FALL 2001 RAPTOR MIGRATION STUDIES IN THE GRAND CANYON OF ARIZONA

HawkWatch International, Inc.
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INTRODUCTION

The Grand Canyon Raptor Migration Project in Arizona is an ongoing effort to monitor long-term trends in populations of raptors using the southern portion of the Intermountain Flyway (*sensu* Hoffman et al. in press). The flight through this region is one of the largest concentrations of migrating raptors known in the western U.S. and Canada. To date, observers have recorded 19 species of migratory raptors at two count sites along the south rim of the canyon, with combined counts typically ranging between 10,000 and 12,000 migrants per season. Chuck LaRue discovered the flyway in 1987 and Christie Van Cleve conducted exploratory counts at points along the south rim in 1989 and 1990. HawkWatch International (HWI) initiated standardized counts of the autumn raptor migration through this region at Lipan Point in 1991, and began standardized monitoring at Yaki Point in 1997. The 2001 season marked the 11th consecutive count at Lipan Point and the 5th consecutive full-season count at Yaki Point. This report summarizes the 2001 count results for both sites.

The Grand Canyon projects constituted 2 of 15 long-term, annual migration counts (12 fall, 3 spring) conducted or co-sponsored by HWI in North America during 2001. The primary objective of these efforts is to track long-term population trends of diurnal raptors throughout primarily western North America (Smith and Hoffman 2000). Raptors feed atop food pyramids, inhabit most ecosystems, occupy large home ranges, and are sensitive to environmental contamination and other human disturbances. Therefore, they serve as important biological indicators of ecosystem health (Cade et al. 1988, Bednarz et al. 1990a, Bildstein 2001). Moreover, due to the remoteness and widespread distribution of most raptor populations, migration counts likely represent the most cost-effective and efficient method for monitoring the regional status and trends of multiple raptor species (Bednarz and Kerlinger 1989, Bednarz et al. 1990b, Titus et al. 1989, Bildstein et al. 1995, Dunn and Hussell 1995, Dixon et al. 1998, Smith and Hoffman 2000, Zalles and Bildstein 2000).

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 by long-time, local volunteer Christi Van Cleve and on-site educators Jim and Avis Light, conducted standardized daily counts of migrant raptors from traditional count sites at Yaki and Lipan points. The official observers—Adam Hutchins, Jody Bartz, Tom Magarian, and Paula Shannon—rotated between sites and observation partners to minimize potential observer bias. Volunteer Christi Van Cleve helped wherever a substitute observer was needed to provide for days off. The on-site educators helped at both sites when their education schedules allowed. This arrangement ensured that at least two counters were present at all times at both sites. Official observer Adam Hutchins had three full-seasons of previous raptor migration counting experience, Jody Bartz and Paula Shannon one each, and this was Tom Magarian's first season of counting (see Appendix A for a complete history of observer participation at the two sites). Christi Van Cleve has worked nearly full-time on the Lipan Point count each year of the project. Other visitors to the sites also occasionally assisted in spotting migrants. The on-site educators routinely facilitated interactions with visitors, including coordinating with personnel from Grand Canyon National Park to conduct educational programs with organized groups of park visitors.

Weather permitting, observations typically began by 0900 hrs Mountain Standard Time (MST) and ended by 1700 hrs MST. 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 species codes used 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), 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 (none, low, moderate, high) for each hour, recorded on the hour.
7. Daily start and end times for each official observer.

The observers used high quality 7–10x binoculars to assist in spotting and identifying birds. Clark and Wheeler (1987), Dunne et al. (1988), and Wheeler and Clark (1995) served as primary identification references. Assessments of wind speed, cloud type, cloud cover, and flight altitude followed guidelines published by the Hawk Migration Association of North America (HMANA). Assessments of thermal lift conditions as poor, fair, good, or excellent involved subjective evaluations of solar intensity, wind speed, and migrant behavior.

After considering input from past observers and debating the issue in our organizational Science Committee (made up of staff, board members, and outside scientific and conservation experts), HWI decided to cease tallying Turkey Vultures at this site beginning with the 2001 season. Our observers had complained of the difficulty distinguishing resident and migrant vultures for several years, but in 2000 repeated observations of a resident, partial-albino vulture confirmed that the task was in fact often impossible. Unlike many of HWI's ridgeline sites, the migration through the area occurs along a broad front, visibility is restricted to the south limiting the observers' ability to track birds effectively, and it is now clear that the local vultures routinely make extended foraging trips over tens of kilometers along similar routes and using similar flight styles as migrants. Therefore, HWI's Science Committee concluded that it was not worthwhile to continue monitoring the species in the Grand Canyon. This decision was predicated on the fact that good trend information for the species would still be collected by HWI at several other sites along the Intermountain Flyway, as well as along both the Rocky Mountain and Pacific Coast flyways.

The observers classified as residents and excluded from daily counts any raptor that exhibited hunting, territorial display, or perching behaviors for extended periods. The observers occasionally recorded as migrants birds that were not moving in a southerly direction, if such birds otherwise displayed migrant characteristics; i.e., continuous flight without stopping or substantially changing directions for several kilometers. Such birds may be dispersing juveniles or adults dispersing relatively short-distances from nesting territories to favored wintering grounds in the same general region. However, we also know from band-return studies and recent satellite telemetry work that species such as Golden Eagles, Prairie Falcons and Ferruginous Hawks frequently "migrate" in non-standard directions to take advantage of favored post-breeding and wintering grounds (Steenhof et al. 1984, personal communication; Watson and Pierce 2000; HWI unpublished data).

For purposes of examining long-term trends in annual count statistics at Lipan Point (still premature for Yaki Point), I manipulated the count data to standardize annual sampling periods and adjust for daily variation in observation effort. The seasonal and daily duration of observation effort can greatly affect count statistics (Hussell 1985, Kerlinger 1989, Bednarz et al. 1990b), and both have varied in the Grand Canyon during the course of the study, particularly during the first several years of observations. To generally adjust for variation in sampling effort due to inclement weather and other unforeseeable events, before analyzing population trends I converted counts to annual passage rates for each species (adjusted total count / total hours of observation for a given year * 100 = raptors/100 hrs). To further standardize seasonal sampling effort, I defined a consistent annual sample period following conventions proposed by Bednarz and Kerlinger (1989) and Bednarz et al. (1990b). Specifically, I converted counts to passage rates on a daily basis (raptors/10 hours of observation) to adjust for daily variation in sampling effort,

summed daily rates by Julian date across all years, and defined standardized passage periods for each species by eliminating approximately 2.5% from each extreme of the cumulative passage-rate distributions. Because entire count days must be either included or excluded, the defined sample period for a given species included between 95–100% of the detected number of migrants. For some species, the sample periods defined in this way encompassed dates earlier or later than periods of continuous observations. In these cases, I further restricted the adjusted sample periods to between mean starting and ending dates of continuous observations for 1991–2001: 29 August – 4 November.

Observers commonly identified distant or otherwise poorly observed migrants only to genus or other common non-specific groupings (e.g., unidentified eagle, which includes two genera). Such identifications sometimes constituted a sizeable proportion of the birds seen, especially for accipiters, varying with observer experience and weather conditions. Excluding these birds from population trend analyses may render inaccurate assessments of true flight volume. Accordingly, prior to analyzing long-term trends in annual passage rates at Lipan Point, I also adjusted the daily counts by distributing incompletely identified birds across relevant species in proportion to the relative abundance of birds identified to each species that day.

Beginning in 2001, HWI adopted a new standard for recording information about incompletely identified accipiters and falcons that should improve the accuracy of classifying incompletely identified birds for trend analysis (see Appendix B). Whenever possible, all observers now seek to classify any accipiters or falcons for which a species identification is not certain as small or large, using the simpler classifications of "unknown accipiter" or "unknown falcon" only as a last resort. For falcons, identification debates usually center on distinguishing kestrels and Merlins or prairie falcons and peregrines (rarely gyrfalcons), and the small and large size classes distinguish which debate applied. For the accipiters, most debates concern distinguishing Sharp-shinned and Cooper's Hawks, and designation of the small size class confirms that this debate applied. Occasionally, however, an observer struggles with distinguishing a large female Cooper's Hawk from a goshawk, and designation of the large size class confirms this and enables a more informed adjustment of the data prior to trend analyses.

Hereafter, I refer to as "adjusted" any data based on counts adjusted for incompletely identified birds and truncated to standardized annual sampling periods.

In most cases, I limit the analyses in this report to comparing 2001 annual statistics against means ± 95% confidence intervals (CI) for previous seasons, in which case I equate significance with a 2001 value falling outside of the CI for the associated mean. To provide additional context, I refer to but do not provide in-depth details concerning recently completed analyses of long-term trends in adjusted annual passage rates for Lipan Point (manuscript in review for publication). These analyses involved linear and quadratic regressions examining trends in annual passage rates for 1991–2001. I commonly refer to the results of these analyses as not significant ($P > 0.10$), marginally significant ($P < 0.10$), significant ($P \leq 0.05$), or highly significant ($P < 0.01$).

RESULTS AND DISCUSSION

WEATHER SUMMARY

In 2001, inclement weather had little affect on the counts, with no days of observation entirely or severely (<4 hrs observation) precluded by weather and only a relatively low 3–4% of active observation days featuring predominantly stormy skies with some rain or snow during the day (see Appendixes C and D for daily weather records from the two sites). Otherwise, roughly 53% of the active observation days featured fair skies, with dust, haze and/or scattered thundershowers present on about 20% of such days;

31% of days featured transitional weather (conditions changed from fair skies to mostly cloudy or overcast during the day), with fog/haze, thundershowers, or rain/snow present on about a third of these days; and roughly 16% of days featured primarily mostly cloudy to overcast skies, with fog/haze, thundershowers, or rain/snow present on about a third of these days. Compared to the last four seasons, this distribution of weather conditions appeared average except for a slightly lower proportion of stormy days with rain or snow. Although only moderately more prevalent than during the past four seasons, it is also noteworthy that smoke from north-rim wildfires was frequently heavy enough to substantially reduce visibility for the observers. In terms of wind conditions, 83% of the active observation days at Lipan Point and 70% of days at Yaki Point featured predominantly light winds (<12 kph), and only 1% of the days at each site featured predominantly strong winds (>28 kph). Compared to the previous four seasons, this distribution of wind velocities is slightly skewed towards moderate winds and away from strong winds (average 5–7% of days for 1997–2000). Winds originating from the southwest to northwest quadrant were most common at both sites in 2001, with such conditions predominating on 58% and 31% of days at Lipan and Yaki point, respectively. This frequently is the case at Lipan Point but, compared to the last four seasons (average 35% of days), the prevalence of such winds was unusually high in 2001. In contrast, north to northeasterly and east to southeasterly winds were less common than usual. The localized wind patterns tend to be more variable at Yaki Point, but the same basic tendencies were evident. The temperature during active observation periods averaged (average of daily values, which in turn were averages of hourly readings) 21.3°C at Lipan Point (range 11.4–30.8°C) and 16.1°C (range 7.1–28.1°C) at Yaki Point. The Lipan Point values generally rank as the highest recorded since 1997, whereas the Yaki Point values are average; reasons for the difference are unclear. At Lipan Point, 63% of the active observation days received a median (of hourly ratings) thermal-lift rating of good to excellent, while 51% of days received that rating at Yaki Point. Both of these proportions are at least slightly above average compared to 1997–2000.

In summary, compared to the last four seasons, 2001 featured relatively mild, warmer weather with somewhat lighter winds, a higher prevalence of westerly winds, and fewer easterly winds.

OBSERVATION EFFORT

Counts occurred at both sites every day (71 days) between 27 August and 5 November (see Appendices E and F for daily count records from each site). This was only the second time since 1991 that counts were able to occur every day of the season at Lipan Point, and the total observation hours (575.08) was the highest ever recorded at the site (15% above average; see Appendix G for annual effort and count summaries). Similarly, at Yaki Point the number of observation days and hours (595.59) were 4% and 18% above average, respectively (see Appendix H for annual effort and count summaries). The 2001 averages of 2.0 observers/hour (including official and guest observers; value is mean of daily values, which are in turn means of hourly values) at both sites were 6% and 21% below average.

MIGRATION SUMMARY

The observers counted 11,042 migrant raptors of 17 species at the two project sites in 2001 (Table 1), with 53% recorded at Lipan Point and 47% at Yaki Point. The combined-site flight was composed of 55% accipiters, 23% buteos, 19% falcons, and about 1% each of Ospreys, harriers, eagles, and unidentified raptors, with Yaki Point attracting proportionately more accipiters (61% of the site total) and fewer buteos (20%) and falcons (17%) than Lipan Point (50%, 26%, 21%; Figure 2). This pattern of compositional differences between the two sites is typical, with Yaki Point consistently attracting a higher proportion of accipiters and fewer buteos than Lipan Point. The migration-composition differences likely reflect topographic variation around the two sites, which effect local thermal production and therefore vary the attractiveness of each site for soaring species. At the combined-site

level, the only significant variation in 2001 compared to the 1997–2000 average flight-composition pattern was that eagles and harriers were relatively less abundant than usual.

As usual, Sharp-shinned, Cooper's Hawks, Red-tailed Hawks, and American Kestrels were the four most abundant species at both sites (Table 1, Appendices G and H). At Lipan Point, the observers recorded record-low counts (time span 1991–2001) for Northern Harriers and Golden Eagles and tied the record-low count for Ferruginous Hawks (Appendix G). In contrast, no record-high counts occurred but the count of 25 Broad-winged Hawks was the second highest ever. At Yaki Point, record-lows (time span 1997–2001) occurred for Northern Harriers, Ferruginous Hawks, and Prairie Falcons, whereas record highs occurred for Cooper's Hawks, Northern Goshawks, and Merlins (Appendix H). At the combined-site level for 1997–2001, record lows occurred for Northern Harriers, Ferruginous Hawks, and Golden Eagles, whereas a record high occurred only for Sharp-shinned Hawks.

At the combined-site level comparing 2001 values against 1997–2000 means, 11 of 15 commonly observed species showed below average passage rates in 2001, with the differences significant for Northern Harrier, Red-tailed Hawk, Ferruginous Hawk, and Golden and Bald Eagles, and no commonly observed species showed a significantly above average passage rate (Table 1). The generally low passage rates recorded in 2001 match the pattern shown at most other western HWI project sites (e.g., Vekasy and Smith 2002, Smith 2002 a, b) and likely reflect the cumulative effects of 2–3 years of widespread drought and wildfires, which have plagued much of the interior West since 1997/98.

Examining long-term (1991–2001) trends in adjusted passage rates for Lipan Point revealed the following: significant quadratic trends for Ospreys and Swainson's Hawks, tracking increasing patterns through 1996/97 but declines thereafter; a significant linear increasing trend for Broad-winged Hawks (see Smith et al. 2001); a significant linear declining trend for Ferruginous Hawks; a significant quadratic trend for Golden Eagles, tracking consecutive moderate and high counts in 1991 and 1992, respectively, and a strong decline thereafter; and no significant trends for the remaining nine species (Figures 3–7). A significant linear declining trend was indicated for Northern Goshawks also (Figure 4); however, this result was strongly influenced by a high count in 1992 corresponding to a boreal-invasion episode (see Mueller et al. 1977) and therefore may be misleading. Although not quite statistically significant (P = 0.107), American Kestrels also appear to be showing a gradual, long-term decline (Figure 7). It is also noteworthy that almost all species have shown a distinct declining trend since 1997 or 1998 (Figures 3–7); again, this is a pattern shown at most long-term HWI sites in the interior West and likely reflects the effects of widespread drought and wildfires. Some of these apparent, recent downward trends are less apparent with 1997–2001 data from Yaki and Lipan points combined, but most species still show some level of decline since 1997. This suggests that, although we still expect that combining data from the two counts ultimately will yield more robust trend data for the region, at this stage it appears that the Lipan Point data alone render a reasonable assessment of long-term trends for most species.

The pronounced, long-term declining trends for Ferruginous Hawks and Golden Eagles are perhaps the most noteworthy of the trends currently indicated for the Grand Canyon. HWI's Manzano Mountains, NM fall migration project shows a similar, strong declining pattern for Ferruginous Hawks since 1991 (Smith 2002a), suggesting that a regional decline may be occurring in the southwest. Our migration data for this species must be considered with caution because of low count totals and the fact that the Ferruginous Hawk is a broad-front migrant not strongly tied to ridgelines. Nevertheless, the species has been the subject of considerable conservation concern (Bechard and Schmutz 1995); therefore, it would seem prudent to consider the migration data a probable sign of continuing problems. Primary threats to the species include conversion of native grasslands to agriculture, degradation of native grassland and shrub-steppe habitats from cheatgrass (*Bromus tectorum*) invasion, control of prairie dogs (*Cynomys* spp.) and ground squirrels (*Spermophilus* spp.), and human disturbance of nesting activities (Olendorff 1993, Bechard and Schmutz 1995, Bak et al. 2001).

The Grand Canyon data are unique among HWI's migration datasets in showing a strong, current species-level declining pattern for Golden Eagles. However, fall-migration data from the Wellsville Mountains (UT) suggest that the abundance of especially immature/subadult birds declined significantly during the early to mid-1980s and has not recovered since (Smith 2002b). Long-term nesting studies in Idaho and Utah also have indicated long-term declines in nesting activity and/or productivity over the past 25–30 years due to loss and degradation of native sagebrush steppe habitats and attendant negative effects on jackrabbits (United States Department of Interior 1996, Knick and Dyer 1997, Steenhof et al. 1997, Kochert et al. 1999, HWI unpublished analyses based on Utah data collected by K. R. Keller). These problems may well extend into the southwest, but otherwise possible reasons for the apparent declining trend in the Grand Canyon are uncertain. Moreover, like for Ferruginous Hawks, annual counts of Golden Eagles in the Grand Canyon are relatively small and therefore the trend data must be considered cautiously.

At the combined-site level, immature : adult ratios were below the 1997–2000 averages for 6 of 10 species with distinguishable age classes, and all but Broad-winged Hawks showed below average abundances of immature birds (Table 2). These statistics again appear to reflect poor recruitment and survival due to the effects of extensive drought and wildfire.

Based on combined-site data for 1997–2001, four species (Northern Harrier, Cooper's Hawk, Broad-winged Hawk, Ferruginous Hawk, and Peregrine Falcon) showed significantly earlier than average median passage dates in 2001, Peregrine Falcons showed significantly late timing, and dates for the remaining 10 species with sufficient data for comparisons fell within the 95% confidence intervals for the respective means (Table 3). The 2001 combined-site, combined-species seasonal distribution pattern showed some variation compared to the 1997–2000 average pattern, but no distinct pattern of variation was evident and the variation typically fell within the bounds of 95% confidence intervals for each five-day period (Figure 8). Examination of age-specific median passage dates generally showed similar patterns as the species-level data, but also suggested that young birds showed the greatest tendency towards early passage in 2001 (Table 4). Thus, there appeared to be some tendency towards early passage in 2001, especially among young birds, but the level of variation compared to the previous four years was generally modest and the tendency towards early timing was not universal.

RESIDENT RAPTORS

Resident birds recorded at Lipan Point this season included at least 20 Turkey Vultures; at least 1 adult and 2-3 immature Sharp-shinned Hawks seen occasionally through early October; at least 1 adult and 1 immature Cooper's Hawk seen frequently through early October; at least one family of light-morph Red-tailed Hawks present throughout the season (2 adults and 1 immature) and possibly a family of dark-morph birds in early September; 2 adult, 1 subadult, and at least 1 immature Golden Eagles seen regularly after mid-September; 1 male American Kestrel seen twice in early September; one pair of adult Peregrine Falcons seen frequently throughout the season and at least 1 immature bird seen occasionally through mid-September; possibly 1 Osprey seen once in mid-September; at least 1 adult Zone-tailed Hawk seen on several occasions in early September; and at least 7 California Condors seen frequently throughout the season.

Resident birds recorded at Yaki Point this season included at least 13 Turkey Vultures; 1 immature Sharp-shinned Hawk seen occasionally in early September; at least 1 adult and 1 immature Cooper's Hawks through mid-September; 1 immature Northern Goshawk seen three times from early to mid-October; at least one family of light-morph Red-tailed Hawks (2 adults and 1 immature) seen throughout the season, and probably a few other birds; one family of Zone-tailed Hawks (2 adults and 1 immature) through September; at least 1 adult, 1 immature, and 1 subadult Golden Eagle seen intermittently after mid-September; 1 male and 1 female American Kestrel seen frequently in early September; at least 2

adult and 2 immature Peregrine Falcons, with the immatures seen only through early October and the adults throughout the season; and at least 10 California Condors seen regularly throughout the season.

VISITOR PARTICIPATION

A total of 1,412 park visitors signed the HWI visitor logs during the 2001 season. Visitation was about 35% higher at Lipan Point than at Yaki Point, primarily because our on-site educators conducted advertised programs twice daily at Lipan Point for park guests. This overall level of visitor participation is about 30% less than last season but similar to 1999, which is encouraging given the general damping effect that the September 11th tragedy had on peoples' travel plans during fall 2001. Ever-present, often thick smoke from north-rim wildfires also appeared to dampen peoples' interest in visiting rim-side vistas. Organized groups that visited the sites (besides park program groups) included an Elderhostel group, a local high school science class, several Audubon groups from Flagstaff, Tucson, and other Arizona communities, and a group of trekkers from the United Kingdom. Other foreign visitors originated in Canada, several European countries, Australia, South America, and Japan.

Beginning with the fall 2001 season, HWI adopted a new approach to quantifying the influence of visitors on counts at all of its project sites. Encouraging visitation and achieving positive public education and outreach are important goals for all HWI projects; however, during migration counts, visitors can represent a distraction for the official observers that may compromise the integrity of the count. Tolerating a certain level of distraction in the interest of positive outreach is a tradeoff that we gladly accept as part of our operations; however, because the distraction potential fluctuates considerably through time, it is important that the data we record include a means of quantifying the distraction potential through statistical modeling. Previously, at each site we had the observers estimate the number of visitors present during each hour of active counts. Two primary problems confounded use of this system for quantifying the visitor-distraction factor.

First, during busy periods (in terms of birds to count or visitors present) tracking visitors often became a difficult task for the observers. This difficulty led to both inconsistent estimation and, in some cases, in and of itself represented an unnecessary distraction. Second, careful reflection over the years suggested that simply recording the number of visitors often failed to capture the true effect of specific situations. For example, a single, highly curious, and talkative individual often represents more of a distraction for the observers than a large group of relatively quiet visitors.

In an effort to overcome these limitations, we have adopted a new system for recording visitor effects, whereby the observers record a subjective, visitor-distraction rating for each hour (none, low, moderate, or high). The new system still requires that the observers keep track of the effects of visitors through the hour, but the task is much easier without having to specify numbers. Furthermore, the new rating system allows the observers to incorporate a broader range of input to generate a more representative index of true visitor effects on their performance. Thus, although data-recording protocol changes such as this can be troublesome with regard to analysis of long-term trends, we believe that in the end this new approach to estimating visitor-distraction effects will significantly improve the integrity of our count systems.

In 2001 at Lipan Point, 539 hourly assessments of visitor disturbance resulted in the following ratings: 89% none, 10% low, 1% moderate, and <1% high. At Yaki Point, 593 hourly assessments of visitor disturbance resulted in the following ratings: 93% none, 5% low, 2% 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. Fall raptor migration counts and passage rates by species in the Grand Canyon, AZ (Lipan Point and Yaki Point data combined): 1997–2000 versus 2001.

SPECIES	COUNTS			RAPTORS / 100 HOURS		
	1997–2000[1]	2001	% CHANGE	1997–2000[1]	2001	% CHANGE
Osprey	144 ± 35.7	117	-18	26.3 ± 7.07	19.4	-26
Northern Harrier	149 ± 25.7	70	-53	27.0 ± 3.61	11.6	-57
Sharp-shinned Hawk	3038 ± 336.1	3401	+12	553.0 ± 45.46	562.6	+2
Cooper's Hawk	2489 ± 323.0	2451	-2	454.4 ± 63.03	405.5	-11
Northern Goshawk	13 ± 6.5	18	+44	2.3 ± 1.20	3.0	+30
Unknown small accipiter	–	170	–	–	28.1	–
Unknown large accipiter	0.3 ± 0.5	1	–	0.05 ± 0.090	0.2	–
Unknown accipiter	368 ± 86.9	0	–	67.3 ± 17.00	0.0	–
TOTAL ACCIPITERS	5907 ± 334.3	6041	+2	1077.1 ± 41.25	999.3	-7
Red-shouldered Hawk	0 ± 0.5	0	-100	0.0 ± 0.09	0.0	-100
Broad-winged Hawk	29 ± 16.7	36	+24	5.4 ± 3.27	6.0	+11
Swainson's Hawk	52 ± 16.4	45	-13	9.4 ± 2.79	7.4	-21
Red-tailed Hawk	2421 ± 124.6	2466	+2	441.9 ± 24.95	407.9	-8
Ferruginous Hawk	16 ± 2.0	9	-42	2.8 ± 0.27	1.5	-47
Rough-legged Hawk	0 ± 0.5	1	+300	0.0 ± 0.09	0.2	+261
Zone-tailed Hawk	1 ± 0.5	1	+33	0.1 ± 0.09	0.2	+21
Unidentified buteo	42 ± 17.4	16	-61	7.6 ± 3.40	2.6	-65
TOTAL BUTEOS	2560 ± 116.8	2574	+1	467.3 ± 25.61	425.8	-9
Golden Eagle	33 ± 12.4	7	-78	5.9 ± 2.26	1.2	-80
Bald Eagle	36 ± 11.7	23	-37	6.6 ± 2.09	3.8	-42
Unidentified eagle	2 ± 2.2	0	-100	0.3 ± 0.37	0.0	-100
TOTAL EAGLES	71 ± 24.0	30	-57	12.8 ± 4.32	5.0	-61
American Kestrel	1993 ± 404.2	2061	+3	362.5 ± 67.53	340.9	-6
Merlin	26 ± 9.7	30	+17	4.7 ± 1.76	5.0	+6
Prairie Falcon	11 ± 2.9	11	0	2.0 ± 0.54	1.8	-10
Peregrine Falcon	17 ± 8.9	13	-22	3.1 ± 1.73	2.2	-30
Unknown small falcon	–	2	–	–	0.3	–
Unknown large falcon	–	3	–	–	0.5	–
Unknown falcon	9 ± 2.5	5	–	1.6 ± 0.50	0.8	–
TOTAL FALCONS	2055 ± 400.2	2125	+3	373.8 ± 66.63	351.5	-6
Unidentified Raptor	108 ± 33.4	85	-21	19.7 ± 6.24	14.1	-29
GRAND TOTAL	10993 ± 565.6	11042	0	2004.1 ± 44.89	1826.6	-9

[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): 1997–2000 versus 2001.

	Total and Age-classified Counts								Immature : Adult	
	1997–2000 Average			2001			% Unknown Age		Ratio	
Species	Total	Imm.	Adult	Total	Imm.	Adult	1997–2000[1]	2001	1997–2000[1]	2001
Northern Harrier	149	43	40	70	9	15	44 ± 5.2	66	1.1 ± 0.34	0.6
Sharp-shinned Hawk	3038	665	1345	3401	579	1043	34 ± 6.2	52	0.5 ± 0.18	0.6
Cooper's Hawk	2489	589	886	2451	491	587	40 ± 6.9	56	0.7 ± 0.24	0.8
Northern Goshawk	13	7	3	18	2	6	20 ± 5.7	56	2.5 ± 1.67	0.3
Broad-winged Hawk	29	7	11	36	10	14	30 ± 21.6	33	0.8 ± 0.37	0.7
Red-tailed Hawk	2421	338	1510	2466	149	1528	24 ± 6.5	32	0.2 ± 0.08	0.1
Ferruginous Hawk	16	4	7	9	0	2	34 ± 13.5	78	0.6 ± 0.28	0.0
Golden Eagle	33	9	15	7	2	2	28 ± 7.5	43	0.6 ± 0.17	1.0
Bald Eagle	36	7	25	23	5	17	12 ± 7.2	4	0.3 ± 0.04	0.3
Peregrine Falcon	17	2	5	13	1	9	58 ± 16.6	23	0.4 ± 0.42	0.1

[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 2001 and 1997–2000 average median passage dates (Lipan Point and Yaki Point data combined).

	2001				1997–2000
Species	First Observed	Last Observed	Bulk Passage Dates [1]	Median Passage Date [2]	Median Passage Date [3]
Osprey	31-Aug	30-Oct	7-Sep – 6-Oct	18-Sep	17-Sep ± 3.3
Northern Harrier	31-Aug	4-Nov	17-Sep – 30-Oct	2-Oct	7-Oct ± 3.7
Sharp-shinned Hawk	27-Aug	5-Nov	16-Sep – 22-Oct	30-Sep	2-Oct ± 1.7
Cooper's Hawk	27-Aug	5-Nov	14-Sep – 8-Oct	23-Sep	29-Sep ± 2.2
Northern Goshawk	30-Aug	30-Oct	7-Sep – 28-Oct	7-Oct	5-Oct ± 8.9
Broad-winged Hawk	14-Sep	8-Oct	17-Sep – 29-Sep	23-Sep	26-Sep ± 2.5
Swainson's Hawk	5-Sep	5-Oct	10-Sep – 2-Oct	23-Sep	20-Sep ± 8.4
Red-tailed Hawk	31-Aug	5-Nov	18-Sep – 22-Oct	5-Oct	8-Oct ± 4.1
Ferruginous Hawk	7-Sep	23-Oct	7-Sep – 23-Oct	2-Oct	17-Oct ± 6.1
Rough-legged Hawk	24-Oct	24-Oct	–	–	–
Zone-tailed Hawk	5-Sep	5-Sep	–	–	–
Golden Eagle	6-Sep	3-Nov	6-Sep – 3-Nov	14-Oct	20-Oct ± 7.0
Bald Eagle	21-Sep	5-Nov	27-Sep – 31-Oct	19-Oct	24-Oct ± 5.0
American Kestrel	27-Aug	1-Nov	9-Sep – 4-Oct	23-Sep	24-Sep ± 3.7
Merlin	18-Sep	1-Nov	20-Sep – 30-Oct	7-Oct	5-Oct ± 3.3
Prairie Falcon	6-Sep	20-Oct	17-Sep – 18-Oct	28-Sep	28-Sep ± 9.3
Peregrine Falcon	7-Sep	25-Oct	10-Sep – 24-Oct	12-Oct	21-Sep ± 4.7
All species	27-Aug	5-Nov	14-Sep – 19-Oct	27-Sep	1-Oct ± 1.3

[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): 1997–2000 versus 2001.

	ADULT		IMMATURE / SUBADULT	
SPECIES	1992–2000[1]	2001	1992–2000[1]	2001
Northern Harrier	8-Oct ± 4.0	12-Oct	5-Oct ± 7.3	27-Sep
Sharp-shinned Hawk	8-Oct ± 0.6	9-Oct	26-Sep ± 2.8	23-Sep
Cooper's Hawk	3-Oct ± 3.3	27-Sep	26-Sep ± 3.4	22-Sep
Northern Goshawk	31-Oct [2]	19-Oct	5-Oct ± 7.1	–
Broad-winged Hawk	25-Sep ± 1.7	19-Sep	26-Sep ± 3.4	20-Sep
Red-tailed Hawk	9-Oct ± 3.2	6-Oct	2-Oct ± 5.9	26-Sep
Bald Eagle	24-Oct ± 5.0	19-Oct	24-Oct ± 8.2	17-Oct
Peregrine Falcon	20-Sep ± 11.2	12-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 2000 only.

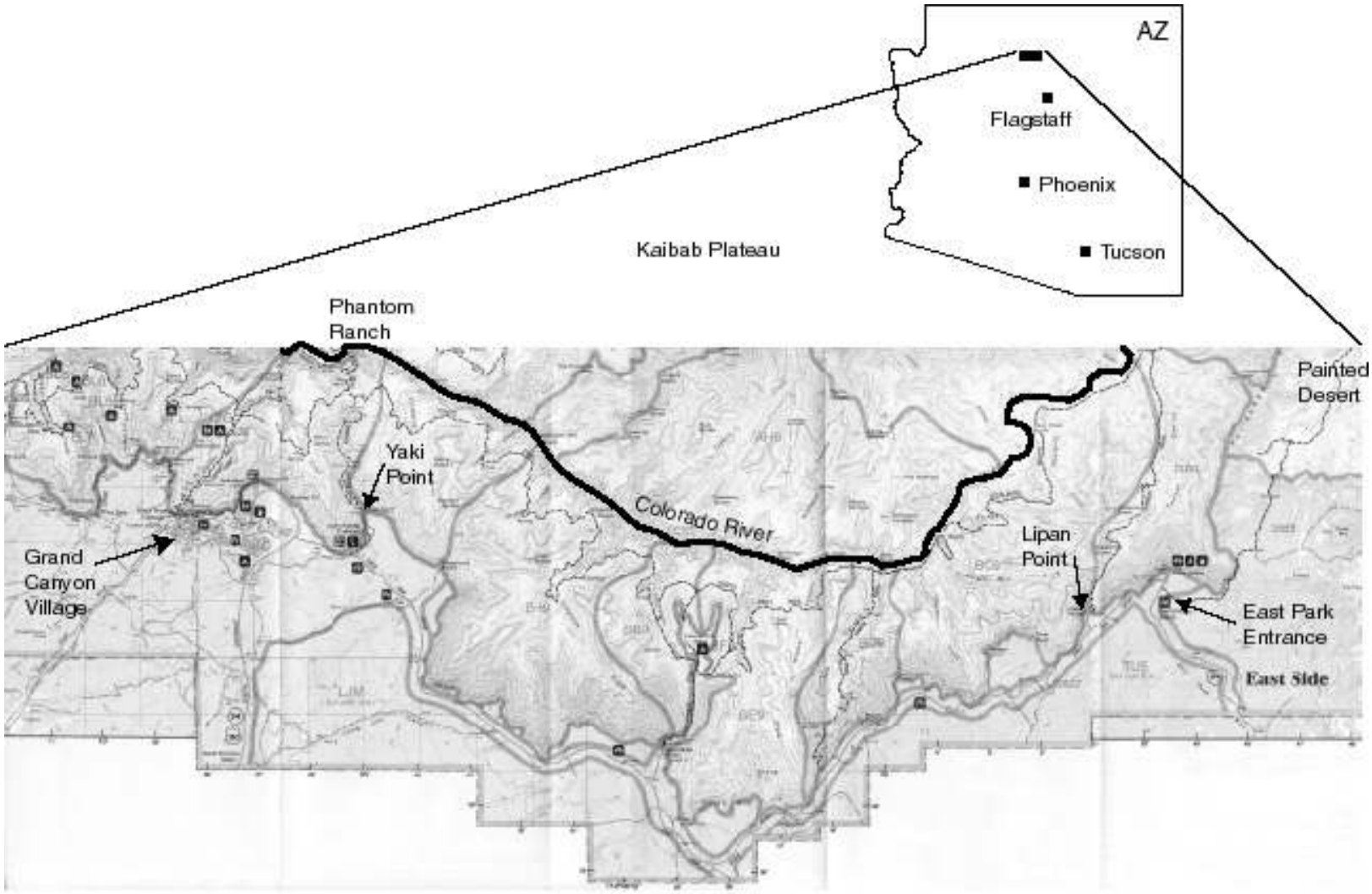

Figure 1. Map showing the Lipan Point and Yaki Point raptor-migration study sites in the Grand Canyon, Arizona.

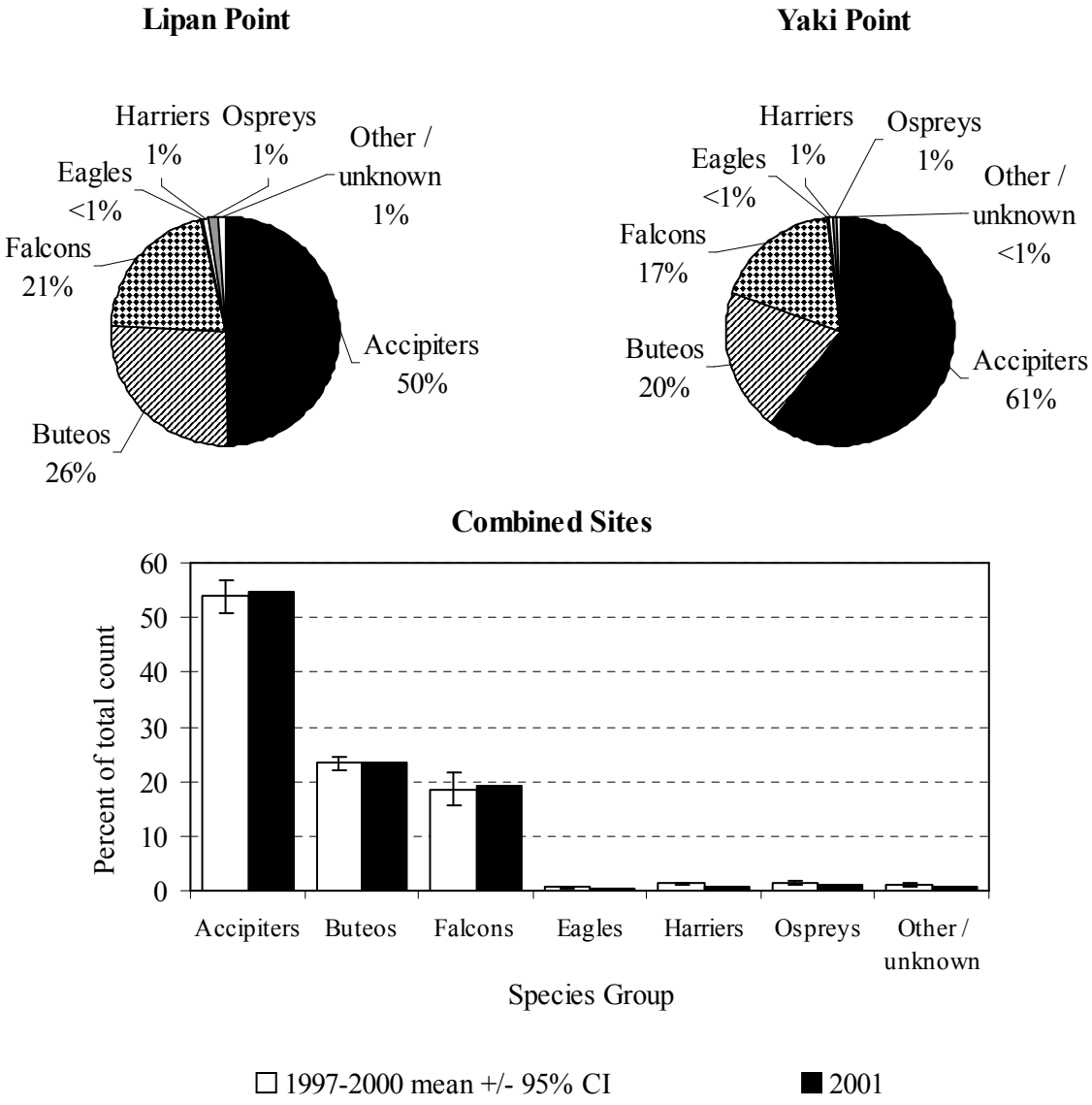

Figure 2. Fall raptor-migration flight composition by major species groups in the Grand Canyon, AZ: 1997–2000 versus 2001.

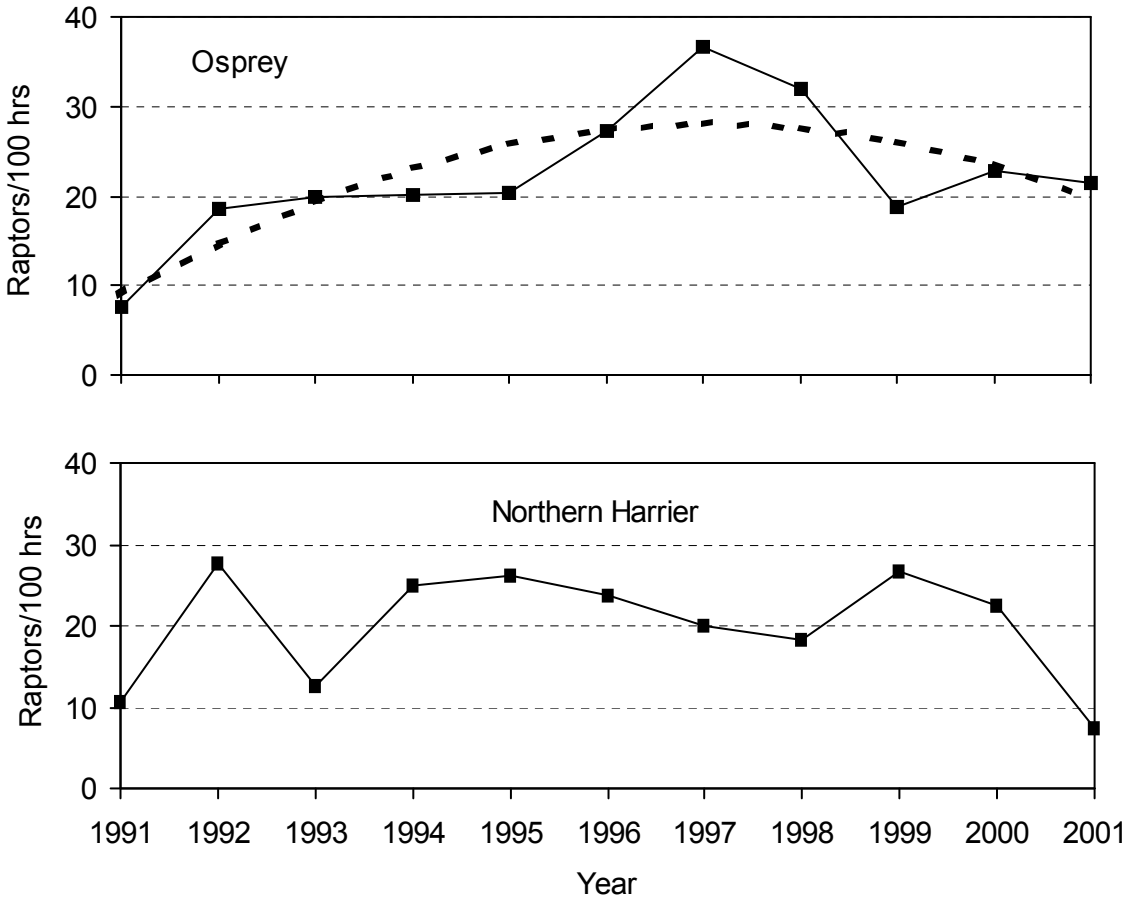

Figure 3. Adjusted (truncated to standardized annual sampling periods and adjusted for incompletely identified birds) fall-migration passage rates for Ospreys and Northern Harriers at Lipan Point, Grand Canyon, AZ: 1991–2001. Dashed lines indicate significant ($P \leq 0.10$) regressions.

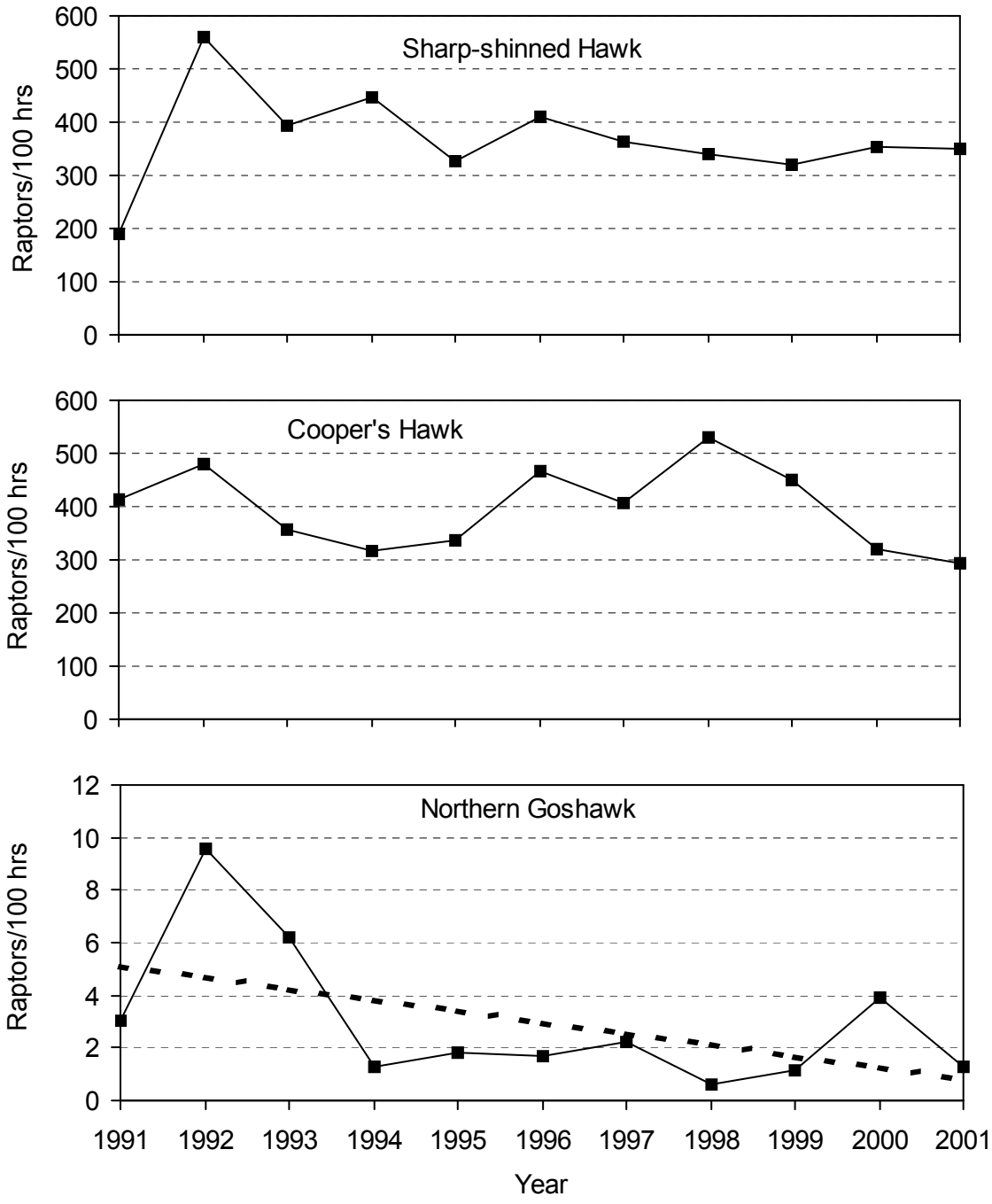

Figure 4. Adjusted (truncated to standardized annual sampling periods and adjusted for incompletely identified birds) fall-migration passage rates for Sharp-shinned Hawks, Cooper's Hawks, and Northern Goshawks at Lipan Point, Grand Canyon, AZ: 1991–2001. Dashed lines indicate significant ($P \leq 0.10$) regressions.

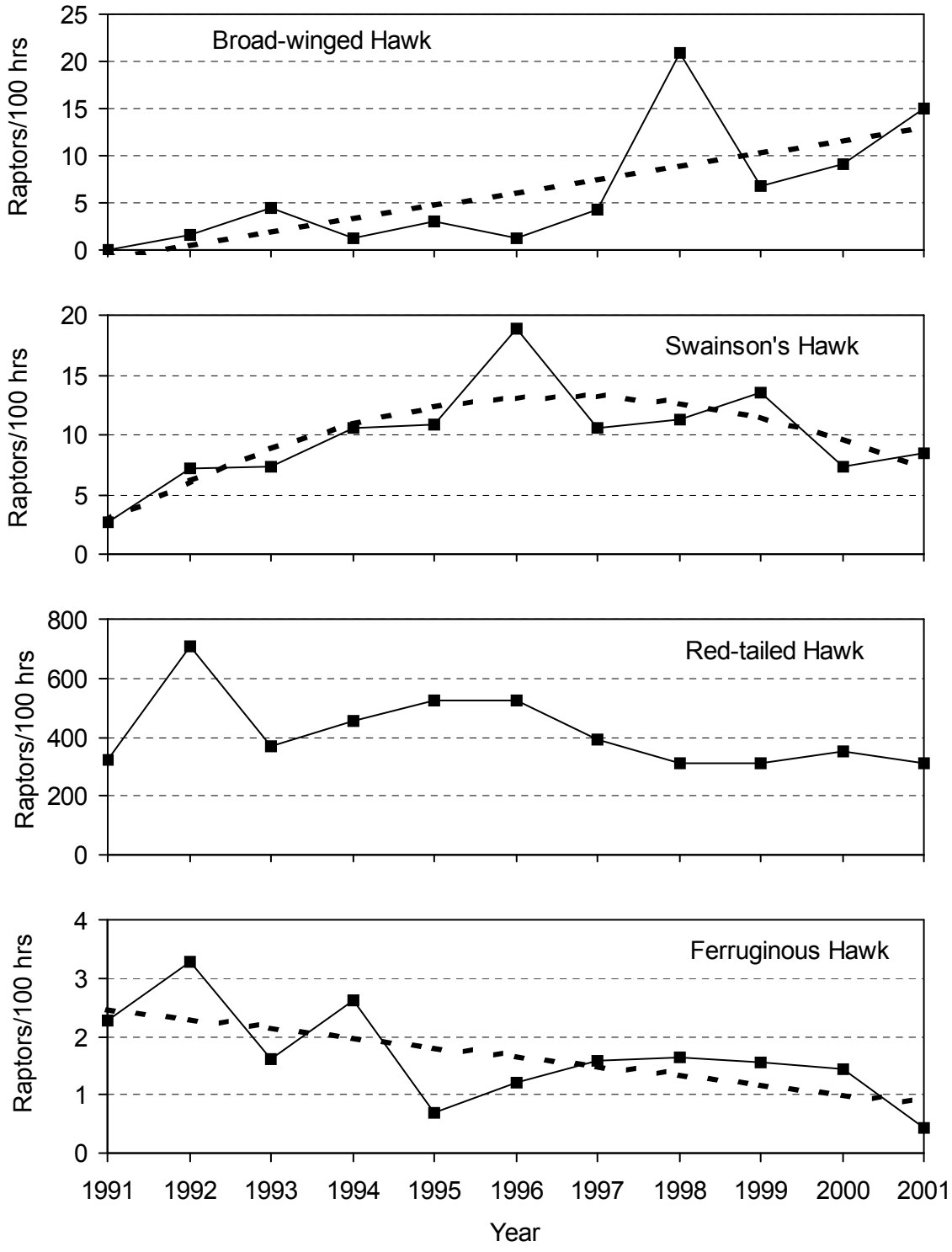

Figure 5. Adjusted (truncated to standardized annual sampling periods and adjusted for incompletely identified birds) fall-migration passage rates for Red-tailed, Swainson's, Broad-winged and Ferruginous Hawks at Lipan Point, Grand Canyon, AZ: 1991–2001. Dashed lines indicate significant ($P \leq 0.10$) regressions.

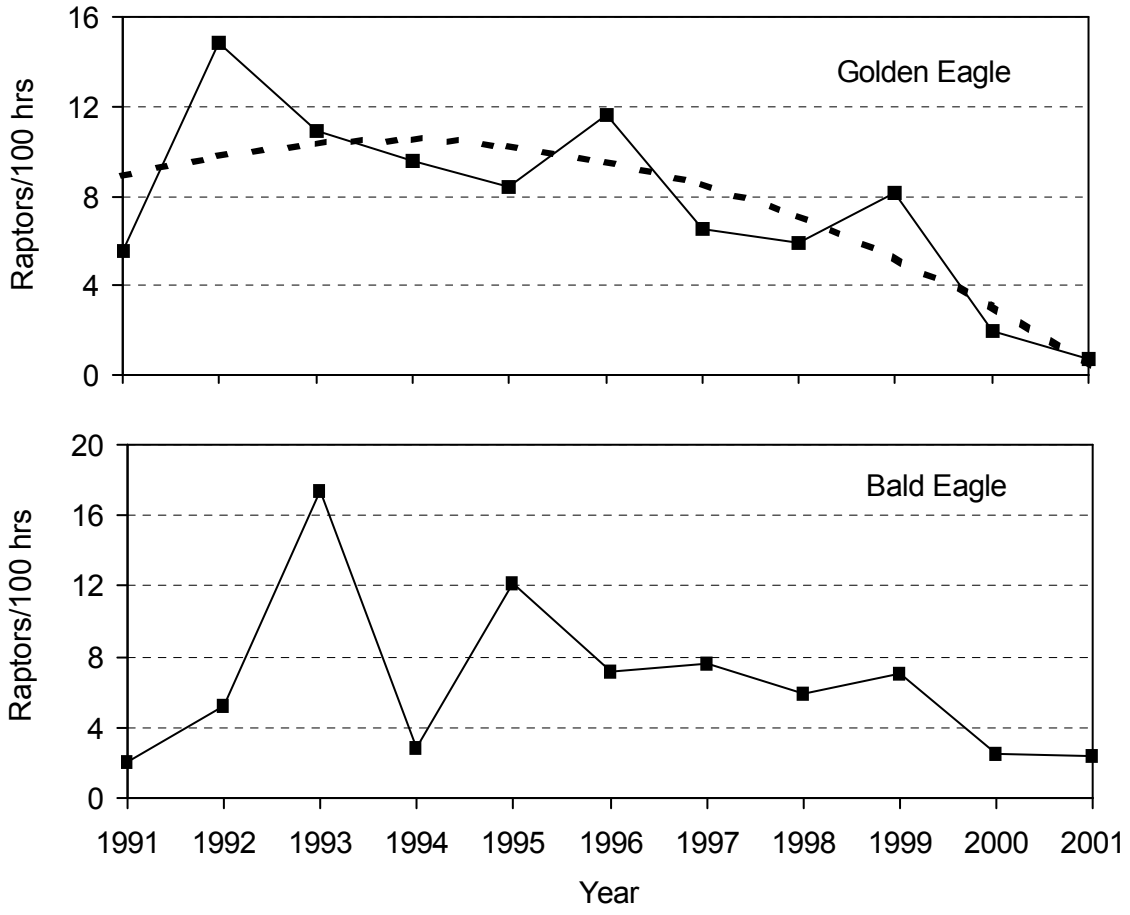

Figure 6. Adjusted (truncated to standardized annual sampling periods and adjusted for incompletely identified birds) fall-migration passage rates for Golden and Bald Eagles at Lipan Point, Grand Canyon, AZ: 1991–2001. Dashed lines indicate significant ($P \leq 0.10$) regressions.

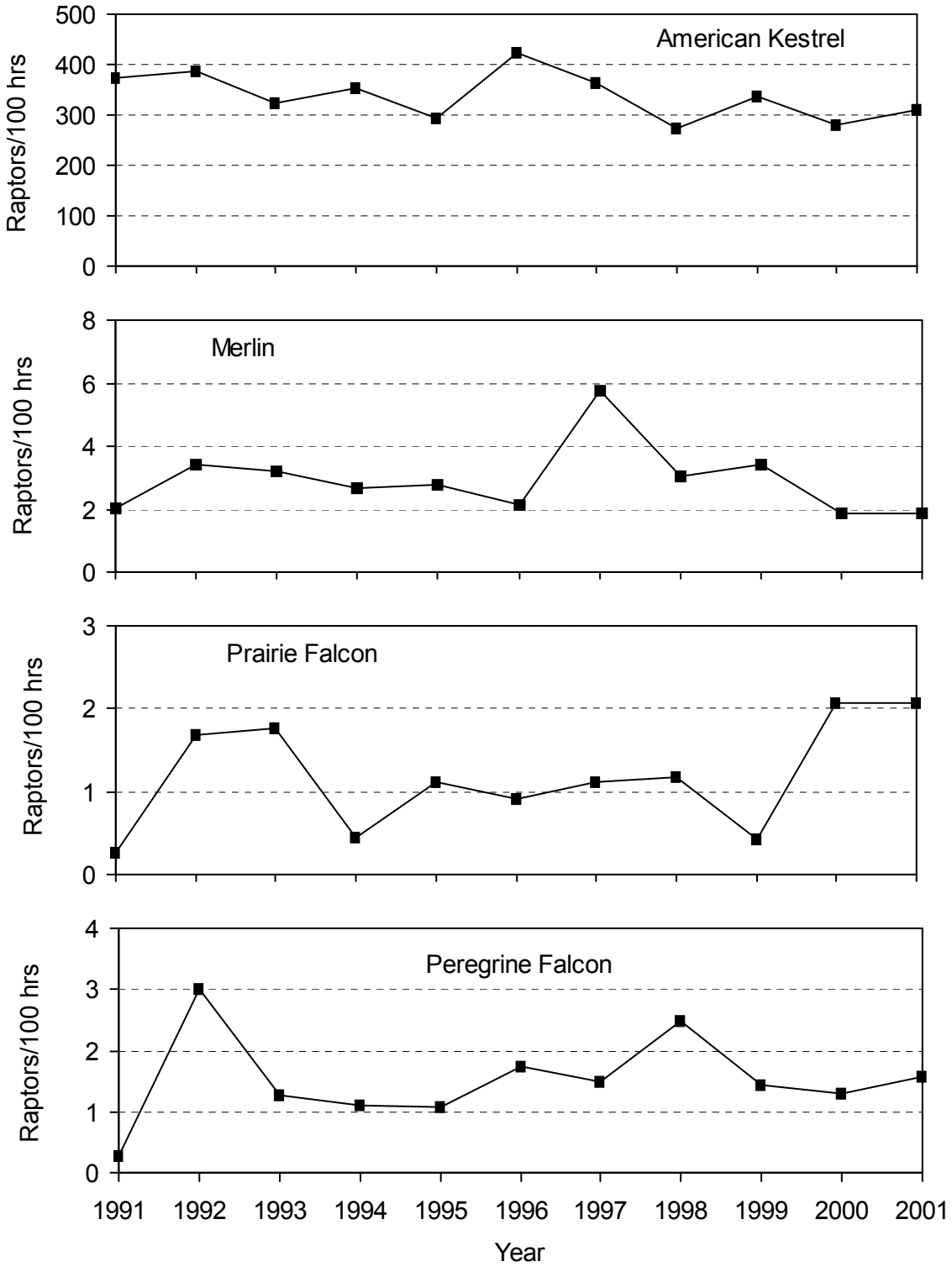

Figure 7. Adjusted (truncated to standardized annual sampling periods and adjusted for incompletely identified birds) fall-migration passage rates for American Kestrels, Merlins, Prairie Falcons, and Peregrine Falcons at Lipan Point, Grand Canyon, AZ: 1991–2001. Dashed lines indicate significant ($P \leq 0.10$) regressions.

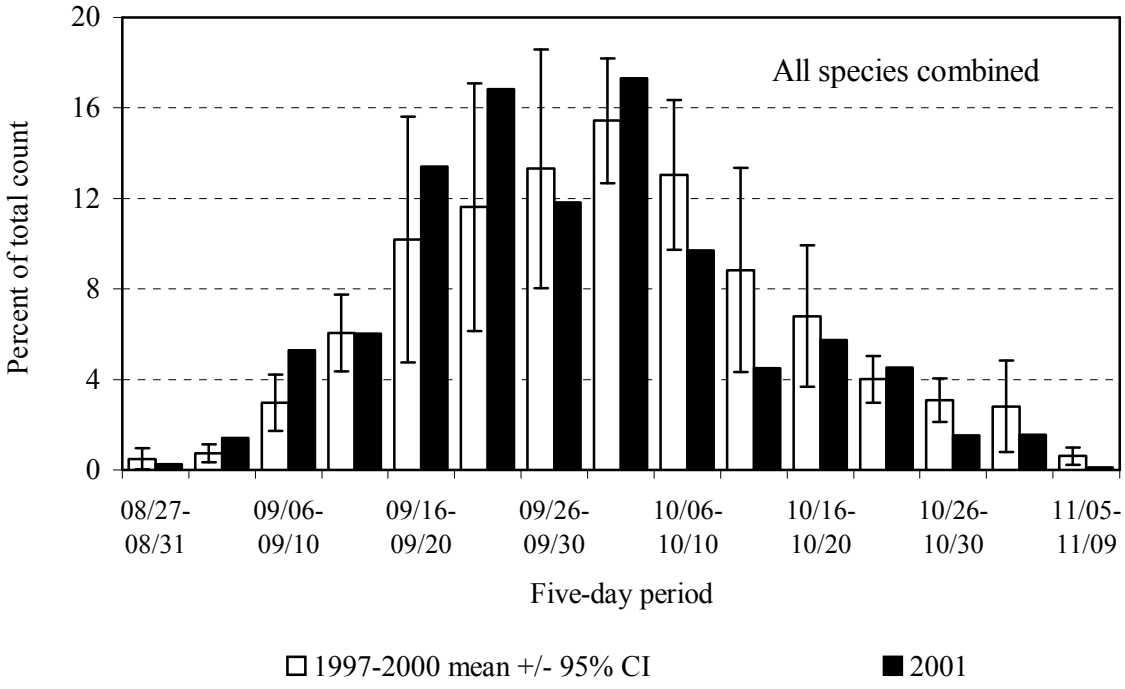

Figure 8. Combined-species, fall-migration passage volume by five-day periods for raptors in the Grand Canyon (Lipan Point and Yaki Point data combined): 1997–2000 versus 2001.

Appendix A. History of official observer participation in the Grand Canyon raptor migration studies: 1991–2001.

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

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

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

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

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

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

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

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

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

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

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

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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: 2001.

Date	Obs. Hours	Obsrvr / Hour[1]	Median Visitor Disturb[2]	Predominant Weather[3]	Wind Speed (kph)[1]	Wind Direction	Temp (°C)[1]	Barom. Press. (in Hg)[1]	Median Thermal Lift[4]	Visib. West (km)[1]	Visib. East (km)[1]	Median Flight Distance[5]	Birds / Hour
27-Aug	8.00	2.0	0	clr	0.9	wsw-w	30.8		2	100	86	2	1.0
28-Aug	6.92	2.0	0	pc-mc	6.8	ene, ssw-sw	29.4		3	97	76	2	0.6
29-Aug	7.67	2.0	0	clr-pc	8.1	wsw-nw	27.8		2	94	84	1	0.4
30-Aug	8.00	2.0	0	clr-pc	3.0	sw-w	24.7		1	90	73	-	0.0
31-Aug	7.75	1.9	0	clr-pc	3.2	ssw-wsw	23.8		3	96	78	2	0.3
1-Sep	7.83	2.9	0	clr-pc	0.7	wsw	24.8		2	94	82	4	0.3
2-Sep	7.67	2.0	0	pc, AM haze	1.7	sw-nw	27.4		2	94	68	2	2.6
3-Sep	7.84	2.0	0	clr-mc	3.4	sw-nw	26.3		1	92	70	2	3.2
4-Sep	8.00	2.0	0	clr-pc	2.3	sw-wnw	26.5		2	94	75	3	3.4
5-Sep	8.17	1.7	0	clr-pc	7.3	wsw	26.4		3	96	82	3	0.6
6-Sep	7.67	2.0	0	clr	23.6	sw-nw	24.4		2	91	64	2	1.7
7-Sep	8.58	2.0	0	clr	9.8	wsw-nw	22.3	30.06	1	91	65	2	10.7
8-Sep	8.08	2.0	0	clr	1.3	var	22.1	30.07	1	75	51	2	7.5
9-Sep	8.50	1.9	0	clr	4.6	ne, calm/var	21.4	30.19	2	95	70	2	10.1
10-Sep	8.00	2.0	0	clr-ovc	5.3	ne-se/calm	23.6	30.26	3	87	62	2	7.8
11-Sep	8.00	1.6	0	clr-mc	11.1	ene	25.3	30.27	4	78	65	1	2.4
12-Sep	7.50	1.9	0	pc-ovc, ts/rain	8.4	ne-e, sw	25.0	30.14	4	57	51	3	1.9
13-Sep	8.17	2.0	0	mc-ovc, ts/rain	7.8	var, sw	24.3	30.19	4	48	49	3	4.5
14-Sep	9.50	2.0	0	pc	7.0	wsw-wnw	25.7	30.55	1	78	49	2	15.1
15-Sep	8.42	2.0	0	clr-pc	7.7	wsw-wnw	24.0	30.24	1	88	71	2	25.8
16-Sep	8.00	2.0	0	pc-mc, scat ts	10.7	wnw	22.9	30.21	3	87	69	2	8.3
17-Sep	8.58	2.0	0	clr-pc	7.9	w-wnw	23.0	30.21	1	90	75	1	13.8
18-Sep	9.50	1.8	0	clr	2.2	var/w-nw	24.2	30.21	1	96	70	2	14.6
19-Sep	8.50	2.0	0	clr-mc	13.2	wsw-wnw	25.3	30.23	1	98	85	2	38.9
20-Sep	8.92	2.0	0	clr-pc	6.9	wsw-nw	24.1	30.30	1	96	70	3	17.4
21-Sep	8.83	2.0	0	clr-pc	5.9	sw-wnw	25.3	30.30	1	92	78	2	30.4
22-Sep	8.42	2.9	1	clr-pc, haze	1.3	ne-calm/var	25.8	30.32	1	94	52	2	13.3
23-Sep	8.17	3.0	0	clr	6.7	ne	25.5	30.34	2	87	69	2	10.3
24-Sep	8.25	2.0	0	clr	2.6	calm/var	25.9	30.42	1	84	63	2	15.8
25-Sep	8.16	2.4	0	clr-pc	2.9	w-nw/var	25.8	30.28	1	94	76	3	34.1
26-Sep	8.00	2.9	0	clr	3.9	nw	24.2	30.27	1	95	73	1	25.6
27-Sep	8.17	3.4	0	clr/haze	5.3	wsw-wnw	24.8	30.31	1	82	61	3	18.7
28-Sep	8.50	2.4	0	pc-mc, haze	1.6	ne, sw	26.3	30.22	1	83	30	3	27.4
29-Sep	8.00	2.0	0	clr-pc, AM haze	2.3	var	25.8	30.26	1	86	55	2	17.0
30-Sep	8.00	2.2	0	clr	5.1	var	23.6	30.34	1	85	60	3	15.1
1-Oct	8.00	2.0	0	mc-ovc	7.7	se-s	22.7	30.35	3	67	51	2	4.8
2-Oct	8.75	1.8	0	pc-mc, haze	6.7	w-nw, se	22.3	30.22	2	55	18	3	31.5
3-Oct	9.17	2.0	0	clr	7.2	wsw	22.4	30.23	2	70	59	3	42.6
4-Oct	8.25	2.0	0	clr, AM haze	7.9	w/var	22.2	30.17	4	28	45	2	18.2
5-Oct	8.16	2.0	0	clr-ovc, AM haze PM rain	12.3	sw-wnw	23.0	30.16	2	80	65	3	21.9
6-Oct	7.33	2.0	0	pc-ovc, ts/rain	20.3	sw-wnw	18.5	30.19	3	59	71	3	9.0
7-Oct	8.00	2.0	0	ovc	6.3	sw-w	15.3	30.28	4	87	55	2	7.8
8-Oct	8.92	2.0	0	pc-ovc, PM rain	17.9	wsw-nw	16.0	30.11	2	87	70	3	18.4
9-Oct	8.33	1.8	0	ovc	10.8	wsw	14.9	30.08	4	69	67	2	7.6
10-Oct	8.00	2.0	0	clr-pc	0.7	var	13.4	30.22	1	100	72	3	13.0
11-Oct	8.33	1.9	0	pc-ovc	9.1	wnw	15.6	30.11	4	94	84	2	9.7
12-Oct	8.00	1.8	0	clr	2.8	calm/var	11.4	30.17	1	100	84	2	1.3
13-Oct	8.50	1.9	0	clr, PM haze	11.7	wsw-nw	15.4	30.09	2	100	62	2	4.6
14-Oct	8.50	2.0	0	clr	3.8	ne-e, wsw	18.8	30.23	2	100	69	2	8.4

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
15-Oct	8.08	1.9	0	clr-mc	1.5	calm/var	19.4	30.36	1	100	81	3	3.3
16-Oct	8.25	1.7	0	pc-ovc	2.7	calm/var	21.8	30.39	2	93	75	3	7.8
17-Oct	8.00	2.0	1.5	pc-mc, PM haze	18.9	wsw-wnw	19.8	30.25	2	71	54	3	4.1
18-Oct	8.16	2.0	0	clr-pc, haze	13.3	sw-wnw	18.9	30.27	2	65	37	2	5.1
19-Oct	8.00	2.0	0	clr	1.4	ne/calm	19.5	30.24	1	99	65	2	8.6
20-Oct	8.25	2.0	0	clr-pc	9.5	sw-wnw	18.0	30.11	2	91	65	3	9.6
21-Oct	7.67	2.0	0	ovc	18.6	sw-w	17.9	30.17	4	65	41	2	3.1
22-Oct	8.00	2.0	0	pc-mc	8.8	wsw-wnw	18.4	30.12	3	96	73	2	9.3
23-Oct	8.00	2.0	0	clr	31.2	sw-nw	17.4	29.97	4	100	75	3	2.0
24-Oct	8.08	2.2	0	clr-mc	0.7	calm/var	15.6	30.19	1	97	81	2	5.4
25-Oct	8.00	2.0	0	pc-mc	3.3	ssw, ne, wnw	17.5	30.36	3	98	62	1	7.8
26-Oct	8.00	1.9	0	clr-pc	8.4	ne-se	17.5	30.47	3	96	77	1	2.8
27-Oct	8.00	1.3	0	ovc	16.4	se, sw-w	20.2	30.32	4	83	68	3	1.1
28-Oct	8.00	2.0	0	clr-ovc	5.2	wsw-wnw	20.2	30.33	3	80	50	2	2.3
29-Oct	8.16	2.2	0	ovc	10.1	sw-wnw	17.3	30.39	3	95	68	3	3.9
30-Oct	7.92	1.9	0	ovc	23.6	sw-wnw	17.4	30.23	4	79	76	2	3.5
31-Oct	6.92	1.9	0	pc-ovc	12.7	wsw-wnw	14.7	30.03	3	96	68	2	5.6
1-Nov	8.00	2.0	0	clr	7.8	wsw-wnw	13.5	30.17	3	100	74	1	2.6
2-Nov	8.00	2.0	0	pc-mc	2.7	calm/var	12.8	30.28	3	100	83	1	0.5
3-Nov	8.00	2.0	0	clr	3.6	calm/var	13.6	30.41	1	100	74	3	2.3
4-Nov	8.00	2.0	0	ovc, scat rain	9.4	ne-se	14.4	30.39	4	81	53	2	0.3
5-Nov	5.08	1.6	0	mc-ovc	9.0	calm/var	15.3	30.23	3	86	60	3	1.4

[1] Average of hourly records.

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

[3] Predominant sky condition during day: clr = clear (0-15% cloud cover); pc = partly cloudy (16-50% cover); mc = mostly cloudy (51-75% cover); ovc = overcast (76-100% cover); ts = thunderstorms.

[4] Median hourly rating concerning prevalence of lift-generating thermals, based on subjective assessments of solar intensity, wind speeds, and migrant behavior: 1 = excellent, 2 = good, 3 = fair, 4 = poor.

[5] Median hourly rating concerning line-of-sight distance of flight from observation site: 1 = close, detection and identification possible with naked eye; 2 = moderate, detection possible with naked eye, but binoculars needed for identification; 3 = far, binoculars needed for both detection and identification; 4 = distant, birds detected and identified only with excellent binoculars or spotting scope and by experienced observers.

Appendix D. Daily observation effort, visitor disturbance ratings, weather records, and raptor-migration flight summaries at Yaki Point, Grand Canyon, AZ: 2001.

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	7.00	2.0	0	clr-pc	5.8	wnw-nw	28.1		2		79	2	0.9
28-Aug	8.00	2.0	0	pc-ovc	3.0	var, nw	24.7		3		81	-	0.0
29-Aug	7.83	1.9	0	pc	9.0	sw-nw	23.2		2		94	-	0.0
30-Aug	8.00	1.9	0	clr-pc	11.7	sw-wnw	19.3		3		84	1	0.4
31-Aug	8.00	1.9	0	clr-mc	7.6	var, w-nw	19.8		2		75	2	0.1
1-Sep	8.25	1.9	0	clr	10.1	wnw-nw	20.2		1		85	1	1.2
2-Sep	8.42	2.0	0	clr-pc, AM haze	7.5	nw	20.9		1		54	1	1.4
3-Sep	8.83	2.0	0	clr-mc, scat rain	7.7	sw-nw	19.8		2		63	1	2.6
4-Sep	8.00	2.0	0	clr-pc	8.0	w-nw	22.3		2		70	1	1.6
5-Sep	9.00	2.0	0	clr-pc	15.3	sw-nw	21.2		2		72	1	2.0
6-Sep	8.42	2.0	0	clr-pc	18.3	wsw-nw	18.1		3		71	3	1.9
7-Sep	9.08	2.0	0	clr/haze	5.9	nw-n	17.6		2		65	1	11.0
8-Sep	8.75	2.0	0	clr, AM haze	4.2	var	16.0		1		48	1	8.8
9-Sep	8.75	2.0	0	clr	7.6	var	17.5		3		66	2	4.9
10-Sep	8.25	2.0	0	clr-mc, PM rain	5.9	var	19.7		2		74	3	4.0
11-Sep	8.25	2.0	0	mc-ovc	5.2	ne-se/calm/var	19.9		3		71	3	5.8
12-Sep	6.83	2.0	0	pc-ovc, rain	11.3	ne-se/var	19.1		4		43	2	1.0
13-Sep	7.92	2.0	0	mc-ovc, ts/rain	18.9	sw-wnw	19.5	30.13	4		69	2	4.5
14-Sep	9.33	2.0	0	pc-mc	7.5	w-nw	18.1	30.16	1		60	2	8.7
15-Sep	8.33	2.0	0	clr-pc	8.4	wnw-nne, wsw	19.1	30.17	2		57	2	7.6
16-Sep	8.25	2.0	0	pc-mc, scat ts/rain	25.9	sw-w	17.5	30.09	4		86	2	4.7
17-Sep	9.92	2.0	0	clr	7.5	sw-w, nw-nne	18.3	30.12	2		72	2	10.4
18-Sep	9.50	2.0	0	clr	8.1	var	19.5	30.16	1		75	2	35.1
19-Sep	9.42	2.0	0	clr-ovc	10.5	sw-nw/var	18.1	30.10	2		75	2	12.2
20-Sep	9.50	2.0	0	pc-mc	10.6	sw-nw	19.0	30.24	2		74	1	8.5
21-Sep	9.25	1.8	0	clr	5.9	wnw-nne	20.5	30.25	1		76	2	10.6
22-Sep	9.33	2.0	0	clr-mc, haze	3.1	var, n	20.7	30.23	1		59	3	29.7
23-Sep	9.08	2.0	0	clr, AM haze	4.9	ene-se	21.5	30.27	2		55	2	8.7
24-Sep	8.92	1.9	0	clr-pc	3.4	calm/var, nw	20.4	30.27	1		90	3	45.4
25-Sep	10.25	2.0	0	clr	6.3	sw-nw/var	19.3	30.15	1		70	3	12.6
26-Sep	9.92	2.9	0	clr/haze	5.3	sw/var, nw	20.2	30.22	1		41	2	3.9
27-Sep	9.17	2.0	0	clr/haze	2.2	wnw-nw, e	21.3	30.22	1		22	2	6.5
28-Sep	9.08	2.0	0	pc	6.4	calm/sw-nw	20.2	30.06	1		32	3	9.4
29-Sep	8.92	1.9	0	clr-mc	4.7	var	18.5	30.18	2		38	2	19.3
30-Sep	8.25	2.0	0	clr-pc	3.7	ne	20.4	30.28	2		41	2	12.5
1-Oct	9.25	1.8	0	ovc	5.8	nne-ne	17.8	30.18	2		60	3	43.5
2-Oct	8.42	2.0	0	mc/haze	5.8	wnw-nw	18.7	30.18	3		34	2	21.4
3-Oct	8.17	2.0	0	clr/haze	11.0	w-nw	17.1	30.17	3		53	2	19.8
4-Oct	8.42	2.0	0	clr	14.0	wsw-nw	15.5	30.10	3		74	1	7.4
5-Oct	8.17	2.0	0	clr-ovc	7.2	calm/var, wnw-nw	15.2	30.13	3		53	2	8.7
6-Oct	7.25	2.0	0	pc-ovc, PM ts	13.5	s-w/var	13.9	30.15	4		55	2	4.0
7-Oct	7.83	1.9	0	ovc, PM rain	4.3	sw-nw	9.6	30.11	4		98	2	16.0
8-Oct	8.25	2.0	0	pc-ovc, PM rain	6.8	sw-nw	11.4	30.08	4		70	1	17.9
9-Oct	8.16	2.0	0	pc-ovc	18.6	sw-nw	9.2	29.94	4		64	2	14.2
10-Oct	9.50	1.9	0	clr-pc	6.1	e, wsw-nw	8.9	30.26	2		71	2	20.5
11-Oct	8.08	2.0	0	mc-ovc	18.6	sw-nw	9.1	30.08	4		90	1	3.3
12-Oct	8.00	2.0	0	clr	3.3	var	7.3	30.13	3		79	2	3.5
13-Oct	8.00	2.0	0	clr, PM haze	17.3	nw-n	11.4	30.05	3		79	2	4.6
14-Oct	8.50	1.8	0	clr-pc	14.4	calm/var, sw-nw	11.9	30.08	1		84	2	13.1

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. West (km)[1]	Visib. East (km)[1]	Median Flight Distance[5]	Birds / Hour
15-Oct	8.25	1.8	0	clr-ovc	7.3	ne-ese	15.0	30.31	3		45	3	7.9
16-Oct	8.08	2.0	0	mc-ovc	5.4	sw-w/var	15.4	30.34	2		57	2	5.2
17-Oct	8.42	2.0	0	clr-pc, haze	12.2	sw-wnw	13.5	30.13	4		27	3	5.2
18-Oct	8.83	1.8	0	pc-mc, haze	13.7	wsw-nw	12.8	30.23	3		50	2	10.3
19-Oct	8.42	2.0	0	clr-pc	4.8	ne-se, sw-nw	15.1	30.19	2		36	2	11.9
20-Oct	8.42	2.0	0	clr-pc	11.5	sw, nw-n	14.0	30.06	3		33	2	8.2
21-Oct	8.00	2.1	0	ovc, AM rain	19.4	sw-nw	11.2	30.01	4		55	3	2.5
22-Oct	8.25	2.0	0	clr-mc	8.7	wnw-nw	12.0	29.96	3		84	2	13.6
23-Oct	8.25	2.1	0	clr	27.9	sw-nw	11.6	29.94	4		100	1	2.9
24-Oct	8.00	1.8	0	clr-pc	4.7	ne-e, sw-nw	11.4	30.14	2		68	2	9.9
25-Oct	7.67	2.7	0	pc-mc	4.0	calm/var	11.4	30.20	2		80	2	6.0
26-Oct	8.00	2.1	0	clr-pc	12.2	ne-se	12.0	30.29	3		82	3	1.4
27-Oct	8.00	2.0	0	mc-ovc	17.4	se, sw-wnw	15.2	30.28	4		57	2	1.8
28-Oct	8.00	2.8	0	pc-ovc	7.8	sw-nw	14.2	30.17	3		79	3	2.0
29-Oct	8.00	1.8	0	mc-ovc	11.7	sse-s, sw-wnw	14.8	30.34	4		67	1	1.1
30-Oct	8.00	1.5	0	ovc	15.3	var	13.2	30.20	4		82	2	1.3
31-Oct	7.50	1.6	0	pc-ovc	18.8	var	8.6	30.00	4		61	1	2.9
1-Nov	8.25	2.0	0	clr	12.0	sw-wnw	7.1	30.02	1		83	2	6.4
2-Nov	8.00	1.6	0	pc-mc	9.4	ne-se	9.3	30.77	3		84	2	0.6
3-Nov	8.00	1.5	0	clr-pc	10.5	ne-se	10.3	31.00	4		78	2	0.4
4-Nov	8.00	1.8	0	mc-ovc	14.7	ne-se	9.0	30.86	4		63	3	0.5
5-Nov	5.25	2.0	0	mc-ovc	5.3	w-wnw, ne-se	9.0	30.19	4		61	2	1.0

[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: 2001.

Date	Obs. Hours	Species[1]																								Birds
		OS	NH	SS	CH	NG	SA	LA	UA	BW	SW	RT	FH	UB	GE	BE	UE	AK	ML	PR	PG	SF	LF	UF	UU	Total / Hour
27-Aug	8.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	8 1.0
28-Aug	6.92	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	4 0.6
29-Aug	7.67	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3 0.4
30-Aug	8.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 0.0
31-Aug	7.75	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2 0.3
01-Sep	7.83	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2 0.3
02-Sep	7.67	0	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	20 2.6
03-Sep	7.84	2	0	7	2	0	0	0	0	0	0	3	0	0	0	0	0	11	0	0	0	0	0	0	0	25 3.2
04-Sep	8.00	1	1	4	9	0	2	0	0	0	0	6	0	0	0	0	0	4	0	0	0	0	0	0	0	27 3.4
05-Sep	8.17	1	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	5 0.6
06-Sep	7.67	0	0	3	0	0	0	0	0	0	1	1	0	0	0	0	0	7	0	1	0	0	0	0	0	13 1.7
07-Sep	8.58	3	0	20	20	1	4	0	0	0	1	12	1	0	0	0	0	27	0	0	0	0	0	0	3	92 10.7
08-Sep	8.08	9	0	6	11	0	4	0	0	0	0	17	0	0	0	0	0	12	0	0	0	0	0	0	2	61 7.5
09-Sep	8.50	6	0	5	7	0	0	0	0	0	0	17	0	0	0	0	0	51	0	0	0	0	0	0	0	86 10.1
10-Sep	8.00	1	0	8	8	0	1	0	0	0	3	25	0	0	0	0	0	16	0	0	0	0	0	0	0	62 7.8
11-Sep	8.00	0	0	2	4	0	1	0	0	0	0	2	0	0	0	0	0	10	0	0	0	0	0	0	0	19 2.4
12-Sep	7.50	2	1	1	3	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	1	14 1.9
13-Sep	8.17	1	0	8	12	0	0	0	0	0	1	8	0	0	0	0	0	7	0	0	0	0	0	0	0	37 4.5
14-Sep	9.50	4	0	53	58	0	4	0	0	0	2	13	0	0	0	0	0	8	0	0	0	0	0	0	1	143 15.1
15-Sep	8.42	4	0	54	78	0	1	0	0	0	1	33	0	0	0	0	0	45	0	0	0	0	0	0	1	217 25.8
16-Sep	8.00	4	0	20	15	0	0	0	0	0	0	7	0	0	0	0	0	20	0	0	0	0	0	0	0	66 8.3
17-Sep	8.58	3	1	30	21	0	0	0	0	0	0	13	0	0	0	0	0	48	0	0	0	0	0	0	2	118 13.8
18-Sep	9.50	0	1	25	29	0	2	0	0	0	0	19	0	0	0	0	0	61	0	0	0	0	0	0	2	139 14.6
19-Sep	8.50	7	0	91	114	0	5	0	0	3	2	39	0	0	0	0	0	62	1	0	0	1	0	0	6	331 38.9
20-Sep	8.92	2	0	57	38	0	5	0	0	4	0	25	0	0	0	0	0	22	0	0	0	0	0	0	2	155 17.4
21-Sep	8.83	4	1	91	66	0	9	0	0	1	0	26	0	0	0	1	0	67	0	0	0	0	0	1	1	268 30.4
22-Sep	8.42	2	0	37	17	1	1	0	0	0	0	9	0	0	0	0	0	44	0	0	0	1	0	0	0	112 13.3
23-Sep	8.17	1	1	15	24	0	1	0	0	0	0	9	0	0	0	0	0	32	1	0	0	0	0	0	0	84 10.3
24-Sep	8.25	1	2	27	25	0	6	0	0	2	5	46	0	0	0	0	0	14	0	0	0	0	0	0	2	130 15.8
25-Sep	8.16	1	2	60	62	0	9	0	0	1	1	71	0	1	1	0	0	66	1	1	0	0	0	0	1	278 34.1
26-Sep	8.00	0	1	61	65	0	3	0	0	1	0	33	0	1	0	0	0	37	0	0	0	0	0	0	3	205 25.6
27-Sep	8.17	3	0	43	49	0	2	0	0	0	0	29	0	2	0	0	0	21	0	0	0	0	0	0	4	153 18.7
28-Sep	8.50	1	1	52	63	0	6	0	0	10	1	45	0	1	0	0	0	50	0	0	0	0	1	1	1	233 27.4
29-Sep	8.00	2	1	24	9	0	2	1	0	1	0	12	0	0	0	0	0	82	0	2	0	0	0	0	0	136 17.0
30-Sep	8.00	1	1	25	25	0	1	0	0	0	1	24	0	0	0	0	0	42	0	0	0	0	0	0	1	121 15.1
01-Oct	8.00	0	0	6	4	0	0	0	0	0	0	3	0	2	0	0	0	21	0	1	0	0	0	0	1	38 4.8
02-Oct	8.75	1	1	58	57	1	3	0	0	0	3	110	0	0	0	0	0	40	0	0	0	0	0	0	2	276 31.5
03-Oct	9.17	4	3	128	93	0	5	0	0	0	1	59	0	0	0	0	0	89	1	1	0	0	0	0	7	391 42.6
04-Oct	8.25	0	1	42	28	0	5	0	0	0	0	36	0	0	0	0	0	35	0	0	0	0	0	0	3	150 18.2
05-Oct	8.16	1	0	34	20	0	6	0	0	0	3	74	1	0	0	0	0	37	0	0	0	0	0	0	3	179 21.9

Appendix E. continued

Date	Obs. Hours	Species[1]																							Total	Birds / Hour
		OS	NH	SS	CH	NG	SA	LA	UA	BW	SW	RT	FH	UB	GE	BE	UE	AK	ML	PR	PG	SF	LF	UF	UU		
06-Oct	7.33	2	0	16	16	0	2	0	0	0	0	24	0	0	0	0	0	5	0	0	0	0	0	0	1	66	9.0
07-Oct	8.00	0	0	16	12	0	1	0	0	2	0	25	0	0	0	0	0	5	0	0	1	0	0	0	0	62	7.8
08-Oct	8.92	4	1	49	14	1	0	0	0	0	0	79	0	0	0	0	0	12	1	0	1	0	0	0	2	164	18.4
09-Oct	8.33	2	0	16	9	0	0	0	0	0	0	33	0	0	0	0	0	3	0	0	0	0	0	0	0	63	7.6
10-Oct	8.00	0	0	26	8	0	3	0	0	0	0	56	0	0	0	0	0	9	0	1	0	0	0	0	1	104	13.0
11-Oct	8.33	0	0	29	20	0	0	0	0	0	0	28	0	0	0	0	0	4	0	0	0	0	0	0	0	81	9.7
12-Oct	8.00	0	0	2	0	0	0	0	0	0	0	7	0	0	0	0	0	1	0	0	0	0	0	0	0	10	1.3
13-Oct	8.50	0	1	13	3	0	0	0	0	0	0	18	0	0	0	0	0	3	0	0	1	0	0	0	0	39	4.6
14-Oct	8.50	1	1	19	11	0	1	0	0	0	0	29	0	0	0	0	0	5	0	0	0	0	1	1	2	71	8.4
15-Oct	8.08	0	0	15	3	0	0	0	0	0	0	5	1	0	1	0	0	1	0	0	0	0	0	0	1	27	3.3
16-Oct	8.25	1	2	12	2	0	2	0	0	0	0	42	0	0	0	0	0	3	0	0	0	0	0	0	0	64	7.8
17-Oct	8.00	0	0	7	0	0	0	0	0	0	0	24	0	1	0	0	0	1	0	0	0	0	0	0	0	33	4.1
18-Oct	8.16	0	2	19	0	0	0	0	0	0	0	17	0	0	0	0	0	4	0	0	0	0	0	0	0	42	5.1
19-Oct	8.00	0	2	38	2	0	0	0	0	0	0	23	0	0	0	0	0	3	0	0	0	0	0	0	1	69	8.6
20-Oct	8.25	0	1	39	2	0	0	0	0	0	0	34	0	0	0	1	0	1	0	1	0	0	0	0	0	79	9.6
21-Oct	7.67	0	0	3	1	0	0	0	0	0	0	16	0	0	0	2	0	1	0	0	1	0	0	0	0	24	3.1
22-Oct	8.00	0	0	30	3	0	0	0	0	0	0	35	0	0	0	1	0	1	2	0	1	0	1	0	0	74	9.3
23-Oct	8.00	0	1	5	2	1	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	16	2.0
24-Oct	8.08	0	0	24	2	0	1	0	0	0	0	16	0	0	0	0	0	0	0	0	0	0	0	0	1	44	5.4
25-Oct	8.00	1	1	40	1	1	0	0	0	0	0	17	0	0	0	0	0	0	0	0	1	0	0	0	0	62	7.8
26-Oct	8.00	0	0	10	3	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	22	2.8
27-Oct	8.00	0	0	3	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	1	9	1.1
28-Oct	8.00	0	0	4	0	1	0	0	0	0	0	11	0	0	0	0	0	1	1	0	0	0	0	0	0	18	2.3
29-Oct	8.16	0	2	11	0	0	0	0	0	0	0	18	0	0	0	1	0	0	0	0	0	0	0	0	0	32	3.9
30-Oct	7.92	0	2	13	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	28	3.5
31-Oct	6.92	0	1	14	0	0	0	0	0	0	0	23	0	0	0	1	0	0	0	0	0	0	0	0	0	39	5.6
01-Nov	8.00	0	0	12	1	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	21	2.6
02-Nov	8.00	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0.5
03-Nov	8.00	0	0	11	0	0	0	0	0	0	0	4	0	0	1	1	0	0	0	0	0	0	0	0	1	18	2.3
04-Nov	8.00	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0.3
05-Nov	5.08	0	0	4	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0	7	1.4
Total	575.08	83	39	1609	1158	7	98	1	0	25	26	1458	3	8	3	9	0	1180	8	8	6	2	3	3	60	5797	10.1

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

Appendix F. Daily raptor migration counts by species at Yaki Point, Grand Canyon, AZ: 2001.

	Obs.	Species[1]																										Birds
Date	Hours	OS	NH	SS	CH	NG	SA	LA	UA	BW	SW	RT	FH	RL	ZT	UB	GE	BE	UE	AK	ML	PR	PG	SF	LF	UF	UU	Total	/ Hour
27-Aug	7.00	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	6	0.9
28-Aug	8.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
29-Aug	7.83	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
30-Aug	8.00	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	3	0.4
31-Aug	8.00	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.1
01-Sep	8.25	0	0	2	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	10	1.2
02-Sep	8.42	0	0	2	1	0	1	0	0	0	0	2	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	12	1.4
03-Sep	8.83	0	0	7	2	0	0	0	0	0	0	2	0	0	0	0	0	0	0	11	0	0	0	0	0	0	1	23	2.6
04-Sep	8.00	0	0	3	3	0	0	0	0	0	0	2	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	13	1.6
05-Sep	9.00	1	0	1	4	0	0	0	0	0	1	1	0	0	1	0	0	0	0	9	0	0	0	0	0	0	0	18	2.0
06-Sep	8.42	0	0	3	1	0	0	0	0	0	0	5	0	0	0	0	1	0	0	6	0	0	0	0	0	0	0	16	1.9
07-Sep	9.08	4	0	30	26	0	5	0	0	0	0	4	0	0	0	0	0	0	0	29	0	0	1	0	0	1	0	100	11.0
08-Sep	8.75	1	0	18	30	0	2	0	0	0	0	3	0	0	0	0	1	0	0	21	0	0	0	0	0	0	1	77	8.8
09-Sep	8.75	0	0	13	8	0	0	0	0	0	0	5	0	0	0	0	0	0	0	17	0	0	0	0	0	0	0	43	4.9
10-Sep	8.25	0	1	5	16	0	0	0	0	0	1	3	0	0	0	0	0	0	0	6	0	0	1	0	0	0	0	33	4.0
11-Sep	8.25	0	0	10	17	0	0	0	0	0	0	8	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	48	5.8
12-Sep	6.83	1	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	7	1.0
13-Sep	7.92	2	0	11	14	0	2	0	0	0	0	2	1	0	0	0	0	0	0	2	0	0	0	0	0	0	2	36	4.5
14-Sep	9.33	2	0	17	26	0	1	0	0	1	0	7	0	0	0	0	0	0	0	27	0	0	0	0	0	0	0	81	8.7
15-Sep	8.33	1	0	11	22	0	3	0	0	1	0	13	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	63	7.6
16-Sep	8.25	1	0	8	8	0	0	0	0	1	1	11	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	39	4.7
17-Sep	9.92	0	2	24	29	0	1	0	0	1	2	7	0	0	0	0	0	0	0	36	0	1	0	0	0	0	0	103	10.4
18-Sep	9.50	1	1	99	119	0	1	0	0	2	3	41	0	0	0	0	0	0	0	64	2	0	0	0	0	0	0	333	35.1
19-Sep	9.42	0	0	27	42	0	1	0	0	0	1	18	0	0	0	0	0	0	0	26	0	0	0	0	0	0	0	115	12.2
20-Sep	9.50	0	0	12	34	0	2	0	0	0	0	7	0	0	0	1	0	0	0	24	1	0	0	0	0	0	0	81	8.5
21-Sep	9.25	0	0	32	35	0	1	0	0	0	0	11	0	0	0	0	0	0	0	18	0	0	0	0	0	0	1	98	10.6
22-Sep	9.33	6	0	103	81	0	10	0	0	0	0	25	0	0	0	0	0	1	0	47	0	0	0	0	0	0	4	277	29.7
23-Sep	9.08	0	0	33	22	0	2	0	0	1	0	3	0	0	0	0	0	0	0	18	0	0	0	0	0	0	0	79	8.7
24-Sep	8.92	1	4	163	121	0	4	0	0	1	2	40	0	0	0	2	0	0	0	66	1	0	0	0	0	0	0	405	45.4
25-Sep	10.25	0	1	40	33	0	4	0	0	0	3	32	0	0	0	2	0	0	0	14	0	0	0	0	0	0	0	129	12.6
26-Sep	9.92	0	2	13	13	0	0	0	0	0	0	7	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	39	3.9
27-Sep	9.17	0	0	24	17	1	3	0	0	1	0	9	0	0	0	0	0	1	0	4	0	0	0	0	0	0	0	60	6.5
28-Sep	9.08	0	1	27	34	0	2	0	0	0	1	5	0	0	0	0	0	0	0	14	0	1	0	0	0	0	0	85	9.4
29-Sep	8.92	3	1	66	47	0	2	0	0	1	0	15	1	0	0	0	0	0	0	36	0	0	0	0	0	0	0	172	19.3
30-Sep	8.25	0	0	37	18	0	2	0	0	0	0	10	0	0	0	0	0	0	0	35	1	0	0	0	0	0	0	103	12.5
01-Oct	9.25	3	3	105	99	0	5	0	0	0	4	36	0	0	0	0	0	1	0	144	1	0	0	0	0	0	1	402	43.5
02-Oct	8.42	2	0	72	65	0	1	0	0	0	0	8	1	0	0	1	0	0	0	28	0	0	0	0	0	0	2	180	21.4
03-Oct	8.17	1	2	52	51	2	3	0	0	0	0	25	1	0	0	0	0	0	0	25	0	0	0	0	0	0	0	162	19.8
04-Oct	8.42	0	1	14	15	0	0	0	0	0	0	16	0	0	0	0	0	0	0	15	1	0	0	0	0	0	0	62	7.4
05-Oct	8.17	1	2	27	8	1	1	0	0	0	0	10	0	0	0	1	0	0	0	19	0	0	1	0	0	0	0	71	8.7

Appendix F. continued

Date	Obs. Hours	Species[1]																									Total	Birds / Hour
		OS	NH	SS	CH	NG	SA	LA	UA	BW	SW	RT	FH	RL	ZT	UB	GE	BE	UE	AK	ML	PR	PG	SF	LF	UF	UU		
06-Oct	7.25	0	0	8	6	0	1	0	0	0	0	9	0	0	0	1	0	0	0	3	0	0	0	0	0	0	1	29	4.0
07-Oct	7.83	0	0	37	16	0	0	0	0	0	0	70	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	125	16.0
08-Oct	8.25	0	0	38	41	0	1	0	0	1	0	53	0	0	0	0	0	0	0	9	3	0	0	0	0	1	1	148	17.9
09-Oct	8.16	0	2	41	20	0	1	0	0	0	0	38	0	0	0	0	0	0	0	13	1	0	0	0	0	0	0	116	14.2
10-Oct	9.50	0	0	95	43	0	2	0	0	0	0	41	0	0	0	0	0	0	0	9	1	0	1	0	0	0	3	195	20.5
11-Oct	8.08	0	0	13	8	0	0	0	0	0	0	5	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	27	3.3
12-Oct	8.00	0	0	13	9	0	0	0	0	0	0	3	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	28	3.5
13-Oct	8.00	0	0	13	7	0	0	0	0	0	0	13	0	0	0	0	0	0	0	2	1	0	1	0	0	0	0	37	4.6
14-Oct	8.50	0	2	57	9	0	0	0	0	0	0	39	0	0	0	0	0	0	0	3	0	0	0	0	0	0	1	111	13.1
15-Oct	8.25	0	0	28	7	0	0	0	0	0	0	27	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	65	7.9
16-Oct	8.08	0	0	14	5	0	0	0	0	0	0	19	0	0	0	0	0	0	0	1	1	0	0	0	0	0	2	42	5.2
17-Oct	8.42	0	0	8	5	0	1	0	0	0	0	29	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	44	5.2
18-Oct	8.83	0	0	32	14	1	0	0	0	0	0	32	0	0	0	0	1	5	0	4	0	1	1	0	0	0	0	91	10.3
19-Oct	8.42	0	0	55	16	0	1	0	0	0	0	26	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	100	11.9
20-Oct	8.42	0	0	21	4	2	1	0	0	0	0	38	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	69	8.2
21-Oct	8.00	0	0	5	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	20	2.5
22-Oct	8.25	0	0	31	5	1	0	0	0	0	0	71	0	0	0	0	0	0	0	1	1	0	0	0	0	0	2	112	13.6
23-Oct	8.25	0	0	16	2	0	1	0	0	0	0	3	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	24	2.9
24-Oct	8.00	0	2	48	9	1	3	0	0	0	0	12	0	1	0	0	0	0	0	1	1	0	1	0	0	0	0	79	9.9
25-Oct	7.67	0	0	35	0	0	0	0	0	0	0	8	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	46	6.0
26-Oct	8.00	1	0	7	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	1.4
27-Oct	8.00	0	0	6	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	2	0	0	0	0	0	1	14	1.8
28-Oct	8.00	0	0	5	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	2.0
29-Oct	8.00	0	0	3	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	1.1
30-Oct	8.00	1	0	0	0	1	0	0	0	0	0	6	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	10	1.3
31-Oct	7.50	0	0	7	1	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	2.9
01-Nov	8.25	0	2	30	1	0	0	0	0	0	0	17	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	53	6.4
02-Nov	8.00	0	1	3	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0.6
03-Nov	8.00	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	3	0.4
04-Nov	8.00	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	0.5
05-Nov	5.25	0	0	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	1.0
Total	595.59	34	31	1792	1293	11	72	0	0	11	19	1008	6	1	1	8	4	14	0	881	22	3	7	0	0	2	25	5245	8.8

[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: 1991–2001.

YEAR	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	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	30-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
Days of observation	57	65	66	64	64	69	70	68	71	67	71	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	505.70
Raptors / 100 hours	1231	1957	1249	1372	1369	1574	1331	1283	1152	1107	1008	1330
SPECIES	RAPTOR COUNTS											
Osprey	26	72	73	73	77	99	135	115	72	88	83	83
Northern Harrier	43	131	64	111	121	111	93	81	130	99	39	93
Sharp-shinned Hawk	698	2472	1643	1802	1441	1680	1566	1366	1427	1449	1609	1559
Cooper's Hawk	1077	1673	1243	974	1052	1322	1332	1715	1515	968	1158	1275
Northern Goshawk	10	42	26	4	5	3	8	2	6	13	7	11
Unknown small accipiter[1]	–	–	–	–	–	–	–	–	–	0	98	–
Unknown large accipiter[1]	–	–	–	–	–	–	–	–	–	1	1	–
Unknown accipiter	360	337	199	200	243	423	213	243	185	252	0	–
TOTAL ACCIPITERS	2145	4524	3111	2980	2741	3428	3119	3326	3133	2682	2873	3097
Red-shouldered Hawk	0	1	0	0	0	1	0	0	0	0	0	<1
Broad-winged Hawk	0	3	7	2	7	2	7	35	11	15	25	10
Swainson's Hawk	6	24	25	33	34	57	32	31	40	22	26	30
Red-tailed Hawk	1194	3229	1613	1898	2299	2275	1704	1390	1401	1498	1458	1814
Ferruginous Hawk	8	15	7	11	3	6	7	6	7	6	3	7
Zone-tailed Hawk	0	0	0	0	0	0	1	1	0	0	0	<1
Unidentified buteo	55	19	2	8	11	16	33	40	17	15	8	20
TOTAL BUTEOS	1263	3291	1654	1952	2354	2357	1784	1503	1476	1556	1520	1883
Golden Eagle	18	62	37	36	32	47	26	22	29	9	3	29
Bald Eagle	5	20	49	8	38	23	25	18	24	11	9	21
Unidentified eagle	0	0	3	0	0	0	0	1	4	0	0	1
TOTAL EAGLES	23	82	89	44	70	70	51	41	57	20	12	51
American Kestrel	1156	1508	1209	1273	1096	1631	1340	978	1218	1045	1180	1239
Merlin	7	14	12	10	12	8	24	12	13	9	8	12
Prairie Falcon	1	8	8	2	5	4	5	5	2	9	8	5
Peregrine Falcon	2	14	5	5	5	8	8	10	8	6	6	7
Unknown small falcon[1]	–	–	–	–	–	–	–	–	–	–	2	–
Unknown large falcon[1]	–	–	–	–	–	–	–	–	–	–	3	–
Unknown falcon	0	4	4	1	1	0	6	8	6	5	3	–
TOTAL FALCONS	1166	1548	1238	1291	1119	1651	1383	1013	1247	1074	1210	1267
Unknown raptor	106	124	24	66	48	60	97	96	107	48	60	76
GRAND TOTAL	4920	10048	6301	6625	6745	8008	6952	6479	6297	5664	5797	6712

[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: 1997–2001.

YEAR	1997	1998	1999	2000	2001	MEAN
Start date	27-Aug	28-Aug	27-Aug	27-Aug	27-Aug	27-Aug
End date	5-Nov	5-Nov	5-Nov	5-Nov	5-Nov	5-Nov
Days of observation	71	66	71	66	71	69
Hours of observation	504.97	455.41	543.20	513.10	595.59	522.45
Raptors / 100 hours	938.3	907.5	997.8	1054.2	880.6	941.5
SPECIES			RAPTOR COUNTS			
Osprey	50	43	28	43	34	40
Northern Harrier	50	44	56	41	31	44
Sharp-shinned Hawk	1474	1190	1906	1772	1792	1627
Cooper's Hawk	856	1109	1204	1256	1293	1144
Northern Goshawk	4	7	1	9	11	6
Unknown small accipiter[1]	–	–	–	–	72	–
Unknown large accipiter[1]	–	–	–	–	0	–
Unknown accipiter	94	140	109	236	0	–
TOTAL ACCIPITERS	2428	2446	3220	3273	3168	2907
Red-shouldered Hawk	1	0	0	0	0	0
Broad-winged Hawk	9	19	14	6	11	12
Swainson's Hawk	15	25	32	10	19	20
Red-tailed Hawk	899	916	985	892	1008	940
Ferruginous Hawk	8	7	11	10	6	8
Rough-legged Hawk	0	0	0	1	1	0
Zone-tailed Hawk	0	0	1	0	1	0
Unidentified buteo	20	20	13	8	8	14
TOTAL BUTEOS	952	987	1056	927	1054	995
Golden Eagle	24	7	2	11	4	10
Bald Eagle	23	18	17	9	14	16
Unidentified eagle	1	0	1	0	0	0
TOTAL EAGLES	48	25	20	20	18	26
American Kestrel	1016	423	918	1035	881	855
Merlin	14	12	14	5	22	13
Prairie Falcon	9	4	6	4	3	5
Peregrine Falcon	7	19	8	1	7	8
Unknown small falcon[1]	–	–	–	–	0	–
Unknown large falcon[1]	–	–	–	–	0	–
Unknown falcon	0	4	2	3	2	2
TOTAL FALCONS	1046	462	948	1048	915	884
Unidentified raptor	20	38	16	10	25	22
GRAND TOTAL	4594	4045	5344	5362	5245	4918

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