagle	0	0	3	0	0	0	0	1	4	0	0	3	0	0	0	1
TOTAL EAGLES	23	82	89	44	70	70	51	41	57	20	12	55	29	23	18	46
American Kestrel	1156	1508	1209	1273	1096	1631	1340	978	1218	1045	1180	1057	1300	689	639	1155
Merlin	7	14	12	10	12	8	24	12	13	9	8	4	9	21	4	11
Prairie Falcon	1	8	8	2	5	4	5	5	2	9	8	1	3	7	9	5
Peregrine Falcon	2	14	5	5	5	8	8	10	8	6	6	14	8	7	10	8
Unknown small falcon[1]	-	-	-	-	-	-	-	-	-	-	2	1	0	1	2	1
Unknown large falcon[1]	-	-	-	-	-	-	-	-	-	-	3	3	1	0	3	2
Unknown falcon	0	4	4	1	1	0	6	8	6	5	3	0	0	1	1	3
TOTAL FALCONS	1166	1548	1238	1291	1119	1651	1383	1013	1247	1074	1210	1080	1321	726	668	1182
Unknown raptor	106	124	24	66	48	60	97	96	107	48	60	83	23	25	20	66
GRAND TOTAL	4920	10048	6301	6625	6745	8008	6952	6479	6297	5664	5797	5023	5547	3313	2926	6043

[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: 1997–2005.

YEAR	1997	1998	1999	2000	2001	2002	2003	2004	2005	MEAN
Start date	27-Aug	28-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	5-Nov
Days of observation	71	66	71	66	71	71	70	68	70	69
Hours of observation	504.97	455.41	543.20	513.10	595.59	585.70	547.90	559.40	570.48	541.74
Raptors / 100 hours	938.3	907.5	997.8	1054.2	880.6	967.6	1228.9	932.4	556.2	932.5
SPECIES	RAPTOR COUNTS									
Osprey	50	43	28	43	34	57	50	42	31	42
Northern Harrier	50	44	56	41	31	45	35	29	38	41
Sharp-shinned Hawk	1474	1190	1906	1772	1792	1932	2323	1743	1008	1682
Cooper's Hawk	856	1109	1204	1256	1293	891	1673	855	516	1073
Northern Goshawk	4	7	1	9	11	6	2	7	2	5
Unknown small accipiter[1]	–	–	–	–	72	218	52	122	108	114
Unknown large accipiter[1]	–	–	–	–	0	3	1	1	4	2
Unknown accipiter	94	140	109	236	0	18	103	125	15	93
TOTAL ACCIPITERS	2428	2446	3220	3273	3168	3068	4154	2853	1653	2918
Red-shouldered Hawk	1	0	0	0	0	0	0	0	0	0
Broad-winged Hawk	9	19	14	6	11	8	14	19	2	11
Swainson's Hawk	15	25	32	10	19	16	147	80	32	42
Red-tailed Hawk	899	916	985	892	1008	1234	1264	1169	765	1015
Ferruginous Hawk	8	7	11	10	6	6	6	1	6	7
Rough-legged Hawk	0	0	0	1	1	2	0	0	0	0
Zone-tailed Hawk	0	0	1	0	1	1	0	0	0	0
Unidentified buteo	20	20	13	8	8	43	42	17	24	22
TOTAL BUTEOS	952	987	1056	927	1054	1310	1473	1286	829	1097
Golden Eagle	24	7	2	11	4	23	11	4	5	10
Bald Eagle	23	18	17	9	14	49	14	10	22	20
Unidentified eagle	1	0	1	0	0	1	0	0	0	0
TOTAL EAGLES	48	25	20	20	18	73	25	14	27	31
American Kestrel	1016	423	918	1035	881	1011	943	930	555	857
Merlin	14	12	14	5	22	5	17	9	9	12
Prairie Falcon	9	4	6	4	3	8	5	7	2	5
Peregrine Falcon	7	19	8	1	7	11	7	6	11	9
Unknown small falcon[1]	–	–	–	–	0	3	0	0	1	1
Unknown large falcon[1]	–	–	–	–	0	1	0	0	2	1
Unknown falcon	0	4	2	3	2	4	1	4	3	3
TOTAL FALCONS	1046	462	948	1048	915	1043	973	956	583	886
Unidentified raptor	20	38	16	10	25	71	23	36	12	28
GRAND TOTAL	4594	4045	5344	5362	5245	5667	6733	5216	3173	5042

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