FALL 1999 RAPTOR MIGRATION STUDIES
IN THE GRAND CANYON OF ARIZONA

Report Prepared by:

Mark Vekasy & Jeff P. Smith

Counts Conducted by:

Scott Rush, Steve Seibel, Adam Hutchins, Christie Van Cleve & Kate James

On-site Education by:

Pat & Ron Brown

Project Coordinated by:

HawkWatch International, Inc.

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

(801) 484-6808

June 2000

EXECUTIVE SUMMARY

HawkWatch International (HWI) has coordinated standardized, full-season, daily counts of the fall raptor migration in the Grand Canyon of Arizona each year since 1991. To date, HWI observers have recorded 18 species of diurnal raptors migrating through the area. The 1999 season marks the ninth consecutive full-season count at Lipan Point and the third full-season count at Yaki Point, both sites on the south rim of the canyon. Unlike many other migrations where mountain ridges provide distinct "leading lines" for migrant raptors to follow, the migration over the Grand Canyon probably originates along a broad front as birds pass over the wide North Kaibab Plateau on their way toward the canyon. For this reason, we hypothesize that monitoring at more than one site will ultimately provide valuable information about variation in daily and seasonal concentrations and a better index to the flight volume in the region.

During fall 1999, HWI coordinated 11 other fall migration counts in Texas, New Mexico, Utah, Nevada, Montana, Washington, Oregon, Florida, and Veracruz, Mexico. The primary objective of HWI migration studies is to track long-term trends in the abundance and distribution of migratory diurnal raptors throughout primarily western North America. Raptors occur in most habitats, occupy large home ranges, feed atop food pyramids, and are known to be sensitive to environmental contamination and disturbance; therefore, they represent valuable biological indicators of ecosystem status. With about 5 million people visiting the park each year and easy accessibility, the Grand Canyon sites also offer excellent opportunities for public outreach and education about the ecology and conservation needs of raptors.

In 1999, a rotating team of 3 official observers, 2 on-site educators, and 2 dedicated volunteers conducted the two counts between 27 August and 5 November. The Lipan count included 6,297 raptors of 16 species tallied during 71 days and 546 hours between 27 August and 5 November. The Yaki count included 5,420 raptors of 17 species tallied during 71 days and 543 hours between 27 August and 5 November. Observation effort at Lipan was about 11% higher than average, whereas effort at Yaki was about 13% higher than average. Inclement weather precluded or interrupted observations on only 2 days at each site. No major storm systems occurred, and rainfall was infrequent, compared to 1998 with rain almost daily between 1–12 September and 20–31 October. Fog in the canyon, snow, thunderstorms, and high winds were also largely absent and did not affect this year's count. Both flights consisted primarily of accipiters (50–59%), buteos (19–23%), and falcons (17–20%). Sharp-shinned Hawk, Cooper's Hawk, Red-tailed Hawk, and American Kestrel were the most common species at both sites. In most respects, the 1999 flight rated average for most species. Exceptions included atypical numbers of Cooper's Hawks and Red-tailed Hawks Lipan Pt., and low numbers of Turkey Vultures and Ospreys at both sites despite indications of widespread increasing trends. The prevalence of fair weather and light winds may have enhanced regional thermal production during the season and thereby contributed to greater dispersal of some species' migrations.

ACKNOWLEDGMENTS

We gratefully acknowledge the financial support of the U.S. Fish and Wildlife Service (Region 2), National and Fish and Wildlife Foundation, Grand Canyon Association, Nancy Perkins, 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. Many thanks to local volunteers Christie Van Cleve and Kate James for their dedicated efforts to help with observations. Finally, thanks to all the visitors to the Grand Canyon hawkwatch for their interest and support.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

HawkWatch International (HWI) has coordinated standardized, full-season, daily counts of the fall raptor migration in the Grand Canyon of Arizona each year since 1991. The flight through this region is one of the largest concentrations of migrating raptors known in North America west of the Mississippi River. To date, observers have recorded 18 species of diurnal raptors migrating through the area. Chuck LaRue discovered the flyway in 1987 and Christie Van Cleve conducted exploratory counts at points along the south rim in 1989 and 1990. During 1991, when HWI conducted the first full-season count, two full-time observers counted migrating raptors at Lipan Point along the south rim of the canyon. The 1999 season marks the ninth consecutive year of full-season counts at this site. HWI also conducted the third consecutive, full-season count at Yaki Point in 1999.

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 conditions. 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* Mueller and Berger 1967) and provide a concentrated, stable source of lift, the migrants probably approach the canyon along a relatively broad front. Accordingly, we hypothesize that 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).

During fall 1999, HWI coordinated 11 other fall migration counts in Florida, Texas, New Mexico, Utah, Nevada, Montana, Washington, Oregon, and Veracruz, Mexico. The primary objective of HWI migration studies is to track long-term trends in the abundance and distribution of migratory diurnal raptors throughout primarily western North America. 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 and Zalles 1995). For example, long-term migration counts in the eastern United States documented declines in several raptor species and helped us understand the deleterious effects of organochlorine pesticides (Spofford 1969, Mueller et al. 1988, Bednarz et al. 1990b). Migration counts, in particular, may also represent the most cost-effective and efficient method for monitoring the regional status and trends of multiple raptor species (Bednarz and Kerlinger 1989, Titus et al. 1989, Bildstein and Zalles 1995, Bildstein et al. 1995, Dunn and Hussell 1995, Dixon et al. 1999, Smith and Hoffman 2000). With about 5 million people visiting the park each year and easy accessibility, the Grand Canyon sites also offer excellent opportunities for public outreach and education about the ecology and conservation needs of raptors and the Grand Canyon ecosystem.

In this report, we summarize observations made at the two Grand Canyon monitoring sites during fall 1999. We discuss 1999 data on seasonal timing, daily flight rhythm, and the species, age, sex, and color-morph composition of flights at the two sites. We compare statistics for the 1999 season with means and annual trends for the previous 7 seasons at Lipan Pt. and previous 2 seasons at Yaki Pt. We also examine comparative patterns for 1997–1999 with counts from the two sites combined.

STUDY SITES

Lipan Pt. is located in Coconino County, Arizona (36° 02' N, 111° 51' W) along the south rim of the Grand Canyon (Figure 1) at an elevation of about 2,420 m (7,380 ft). The site is an established lookout for visitors to Grand Canyon National Park, which can be accessed by driving 3.2 km (2 mi) southwest on Hwy 64 from the east entrance to the park. The observation point is located about 170 m (520 ft) 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^{o} 04' N, 112° 05' W) along the south rim of the Grand Canyon (Figure 2) at an elevation of about 2,380 m (7,260 ft). This site also is a popular canyon lookout, which visitors can access from Hwy 64 about 11.2 km (7 mi) 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.

METHODS

Three official or designated observers, assisted by local volunteers Christi Van Cleve and Kate James and on-site educators Pat and Ron Brown, conducted standardized daily counts of migrant raptors from late August to early November at Yaki and Lipan Pts. The official observers—Scott Rush, Steve Seibel, and Adam Hutchins—rotated between sites and observation partners to minimize potential observer bias. Volunteers Christi Van Cleve and Kate James helped with observations at Lipan Pt. only. On-site educators Pat and Ron Brown helped with observations at both sites when their education schedules allowed. This arrangement ensured that at least two counters were present at all times at Lipan Pt., and that two counters were generally present at Yaki Point at least 5 days a week. Each of the three official observers had a single season of previous raptor migration counting experience, with Adam and Steve having worked previously for HWI (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, and Kate James has helped with the Lipan Pt. count on a more limited basis for several years. Other visitors to the sites also occasionally assisted in spotting migrants (see Smith and Hoffman [in review] for a discussion of visitor effects). Pat and Ron Brown 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; however, during peak flight periods, observations sometimes began earlier in the morning and extended later in the evening. 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 mean number of observers (official observers plus visitors who actively scanned for migrants for more than 10 minutes in a given hour) and visitors (all other guests) present during each hour.
6. Daily start and end times for each official observer.

The observers used high quality 8–10x 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.

The observers classified as residents and excluded from daily counts any raptor that exhibited hunting, territorial display, or perching behaviors for extended periods. They classified as northbound migrants and included in daily counts all raptors that passed the lookouts moving in a northerly direction without stopping or changing directions for several kilometers. We assume that these birds were either dispersing juveniles or adults dispersing short-distances from their nesting territories to favored wintering grounds in the same general region.

In this report, we compare results from the 1999 season at Lipan to means for 1991–1998, and examine long-term trends in annual passage rates (migrants counted per 100 hours of observation). We do not analyze the results statistically, except for providing estimates of 95% confidence intervals (CIs) for 1991–1998 means. If a current point estimate falls outside the 95% CI for the relevant 1991–1998 mean, then we conclude that it is significantly different from the mean at an α level of 0.05. A similar scenario applies for comparing 1999 data from Yaki Pt. against means and 95% CIs for 1997–1998.

RESULTS

WEATHER SUMMARY

Only three prominent weather systems moved through the Grand Canyon during the 1999 count-period, bringing strong winds and rain for short periods during the first four weeks of the season (see Appendixes C and D for daily weather records from the two sites). The rain, sometimes mixed with fog, did not entirely preclude any days of observation and severely restricted observations on only 2 days at each site. Clear skies predominated for the rest of the season, although dust or haze hampered visibility on a high proportion of days. High winds (>12 kph) occurred on 6 days at Lipan Pt. and 10 days at Yaki Pt. At Lipan, these high winds typically originated from the west to southwest. High winds at Yaki Pt. also originated primarily from the west to southwest, but high northwesterly winds occurred on 2 days. Both sites experienced a high percentage of days with westerly winds (27% Lipan, 17% Yaki) or variable winds (35% Lipan, 17% Yaki). Yaki also had high percentages of east, northwest, and southwest winds (18%, 16%, and 13%).

OBSERVATION SUMMARY

Lipan Pt.—The observers counted 6,297 raptors of 16 species during 71 days and 546.7 hours of observation between 27 August and 5 November 1999 (Tables 1 and 3; see Appendix E for 1999 daily count records and Appendix F for annual observation summaries). The numbers of observation days and hours in 1999 are 9% and 11% higher than average, respectively (Table 1). The 1999 combined-species

annual count and passage rate of 1,152 raptors/100 hrs are 10% and 19% lower than average, respectively, but only the difference in passage rates is significant (Table 1) and no distinct long-term trend in passage rates is evident (Figure 3). The 1999 flight consisted primarily of accipiters (50%), buteos (23%), and falcons (20%; Figure 4). Cooper's Hawk (1,515), Sharp-shinned Hawk (1,427), Red-tailed Hawk (1,401), and American Kestrel (1,218) were the most common species (Table 1). Turkey Vulture, Red-tailed Hawk, and Prairie Falcon showed significantly lower than average counts and passage rates in 1999, whereas Northern Harrier was the only species that showed a significantly higher than average count (a record high; Appendix F) and passage rate (Table 1). Ferruginous Hawk, Golden Eagle, and American Kestrel showed average counts but significantly lower than average passage rates. Cooper's Hawk showed a significantly higher than average count but an average passage rate. Two uncommon migrant species, Red-shouldered and Zone-tailed Hawks, were not seen this season.

Two of 10 species classified by age showed significantly higher than average immature : adult ratios in 1999, 2 species showed significantly lower than average ratios, and 6 species showed ratios that fell within the bounds of 95% CIs for the relevant means (Table 2). However, for 5 of the 10 species, significantly higher or lower than average proportions of unknown-age birds may confound the comparisons.

The 1999 combined-species daily flight rhythm followed a typical pattern for the site. Peak activity occurred between 1100–1300 hrs MST, with a sharp increase in activity through morning hours to the noon hour, and a gradual decrease in activity through the remainder of the afternoon (Figure 5).

The combined-species median passage date of 30 September is only 1 day earlier than average (Table 3). However, the near-average passage date is not clearly evident in the combined species seasonal activity pattern, as activity was significantly higher than average during mid-September, significantly below average for the first 10 days of October, and again significantly above average during the following 5-day period (Figure 6). Peak activity was concentrated during two 5-day periods, separated by lower than normal activity. The peak typically persists across four 5-day periods. At the species level, Northern Harrier, Northern Goshawk, Red-tailed Hawk, and Merlin showed significantly later than average median passage dates in 1999, whereas Sharp-shinned Hawk, Bald Eagle, and Peregrine Falcon were significantly earlier than average (Table 3). The remaining 8 species for which a comparison was possible showed nearly average passage dates. Age-specific comparisons revealed similar results as the species-level comparisons for Northern Harriers and Golden Eagles (Table 4). In contrast, contrary to the species level patterns, neither adult nor immature red-tails were significantly late and neither adult nor immature Sharp-shinned Hawks were significantly early (Table 4). In addition, although an average passage date was indicated at the species level for Cooper's Hawk, this applied only to adults, with immatures significantly later than average. The observers identified only 2 immature Bald Eagles, leaving the early species passage date due almost entirely to an earlier than average adult flight. Sex specific median passage dates for harriers and American Kestrels were all about average, although female kestrels were slightly later than average (Table 5). Both species followed the usual pattern of females preceding males.

Yaki Pt.—The observers counted 5,420 raptors of 17 species during 71 days and 543.2 hours of observation between 27 August and 5 November 1999 (Tables 6 and 8; see Appendix G for 1999 daily count records and Appendix H for annual observation summaries). The numbers of observation days and hours are 4% and 13% higher, respectively, than the 1997–1998 average (Table 6). The 1999 count consisted primarily of accipiters (59%), buteos (19%), and falcons (17%; Figure 7). Sharp-shinned Hawk (1,906), Cooper's Hawk (1,204), Red-tailed Hawk (985), and American Kestrel (918) were the most common species (Table 6). The 1999 combined-species annual count and passage rate of 998 raptors/100 hrs are 22% and 8% higher than average, respectively (Table 6). Most species' counts did not differ significantly from the 1997–1998 averages; however, counts for Osprey and Northern Goshawk were significantly lower than average. The 1999 passage rates were significantly lower than

average for Turkey Vulture, Osprey, Northern Goshawk, and Bald Eagle; significantly higher than average for Sharp-shinned hawk and Ferruginous Hawk; and within the bounds of 95% CIs for all other species (Table 6). All species for which a comparison is possible showed immature : adult ratios that did not differ significantly from the 1997–1998 means (Table 7).

The 1999 combined-species daily flight rhythm was similar to the average pattern, showing a unimodal pattern with peak activity between 1200 and 1300 hours (Fig 8).

The combined-species median passage date of 3 October is 3 days later than average (Table 8). The 1997–1998 average pattern shows a peak during the last week of September, with a gradual building of numbers early in the season and more gradual decline through the remainder of the season. The 1999 pattern is similar, but the peak occurred slightly earlier and numbers dropped from the peak but remained relatively steady until mid-October (Figure 9). Eight of 13 species for which comparative data were available showed median passage dates in 1999 that nearly matched the average pattern, whereas Bald Eagle, Merlin, and Peregrine Falcon were significantly earlier than average and Sharp-shinned and Cooper's Hawks were significantly later than average (Table 8). Classification by age revealed additional details, most notably, late passage of adult Northern Harriers and early passage of immature Sharp-shinned Hawks (Table 9). Sex-specific passage dates revealed significant differences only for male kestrels and male harriers (5 days later and 13 days earlier than average, respectively; Table 10).

***Combined Counts and Passage Rates*—**The 1999 combined-species, combined-site count of 11,717 raptors and passage rate of 2,150 raptors/100 hrs are 5% higher and 4% lower, respectively, than the 1997–1998 averages (Tables 11 and 12). For many species, passage rates from Yaki and Lipan give divergent indications of trend between the average and 1999. Most notably, opposite trends are indicated for Sharp-shinned Hawk, Cooper's Hawk, Northern Goshawk, Golden and Bald Eagles, and American Kestrel (Table 12). With counts from the two sites combined, 5 of 18 species showed higher counts and passage rates in 1999 than average, and 10 species showed lower values in 1999.

INDIVIDUAL SPECIES ACCOUNTS

Turkey Vulture

***Lipan Pt.*—**The observers counted 75 Turkey Vultures on 15 days between 13 September and 13 October (Tables 1 and 3). The annual count and passage rate of 14 raptors/100 hrs are both significantly lower than average (63% and 67%, respectively; Table 1). No distinct long-term trend in passage rates is evident at this time; rates had risen steadily since a low in 1993, but the 1999 rate is the second lowest for the study (Figure 10). The median passage date of 25 September is 2 days earlier but not significantly different than average (Table 3), and the seasonal activity pattern is within the normal range (Figure 11).

***Yaki Pt.*—**The observers counted 76 Turkey Vultures on 16 days between 20 September and 13 October (Tables 6 and 8). The annual count and passage rate of 14 raptors/100 hrs are significantly lower than average (34% and 42%, respectively; Table 6). The median passage date of 27 September is 3 days later than average (Table 8), but the seasonal activity pattern falls within the normal range (Figure 12).

***Combined Counts and Passage Rates*—**The combined-site count of 151 and passage rate of 28 raptors/100 hrs are 63% and 66% lower than average, respectively (Tables 11 and 12). In previous years, the count at Lipan was more than twice as high as at Yaki, but the count at Lipan decreased by 63% in 1999 while the count at Yaki decreased by only 34%.

Osprey

***Lipan Pt.*—**The observers counted 72 Ospreys on 28 days between 28 August and 15 October (Tables 1 and 3). The annual count and passage rate of 13 raptors/100 hrs are 14% and 21% lower than average,

respectively, but neither difference is significant (Table 1). Passage rates followed a distinct increasing trend between 1991–1997, but then dropped again in 1998 and 1999 (Figure 10). The median passage date of 16 September is only 1 day earlier than average (Table 3), but annual variation in seasonal activity patterns has been high (Figure 11).

Yaki Pt.—The observers counted 28 Ospreys on 22 days between 30 August and 12 October (Tables 6 and 8). The annual count and passage rate of 5.2 raptors/100 hrs are both significantly lower than average (40% and 47%, respectively; Table 6). The median passage date of 20 September is only 1 day later than average (Table 8), but annual variation in seasonal activity patterns has been high (Figure 12).

Combined Counts and Passage Rates—The combined-site count of 100 and passage rate of 18 raptors/100 hrs are 42% and 46% lower than average, respectively (Tables 11 and 12). Both sites showed the same trend between 1997 and 1999, and in all years the Lipan count was nearly three times higher than at Yaki.

Northern Harrier

Lipan Pt.—The observers counted 130 Northern Harriers on 43 days between 4 September and 5 November (Tables 1 and 3). The annual count and passage rate of 24 raptors/100 hrs are both significantly higher than average (38% and 25%, respectively; Table 1), and a possible gradual increasing trend in passage rates may be emerging (Figure 10). The 1999 flight consisted of 19% adult males, 6% adult females, 20% immature birds of unknown sex, and 55% birds of unknown sex and age. The immature : adult ratio of 0.79 is 21% lower than average, but the difference is not significant (Table 2). The median passage date for the species of 11 October is significantly later (5 days) than average (Table 3), a shift clearly illustrated by comparing seasonal activity patterns (Figure 11). However, age–sex specific dates show that only adult males were significantly later (9 days) than average (Tables 4 and 5). The 1999 data show a typical pattern of adult females preceding adult males, and immatures preceding adults (Table 4).

Yaki Pt.—The observers counted 56 Northern Harriers on 32 days between 5 September and 4 November (Tables 6 and 8). The annual count and passage rate of 10 raptors/100 hrs are 19% and 5% higher than average, respectively, but only the difference in counts is significant (Table 6). The 1999 flight consisted of 27% adult males, 7% adult females, 41% immature birds of unknown sex, and 25% birds of unknown sex and age. The immature : adult ratio of 1.21 is 18% lower than average, but the difference is not significant (Table 7). The median passage date for the species of 7 October is 3 days earlier than average, but the difference is not significant (Table 8). Nevertheless, a shift in activity is evident in comparing seasonal activity patterns, with the 1999 pattern showing a large peak during the second week of October (Figure 12). Age and sex specific median passage dates showed that adults, considered irregardless of sex, were 6 days later than average; however, consideration of adult males alone indicated significantly earlier (13 days) than average passage (Tables 9 and 10). The 1999 count for adult females was too low to enable calculation of a meaningful median date.

Combined Counts and Passage Rates—The combined-site count of 186 birds and passage rate of 34 raptors/100 hrs are 39% and 28% higher than average, respectively (Tables 11 and 12). Both sites showed the same trend between 1997–1999, and the Lipan count was nearly twice as high as at Yaki during all years.

Sharp-shinned Hawk

Lipan Pt.—The observers counted 1,427 Sharp-shinned Hawks on 61 days between 28 August and 5 November (Tables 1 and 3). The annual count and passage rate of 261 raptors/100 hrs are 10% and 18% lower than average, respectively, but neither difference is significant (Table 1). No distinct long-term trend in passage rates is evident at this time (Figure 13). The 1999 flight consisted of 47% adults, 17%

immatures, and 36% birds of unknown age. The immature: adult ratio of 0.37 is 20% lower than average, but the difference is not significant (Table 2). The median passage date for the species of 1 October is significantly earlier (4 days) than average (Table 3), which is reflected in the 1999 seasonal activity pattern as a late-September peak and reduced activity in October (Figure 14). However, the 1999 median passage date for immatures is 2 days earlier than average, whereas the passage date for adults is 3 days later than average (only the adult difference is significant; Table 4). The 1999 median dates show the typical pattern of immatures preceding adults.

Yaki Pt.—The observers counted 1,906 Sharp-shinned Hawks on 60 days between 4 September and 5 November (Tables 6 and 8). The annual count and passage rate of 351 raptors/100 hrs are 43% and 27% higher than average, respectively (Table 6). The flight consisted of 60% adults, 20% immatures, and 20% birds of unknown age. The immature : adult ratio of 0.34 is 45% lower than average, but the difference is not significant (Table 7). The median passage date for the species of 4 October is significantly later than average (3 days; Table 8); however, the seasonal activity pattern does not obviously reflect this difference (Figure 15). The average activity is relatively concentrated during mid-to-late September, with a smaller concentration during mid-October, whereas 1999 activity showed a single large peak in late September followed by broadly distributed activity through early October. Age-specific median passage dates for 1999 show that adults passed through on an average schedule, whereas immatures passed through significantly earlier than average (3 days; Table 9). The 1999 median dates show the typical pattern of immatures preceding adults.

Combined Counts and Passage Rates—The combined-site count of 3,333 and passage rate of 612 raptors/100 hrs are 19% and 9% higher than average, respectively (Tables 11 and 12). Both sites showed similar trends between 1997 and 1998, but counts are much higher at Yaki for 1999 and slightly lower at Lipan. In previous years, the count at Lipan was slightly higher than at Yaki.

Cooper's Hawk

Lipan Pt.—The observers counted 1,515 Cooper's Hawks on 59 days between 28 August and 5 November (Tables 1 and 3). The annual count and passage rate of 277 raptors/100 hrs are 17% and 5% higher than average, respectively (Table 1), but only the difference in counts is significant. No distinct long-term trend in passage rates is evident at this time (Figure 13). The 1999 flight consisted of 38% adults, 19% immatures, and 43% birds of unknown age. The immature : adult ratio of 0.51 is 13% lower than average and the difference is nearly significant (Table 2); however, the percentage of unknown-age birds is higher than average, possibly confounding the comparison. The median passage date for the species of 26 September matches the average (Table 3); however, age-specific dates show that immatures were significantly early (4 days) while adults showed average timing (Table 4). The 1999 median dates show the typical pattern of immatures preceding adults. The seasonal activity pattern is consistent with average timing (Figure 14).

Yaki Pt.—The observers counted 1,204 Cooper's Hawks on 55 days between 28 August and 3 November (Tables 6 and 8). The annual count and passage rate of 222 raptors/100 hrs are 23% and 7% higher than average, but neither difference is significant (Table 6). The flight consisted of 51% adults, 23% immatures, and 27% birds of unknown age. The immature : adult ratio of 0.45 is 48% lower than average, but the difference is not significant (Table 7). The median passage date for the species of 3 October is significantly later than average (4 days; Table 8). However, age-specific median passage dates show no significant differences, with immatures 2 days late and adults 2 days early (Table 9). The 1999 seasonal pattern also shows little difference from the average pattern, except for showing proportionately greater activity in mid-September and mid- October (Figure 15).

Combined Counts and Passage Rates—The combined count of 2,719 and passage rate of 499 raptors/100 hrs are 8% higher and 1% lower than average, respectively (Tables 11 and 12). Both sites

showed similar trends between 1997 and 1998, but the Lipan count was nearly average in 1999 while the 1999 Yaki count increased by 23% compared to the 1997–1998 average.

Northern Goshawk

Lipan Pt.—The observers counted 6 Northern Goshawks on 6 days between 20 September and 28 October (Tables 1 and 3). The annual count and passage rate of 1.1 raptors/100 hrs are 52% and 57% lower than average, respectively, but neither difference is significant (Table 1). Following the irruptive influx of birds that occurred between 1991 and 1993, passage rates have remained fairly stable (Figure 13). The 1999 flight included no adults, 5 immatures, and 1 bird of unknown age. The estimated immature : adult ratio of at least 5.0 is much higher than average (Table 2). The median passage date for the species of 14 October is significantly later than average (6 days; Table 3). The 1999 seasonal activity pattern fell within the normal, highly variable range of activity periods (Figure 14).

Yaki Pt.—The observers counted 1 immature Northern Goshawk on 10 October (Tables 6 and 8). The annual count and passage rate of 0.2 raptors/100 hrs are both significantly lower than average (82% and 84%, respectively; Table 6). Meaningful age ratios and median passage dates could not be calculated (Tables 7 and 8). In both of the first 2 years, the first goshawk was seen during 6–10 September, but the 1997 count also included 2 birds seen in late October (Figure 15). The only 1999 bird was seen in early October.

Combined Counts and Passage Rates—The combined count of 7 birds and passage rate of 1.3 raptors/100 hrs are 33% and 40% lower than average, respectively (Tables 11 and 12). The two sites show opposite trends in counts and passage rates between 1997–1999, with the lowest count at Lipan but highest count at Yaki in 1998.

Red-shouldered Hawk

No Red-shouldered Hawks were seen at either site during the 1999 season. Two birds were previously seen at Lipan in 1992 and 1996 (Appendix F), and 1 at Yaki in 1997 (Appendix H).

Broad-winged Hawk

Lipan Pt.—The observers counted 11 Broad-winged Hawks on 4 days between 18 September and 25 September (Tables 1 and 3). The annual count and passage rate of 2.0 raptors/100 hrs are 40% and 29% higher than average, but neither difference is significant (Table 1). Although the passage rate dropped in 1999 compared to the record high rate in 1998, a long-term increasing trend in passage rates is evident (Figure 16). The 1999 flight consisted of 18% adults, 46% immatures, and 36% birds of unknown age. The immature : adult ratio of 2.50 is significantly higher than average (150%; Table 2). The 1999 flight consisted of 36% light-morphs, 18% dark morphs, and 46% birds of unknown color morph. The median passage date for the species of 24 September is 2 days earlier than average, but the difference is not significant (Table 3). The 1999 seasonal activity pattern is unusual in that it is limited to mid-September, the typical pattern extending into early-October (Figure 17). The data are insufficient to calculate meaningful age-specific median passage dates.

Yaki Pt.—The observers counted 14 Broad-winged Hawks on 7 days between 23 September and 2 October (Tables 6 and 8). The annual count matches the 1997–1998 average and the annual passage rate of 2.6 raptors/100 hrs is 13% lower but not significantly different than average (Table 6). The flight consisted of 43% adults, 29% immatures, and 29% birds of unknown age. The immature : adult ratio of 0.67 is significantly higher than average (116%; Table 7). The flight consisted of 21% light-morphs, 7% dark-morphs, and 71% birds of unknown color morph. The median passage date for the species of 24 September is 2 days earlier but not significantly different than average (Table 8). However, the seasonal activity pattern in 1999 shows relatively restricted activity both early and late in the season (Figure 18).

Combined Counts and Passage Rates—The combined-site count of 25 birds and passage rate of 4.6 raptors/100 hrs are 29% and 35% lower than average, respectively (Tables 11 and 12). The two sites had similar counts in 1997 and both show the same basic trend between 1997–1999; however, the peak increase that occurred in 1998 was about four times greater at Lipan Pt. than at Yaki Pt.

Swainson's Hawk

Lipan Pt.—The observers counted 40 Swainson's Hawks on 19 days between 8 September and 12 October (Tables 1 and 3). The annual count and passage rate of 7.0 raptors/100 hrs are 32% and 21% higher than average, respectively, but neither difference is significant (Table 1). Annual passage rates increased steadily between 1991 and 1996, but then dropped and have remained at moderately high levels since 1997 (Figure 16). The 1999 flight consisted of 68% light-morphs, 8% dark morphs, and 25% birds of unknown color morph. The median passage date of 23 September matches the long-term average (Table 3) and the 1999 and average seasonal activity patterns are similar (Figure 17).

Yaki Pt.—The observers counted 32 Swainson's Hawks on 12 days between 1 September and 7 October (Tables 6 and 8). The annual count and passage rate of 5.9 raptors/100 hrs are 60% and 39% higher than average, respectively, but only the count difference is significant (Table 6). The 1999 flight consisted of 56% light-morphs, 28% dark morphs, and 16% birds of unknown color morph. The median passage date of 26 September is 3 days later but not significantly different than average (Table 8), and the seasonal activity pattern is similar to the average pattern (Figure 18).

Combined Counts and Passage Rates—The combined-site count of 72 birds and passage rate of 13 raptors/100 hrs are 40% and 27% higher than average, respectively (Tables 11 and 12). The count and passage rate at Lipan Pt. have remained relatively constant between 1997 and 1999, whereas the count and passage rate at Yaki have increased each year during the same period. The Lipan count was nearly double the Yaki count in 1997, but the 1998 and 1999 counts were similar at the two sites.

Red-tailed Hawk

Lipan Pt.—The observers counted 1,401 Red-tailed Hawks on 61 days between 29 August and 5 November (Tables 1 and 3). The annual count and passage rate of 256 raptors/100 hrs are both significantly lower than average (28% and 35%; Table 1). The 1999 passage rate is the lowest for the study, with the previous low having occurred in 1998 (Figure 16). The 1999 flight consisted of 65% adults, 12% immatures, and 23% birds of unknown age. The immature : adult ratio of 0.19 nearly matches the long-term average; however, a significantly lower than average percentage of unknown-age birds may confound the comparison (Table 2). The flight consisted of 56% light-morphs, 13% dark morphs, and 32% birds of unknown color morph. The median passage date for the species of 14 October is significantly later than average (4 days; Table 3), which is clearly reflected in the seasonal activity pattern as low seasonal activity in early October followed by a large peak in mid-October (Figure 19). However, although age-specific median passage dates indicated that adults were 3 days later than average, no significant differences in age-specific timing emerged. The age-specific dates did follow the typical pattern of immatures preceding adults (Table 4).

Yaki Pt.—The observers counted 985 Red-tailed Hawks on 58 days between 27 August and 5 November (Tables 6 and 8). The annual count and passage rate of 181 raptors/100 hrs are 9% higher and 4% lower than average, respectively (Table 6). The 1999 flight consisted of 67% adults, 21% immatures, and 12% birds of unknown age. The immature : adult ratio of 0.32 nearly matches the 1997–1998 average (Table 7). The flight consisted of 74% light-morphs, 12% dark morphs, and 8% birds of unknown color morph. The median passage date for the species of 9 October matches the average (Table 8) and the 1999 seasonal activity pattern is roughly similar to the average pattern (Figure 20). However, age-specific median passage dates showed that although adults were only 1 day earlier than average, immatures were

significantly later than average (10 days; Table 9). Age-specific median passage dates showed the typical pattern of immatures preceding adults, but with a greater separation of age-class activity in 1999.

Combined Counts and Passage Rates—The combined-site count of 2,386 birds and passage rate of 438 raptors/100 hrs are 3% and 11% lower than average, respectively (Tables 11 and 12). The two sites showed different trends between 1997–1999. Passage rates dropped each year at Lipan, whereas at Yaki passage rates increased in 1998 then dropped again to a moderate level in 1999.

Ferruginous Hawk

Lipan Pt.—The observers counted 7 Ferruginous Hawks on 7 days between 12 September and 22 October (Tables 1 and 3). The annual count and passage rate of 1.0 raptors/100 hrs are 11% and 21% lower than average, respectively, but only the difference in passage rates is significant (Table 1). A gradual decline in passage rates is evident, although rates stabilized during the past 4 years (Figure 16). The 1999 flight consisted of 3 adults, 1 immature, and 3 birds of unknown age. The immature : adult ratio of 0.33 is 63% lower but not significantly different than average (Table 2). The flight consisted of 3 light-morphs, 1 dark morph, and 3 birds of unknown color morph. The median passage date for the species of 11 October is 3 days earlier than average, but the difference is not significant (Table 3). In 1999, seasonal activity was slightly more restricted to the middle of the season than in previous years (Figure 19).

Yaki Pt.—The observers counted 11 Ferruginous Hawks on 9 days between 12 September and 27 October (Tables 6 and 8). The annual count and passage rate of 2.0 raptors/100 hrs are both significantly higher than average (47% and 30%, respectively; Table 6). The 1999 flight consisted of 46% adults, 18% immatures, and 36% birds of unknown age. The immature : adult ratio of 0.40 is 50% lower than average and falls just outside the 95% CI for the 1997–1998 mean (Table 7). The flight consisted of 46% light-morphs, 9% dark morphs, and 46% birds of unknown color morph. The median passage date for the species of 13 October is 6 days earlier than average, but the difference is not significant (Table 8) and the seasonal activity pattern is roughly similar to the average pattern (Figure 20).

Combined Counts and Passage Rates—The combined count of 18 birds and passage rate of 3.3 raptors/100 hrs are 29% and 17% higher than average, respectively (Tables 11 and 12). Both sites showed similar trends between 1997–1998, but opposite patterns in 1999.

Zone-tailed Hawk

The observers saw no Zone-tailed Hawks at Lipan Point, but counted 1 at Yaki Pt. on 30 August 1999. In 1997, the observers recorded the first migrant for the site at Lipan Point (Appendix F). Zone-tailed Hawks nest near Yaki Pt., but this is the first season that migrants have been recorded there.

Golden Eagle

Lipan Pt.—The observers counted 29 Golden Eagles on 20 days between 3 September and 3 November (Tables 1 and 3). The annual count and passage rate of 5.0 raptors/100 hrs are 17% and 25% lower than average, respectively (Table 1). Neither of these differences is significant; however, a decline in passage rates is evident since 1992 (Figure 21). The 1999 flight consisted of 34% adults, 28% immatures and subadults, and 38% birds of unknown age. The immature/subadult : adult ratio of 0.80 is 38% lower than average, but the difference is not significant (Table 2). The median passage date for the species of 19 October is 1 day earlier than average (Table 3); however, although the differences are not significant, age-specific dates suggest that both adults and immatures/subadults were 3 days later than average (Table 4). The seasonal activity pattern was similar to the average pattern, except for showing a large peak in

mid-October (Figure 22). Median passage dates show the typical pattern of adults preceding immatures/subadults (Table 4).

Yaki Pt.—The observers counted 2 Golden Eagles on 18 September and 3 November (Tables 6 and 8). The annual count and passage rate of 0.4 raptors/100 hrs are 87% and 88% lower than average, respectively, but neither difference is significant due to high annual variation (Table 6). The flight consisted of 1 adult and 1 bird of unknown age (Table 7). Too few birds precluded calculation of a meaningful median passage date (Table 8), but the timing of passage for the two 199 birds fell within the range of previous activity (Figure 23).

Combined Counts and Passage Rates—The combined-site count of 31 birds and passage rate of 5.7 raptors/100 hrs are 22% and 27% lower than average, respectively (Tables 11 and 12). Both sites showed similar counts in 1997 and a drop in counts in 1998. The drop in 1998 was much greater at Yaki Pt. than at Lipan Pt., however, and in 1999 the Yaki count dropped again whereas the Lipan count rose higher than in 1997.

Bald Eagle

Lipan Pt.—The observers counted 24 Bald Eagles on 16 days between 7 September and 4 November (Tables 1 and 3). The annual count and passage rate of 4.0 raptors/100 hrs are 3% higher and 4% lower than average, respectively, but neither difference is significant (Table 1). No distinct long-term trend in passage rates is evident at this time (Figure 21). The 1999 flight consisted of 83% adults, 8% immatures and subadults, and 8% birds of unknown age. The immature/subadult : adult ratio of 0.10 is significantly lower than average (66%; Table 2). The median passage date for the species of 21 October is significantly earlier than average (4 days; Table 3). Age-specific dates indicated the same pattern for adults (6 days early), but too few immatures/subadults were counted to calculate a meaningful median date for this age class (Table 4).

Yaki Pt.—The observers counted 17 Bald Eagles on 9 days between 24 September and 4 November (Tables 6 and 8). The annual count and passage rate of 3.1 raptors/100 hrs are 17% and 26% lower than average, respectively (Table 6). The 1999 flight consisted of 29% adults, 29% immatures and subadults, and 41% unknown-age birds. The immature/subadult : adult ratio of 1.0 is significantly higher than average (75%); however, a significantly higher than average percentage of unknown-age birds may confound the comparison (Table 7). The median passage date for the species of 19 October is significantly earlier than average (11 days; Table 8). Age-specific dates indicated the same pattern for adults (12 days early), but too few immatures/subadults were counted to calculate a meaningful median date for this age class (Table 9).

Combined Counts and Passage Rates—The combined-site count of 41 birds and passage rate of 7.5 raptors/100 hrs are 2% and 11% lower than average, respectively (Tables 11 and 12). The two sites show similar counts in all years and similar trends between 1997–1999.

American Kestrel

Lipan Pt.—The observers counted 1,281 American Kestrels on 59 days between 27 August and 4 November (Tables 1 and 3). The annual count and passage rate of 223 raptors/100 hrs are 4% and 14% lower than average, respectively, but only the passage rate difference is significant (Table 1). A possible declining trend in passage rates is evident (Figure 24). The 1999 flight consisted of 35% males, 34% females, and 31% birds of unknown sex. The median passage date for the species of 25 September matches the long-term average (Table 3). The 1999 seasonal activity pattern is similar to the average pattern except for showing a higher than average concentration of activity during 21–25 September (Figure 25). Sex-specific median dates show that females were 3 days later than average (a significant difference), whereas males were 3 days earlier than average (not a significant difference; Table 5).

Yaki Pt.—The observers counted 918 American Kestrels on 51 days between 3 September and 29 October (Tables 6 and 8). The annual count and passage rate of 169 raptors/100 hrs are 28% and 15% higher than average, respectively, but neither difference is significant (Table 6). The flight consisted of 47% males, 39% females, and 14% birds of unknown sex. The median passage date for the species of 26 September is 2 days earlier than average, but the difference is not significant (Table 8). Moreover, sex-specific dates indicate average timing for females but significantly later than average (5 days) passage for males (Table 10). Sex-specific median dates also show the typical pattern of females preceding males (Table 10). The species-level seasonal activity pattern is similar to the average pattern except for showing depressed activity during 16–20 and 26–30 September (Figure 26).

Combined Counts and Passage Rates—The combined-site count of 2,136 and passage rate of 392 raptors/100 hrs are 14%and 5% higher than average, respectively (Tables 11 and 12). Both sites show the same general trend in passage rates between 1997–1999, with a highest rate in 1997 and the lowest rate in 1998. Counts at Lipan have consistently ranged about 30% higher than at Yaki.

Merlin

Lipan Pt.—The observers counted 13 Merlins on 11 days between 18 September and 26 October (Tables 1 and 3). The annual count and passage rate of 2.0 raptors/100 hrs are 5% higher and 4% lower than average, respectively, but neither difference is significant (Table 1). No distinct trend in passage rates is evident at this time (Figure 24). The 1999 observers did not classify any Merlins by subspecies. The median passage date of 14 October is significantly later than average (5 days; Table 3); however, this is not readily apparent in comparing seasonal activity patterns (Figure 25).

Yaki Pt.—The observers counted 14 Merlins on 11 days between 5 September and 26 October (Tables 6 and 8). The annual count and passage rate of 2.6 raptors/100 hrs are 8% higher and 5% lower than average, respectively, but neither difference is significant (Table 6). The 1999 observers did not classify any Merlins to the sub-species level. The median passage date for the species of 3 October is significantly earlier than average (4 days; Table 8); however, the seasonal activity pattern is roughly similar to the average pattern (Figure 26).

Combined Counts and Passage Rates—The combined-site count of 27 and passage rate of 5.0 raptors/100 hrs are 13% and 20% lower than average, respectively (Tables 11 and 12). Both sites show the same pattern in passage rates between 1997–1999, with high rates in 1997 and the same lower passage rates in 1998 and 1999; however, the passage rate at Lipan dropped 48% between 1997 and 1998, while the rate dropped only 7% at Yaki during the same period.

Prairie Falcon

Lipan Pt.—The observers counted 2 Prairie Falcons on 12 and 25 September (Tables 1 and 3). The annual count and passage rate of 0.4 raptors/100 hrs are both significantly lower than average (58% and 61%, respectively; Table 1); however, no long-term trend in passage rates is evident (Figure 24). The observers recorded too few birds to calculate a meaningful median passage date (Table 3), but the timing of passage for the two 1999 birds fell within the range seen in previous years (Figure 27).

Yaki Pt.—The observers counted 6 Prairie Falcons on 5 days between 25 September and 1 November (Tables 6 and 8). The annual count and passage rate of 1.1 raptors/100 hrs are 8% and 17% lower than average, respectively, but neither difference is significant (Table 6). The median passage date of 3 October is 10 days later than in 1997; too few birds were seen in 1998 to calculate a meaningful comparison (Table 8).

Combined Counts and Passage Rates—The combined-site count of 8 birds and passage rate of 1.5 raptors/100 hrs are 30% and 36% lower than average, respectively (Tables 11 and 12). The two sites

showed different trends between 1997 and 1998, with little change at Lipan Pt. but a substantial decrease at Yaki Pt. The 1999 counts reverse that trend, with a decrease at Lipan and an increase at Yaki.

Peregrine Falcon

Lipan Pt.—The observers counted 8 Peregrine Falcons on 7 days between 27 August and 26 October (Tables 1 and 3). The annual count and passage rate of 1.0 raptors/100 hrs are 12% and 3% higher than average, respectively, but neither difference is significant (Table 1) and no distinct trend in passage rates is evident at this time (Figure 24). The 1999 flight consisted of 50% adults and 50% birds of unknown age. The apparent absence of immature birds is atypical for the site; however, a higher than average percentage of unknown-age birds may confound the comparison (Table 2). The median passage date for the species of 13 September is significantly earlier than the average (10 days; Table 3), which is reflected in the seasonal activity pattern as a higher than average peak in activity during 11–15 September (Figure 27). Too few birds were classified by age to calculate meaningful age-specific median passage dates.

Yaki Pt.—The observers counted 8 Peregrine Falcons on 8 days between 15 September and 16 October (Tables 6 and 8). The annual count and passage rate of 1.5 raptors/100 hrs are 38% and 47% lower than average, respectively, but yearly counts have shown high variation and the differences are not significant (Table 6). The flight consisted of 12% adults, 12% immatures, and 75% birds of unknown age. The immature : adult ratio of 1.0 is significantly higher (50%) than average; however, high annual variation in the percentages of unknown-age birds may confound comparisons (Table 7). The median passage date for the species of 19 September is significantly earlier than average (7 days; Table 8), which is reflected in the seasonal activity pattern as a relatively high concentration of activity during 16–25 September (Figure 28). Too few birds were classified by age to calculate meaningful age-specific median passage dates.

Combined Counts and Passage Rates—The combined-site count of 16 and passage rate of 2.9 raptors/100 hrs are 27% and 35% lower than average, respectively (Tables 11 and 12). Both sites show the same general trend in passage rates between 1997 and 1998. Counts at the two sites were similar in 1997 and 1999, but the 1998 count at Yaki was nearly twice as high at Lipan.

RESIDENT AND NORTHBOUND RAPTORS

Lipan Pt.—The observers classified Golden Eagles, Red-tailed Hawks, Peregrine Falcons, Cooper's Hawks and Turkey Vultures as residents, but recorded no northbound migrants. They also frequently saw local California Condors.

Yaki Pt.—The observers classified Golden Eagles, Red-tailed Hawks, Zone-tailed Hawks, Peregrine Falcons, and Turkey Vultures as residents, but recorded no northbound migrants. They also frequently saw local California Condors.

VISITOR PARTICIPATION

More than 1,000 people visited Lipan Pt. during the 1999 season, and more than 600 people visited Yaki Pt. Many of the visitors were part of education programs led by HWI's on-site educator. At Yaki Pt., visitors to the site were often directed by shuttle bus drivers, who themselves have a great interest in the migration and often came to the site to get updates on the day's migration.

DISCUSSION

WEATHER

The weather this season in the Grand Canyon was largely unremarkable, with fewer storm fronts and strong wind days than in previous seasons. The main effect this probably has on the raptor flight is to disperse birds across wide areas with good thermal development, which might then restrict our ability to effectively spot and identify migrants. Yaki Point had slightly higher than average counts and passage rates, while Lipan had slightly lower than average counts and rates. The main weather-related difference between the two sites was wind direction, with more variable-wind days at Lipan than at Yaki. Good thermal conditions and variable winds both tend to disperse migrations, which may explain the relatively low counts at Lipan compared to Yaki. Recent analyses of long-term data from Hawk Mountain in Pennsylvania indicated that annual variation in the frequency of cold fronts does not significantly affect the magnitude of annual counts at that site (Allen et al. 1996). However, at sites where strong thermal development over wide areas can disperse flights and where consistent winds can concentrate migrants along leading-lines, significant differences in frequency of variable wind conditions could alter the proportion of the migration sampled by observers.

DAILY FLIGHT RHYTHM

Several factors determine what time of day a particular species chooses to migrate. Feeding behavior and wing loading are probably most important. Migratory activity of soaring raptors such as buteos and eagles often is constrained to mid-day periods when solar or wind-driven updrafts are prevalent. In contrast, accipiters and falcons, which also utilize thermals and updrafts, but use powered flight more often than buteos during migration, are more frequently observed migrating during morning and evening hours (Mueller 1973).

The 1999 daily flight rhythms at the two Grand Canyon sites differed from previous seasons only in showing slightly earlier than average activity at Lipan Pt. The difference this season at Lipan Pt. probably reflects the slightly increased proportion of accipiters and corresponding decrease in proportions of soaring species, particularly buteos. However, the average activity at Yaki Pt. differs from Lipan Pt. by showing more activity later in the day, despite a higher proportion of accipiters and lower proportion of buteos. Reasons for this discrepancy between sites may be related to differing weather or physiographic features that influence flying conditions. There is some evidence for site differences that affect, or are affected by wind direction. Yaki experienced nearly equal percentages of days with winds predominately from the east, west, northeast, southwest or variable directions, while Lipan had winds predominantly from the west or had variable winds. In general, this season's nearly average results suggest that climate and foraging conditions that affect daily flight patterns remained within the range of normal variation.

SEASONAL TIMING

The combined-species seasonal activity pattern was nearly typical for both Lipan and Yaki Points, with the exception that both sites showed higher than average activity during the 21–25 September period. At both sites, peak counts occurred during this period, which is typical; however, activity was even more concentrated than usual during this period in 1999. Most species showed higher than average activity during this period, suggesting a universal effect such as that produced by passage of a large frontal system. No obvious, local weather effects appeared to contribute to this pattern; however, it is possible that some distant weather event acted to concentrate the migration before it reached the Grand Canyon.

In 1999, 8 of 15 species with comparative data at Lipan Pt. and 8 of 13 species at Yaki Pt. showed average species-level median passage dates. At Lipan, 4 species showed late dates in 1999 and 3 showed early dates. At Yaki, 2 species showed late dates and 3 showed early dates. Despite these apparently similar overall patterns, species-specific comparisons yielded very little consistency between the two sites. The only consistent patterns were for Bald Eagles and Peregrine Falcons, both being significantly earlier than average at both sites. However, many of these subtle differences in pattern likely result from the difference in time frames reflected in the averages against which the 1999 values were compared (1991–1998 at Lipan versus 1997–19998 at Yaki). Examining results from the two sites together, seasonal timing in 1999 appeared average, whereas in 1998 a number of species showed later than average timing. Evidence of generally average median passage dates is consistent with indicators from several other sites in the western U.S. where HWI conducted fall counts in 1999 (e.g., Neal et al. 2000, Vekasy and Smith, 2000a).

FLIGHT COMPOSITION, PASSAGE RATES, AND LONG-TERM TRENDS

The flight composition at Yaki Pt. in 1999 appeared typical with near average proportions of each species group (e.g., accipiters, buteos, falcons). In contrast, the species composition in 1999 at Lipan Pt. featured atypical proportions of accipiters and buteos, which rendered composition at the two sites more similar than usual. The two sites typically differ in the proportions of each group seen, with observers at Yaki counting higher numbers of accipiters and fewer buteos than at Lipan. Proportions of falcons are usually similar at each site, as are numbers for the remaining groups, each comprising less than 2% of the total.

Reasons for differences between sites are not known, but may have to do with differences in topography, both at the sites and in the general vicinity of the sites. Locally, the two sites differ in the orientation of the canyon rim, and regionally, they differ in the presence of significant topographic features. Lipan Point is essentially at the mouth of the Grand Canyon, with the rim running northward into narrow Marble Canyon, and the vast expanse of House Rock Valley and the Painted Desert to the northwest and northeast. Each of these is bordered by rising plateaus, with the Kaibab Plateau to the west and the Echo Cliffs and Kaibito Plateau to the east. The canyon rim near Yaki Point is convoluted but generally runs east to west, and the point lies across from the forested heights of the Kaibab Plateau, with the open plains of the Kanab Plateau far to the west. Crossing the canyon near Yaki may represent a barrier for buteos, as soaring conditions over the canyon can be highly variable, with erratic winds and downdrafts. As a draw to accipiters, the wooded slopes of the Kaibab may offer hunting opportunities before the canyon crossing. Features that promote thermal development near Lipan may enhance flights of soaring species at that site, and the broad open desert is largely devoid of prey that might attract accipiters.

Differences in proportions of accipiters and buteos at Lipan this season can be attributed to a significant increase in the number of Cooper's Hawks, and a significant decrease in numbers of Red-tailed Hawks. Reasons for the change in numbers for these two species are difficult to determine. At Yaki Pt. Cooper's Hawk numbers were only slightly higher than average and Red-tailed Hawk numbers were average. Mild weather and good thermal development may have differentially dispersed red-tail flights at the two sites. This is possible based on local topography and likelihood of thermal development near each site. Thermal conditions near Lipan may tend to disperse buteos over a larger area compared to Yaki. Immature : adult ratios were will within average for both species, suggesting that reproductive success may not have been a major factor in observed differences. However, a closer look at Cooper's Hawk age ratios reveals that both immature and adult numbers were high in 1999. The higher adult numbers likely reflect strong recruitment of second-year birds produced during 1998, and the high immature numbers may indicate good reproductive success in 1999. The same may also apply to Sharp-shinned Hawks and Northern Harriers, each of which had low immature : adult ratios at both Lipan and Yaki, but also had higher than average numbers of both immatures and adults.

Passage rates for most species at both sites were near average, and the only significant passage rate difference in common between the two sites was for Turkey Vultures, which had a lower than average passage rate. Turkey Vultures have been increasing at most sites across the west, but this trend was not well supported in 1999 (Vekasy and Smith 2000a, 2000b). Long-term increases in the number of Turkey Vultures may reflect northward expansion of this tropical species' range in response to global warming, as well as general increases in population density in response to greater availability of carrion on roadways, around domestic livestock operations, and in other human-altered environments (Wilbur 1983, Kiff 2000). Lower numbers could signal the beginning of population stabilization for this species. Alternatively, mild weather and strong thermal development may have served to disperse Turkey Vulture flights. There was no evidence for an early or delayed migration that might have resulted in birds missed outside of the count period. Changes in reproductive success can influence migration counts, but we do not derive age-specific data for Turkey Vultures from our migration counts.

Osprey passage rates were significantly lower than average at Yaki Pt. in 1999, and the decrease at Lipan was nearly significant. Osprey passage rates were highly variable across the West in 1999, including both above average (Vekasy and Smith 2000b, 2000c) and below average values (Vekasy and Smith 2000a, 2000d). There is no evidence in the seasonal activity pattern to indicate a delayed migration, despite mild fall and winter weather leaving water sources ice-free later into the year. HWI's monitoring site in the Goshute Mountains, NV had above average numbers, and the Grand Canyon presumably lies along the same flyway, leading to expectations of a good flight. Again, we may look to mild weather and widespread thermal development as a source for dispersing birds away from traditional leading-lines such as ridges and river corridors.

Another difference between trend indicators from the Goshutes and Grand Canyon is the showing of a significant increasing trend for American Kestrels in the Goshutes but a possible declining trend at Lipan Point. American Kestrel passage rates were again below average at Lipan, but above average at Yaki Point. Mixed indicators are currently the rule for American Kestrels in the West, with some populations showing increases in response to expansion of mosaic woodland/open habitats and others showing decreases as re-growth of cut forests reduces availability of such habitats. However, rather than a true decreasing trend, kestrel flights in the Grand Canyon may be more variable from point to point than along the well-defined Goshute Range. Continued monitoring at multiple sites along the canyon rim will help to understand the influences behind the variation between sites in the Canyon and between sites along the same flyway.

There are a number of other notable differences between trend indicators from the Grand Canyon and other longer-term HWI sites. Peregrines and Merlins, both of which are showing widespread increasing trends in the West (Smith et al. in review), are not showing similar trends at the Grand Canyon. The lack of a trend for Peregrine Falcons may be due to the large number of pairs nesting in the Canyon. Resident birds may discourage some migrants from moving through the area, and counts may represent primarily local migrants rather than the long-distance migrants detected at other sites. The Grand Canyon dataset is still limited, however, and it simply may be that additional counts are needed to establish definitive trends.

LITERATURE CITED

Allen, P. E., L. J. Goodrich, and K. L. Bildstein. 1996. Within-and-among-year effects of cold fronts on migrating raptors at Hawk Mountain, PA, 1934–1991. Auk 113:329–338.

Bednarz, J. C., T. J. Hayden, and T. Fischer. 1990a. The raptor and raven community of the Los Medanos area in southeastern New Mexico: a unique and significant resource. Pages 92–101 *in* R.

S. Mitchell, C. J. Sheviak, and D. J. Leopold, editors. Ecosystem management: rare species and significant habitats. Bulletin No. 471. New York State Museum, Albany, New York, USA.

Bednarz, J. C., and P. Kerlinger. 1989. Monitoring hawk populations by counting migrants. Pages 328–342 *in* B. Pendleton, editor. Proceedings of the Northeast Raptor Management Symposium and Workshop. National Wildlife Federation, Washington, D.C., USA.

Bednarz, J. C., D. Klem Jr., L. J. Goodrich, and S. E. Senner. 1990b. Migration counts of raptors at Hawk Mountain, PA, as indicators of populations trends, 1934–1986. Auk 107:96–109.

Bildstein, K. L., J. J. Brett, L. J. Goodrich, and C. Viverette. 1995. Hawks Aloft Worldwide: a network to protect the world's migrating birds of prey and the habitats essential to their migrations. Pages 504–516 *in* D. A. Saunders, J. L. Craig, and E. M. Mattiske, editors. Nature conservation 4: the role of networks. Surrey Beatty & Sons, Chipping Norton, New South Wales, Australia.

Bildstein, K. L., and J. I. Zalles (editors). 1995. Raptor migration watch-site manual. Hawk Mountain Sanctuary Association, Kempton, Pennsylvania, USA.

Cade, T. J., J. E. Enderson, C. G. Thelander, and C. M. White. 1988. Peregrine falcon populations, their management and recovery. The Peregrine Fund, Inc., Boise, Idaho, USA.

Clark, W. S., and B. K. Wheeler. 1987. A field guide to hawks of North America. Houghton Mifflin Co., Boston, Massachusetts, USA. 198 pp.

Dixon, P. M., A. R. Olsen, and B. M. Kahn. 1999. Measuring trends in ecological resources. Ecological Applications 8:225–227

Dunn, E. H., and D. J. T. Hussell. 1995. Using migration counts to monitor landbird populations: review and evaluation of status. Pages 43–88 *in* D. M. Power, editor. Current Ornithology, Vol. 12. Plenum Press, New York, New York, USA.

Dunne, P., D. Sibley, and C. Sutton. 1988. Hawks in flight. Houghton Mifflin Co., Boston, Massachusetts, USA. 254 pp.

Kerlinger, P. 1989. Flight strategies of migrating hawks. University of Chicago Press, Chicago, Illinois, USA. 375 pp.

Kiff, L. 2000. The current population status of North American cathartid vultures. *In* R. Chancellor and B.-U. Meyburg, editors. Raptors at risk. Proceedings of the Vth World Working Group on Birds of Prey and Owls, Midrand, South Africa, 4–11 August 1998. World Working Group on Birds of Prey and Owls, Berlin, Germany.

Mueller, H. C. 1973. Daily rhythm of hawk migration at Cedar Grove, Wisconsin. Auk 90:591–596.

Mueller, H. C., and D. D. Berger. 1967. Wind drift, leading lines, and diurnal migration. Wilson Bulletin 79:50–63.

Mueller, H. C., D. D. Berger, and G. Allez. 1988. Population trends in migrating peregrines at Cedar Grove, Wisconsin, 1936–1985. Pages 497–506 *in* T. J. Cade, J. H. Enderson, C. G. Thelander, and C. M. White, editors. Peregrine falcon populations, their management and recovery. The Peregrine Fund, Boise, Idaho, USA.

Neal, M. C., M. S. Vekasy, and J. P. Smith. 2000. Fall 1999 raptor migration study in the Bridger Mountains, Montana. HawkWatch International, Salt Lake City, Utah, USA. 45 pp.

Smith, J. P., and S. W. Hoffman. 2000. The value of extensive raptor migration monitoring in western North America. *In* R. Chancellor and B.-U. Meyburg, editors. Raptors at risk. Proceedings of the Vth World Working Group on Birds of Prey and Owls, Midrand, South Africa, 4–11 August 1998. World Working Group on Birds of Prey and Owls, Berlin, Germany.

Smith, J. P., and S. W. Hoffman. In review. Observer and visitor effects on counts of migrating raptors. Journal of Wildlife Management.

Smith, J. P., S. W. Hoffman, W. R. DeRagon, and J. C. Bednarz. In review. Recent population trends of migratory raptors in western North America. Ecological Applications.

Spofford, W. R. 1969. Hawk Mountain counts as population indices in northeastern America. Pages 323–332 *in* J. J. Hickey, editor. Peregrine Falcon populations: their biology and decline. University of Wisconsin Press, Madison, Wisconsin, USA.

Titus, K., M. R. Fuller, and J. L. Ruos. 1989. Considerations for monitoring raptor population trends based on counts of migrants. Pages 19–32 *in* B. U. Meyburg and R. D. Chancellor, editors. Raptors in the modern world. Proceedings of the III World Conference on Birds of Prey and Owls, Eilat, Israel, 1987. World Working Group on Birds of Prey and Owls, Berlin, Germany.

Vekasy, M. S. and J. P. Smith. 2000a. Fall 1999 raptor migration study in the Manzano Mountains of central New Mexico. HawkWatch International, Salt Lake City, Utah, USA. 48 pp.

Vekasy, M. S. and J. P. Smith. 2000b. Fall 1999 raptor migration study in the Goshute Mountains, Nevada. HawkWatch International, Salt Lake City, Utah, USA. 48 pp.

Vekasy, M. S. and J. P. Smith. 2000c. Fall 1999 raptor migration study at Bonney Butte, Oregon. HawkWatch International, Salt Lake City, Utah, USA. 45 pp.

Vekasy, M. S. and J. P. Smith. 2000d. Fall 1999 raptor migration study in the Wellsville Mountains of northern Utah. HawkWatch International, Salt Lake City, Utah, USA. 46 pp.

Wheeler, B. K., and W. S. Clark. 1995. A photographic guide to North American raptors. Academic Press, London, England. 198 pp.

Wilbur, S. R. 1983. The status of vultures in the Western Hemisphere. Pages 113–123 *in* S. R. Wilbur and J. A. Jackson, editors. Vulture biology and management. University of California Press, Berkeley, California, USA.

Table 1. Annual observation effort, and counts and passage rates by species at Lipan Point: 1991–1998 versus 1999.

	1991–1998[1]	1999	% Change	1991–1998[1]	1999	% Change
Start date	30-Aug ± 2.8 d	27-Aug				
End date	4-Nov ± 0.3 d	5-Nov				
Observation days	65 ± 2.8	71	+9			
Observation hours	491.17 ± 26.955	546.70	+11			
Species	Counts			Raptors / 100 hours		
Turkey Vulture	203 ± 64.2	75	-63	41 ± 12.1	14	-67
Osprey	84 ± 22.8	72	-14	17 ± 4.1	13	-21
Northern Harrier	94 ± 20.9	130	+38	19 ± 3.8	24	+25
Sharp-shinned Hawk	1584 ± 341.7	1427	-10	318 ± 60.7	261	-18
Cooper's Hawk	1299 ± 191.3	1515	+17	264 ± 33.5	277	+5
Northern Goshawk	13 ± 9.8	6	-52	2.5 ± 1.91	1.1	-57
Unidentified accipiter	277 ± 58.7	185	-33	57 ± 13.9	34	-41
Total accipiters	3172 ± 468.6	3133	-1	642 ± 74.1	573	-11
Red-shouldered Hawk	0 ± 0.3	0	-100	0.0 ± 0.06	0.0	-100
Broad-winged Hawk	8 ± 7.8	11	+40	1.6 ± 1.55	2.0	+29
Swainson's Hawk	30 ± 9.8	40	+32	6.0 ± 1.88	7.3	+21
Red-tailed Hawk	1950 ± 448.0	1401	-28	394 ± 81.4	256	-35
Ferruginous Hawk	8 ± 2.5	7	-11	1.6 ± 0.51	1.0	-21
Zone-tailed Hawk	0 ± 0.3	0	-100	0.0 ± 0.06	0.0	-100
Unidentified buteo	23 ± 12.5	17	-26	4.9 ± 3.01	3.1	-36
Total buteos	2020 ± 444.1	1476	-27	409 ± 80.2	270	-34
Golden Eagle	35 ± 9.9	29	-17	7.1 ± 1.83	5.4	-25
Bald Eagle	23 ± 10.1	24	+3	4.6 ± 1.98	4.7	-5
Unidentified eagle	1 ± 0.7	4	+700	0.1 ± 0.15	0.7	+638
Total eagles	59 ± 15.7	57	-3	12 ± 2.9	10	-12
American Kestrel	1274 ± 149.1	1218	-4	260 ± 28.6	223	-14
Merlin	12 ± 3.6	13	+5	2.5 ± 0.65	2.4	-4
Prairie Falcon	5 ± 1.7	2	-58	0.9 ± 0.33	0.4	-61
Peregrine Falcon	7 ± 2.6	8	+12	1.4 ± 0.48	1.5	+3
Unidentified falcon	3 ± 2.1	6	+100	0.6 ± 0.40	1.1	+86
Total falcons	1301 ± 150.1	1247	-4	265 ± 28.2	228	-14
Unidentified Raptor	78 ± 23.2	107	+38	16 ± 5.1	20	+22
Grand Total	7010 ± 1034.5	6297	-10	1421 ± 167.4	1152	-19

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

Table 2. Counts by age class and immature : adult ratios for selected species at Lipan Point: 1991–1998 versus 1999.

	Total and Age-classified Counts								Immature : Adult	
	1991–1998 Average			1999			% Unknown Age		Ratio	
Species	Total	Imm.	Adult	Total	Imm.	Adult	1991–1998[1]	1999	1991–1998[1]	1999
Northern Harrier	53	18	19	130	26	33	28 ± 7.8	55	1.00 ± 0.232	0.79
Sharp-shinned Hawk	1584	264	617	1427	249	665	43 ± 5.0	36	0.46 ± 0.109	0.37
Cooper's Hawk	1299	243	372	1515	292	575	52 ± 6.5	43	0.71 ± 0.199	0.51
Northern Goshawk	13	5	3	6	5	0	38 ± 16.2	17	1.64 ± 0.972	≥5
Broad-winged Hawk	8	2	2	11	5	2	15 ± 24.5	36	1.00 ± 0.709	2.50
Red-tailed Hawk	1950	176	1017	1401	171	907	37 ± 7.3	23	0.18 ± 0.047	0.19
Ferruginous Hawk	8	1	2	7	1	3	55 ± 17.2	43	0.90 ± 0.726	0.33
Golden Eagle	35	10	11	29	8	10	40 ± 13.9	38	1.28 ± 0.699	0.80
Bald Eagle	23	5	16	24	2	20	8 ± 6.1	8	0.29 ± 0.087	0.10
Peregrine Falcon	7	1	4	8	0	4	30 ± 14.5	50	0.72 ± 0.695	0.00

[1] Mean ± 95% confidence interval. For age ratios, note that the 1991–1998 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 1999 at Lipan Point, with a comparison to 1991–1998 average median passage dates.

	1999				1991–1998
Species	First Observed	Last Observed	Bulk Passage Dates [1]	Median Passage Date [2]	Median Passage Date [3]
Turkey Vulture	13-Sep	13-Oct	16-Sep – 4-Oct	25-Sep	27-Sep ± 2.5
Osprey	28-Aug	15-Oct	4-Sep – 2-Oct	16-Sep	17-Sep ± 2.1
Northern Harrier	4-Sep	5-Nov	18-Sep – 27-Oct	11-Oct	6-Oct ± 4.8
Sharp-shinned Hawk	28-Aug	5-Nov	17-Sep – 26-Oct	1-Oct	5-Oct ± 3.0
Cooper's Hawk	28-Aug	5-Nov	17-Sep – 14-Oct	26-Sep	26-Sep ± 3.2
Northern Goshawk	20-Sep	28-Oct	20-Sep – 28-Oct	14-Oct	8-Oct ± 5.5
Broad-winged Hawk	18-Sep	25-Sep	18-Sep – 25-Sep	24-Sep	26-Sep ± 5.8
Swainson's Hawk	8-Sep	12-Oct	12-Sep – 4-Oct	23-Sep	23-Sep ± 5.0
Red-tailed Hawk	29-Aug	5-Nov	18-Sep – 27-Oct	14-Oct	10-Oct ± 3.8
Ferruginous Hawk	12-Sep	22-Oct	12-Sep – 22-Oct	11-Oct	14-Oct ± 4.3
Golden Eagle	3-Sep	3-Nov	21-Sep – 29-Oct	19-Oct	20-Oct ± 4.3
Bald Eagle	7-Sep	4-Nov	9-Oct – 3-Nov	21-Oct	25-Oct ± 3.3
American Kestrel	27-Aug	4-Nov	12-Sep – 11-Oct	25-Sep	25-Sep ± 3.2
Merlin	18-Sep	26-Oct	21-Sep – 26-Oct	14-Oct	9-Oct ± 4.5
Prairie Falcon	12-Sep	25-Sep	12-Sep – 25-Sep	–	29-Sep ± 13.8
Peregrine Falcon	27-Aug	26-Oct	27-Aug – 26-Oct	13-Sep	23-Sep ± 6.9
All raptors	27-Aug	5-Nov	15-Sep – 24-Oct	30-Sep	1-Oct ± 1.8

[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. Age-specific median passage dates for selected species at Lipan Point: 1991–1998 versus 1999.

	ADULT		IMMATURE	
SPECIES	1991–1998[1]	1999	1991–1998[1]	1999
Northern Harrier	7-Oct ± 8.8	16-Oct	6-Oct ± 5.5	11-Oct
Sharp-shinned Hawk	10-Oct ± 2.7	13-Oct	27-Sep ± 3.8	25-Sep
Cooper's Hawk	1-Oct ± 4.2	1-Oct	22-Sep ± 3.5	26-Sep
Red-tailed Hawk	10-Oct ± 3.6	13-Oct	7-Oct ± 5.0	7-Oct
Golden Eagle	20-Oct ± 5.7	23-Oct	13-Oct ± 10.5	16-Oct
Bald Eagle	26-Oct ± 3.5	20-Oct	26-Oct ± 4.5	–

Note: Median passage date is the date by which 50% of the flight had passed; 1999 values are given only for species with annual counts ≥5 birds, and long-term means are given only for species with annual counts of ≥5 birds for ≥3 years.

[1] Mean ± 95% confidence interval in days.

Table 5. Sex-specific median passage dates for selected species at Lipan Point: 1991–1998 versus 1999.

	FEMALE		MALE	
SPECIES	1991–1998[1]	1999	1991–1998[1]	1999
Adult Northern Harrier	6-Oct ± 12.3	13-Oct	9-Oct ± 7.3	18-Oct
American Kestrel	22-Sep ± 2.7	25-Sep	29-Sep ± 3.3	26-Sep

Note: Median passage date is the date by which 50% of the flight had passed; 1999 values are given only for species with annual counts ≥5 birds, and long-term means were calculated only for species with annual counts of ≥5 birds for ≥3 years.

[1] Mean ± 95% confidence interval in days.

Table 6. Annual observation effort, and counts and passage rates by species at Yaki Point: 1997–1998 versus 1999.

	1997–1998[1]	1999	% CHANGE	1997–1998[1]	1999	% CHANGE
Start date	26-Aug ± 1.0 d	27-Aug				
End date	4-Nov ± 0.0 d	5-Nov				
Observation days	69 ± 4.9	71	+4			
Observation hours	480.19 ± 48.569	543.20	+13			
SPECIES	COUNTS			RAPTORS / 100 HOURS		
Turkey Vulture	116 ± 54.9	76	-34	24 ± 9.0	14	-42
Osprey	47 ± 6.9	28	-40	9.7 ± 0.45	5.2	-47
Northern Harrier	47 ± 5.9	56	+19	9.8 ± 0.24	10.3	+5
Sharp-shinned Hawk	1332 ± 278.3	1906	+43	277 ± 30.0	351	+27
Cooper's Hawk	983 ± 247.9	1204	+23	207 ± 72.5	2226	+7
Northern Goshawk	6 ± 2.9	1	-82	1.2 ± 0.73	0.2	-84
Unidentified accipiter	117 ± 45.1	109	-7	25 ± 11.9	20	-19
TOTAL ACCIPITERS	2437 ± 17.6	3220	+32	509.0 ± 55.15	592.8	+16
Red-shouldered Hawk	1 ± 1.0	0	-100	0.1 ± 0.19	0.0	-100
Broad-winged Hawk	14 ± 9.8	14	0	3.0 ± 2.34	2.6	-13
Swainson's Hawk	20 ± 9.8	32	+60	4.2 ± 2.47	5.9	+39
Red-tailed Hawk	908 ± 16.7	985	+9	190 ± 22.6	181	-4
Ferruginous Hawk	8 ± 1.0	11	+47	1.6 ± 0.05	2.0	+30
Zone-tailed Hawk	0 ± 0.0	1	–	0.0 ± 0.00	0.2	–
Unidentified buteo	20 ± 0.0	13	-35	4.2 ± 0.42	2.4	-43
TOTAL BUTEOS	970 ± 34.3	1056	+9	203 ± 27.6	194	-4
Golden Eagle	16 ± 16.7	2	-87	3.1 ± 3.15	0.4	-88
Bald Eagle	21 ± 4.9	17	-17	4.3 ± 0.59	3.1	-26
Unidentified eagle	1 ± 1.0	1	+100	0.1 ± 0.19	0.2	+86
TOTAL EAGLES	37 ± 22.5	20	-45	7.5 ± 3.94	3.7	-51
American Kestrel	720 ± 581.1	918	+28	147 ± 106.2	169	+15
Merlin	13 ± 2.0	14	+8	2.7 ± 0.13	2.6	-5
Prairie Falcon	7 ± 4.9	6	-8	1.3 ± 0.89	1.1	-17
Peregrine Falcon	13 ± 11.8	8	-38	2.8 ± 2.73	1.5	-47
Unidentified falcon	2 ± 3.9	2	--	0.4 ± 0.86	0.4	--
TOTAL FALCONS	754 ± 572.3	948	+26	154 ± 103.6	175	+13
Unidentified Raptor	29 ± 17.6	16	-45	6.2 ± 4.30	2.9	-52
GRAND TOTAL	4436 ± 592.9	5420	+22	923 ± 30.1	998	+8

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

Table 7. Counts by age class and immature : adult ratios for selected species at Yaki Point: 1997–1998 versus 1999.

	Total and Age-classified Counts								Immature : Adult	
	1997–1998 Average			1999			% Unknown Age		Ratio	
Species	Total	Imm.	Adult	Total	Imm.	Adult	1997–1998[1]	1999	1997–1998[1]	1999
Northern Harrier	47	19	14	56	23	19	30 ± 15.0	25	1.47 ± 0.679	1.21
Sharp-shinned Hawk	1332	335	594	1906	384	1136	31 ± 10.9	20	0.62 ± 0.361	0.34
Cooper's Hawk	983	288	360	1204	272	610	33 ± 14.3	27	0.83 ± 0.520	0.45
Northern Goshawk	6	4	2	1	1	0	7 ± 14.0	0	2.50 ± 0.980	≥1.00
Broad-winged Hawk	14	3	10	14	4	6	8 ± 5.7	29	0.31 ± 0.047	0.67
Red-tailed Hawk	908	187	561	985	210	658	18 ± 8.4	12	0.33 ± 0.201	0.32
Ferruginous Hawk	8	3	4	11	2	5	21 ± 42.0	36	0.80 ± 0.392	0.40
Golden Eagle	16	3	7	2	0	1	35 ± 12.8	50	0.89 ± 1.203	0.00
Bald Eagle	21	4	15	17	5	5	9 ± 17.0	41	0.24 ± 0.096	1.00
Peregrine Falcon	13	2	4	8	1	1	49 ± 39.1	75	0.58 ± 0.163	1.00

[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 8. First and last dates of observation, bulk passage dates, and median passage dates by species for 1999 at Yaki Point, with a comparison to 1997–1998 average median passage dates.

	1999				1997–1998
Species	First Observed	Last Observed	Bulk Passage Dates [1]	Median Passage Date [2]	Median Passage Date [3]
Turkey Vulture	20-Sep	13-Oct	24-Sep – 9-Oct	27-Sep	24-Sep ± 4.0
Osprey	30-Aug	12-Oct	1-Sep – 8-Oct	20-Sep	19-Sep ± 3.5
Northern Harrier	5-Sep	5-Nov	19-Sep – 27-Oct	7-Oct	10-Oct ± 5.5
Sharp-shinned Hawk	4-Sep	5-Nov	19-Sep – 23-Oct	4-Oct	1-Oct ± 2.5
Cooper's Hawk	28-Aug	3-Nov	19-Sep – 12-Oct	3-Oct	29-Sep ± 3.0
Northern Goshawk	10-Oct	10-Oct	10-Oct – 12-Oct	–	18-Sep [4]
Broad-winged Hawk	23-Sep	2-Oct	24-Sep – 1-Oct	24-Sep	26-Sep ± 2.0
Swainson's Hawk	1-Sep	7-Oct	7-Sep – 3-Oct	26-Sep	23-Sep ± 11.5
Red-tailed Hawk	27-Aug	5-Nov	24-Sep – 27-Oct	9-Oct	9-Oct ± 4.0
Ferruginous Hawk	12-Sep	27-Oct	15-Sep – 26-Oct	13-Oct	19-Oct ± 10.0
Zone-tailed Hawk	30-Aug	30-Aug	–	–	–
Golden Eagle	18-Sep	3-Nov	18-Sep – 3-Nov	–	23-Oct ± 9.0
Bald Eagle	24-Sep	4-Nov	9-Oct – 4-Nov	19-Oct	30-Oct ± 3.5
American Kestrel	3-Sep	29-Oct	7-Sep – 11-Oct	26-Sep	28-Sep ± 3.0
Merlin	5-Sep	26-Oct	12-Sep – 19-Oct	3-Oct	7-Oct ± 2.0
Prairie Falcon	25-Sep	1-Nov	25-Sep – 1-Nov	3-Oct	23-Sep [5]
Peregrine Falcon	15-Sep	16-Oct	15-Sep – 16-Oct	19-Sep	26-Sep ± 4.5
All raptors	27-Aug	5-Nov	17-Sep – 21-Oct	3-Oct	1-Oct ± 3.5

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

[2] Date by which 50% of the flight had passed; values are given only for species with annual counts ≥ 5 birds.

[3] Mean of annual values ± 95% confidence interval in days; calculated only for species with annual counts ≥5 birds for at least 1 year.

[4] 1998 only.

[5] 1997 only.

Table 9. Age-specific median passage dates for selected species at Yaki Point: 1997–1998 versus 1999.

	ADULT		IMMATURE	
SPECIES	1997–1998[1]	1999	1997–1998[1]	1999
Northern Harrier	3-Oct ± 5.5	9-Oct	8-Oct ± 7.5	7-Oct
Sharp-shinned Hawk	9-Oct ± 3.0	9-Oct	27-Sep ± 2.0	24-Sep
Cooper's Hawk	2-Oct ± 4.5	4-Oct	28-Sep ± 3.0	26-Sep
Red-tailed Hawk	10-Oct ± 5.0	9-Oct	7-Oct ± 7.0	27-Sep
Bald Eagle	30-Oct ± 3.0	18-Oct	–	19-Oct

Note: Median passage date is the date by which 50% of the flight had passed; 1999 values are given only for species with annual counts ≥5 birds, and long-term means are given only for species with annual counts of ≥5 birds for at least 1 year.

[1] Mean ± 95% confidence interval in days.

Table 10. Sex-specific median passage dates for selected species at Yaki Point: 1997–1998 versus 1999.

	FEMALE		MALE	
SPECIES	1997–1998[1]	1999	1997–1998[1]	1999
Adult Northern Harrier	26-Sep [2]	–	20-Oct ± 11.5	7-Oct
American Kestrel	24-Sep ± 3.0	24-Sep	28-Sep ± 3.5	3-Oct

Note: Median passage date is the date by which 50% of the flight had passed; 1999 values are given only for species with annual counts ≥5 birds, and long-term means were calculated only for species with annual counts of ≥5 birds for at least 1 year.

[1] Mean ± 95% confidence interval in days.
[2] 1998 only.

Table 11. Comparison of 1997–1998 average and 1999 counts for Lipan Point, Yaki Point, and both sites combined.

	Lipan Point			Yaki Point			Combined		
Species	1997-98	1999	% Change	1997–98	1999	% Change	1997–98	1999	% Change
Turkey Vulture	297	75	-75	116	76	-34	413	151	-63
Osprey	125	72	-42	47	28	-40	172	100	-42
Northern Harrier	87	130	49	47	56	19	134	186	39
Sharp-shinned Hawk	1466	1427	-3	1332	1906	43	2798	3333	19
Cooper's Hawk	1524	1515	-1	983	1204	23	2506	2719	8
Northern Goshawk	5	6	20	6	1	-82	11	7	-33
Unidentified accipiter	228	185	-19	117	109	-7	345	294	-15
Total accipiters	3223	3133	-3	2437	3220	32	5660	6353	12
Red-shouldered Hawk	0	0	–	1	0	-100	1	0	-100
Broad-winged Hawk	21	11	-48	14	14	0	35	25	-29
Swainson's Hawk	32	40	27	20	32	60	52	72	40
Red-tailed Hawk	1547	1401	-9	908	985	9	2455	2386	-3
Ferruginous Hawk	7	7	8	8	11	47	14	18	29
Zone-tailed Hawk	1	0	-100	0	1	–	1	1	0
Unidentified buteo	37	17	-53	20	13	-35	57	30	-47
Total buteos	1644	1476	-10	970	1056	9	2613	2532	-3
Golden Eagle	24	29	21	16	2	-87	40	31	-22
Bald Eagle	22	24	12	21	17	-17	42	41	-2
Unidentified eagle	1	4	700	1	1	100	1	5	400
Total eagles	46	57	24	37	20	-45	83	77	-7
American Kestrel	1159	1218	5	720	918	28	1879	2136	14
Merlin	18	13	-28	13	14	8	31	27	-13
Prairie Falcon	5	2	-60	7	6	-8	12	8	-30
Peregrine Falcon	9	8	-11	13	8	-38	22	16	-27
Unidentified falcon	7	6	-14	2	2	0	9	8	-11
Total falcons	1198	1247	4	754	948	26	1952	2195	12
Unidentified Raptor	97	107	11	29	16	-45	126	123	-2
Grand Total	6716	6297	-6	4436	5420	22	11151	11717	5

Table 12. Comparison of 1997–1998 average and 1999 passage rates (raptors / 100 hours) for Lipan Point, Yaki Point, and both sites combined.

	Lipan Point			Yaki Point			Combined		
Species	1997-98	1999	% Change	1997–98	1999	% Change	1997–98	1999	% Change
Turkey Vulture	58	14	-76	24	14	-42	82	28	-66
Osprey	24	13	-46	9.7	5.2	-47	34	18	-46
Northern Harrier	167	24	41	9.8	10.3	5	27	34	28
Sharp-shinned Hawk	285	261	-8	277	351	27	562	612	9
Cooper's Hawk	297	277	-7	207	222	7	504	499	-1
Northern Goshawk	1.0	1.1	14	1.2	0.2	-84	2.1	1.3	-40
Unidentified accipiter	44	34	-24	25	20	-19	69	54	-22
Total accipiters	628	573	-9	509	593	16	1137	1166	3
Red-shouldered Hawk	0.0	0.0	0	0.1	0.0	-100	0.1	0.0	-100
Broad-winged Hawk	4.1	2.0	-51	3.0	2.6	-13	7.1	4.6	-35
Swainson's Hawk	6.1	7.3	19	4.2	5.9	39	10	13	27
Red-tailed Hawk	301	256	-15	190	181	-4	490	438	-11
Ferruginous Hawk	1.3	1.3	1	1.6	2.0	30	2.8	3.3	17
Zone-tailed Hawk	0.2	0.0	-100	0.0	0.2	–	0.2	0.2	-5
Unidentified buteo	7.1	3.1	-56	4.2	2.4	-43	11	5.5	-51
Total buteos	320	270	-16	203	194	-4	522	464	-11
Golden Eagle	4.7	5.3	14	3.1	0.4	-88	7.8	5.7	-27
Bald Eagle	4.2	4.4	5	4.3	3.1	-26	8.4	7.5	-11
Unidentified eagle	0.1	0.7	639	0.1	0.2	86	0.2	0.9	363
Total eagles	8.9	10.4	17	7.5	3.7	-51	16	14	-14
American Kestrel	225	223	-1	147	169	15	372	392	5
Merlin	3.5	2.4	-32	2.7	2.6	-5	6.2	5.0	-20
Prairie Falcon	1.0	0.4	-62	1.3	1.1	-17	2.3	1.5	-36
Peregrine Falcon	1.8	1.5	-17	2.8	1.5	-47	4.5	2.9	-35
Unidentified falcon	1.4	1.1	-20	0.4	0.4	-16	1.8	1.5	-19
Total falcons	233	228	-2	154	175	13	387	403	4
Unidentified Raptor	19	20	4	6.2	2.9	-52	25	23	-10
Grand Total	1307	1152	-12	923	998	8	2230	2150	-4

Figure 1. Study site map for Lipan Point in the Grand Canyon of Arizona.

Figure 2. Study site map for Yaki Point in the Grand Canyon of Arizona.

Figure 3. Combined-species annual passage rates at Lipan Point: 1991–1999.

Figure 4. Flight composition by raptor groups at Lipan Point: 1991–1998 versus 1999.

Figure 5. Combined-species passage volume by hourly periods of the day at Lipan Point: 1991–1998 versus 1999.

Figure 6. Combined-species passage volume by five-day periods at Lipan Point: 1991–1998 versus 1999.

Figure 7. Flight composition by raptor groups at Yaki Point: 1997–1998 versus 1999.

Figure 8. Combined-species passage volume by hourly periods of the day at Yaki Point: 1997–1998 versus 1999.

Figure 9. Combined-species passage volume by five-day periods at Yaki Point: 1997–1998 versus 1999.

Figure 10. Annual passage rates for Turkey Vultures, Ospreys, and Northern Harriers at Lipan Point: 1991–1999.

Figure 11. Passage volume by five-day periods for Turkey Vultures, Ospreys, and Northern Harriers at Lipan Point: 1991–1998 versus 1999.

Figure 12. Passage volume by five-day periods for Turkey Vultures, Ospreys, and Northern Harriers at Yaki Point: 1997–1998 versus 1999.

Figure 13. Annual passage rates for Sharp-shinned Hawks, Cooper's Hawks, and Northern Goshawks at Lipan Point: 1991–1999.

Figure 14. Passage volume by five-day periods for Sharp-shinned Hawks, Cooper's Hawks, and Northern Goshawks at Lipan Point: 1991–1998 versus 1999.

Figure 15. Passage volume by five-day periods for Sharp-shinned Hawks, Cooper's Hawks, and Northern Goshawks at Yaki Point: 1997–1998 versus 1999.

Figure 16. Annual passage rates for Red-tailed Hawks, Swainson's Hawks, Broad-winged Hawks, and Ferruginous Hawks at Lipan Point: 1991–1999.

Figure 17. Passage volume by five-day periods for Broad-winged Hawks and Swainson's Hawks at Lipan Point: 1991–1998 versus 1999.

Figure 18. Passage volume by five-day periods for Broad-winged Hawks and Swainson's Hawks at Yaki Point: 1997–1998 versus 1999.

Figure 19. Passage volume by five-day periods for Red-tailed Hawks and Ferruginous Hawks at Lipan Point: 1991–1998 versus 1999.

Figure 20. Passage volume by five-day periods for Red-tailed Hawks and Ferruginous Hawks at Yaki Point: 1997–1998 versus 1999.

Figure 21. Annual passage rates for Golden and Bald Eagles at Lipan Point: 1991–1999.

Figure 22. Passage volume by five-day periods for Golden and Bald Eagles at Lipan Point: 1991–1998 versus 1999.

Figure 23. Passage volume by five-day periods for Golden and Bald Eagles at Yaki Point: 1997–1998 versus 1999.

Figure 24. Annual passage rates for American Kestrels, Merlins, Prairie Falcons, and Peregrine Falcons at Lipan Point: 1991–1999.

Figure 25. Passage volume by five-day periods for American Kestrels and Merlins at Lipan Point: 1991–1998 versus 1999.

Figure 26. Passage volume by five-day periods for American Kestrels and Merlins at Yaki Point: 1997–1998 versus 1999.

Figure 27. Passage volume by five-day periods for Prairies Falcons and Peregrine Falcons at Lipan Point: 1991–1998 versus 1999.

Figure 28. Passage volume by five-day periods for Prairie and Peregrine Falcons at Yaki Point: 1997–1998 versus 1999.

Appendix A. History of official observer participation in the Grand Canyon raptor migration studies: 1991–1999.

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), Chrisite 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).

---

[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 raptor species observed during migration in the Grand Canyon.

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 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
Zone-tailed Hawk	*Buteo albonotatus*	ZT	A I U	U	NA
Unknown buteo	*Buteo* spp.	UB	U	U	D L U
Golden Eagle	*Aquila chrysaetos*	GE	A 2 1 I/S U[4]	U	NA
Bald Eagle	*Haliaeetus leucocephalus*	BE	A 3 2 1 I/S 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	M U	NA
Prairie Falcon	*Falco mexicanus*	PR	U	U	NA
Peregrine Falcon	*Falco peregrinus*	PG	U	U	NA
Unknown falcon	*Falco* spp.	UF	U	U	NA
Unknown raptor	Falconiformes	UU	U	U	NA

[1] Age classification codes: A = adult, I = immature (HY), Br = brown (adult female or immature), U – unknown age.

[2] Sex classification codes: M = male, F = female, U = unknown.

[3] Color morph classification codes: D = dark or rufous, L = light, U – unknown, NA = not applicable.

[4] Golden Eagle age codes: A = adult - no white in wings or tail; 2 = plumage class 2 - no white patch in wings, obvious white in tail; 1 = plumage class 1- white wing patch visible below, small wing patch may be visible above, bold white in tail; I/S = unknown age immature or subadult - obvious white in tail, wings not adequately observed

[5] Bald Eagle age codes: A = adult - completely white head and tail; 3 = plumage class 3 -head mostly white, with osprey-like dark eyeline; 2 = plumage class 2 - dark head, light belly, and/or upside-down white triangle on back; 1 = plumage class 1 - dark head, breast, and belly; I/S = unknown age immature or subadult - dark or mottled head, other plumage features not adequately observed.

Appendix C. Daily observation effort, visitation, weather, and flight-summary records for Lipan Pt.: 1999.

Date	Hours	Avg. Obsrvrs / Hour	Avg. Visitors / Hour	Sky Condition[1]	Thermal Lift[2]	Wind Speed[3]	Wind Direct	Avg. Temp. (°C)	Baro. Press. (mm)	Avg. Visib. E (km)	Avg. Visib. W (km)	Flight Dist.[4]	Raptors / Hour
27-Aug	6.33	2.0	0.0	rain-mc	3	2	w-e	24.9	–	57	66	2	0.5
28-Aug	7.75	2.9	0.0	pc, brief rain	1	1	var	31.6	779.8	106	106	2	0.6
29-Aug	7.75	2.0	0.0	mc	3	0	s	28.7	780.3	88	77	3	0.4
30-Aug	6.50	2.0	0.0	ovc,rain	4	4	s-sw	22.4	–	51	58	–	0.0
31-Aug	7.67	2.0	0.0	ovc	4	2	se	18.1	778.1	67	61	2	0.4
1-Sep	7.67	2.0	0.0	clr, ts	3	5	w	18.7	775.6	48	69	2	0.3
2-Sep	8.00	2.0	0.0	pc	2	2	s-w	20.3	773.9	90	90	2	0.6
3-Sep	8.00	2.0	0.0	clr	1	3	w	21.1	–	100	100	2	1.0
4-Sep	8.08	2.6	0.0	clr	1	0	nw	22.8	780.1	73	87	3	6.6
5-Sep	8.00	2.0	0.0	clr	1	0	e	23.5	768.1	90	90	2	3.4
6-Sep	8.00	2.7	0.3	clr	1	1	w	26.1	774.7	83	77	2	2.3
7-Sep	8.50	1.9	2.0	clr	1	0	w	27.3	–	90	90	2	6.0
8-Sep	8.00	2.4	1.4	clr	1	1	var	31.0	–	100	100	2	7.4
9-Sep	8.00	2.0	0.0	ovc	3	1	w	22.7	778.5	70	59	3	1.6
10-Sep	8.17	2.0	0.4	pc	1	2	w	24.6	–	100	100	3	4.8
11-Sep	0.58	3.0	0.0	ts	4	1	var	17.5	777.0	21	31	1	1.7
12-Sep	8.33	3.6	0.2	pc-mc	1	0	w	22.7	–	88	89	2	19.0
13-Sep	8.00	2.8	7.6	clr-pc	1	1	w	22.5	778.6	100	100	2	22.1
14-Sep	4.83	2.7	4.6	ts	4	1	ese	14.2	–	63	40	2	0.6
15-Sep	8.58	2.2	1.1	pc, brief rain	2	0	var	19.8	775.3	60	82	2	6.9
16-Sep	6.08	2.3	0.9	ovc-ts	3	0	var	18.7	–	59	59	2	9.0
17-Sep	8.00	2.0	0.1	pc	2	0	nnw	22.4	–	80	67	3	10.3
18-Sep	7.25	2.9	1.1	ovc-ts	2	1	var	19.4	775.8	64	50	2	27.0
19-Sep	8.00	3.8	0.6	pc	2	4	w	18.7	–	100	100	2	11.8
20-Sep	8.67	2.8	0.2	pc	1	0	w	20.8	778.0	62	44	2	15.5
21-Sep	8.25	2.3	0.4	clr	1	0	var	21.2	780.1	76	72	3	12.8
22-Sep	2.00	2.8	1.0	ovc-rain	4	2	se	13.8	–	9	3	–	0.0
23-Sep	6.83	2.0	0.0	ovc-rain	4	1	var	16.0	777.3	18	21	2	3.8
24-Sep	9.25	2.9	0.9	clr	2	2	nw	19.4	776.0	56	56	3	49.3
25-Sep	9.92	3.6	0.4	clr	1	0	w	21.9	–	49	31	2	64.5
26-Sep	9.83	3.3	0.3	clr	2	1	w	22.3	774.6	72	49	3	46.4
27-Sep	8.50	2.5	0.9	clr	2	2	nw	21.3	772.4	86	54	3	9.4
28-Sep	8.25	2.6	3.7	clr	1	1	n	16.1	–	69	69	2	3.6
29-Sep	8.17	2.7	0.3	clr	1	0	var	14.3	782.5	90	61	2	4.4
30-Sep	9.17	2.5	6.2	clr	1	1	var	18.2	–	75	63	2	10.8
1-Oct	8.42	1.8	0.0	clr	1	0	ne	–	–	52	34	2	10.6
2-Oct	8.00	2.9	1.9	clr	1	4	w	21.3	–	36	34	2	11.5
3-Oct	9.00	3.0	0.0	clr, haze	2	0	var	19.3	777.3	57	25	3	15.3
4-Oct	8.00	2.8	1.3	clr, haze	1	1	var	21.5	–	28	35	2	14.9
5-Oct	8.33	2.2	3.3	pc	3	3	sw	21.3	778.3	73	58	2	7.7
6-Oct	8.25	2.8	0.4	clr, haze/dust	3	2	s	16.5	–	42	42	2	2.9
7-Oct	8.50	2.0	0.8	clr	2	0	w	13.8	774.5	93	46	2	23.1
8-Oct	8.00	2.3	0.8	clr	1	1	var	17.8	–	75	75	2	5.4
9-Oct	7.92	2.9	0.0	clr, haze	2	0	var	21.4	–	66	37	3	16.7
10-Oct	8.08	2.8	0.0	clr	1	0	var	21.3	778.9	87	49	2	17.2

Appendix C. continued

Date	Hours	Avg. Obsrvrs / Hour	Avg. Visitors / Hour	Sky Condition[1]	Thermal Lift[2]	Wind Speed[3]	Wind Direct	Avg. Temp. (°C)	Baro. Press. (mm)	Avg. Visib. E (km)	Avg. Visib. W (km)	Flight Dist.[4]	Raptors / Hour
11-Oct	8.00	3.1	1.8	clr	1	1	var	20.8	785.8	75	75	2	15.3
12-Oct	8.08	2.9	1.0	clr, haze	1	0	nw	20.7	–	62	24	2	30.9
13-Oct	8.50	2.3	0.3	clr, haze	1	1	var	22.0	784.6	80	45	2	19.5
14-Oct	8.37	2.5	1.2	clr	1	2	w	21.7	–	75	75	3	36.8
15-Oct	8.00	2.0	1.1	clr, haze	3	0	var	18.0	–	51	22	2	6.3
16-Oct	7.83	3.6	0.0	clr	1	1	w	12.7	778.0	76	49	2	32.3
17-Oct	7.92	3.9	0.8	clr, haze	2	0	ne	6.6	–	67	33	3	2.5
18 Oct	8.50	2.6	0.2	clr	1	1	var	15.3	777.0	75	60	2	6.0
19 Oct	8.33	2.0	1.3	clr	1	0	e-s	12.3	–	75	75	2	4.6
20 Oct	8.00	2.7	0.6	clr	1	0	var	15.9	782.6	80	48	3	6.0
21 Oct	8.00	2.0	1.5	clr	1	1	ne	15.0	–	60	60	2	4.8
22 Oct	7.67	2.3	0.0	clr, haze	2	0	ne	13.0	–	64	36	2	4.3
23 Oct	7.58	3.2	0.3	mc, haze	2	1	e	16.9	782.1	76	39	2	8.4
24 Oct	8.17	3.3	0.2	pc-mc	2	0	var	19.0	–	58	31	2	22.2
25 Oct	7.58	2.0	0.0	clr	1	0	se	17.2	779.7	76	39	2	6.2
26 Oct	7.50	2.5	0.8	clr-pc	1	0	var	17.1	–	50	56	2	15.2
27 Oct	7.42	2.0	0.4	clr, haze	2	1	sw	19.2	–	68	36	2	9.8
28 Oct	8.25	2.8	0.4	mc	4	2	s	15.2	–	60	46	2	2.9
29 Oct	7.75	3.0	0.4	clr	1	1	var	8.8	781.2	80	48	2	3.2
30 Oct	7.75	1.9	0.0	clr, haze	2	0	ne	9.2	–	74	47	3	3.0
31 Oct	7.25	1.8	0.3	clr	1	1	e-sw	13.9	782.2	89	47	2	2.9
01 Nov	7.17	2.0	0.0	clr-mc	2	1	ne	14.5	780.7	73	56	3	0.6
02 Nov	7.00	2.0	0.0	clr	1	1	e-w	14.6	–	73	58	2	3.6
03 Nov	6.50	2.0	0.0	clr	2	0	ne	16.9	–	65	27	3	6.0
04 Nov	6.67	1.9	0.0	clr	2	0	var	15.8	776.1	54	32	2	6.3
05 Nov	5.50	2.0	0.0	clr	1	1	var	17.3	–	15	31	1	4.5

[1] 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 = thunder storms.

[2] Average of hourly ratings 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.

[3] Average of hourly categorical ratings: 0 = less than 1 km/h; 1 = 1–5 km/h; 2 = 6–11 km/h; 3 = 12–19 km/h; 4 = 20–28 km/h; 5 = 29–38 km/h, etc.

[4] Average of hourly line-of-sight ratings concerning 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, visitation, weather, and flight-summary records for Yaki Point: 1999.

Date	Hours	Avg. Obsrvrs / Hour	Avg. Visitors / Hour	Sky Condition[1]	Thermal Lift[2]	Wind Speed[3]	Wind Direct.	Avg. Temp. (°C)	Baro. Press. (mm)	Avg. Visib. E (km)	Avg. Visib. W (km)	Flight Dist.[4]	Raptors / Hour
27-Aug	5.50	1.0	0.0	mc, ts	3	2	se	26.0	784.6	–	83	1	0.2
28-Aug	8.00	1.0	0.3	pc	2	1	e-nw	24.6	770.5	90	90	1	0.1
29-Aug	8.00	2.0	0.0	pc-mc	3	1	e-s	23.9	–	70	78	3	0.1
30-Aug	7.00	1.0	0.0	mc	3	3	sw	24.1	781.6	–	59	1	0.3
31-Aug	6.00	1.0	0.0	mc	3	4	w	21.3	–	–	79	2	0.2
1-Sep	7.58	1.0	1.0	mc	3	2	sw	20.5	765.5	–	32	1	0.5
2-Sep	6.58	1.0	0.4	clr	2	3	sw	21.3	–	–	100	1	0.2
3-Sep	8.50	1.0	0.0	clr	2	2	sw	18.2	777.9	–	68	2	0.8
4-Sep	6.92	2.0	1.3	clr	2	0	w	24.2	–	–	90	1	0.9
5-Sep	8.67	1.3	3.4	clr	1	1	se	24.1	777.8	–	76	2	4.4
6-Sep	8.50	1.0	2.2	clr	1	1	s-w	25.8	767.5	–	90	1	1.2
7-Sep	9.92	2.5	0.4	clr	1	1	nw	25.6	777.0	–	100	2	9.0
8-Sep	8.50	1.0	0.6	clr	1	0	ne	28.3	–	–	74	2	2.4
9-Sep	7.75	1.4	1.1	ovc	4	4	nw	–	–	–	18	1	1.3
10-Sep	8.25	2.0	4.6	clr-mc	1	0	nw	23.5	778.1	–	71	2	3.3
11-Sep	1.92	1.8	0.0	ts	4	2	var	13.3		–	4	–	0.0
12-Sep	9.75	2.7	1.1	pc	2	0	nw	21.6	781.4	–	65	2	22.4
13-Sep	8.00	2.0	3.3	pc	2	0	nw	24.9	–	–	87	1	6.8
14-Sep	6.00	2.1	1.5	ts	3	1	e	16.3	781.5	–	83	1	0.2
15-Sep	8.25	2.2	2.1	clr-mc	2	1	var	19.5	–	–	75	2	4.5
16-Sep	6.92	2.0	1.5	ovc	3	0	e	18.2	783.0	–	48	2	1.2
17-Sep	9.00	2.4	6.3	clr-mc	1	1	e-w	20.7	–	96	96	2	7.3
18-Sep	8.00	3.0	2.9	mc	2	0	var	20.9	–	–	37	2	7.3
19-Sep	8.25	3.2	6.7	clr-pc	2	2	s	19.3	–	–	64	3	6.4
20-Sep	9.17	1.9	0.7	pc	1	1	n-nw	21.0	–	–	41	2	6.9
21-Sep	9.00	2.0	0.4	clr	1	0	se-ne	21.1	–	–	30	2	15.7
22-Sep	2.67	7.7	–	ovc-rain	4	2	e	16.5	788.6	–	23	1	0.4
23-Sep	6.58	1.8	0.3	ovc	3	0	var	17.8	–	–	11	2	5.0
24-Sep	9.25	2.6	1.3	pc	2	1	w	18.1	779.9	–	55	2	59.9
25-Sep	9.42	2.5	1.3	clr	2	3	w	19.1	778.8	60	60	2	32.7
26-Sep	8.58	2.9	5.6	clr	2	3	nw	20.2	–	–	57	2	26.7
27-Sep	6.67	2.0	0.5	clr	1	2	n	23.0	–	–	38	2	6.3
28-Sep	7.50	1.8	2.0	clr	2	1	e	14.4	785.2	–	67	2	15.2
29-Sep	8.00	2.0	0.0	clr	1	2	e	–	–	–	82	2	5.9
30-Sep	8.42	1.0	1.1	clr	1	0	e	–	–	–	23	2	12.2
1-Oct	8.00	1.9	0.6	clr	1	4	w	21.1	–	–	67	2	4.4
2-Oct	7.92	2.4	1.3	clr, dust/haze	2	1	s	22.4	–	–	24	2	9.8
3-Oct	9.17	2.5	3.0	clr, AM haze	1	1	w	20.3	–	–	21	2	49.0
4-Oct	7.67	1.8	0.5	clr, PM haze	2	0	var	19.9	783.0	–	30	2	25.3
5-Oct	8.67	1.7	0.9	pc, dust	1	1	se-sw	22.7	–	–	40	2	8.5
6-Oct	8.00	1.6	0.9	clr-mc	3	5	sw	16.0	775.6	–	53	2	4.8
7-Oct	9.00	2.0	0.7	clr, haze	2	0	var	15.5	–	–	26	2	22.7
8-Oct	7.92	2.5	2.9	clr, haze	1	1	ne	17.5	780.5	–	22	2	16.4
9-Oct	8.42	2.8	0.2	clr	1	1	se-nw	20.7	781.9	–	56	2	34.2
10-Oct	8.58	2.2	2.6	clr, haze	2	0	var	20.9	–	–	28	2	17.7

Appendix D. continued

Date	Hours	Avg. Obsrvrs / Hour	Avg. Visitors / Hour	Sky Condition[1]	Thermal Lift[2]	Wind Speed[3]	Wind Direct.	Avg. Temp. (°C)	Baro. Press. (mm)	Avg. Visib. E (km)	Avg. Visib. W (km)	Flight Dist.[4]	Raptors / Hour
11-Oct	8.25	1.9	0.0	clr, haze	2	0	var	20.7	–	–	26	2	12.0
12-Oct	8.75	2.2	2.3	clr, PM haze	2	1	w	22.6	788.9	–	44	2	22.2
13-Oct	8.17	2.7	0.7	clr, haze	1	0	se	21.6	–	–	31	2	31.1
14-Oct	8.00	2.0	0.6	clr, haze	2	0	s	23.7	–	–	25	2	9.0
15-Oct	8.33	2.0	0.9	clr	2	4	w	19.6	776.6	–	63	2	4.9
16-Oct	8.00	1.7	2.3	clr, haze	2	0	ne	18.2	–	–	24	2	11.3
17-Oct	7.83	1.0	0.3	clr	2	1	ne	9.1	788.8	–	54	3	1.4
18 Oct	6.67	3.0	0.1	clr, haze	2	0	e	17.7	–	–	54	2	8.2
19 Oct	7.00	2.6	0.4	clr	1	1	e	14.3	785.4	–	60	3	4.7
20 Oct	8.00	1.2	0.0	clr	1	1	se-w	16.5	–	–	47	2	3.6
21 Oct	8.17	2.0	0.3	clr, haze	2	1	e	19.2	–	–	25	2	8.0
22 Oct	7.58	1.7	1.2	clr	1	1	e	17.7	–	–	43	2	10.3
23 Oct	7.50	2.0	0.5	pc	2	2	e	18.1	–	–	22	2	4.4
24 Oct	6.75	3.4	0.4	clr	1	1	nw	19.2	783.6	–	25	2	3.9
25 Oct	7.33	2.0	0.0	clr, haze	2	0	e	21.2	–	–	25	2	8.5
26 Oct	7.83	2.0	0.0	clr-pc	2	1	var-sw	17.9	782.6	–	46	2	2.2
27 Oct	8.00	2.7	0.0	clr	2	1	nw	16.9	783.4	–	46	2	12.3
28 Oct	8.00	1.4	0.0	ovc	3	5	sw	17.3	–	–	40	1	2.0
29 Oct	6.42	1.3	0.0	clr, haze	2	0	ne	15.1	–	–	58	2	2.8
30 Oct	7.67	2.5	0.0	clr	2	1	ne	9.9	788.5	–	57	2	3.3
31 Oct	7.50	2.9	0.6	clr	2	0	ne	18.4	–	–	39	2	3.2
01 Nov	7.50	1.0	0.0	pc-ovc	3	1	ne	17.7	–	–	26	3	2.7
02 Nov	6.33	1.0	0.0	clr	2	0	var	15.8	783.4	–	51	2	1.1
03 Nov	5.50	1.0	0.2	clr	1	1	w	18.4	–	–	15	2	4.2
04 Nov	6.50	1.0	0.0	clr, haze	2	0	var-sw	21.4	–	–	18	2	2.6
05 Nov	5.25	1.0	0.0	clr	1	0	var	16.1	782.4	–	42	2	4.4

[1] 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 = thunder storms.

[2] Average of hourly ratings 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.

[3] Average of hourly categorical ratings: 0 = less than 1 km/h; 1 = 1–5 km/h; 2 = 6–11 km/h; 3 = 12–19 km/h; 4 = 20–28 km/h; 5 = 29–38 km/h, etc.

[4] Average of hourly line-of-sight ratings concerning 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 count records by species for Lipan Point: 1999.

Date	Obs. Hours	Species[1]																						Total	Raptors / Hour
		TV	OS	NH	SS	CH	NG	UA	RS	BW	SW	RT	FH	ZT	UB	GE	BE	UE	AK	ML	PR	PG	UF	UU	
27-Aug	6.33	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0	3	0.5
28-Aug	7.75	0	1	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	0.6
29-Aug	7.75	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	3	0.4
30-Aug	6.50	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	7.67	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0	0	0	0	0	3	0.4
01-Sep	7.67	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0.3
02-Sep	8.00	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2	0	0	0	0	1	5	0.6
03-Sep	8.00	0	3	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	3	0	0	0	0	0	8	1.0
04-Sep	8.08	0	2	2	7	3	0	1	0	0	0	8	0	0	2	0	0	0	26	0	0	1	0	1	53	6.6
05-Sep	8.00	0	0	1	3	3	0	0	0	0	0	4	0	0	1	0	0	0	13	0	0	0	0	2	27	3.4
06-Sep	8.00	0	1	2	7	2	0	1	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	1	18	2.3
07-Sep	8.50	0	2	3	10	8	0	0	0	0	0	3	0	0	0	0	1	0	22	0	0	0	0	2	51	6.0
08-Sep	8.00	0	0	1	5	4	0	0	0	0	2	4	0	0	0	0	0	0	38	0	0	0	0	5	59	7.4
09-Sep	8.00	0	1	0	3	4	0	1	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	13	1.6
10-Sep	8.17	0	2	0	16	8	0	2	0	0	0	1	0	0	0	0	0	0	6	0	0	0	0	4	39	4.8
11-Sep	0.58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1.7
12-Sep	8.33	0	10	1	25	33	0	4	0	0	5	22	1	0	2	0	0	0	51	0	1	0	2	1	158	19.0
13-Sep	8.00	2	9	0	43	29	0	7	0	0	1	47	0	0	0	0	0	0	36	0	0	2	0	1	177	22.1
14-Sep	4.83	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0.6
15-Sep	8.58	2	2	0	10	24	0	3	0	0	1	6	0	0	0	0	0	0	10	0	0	1	0	0	59	6.9
16-Sep	6.08	5	8	0	10	15	0	1	0	0	0	1	0	0	0	0	0	0	13	0	0	0	0	2	55	9.0
17-Sep	8.00	2	1	2	22	19	0	3	0	0	2	20	0	0	0	0	0	0	9	0	0	0	0	2	82	10.3
18-Sep	7.25	0	1	3	47	67	0	1	0	4	2	45	0	0	0	1	0	0	24	1	0	0	0	0	196	27.0
19-Sep	8.00	0	1	0	27	21	0	16	0	0	0	6	0	0	0	0	0	0	21	0	0	0	0	2	94	11.8
20-Sep	8.67	1	4	0	35	37	1	3	0	0	1	12	0	0	0	0	0	0	40	0	0	0	0	0	134	15.5
21-Sep	8.25	0	1	6	14	31	0	3	0	1	2	11	0	0	0	1	0	0	31	1	0	0	0	4	106	12.8
22-Sep	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
23-Sep	6.83	0	1	0	7	6	0	0	0	0	4	0	0	0	0	0	0	0	7	0	0	0	0	1	26	3.8
24-Sep	9.25	0	3	3	97	118	0	35	0	3	0	46	1	0	2	0	0	0	131	1	0	0	1	15	456	49.3
25-Sep	9.92	25	0	3	162	206	0	21	0	3	4	33	1	0	1	0	0	1	163	1	1	1	2	12	640	64.5
26-Sep	9.83	15	0	3	89	160	0	5	0	0	2	46	0	0	2	0	0	0	126	1	0	0	0	7	456	46.4
27-Sep	8.50	2	1	4	22	23	0	6	0	0	2	5	0	0	1	0	0	0	12	0	0	0	0	2	80	9.4
28-Sep	8.25	0	0	0	6	8	0	0	0	0	0	5	0	0	0	0	0	0	10	0	0	0	0	1	30	3.6
29-Sep	8.17	1	1	1	3	11	0	0	0	0	0	13	0	0	0	0	0	0	5	0	0	0	0	1	36	4.4
30-Sep	9.17	0	3	2	18	29	0	1	0	0	1	16	0	0	0	1	0	0	28	0	0	0	0	0	99	10.8
01-Oct	8.42	0	0	0	28	47	0	1	0	0	2	5	0	0	0	0	0	0	6	0	0	0	0	0	89	10.6
02-Oct	8.00	0	5	3	17	16	0	13	0	0	2	7	0	0	0	0	0	0	27	0	0	0	0	2	92	11.5
03-Oct	9.00	0	0	3	22	25	0	1	0	0	1	15	0	0	0	0	0	0	70	0	0	0	0	1	138	15.3
04-Oct	8.00	13	1	3	28	29	0	3	0	0	4	14	0	0	0	0	0	0	24	0	0	0	0	0	119	14.9
05-Oct	8.33	2	0	0	4	14	0	1	0	0	0	26	0	0	0	0	0	0	15	0	0	0	0	2	64	7.7
06-Oct	8.25	1	0	0	8	8	0	3	0	0	0	2	0	0	0	0	0	0	2	0	0	0	0	0	24	2.9
07-Oct	8.50	1	0	9	26	93	0	1	0	0	0	23	0	0	0	1	0	0	36	1	0	0	0	5	196	23.1
08-Oct	8.00	0	0	3	13	6	0	0	0	0	1	9	0	0	0	0	1	0	9	0	0	0	0	1	43	5.4

Appendix E. continued

Date	Obs. Hours	Species[1]																							Raptors / Hour
		TV	OS	NH	SS	CH	NG	UA	RS	BW	SW	RT	FH	ZT	UB	GE	BE	UE	AK	ML	PR	PG	UF	UU	Total	
09-Oct	7.92	0	0	3	28	26	0	5	0	0	0	36	0	0	0	1	1	1	30	0	0	0	0	1	132	16.7
10-Oct	8.08	0	1	3	26	45	0	0	0	0	0	34	0	0	0	0	0	0	26	0	0	0	0	4	139	17.2
11-Oct	8.00	0	0	3	20	43	1	5	0	0	0	30	1	0	0	0	0	0	17	0	0	0	0	2	122	15.3
12-Oct	8.08	0	0	3	43	59	0	5	0	0	1	106	0	0	1	1	0	0	27	0	0	0	0	4	250	30.9
13-Oct	8.50	2	2	7	51	59	0	2	0	0	0	16	1	0	0	0	0	0	26	0	0	0	0	0	166	19.5
14-Oct	8.37	0	2	2	37	44	1	14	0	0	0	181	0	0	1	0	2	0	19	2	0	1	0	2	308	36.8
15-Oct	8.00	0	1	1	12	19	0	0	0	0	0	14	0	0	0	0	0	0	3	0	0	0	0	0	50	6.3
16-Oct	7.83	0	0	10	33	50	0	8	0	0	0	135	0	0	0	3	0	1	10	1	0	0	0	2	253	32.3
17-Oct	7.92	0	0	0	1	5	1	1	0	0	0	6	0	0	0	4	1	0	1	0	0	0	0	0	20	2.5
18-Oct	8.50	0	0	2	12	8	0	0	0	0	0	24	0	0	0	0	0	0	4	0	0	0	0	1	51	6.0
19-Oct	8.33	0	0	2	4	3	0	2	0	0	0	16	0	0	1	3	3	0	1	0	0	0	0	3	38	4.6
20-Oct	8.00	0	0	3	11	6	1	1	0	0	0	18	1	0	0	1	2	0	4	0	0	0	0	0	48	6.0
21-Oct	8.00	0	0	2	15	5	0	0	0	0	0	7	0	0	0	1	1	1	3	0	0	0	0	3	38	4.8
22-Oct	7.67	0	0	2	18	1	0	0	0	0	0	9	1	0	0	0	0	0	2	0	0	0	0	0	33	4.3
23-Oct	7.58	0	0	2	34	2	0	1	0	0	0	17	0	0	0	2	1	0	5	0	0	0	0	0	64	8.4
24-Oct	8.17	0	0	4	68	15	0	0	0	0	0	83	0	0	1	1	3	0	4	1	0	0	0	1	181	22.2
25-Oct	7.58	0	0	0	34	2	0	0	0	0	0	5	0	0	0	1	1	0	2	1	0	0	0	1	47	6.2
26-Oct	7.50	0	0	10	37	3	0	3	0	0	0	53	0	0	0	1	0	0	1	2	0	1	1	2	114	15.2
27-Oct	7.42	0	0	1	18	3	0	0	0	0	0	45	0	0	0	2	1	0	3	0	0	0	0	0	73	9.8
28-Oct	8.25	0	0	0	10	1	1	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	24	2.9
29-Oct	7.75	0	0	1	8	2	0	0	0	0	0	10	0	0	1	1	0	0	2	0	0	0	0	0	25	3.2
30-Oct	7.75	0	0	1	4	0	0	0	0	0	0	15	0	0	0	1	1	0	0	0	0	0	0	1	23	3.0
31-Oct	7.25	0	0	0	16	0	0	0	0	0	0	4	0	0	0	0	0	0	1	0	0	0	0	0	21	2.9
01-Nov	7.17	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	1	0	0	0	0	0	0	0	4	0.6
02-Nov	7.00	0	0	3	9	1	0	0	0	0	0	11	0	0	0	0	0	0	1	0	0	0	0	0	25	3.6
03-Nov	6.50	0	0	1	13	2	0	0	0	0	0	19	0	0	0	1	3	0	0	0	0	0	0	0	39	6.0
04-Nov	6.67	0	0	3	20	0	0	0	0	0	0	16	0	0	0	0	1	0	2	0	0	0	0	0	42	6.3
05-Nov	5.50	0	0	3	8	1	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	25	4.5
Total	546.70	75	72	130	1427	1515	6	185	0	11	40	1401	7	0	17	29	24	4	1218	13	2	8	6	107	6297	11.5

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

Appendix F. Summary information on observation effort and raptor count totals by year and species for Lipan Point: 1991–1999.

YEAR	1991	1992	1993	1994	1995	1996	1997	1998	1999	MEAN
Start date	8-Sep	1-Sep	31-Aug	1-Sep	1-Sep	27-Aug	27-Aug	27-Aug	27-Aug	29-Aug
End date	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	64	69	70	68	71	66
Hours of observation	399.66	513.50	504.50	482.92	492.54	508.84	522.19	505.18	546.70	497.34
Raptors / 100 hours	1231	1957	1249	1372	1369	1574	1331	1283	1152	1391
SPECIES	RAPTOR COUNTS									
Turkey Vulture	148	276	48	108	215	232	290	304	75	188
Osprey	26	72	73	73	77	99	135	115	72	82
Northern Harrier	43	131	64	111	121	111	93	81	130	98
Sharp-shinned Hawk	698	2472	1643	1802	1441	1680	1566	1366	1427	1566
Cooper's Hawk	1077	1673	1243	974	1052	1322	1332	1715	1515	1323
Northern Goshawk	10	42	26	4	5	3	8	2	6	12
Unidentified accipiter	360	337	199	200	243	423	213	243	185	267
TOTAL ACCIPITERS	2145	4524	3111	2980	2741	3428	3119	3326	3133	3167
Red-shouldered Hawk	0	1	0	0	0	1	0	0	0	0
Broad-winged Hawk	0	3	7	2	7	2	7	35	11	8
Swainson’s Hawk	6	24	25	33	34	57	32	31	40	31
Red-tailed Hawk	1194	3229	1613	1898	2299	2275	1704	1390	1401	1889
Ferruginous Hawk	8	15	7	11	3	6	7	6	7	8
Zone-tailed Hawk	0	0	0	0	0	0	1	1	0	0
Unidentified buteo	55	19	2	8	11	16	33	40	17	22
TOTAL BUTEOS	1263	3291	1654	1952	2354	2357	1784	1503	1476	1959
Golden Eagle	18	62	37	36	32	47	26	22	29	34
Bald Eagle	5	20	49	8	38	23	25	18	24	23
Unidentified eagle	0	0	3	0	0	0	0	1	4	1
TOTAL EAGLES	23	82	89	44	70	70	51	41	57	59
American Kestrel	1156	1508	1209	1273	1096	1631	1340	978	1218	1268
Merlin	7	14	12	10	12	8	24	12	13	12
Prairie Falcon	1	8	8	2	5	4	5	5	2	4
Peregrine Falcon	2	14	5	5	5	8	8	10	8	7
Unidentified falcon	0	4	4	1	1	0	6	8	6	3
TOTAL FALCONS	1166	1548	1238	1291	1119	1651	1383	1013	1247	1295
Unidentified raptor	106	124	24	66	48	60	97	96	107	81
GRAND TOTAL	4920	10048	6301	6625	6745	8008	6952	6479	6297	6931

Appendix G. Daily count records by species for Yaki Point: 1999.

Date	Obs. Hours	Species[1]																							Raptors
		TV	OS	NH	SS	CH	NG	UA	RS	BW	SW	RT	FH	ZT	UB	GE	BE	UE	AK	ML	PR	PG	UF	UU	Total / Hour
27-Aug	5.50	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1 0.2
28-Aug	8.00	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1 0.1
29-Aug	8.00	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1 0.1
30-Aug	7.00	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2 0.3
31-Aug	6.00	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1 0.2
01-Sep	7.58	0	1	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	4 0.5
02-Sep	6.58	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1 0.2
03-Sep	8.50	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	5	0	0	0	0	0	7 0.8
04-Sep	6.92	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	6 0.9
05-Sep	8.67	0	0	2	6	3	0	0	0	0	0	1	0	0	1	0	0	0	24	1	0	0	0	0	38 4.4
06-Sep	8.50	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	7	0	0	0	0	0	10 1.2
07-Sep	9.92	0	4	1	14	3	0	0	0	0	1	7	0	0	0	0	0	0	59	0	0	0	0	0	89 9.0
08-Sep	8.50	0	0	0	5	5	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	20 2.4
09-Sep	7.75	0	1	1	3	0	0	1	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	1	10 1.3
10-Sep	8.25	0	0	0	7	4	0	1	0	0	0	3	0	0	0	0	0	0	12	0	0	0	0	0	27 3.3
11-Sep	1.92	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
12-Sep	9.75	0	1	1	55	42	0	2	0	0	1	38	1	0	0	0	0	0	75	2	0	0	0	0	218 22.4
13-Sep	8.00	0	0	0	18	11	0	0	0	0	1	16	0	0	0	0	0	0	8	0	0	0	0	0	54 6.8
14-Sep	6.00	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1 0.2
15-Sep	8.25	0	0	0	13	10	0	2	0	0	0	1	1	0	0	0	0	0	9	0	0	1	0	0	37 4.5
16-Sep	6.92	0	0	0	1	6	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	8 1.2
17-Sep	9.00	0	1	0	36	15	0	4	0	0	0	1	0	0	0	0	0	0	8	0	0	1	0	0	66 7.3
18-Sep	8.00	0	0	0	27	13	0	6	0	0	0	1	0	0	0	1	0	0	8	1	0	1	0	0	58 7.3
19-Sep	8.25	0	0	1	20	15	0	2	0	0	1	6	0	0	0	0	0	0	7	0	0	1	0	0	53 6.4
20-Sep	9.17	2	2	0	31	11	0	4	0	0	0	2	0	0	0	0	0	0	11	0	0	0	0	0	63 6.9
21-Sep	9.00	0	0	1	38	29	0	3	0	0	0	6	0	0	3	0	0	0	58	0	0	0	0	3	141 15.7
22-Sep	2.67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1 0.4
23-Sep	6.58	0	0	0	12	7	0	2	0	1	0	3	0	0	0	0	0	0	8	0	0	0	0	0	33 5.0
24-Sep	9.25	21	2	1	232	137	0	7	0	7	6	81	0	0	1	0	1	0	57	0	0	1	0	0	554 59.9
25-Sep	9.42	14	1	2	87	77	0	11	0	2	0	57	1	0	0	0	0	0	51	1	2	1	0	1	308 32.7
26-Sep	8.58	0	1	1	75	44	0	3	0	1	4	33	0	0	0	0	0	0	66	0	0	1	0	0	229 26.7
27-Sep	6.67	1	0	0	7	10	0	0	0	0	1	13	0	0	0	0	0	0	10	0	0	0	0	0	42 6.3
28-Sep	7.50	0	0	1	36	38	0	1	0	1	0	26	0	0	0	0	0	0	11	0	0	0	0	0	114 15.2
29-Sep	8.00	6	0	0	17	6	0	5	0	0	0	3	0	0	0	0	0	0	10	0	0	0	0	0	47 5.9
30-Sep	8.42	0	1	0	39	52	0	0	0	0	0	8	0	0	1	0	0	0	2	0	0	0	0	0	103 12.2
01-Oct	8.00	0	1	0	8	11	0	5	0	1	0	7	0	0	0	0	0	0	2	0	0	0	0	0	35 4.4
02-Oct	7.92	2	2	2	7	19	0	2	0	1	2	8	0	0	0	0	0	0	32	1	0	0	0	0	78 9.8
03-Oct	9.17	11	0	6	135	110	0	7	0	0	9	72	1	0	3	0	0	0	90	2	1	0	1	1	449 49.0
04-Oct	7.67	2	1	0	62	69	0	3	0	0	2	15	0	0	1	0	0	0	39	0	0	0	0	0	194 25.3
05-Oct	8.67	0	0	1	27	23	0	0	0	0	0	10	0	0	0	0	0	0	13	0	0	0	0	0	74 8.5
06-Oct	8.00	2	1	2	3	10	0	1	0	0	0	11	0	0	0	0	0	0	8	0	0	0	0	0	38 4.8
07-Oct	9.00	2	1	6	70	37	0	8	0	0	1	38	1	0	1	0	0	0	37	1	0	0	0	1	204 22.7
08-Oct	7.92	4	1	0	35	46	0	2	0	0	0	18	0	0	0	0	0	0	21	0	1	0	0	2	130 16.4

Appendix G. continued

Date	Obs. Hours	Species[1]																						Raptors / Hour
		TV	OS	NH	SS	CH	NG	UA	RS	BW	SW	RT	FH	ZT	UB	GE	BE	UE	AK	ML	PR	PG	UF	UU	Total	
09-Oct	8.42	3	0	4	109	86	0	4	0	0	0	50	0	0	0	0	2	0	28	0	0	0	1	1	288	34.2
10-Oct	8.58	1	1	1	56	36	1	5	0	0	0	19	0	0	1	0	2	0	29	0	0	0	0	0	152	17.7
11-Oct	8.25	3	0	1	22	38	0	0	0	0	0	20	0	0	0	0	0	0	14	0	0	0	0	1	99	12.0
12-Oct	8.75	1	1	0	76	64	0	5	0	0	0	30	0	0	0	0	0	0	14	1	0	0	0	2	194	22.2
13-Oct	8.17	1	0	2	118	39	0	5	0	0	0	57	2	0	1	0	0	0	28	0	0	0	0	1	254	31.1
14-Oct	8.00	0	0	1	22	21	0	1	0	0	0	13	2	0	0	0	0	0	10	2	0	0	0	0	72	9.0
15-Oct	8.33	0	0	3	10	8	0	1	0	0	0	11	0	0	0	0	0	0	7	0	0	0	0	1	41	4.9
16-Oct	8.00	0	0	2	32	17	0	0	0	0	0	37	0	0	0	0	0	0	1	0	0	1	0	0	90	11.3
17-Oct	7.83	0	0	1	2	2	0	0	0	0	0	2	0	0	0	0	1	0	3	0	0	0	0	0	11	1.4
18-Oct	6.67	0	0	1	12	7	0	0	0	0	0	30	0	0	0	0	1	0	4	0	0	0	0	0	55	8.2
19-Oct	7.00	0	0	0	16	6	0	1	0	0	0	5	0	0	0	0	3	0	1	1	0	0	0	0	33	4.7
20-Oct	8.00	0	0	0	21	1	0	0	0	0	0	5	0	0	0	0	0	0	2	0	0	0	0	0	29	3.6
21-Oct	8.17	0	0	2	38	2	0	1	0	0	0	20	0	0	0	0	0	0	2	0	0	0	0	0	65	8.0
22-Oct	7.58	0	0	0	41	0	0	2	0	0	0	29	0	0	0	0	0	1	5	0	0	0	0	0	78	10.3
23-Oct	7.50	0	0	1	28	1	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	33	4.4
24-Oct	6.75	0	0	0	18	1	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	26	3.9
25-Oct	7.33	0	0	1	42	1	0	0	0	0	0	17	0	0	0	0	0	0	1	0	0	0	0	0	62	8.5
26-Oct	7.83	0	0	0	12	1	0	0	0	0	0	2	1	0	0	0	0	0	0	1	0	0	0	0	17	2.2
27-Oct	8.00	0	0	3	30	1	0	0	0	0	0	57	1	0	0	0	3	0	2	0	1	0	0	0	98	12.3
28-Oct	8.00	0	0	1	4	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	16	2.0
29-Oct	6.42	0	0	0	14	1	0	0	0	0	0	2	0	0	0	0	0	0	1	0	0	0	0	0	18	2.8
30-Oct	7.67	0	0	0	16	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	1	25	3.3
31-Oct	7.50	0	0	1	16	1	0	1	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	24	3.2
01-Nov	7.50	0	0	0	4	1	0	0	0	0	0	13	0	0	0	0	1	0	0	0	1	0	0	0	20	2.7
02-Nov	6.33	0	0	1	4	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	7	1.1
03-Nov	5.50	0	0	0	3	2	0	0	0	0	0	17	0	0	0	1	0	0	0	0	0	0	0	0	23	4.2
04-Nov	6.50	0	0	0	7	0	0	0	0	0	0	7	0	0	0	0	3	0	0	0	0	0	0	0	17	2.6
05-Nov	5.25	0	0	1	4	0	0	0	0	0	0	18	0	0	0	0	0	0	0	0	0	0	0	0	23	4.4
Total	543.20	76	28	56	1906	1204	1	109	0	14	32	985	11	1	13	2	17	1	918	14	6	8	2	16	5420	10.0

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

Appendix H. Summary information on observation effort and raptor count totals by year and species for Yaki Point: 1997–1999.

YEAR	1997	1998	1999	MEAN
Start date	27-Aug	28-Aug	27-Aug	26-Aug
End date	5-Nov	5-Nov	5-Nov	4-Nov
Days of observation	71	66	71	69
Hours of observation	504.97	455.41	543.20	501.19
Raptors / 100 hours	938.3	907.5	997.8	947.9
SPECIES		RAPTOR COUNTS		
Turkey Vulture	144	88	76	103
Osprey	50	43	28	40
Northern Harrier	50	44	56	50
Sharp-shinned Hawk	1474	1190	1906	1523
Cooper's Hawk	856	1109	1204	1056
Northern Goshawk	4	7	1	4
Unidentified accipiter	94	140	109	114
TOTAL ACCIPITERS	2428	2446	3220	2698
Red-shouldered Hawk	1	0	0	0
Broad-winged Hawk	9	19	14	14
Swainson's Hawk	15	25	32	24
Red-tailed Hawk	899	916	985	933
Ferruginous Hawk	8	7	11	9
Zone-tailed Hawk	0	0	1	0
Unidentified buteo	20	20	13	18
TOTAL BUTEOS	952	987	1056	998
Golden Eagle	24	7	2	11
Bald Eagle	23	18	17	19
Unidentified eagle	1	0	1	1
TOTAL EAGLES	48	25	20	31
American Kestrel	1016	423	918	786
Merlin	14	12	14	13
Prairie Falcon	9	4	6	6
Peregrine Falcon	7	19	8	11
Unidentified falcon	0	4	2	2
TOTAL FALCONS	1046	462	948	819
Unidentified raptor	20	38	16	25
GRAND TOTAL	4738	4133	5420	4764