FALL 1999 RAPTOR MIGRATION STUDY
IN THE BRIDGER MOUNTAINS, MONTANA

Prepared by

Mike C. Neal, Mark S. Vekasy & Jeff P. Smith

Counts conducted by

Mike C. Neal

Greg Levandoski

Prepared for

USDA Forest Service

Gallatin National Forest, Bozeman Ranger District

Bozeman, Montana

Submitted by

HawkWatch International, Inc.

1800 S. West Temple, Suite 226, Salt Lake City, Utah 84115

(801) 484-6808

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EXECUTIVE SUMMARY

The Bridger Mountains of Montana are a major migratory corridor for raptors, especially Golden Eagles. The fall flight of Golden Eagles in the Bridgers is the largest known migratory concentration of this species in the United States, with counts averaging about 1,600 migrants per season. Westerly winds meeting the north-south tending Bridger Range create strong updrafts, which facilitate soaring flight and allow migrants to conserve energy during their long journeys. Each fall since 1991, HawkWatch International (HWI) has conducted season-long migration counts from atop a helicopter pad above the Bridger Bowl Ski Area in the Gallatin National Forest near Bozeman, Montana. This report summarizes results of the 1999 season.

In 1999, two official observers tallied 3,123 migrant raptors of 18 species during 64 days and 358.24 hours of observation between 29 August and 31 October. The combined-species total is significantly higher than average, and exceeds the 1991–1998 mean by 17%. Except for a dip in 1994 and 1995, combined counts have been increasing, but this trend is confounded by consistent increases in yearly observation hours between 1991 and 1996. The 1999 passage rate of 872 raptors per 100 hours of observation is only 4% lower than average. The number of observation hours in 1999 was higher than in 1998, but lower than in 1996 and 1997, despite the highest number of observation days ever. Poor weather resulted in a number of partial observation days and the lower hourly total. In general, observation effort has stabilized since 1996, with adoption of a consistent late August to late October observation period.

As is typical for the site, the Golden Eagle was the most common species observed in 1999 (60% of the flight), followed by Sharp-shinned Hawk (14%), Cooper's Hawk (5%), Red-tailed Hawk (4%), American Kestrel (4%), and Bald Eagle (3%). Counts were significantly higher than average for 6 species, reaching record highs for Rough-legged Hawk, Prairie Falcon, and Peregrine Falcon. Counts were average for another 11 species. In comparison, passage rates were significantly higher than average for only 3 species (those with record counts), near average for 12 species, and significantly lower than average for 2 species. While the Golden Eagle count of 1,870 was significantly higher than average and only two short of a site record, the passage rate of 522 birds/100 hours was 5% lower than average. Opposite trends for Golden Eagle counts and passage rates is likely the result of annual increases in observation hours. Overall, the data collected thus far suggest that Golden Eagle populations migrating through the Bridgers are probably stable. Broad-winged Hawk, Rough-legged Hawk, Prairie Falcon, Peregrine Falcon, Golden Eagle, and Northern Goshawk all showed record or near record high counts in 1999. High counts can indicate high reproductive success; however, average to lower than average immature : adult ratios failed to substantiate this possibility for any species in 1999. Alternatively, we may be witnessing the first signs of an irruptive cycle for the 3 northern species (eagles, goshawks and rough-legs; e.g. Mueller et al. 1977). Fewer immature Golden Eagles than average, coupled with near record counts, also support the irruptive cycle theory. Peregrine Falcon counts have shown a significant increasing trend at this site and sites across the West, so near record highs are not surprising. Prairie Falcon counts have shown high annual variability that, without nesting survey data, we are unable to correlate with annual productivity. Osprey, Broad-winged Hawk, Red-tailed Hawk, and Merlin also are showing signs of long-term increasing trends in the Bridgers, which in most cases are consistent with evidence from other HWI migration sites and other sources.

The fall migration site along the Bridger Range is a popular destination for Bozeman locals, as well as for raptor enthusiasts from the surrounding area. Visitation to the count site during 1999 averaged 0.7 visitors per hour of observation. In addition, for the fourth consecutive year, the Bridger Raptor Festival was held during the fall count, in part at Bridger Bowl Ski Area's Deer Park Chalet. Jeff Smith, HawkWatch International's Science Director, gave the keynote address, a raptor identification seminar, and led a group of hardy individuals out to the count site for a day of field observations.

ACKNOWLEDGMENTS

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INTRODUCTION

The Bridger Mountain raptor migration study in southwestern Montana is an ongoing effort to monitor long-term trends in populations of raptors using this northern Rocky Mountain migratory flyway. 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. 1998, Smith et al. in review).

Fred Tilly discovered that the Bridger Range was an important fall flyway for raptors. He conducted limited migration counts in 1979, 1980, and 1982. HawkWatch International (HWI) then initiated annual, full-season counts in 1991. This flyway is noted for large concentrations of Golden Eagles (see Appendix A for scientific names of all raptor species encountered at the site). In this report, we summarize observations from fall 1999, the ninth consecutive season-long count at this site. We report on aspects of seasonal and daily timing, passage rates, and the species, age, sex, and color-morph composition of the flight. We also compare statistics from 1999 with means for the previous 7 years and discuss apparent trends in annual passage rates.

STUDY SITE

The Bridger Mountains are a relatively small range that runs primarily along a north–south axis (Fig. 1). From Sacajawea Peak (2,950 m [9,666 ft] elevation), the range extends southward for 40 km before meeting the Gallatin Valley 5 km northeast of Bozeman, Montana. Consistent westerly winds collide with the Bridger range and create the lift that attracts southbound migrating raptors each fall.

The primary observation site (OP1) is a helicopter landing platform atop the Bridger Bowl Ski Area at an elevation of 2,610 m (8,600 ft; 45° 49.022' N, 110° 55.778' W; Fig. 2). The site lies within the Gallatin National Forest on the east slope of the mountain range 25 km north of Bozeman and 3 km north of Saddle Peak. The helicopter pad is a 5 m x 5 m wooden platform located approximately 50 m north of an avalanche cache/ski patrol hut. The site is accessed by following a primitive dirt road for 2.5 km (780 m rise in elevation) to the top of the Bridger chair-lift, then continuing a short way along a footpath to the observation site at the top of the ridge. In the past, a secondary observation site (OP2) situated at the base of the western slope of the Bridger Mountains 8.3 km southwest of OP1 was occasionally used when low clouds obscured the ridgetop. OP2 was not used during the 1999 season.

Primary vegetation on top of the Bridger Mountains includes Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*). Limber pine (*Pinus flexilis*) and white-bark pine (*Pinus albicaulis*) also are present. The primary observation site is near tree line. Forested zones are interspersed among rocky bluffs and talus slopes.

METHODS

Two official observers, relieved or supplemented by other designated observers, conducted standardized daily counts of migrating raptors from a single, traditional observation site between 29 August and 31 October 1999. Counting occurred every day unless precluded by inclement weather. Observations typically began at 0900 hrs and ended at 1600 hrs Mountain Standard Time (MST). Stop times were extended when evening flight activity was heavy. Both official observers had at least one season of prior raptor migration counting experience, with lead observer Mike Neal having counted at this site in 1998 (see Appendix B for a complete history of observer participation). Visitors occasionally assisted with spotting migrants (see Smith and Hoffman [in review] for a discussion of visitor effects).

The observers routinely recorded the following data:

1. Species, age, sex, and color morph of each migrant raptor, whenever possible and applicable (Appendix A lists common and scientific names for all species, information about the applicability of age, sex, and color morph distinctions, and two-letter codes used to identify species in some tables and figures).
2. Hour of passage for each migrant; e.g., the 1000 hour, always using Mountain Standard Time.
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 any person that actively assisted with scanning and locating raptors for more than 10 minutes in a given hour) and visitors (all other guests) present during each hour.
6. Daily start and stop times for each observer.

The observers used high quality 7–10x binoculars to assist in spotting and identifying birds. A Kowa 80 mm spotting scope also was used to identify, age, or sex passing migrants, but not to spot them. 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. All weather variables were recorded on-site.

In this report, we compare results from the 1999 season to means for previous seasons and examine long-term trends in annual passage rates (raptors counted per 100 hours of observation) and age composition for selected species. We do not analyze the results statistically, except for providing estimates of 95% confidence intervals for long-term means. If a current point estimate falls outside the 95% confidence interval for the relevant long-term mean, then we conclude that it is significantly different from the mean at an α level of 0.05.

Passage rates are a useful statistic because they help adjust for moderate variation in observation effort during standardized observation periods (Bednarz and Kerlinger 1989). Such variation in effort can result from inclement weather, for example, and often introduces unacceptable biases in total counts. However, great differences in annual observation effort adversely affect the consistency of both counts and estimates of passage rates. Such cases warrant careful consideration of both total counts and passage rates when attempting to discern trends in annual statistics. Pronounced variation in observation effort during the first several years of migration monitoring projects is typical, because it takes a few years to identify the best observation periods for documenting the migration at a given site. This was the case with the Bridger project. Except for some inconsistency between 1993 and 1994, the annual hours of observation increased each year between 1991 and 1997 and then stabilized in 1998 and 1999 (see Appendix C for summaries of observation effort and counts by species for each year of the project). Markedly higher effort in 1996 and 1997 resulted primarily from expansion of the observation period to begin earlier in the season, whereas other differences resulted from variation in observation intensity during similar periods. Expansion of the observation period tends to increase counts for most species. In contrast, increasing the hours of observations typically results in lower annual passage rates, because the increased effort usually encompasses more hours of relatively low passage activity. The data can be adjusted to reduce some biases associated with pronounced variation in effort (e.g., truncating to common observation periods; Bednarz and Kerlinger 1989); however, we have not yet sought to adjust the data at this early stage in the Bridger project. Accordingly, although we present graphics and statistics comparing trends in unadjusted counts and passage rates for the 8-year Bridger study period, we caution that these are as yet preliminary comparisons. An additional 5–10 years of data and intensive analyses with adjusted data will be necessary to provide robust assessments of population trends for raptors using the Bridger flyway.

Migrant raptors tend to have a direct flight pattern. Therefore, the observers typically classified all birds observed perching, hunting, or performing territorial displays as residents and excluded them from the count. The observers kept a separate journal of all observations involving birds exhibiting "resident-like" behavior.

The observers recorded as northbound migrants all raptors seen heading north past the lookout that did not appear to stop or change direction while in view. We assume that northbound birds were dispersing juveniles or non-migratory adults searching for productive wintering grounds in the local region (i.e., within 100 km of their usual territory). The observers routinely included northbound migrants in the season's tally.

RESULTS

WEATHER SUMMARY

The 1999 fall season featured a high proportion of dry days and very mild temperatures for this site (see Appendix D for daily weather summaries). However, low clouds and excessive rain or snow suspended observations completely on 9 days, including the first two scheduled days of observation (27-28 August). Similar weather interrupted observations on 13 other days in September and October. The primary observation post (OP1) was used on all 64 days; OP2 was not used this season. Approximately six significant cold fronts moved through the Bridgers during the observation period. Each front generally stayed in the area for 1–3 days. Winds were predominantly from the west or southwest on 51 days (80%) and from varying directions on the remaining 13 days (20%). Moderate to strong winds (12–49 kph) predominated on 33 days (52%) and were most common in October. September was characterized by calm to light winds (0–11 kph) which made up the remaining 31 days (48%). Average temperatures ranged from a high of 22.4°C on 30 August to a low of –3.5°C on 29 October.

FLIGHT SUMMARY

The observers counted 3,123 migrant raptors of 18 species during 358.24 observation hours on 64 days between 29 August and 31 October (Table 1; see Appendix E for daily count records). This yields a combined-species annual passage rate of 872 raptors/100 hrs. While the 1999 count is significantly higher (17%) than the 1991–1998 average, the passage rate is 4% lower but not significantly different than average (Table 1, Fig. 3). As is typical for this site, eagles were the most frequently counted group during 1999, comprising 63% of the total flight. The next most abundant groups were accipiters (22%), buteos (7%), and falcons (5%; Fig. 4). The Golden Eagle was the most common species (60% of all migrants counted), followed by Sharp-shinned Hawk (14%), Cooper's Hawk (5%), Red-tailed Hawk (4%), American Kestrel (4%), and Rough-legged Hawk (2.5%). A Gyrfalcon was the only new species observed in 1999. The 1999 count included record numbers of Rough-legged Hawks (77), Prairie Falcons (20), and Peregrine Falcons (18; Appendix C). Counts exceeded 100 birds on 10 different days, including one day with 229 birds (13 October; Appendix E).

Eight of 9 species, excepting the Bald Eagle, with sufficient age-specific data showed lower than average immature : adult ratios in 1999 (Bald Eagle age ratio matched the long-term average); however, only Sharp-shinned Hawk and Golden Eagle showed significantly lower than average ratios. Both these species also had significantly fewer than average unknown-age birds, which may confound the age-ratio comparisons. Only 2 of 18 species, Northern Harrier and American Kestrel, can be accurately sexed in the field. Northern Harrier identification is complicated by the difficulty of distinguishing immatures of both sexes from adult females, and results for American Kestrels are suspect due to a high percentage of unidentified birds (77% on average, 75% for 1999). The 1999 female : male ratio for Northern Harriers of 1.17 is higher than average (44% higher), but the difference is not significant, whereas the female : male ratio for American Kestrels of 1.23 is significantly higher (50%) than average (Table 3).

The 1999 combined-species daily rhythm showed significantly more mid-day activity than the average pattern and significantly less activity for the first 4 hours of observation (Fig. 5). Peak activity occurred from 1200–1359 hrs, low activity from 0900–1059 hrs, and moderate activity from 1400–1559 hrs.

The 1999 combined-species bulk passage dates (dates between which the central 80% of the flight passed) were 14 September and 22 October (Table 4). The 1999 combined-species median passage date (date by which 50% of the flight passed) of 6 October is 1 day later than average, but the difference is not significant (Table 4). A plot of combined-species passage volume by five-day periods shows that more than 40% of the activity occurred during the first two weeks of October, preceded by uncharacteristically low activity from 21 to 30 September (Fig.6). Species-specific median passage dates were average for 8 species, significantly earlier than average for 4 species, and significantly later than average for 2 species (Table 4). Northern Harriers and Sharp-shinned Hawks showed significantly later than average median passage dates, whereas Red-tailed Hawks, Broad-winged Hawks, Rough-legged Hawks, and Peregrine Falcons were significantly earlier than average. Four of 7 species for which age-specific median passage dates could be calculated showed patterns for both adults and immatures that were consistent with species-level results (Table 5). However, Sharp-shinned Hawk adults were later than average, whereas immature birds were significantly earlier than average. Northern Goshawk immatures also were significantly earlier than average, but adults showed an average passage date. Bald Eagle adults also showed an average passage date, whereas immatures and subadults were significantly later than average. Analysis of harrier and kestrel passage dates by sex showed an atypical pattern, with males for both species uncharacteristically earlier than females (Table 6). This resulted from male kestrels being significantly earlier than average while females showed an average passage date, and female harriers being significantly later than average while males showed an average passage date.

Species Accounts

The observers counted 2 immature **Turkey Vultures** on 19 September. The average annual count for the site is 1 bird (Table 1, Fig. 7, Appendix E).

The observers counted 9 **Ospreys** on 7 days between 31 August and 8 September (Tables 1 and 4, Appendix E). The annual count and passage rate of 2.5 raptors/100 hrs are both higher than average (33% and 23%, respectively; Table 1), but neither difference is significant. Except for a major dip in 1995, the annual passage rate for Ospreys has increased steadily since 1991 (Fig. 7). The median passage date of 12 September is 4 days earlier but not significantly different from average (Table 4, Fig. 8).

The observers counted 52 **Northern Harriers** on 26 days between 30 August and 23 October (Tables 1 and 4, Appendix E). The count is substantially lower than last year's record total (230) and is 13% lower than average (not a significant difference); nevertheless, the 1999 count is the fourth highest for the project (Appendix C). The annual passage rate of 15 raptors/100 hrs is 23% lower but not significantly different from average (Table 1), and no distinct long-term trend is evident (Fig. 7). The 1999 flight consisted of 12% adult males, 13% adult females, 56% immatures, and 19% "brown" birds (indistinguishable immatures of both sexes and adult females). The immature : adult ratio of 2.23 is 65% lower than average, but the difference is not significant due to high annual variation (Fig. 9). The 1999 ratio is actually the fourth highest on record. The adult female : adult male ratio of 1.17 is 44% higher than average, but the difference is not significant (Table 3). The 1999 median passage date for the species of 4 October is significantly later (16 days) than average (Table 4), which is illustrated by higher than average activity during the first half of October (Fig. 8). Age-specific median passage dates show the same pattern, but among adults only females were significantly late (Tables 5 and 6).

The observers counted 442 **Sharp-shinned Hawks** on 50 days between 30 August and 31 October (Tables 1 and 4, Appendix E). This was the second most common species, comprising 14% of the total flight. The annual count and passage rate of 123 raptors/100 hrs are 26% and 8% higher than average, respectively, but neither difference is significant (Table 1). Annual passage rates have shown an increasing trend during the study (Fig. 10). The 1999 flight consisted of 53% adults, 19% immatures, and 28% birds of unknown age. The immature : adult ratio of 0.35 is significantly lower (44%) than average (Table 2), but this is due more to high abundance of adults rather than low abundance of immatures (Fig. 11). The 1999 median passage date for the species of 4 October is significantly later than average (Table 4), which is illustrated by depressed activity during late September and slightly higher than average activity during much of October (Fig. 12). However, age-specific median passage dates show that adults were significantly later (6 days) than average, whereas immatures were significantly earlier than average (10 days, Table 5).

The observers counted 149 **Cooper's Hawks** on 36 days between 1 September and 22 October (Tables 1 and 4, Appendix E). This was the third most common species, comprising 5% of the total flight. The annual count and passage rate of 42 raptors/100 hrs are 23% and 34% lower than average, respectively; but only the difference in passage rates is significant (Table 1). The 1999 flight consisted of 44% adults, 34% immatures, and 21% birds of unknown age. The immature : adult ratio of 0.77 is 30% lower than average, but the difference is not significant (Table 2, Fig. 11). The 1999 median passage date for the species of 20 September is only 2 days earlier than average (Table 4), and no consistent pattern of deviation from the normal activity pattern is evident (Fig. 12).

The observers counted 61 **Northern Goshawks** on 27 days between 5 September and 30 October (Tables 1 and 4, Appendix E). The annual count and passage rate of 17 raptors/100 hrs are 56% and 23% higher than average, but only the difference in counts is significant (Table 1). The 1999 count is the second highest on record, exceeded only by a very high count in 1992 when many otherwise non-migratory boreal adults moved south for the winter because of poor prey conditions (Fig. 10, Appendix C). The 1999 flight consisted of 39% adults, 46% immatures, and 15% birds of unknown age. The immature : adult ratio of 1.17 is 36% lower than average, but the difference is not significant (Table 2). Moreover, the number of immature birds counted in 1999 is the second highest on record for the site (Fig. 11). The 1999 median passage date for the species of 5 October is 3 days earlier than average, but the difference is not significant (Table 4). The seasonal activity pattern shows only one higher than average, early season peak in activity during 6–10 September (Fig. 12). Moreover, the median passage date for adults of 11 October is 3 days later than average, whereas the date for immatures of 20 September is significantly earlier (10 days) than average (Table 5).

The observers counted 13 **Broad-winged Hawks** on 7 days between 9 September and 23 September (Tables 1 and 4, Appendix E). The count is the second highest on record for the site (Appendix C). The annual count and passage rate of 3.6 raptors/100 hrs are both significantly higher than average (104% and 74%, respectively; Table 1). Passage rates show a possible increasing trend through the study (Fig.13). The flight consisted of 8 adults, 2 immatures, and 3 birds of unknown age. The immature : adult ratio of 0.25 is 76% lower than average, but the difference is not significant due to high annual variability (Table 2). The flight consisted of 9 light morphs (77%), 2 dark morphs (15%), and 1 bird of unknown color morph (8%; Table 7). This is the second season in a row that dark morph birds have been identified at the site, resulting in a low light : dark ratio (5.0, Table 7). The 1999 median passage date for the species of 14 September is significantly earlier (6 days) than average (Table 4); however, the only anomaly in the seasonal migration pattern is the high percentage of birds (69%) counted from 14–17 September (Fig. 14). The observers often spotted Broad-winged Hawks flying west to east from Ross Peak over the Bangtail Mountains, about 3–5 km from the observation post.

The observers counted 3 **Swainson's Hawks** on 3 days between 12 and 28 September (Tables 1 and 4; Appendix E). The annual count and passage rate of 0.8 raptors/100 hrs are 4% and 26% lower than average, respectively, but neither difference is significant (Table 1). No distinct trend in passage rates is evident (Fig. 13). Too few Swainson's Hawks were observed to calculate a meaningful median passage date, but passage of the 3 birds occurred later than for most previous birds (Table 4; Fig. 14). The birds included 2 light morphs and 1 dark morph (Table 7).

The observers counted 121 **Red-tailed Hawks** on 35 days between 9 August and 30 October (Tables 1 and 4, Appendix E). This was the fourth most common species, comprising 4% of the total flight. The annual count and passage rate of 34 raptors/100 hrs are 13% higher and 3% lower than average, respectively, but neither difference is significant (Table 1). Nevertheless, an increasing trend in passage rates is evident for the species (Fig. 15). The flight consisted of 54% adults, 31% immatures, and 15% birds of unknown age. The immature : adult ratio of 0.58 is 40% lower than average, but the difference is not significant (Table 2). Moreover, the low age ratio is due to a high number of adults (the highest adult count on record), rather than a low number of immatures (actually the third highest immature count on record; Fig. 16). The flight consisted of 89% light morphs, 7% dark morphs, and 3% birds of unknown color morph. The light : dark ratio of 12.0 is significantly higher (82%) than average (Table 7). The 1999 median passage date for the species of 14 September is significantly earlier (5 days) than average (Table 4); however, the only indication of this is higher than average activity during 6–10 September and lower than average activity during late September (Fig. 14). Nevertheless, the early pattern held true for both adults (8 days early) and immatures (9 days early; Table 5).

The observers counted 4 **Ferruginous Hawks** on 2 days between 8 September and 10 October (Tables 1 and 4, Appendix C). The annual count and passage rate of 1.1 raptors/100 hrs are 45% and 26% higher than average, respectively, but neither difference is significant (Table 1) and no distinct long-term trend in passage rates is evident (Fig. 13). All four birds were light color morph (Table 7). Too few Ferruginous Hawks were counted in 1999 or previous years to generate median passage dates for comparison (Table 4). The seasonal migration pattern is highly variable (Fig. 17).

The observers counted 77 **Rough-legged Hawks** on 19 days between 23 September and 30 October (Tables 1 and 4, Appendix E). The annual count and passage rate of 21.5 raptors/100 hrs are both significantly higher than average (141% and 97%, respectively; Table 1). The 1999 count is a record high for the site (Appendix C); however, no distinct long-term trend in passage rates is evident at this time (Fig. 15). The flight consisted of 74% light morphs, 14% dark morphs, and 12% birds of unknown color morph. Eleven dark-morph birds is a record high for the site, and although the light : dark ratio of 5.2 is 45% lower than average, it falls well within the 95% confidence interval for the mean (Table 7). In addition, the percentage of birds with unknown color-morph (12%) is significantly lower than the average, which may confound the comparison. The 1999 median passage date for the species of 18 October is significantly earlier (3 days) than average (Table 4), and a slight early shift is evident in the seasonal activity pattern (Fig. 17).

The observers counted 1,870 **Golden Eagles** on 54 days between 29 August and 31 October (Tables 1 and 4, Appendix E). This was the most common species, comprising 60% of the total flight. The annual count is just two birds short of a site record (Appendix C) and is significantly higher (19%) than average; however, the passage rate of 522 raptors/100 hrs is 5% lower than average, although the difference is not significant (Table 1). At this site, interpretation of trends in Golden Eagle counts and passage rates is confounded by an increasing trend in the annual hours of observation between 1991 and 1996. Annual counts show an increasing trend, but annual passage rates show a decreasing trend. This is because observation hours have increased and counts are positively correlated with observation hours, whereas passage rates are negatively correlated with observation hours (Fig. 18). Data since 1996, when observation hours began to be standardized, suggest that the migratory population of Golden Eagles using the Bridger flyway is probably stable. The 1999 flight consisted of 32% birds of plumage class 1, 4% birds of plumage class 2, 4% subadults that could not be classified into a specific plumage class, 45% adults, and 15% birds of unknown age (Table 8). The immature/subadult : adult ratio of 0.88 is significantly lower (25%) than average (Table 2), but this reflects the highest ever count of adults rather than a low number of immatures/subadults (Fig. 19). The 1999 median passage date for the species of 11 October matches the long-term average (Table 4; Fig. 20). Age-specific median passage dates followed nearly the same pattern; the 1999 date for adults matched the long-term average and immatures/subadults were 4 days earlier but not significantly different from average (Table 5).

The observers counted 92 **Bald Eagles** on 32 days between 1 September and 30 October (Tables 1 and 4, Appendix E). The annual count and passage rate of 25 raptors/100 hrs are 16% higher and 4% lower than average, respectively, but neither difference is significant (Table 1). Moreover, no distinct long-term trend in passage rates is evident at this time (Fig. 21). The 1999 flight consisted of 5% birds of plumage class 1, 21% birds of plumage class 2, 7% subadults that could not be classified into a specific plumage class, 56% adults, and 11% birds of unknown age (Table 8). The immature/subadult : adult ratio of 0.59 matches the long-term average (Table 2, Fig. 19). The 1999 median passage date for the species of 15 October is 3 days later than average (Table 4). This difference is not significant; however, the seasonal activity pattern does show higher than average activity in late October (Fig. 20). Age-specific median dates show that both adults and immatures/subadults were later than average, but the difference is significant only for immatures/subadults (Table 5).

The observers counted 113 **American Kestrels** on 35 days between 30 August and 20 October (Tables 1 and 4, Appendix E). The annual count and passage rate of 32 raptors/100 hrs are 33% and 15% higher than average, respectively, but neither difference is significant (Table 1). The annual passage rate for kestrels dropped substantially in 1996; otherwise, a possible increasing trend is apparent for the species (Fig. 22). However, because kestrels are an early season migrant, starting the monitoring season 10 days earlier beginning in 1996 has contributed significantly to the rise in counts and passage rates. Thus, at this time it is unwise to attach significance to the apparent increasing trend. The 1999 flight consisted of 27% males, 33% females, and 41% birds of unknown sex. The female : male ratio of 1.23 is significantly higher (50%) than average (Table 3). The 1999 median passage date for the species of 17 September is significantly earlier (4 days) than average (Table 4); however, it is difficult to discern any consistent pattern of deviation in comparing the seasonal activity patterns (Fig. 23). Males were significantly earlier than average, whereas females showed an average passage date (Table 6).

The observers counted 8 **Merlins** on 7 days between 6 September and 10 October (Tables 1 and 4, Appendix E). The annual count and passage rate of 2.2 raptors/100 hrs are 29% and 37% lower than average, respectively, but only the difference in passage rates is significant (Table 1). The observers recorded both taiga (*F. c. columbarius*) and prairie (*F. c. richardsoni*) subspecies in 1999. The 1999 median passage date for the species of 28 September is 3 days earlier than average, but the difference is not significant (Table 4). The extent of seasonal activity is more restricted than in previous years, and does show one higher than average activity peak during 6–10 September (Fig. 23).

The observers counted 20 **Prairie Falcons** on 14 days between 30 August and 30 October (Tables 1 and 4, Appendix E). The annual count and passage rate of 5.6 raptors/100 hrs are both significantly higher than average (68% and 34%, respectively; Table 1), and the 1999 count is a record high for the site (Appendix C). Annual variability in passage rates has been high and no distinct long-term trend is evident at this time (Fig. 22). The median passage date for the species of 16 September is 6 days earlier than average, but the difference is not significant (Table 4). Nevertheless, the seasonal activity pattern shows an unusual early season peak, no birds during the typical mid-season peak, and scattered activity for the remainder of the season (Fig. 24).

The observers counted 18 **Peregrine Falcons** on 11 days between 15 September and 30 October (Tables 1 and 4, Appendix E). The annual count and passage rate of 5.0 raptors/100 hrs are both significantly higher than average (129% and 101%, respectively; Table 1). The count equals the previous record for the site (Appendix C), extending a strong increasing trend in annual passage rates for the species (Fig. 22). The 1999 median passage date for the species of 18 September is significantly earlier (6 days) than average (Table 4), which the seasonal activity pattern clearly illustrates (Fig. 24).

The observers spotted 1 gray-phase **Gyrfalcon** on 3 October (Tables 1 and 4). While this is the first recorded sighting in the Bridgers, Gyrfalcons are occasionally spotted in the area during the winter months. The observers believed that this was probably an immature bird.

In addition to identified migrants, the observers recorded 69 migrants that could not be identified to species, which accounted for 2% of the total count. This total is lower than average largely due to the use of an 80mm spotting scope to further identify distant birds. This group included 39 unidentified accipiters, 3 unidentified buteos, 6 unidentified falcons, 5 unidentified eagles, and 16 unidentified raptors (Table 1). Only unidentified buteo and raptor totals were significantly lower than average.

RESIDENT AND NORTHBOUND RAPTORS

This season, residents included Golden Eagles (more than 100 individual sightings: >70 adults, 10 plumage class 1, 1 plumage class 2, and 15 unknown-age), American Kestrels (38 total: 10 male, 9 female, and 9 unknown sex), Red-tailed Hawks (20 total: 9 adult light-morph, 8 immature light-morph, and 3 unknown-age light-morphs), Prairie Falcons (6 total: 3 adult and 3 unknown-age), Sharp-shinned Hawks (*5* adults), Cooper's Hawks (5 total: 2 adults, 2 immatures, and 1 unknown-age), and Northern Goshawks (3 total: 1 immature and 2 unknown-age).

In 1999, the observers classified 18 raptors as northbound migrants: 1 plumage class 2 and 1 unknown age Bald Eagle; 3 immature/subadult, 3 adult, and 2 unknown-age Golden Eagles; 1 unknown eagle; 1 adult, 2 immature, and 1 unknown-age Northern Goshawks; 1 Rough-legged Hawk; 1 adult Red-tailed Hawk; and 1 unknown buteo.

VISITOR ATTENDANCE

The fall migration site along the Bridger Range is a popular destination for Bozeman locals, as well as for raptor enthusiasts from the surrounding area. Visitation to the count site during 1999 averaged 0.7 visitors per hour of observation, which is 7% higher than the 1993–1998 average (see Appendix D for 1999 daily averages). In addition, for the fourth consecutive year, the Bridger Raptor Festival was held at the Bridger Bowl Ski Area's Deer Park Chalet during the fall count. The event was publicized through public-service radio announcements, posters in local establishments, and television interviews. The three-day event was held from 10–12 September and was organized by representatives of Big Sky Wildcare (Julie Chantler), Gallatin National Forest (Bev Dixon), Bridger Bowl (Doug Wales), Museum of the Rockies, HawkWatch International (Mike Neal), Wild Birds Unlimited (David Mann), and the Bridger Outdoor Science School (Bobbie Geisse). HWI Science Director, Dr. Jeff Smith, gave the keynote address to open the festivities on 11 September, presenting an overview of HWI and the Bridger Raptor Migration Project. The following day, Dr. Smith reviewed raptor identification techniques at the Deer Park Chalet and then led a hearty group of about 40 visitors to the count site for a cold but productive day of hawkwatching. The third and final day of the festival included additional presentations on diverse aspects of raptor ecology and free access for all to the "Hunters of the Sky" exhibit at Bozeman's Museum of the Rockies.

DISCUSSION

WEATHER

Cold fronts had a discernible effect on observations at the beginning of the season, delaying the start for 2 days, and also resulting in lower than average total counts for late August and early September. This early season period was cooler than average, but the bulk of the season proved to be warmer and dryer than average. Rain and snow days in October were followed by large flights, mainly composed of Golden Eagles. Peak flights generally occurred during the first two weeks of October on days with milder temperatures and light to moderate winds. While a few birds were observed to the distant east (over Battle Ridge and the Bangtail Mountains) on east wind days, activity in this area was more or less normal compared to previous years.

The 1999 fall season was relatively dry, but several fronts bearing massive clouds did descend upon the Bridgers. These very low clouds created low to zero visibility for hours or days at a time, requiring observations to be suspended for 9 full days and 13 partial days. This weather led to lower fewer total observation hours in 1999 compared to 1997 and 1998.

Regional weather patterns were variable, but tended to be average throughout much of the Northwest (National Climatic Data Center, NOAA web-site, and Environment Canada web-site). Long-term precipitation patterns were normal to above normal during most of the breeding season. However, soil moisture indices dropped to below normal by June for most of the northwestern U.S. and northern Rocky Mountain regions, and continued to decline through summer and into the fall migration period. Low soil moisture is associated with poor vegetative growth, and may have negatively affected rodent and avian populations by impacting food resources. Low prey availability through summer and early fall, either from low rodent survival or early passerine migration, could alter the magnitude and timing of fall raptor migration.

DAILY FLIGHT RHYTHM

The overall shape of the 1999 daily flight rhythm was similar to the average pattern, but mid-day (1200–1359 hrs) activity was significantly higher than average and early (0900–1159 hrs) activity was significantly lower than average. While fall temperatures were milder on average, mornings could still be quite cool. The observers believed that substantial thermal updrafts did not develop until mid-day. Because many raptor species, especially large soaring raptors like Golden Eagles, routinely rely on lift-generating thermals during migration to conserve energy, a delay in daily thermal activity would be expected to shift flight activity toward afternoon hours.

SEASONAL TIMING

While the seasonal timing of flight activity was normal throughout most of 1999, flight activity was significantly lower than average during two 10-day periods (8/27–9/05 and 9/21–9/30). Inclement weather and decreased observation effort affected the first 10-day period, whereas unusually mild weather may have depressed activity during the second period. Mild weather can delay migration or hibernation of prey species, places lower demands on raptor energy reserves, and offers continued access to prey populations in the absence of snow cover. These factors allow many species to delay or even "short-stop" their normal migration when weather conditions and prey availability are favorable. Clear, warm weather during this period also may have stimulated widespread thermal development, which tends to disperse the migration as migrants rely less on ridge updrafts.

Seasonal timing for individual species showed mostly minor deviations from average patterns. Northern Harrier and Sharp-shinned Hawk showed later than average profiles, whereas Broad-winged, Red-tailed and Rough-legged Hawks, and Peregrine Falcon were all earlier than average. Late passage of adult Sharp-shinned Hawks and early passage of immature sharp-shins suggests the effects of mild fall weather and possibly high prey availability near breeding areas. Under such conditions, adults may be reluctant to abandon productive breeding territories, whereas high prey densities may allow fledglings to reach physiological readiness for migration earlier than during seasons with average or low prey densities. Unusually site-tenacious and competitively superior adults also may force immatures to leave natal territories and surrounding foraging areas sooner than usual. A lower than average immature : adult ratio suggests that juvenile recruitment may not have been particularly high; however, the low age ratio was due mostly to an increase in adults, not a decline in immatures. The latter likely reflects the carryover effects of 1998 having been a highly productive year, producing high adult recruitment the following year. Thus, instead of good prey conditions allowing immatures to leave early, it is possible that a high abundance of non-breeding adults forced the first-year birds to disperse early to avoid excessive competition for prey resources.

Differential timing of passage dates between widely separated migration count sites along the same flyway can also help us to understand migration patterns. Sharp-shinned Hawk passage dates were near normal at other HWI sites, particularly in the Manzano Mountains of New Mexico (Vekasy and Smith 2000a). However, the average median passage date for the Bridger site compared to more southerly sites in Nevada (Vekasy and Smith 2000b), Utah (Vekasy and Smith 2000c), and New Mexico is surprisingly earlier. This is unexpected if the sites lie along the same basic flyways and the species typically travels the full pathway between the sites, and is true for only 2 other species, the Northern Goshawk and Peregrine Falcon. Unlike the Sharp-shinned Hawk, the goshawk is generally a short-distance migrant and therefore median passage dates are not expected to be relational between widely separated sites. Peregrines travel distances as great or greater than sharp-shins, but they wander widely and often do not follow traditional flyways (Fuller et al. 1998). It is possible that late-season Sharp-shinned Hawk flights in the Manzanos are primarily composed of Bridger migrants. Bridger Sharp-shinned Hawk counts average about 25% of Manzano counts, and it is possible that more southerly sharp-shins, with expected earlier passage dates, compose a large fraction of the early and mid-season Manzano flight. HWI has accumulated 5 banding recoveries of Sharp-shinned Hawks banded in the Manzanos and recovered north of the Bridger site. Two of these recoveries involved adults with original banding dates after 1 October, a minimum of 2 days later than the median passage date in the Manzanos. This lends some support to the theory that late-season Manzano migrants are northern U.S. or Canadian birds. It is also possible that most Bridger migrants winter north of HWI's more southerly migration count sites. Continued banding projects, more recoveries, and new telemetry studies will help us to better understand flyway dynamics and inter-site relationships.

Northern Harriers were also late migrants in 1999, but unlike for Sharp-shinned Hawks, this pattern applied to immatures as well as adults. The Northern Harrier age ratio also was moderately high, indicating that productivity was probably at least average. Late passage of adult harriers may again reflect the effects of mild fall weather delaying their departure, whereas late passage of immature harriers may reflect poor summer/fall prey conditions. Dry conditions over much of the interior Northwest after the breeding season may have negatively impacted rodent populations, resulting in poor immature harrier hunting success, delayed physiological readiness, and therefore late migration dates. Adults, which are better hunters capable of taking small birds as well as rodents, may have been less affected by low rodent availability (Palmer 1988).

Early passage of buteos also may reflect the effects of low rodent availability. While there is certainly much overlap, Sharp-shinned Hawks and at least adult Northern Harriers are more efficient predators of small birds than any of the buteos (Palmer 1988). Most of the buteo species all rely heavily on small rodents. While Red-tailed Hawk and Broad-winged Hawk age-ratios do not indicate any severe affect of low prey densities on productivity, declining rodent densities in response to dry conditions following the breeding season may have caused most buteos, regardless of age, to migrate early.

The Peregrine Falcon also exhibited an earlier than usual passage date. Dry conditions might be expected to impact peregrines, as they tend to nest near water and take associated species of waterfowl and shorebirds. However, they also prey on many species of open country passerines, which are less affected by dry conditions. Early passage dates for peregrines were not evident at most other HWI sites in the West; thus, reasons for the unusual Bridger results are unclear.

FLIGHT COMPOSITION, PASSAGE RATES AND LONG-TERM TRENDS

Flight composition was nearly identical to the usual pattern, with only slight increases in the proportions of falcons and buteos. High falcon representation reflects record numbers of Peregrine and Prairie Falcons, and above average counts of American Kestrels. High buteo counts reflect record high numbers of Rough-legged Hawks and above average counts of Broad-winged and Ferruginous Hawks.

High counts are suspect due to recent increases in observation effort. An increase in observation hours tends to raise counts but lower passage rates. This seemed to be the case for 1999, as observation hours were 17% higher than average, 6 species had significantly higher counts, but only 3 of these also had higher passage rates. Another 2 species had nearly average counts but significantly lower passage rates. Continued use of standardized count periods will help improve data collection at this site.

The observers recorded 2 immature Turkey Vultures migrating past the site. This is only the fourth season out of 9 that vultures have been noted, but it is the third time in the last 4 seasons. Turkey vultures have shown increasing trends at other sites throughout the West (Smith et al. in review), and the recent increase in frequency of sightings at the Bridger site may mirror those findings.

There continues to be a significant increasing trend in Osprey passage rates. This is consistent with evidence of increasing populations throughout much of this species range, resulting from post-DDT recovery and increased habitat availability from artificial reservoirs and nest platforms (Houghton and Rymon 1997, Smith et al. in review). However, passage rates were average this season in the Bridgers and below average at other sites in the West (e.g., Vekasy and Smith 2000a), which may be an indication that western populations are beginning to stabilize. Mild weather may also be responsible for lower counts, keeping water ice-free and potentially delaying migration. Ospreys are generally early to mid-season migrants through the Bridgers, and that pattern held true for 1999, giving no indication of delayed migration.

The Northern Harrier has shown consistent passage rates, with the exception of last year, when rates were more than 3 times the average. This was partly the result of high productivity, as evidenced by very large numbers of immature birds and a high immature : adult ratio, but there was also an unusually high number of adults. This suggests some other factor influenced harrier numbers in 1998, such as weather influences on selection of migration routes, or low prey densities causing irruptive migrations, leading to record flights. Whatever the cause, it was not apparent in 1999, as values returned to near normal levels. Over-winter mortality of inexperienced immatures is often cited as a reason for low migration counts following boom years, when one would expect at least a small increase above average values. However, we must consider alternative explanations, such as shifts in migration pathways, when values are unexpectedly low.

Record high counts for Rough-legged Hawk, Peregrine Falcon, and Prairie Falcon translated into significantly higher passage rates. The Rough-legged Hawk can undergo irruptive migrations similar to other northern dwelling raptors such as Northern Goshawks and Snowy Owls (*Nyctea scandiaca*), usually in response to cyclical prey populations or severe weather (Palmer 1988). There was little indication of a goshawk irruption in the West, with numbers at most sites average to below average, but goshawks are able to exploit a wide variety of prey and may not be affected by changes in small mammal populations alone. Dry conditions may have negatively influenced rodent densities and forced greater numbers of Rough-legged Hawks south than usual. The early migration of Red-tailed and Broad-winged Hawks also lends support to the possibility that poor prey resources influenced rough-leg numbers. HWI's Goshute Mountains site in northeastern Nevada and Bonney Butte site in the Oregon Cascade Mountains also showed a record high counts of Rough-legged Hawks (Vekasy and Smith 2000b, d). Without age-specific data for the Rough-legged Hawk, we cannot speculate about whether or not high productivity contributed to the high counts. However, age ratios for Red-tailed hawks and Northern Harriers, which occupy similar open habitats and rely at least in part on similar prey, were near average, not high. However, Rough-legged Hawk counts also reached record highs in 1998, at which time similarly high counts for red-tails and harriers did reflect high productivity. Thus, high counts in 1999 may reflect carryover from high productivity in 1998.

Data from several long-term migration sites and other sources consistently indicate strong increasing trends for both the Merlin and Peregrine Falcon (Smith et al. in review). A record high count for the Peregrine Falcon is not surprising, as the Bridger site has also shown an increasing trend. Banning DDT has been a key to Peregrine Falcon recovery and removal from the Endangered Species list, but captive propagation and conservation efforts have played a significant role (Cade et al. 1988). The same factors have likely benefited the Merlin as well (Platt and Enderson 1989). In addition, Merlins have probably benefited from increasing populations of small flocking birds around urban and rural areas (e.g., waxwings, *Bombycilla* spp., House Finches, *Carpodacus mexicanus*, and several exotic species such as European Starlings, *Sturnus vulgaris*, and House Sparrows, *Passer domesticus*). Merlins have shown strong increasing trends in the Bridgers; however, passage rates in 1999 were significantly lower than average. Merlin passage rates at the Manzano site also were significantly lower than average in 1999, but this did not change the significance of an increasing trend for that site. The drop in 1999 may be an indication that Merlin populations are beginning to stabilize, but mild weather may also have allowed significant numbers of Merlins to winter further north than usual. Passage volume profiles give no indication of delayed migration.

Prairie Falcons have shown increasing trends in the Manzanos and Goshutes (Vekasy and Smith 2000a, b), but this has not been the case at the Bridger site. Record high counts this season stabilize what was previously a decreasing trend in the Bridgers. DDT and its metabolites are believed to have affected Prairie Falcon populations, including Canadian populations that are likely to migrate through the Bridgers (Fyfe et al. 1969, Steenhof 1998). Whether or not Canadian and U.S. populations were affected to the same degree is unknown. Differences in agriculture use, development, and past pesticide use in Canada and the U.S. could yield information supporting lower impacts on Canadian Prairie Falcon populations, which could be one reason why Bridger counts have not shown an increasing trend. There is some evidence that Canadian populations were recovering while some U.S. populations were still in decline (Steenhof 1998).

Other than the Merlin, the Cooper's Hawk was the only species to show a decline in passage rates in 1999. The Cooper's Hawk age-ratio was near average, giving no obvious indication of low productivity to account for reduced passage rates. Median passage dates for both adult and immature birds were near average, suggesting normal migration times. The 1999 Cooper's Hawk passage rates in the Wellsville Mountains, Utah and at Bonney Butte, Oregon also were lower than average (11% and 26%, respectively; Vekasy and Smith 2000c, d), but rates in Nevada and New Mexico were above average (Vekasy and Smith 2000a, b). Thus, either there was considerable regional variation in productivity for this species in 1999, or there was considerable, atypical variation in the flight paths followed through different areas.

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Table 1. Annual counts and passage rates by species: 1999 versus 1991–1998.

	Count			Raptors / 100 hours		
Species	1991–1998[1]	1999	% Change	1991–1998[1]	1999	% Change
Turkey Vulture	1 ± 1.5	2	+60	0.4 ± 0.47	0.6	+37
Osprey	7 ± 3.7	9	+33	2.0 ± 0.91	2.5	+23
Northern Harrier	60 ± 49.8	52	-13	19 ± 14.4	15	-23
Sharp-shinned Hawk	351 ± 110.9	442	+26	114 ± 27.5	123	+8
Cooper's Hawk	193 ± 69.3	149	-23	63 ± 14.3	42	-34
Northern Goshawk	39 ± 18.2	61	+56	14 ± 7.7	17	+23
Unidentified accipiter	42 ± 11.3	39	-8	15 ± 6.2	11	-28
Total accipiters	626 ± 178.3	691	+10	206 ± 36.4	193	-6
Broad-winged Hawk	6 ± 4.4	13	+104	2.1 ± 1.42	3.6	+74
Swainson's Hawk	3 ± 2.6	3	-4	1.1 ± 1.02	0.8	-26
Red-tailed Hawk	108 ± 52.5	121	+13	35 ± 14.5	34	-3
Ferruginous Hawk	3 ± 1.7	4	+45	0.9 ± 0.50	1.1	+26
Rough-legged Hawk	32 ± 14.9	77	+141	11 ± 5.0	21.5	+97
Unidentified buteo	15 ± 2.7	3	-80	5.2 ± 1.11	0.8	-84
Total buteos	167 ± 68.4	221	+33	55.3 ± 19.40	61.7	+11
Golden Eagle	1576 ± 151.7	1870	+19	548 ± 64.7	522	-5
Bald Eagle	78 ± 20.2	91	+16	27 ± 6.3	25	-4
Unidentified eagle	10 ± 6.4	5	-49	3.3 ± 2.21	1.4	-58
Total eagles	1665 ± 164.1	1966	+18	578 ± 65.8	549	-5
American Kestrel	85 ± 31.1	113	+33	28 ± 7.7	32	+15
Merlin	11 ± 5.1	8	-29	3.6 ± 1.16	2.2	-37
Prairie Falcon	12 ± 1.8	20	+68	4.2 ± 0.75	5.6	+34
Peregrine Falcon	8 ± 3.5	18	+129	2.5 ± 0.94	5.0	+101
Gyrfalcon	0 ± 0.0	1	–	0.0 0.00	0.3	–
Unidentified falcon	6 ± 3.4	6	+4	1.8 ± 0.78	1.7	-8
Total falcons	122 ± 40.9	166	+37	40 ± 9.1	46	+17
Unidentified Raptor	32 ± 7.7	16	-50	12 ± 4.0	4	-61
All Species	2679 ± 414.3	3123	+17	912 ± 70.0	872	-4

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

Table 2. Counts by age class and immature : adult ratios for selected species: 1992–1998 versus 1999.

	TOTAL AND AGE-CLASSIFIED COUNTS						% UNKNOWN AGE		IMMATURE : ADULT RATIO	
	1992–1998 AVERAGE			1999						
	TOTAL	IMM.	ADULT	TOTAL	IMM.	ADULT	1992–1998[1]	1999	1992–1998[1]	1999
Northern Harrier	65	35	12	52	29	13	30 ± 7.8	19	6.44 ± 8.112	2.23
Sharp-shinned Hawk	389	84	145	442	83	234	39 ± 10.4	28	0.62 ± 0.151	0.35
Cooper's Hawk	209	66	59	149	51	66	39 ± 7.0	21	1.10 ± 0.436	0.77
Northern Goshawk	41	15	20	61	28	24	15 ± 7.1	15	1.83 ± 1.059	1.17
Broad-winged Hawk	7	2	3	13	2	8	20 ± 22.0	23	1.04 ± 0.806	0.25
Red-tailed Hawk	119	46	46	121	38	65	24 ± 7.2	15	0.97 ± 0.767	0.58
Golden Eagle	1619	664	572	1870	744	849	24 ± 4.5	15	1.18 ± 0.255	0.88
Bald Eagle	83	28	51	91	30	51	2 ± 2.2	11	0.59 ± 0.194	0.59

[1] Mean ± 95% confidence interval. For age ratios, note that the long-term mean immature : adult ratio is an average of annual ratios and may differ from the value obtained by dividing long-term average numbers of immatures and adults. Discrepancies in the two values reflect high annual variability in the observed age ratio.

Table 3. Counts by sex and female : male ratios for selected species: 1992–1998 versus 1999.

	TOTAL AND SEX-CLASSIFIED COUNTS						% UNKNOWN SEX		FEMALE : MALE RATIO	
	1992–1998 AVERAGE			1999						
	TOTAL	FEMALE	MALE	TOTAL	FEMALE	MALE	1992–1998[1]	1999	1992–1998[1]	1999
Adult										
Northern Harrier	65	6	6	52	7	6	77 ± 12.8	75	0.81 ± 0.518	1.17
American Kestrel	92	24	31	113	37	30	37 ± 8.1	41	0.82 ± 0.199	1.23

[1] Mean ± 95% confidence interval. For sex ratios, note that the long-term mean female : male ratio is an average of annual ratios and may differ from the value obtained by dividing long-term average numbers of females and males. Discrepancies in the two values reflect high annual variability in the observed sex ratio.

Table 4. First and last observation, bulk passage, and median passage dates by species for 1999, with a comparison of median passage dates for 1999 versus 1992–1998 means.

	1999				1992–1998
Species	First Observed	Last Observed	Bulk Passage Dates[1]	Median Passage Date[2]	Median Passage Date[3]
Turkey Vulture	19-Sep	19-Sep	–	–	–
Osprey	31-Aug	28-Sep	31-Aug – 28-Sep	12-Sep	16-Sep ± 4.5
Northern Harrier	30-Aug	23-Oct	6-Sep – 14-Oct	4-Oct	18-Sep ± 4.6
Sharp-shinned Hawk	30-Aug	31-Oct	9-Sep – 21-Oct	4-Oct	30-Sep ± 1.9
Cooper's Hawk	1-Sep	22-Oct	9-Sep – 11-Oct	20-Sep	22-Sep ± 3.5
Northern Goshawk	5-Sep	30-Oct	10-Sep – 26-Oct	5-Oct	8-Oct ± 9.7
Broad-winged Hawk	9-Sep	23-Sep	14-Sep – 21-Sep	14-Sep	20-Sep ± 2.6
Swainson's Hawk	12-Sep	28-Sep	–	–	–
Red-tailed Hawk	29-Aug	30-Oct	1-Sep – 7-Oct	14-Sep	19-Sep ± 3.3
Ferruginous Hawk	8-Sep	10-Oct	–	–	–
Rough-legged Hawk	23-Sep	30-Oct	7-Oct – 26-Oct	18-Oct	21-Oct ± 2.3
Golden Eagle	29-Aug	31-Oct	29-Sep – 22-Oct	11-Oct	11-Oct ± 4.1
Bald Eagle	1-Sep	30-Oct	23-Sep – 30-Oct	18-Oct	15-Oct ± 4.0
American Kestrel	30-Aug	20-Oct	6-Sep – 10-Oct	17-Sep	21-Sep ± 4.0
Merlin	6-Sep	10-Oct	6-Sep – 10-Oct	28-Sep	1-Oct ± 3.0
Prairie Falcon	30-Aug	30-Oct	9-Sep – 24-Oct	16-Sep	22-Sep ± 8.0
Peregrine Falcon	15-Sep	13-Oct	15-Sep – 6-Oct	18-Sep	24-Sep ± 3.9
Gyrfalcon	3-Oct	3-Oct	–	–	–
All species	29-Aug	31-Oct	14-Sep – 22-Oct	6-Oct	7-Oct ± 2.2

[1] Dates between which the central 80% of the flight passed; values are given only for species with annual counts of at least 5 birds.

[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 5. Median passage dates by age for selected species: 1992–1998 versus 1999.

	Adult		Immature	
Species	1992–1998[1]	1999	1992–1998[1]	1999
Northern Harrier	26-Sep ± 5.7	5-Oct	16-Sep ± 6.1	4-Oct
Sharp-shinned Hawk	3-Oct ± 2.3	9-Oct	23-Sep ± 3.9	13-Sep
Cooper's Hawk	28-Sep ± 4.5	2-Oct	17-Sep ± 5.3	16-Sep
Northern Goshawk	8-Oct ± 14.1	11-Oct	30-Sep ± 5.9	20-Sep
Red-tailed Hawk	24-Sep ± 4.1	16-Sep	17-Sep ± 5.5	8-Sep
Golden Eagle	12-Oct ± 3.3	12-Oct	9-Oct ± 4.4	5-Oct
Bald Eagle	15-Oct ± 4.2	18-Oct	14-Oct ± 3.8	20-Oct

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

Table 6. Median passage dates by sex for selected species: 1992–1998 versus 1999.

	Female		Male	
Species	1992–1998[1]	1999	1992–1998[1]	1999
Adult Northern Harrier	15-Sep ± 11.8	9-Oct	3-Oct 9.0	4-Oct
American Kestrel	20-Sep ± 5.4	16-Sep	19-Sep 2.9	10-Sep

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

Table 7. Counts by color morph and light : dark ratios for buteos: 1992–1998 versus 1999.

	Total and Morph-classified Counts						% Unknown Morph		Light : Dark Ratio	
	1992–1998[1]			1999						
	Total	Light	Dark	Total	Light	Dark	1992–1998[2]	1999	1992–1998[2]	1999
Broad-winged Hawk	51	25	3	13	10	2	45	8	8.3	5.0
Swainson's Hawk	24	8	1	3	2	1	63	0	8.0	2.0
Red-tailed Hawk	119	88	13	121	108	9	20 ± 8.5	3	6.6 ± 2.58	12.0
Ferruginous Hawk	19	12	1	4	4	0	32	0	12.0	4.0
Rough-legged Hawk	35	18	2	77	57	11	56 ± 34.4	12	9.4 ± 7.00	5.2

[1] For Red-tailed and Rough-legged Hawks the values given are averages of annual totals; for all other species the values given are grand totals for the 7-year period.

[2] For Red-tailed and Rough-legged Hawks, the values given are means of annual values ± 95% confidence intervals. For morph ratios, note that the long-term mean light : dark ratio is an average of annual ratios and may differ from the value obtained by dividing long-term average numbers of light and dark morph birds. Discrepancies in the two values reflect high annual variability in the observed morph ratio. For other species, the values given are derived from cumulative totals for the 7-year period.

Table 8. Age composition by plumage class for Golden and Bald Eagles: 1992–1998 versus 1999.

			Plumage class[1]			Unknown		Unknown	
			1	2	3	Subadult[1]	Adult[1]	Age	Total
Golden	1992–98[2]	#	383 ± 67.5	226 ± 86.3	–	55 ± 30.6	572 ± 49.5	383 ± 73.4	1619 ± 146.6
Eagle	1999		593	72	–	79	849	277	1870
	1992–98[2]	%	23 ± 2.9	13 ± 4.5	–	3 ± 1.9	36 ± 5.3	24 ± 4.5	–
	1999		32	4	–	4	45	15	–
Bald	1992–98[2]	#	9 ± 4.8	10 ± 2.4	3 ± 0.8	7 ± 4.0	53 ± 14.2	2 ± 2.4	83 ± 20.3
Eagle	1999		5	19	0	6	51	10	91
	1992–98[2]	%	10 ± 4.0	12 ± 3.9	3 ± 1.0	9 ± 5.2	63 ± 7.5	2 ± 2.2	–
	1999		5	21	0	7	56	11	–

[1] Golden Eagle: 1 = white wing patch visible below, small patch may be visible above; 2 = no white patch on wings, obvious white on tail; unknown immature/subadult = obvious white in tail, wings not observed; adult = no white in wings or tail. Bald Eagle: 1 = dark breast and belly; 2 = light belly or upside-down white triangle on back; 3 = head mostly white, with osprey-like dark eyeline; unknown immature/subadult = dark or mottled head, but body not adequately observed to make finer determination; adult = completely white head and tail, no white elsewhere.

[2] Mean ± 95% confidence interval.

Figure 1. Location of the Bridger Mountains study area in Montana, also showing location of HWI Roger's Pass spring migration site.

Figure 2. Location of the Bridger Mountains observation site.

Figure 3. Combined-species annual passage rate: 1991–1999.

Figure 4. Group composition of the Bridger migration: 1991–1998 versus 1999.

Figure 5. Combined-species daily migration rhythm: 1991–1998 versus 1999.

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

Figure 7. Annual passage rates for Turkey Vultures, Ospreys, and Northern Harriers: 1991–1999.

Figure 8. Passage volume by five-day periods for Ospreys and Northern Harriers: 1991–1998 versus 1999.

Figure 9. Age composition of annual flights of Northern Harriers: 1991–1999.

Figure 10. Annual passage rates for Sharp-shinned Hawks, Cooper's Hawks, and Northern Goshawks: 1991–1999.

Figure 11. Age composition of annual flights of Sharp-shinned Hawks, Cooper's Hawks, and Northern Goshawks: 1991–1999.

Figure 12. Passage volume by five-day periods for Sharp-shinned Hawks, Cooper's Hawks, and Northern Goshawks: 1991–1998 versus 1999.

Figure 13. Annual passage rates for Broad-winged Hawks, Swainson's Hawks, and Ferruginous Hawks: 1991–1999.

Figure 14. Passage volume by five-day periods for Broad-winged Hawks, Swainson's Hawks, and Red-tailed Hawks: 1991–1998 versus 1999.

Figure 15. Annual passage rates for Red-tailed Hawks and Rough-legged Hawks: 1991–1999.

Figure 16. Age composition of annual flights of Red-tailed Hawks: 1991–1999.

Figure 17. Passage volume by five-day periods for Ferruginous Hawks and Rough-legged Hawks: 1991–1998 versus 1999.

Figure 18. Annual counts and passage rates for Golden Eagles in comparison to annual hours of observation: 1991–1999.

Figure 19. Age composition of annual flights of Golden and Bald Eagles: 1991–1999.

Figure 20. Passage volume by five-day periods for Golden and Bald Eagles: 1991–1998 versus 1999.

Figure 21. Annual passage rates for Bald Eagles: 1991–1999.

Figure 22. Annual passage rates for American Kestrels, Merlins, Prairie Falcons, and Peregrine Falcons: 1991–1999.

Figure 23. Passage volume by five-day periods for American Kestrels and Merlins: 1992–1998 versus 1999.

Figure 24. Passage volume by five-day periods for Prairie and Peregrine Falcons: 1991–1998 versus 1999.

Appendix A. Common and scientific names, species codes, and regularly applied age, sex, and color morph classifications for all raptor species observed during fall migration in the Bridger Mountains, Montana.

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 Haw	*Accipiter cooperii*	CH	A I U	U	NA
Northern Goshawk	*Accipiter gentilis*	NG	A I U	U	NA
Unidentified accipiter	*Accipiter spp.*	UA	U	U	NA
Broad-winged Hawk	*Buteo platypterus*	BW	A I U	U	D L U
Swainson's Hawk	*Buteo swainsoni*	SW	U	U	D L U
Red-tailed Hawk	*Buteo jamaicensis*	RT	A I U	U	D L U
Ferruginous Hawk	*Buteo regalis*	FH	A I U	U	D L U
Rough-legged Hawk	*Buteo lagopus*	RL	U	U	D L U
Unidentified 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
Unidentified 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
Gyrfalcon	*Falco rusticolus*	GY	A I U	U	D G W U
Unidentified falcon	*Falco spp.*	UF	U	U	NA
Unidentified 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, G = gray; W = white; 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 B. A history of primary observers at the Bridger Mountain Raptor Migration Study.

1991: Kristian Shawn Omland (0), Phil West (1); LisaBeth Daly (2); Craig Limpach (1)

1992: Emily Teachout (1); Phil West (2)

1993: Adam Kaufman (0); Anne-Marie Gillesberg (0)

1994: Chris Gill (0); Stephanie Schmidt (1)

1995: Scott Harris (0); Sue Thomas (0)

1996: Jason Beason (0); Niels Maumenee (0)

1997: Jason Beason (1); Patty Scifres (0)

1998: Jason Beason (2), Mike Neal (0)

1999: Mike Neal (2), Greg Levandoski (1)

Note: Numbers in parentheses indicate number of full-seasons of previous raptor migration monitoring experience.

Appendix C. Annual summaries of observation effort and raptor counts by species in the Bridger Mountains: 1991–1999.

	1991	1992	1993	1994	1995	1996	1997	1998	1999	Mean
Start date	15-Sep	6-Sep	9-Sep	13-Sep	10-Sep	1-Sep	27-Aug	28-Aug	29-Aug	4-Sep
End date	3-Nov	28-Oct	31-Oct	30-Oct	2-Nov	30-Oct	31-Oct	31-Oct	31-Oct	30-Oct
Observation days	32	39	46	36	42	53	62	56	64	49
Observation hours	191.1	242.58	298.50	239.25	269.17	378.25	422.92	339.33	358.24	304.37
Raptors / 100 hours	926.7	1000.1	872.0	1027.8	824.0	808.5	796.1	1040.9	871.8	907.5
SPECIES					RAPTOR COUNTS					
Turkey Vulture	3	0	0	0	0	1	6	0	2	1
Osprey	2	2	5	5	1	14	12	13	9	7
Northern Harrier	19	13	41	59	10	38	66	230	52	59
Sharp-shinned Hawk	88	248	279	364	304	436	480	612	442	361
Cooper's Hawk	87	175	124	134	131	206	347	343	149	188
Northern Goshawk	27	96	39	17	10	37	36	50	61	41
Unidentified accipiter	70	35	27	20	33	51	53	49	39	42
TOTAL ACCIPITERS	272	554	469	535	478	730	916	1054	691	633
Broad-winged Hawk	0	2	3	11	5	5	5	20	13	6
Swainson's Hawk	1	11	0	3	2	0	6	2	3	3
Red-tailed Hawk	26	67	65	110	79	106	130	277	121	109
Ferruginous Hawk	3	1	1	1	0	5	4	7	4	3
Rough-legged Hawk	9	10	54	48	29	17	23	66	77	37
Unidentified buteo	14	8	19	15	18	13	20	13	3	14
TOTAL BUTEOS	53	99	142	193	133	146	188	385	221	173
Golden Eagle	1280	1579	1699	1500	1322	1871	1844	1516	1870	1609
Bald Eagle	43	95	124	41	57	79	93	95	91	80
Unidentified eagle	5	2	17	0	25	14	0	15	5	9
TOTAL EAGLES	1328	1676	1840	1541	1404	1964	1937	1626	1966	1698

Appendix C. continued

	1991	1992	1993	1994	1995	1996	1997	1998	1999	Mean
American Kestrel	33	38	54	67	117	82	146	141	113	88
Merlin	2	10	7	7	12	9	26	17	8	11
Prairie Falcon	9	14	10	10	14	16	10	12	20	12
Peregrine Falcon	1	7	6	4	7	10	10	18	18	9
Gyrfalcon	0	0	0	0	0	0	0	0	1	0
Unidentified falcon	5	3	2	4	2	5	17	8	6	6
TOTAL FALCONS	50	72	79	93	152	122	209	196	166	127
Unidentified raptor	44	10	27	33	40	43	33	28	16	30
GRAND TOTAL	1771	2426	2603	2459	2218	3058	3367	3532	3123	2729

Appendix D. Daily summaries of predominant weather conditions and raptor observation results during fall 1999 in the Bridger Mountains.

Date	Obs. Hours	Average Observers / Hour	Average Visitors / Hour	Sky Condition[1]	Thermal Lift[2]	Wind Speed[3]	Wind Direct.	Avg. Temp. (°C)	Avg. Visib. E (km)	Avg. Visib. W (km)	Flight Dist.[4]	Raptors / Hour
27-Aug	0.00	–	–	rain, ts	4	2	w	21.5	64	40	–	–
28-Aug	0.00	–	–	rain	4	3	w	20.2	3	2	–	–
29-Aug	4.50	2.6	1.3	ovc-clr	2	1	w	19.9	93	73	2	1.3
30-Aug	8.00	1.6	0.0	pc-ovc/rain	3	3	sse-ssw	22.4	92	85	2	3.6
31-Aug	5.33	1.0	0.2	fog/snow-clr	3	2	w-nw	8.4	65	65	3	1.3
01-Sep	6.92	1.3	0.6	ovc	4	2	ne	9.9	114	68	1	1.6
02-Sep	0.00	–	–	fog/rain	4	4	e-se	2.2	0	0	–	–
03-Sep	0.00	–	–	fog/rain	4	2	e-se	6.5	0	0	–	–
04-Sep	3.08	1.8	3.0	pc-ovc	3	1	ssw-w	13.6	94	84	2	0.6
05-Sep	8.33	1.8	0.0	clr-pc, haze	2	3	w-sw	15.1	104	101	2	3.2
06-Sep	7.50	1.7	0.6	clr-mc, haze	2	2	w-sw	17.4	84	91	2	6.8
07-Sep	7.00	1.6	0.0	pc-mc	3	3	w-sw	10.2	100	98	2	1.6
08-Sep	4.00	1.0	0.4	clr	1	2	w-sw	15.2	100	100	2	3.5
09-Sep	8.25	1.8	0.4	clr-pc, haze	1	2	w-sw	17.2	102	87	2	4.8
10-Sep	6.75	1.9	0.1	mc-ovc	4	2	w	18.3	82	63	2	5.6
11-Sep	6.25	2.9	8.3	mc-ovc, fog	3	3	w-nw	7.9	74	83	3	2.6
12-Sep	7.00	1.2	5.9	pc	2	1	w	9.7	131	101	1	2.3
13-Sep	6.50	1.0	1.6	clr	1	2	w	13.5	111	96	2	3.2
14-Sep	6.50	1.0	0.0	clr-pc, haze	2	2	var, w	15.9	110	100	2	5.2
15-Sep	8.08	2.2	0.4	clr-pc	1	1	w-wsw	14.9	129	104	2	6.1
16-Sep	7.50	1.4	1.6	clr, fog	1	2	w-sw	18.3	108	89	2	5.7
17-Sep	7.75	2.4	0.3	pc, haze	1	1	w-wsw	17.3	64	49	2	9.7
18-Sep	3.58	2.0	1.0	ovc, fog/rain	4	3	var	14.4	48	35	2	2.5
19-Sep	5.00	2.3	1.0	ovc/snow, clr-pc	3	3	ne	10.6	77	67	2	2.8
20-Sep	7.00	1.0	0.0	clr	2	2	w-sw	12.5	183	166	1	4.6
21-Sep	6.00	1.7	0.3	clr, haze	2	2	w-wsw	14.3	145	82	3	5.2
22-Sep	7.50	1.4	0.1	clr, haze	2	3	w-wsw	16.6	98	54	2	4.1
23-Sep	8.00	2.0	0.7	clr, haze	2	3	w-sw	17.4	50	73	3	7.4
24-Sep	5.50	2.0	0.8	ovc	4	3	w-sw	13.6	78	69	3	1.8
25-Sep	0.00	–	–	ovc/snow	4	4	w-wnw	7.4	23	29	–	–
26-Sep	2.50	2.0	2.0	ovc/snow	4	4	w-wsw	4.4	28	26	–	0.0
27-Sep	2.00	2.0	0.0	ovc, fog/snow	4	1	sw	-0.4	47	17	2	0.5
28-Sep	7.00	2.0	0.5	clr-pc, fog	3	3	w-sw	2.5	184	157	2	2.1
29-Sep	6.58	2.3	1.1	pc-ovc	3	3	sw	12.1	146	103	2	24.5
30-Sep	6.00	1.8	1.1	ovc	4	2	w-sw	9.1	153	117	2	1.5
01-Oct	5.50	1.7	0.8	fog/snow, mc-ovc	3	2	w-sw	3.6	55	60	2	11.3
02-Oct	0.00	–	–	ovc, fog/snow	4	2	w	1.3	0	0	–	–

Appendix D. continued

DATE	OBS. HOURS	AVERAGE OBSERVERS / HOUR	AVERAGE VISITORS / HOUR	SKY CONDITION[1]	THERMAL LIFT[2]	WIND SPEED[3]	WIND DIRECT.	AVG. TEMP. (°C)	AVG. VISIB. E (KM)	AVG. VISIB. W (KM)	FLIGHT DIST.[4]	RAPTORS / HOUR
03-Oct	8.00	2.1	0.9	clr	3	4	w-wsw	6.1	197	130	3	14.4
04-Oct	8.00	2.8	0.4	clr-pc, haze	2	3	w-sw	10.3	143	70	3	16.1
05-Oct	8.00	1.7	0.0	pc-ovc, haze	2	2	var, w-sw	16.4	96	80	2	22.8
06-Oct	6.50	1.9	0.0	ovc, rain	4	2	var	12.5	49	33	1	20.5
07-Oct	5.33	1.0	0.0	ovc	4	4	w	5.6	90	69	2	14.8
08-Oct	6.17	2.6	0.0	mc	3	5	w	13.7	160	130	3	5.0
09-Oct	0.00	–	–	ovc/rain	4	3	w-wsw	11.7	10	4	–	–
10-Oct	7.25	2.9	1.5	clr-ovc	2	1	w-wsw	10.0	196	159	2	23.4
11-Oct	6.75	1.7	0.0	ovc	4	3	w-wsw	13.1	148	109	3	5.6
12-Oct	7.50	1.9	0.0	ovc, rain/snow	4	4	w-wsw	7.0	104	133	2	18.7
13-Oct	8.00	2.0	0.0	clr-pc	2	3	w-wsw	13.2	149	113	2	28.6
14-Oct	6.75	1.7	0.1	ovc/fog, pc-mc	3	3	w	8.8	120	111	2	18.5
15-Oct	2.42	1.0	0.0	ovc/snow	4	2	w-nw	0.1	25	34	1	12.0
16-Oct	5.17	1.0	0.3	ovc/fog, clr-pc	3	3	w	-3.4	105	63	1	14.7
17-Oct	4.75	1.9	0.4	ovc/snow	4	3	w-wsw	2.1	48	48	2	6.1
18-Oct	4.67	1.5	0.0	ovc/snow	4	2	wnw	2.9	50	55	1	5.6
19-Oct	8.00	1.4	0.0	clr	2	4	w-wsw	4.1	163	96	2	9.3
20-Oct	8.75	1.5	0.2	pc-mc	3	4	w-wsw	9.7	164	144	1	11.3
21-Oct	8.75	1.5	1.1	pc-mc, haze	2	2	w-wsw	9.5	125	87	1	16.0
22-Oct	7.75	2.6	1.8	clr	1	1	w	7.8	162	100	1	10.8
23-Oct	7.00	1.7	1.3	clr-mc	1	1	sw-w	11.9	166	116	1	6.6
24-Oct	5.50	2.5	0.0	pc-ovc	3	3	w-wsw	10.2	97	64	2	10.0
25-Oct	7.50	1.8	0.0	mc-ovc	2	4	w-sw	10.8	136	88	2	4.8
26-Oct	7.00	2.0	0.0	clr-pc, haze	1	2	wnw-wsw	10.8	147	90	2	6.4
27-Oct	0.00	–	–	snow				–	–	–	–	–
28-Oct	0.00	–	–	snow				–	–	–	–	–
29-Oct	2.00	1.0	0.0	pc-ovc	4	6	w	-3.5	140	125	2	4.5
30-Oct	6.83	1.5	0.0	ovc-pc	2	4	w-wsw	5.2	160	118	2	10.4
31-Oct	2.50	1.5	0.0	clr-ovc	4	6	sw	6.3	200	160	2	3.6

[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 = thunderstorms; others self explanatory.

[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 kph; 1 = 1–5 kph; 2 = 6–11 kph; 3 = 12–19 kph; 4 = 20–28 kph; 5 = 29–38 kph, 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 fall 1999 in the Bridger Mountains.

		Species[1]																								Raptors
Date	Hours	TV	OS	NH	SS	CH	NG	UA	BW	SW	RT	FH	RL	UB	GE	BE	UE	AK	ML	PR	PG	GY	UF	UU	Total	/ hour
29-Aug	4.50	0	0	0	0	0	0	0	0	0	3	0	0	0	2	0	0	0	0	0	0	0	1	0	6	1.3
30-Aug	8.00	0	0	4	5	0	0	0	0	0	6	0	0	0	7	0	0	5	0	2	0	0	0	0	29	3.6
31-Aug	5.33	0	1	0	2	0	0	0	0	0	3	0	0	0	0	0	0	1	0	0	0	0	0	0	7	1.3
01-Sep	6.92	0	0	0	4	1	0	0	0	0	1	0	0	0	3	1	0	1	0	0	0	0	0	0	11	1.6
02-Sep	0.00																									
03-Sep	0.00																									
04-Sep	3.08	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2	0.6
05-Sep	8.33	0	0	0	4	0	1	0	0	0	9	0	0	0	9	0	0	3	0	0	0	0	0	1	27	3.2
06-Sep	7.50	0	1	5	14	8	1	0	0	0	3	0	0	0	5	1	0	12	1	0	0	0	0	0	51	6.8
07-Sep	7.00	0	0	1	2	1	0	0	0	0	3	0	0	0	0	0	0	3	1	0	0	0	0	0	11	1.6
08-Sep	4.00	0	1	1	3	1	0	0	0	0	2	2	0	0	3	0	0	1	0	0	0	0	0	0	14	3.5
09-Sep	8.25	0	0	1	12	9	1	1	1	0	7	0	0	0	4	0	0	1	0	2	0	0	0	1	40	4.8
10-Sep	6.75	0	1	1	7	2	9	0	0	0	7	0	0	0	4	0	0	3	0	3	0	0	1	0	38	5.6
11-Sep	6.25	0	0	1	4	2	0	0	0	0	2	0	0	0	3	1	0	3	0	0	0	0	0	0	16	2.6
12-Sep	7.00	0	0	1	6	2	1	0	0	1	3	0	0	0	1	0	1	0	0	0	0	0	0	0	16	2.3
13-Sep	6.50	0	1	0	7	3	2	1	0	0	3	0	0	0	2	0	0	2	0	0	0	0	0	0	21	3.2
14-Sep	6.50	0	0	1	10	8	0	2	2	0	2	0	0	0	5	0	0	4	0	0	0	0	0	0	34	5.2
15-Sep	8.08	0	0	0	8	7	2	1	5	0	9	0	0	0	11	1	0	2	0	1	2	0	0	0	49	6.1
16-Sep	7.50	0	0	0	11	10	0	5	0	0	4	0	0	0	10	0	0	2	0	0	1	0	0	0	43	5.7
17-Sep	7.75	0	2	1	21	14	1	1	2	1	7	0	0	0	7	0	0	13	1	2	2	0	0	0	75	9.7
18-Sep	3.58	0	0	0	0	1	0	0	0	0	1	0	0	0	1	1	0	3	0	0	2	0	0	0	9	2.5
19-Sep	5.00	2	1	2	1	2	0	0	0	0	0	0	0	0	3	1	0	0	0	0	2	0	0	0	14	2.8
20-Sep	7.00	0	0	1	6	2	2	1	1	0	4	0	0	0	9	2	0	2	0	0	2	0	0	0	32	4.6
21-Sep	6.00	0	0	1	9	4	2	0	1	0	3	0	0	0	10	0	0	1	0	0	0	0	0	0	31	5.2
22-Sep	7.50	0	0	1	7	4	1	1	0	0	3	0	0	0	8	0	0	4	0	0	1	0	0	1	31	4.1
23-Sep	8.00	0	0	0	11	5	1	3	1	0	4	0	1	0	23	2	0	5	0	0	0	0	1	2	59	7.4
24-Sep	5.50	0	0	1	4	1	0	0	0	0	1	0	0	0	3	0	0	0	0	0	0	0	0	0	10	1.8
25-Sep	0.00																									
26-Sep	2.50	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
27-Sep	2.00	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0.5
28-Sep	7.00	0	1	0	1	0	2	0	09	1	0	0	0	0	5	1	0	2	0	0	2	0	0	0	15	2.1
29-Sep	6.58	0	0	0	14	9	1	1	0	0	4	0	1	0	122	2	0	6	1	0	0	0	0	0	161	24.5
30-Sep	6.00	0	0	1	2	1	0	0	0	0	1	0	0	0	3	0	0	1	0	0	0	0	0	0	9	1.5

Appendix E. continued

		Species[1]																								Raptors
Date	Hours	TV	OS	NH	SS	CH	NG	UA	BW	SW	RT	FH	RL	UB	GE	BE	UE	AK	ML	PR	PG	GY	UF	UU	Total	/ hour
01-Oct	5.50	0	0	1	9	5	1	0	0	0	0	0	1	1	39	0	0	3	2	0	0	0	0	0	62	11.3
02-Oct	0.00																									
03-Oct	8.00	0	0	0	11	6	0	1	0	0	2	0	0	0	89	2	0	1	1	1	0	1	0	0	115	14.4
04-Oct	8.00	0	0	0	13	6	0	5	0	0	3	0	0	1	95	2	0	3	0	1	0	0	0	0	129	16.1
05-Oct	8.00	0	0	9	30	11	2	0	0	0	7	0	3	0	106	2	0	9	0	0	2	0	0	1	182	22.8
06-Oct	6.50	0	0	6	29	4	1	2	0	0	1	0	0	0	86	1	0	0	0	2	1	0	0	0	133	20.5
07-Oct	5.33	0	0	0	5	2	2	1	0	0	1	0	2	0	60	2	0	2	0	0	0	0	2	0	79	14.8
08-Oct	6.17	0	0	1	15	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	31	5.0
09-Oct	0.00																									
10-Oct	7.25	0	0	5	43	2	4	4	0	0	4	2	10	1	88	1	0	4	1	1	0	0	0	0	170	23.4
11-Oct	6.75	0	0	0	4	2	0	1	0	0	0	0	0	0	29	1	0	1	0	0	0	0	0	0	38	5.6
12-Oct	7.50	0	0	0	4	0	3	1	0	0	0	0	1	0	120	9	0	1	0	0	0	0	0	1	140	18.7
13-Oct	8.00	0	0	0	25	4	3	2	0	0	0	0	5	0	178	2	0	7	0	0	1	0	0	2	229	28.6
14-Oct	6.75	0	0	1	5	2	1	1	0	0	3	0	3	0	101	4	1	1	0	1	0	0	0	1	125	18.5
15-Oct	2.42	0	0	1	1	0	0	0	0	0	0	0	2	0	25	0	0	0	0	0	0	0	0	0	29	12.0
16-Oct	5.17	0	0	0	2	0	0	0	0	0	0	0	5	0	67	0	1	0	0	0	0	0	0	1	76	14.7
17-Oct	4.75	0	0	0	0	0	0	0	0	0	0	0	0	0	28	1	0	0	0	0	0	0	0	0	29	6.1
18-Oct	4.67	0	0	0	1	0	0	1	0	0	0	0	0	0	21	3	0	0	0	0	0	0	0	0	26	5.6
19-Oct	8.00	0	0	0	7	1	4	0	0	0	0	0	5	0	54	3	0	0	0	0	0	0	0	0	74	9.3
20-Oct	8.75	0	0	0	14	1	0	0	0	0	0	0	9	0	66	5	1	1	0	1	0	0	0	1	99	11.3
21-Oct	8.75	0	0	2	16	5	1	1	0	0	2	0	3	0	104	4	0	0	0	0	0	0	0	2	140	16.0
22-Oct	7.75	0	0	1	8	1	3	1	0	0	0	0	13	0	49	6	0	0	0	0	0	0	0	2	84	10.8
23-Oct	7.00	0	0	1	10	0	2	0	0	0	2	0	3	0	26	1	0	0	0	1	0	0	0	0	46	6.6
24-Oct	5.50	0	0	0	3	0	0	0	0	0	0	0	0	0	49	1	1	0	0	1	0	0	0	0	55	10.0
25-Oct	7.50	0	0	0	1	0	0	0	0	0	0	0	0	0	34	1	0	0	0	0	0	0	0	0	36	4.8
26-Oct	7.00	0	0	0	7	0	6	1	0	0	0	0	8	0	15	8	0	0	0	0	0	0	0	0	45	6.4
27-Oct	0.00																									
28-Oct	0.00																									
29-Oct	2.00	0	0	0	0	0	0	0	0	0	0	0	1	0	3	5	0	0	0	0	0	0	0	0	9	4.5
30-Oct	6.83	0	0	0	3	0	1	0	0	0	1	0	1	0	49	14	0	0	0	1	0	0	1	0	71	10.4
31-Oct	2.50	0	0	0	1	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	9	3.6
Total	358.24	2	9	52	442	149	61	39	13	3	121	4	77	3	1870	91	5	113	8	20	18	1	6	16	3123	8.7

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