FALL 2000 RAPTOR MIGRATION STUDY IN THE BRIDGER MOUNTAINS, MONTANA

Report prepared by:

Jeff P. Smith

Counts conducted by:

Ryan Wagner and Tracy Elsey

Project coordinated by:

HawkWatch International, Inc.

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

(801) 484-6808

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The Bridger Mountains Raptor Migration Project in southwestern Montana is an ongoing effort to monitor long-term population trends of raptors using this northern portion of the Rocky Mountain migratory flyway (Hoffman 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. To date, 18 species of raptors have been observed migrating along the Bridger Mountains, with annual counts typically ranging between 2,000 and 3,500 migrants. This report summarizes count results from the 2000 season, which marked the 10th consecutive standardized full-season autumn count of migratory raptors at the site.

The Bridger project was 1 of 15 long-term, annual migration counts (12 fall, 3 spring) conducted or sponsored by HWI in North America during 2000. The primary objective of these efforts is to track long-term population trends of diurnal raptors throughout primarily western North America (see Smith and Hoffman 2000 for a comprehensive review of raptor migration monitoring in 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). Moreover, due to the remoteness and widespread distribution of most raptor populations, migration counts likely represent the most cost-effective and efficient method for monitoring the regional status and trends of multiple raptor species (Bednarz and Kerlinger 1989, Titus et al. 1989, Bildstein and Zalles 1995, Bildstein et al. 1995, Dunn and Hussell 1995, Dixon et al. 1998, Smith and Hoffman 2000).

STUDY SITE

The Bridger Mountains are a relatively small range that runs primarily along a north–south axis. From Sacagawea 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; Figure 1). 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. A secondary observation site (OP2) situated at the base of the western slope of the Bridger Mountains 8.3 km southwest of OP1 in Middle Cottonwood Canyon has been used on occasion in past years when low clouds obscured the ridgetop. In 2000, temporary closure of the Gallatin National Forest due to extensive wildfires forced us to use this site for the first eight days of the 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

Weather permitting, two official observers, relieved or supplemented by other designated observers, conducted standardized daily counts of migrating raptors from a single, traditional observation site. Observations typically began by 0900 hrs and ended by 1630 hrs Mountain Standard Time (MST). Observers Ryan Wagner and Tracy Elsey had one and no previous full seasons of experience counting migrating raptors (see Appendix A for a complete history of observer participation). Visitors also occasionally assisted with spotting migrants.

The observers routinely recorded the following data:

1. Species, age, sex, and color morph of each migrant raptor, whenever possible and applicable (Appendix B lists common and scientific names for all species, information about the applicability of age, sex, and color morph distinctions, and two-letter codes used to identify species in some tables and figures).
2. Hour of passage for each migrant; e.g., the 1000 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. 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.

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

For purposes of examining long-term variation in annual counts, it is often recommended that count data be standardized for sampling period and adjusted for daily variation in observation effort because seasonal and daily duration of observation effort can greatly affect count statistics (Hussell 1985, Kerlinger 1989, Bednarz et al. 1990b). For purposes of this report, I converted counts to passage rates (typically raptors/100 hours of observation) to adjust for daily variation in sampling effort, and present both raw counts and passage rates for comparison. I also routinely compare results from the 2000 season to means for previous seasons and examine trends in annual passage rates. In comparing 2000 annual

statistics against means and 95% confidence intervals for previous seasons, I equate significance with a 2000 value falling outside the bounds of the confidence interval for the associated mean.

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, but stabilized thereafter (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 observation 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 10-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.

RESULTS

WEATHER SUMMARY

Inclement weather resulted in the highest number of no-observation days (12) in the past four years (see Appendix D for daily weather summaries). Otherwise, the range of sky conditions on active observation days was about average compared to the past three years, with 33% of days featuring fair skies, 40% transitional weather (i.e., clear to partly cloudy skies changing to mostly cloudy or overcast skies during the day, or the reverse; 2% including some rain or snow), and 27% mostly cloudy to overcast skies (8% including some rain or snow). However, the wind conditions in 2000 were unusual compared to the past three seasons, averaging calm to light (<12 kph) on 96% of the active observation days, compared to 48%, 86%, and 49% during the past three years, respectively. The light winds translated to a relatively high proportion of days with thermal conditions rated excellent (33% compared to 0–16% during the previous three seasons). The predominant wind directions remained similar to the previous three seasons, however, with westerly winds (varying from southwest to northwest) predominating on 77% of the active observation days. The temperature regime and visibility patterns also remained similar to the past three seasons.

OBSERVATION EFFORT

The observers worked on 52 of 66 possible observation days between 27 August and 31 October (Table 1). The first two days of scheduled observations did not occur because of unexpected difficulties

associated with closure of Gallatin National Forest, and inclement weather forced closure of the season two days earlier than scheduled. The number of observation days and hours were 10–11% higher than the 1991–1999 average (Table 1), but were 10–11% lower than the 1997–1999 average. The 1997 season is when we began to employ a standardized observation period of 27 August to 31 October (Appendix C).

The 2000 average of 1.8 observers per hour (includes official and guest observers; value is mean of daily values, which are in turn means of hourly values) is a statistically insignificant 8% lower than the 1992–1999 average (1.9 ± 95% CI of 0.11).

FLIGHT SUMMARY

The observers tallied 2,116 migrant raptors of 16 species during the 2000 season (Table 1, and see Appendix E for daily count records). Counts dropped to the lowest or second lowest count ever for Sharp-shinned Hawks, Cooper's Hawks, Broad-winged Hawks, Red-tailed Hawks, and all four of the commonly seen falcons; however, the count of Bald Eagles reached a record high (Appendix C).

The 2000 flight was composed of 74% eagles, 17% accipiters, 4% buteos, 3% falcons, 1% harriers, <1% Ospreys, and 1% unidentified raptors. These values represent a significantly higher than average proportion of eagles and significantly lower than average proportions of accipiters, buteos, and falcons (Figure 2). The most numerous species were the Golden Eagle (68% of the total count), Sharp-shinned Hawk (9%), Bald Eagle (6%), and Cooper's Hawk (5%).

Annual passage rates were 15% or more below average for all species except the Bald Eagle (44% above average), with the differences significant for 10 species (Table 1). Simple linear regression analyses of annual passage rates currently indicate no significant long-term trends, except for Golden Eagles (Figures 3–9). However, Ospreys are showing a marginally significant ($P = 0.10$) increasing trend (Figure 3) and several other species were showing probable increasing trends up until the low 2000 counts occurred (i.e., Sharp-shinned Hawk [Figure 4], Broad-winged Hawk [Figure 5], Red-tailed Hawk [Figure 6], American Kestrel, and Peregrine Falcon [Figure 9]). Based on annual passage rates, Golden Eagles are showing a significant declining trend; however, 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 (Figure 7). 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.

All seven species with sufficient data for comparisons showed below average immature : adult ratios this season (significant differences for Northern Goshawks and Red-tailed Hawks), and for all species except Bald Eagles the differences resulted in part from low numbers of immature birds (Table 2). This suggests that low productivity and juvenile recruitment might have contributed to the generally low counts and passage rates. However, for all species except the two eagles and Red-tailed Hawks, the comparisons are confounded by significantly higher than average proportions of unknown-age birds and therefore must be considered with caution (Table 2).

There was no universally consistent pattern of variation in seasonal timing evident this season (Tables 3 and 4). However, all three species of accipiters, Red-tailed Hawks, both species of eagles (goldens only if age-specific data are examined; Table 4), and Prairie Falcons all showed some tendency towards late passage. This pattern may have resulted in part from having to count from the alternate site early in the season, but each of these species showed periods of below average flight volume from mid-September through early October and above average spikes in activity from mid to late October (as illustrated by the overall combined-species pattern (Figure 10). This pattern was driven primarily by the occurrence of a

significant storm system that severely restricted observations between 19 and 23 September and again on 30 September and 1 October (Appendix D). Another significant storm system passed through between 11 and 14 October, but by then a backlog of birds needing to move south had occurred and passage rates were very high right before and after the storm passed. However, the only species for which late passage could have contributed to below average counts was for typically late-season species such Northern Goshawks and the two eagles.

Thus, below average productivity and late passage might have contributed to the generally below average counts and passage rates. However, low passage rates were common across many of HWI's monitoring sites this season, which suggests that unusual weather patterns also may have contributed. In particular, in the Bridger Mountains unusually calm winds and an attendant greater reliance on thermals for lift may have dispersed the flight away from the ridge and thereby resulted in sampling of a smaller than usual proportion of the actual flight.

RESIDENT RAPTORS

This season, residents included at least two adult, two first-year, and one subadult Golden Eagles; one adult male and at least one other American Kestrels; at least two adult and one immature Red-tailed Hawks; at least one Prairie Falcon; at least one immature and one other Sharp-shinned Hawks; at least two Cooper's Hawks; at least one adult Northern Goshawk; at least one immature and one adult female Northern Harriers; and possibly one Merlin. A Prairie Falcon was seen intermittently throughout the season, the Golden Eagles were seen regularly until mid-October, and one Cooper's Hawk was seen in late October; otherwise most resident activity ceased by late September.

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 2000 averaged 0.5 visitors per hour of observation, which is 31% lower than the 1993–1999 average. The extensive early-season wildfires and poor weather undoubtedly contributed to this decline in visitation. For the fifth consecutive year, the Bridger Raptor Festival was held at Montana State University and the Bridger Bowl Ski Area's Deer Park Chalet during the fall count. HWI Outreach Coordinator Paul Grindrod gave a presentation at the event, with the opening-night presentations attended by at least 60 people. Unfortunately, as has been the case most years, the weather did not cooperate and largely precluded visitation to the count site during the event.

ACKNOWLEDGMENTS

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Table 1. Observation effort and adjusted annual counts and passage rates by species: 1991–1999 versus 2000.

	1991–1999[1]	2000	%CHANGE	1991–1999[1]	2000	%CHANGE
Start date	4-Sep ± 4.7	29-Aug				
End date	30-Oct ± 1.0	29-Oct				
Observation days	47 ± 6.8	52	+11			
Observation hours	304.37 ± 49.433	335.40	+10			
SPECIES	COUNTS			RAPTORS/100HRS		
Turkey Vulture	1 ± 1.3	0	-100	0.4 ± 0.42	0.0	-100
Osprey	7 ± 3.3	6	-14	2.1 ± 0.81	1.8	-15
Northern Harrier	59 ± 44.0	20	-66	18.4 ± 12.76	6.0	-68
Sharp-shinned Hawk	361 ± 99.8	190	-47	115.5 ± 24.34	56.6	-51
Cooper's Hawk	188 ± 61.9	109	-42	60.3 ± 13.44	32.5	-46
Northern Goshawk	41 ± 16.8	34	-18	14.2 ± 6.80	10.1	-29
Unidentified accipiter	42 ± 10.0	35	-16	14.7 ± 5.56	10.4	-29
TOTAL ACCIPITERS	633 ± 157.9	368	-42	204.7 ± 32.21	109.7	-46
Broad-winged Hawk	7 ± 4.2	3	-58	2.3 ± 1.30	0.9	-60
Swainson's Hawk	3 ± 2.3	3	-4	1.1 ± 0.90	0.9	-19
Red-tailed Hawk	109 ± 46.4	45	-59	34.7 ± 12.82	13.4	-61
Ferruginous Hawk	3 ± 1.5	1	-65	0.9 ± 0.44	0.3	-67
Rough-legged Hawk	37 ± 16.4	26	-30	12.1 ± 4.97	7.8	-36
Unidentified buteo	14 ± 3.5	8	-41	4.8 ± 1.37	2.4	-50
TOTAL BUTEOS	173 ± 61.5	86	-50	55.8 ± 17.01	25.6	-54
Golden Eagle	1609 ± 148.3	1429	-11	545.3 ± 57.32	426.1	-22
Bald Eagle	80 ± 18.0	128	+60	26.4 ± 5.53	38.2	+44
Unidentified eagle	9 ± 5.8	3	-67	3.1 ± 2.00	0.9	-71
TOTAL EAGLES	1698 ± 158.9	1560	-8	574.8 ± 58.35	465.1	-19
American Kestrel	88 ± 28.1	39	-56	28.0 ± 6.87	11.6	-58
Merlin	11 ± 4.6	3	-72	3.4 ± 1.06	0.9	-74
Prairie Falcon	13 ± 2.4	9	-30	4.3 ± 0.73	2.7	-38
Peregrine Falcon	9 ± 3.8	1	-89	2.8 ± 1.00	0.3	-89
Gyrfalcon	0 0.2	0	-100	0.03 0.061	0.0	-100
Unidentified falcon	6 ± 3.0	4	-31	1.8 ± 0.69	1.2	-34
TOTAL FALCONS	126 ± 37.3	56	-56	40.3 ± 8.19	16.7	-59
Unidentified raptor	30 ± 7.6	20	-34	10.7 ± 3.85	6.0	-45
GRAND TOTAL	2728 ± 378.0	2116	-22	907.3 ± 62.12	630.9	-30

[1] Mean ± 95% confidence interval.

Table 2. Counts by age class and immature : adult ratios for selected species: 1992–1999 versus 2000.

	Total and Age-classified Counts						% Unknown Age		Immature : Adult Ratio	
	1992–1999 Average			2000						
	Total	Imm.	Adult	Total	Imm.	Adult	1992–1999[1]	2000	1992–1999[1]	2000
Northern Harrier	64	34	12	20	2	7	29 ± 7.2	55	5.92 ± 7.101	0.29
Sharp-shinned Hawk	396	84	156	190	26	50	38 ± 9.4	60	0.58 ± 0.145	0.52
Cooper's Hawk	201	64	60	109	19	21	37 ± 7.4	63	1.06 ± 0.386	0.90
Northern Goshawk	43	17	20	34	5	13	15 ± 6.1	47	1.75 ± 0.931	0.38
Broad-winged Hawk	8	2	3	3	0	0	21 ± 19.0	100	0.94 ± 0.724	–
Red-tailed Hawk	119	45	48	45	5	30	23 ± 6.6	22	0.92 ± 0.671	0.17
Golden Eagle	1650	674	607	1429	574	595	23 ± 4.5	18	1.14 ± 0.233	0.96
Bald Eagle	84	29	51	128	44	83	2 ± 1.9	1	0.64 ± 0.121	0.53

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

Table 3. First and last observation, bulk passage, and median passage dates by species for 2000, with a comparison of median passage dates for 2000 versus 1992–1999 means.

	2000				1992–1999
Species	First Observed	Last Observed	Bulk Passage Dates[1]	Median Passage Date[2]	Median Passage Date[3]
Osprey	31-Aug	25-Sep	31-Aug – 25-Sep	8-Sep	16-Sep ± 4.0
Northern Harrier	12-Sep	4-Oct	12-Sep – 4-Oct	14-Sep	20-Sep ± 5.5
Sharp-shinned Hawk	4-Sep	29-Oct	14-Sep – 20-Oct	2-Oct	1-Oct ± 1.8
Cooper's Hawk	29-Aug	28-Oct	4-Sep – 18-Oct	28-Sep	22-Sep ± 3.1
Northern Goshawk	31-Aug	28-Oct	8-Sep – 28-Oct	17-Oct	8-Oct ± 8.5
Broad-winged Hawk	14-Sep	10-Oct	–	–	19-Sep ± 2.9
Swainson's Hawk	1-Sep	14-Sep	–	–	–
Red-tailed Hawk	4-Sep	20-Oct	12-Sep – 15-Oct	27-Sep	18-Sep ± 3.1
Ferruginous Hawk	14-Sep	14-Sep	–	–	–
Rough-legged Hawk	8-Oct	29-Oct	16-Oct – 28-Oct	20-Oct	20-Oct ± 2.2
Golden Eagle	2-Sep	29-Oct	28-Sep – 27-Oct	10-Oct	11-Oct ± 3.6
Bald Eagle	14-Sep	29-Oct	6-Oct – 28-Oct	18-Oct	15-Oct ± 3.5
American Kestrel	3-Sep	9-Oct	7-Sep – 29-Sep	16-Sep	20-Sep ± 3.6
Merlin	12-Sep	19-Oct	–	–	1-Oct ± 2.7
Prairie Falcon	4-Sep	20-Oct	4-Sep – 20-Oct	10-Oct	21-Sep ± 7.1
Peregrine Falcon	20-Sep	20-Sep	–	–	23-Sep ± 3.8
All species	29-Aug	29-Oct	17-Sep – 27-Oct	10-Oct	7-Oct ± 1.9

[1] Dates between which the central 80% of the flight passed; values are given only for species with annual counts ≥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 4. Median passage dates by age for selected species: 1992–1999 versus 2000.

	Adult		Immature	
Species	1992–1999[1]	2000	1992–1999[1]	2000
Northern Harrier	27-Sep ± 5.5	27-Sep	19-Sep ± 7.6	–
Sharp-shinned Hawk	4-Oct ± 2.4	9-Oct	22-Sep ± 4.2	25-Sep
Cooper's Hawk	28-Sep ± 4.0	8-Oct	17-Sep ± 4.6	20-Sep
Northern Goshawk	8-Oct ± 11.6	16-Oct	28-Sep ± 5.7	14-Sep
Red-tailed Hawk	23-Sep ± 4.1	25-Sep	16-Sep ± 5.3	27-Sep
Golden Eagle	12-Oct ± 2.8	15-Oct	8-Oct ± 4.0	10-Oct
Bald Eagle	15-Oct ± 3.7	19-Oct	15-Oct ± 3.5	16-Oct

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

Figure 1. Location of the main (OP1) and secondary (OP2) observation sites in the Bridger Mountains.

Figure 2. Flight compostion by major species groups: 1991–1999 versus 2000.

Figure 3. Annual passage rates for Turkey Vultures, Ospreys, and Northern Harriers: 1991–2000.

Figure 4. Annual passage rates for Sharp-shinned Hawks, Cooper's Hawks, and Northern Goshawks: 1991–2000.

Figure 5. Annual passage rates for Broad-winged Hawks, Swainson's Hawks, and Ferruginous Hawks: 1991–2000.

Figure 6. Annual passage rates for Red-tailed Hawks and Rough-legged Hawks: 1991–2000.

Figure 7. Annual counts and passage rates for Golden Eagles in comparison to annual hours of observation: 1991–2000.

Figure 8. Annual passage rates for Bald Eagles: 1991–2000.

Figure 9. Annual passage rates for American Kestrels, Merlins, Prairie Falcons, and Peregrine Falcons: 1991–2000.

Figure 10. Combined-species passage volume by five-day periods: 1991–1999 versus 2000.

Appendix A. A history of primary observers for the Bridger Mountains Raptor Migration Project.

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)

2000: Ryan Wagner (1), Tracy Elsey (0)

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

Appendix B. Common and scientific raptor names, species codes, and regularly applied age, sex, and color morph classifications.

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 C. Annual summaries of observation effort and raptor counts by species: 1991–2000.

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	Mean
Start date	15-Sep	6-Sep	9-Sep	13-Sep	10-Sep	1-Sep	27-Aug	28-Aug	29-Aug	29-Aug	3-Sep
End date	3-Nov	28-Oct	31-Oct	30-Oct	2-Nov	30-Oct	31-Oct	31-Oct	31-Oct	29-Oct	30-Oct
Observation days	32	39	46	36	42	53	62	56	64	52	48
Observation hours	191.1	242.58	298.50	239.25	269.17	378.25	422.92	339.33	358.24	335.40	307.47
Raptors / 100 hours	926.7	1000.1	872.0	1027.8	824.0	808.5	796.1	1040.9	871.8	630.9	879.6
SPECIES	RAPTOR COUNTS										
Turkey Vulture	3	0	0	0	0	1	6	0	2	0	1
Osprey	2	2	5	5	1	14	12	13	9	6	7
Northern Harrier	19	13	41	59	10	38	66	230	52	20	55
Sharp-shinned Hawk	88	248	279	364	304	436	480	612	442	190	344
Cooper's Hawk	87	175	124	134	131	206	347	343	149	109	181
Northern Goshawk	27	96	39	17	10	37	36	50	61	34	41
Unidentified accipiter	70	35	27	20	33	51	53	49	39	35	41
TOTAL ACCIPITERS	272	554	469	535	478	730	916	1054	691	368	607
Broad-winged Hawk	0	2	3	11	5	5	5	20	13	3	7
Swainson's Hawk	1	11	0	3	2	0	6	2	3	3	3
Red-tailed Hawk	26	67	65	110	79	106	130	277	121	45	103
Ferruginous Hawk	3	1	1	1	0	5	4	7	4	1	3
Rough-legged Hawk	9	10	54	48	29	17	23	66	77	26	36
Unidentified buteo	14	8	19	15	18	13	20	13	3	8	13
TOTAL BUTEOS	53	99	142	193	133	146	188	385	221	86	164
Golden Eagle	1280	1579	1699	1500	1322	1871	1844	1516	1870	1429	1591
Bald Eagle	43	95	124	41	57	79	93	95	91	128	85
Unidentified eagle	5	2	17	0	25	14	0	15	5	3	9
TOTAL EAGLES	1328	1676	1840	1541	1404	1964	1937	1626	1966	1560	1684
American Kestrel	33	38	54	67	117	82	146	141	113	39	83
Merlin	2	10	7	7	12	9	26	17	8	3	10
Prairie Falcon	9	14	10	10	14	16	10	12	20	9	12
Peregrine Falcon	1	7	6	4	7	10	10	18	18	1	8
Gyrfalcon	0	0	0	0	0	0	0	0	1	0	0.1
Unidentified falcon	5	3	2	4	2	5	17	8	6	4	6
TOTAL FALCONS	50	72	79	93	152	122	209	196	166	56	119
Unidentified raptor	44	10	27	33	40	43	33	28	16	20	29
GRAND TOTAL	1771	2426	2603	2459	2218	3058	3367	3532	3123	2116	2667

Appendix D. Daily observation effort, visitation, and weather records: 2000.

Date	Obs. Hours	Average Observers / Hour	Average Visitors / Hour	Sky Condition[1]	Thermal Lift[2]	Wind Speed[3]	Wind Direct.	Avg. Temp. (°C)	Baro. Press. (in Hg)	Avg. Visib. E (km)	Avg. Visib. W (km)	Flight Dist.[4]	Raptors / Hour
29-Aug	5.50	2.5	0.3	clr/haze	2	1	wsw-w	26.0	29.85	71	53	2	0.2
30-Aug	6.50	2.1	0.0	ovc, clr PM	4	0	calm/s-sw	23.9	29.84	70	70		0.0
31-Aug	6.75	2.0	0.0	clr-mc	1	1	w	24.1	29.68	78	70	3	0.6
01-Sep	3.83	2.2	0.0	mc-ovc, rain AM	4	2	w, s, e	21.1	29.75	75	80	3	0.3
02-Sep	6.75	2.6	0.1	pc-mc	2	2	s-sw	22.4	29.71	99	99	3	0.3
03-Sep	7.00	2.2	1.5	clr-mc, scat rain	2	1	wnw	19.3	29.86	100	100	4	1.0
04-Sep	9.00	1.7	0.2	clr-pc	2	1	nw	21.5	29.87	95	95	3	1.8
05-Sep	1.75	1.0	0.0	clr	1	1	w	20.8	29.84	90	90		0.0
06-Sep	1.67	2.0	0.0	mc-ovc	3	1	w	10.7	30.31	90	90		0.0
07-Sep	7.33	1.8	0.3	clr	1	2	w, sw	17.3	29.79	92	92	2	1.6
08-Sep	6.75	1.9	0.6	clr-ovc	3	2	s-sw	17.5	29.45	96	95	2	2.4
09-Sep	6.58	2.0	0.0	ovc-pc	3	2	w, s	3.4	29.51	98	98	1	0.5
10-Sep	2.00	3.3	0.0	ovc/snow	4	2	sw-w	5.3	29.58	53	40		0.0
11-Sep	6.00	1.0	0.0	mc-ovc, fog AM	4	2	w	10.3	29.81	34	34		0.0
12-Sep	8.00	1.4	0.2	clr	1	2	sw	18.3	29.91	89	88	2	3.5
13-Sep	7.25	2.0	0.4	clr	1	1	sw-w	19.8	30.06	94	91	2	4.3
14-Sep	7.00	1.9	0.0	pc	1	0	calm/w-nw	21.1	30.13	87	84	2	6.6
15-Sep	7.25	2.9	0.0	clr-mc	2	0	sw-w	23.4	30.03	91	84	2	3.0
16-Sep	7.00	1.8	0.3	pc-mc	2	1	w	19.6	30.05	85	73	2	1.9
17-Sep	8.50	3.0	0.0	clr-mc	2	1	w-nw	17.8	29.97	83	83	2	5.5
18-Sep	7.00	1.0	0.0	ovc	4	2	w	13.6	29.81	90	88	1	0.7
19-Sep	0.00												
20-Sep	8.00	2.0	0.0	clr-ovc	4	0	w-nw	6.1	29.72	87	82	1	1.3
21-Sep	0.00												
22-Sep	0.00												
23-Sep	0.00												
24-Sep	7.00	2.0	2.0	clr	1	3	w	1.2	29.97	100	97	1	1.0
25-Sep	7.50	2.0	0.0	pc	2	0	calm/w	8.6	29.95	96	86	2	5.6
26-Sep	7.50	1.0	0.0	clr	1	1	w	8.0	29.95	96	87	1	3.2
27-Sep	8.00	2.0	0.0	clr	1	1	w-nw	11.3	30.04	84	80	2	5.9
28-Sep	8.25	2.0	0.0	pc-mc	1	1	w-nw	13.3	29.93	95	88	2	10.7
29-Sep	8.00	2.0	0.1	pc-ovc	1	2	w	11.7	29.77	82	74	2	11.8
30-Sep	4.33	1.8	4.2	ovc, scat rain	4	2	sw-w	10.2	29.63	90	88	2	0.5
01-Oct	0.00												
02-Oct	7.50	1.8	1.5	pc-ovc PM	2	1	w	5.6	29.80	90	88	2	8.8
03-Oct	6.00	1.9	0.6	pc-ovc	2	1	w	4.4	29.93	87	81	1	6.7
04-Oct	7.00	1.3	0.0	mc	3	1	w	3.4	29.82	88	80	1	1.9
05-Oct	4.50	1.0	0.0	pc-mc	4	2	w	2.0	30.02	0	70	1	0.2
06-Oct	7.50	1.6	0.0	clr-pc	1	0	calm/ne PM	1.1	30.11	95	76	1	7.2
07-Oct	5.00	1.0	6.0	clr	1	3	e-se	4.7	30.16	98	85	1	0.2
08-Oct	7.50	1.0	5.5	clr-pc	1	1	wsw-w	9.1	30.12	94	91	2	9.7
09-Oct	7.50	2.6	0.3	clr	1	0	w-nw	12.6	29.92	93	88	1	10.9
10-Oct	8.00	2.0	0.1	mc-ovc	2	1	e-se	12.0	29.59	94	83	2	34.3
11-Oct	4.50	1.4	0.0	mc-ovc	3	1	e-se	7.5	29.67	62	22	1	14.2
12-Oct	0.00												
13-Oct	0.00												
14-Oct	0.00												
15-Oct	3.50	2.0	0.0	mc	3	1	sw-w	5.4	29.71	90	85	1	42.9
16-Oct	6.50	1.9	0.0	mc	2	1	sw-w	8.6	29.98	91	80	2	19.8

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)	Baro. Press. (in Hg)	Avg. Visib. E (km)	Avg. Visib. W (km)	Flight Dist.[4]	Raptors / Hour
17-Oct	6.50	1.9	0.0	clr-mc	1	0	sw/calm	10.1	30.14	90	90	1	8.0
18-Oct	7.83	2.1	0.0	pc-ovc	2	2	sw-w	9.8	29.99	97	89	2	18.5
19-Oct	7.00	1.6	0.0	ovc-pc	3	1	sw-w	6.5	29.97	93	84	2	7.3
20-Oct	7.00	1.7	0.0	ovc	3	1	sw-w	9.6	29.79	95	88	1	8.3
21-Oct	0.00												
22-Oct	5.33	1.0	0.2	pc	3	2	e, w	2.1	30.10	79	67	1	1.7
23-Oct	6.50	1.9	0.1	clr	1	1	w	6.8	30.06	95	100	1	2.8
24-Oct	7.00	1.8	0.1	pc-ovc	3	2	sw-w	8.3	29.91	91	91	1	3.6
25-Oct	0.00												
26-Oct	6.00	1.7	0.0	pc-ovc	3	2	e	5.4	29.85	31	29	1	4.5
27-Oct	7.50	1.2	0.0	pc-mc	3	1	s-sw	6.0	29.78	74	72	1	16.7
28-Oct	6.75	1.0	0.5	mc-ovc	2	1	sw	8.0	29.63	95	89	2	6.4
29-Oct	5.00	1.0	0.0	mc-ovc, snow PM	2	2	s-w	6.8	29.71	100	83	2	9.6

[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: 2000.

			Species[1]																						Raptors	
Date	Site[2]	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	MC	5.50	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
30-Aug	MC	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	MC	6.75	0	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0.6
01-Sep	MC	3.83	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.3
02-Sep	MC	6.75	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	
03-Sep	MC	7.00	0	0	0	0	2	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	3	7	
04-Sep	MC	9.00	0	0	0	4	6	0	1	0	1	1	0	0	1	0	0	0	1	0	1	0	0	0	0	16	1.8
05-Sep	MC	1.75	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
06-Sep	BB	1.67	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
07-Sep	BB	7.33	0	1	0	1	1	2	0	0	0	0	0	0	0	2	0	1	4	0	0	0	0	0	0	12	1.6
08-Sep	BB	6.75	0	1	0	3	1	1	1	0	0	1	0	0	0	4	0	0	3	0	0	0	0	0	1	16	2.4
09-Sep	BB	6.58	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	3	0.5
10-Sep	BB	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
11-Sep	BB	6.00	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
12-Sep	BB	8.00	0	0	3	3	2	0	1	0	0	3	0	0	0	11	0	0	3	1	0	0	0	0	1	28	3.5
13-Sep	BB	7.25	0	0	1	4	4	1	3	0	0	2	0	0	0	10	0	0	3	0	0	0	0	1	2	31	4.3
14-Sep	BB	7.00	0	0	7	6	7	1	4	2	1	4	1	0	2	6	1	0	2	0	1	0	0	0	1	46	6.6
15-Sep	BB	7.25	0	0	0	8	2	0	1	0	0	2	0	0	0	7	0	0	1	0	1	0	0	0	0	22	3.0
16-Sep	BB	7.00	0	0	0	1	5	0	0	0	0	1	0	0	0	4	0	0	2	0	0	0	0	0	0	13	1.9
17-Sep	BB	8.50	0	2	1	14	11	0	2	0	0	5	0	0	0	4	0	0	8	0	0	0	0	0	0	47	5.5
18-Sep	BB	7.00	0	0	0	2	0	0	0	0	0	0	0	0	0	2	0	0	1	0	0	0	0	0	0	5	0.7
19-Sep		0.00																									
20-Sep	BB	8.00	0	0	0	3	2	0	0	0	0	0	0	0	0	4	0	0	0	0	0	1	0	0	0	10	1.3
21-Sep		0.00																									
22-Sep		0.00																									
23-Sep		0.00																									
24-Sep	BB	7.00	0	0	0	1	1	1	0	0	0	0	0	0	0	2	0	2	0	0	0	0	0	0	0	7	1.0
25-Sep	BB	7.50	0	1	0	12	3	1	1	0	0	1	0	0	0	19	4	0	0	0	0	0	0	0	0	42	
26-Sep	BB	7.50	0	0	0	7	1	0	0	0	0	1	0	0	0	14	0	0	0	0	0	0	0	0	1	24	3.2
27-Sep	BB	8.00	0	0	2	2	0	0	4	0	0	2	0	0	0	30	1	0	3	0	0	0	0	0	3	47	5.9
28-Sep	BB	8.25	0	0	0	11	6	0	3	0	0	4	0	0	1	60	1	0	1	0	0	0	0	0	1	88	10.7
29-Sep	BB	8.00	0	0	1	11	3	0	2	0	0	1	0	0	0	70	1	0	3	0	0	0	0	1	1	94	11.8
30-Sep	BB	4.33	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0.5
01-Oct		0.00																									
02-Oct	BB	7.50	0	0	0	3	4	0	1	0	0	1	0	0	1	53	1	0	1	1	0	0	0	0	0	66	

Appendix E. continued

			Species[1]																							Raptors
Date	Site[2]	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
03-Oct	BB	6.00	0	0	3	7	5	0	0	0	0	0	0	0	0	25	0	0	0	0	0	0	0	0	0	40	6.7
04-Oct	BB	7.00	0	0	2	0	2	0	0	0	0	0	0	0	0	6	3	0	0	0	0	0	0	0	0	13	1.9
05-Oct	BB	4.50	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.2
06-Oct	BB	7.50	0	0	0	5	4	1	0	0	0	5	0	0	0	30	8	0	0	0	1	0	0	0	0	54	7.2
07-Oct	BB	5.00	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0.2
08-Oct	BB	7.50	0	0	0	6	5	2	1	0	0	2	0	1	0	50	5	0	0	0	0	0	0	0	1	73	9.7
09-Oct	BB	7.50	0	0	0	15	4	1	0	0	0	0	0	1	1	56	3	0	1	0	0	0	0	0	0	82	
10-Oct	BB	8.00	0	0	0	10	1	0	0	1	0	0	0	0	0	245	14	0	0	0	2	0	0	1	0	274	34.3
11-Oct	BB	4.50	0	0	0	6	2	1	0	0	0	1	0	0	0	49	5	0	0	0	0	0	0	0	0	64	14.2
12-Oct		0.00																									
13-Oct		0.00																									
14-Oct		0.00																									
15-Oct	BB	3.50	0	0	0	6	3	1	1	0	0	3	0	0	0	131	4	0	0	0	0	0	0	0	1	150	42.9
16-Oct	BB	6.50	0	0	0	2	4	2	1	0	0	2	0	1	0	109	5	0	0	0	0	0	0	0	3	129	19.8
17-Oct	BB	6.50	0	0	0	5	2	4	1	0	0	0	0	1	0	36	3	0	0	0	0	0	0	0	0	52	8.0
18-Oct	BB	7.83	0	0	0	9	4	2	1	0	0	0	0	1	0	118	7	0	0	0	2	0	0	0	1	145	18.5
19-Oct	BB	7.00	0	0	0	1	3	0	1	0	0	0	0	0	0	40	5	0	0	1	0	0	0	0	0	51	7.3
20-Oct	BB	7.00	0	0	0	8	3	3	0	0	0	2	0	8	0	31	2	0	0	0	1	0	0	0	0	58	8.3
21-Oct		0.00																									
22-Oct	BB	5.33	0	0	0	2	0	3	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	9	1.7
23-Oct	BB	6.50	0	0	0	1	0	1	0	0	0	0	0	4	0	9	3	0	0	0	0	0	0	0	0	18	2.8
24-Oct	BB	7.00	0	0	0	1	1	1	0	0	0	0	0	2	1	15	4	0	0	0	0	0	0	0	0	25	3.6
25-Oct		0.00																									
26-Oct	BB	6.00	0	0	0	2	0	0	1	0	0	0	0	3	0	19	2	0	0	0	0	0	0	0	0	27	4.5
27-Oct	BB	7.50	0	0	0	1	0	0	2	0	0	0	0	0	1	88	32	0	0	0	0	0	0	1	0	125	
28-Oct	BB	6.75	0	0	0	3	1	4	0	0	0	0	0	2	0	30	3	0	0	0	0	0	0	0	0	43	
29-Oct	BB	5.00	0	0	0	4	0	0	0	0	0	0	0	2	0	31	11	0	0	0	0	0	0	0	0	48	9.6
Total		335.40	0	6	20	190	109	34	35	3	3	45	1	26	8	1429	128	3	39	3	9	1	0	4	20	2116	6.3

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

[2] MC = Middle Cottonwood Canyon OP2 secondary observation site; BB = Bridger Bowl OP1 main observation site.