FALL 2002 RAPTOR MIGRATION STUDY AT COMMISSARY RIDGE IN SOUTHWESTERN WYOMING

HawkWatch International, Inc.
Salt Lake City, Utah

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INTRODUCTION

HawkWatch International (HWI) and its organizational precursors have been monitoring raptor migrations in North America since the late 1970s. During 2002, HWI conducted or co-sponsored 13 long-term, annual migration counts (11 fall, 2 spring) and six migration banding studies (5 fall, 1 spring) in eight states. The primary objective of these efforts is to track long-term population trends of diurnal raptors throughout primarily western North America (Smith and Hoffman 2000, Hoffman et al. 2002, Hoffman and Smith in review). 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 (Bildstein 2001). Moreover, due to the remoteness and widespread distribution of most raptor populations, migration counts likely represent a particularly cost-effective and efficient method for monitoring the regional status and trends of multiple raptor species (Bednarz and Kerlinger 1989, Dunn and Hussell 1995, Dixon et al. 1998, Zalles and Bildstein 2000, Smith and Hoffman 2000).

Intensive counting and banding operations also provide valuable information about breeding and wintering distributions, migratory routes, migratory behavior, mortality factors and longevity, morphometric variation, molt sequences and timing, and health assessments (e.g., Hoffman et al. 2002). This information enables us to better understand the life histories, ecology, status, and conservation needs of raptor populations in North America. In addition, these migration studies offer unique opportunities for the public to learn about raptors and the natural environment, and providing such opportunities is another important component of HWI's mission.

Most of HWI's migration-monitoring projects are located atop mountain ridges. Migrating raptors frequently concentrate along north–south aligned mountain ranges for several reasons. Many raptor species seek to save energy on their long journeys by taking advantage of wind-driven updrafts that routinely occur along such ranges. In western North America, strong updrafts frequently occur along the western flanks of north–south ranges as predominantly westerly winds are deflected upward by the montane topography. Long north–south ranges also serve as navigational aids by forming a "leading line" (*sensu* Geyr von Shweppenberg 1963:192) that raptors can follow en route to their seasonal destination. In many cases, especially in arid landscapes such as the Great Basin, montane ridges may also attract migrants because they provide the only available forested habit. For species such as the accipiter hawks, forest cover may be a necessary requirement to provide suitable stopover and foraging habitat.

To be effective for regional monitoring of broadly distributed species, migration monitoring must involve a network of well-distributed, standardized counts that effectively sample all major flyways and known subpopulations (Smith and Hoffman 2000). Currently, no long-term raptor migration surveys are being conducted in the state of Wyoming, and coverage of the central Rockies between Montana and New Mexico is generally sparse. Moreover, exploratory surveys conducted by HWI during 1997 in southwestern and southern Colorado generally failed to reveal concentrations worthy of additional attention (Harrington 1998). Hence, in 2000 HWI expanded its exploratory efforts to 26 sites across Wyoming and southern Montana (Figure 1; Smith and Neal 2001). This fall survey concentrated on the prominent mountains of western Wyoming, but also included many more isolated ranges throughout the state and adjacent portions of southwestern Montana.

The 2000 surveys revealed potential concentrations in the southern Wind River Range of central Wyoming, and on Commissary Ridge and in the Salt River Range of western Wyoming (Figure 1; Smith and Neal 2001). The southern Wind River area appeared of particular interest because of the volume of Golden Eagle (see Appendix A for scientific names) migration (125 birds in 3 days), whereas the other two sites showed higher overall volume with greater diversity. Determining whether another significant Golden Eagle concentration could be found in the central Rocky Mountains to extend coverage of the significant concentrations already monitored in Montana (Smith 2003a, Tilly et al. 2002) and Alberta

(Sherrington 2000) was one important objective for this exploratory work. Thus, during fall 2001, HWI conducted a second round of more intensive counts at these three locations (20–22 days at each site, evenly distributed in 4-5 periods across September and October) to verify whether the activity in these areas warranted long-term monitoring (Smith 2001).

The 2001 surveys confirmed our expectations concerning the Salt River Range–Commissary Ridge complex, with an overall flight volume that likely rivals most other similar, long-term HWI projects in the West and at least a moderately high concentration of eagles (Smith 2001). In contrast, two-years of surveys in the southern Wind River Range yielded at best inconsistent, modest concentrations of Golden Eagles and little else. Moreover, although the flight volume in the Salt River Range proved almost as great as at Commissary Ridge, the logistic feasibility of establishing a long-term project was much greater at Commissary Ridge (primarily drive-up access rather than a strenuous, half-day hike to a remote location). Thus, in 2002 HWI conducted the first full-season count at Commissary Ridge to provide final confirmation of the suitability for establishing a long-term project at the site. This report summarizes the results of that effort.

STUDY SITE

The study site was located atop the southern end of Commissary Ridge on the southwestern tip of South Fork Mountain, about 37 km north of Kemmerer, Wyoming, on land managed by the Bureau of Land Management, Kemmerer Field Office (42°01'29"N 110°35'22"W; T24 R116 S28 SESW; elevation ~2,700 m; Figure 1). The site is accessed from Hwy 233 just northeast of Lake Viva Naughton (Figure 2). The count site was located on the western edge of a broad ridgetop overlooking the Ham's Fork River Valley and Lake Viva Naughton to the west. The location provided an unobstructed 360° view of the surrounding landscape. The ridgetop featured primarily rocky substrates and low growing, desert shrubs and grasses, with scattered stands of mixed-conifer and aspen forest in sheltered pockets and ravines.

road-accessible base camp
200 m from count site

METHODS

Trained observers conducted daily counts from a single observation post from late August through late October 2002, except when excessive fog or other severe weather precluded effective counting or safety issues precluded access to the site. Counts generally occurred from approximately 0830–1700 hrs Mountain Standard Time (MST).

Primary, full-time observer Mike Neal was involved in all previous exploratory work that led up to this project and had conducted prior full-season migration counts for HWI at several other western sites. Observer Jason Beason, who joined Mike for a week in late September, also had several full-seasons of prior counting experience with HWI and Rocky Mountain Bird Observatory. Observer Nick Meyer, who worked with Mike during October, was new to raptor-migration counting but was a well-trained avian field biologist. Experienced observers Cress Bohnn and the author filled on a few occasions.

During all observations, the observers routinely recorded the following data on standardized forms used for all HWI migration counts:

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 1000–1059 hrs MST.
3. Wind speed and direction, air temperature, percent cloud cover, predominant cloud type(s), presence of precipitation, visibility, and an assessment of thermal-lift conditions, recorded for each hour of observation on the half hour.
4. Predominant direction, altitude, and distance from the lookout of the flight during each hour.
5. Total minutes observed and the mean number of observers present during each hour (including designated observers plus volunteers/visitors who actively contributed to the count [active scanning, pointing out birds, recording data, etc.] for more than 10 minutes in a given hour), recorded on the hour.
6. A subjective visitor-disturbance rating for each hour, recorded on the hour.
7. Daily start and end times for each official observer.

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

The observers classified as residents and excluded from daily counts any raptor that exhibited hunting, territorial display, or perching behaviors for extended periods (i.e., more than 10–15 minutes). 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 moving relatively short-distances from their nesting territories to favored wintering grounds in the same general area. We also know from banding studies and satellite-telemetry work that species such as Golden Eagles, Prairie Falcons, and Ferruginous Hawks frequently may migrate in a variety of directions to take advantage of favored post-breeding and wintering grounds (Steenhof et al. 1984, Watson and Pierce 2000, K. Steenhof personal communication, HWI unpublished data).

The seasonal and daily duration of observation effort can greatly affect count statistics (Hussell 1985, Bednarz and Kerlinger 1989, Bednarz et al. 1990). To generally adjust for variation in sampling effort due to inclement weather and other unforeseeable events, and therefore render data from different years and sites comparable, common practice calls for converting counts to annual passage rates (total number of migrants counted / total hours of observation * 100 = birds / 100 hrs).

RESULTS AND DISCUSSION

WEATHER

Inclement weather precluded 9 full days of potential observations in 2002 and severely hampered (<4 hrs) observations on another 5 days (see Appendix B for daily weather records). Otherwise, 42% of the active observation days featured predominantly fair skies (2% including some fog or haze), 27% transitional skies (shifted from fair skies to mostly cloudy or overcast skies during the day, or vice versa; 6% including some fog/haze or rain/snow), and 31% mostly cloudy to overcast/stormy skies (22% including fog/haze and/or rain/snow). The temperature during active observation periods averaged 12.5°C (average of daily values, which were in turn averages of hourly readings), ranging from 0.5–21.3°C. Barometric pressure during active observation periods averaged 30.51 in Hg (average of daily values, which were in turn averages of hourly readings), ranging from 29.73–30.49 in Hg. Light winds (<12 kph) predominated on 4% of the active observation days, moderate winds (12–28 kph) on 60%, and strong winds (>28 kph) on 36%. West to west-northwest winds predominated on 77% of the active observation days, variable south to west winds on 2%, east to northeast winds on 9%, and on the remaining 11% of days the winds switched from predominantly westerly to predominantly easterly winds (or vice versa) at some point during the day. Fair thermal-lift conditions predominated on 62% of days, good to excellent conditions on 38%. Visibility averaged roughly 66 km to the east and 76 km to the west.

OBSERVATION EFFORT

Observation effort totaled 45 days and 322.67 hours (Table 1) between 27 August and 29 October 2002 (Table 1, and see Appendix B for daily records of observation effort). Daily coverage ranged from 0.50–9.25 hrs, averaging 7.2 hrs per day of active observation. Although it turned out that the area surrounding the project site was never threatened, an unfortunate 12-day gap in our coverage occurred because a nearby wildfire precluded access to the site from 30 August through 10 September. Otherwise, inclement weather precluded observations on another 9 days, but on these days it is unlikely that we missed much migration activity.

Our goal was to have two observers work together on as many days as possible, which is the standard for all HWI migration projects. Due to funding and personnel limits, we were able to achieve this goal on only 29 of the 45 days on which counts occurred, with an average of 1.6 observers per hour of observation (see Appendix B). Most of the one-observer counts occurred early and late in the season when flight volume was relatively low, so the effect on count efficiency was probably minor.

FLIGHT VOLUME AND COMPOSITION

The observers tallied 3,197 migrants of 17 species during the 2002 season (Table 1, and see Appendix C for daily count records). The flight was composed of 38% accipiters, 29% buteos, 19% eagles, 9% falcons, 3% vultures, and 2% other species and unidentified raptors (Figure 3). The most abundant species were the Red-tailed Hawk (26% of the total count), Sharp-shinned Hawk (21%), Cooper's Hawk (13%), Golden Eagle (11%), American Kestrel (8%), Bald Eagle (7%), Swainson's Hawk (3%), and Turkey Vulture (3%). All other species each comprised ≤1% of the total.

Because the 2001 count effort was about half of the 2002 effort, comparing data from the two seasons is of limited value. Nevertheless, for five species (Osprey, Northern Harrier, Ferruginous Hawk, Rough-legged Hawk, and Peregrine Falcon) the 2002 count totals were less than those documented by the limited 2001 count (Table 1). Moreover, when converted to passage rates, which places the comparisons on a better footing, 11 species showed lower values in 2002 than in 2001 (Table 1). One would normally expect the 2002 effort to yield lower passage-rate estimates because it covered comparatively more times when flight volume was expected to be low (e.g., early and late in the season). For most of these species, however, the magnitude of the apparent drops in passage rates ranged from 30–70%, which is significantly greater than expected given the difference in effort. Moreover, if we base the comparisons on counts from essentially the same range of dates in both years, 10 species still show drops of 5–90%.

The reason I focus attention on such comparisons is that most of HWI's other long-term migration sites in the interior West have shown distinct downturns for most species since 1998 when prolonged drought began plaguing much of the West, including southwestern Wyoming (Hoffman and Smith in review). In addition, 2002 was a year of stark contrasts within each of the three major western flyways (Rocky Mountain, Intermountain, and Pacific Coast; *sensu* Hoffman et al. 2002); therefore, any additional insight concerning apparent patterns is currently of special interest. Among the sites closest to Commissary Ridge, the 2002 overall combined-species counts dropped to record lows in the Bridger Mountains of southwestern Montana (Smith 2003a) and the Goshute Mountains of northeastern Nevada (Smith 2003b), but were above average at Boise Ridge in western Idaho (Shannon 2003) and average in the Manzano Mountains of central New Mexico (Smith 2003c).

DAILY AND SEASONAL MIGRATION PATTERNS

The average daily rhythm of the migration at Commissary Ridge followed a similar pattern in 2001 and 2002 (Figure 4). Flight activity typically increased rapidly to a peak during the 1000 hour, tapered off slightly during the next hour, and then remained fairly steady through the 1500 hour before rapidly tapering off to minimal activity by the end of the 1700-hour.

Although the picture is incomplete due to gaps in coverage during both years, the seasonal distribution of activity also appeared to follow roughly similar patterns in 2001 and 2002 (Figure 5). The seasonal pattern appears to fit a roughly unimodal distribution with peak activity from late September through early October. However, as illustrated by comparing bulk (dates between the central 80% of the flight passed) and median (date by which 50% of the flight had passed) passage dates, the timing and overall seasonal distribution of activity varied significantly across species (Table 2). Most species showed peak activity in late September with relatively little activity beyond mid-October. In contrast, Red-tailed Hawks showed a broad activity peak from late September through mid-October; peak activity for Northern Goshawks, Golden Eagles, and Prairie Falcons did not occur until mid-October; and peak activity for Rough-legged Hawks and Bald Eagles did not occur until late October.

For many species, different age classes also showed significant variation in passage timing, with median passage dates for immature birds up to 18 days earlier than for adults of the same species (Table 3).

AGE RATIOS

Among 10 species that show sufficient age-related plumage variation to allow for in-flight differentiation of immature and adult birds, identified adults were roughly twice as common as identified immatures for four species (Northern Harrier, Broad-winged Hawk, Red-tailed Hawk, and Bald Eagle) and 20% more common than immatures for Northern Goshawks (Table 4). In contrast, immature and adult Sharp-shinned Hawks were equally abundant, while immature Cooper's Hawks, Ferruginous Hawks, Golden Eagles, and Peregrine Falcons were at least 50% more common than adults of the same species. It may also be noteworthy that Golden Eagles and all species for which the 2002 immature : adult ratios were

below 1 showed lower age ratios in 2002 than in 2001. Low or declining immature : adult ratios may be indicative of poor nesting success and juvenile recruitment.

RESIDENT RAPTORS

Distinguishing resident from migrant raptors can be a difficult challenge and, if not done consistently, may represent a significant confounder with regard to accurate migration monitoring. Hence, at all HWI monitoring sites, observers maintain a journal in which they record observations of resident birds and notes about difficult resident–migrant distinctions. These records provide a means for observers to potentially adjust questionable early-season designations once they discern patterns of resident activity. They may also ultimately provide HWI with a means of assessing the relative skill levels of different observers at distinguishing resident from migrant birds. Most importantly, over time the resident journal will illustrate the nature of the typical resident community so that future observers are better prepared from the start to deal with the challenge of distinguishing resident from migrant birds. As an added bonus, the records may also allow us to track, albeit at a coarse scale, annual variation in the status of the local breeding population.

Observations in 2002 suggested that a family of two adult and two immature Red-tailed Hawks occupied a territory to the south of the count site where a likely nest was located in an aspen not far from the main access road. This family included two distinctive, rufous-morph birds: one adult and one immature. At least one or two additional families of light-morph birds likely nested to the north of the count site near the southern border of the Bridger-Teton National Forest. There also appeared to be at least one resident, extended family group of Golden Eagles, consisting of two adults, a subadult, and at least one juvenile bird. Other individual adult birds likely wandered into the area on several occasions, but a single dominant family group appeared to be the norm in the area. At least one light-morph adult red-tail and the family of Golden Eagles were still in the area when our observations ceased in late October, but the immature red-tails probably vacated the area by mid-October.

A pair of American Kestrels was seen regularly near the count site through early-to mid-October. Similarly, at least five local Turkey Vultures cruised the ridgeline regularly during September, but then vacated the area. It also appeared that at least one pair of adult Sharp-shinned Hawks resided in the area, with intermittent sightings recorded through the third week of October. Two observations each of an apparently local adult Cooper's Hawk and an immature Northern Goshawk in September, and four scattered observations of an adult Prairie Falcon between late September and late October suggested that these species also may have nested somewhere nearby. In contrast, at least five adult Bald Eagles were regularly seen hunting in the valley below, but not until late October, suggesting that these birds had simply moved in for the winter.

CONCLUSIONS

Although a 12-day gap in coverage due to wildfire-related access restrictions compromised our first attempt at a full-season count, our 2002 effort unequivocally confirmed that the Commissary Ridge flight is worthy of long-term monitoring. Despite the 12-day gap, which probably caused us to miss at least 300–500 migrants (see Figure 5), the total count ranked favorably and the overall passage rate ranked high among 10 other comparable efforts in the western U.S. (Table 5). Of particular interest are the relatively high counts of Golden Eagles (third highest) and Bald Eagles (second highest). Thus, our expectations based on prior exploratory work were well met and, subject to sufficient funding, HWI now intends to move ahead with plans to develop the project into a long-term endeavor, including hopes of initiating a banding program at the site in 2003.

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Table 1. Observation effort and fall-migration counts and passage rates by raptor species at Commissary Ridge, Wyoming: 2001–2002.

	2001	2002	% CHANGE	2001	2002	% CHANGE
Start date	2-Sep	27-Aug				
End date	22-Oct	29-Oct				
Observation days	22	45	+105			
Observation hours	145.88	322.67	+121			
SPECIES	RAPTOR COUNTS			RAPTORS / 100 HOURS		
Turkey Vulture	67	97	+45	45.9	30.1	-35
Osprey	16	11	-31	11.0	3.4	-69
Northern Harrier	40	32	-20	27.4	9.9	-64
Sharp-shinned Hawk	303	675	+123	207.7	209.2	+1
Cooper's Hawk	256	409	+60	175.5	126.8	-28
Northern Goshawk	11	21	+91	7.5	6.5	-14
Unknown small accipiter	11	78	+609	7.5	24.2	+221
Unknown large accipiter	4	6	+50	2.7	1.9	-32
Unknown accipiter	29	16	-45	19.9	5.0	-75
TOTAL ACCIPITERS	614	1205	+96	420.9	373.4	-11
Broad-winged Hawk	1	8	+700	0.7	2.5	+262
Swainson's Hawk	18	82	+356	12.3	25.4	+106
Red-tailed Hawk	323	823	+155	221.4	255.1	+15
Ferruginous Hawk	7	6	-14	4.8	1.9	-61
Rough-legged Hawk	20	5	-75	13.7	1.5	-89
Unidentified buteo	19	17	-11	13.0	5.3	-60
TOTAL BUTEOS	388	941	+143	266.0	291.6	+10
Golden Eagle	279	352	+26	191.3	109.1	-43
Bald Eagle	72	233	+224	49.4	72.2	+46
Unidentified eagle	5	10	+100	3.4	3.1	-10
TOTAL EAGLES	356	595	+67	244.0	184.4	-24
American Kestrel	166	258	+55	113.8	80.0	-30
Merlin	7	9	+29	4.8	2.8	-42
Prairie Falcon	1	6	+500	0.7	1.9	+171
Peregrine Falcon	5	3	-40	3.4	0.9	-73
Unknown small falcon	2	0	-100	1.4	0.0	-100
Unknown large falcon	5	0	-100	3.4	0.0	-100
Unknown falcon	0	2	–	0.0	0.6	–
TOTAL FALCONS	186	278	+49	127.5	86.2	-32
Unidentified raptor	19	38	+100	13.0	11.8	-10
GRAND TOTAL	1686	3197	+90	1155.7	990.8	-14

Table 2. First and last observed, bulk passage, and median passage dates by species for the fall raptor migration at Commissary Ridge, Wyoming: 2002.

Species	First Observed	Last Observed	Bulk Passage Dates[1]	Median Passage Date[2]
Turkey Vulture	28-Aug	12-Oct	14-Sep – 27-Sep	24-Sep
Osprey	14-Sep	14-Oct	16-Sep – 7-Oct	21-Sep
Northern Harrier	11-Sep	18-Oct	12-Sep – 9-Oct	23-Sep
Sharp-shinned Hawk	27-Aug	27-Oct	15-Sep – 15-Oct	26-Sep
Cooper's Hawk	27-Aug	27-Oct	14-Sep – 6-Oct	24-Sep
Northern Goshawk	14-Sep	27-Oct	19-Sep – 20-Oct	6-Oct
Broad-winged Hawk	22-Sep	26-Sep	22-Sep – 26-Sep	24-Sep
Swainson's Hawk	11-Sep	30-Sep	16-Sep – 30-Sep	28-Sep
Red-tailed Hawk	27-Aug	27-Oct	17-Sep – 21-Oct	7-Oct
Ferruginous Hawk	19-Sep	25-Oct	19-Sep – 25-Oct	20-Sep
Rough-legged Hawk	14-Oct	25-Oct	14-Oct – 25-Oct	21-Oct
Golden Eagle	28-Aug	27-Oct	24-Sep – 21-Oct	10-Oct
Bald Eagle	22-Sep	27-Oct	9-Oct – 27-Oct	17-Oct
American Kestrel	27-Aug	15-Oct	14-Sep – 6-Oct	24-Sep
Merlin	22-Sep	13-Oct	22-Sep – 13-Oct	25-Sep
Prairie Falcon	20-Sep	9-Oct	20-Sep – 9-Oct	24-Sep
Peregrine Falcon	13-Sep	22-Sep	–	–
Total	27-Aug	27-Oct	16-Sep – 20-Oct	27-Sep

[1] Dates between which the central 80% of the flight passed the lookout; calculated only for species with a total count ≥5 birds.

[2] Date by which 50% of the flight had passed the lookout; calculated only for species with a total count ≥5 birds.

Table 3. Fall-migration median passage dates by age classes for selected raptor species at Commissary Ridge, Wyoming: 2002.

Species	Immature/Subadult	Adult
Northern Harrier	26-Sep	26-Sep
Sharp-shinned Hawk	21-Sep	9-Oct
Cooper's Hawk	21-Sep	25-Sep
Northern Goshawk	23-Sep	10-Oct
Red-tailed Hawk	25-Sep	10-Oct
Golden Eagle	10-Oct	12-Oct
Bald Eagle	16-Oct	17-Oct

Note: Median passage dates are dates by which 50% of the flight had passed the lookout; calculated only for species with age-specific total counts of ≥5 birds.

Table 4. Annual fall-migration counts by age classes and immature : adult ratios for selected raptor species at Commissary Ridge, Wyoming: 2001–2002.

	Total and Age-classified Counts						% Unknown Age		Imm. : Adult Ratio	
	2001			2002						
	Total	Imm.	Adult	Total	Imm.	Adult	2001	2002	2001	2002
Northern Harrier	40	10	13	32	5	10	43	53	0.8	0.5
Sharp-shinned Hawk	303	84	121	675	220	213	32	36	0.7	1.0
Cooper's Hawk	256	41	133	409	163	109	32	33	0.3	1.5
Northern Goshawk	11	6	3	21	8	10	18	14	2.0	0.8
Broad-winged Hawk	1	0	0	8	2	5	100	13	–	0.4
Red-tailed Hawk	323	102	146	823	212	411	23	24	0.7	0.5
Ferruginous Hawk	7	3	4	6	3	2	0	17	0.8	1.5
Golden Eagle[1]	279	189	63	352	172	117	10	18	3.0	1.5
Bald Eagle[1]	72	37	31	233	75	158	6	0	1.2	0.5
Peregrine Falcon	5	0	3	3	2	0	40	33	0.0	≥2

[1] For Golden and Bald Eagles, counts of immature birds include all juvenile and subadult plumage classes (see Appendix A).

Table 5. Combined-species, fall raptor-migration counts and passage rates (migrants counted per 100 hours of observation) at Commissary Ridge, Wyoming and 10 other long-term (5–20 yrs) count sites in the western United States.

	Count		Birds / 100 hrs	
Site	Average	2002	Average	2002
Goshute Mountains, NV	15101	11349	2234.8	1563.9
Lipan Pt, AZ	6572	5023	1294.5	900.6
Boise Ridge, ID	5456	6454	1157.3	1293.4
Manzano Mountains, NM	5180	5040	1031.4	972.0
Wellsville Mountains, UT	3645	–	1020.0	–
Commissary Ridge, WY	**–**	**3197**	**–**	**990.8**
Yaki Point, AZ	5043	5667	945.8	967.6
Bridger Mountains, MT	2576	2034	832.4	556.0
Bonney Butte, OR	2718	1922	805.7	453.7
Mt. Lorette, Alberta	4225	–	656.7	–
Chelan Ridge, WA	2464	2565	559.4	522.1

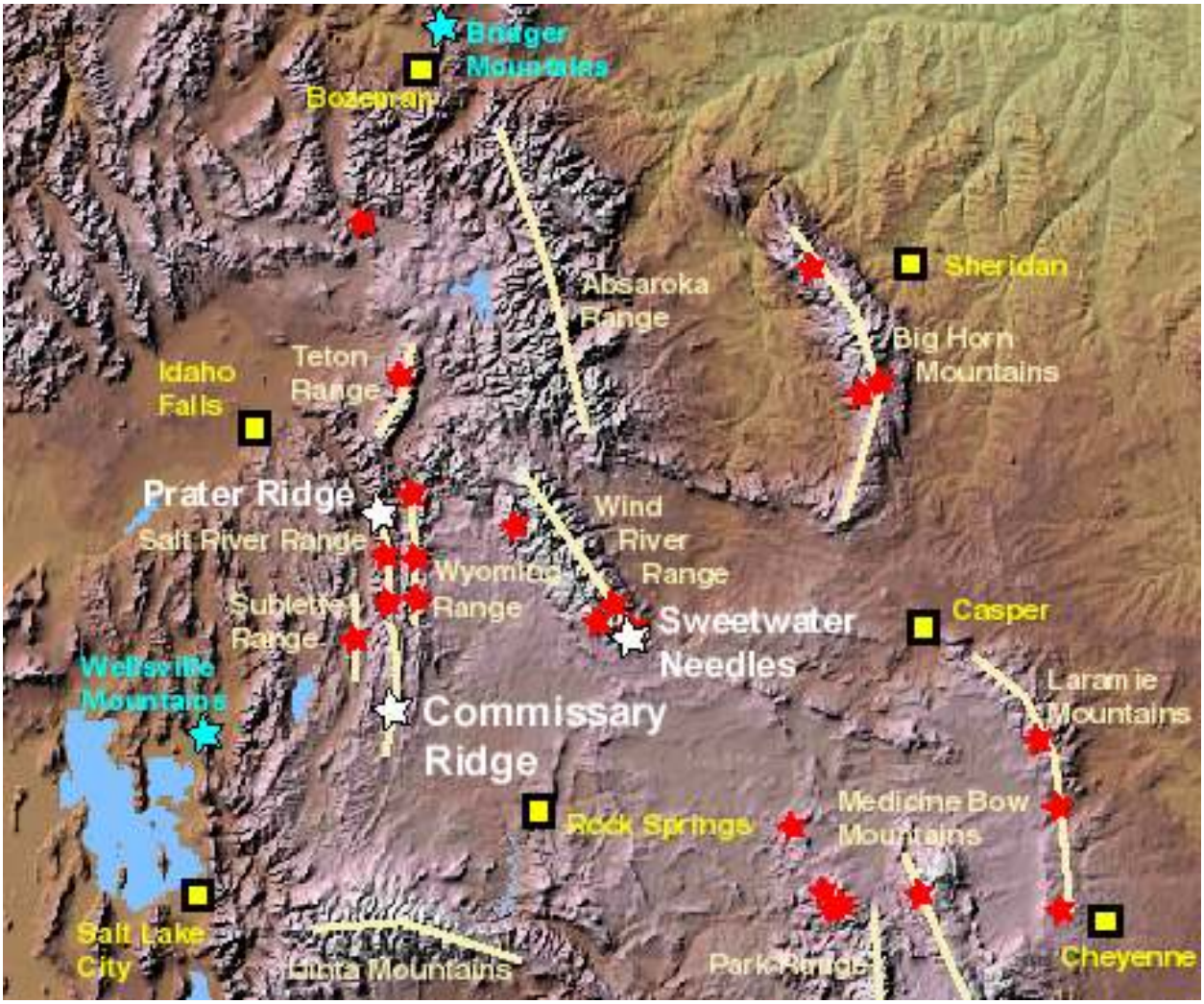
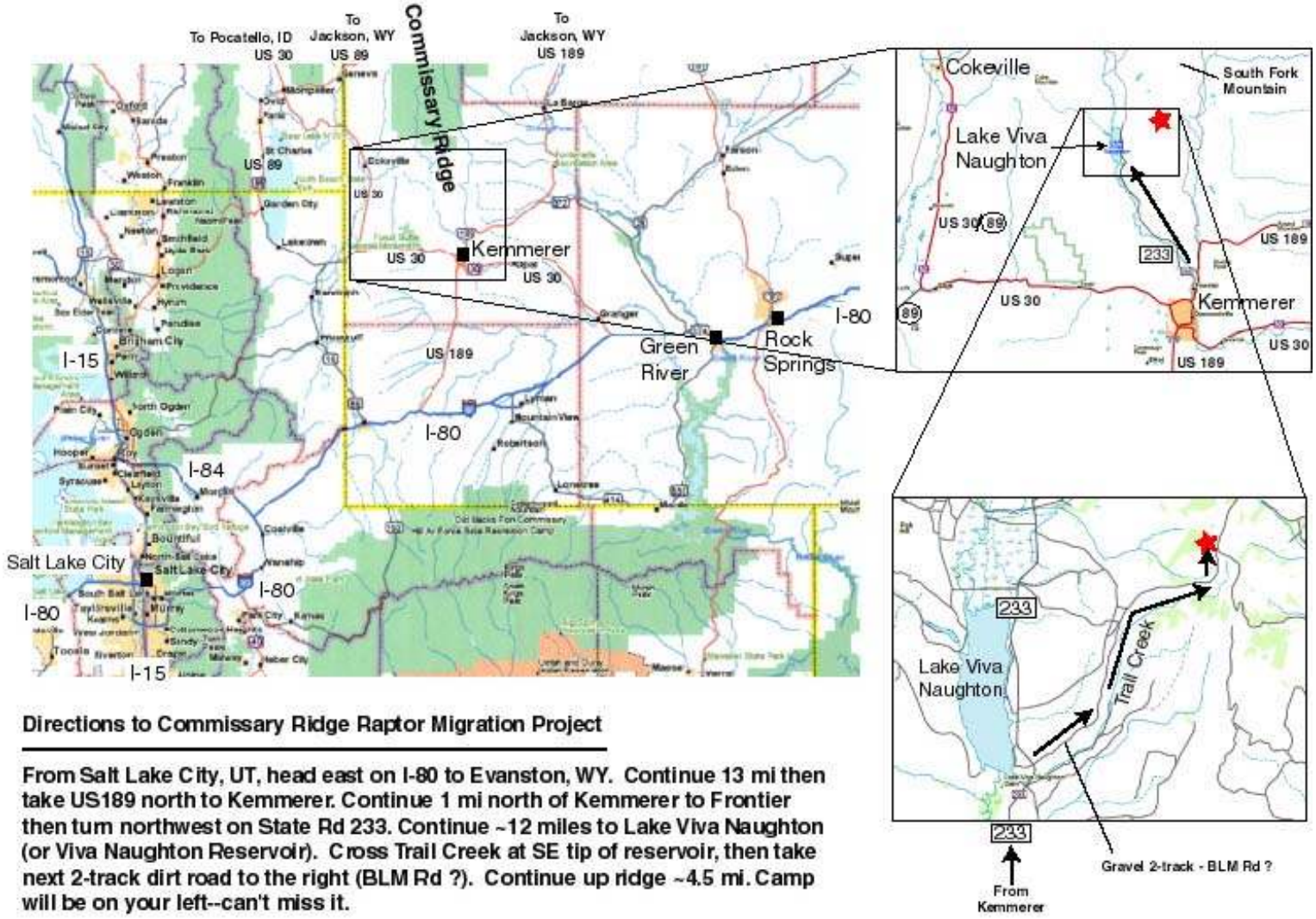


Figure 1. Location of Commissary Ridge Raptor Migration Project site in southwestern Wyoming. Other white stars indicate sites sampled in 2000 and 2001. Red stars indicate other sites sampled in 2000 only. Blue stars indicate other nearby HWI migration count sites in Utah and Montana.



Directions to Commissary Ridge Raptor Migration Project

From Salt Lake City, UT, head east on I-80 to Evanston, WY. Continue 13 mi then take US189 north to Kemmerer. Continue 1 mi north of Kemmerer to Frontier then turn northwest on State Rd 233. Continue ~12 miles to Lake Viva Naughton (or Viva Naughton Reservoir). Cross Trail Creek at SE tip of reservoir, then take next 2-track dirt road to the right (BLM Rd ?). Continue up ridge ~4.5 mi. Camp will be on your left--can't miss it.

From Rock Springs, WY, head west on I-80 37 mi, then take US30 northwest to Kemmerer. Continue as above.
From Idaho, proceed to Pocatello then take I-15 south to US30. Proceed southeast on US 30 to Kemmerer. Continue as above.

Figure 2. Directions for accessing the Commissary Ridge Raptor Migration Project site in southwestern Wyoming.

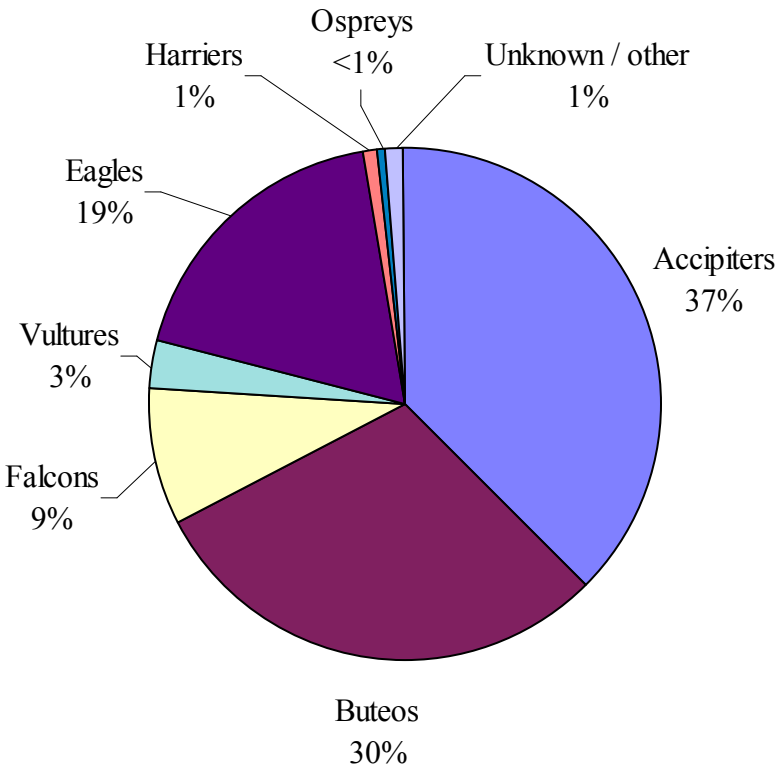


Figure 3. Composition by major species groups of the fall raptor migration at Commissary Ridge, Wyoming: 2002.

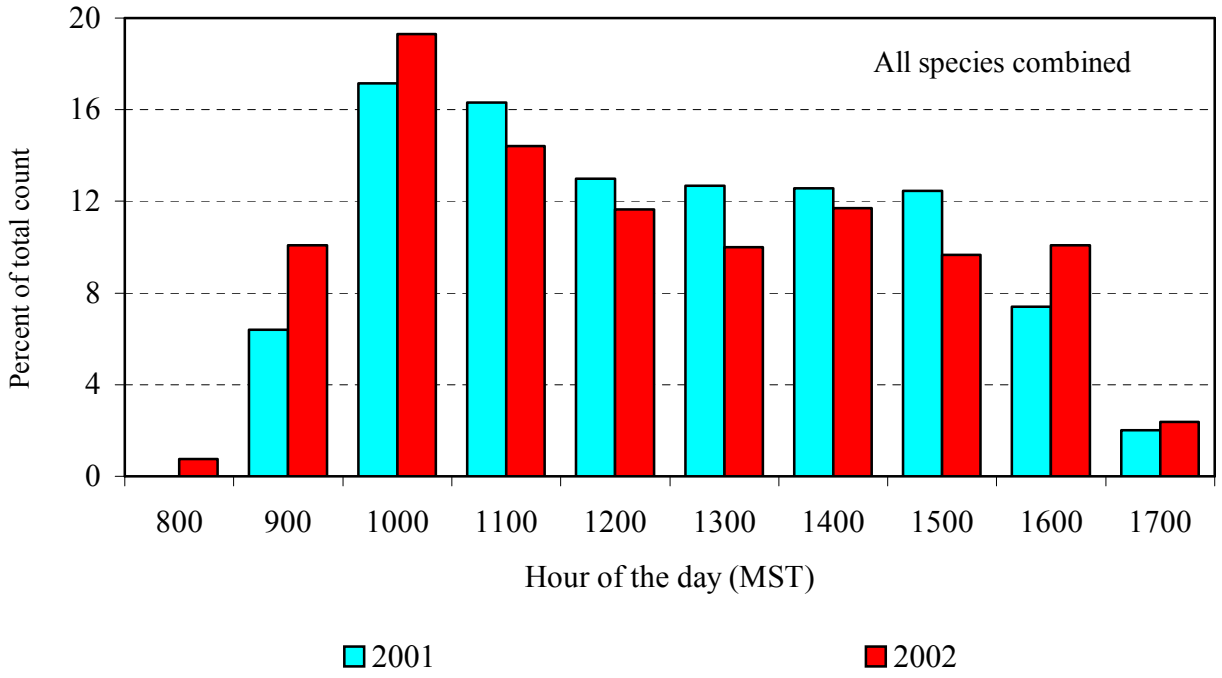


Figure 4. Daily rhythm of the fall raptor migration at Commissary Ridge, Wyoming: 2001–2002.

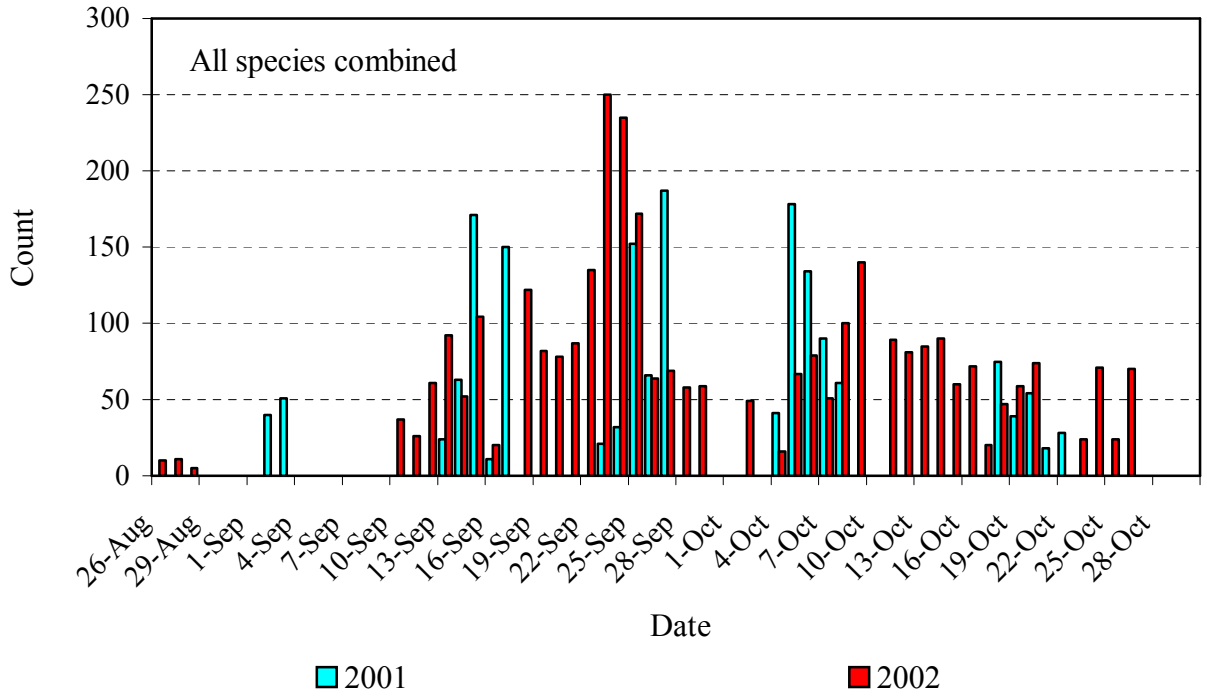


Figure 5. Combined-species seasonal pattern of the fall raptor migration at Commissary Ridge, Wyoming: 2001–2002.

Appendix A. Common and scientific names, species codes, and regularly applied age, sex, and color-morph classifications for all raptors observed on migration at Commissary Ridge, Wyoming.

Common Name	Scientific Name	Species Code	Age[1]	Sex[2]	Color Morph[3]
Turkey Vulture	*Cathartes aura*	TV	U	U	NA
Osprey	*Pandion haliaetus*	OS	U	U	NA
Northern Harrier	*Circus cyaneus*	NH	A I Br U	M F U	NA
Sharp-shinned Hawk	*Accipiter striatus*	SS	A I U	U	NA
Cooper's Hawk	*Accipiter cooperii*	CH	A I U	U	NA
Northern Goshawk	*Accipiter gentilis*	NG	A I U	U	NA
Unknown small accipiter	*A. striatus* or *cooperii*	SA	U	U	NA
Unknown large accipiter	*A. cooperii* or *gentilis*	LA	U	U	NA
Unknown accipiter	*Accipiter* spp.	UA	U	U	NA
Broad-winged Hawk	*Buteo platypterus*	BW	A I U	U	D L U
Swanson's Hawk	*Buteo swainsoni*	SW	U	U	D L U
Red-tailed Hawk	*Buteo jamaicensis*	RT	A I U	U	D L U
Ferruginous Hawk	*Buteo regalis*	FH	A I U	U	D L U
Rough-legged Hawk	*Buteo lagopus*	RL	U	U	D L U
Unknown buteo	*Buteo* spp.	UB	U	U	D L U
Golden Eagle	*Aquila chrysaetos*	GE	I, S, NA, A, U[4]	U	NA
Bald Eagle	*Haliaeetus leucocephalus*	BE	I, S1, S2, NA, A, U[5]	U	NA
Unknown eagle	*Aquila* or *Haliaeetus spp.*	UE	U	U	NA
American Kestrel	*Falco sparverius*	AK	U	M F U	NA
Merlin	*Falco columbarius*	ML	AM Br	AM U	NA
Prairie Falcon	*Falco mexicanus*	PR	U	U	NA
Peregrine Falcon	*Falco peregrinus*	PG	A I U	U	NA
Unknown small falcon	*F. sparverius* or *columbarius*	SF	U	U	NA
Unknown large falcon	*F. mexicanus* or *peregrinus*	LF	U	U	NA
Unknown falcon	*Falco* spp.	UF	U	U	NA
Unknown raptor	Falconiformes	UU	U	U	NA

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

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

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

[4] Golden Eagle age codes: I = Immature: juvenile or first-year bird, bold white wing patch visible below, bold white in tail, no molt; S = Subadult: white wing patch variable or absent, obvious white in tail and molt or tawny bar visible on upper wing; NA = Not adult: unknown age immature/subadult; A = Adult: no white in wings or tail; U = Unknown.

[5] Bald Eagle age codes: I = Immature: juvenile or first-year bird, dark breast and tawny belly; S1 = young Subadult: Basic I and II plumages, light belly, upside-down triangle on back; S2 = older Subadult: Basic III plumage, head mostly white with osprey-like dark eye line and dark band on tail; NA = Not adult: unknown age immature/subadult; A = Adult: includes near adult with dark flecks in head and dark tail tip, and adult with white head and tail; U = Unknown.

Appendix B. Daily observation effort, visitor disturbance ratings, weather records, and flight summaries for the fall raptor migration at Commissary Ridge, Wyoming: 2002.

Date	Obs. Hours	Obsrvr / Hour[1]	Median Visitor Disturb[2]	Predominant Weather[3]	Wind Speed (kph)[1]	Wind Direction	Temp (°C)[1]	Barom. Press. (in Hg)[1]	Median Thermal Lift[4]	Visib. East (km)[1]	Visib. West (km)[1]	Median Flight Distance[5]	Birds / Hour
27-Aug	8.00	1.0	0	mc, ts	22.3	ne, var	18.9	30.33	3	56	57	0	1.3
28-Aug	7.00	1.0	0	pc-mc	24.6	ne-e	18.6	30.39	4	73	75	0	1.6
29-Aug	5.00	1.0	0	pc-mc, ts/rain	12.6	ene, sw	18.4	30.33	3	44	66	2	1.0
30-Aug	0.00												
31-Aug	0.00												
1-Sep	0.00												
2-Sep	0.00												
3-Sep	0.00												
4-Sep	0.00			wildfire closure									
5-Sep	0.00												
6-Sep	0.00												
7-Sep	0.00												
8-Sep	0.00												
9-Sep	0.00												
10-Sep	0.00												
11-Sep	8.00	1.0	0	mc-ovc	23.0	w-wnw	16.9	30.24	4	51	37	0	4.6
12-Sep	6.25	1.0	0	ovc, PM rain	22.6	wnw	15.4	30.24	4	30	18	0	4.2
13-Sep	9.00	1.6	0	clr-pc	28.6	wnw	18.7	30.20	3	76	91	0	6.8
14-Sep	8.50	3.0	0	clr	11.6	wnw	20.4	30.44	2	73	89	3	10.8
15-Sep	7.50	2.0	0	ovc-pc	14.9	se, wnw	20.6	30.43	2	64	98	0	6.9
16-Sep	9.00	2.0	0	pc-mc/haze	17.9	s-sw, wnw	21.3	30.14	2	72	77	0	11.6
17-Sep	2.50	2.0	0	ovc, fog/haze	30.5	wnw	8.5	29.97	4	14	23	0	8.0
18-Sep	0.00			snow									
19-Sep	9.00	1.0	0	mc-clr	24.8	0	13.9	30.23	3	75	78	1	13.6
20-Sep	8.00	1.0	0	mc-pc	24.9	wnw	14.3	30.25	3	69	93	0	10.3
21-Sep	8.00	1.0	0	clr-mc	27.2	wnw	13.1	30.28	3	75	75	1	9.8
22-Sep	9.00	1.0	0	clr	28.7	wnw	14.6	30.37	4	77	100	1	9.7
23-Sep	9.25	1.6	0	clr	23.2	wnw	17.6	30.36	2	87	100	0	14.6
24-Sep	8.75	2.0	0	pc	37.6	wnw	16.8	30.21	3	81	96	4	28.6
25-Sep	8.00	2.0	0	pc-mc	39.1	wnw	17.1	30.08	3	73	93	1	29.4
26-Sep	8.00	2.0	0	clr-mc	30.1	wnw	15.8	30.05	3	68	77	6	21.5
27-Sep	7.25	1.7	0	mc-ovc	32.0	wnw	15.7	29.85	4	55	68	1	8.8
28-Sep	8.00	2.0	0	mc-ovc, rain	13.7	e-s, wsw-wnw	14.6	30.04	3	63	78	3	8.6
29-Sep	3.50	2.0	0	mc-ovc, rain	33.8	wnw	14.3	29.97	4	81	88	0	16.6
30-Sep	3.75	1.8	0	ovc, scat snow	32.0	wnw	7.6	29.95	4	48	58	0	15.7
1-Oct	0.00			snow									
2-Oct	0.00			mc									
3-Oct	7.00	1.0	0	pc-mc	29.0	var, w	7.1	29.85	3	36	46	0	7.0
4-Oct	0.00			fog									
5-Oct	5.00	2.0	0	ovc, blw snow	50.2	w	5.2	30.07	4	34	22	0	3.2
6-Oct	8.00	2.0	0	mc-pc	36.7	wnw	8.3	30.37	3	69	98	0	8.4
7-Oct	8.00	2.0	0	clr	31.9	wnw	11.0	30.28	2	83	97	0	9.9
8-Oct	8.50	1.7	0	clr	28.5	wnw	11.5	30.16	2	88	100	3	6.0
9-Oct	8.25	2.0	0	clr	33.9	wnw	11.0	30.18	2	92	98	0	12.1
10-Oct	8.25	2.0	0	mc-ovc	35.8	wnw	14.2	30.05	4	82	99	0	17.0
11-Oct	0.00												
12-Oct	8.00	2.0	0	clr	22.9	wnw	7.9	30.49	2	66	89	2	11.1
13-Oct	8.25	2.0	0	clr	28.6	w-wnw	11.8	30.38	2	86	100	3	9.8
14-Oct	8.25	2.0	0	clr	26.2	w	10.4	30.28	2	83	99	1	10.3
15-Oct	8.25	2.0	0	clr	33.8	w	12.4	30.18	2	85	99	0	10.9
16-Oct	7.50	2.0	0	pc	20.6	w-wnw	12.6	30.13	2	59	94	1	8.0

Appendix B. continued

Date	Obs. Hours	Obsrvr / Hour[1]	Median Visitor Disturb[2]	Predominant Weather[3]	Wind Speed (kph)[1]	Wind Direction	Temp (°C)[1]	Barom. Press. (in Hg)[1]	Median Thermal Lift[4]	Visib. East (km)[1]	Visib. West (km)[1]	Median Flight Distance[5]	Birds / Hour
17-Oct	8.00	2.1	0	clr	30.8	w	12.1	30.05	2	91	98	0	9.0
18-Oct	7.50	2.3	0	clr-pc, haze	26.1	w	13.0	30.06	2	69	76	0	2.7
19-Oct	7.50	2.6	0	clr	24.1	w	12.4	30.14	2	91	100	0	6.3
20-Oct	7.50	1.5	0	pc-mc	28.9	w	12.1	30.06	2	93	98	0	7.9
21-Oct	7.75	2.0	0	mc-pc	12.9	e, sw-wnw	11.5	30.05	2	89	98	0	9.5
22-Oct	1.67	1.0	0	ovc, snow	28.0	e	4.0	30.03	4	28	5	0	0.0
23-Oct	0.00			fog /snow									
24-Oct	4.50	1.0	0	ovc, AM fog/snow	25.1	w	3.6	29.90	4	16	6	0	5.3
25-Oct	8.25	1.0	0	mc-ovc	8.0	wnw	4.8	29.99	3	66	80	0	8.6
26-Oct	7.25	1.0	0	pc-mc, haze	18.6	ene-ese	5.6	29.91	3	74	73	0	3.3
27-Oct	7.75	1.0	0	clr	28.9	w	5.2	29.97	3	84	96	0	9.0
28-Oct	0.00			fog /snow									
29-Oct	0.50	1.0	0	ovc, snow	56.3	e	0.5	29.73	4	3	6	0	0.0
30-Oct	0.00			fog /snow									
31-Oct	0.00			fog /snow									

[1] Average of hourly records.

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

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

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

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

Appendix C. Fall raptor-migration counts by day and species at Commissary Ridge, Wyoming: 2002.

		Species[1]																											
Date	Hours	TV	OS	NH	SS	CH	NG	SA	LA	UA	BW	SW	RT	FH	RL	UB	GE	BE	UE	AK	ML	PR	PG	SF	LF	UF	UU	Total	/ Hour
27-Aug	8.00	0	0	0	1	1	0	0	0	0	0	0	3	0	0	1	0	0	0	3	0	0	0	0	0	0	1	10	1.3
28-Aug	7.00	4	0	0	2	0	0	0	0	0	0	0	1	0	0	1	3	0	0	0	0	0	0	0	0	0	0	11	1.6
29-Aug	5.00	0	0	0	0	1	0	0	0	0	0	0	3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	5	1.0
30-Aug	0.00																												
31-Aug	0.00																												
01-Sep	0.00																												
02-Sep	0.00																												
03-Sep	0.00																												
04-Sep	0.00																												
05-Sep	0.00			wildfire closure																									
06-Sep	0.00																												
07-Sep	0.00																												
08-Sep	0.00																												
09-Sep	0.00																												
10-Sep	0.00																												
11-Sep	8.00	0	0	2	7	10	0	3	0	0	0	1	6	0	0	0	1	0	0	7	0	0	0	0	0	0	0	37	4.6
12-Sep	6.25	2	0	2	4	9	0	2	0	0	0	0	4	0	0	0	0	0	0	3	0	0	0	0	0	0	0	26	4.2
13-Sep	9.00	3	0	1	14	14	0	9	0	0	0	0	10	0	0	1	0	0	0	8	0	0	1	0	0	0	0	61	6.8
14-Sep	8.50	4	1	1	27	22	1	7	0	2	0	0	8	0	0	3	3	0	0	12	0	0	0	0	0	0	1	92	10.8
15-Sep	7.50	4	0	1	25	7	0	1	0	1	0	0	5	0	0	1	3	0	0	4	0	0	0	0	0	0	0	52	6.9
16-Sep	9.00	0	3	0	29	16	1	0	0	0	0	8	36	0	0	0	2	0	0	6	0	0	1	0	0	0	2	104	11.6
17-Sep	2.50	0	0	0	8	0	0	0	0	0	0	1	10	0	0	0	1	0	0	0	0	0	0	0	0	0	0	20	8.0
18-Sep	0.00	No observations – inclement weather																											
19-Sep	9.00	2	0	2	29	36	1	5	0	0	0	6	25	2	0	2	4	0	0	8	0	0	0	0	0	0	0	122	13.6
20-Sep	8.00	0	1	2	21	26	0	4	1	0	0	3	13	1	0	0	3	0	0	6	0	1	0	0	0	0	0	82	10.3
21-Sep	8.00	2	1	1	14	26	0	2	0	0	0	3	20	0	0	0	2	0	0	7	0	0	0	0	0	0	0	78	9.8
22-Sep	9.00	1	0	1	24	20	0	6	1	0	1	0	14	0	0	0	4	1	0	11	1	1	1	0	0	0	0	87	9.7
23-Sep	9.25	7	0	3	21	13	2	3	0	1	1	2	24	0	0	1	7	0	0	45	3	0	0	0	0	0	2	135	14.6
24-Sep	8.75	30	0	0	56	44	0	7	0	4	4	12	49	0	0	0	15	0	0	25	0	1	0	0	0	0	3	250	28.6
25-Sep	8.00	12	0	1	44	47	0	5	0	1	0	1	59	0	0	1	5	0	0	56	1	0	0	0	0	0	2	235	29.4
26-Sep	8.00	16	1	3	36	31	1	3	1	2	2	2	38	0	0	2	5	0	0	23	0	0	0	0	0	0	6	172	21.5
27-Sep	7.25	3	1	0	17	13	1	4	0	0	0	1	11	0	0	0	8	2	0	3	0	0	0	0	0	0	0	64	8.8
28-Sep	8.00	6	0	0	11	14	1	1	0	0	0	2	9	1	0	0	18	5	0	1	0	0	0	0	0	0	0	69	8.6
29-Sep	3.50	0	1	1	33	10	0	1	0	0	0	0	9	0	0	0	2	0	0	1	0	0	0	0	0	0	0	58	16.6
30-Sep	3.75	0	0	0	10	1	1	0	0	0	0	40	2	0	0	0	5	0	0	0	0	0	0	0	0	0	0	59	15.7
01-Oct	0.00	No observations – inclement weather																											

Appendix C. continued

		Species[1]																										
Date	Hours	TV	OS	NH	SS	CH	NG	SA	LA	UA	BW	SW	RT	FH	RL	UB	GE	BE	UE	AK	ML	PR	PG	SF	LF	UF	UU	Total	/ Hour
02-Oct	0.00	No observations – inclement weather																										
03-Oct	7.00	0	0	4	10	1	0	1	3	0	0	0	19	0	0	1	6	0	0	1	0	0	0	0	0	0	3	49	7.0
04-Oct	0.00	No observations – inclement weather																										
05-Oct	5.00	0	0	0	6	1	0	0	0	0	0	0	5	0	0	0	3	0	0	1	0	0	0	0	0	0	0	16	3.2
06-Oct	8.00	0	0	1	5	10	2	0	0	0	0	0	25	0	0	0	15	2	0	3	2	0	0	0	0	1	1	67	8.4
07-Oct	8.00	0	1	1	16	4	0	1	0	0	0	0	27	0	0	1	15	8	0	4	0	1	0	0	0	0	0	79	9.9
08-Oct	8.50	0	0	1	9	2	0	1	0	3	0	0	10	0	0	0	10	4	0	9	0	0	0	0	0	0	2	51	6.0
09-Oct	8.25	0	0	1	26	6	0	2	0	1	0	0	27	0	0	0	16	13	0	3	1	2	0	0	0	0	2	100	12.1
10-Oct	8.25	0	0	0	34	5	3	1	0	0	0	0	43	0	0	0	28	16	3	3	0	0	0	0	0	0	4	140	17.0
11-Oct	0.00	No observations – inclement weather																										
12-Oct	8.00	1	0	0	16	3	0	3	0	0	0	0	37	0	0	0	18	10	0	0	0	0	0	0	0	0	1	89	11.1
13-Oct	8.25	0	0	1	23	4	0	0	0	0	0	0	33	0	0	0	9	6	0	3	1	0	0	0	0	0	1	81	9.8
14-Oct	8.25	0	1	0	17	1	0	2	0	0	0	0	34	0	1	0	13	16	0	0	0	0	0	0	0	0	0	85	10.3
15-Oct	8.25	0	0	1	14	2	2	1	0	0	0	0	37	0	0	0	15	16	0	1	0	0	0	0	0	1	0	90	10.9
16-Oct	7.50	0	0	0	17	1	0	2	0	0	0	0	29	0	0	0	5	6	0	0	0	0	0	0	0	0	0	60	8.0
17-Oct	8.00	0	0	0	12	3	1	0	0	0	0	0	14	1	0	1	20	18	2	0	0	0	0	0	0	0	0	72	9.0
18-Oct	7.50	0	0	1	2	0	0	0	0	0	0	0	4	0	0	0	7	5	0	0	0	0	0	0	0	0	1	20	2.7
19-Oct	7.50	0	0	0	5	3	0	0	0	1	0	0	11	0	0	0	16	10	0	0	0	0	0	0	0	0	1	47	6.3
20-Oct	7.50	0	0	0	6	0	2	0	0	0	0	0	21	0	1	0	13	16	0	0	0	0	0	0	0	0	0	59	7.9
21-Oct	7.75	0	0	0	11	0	1	1	0	0	0	0	27	0	1	0	19	12	1	0	0	0	0	0	0	0	1	74	9.5
22-Oct	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	0	0.0
23-Oct	0.00	No observations – inclement weather																										
24-Oct	4.50	0	0	0	2	0	0	0	0	0	0	0	7	0	0	0	4	10	0	0	0	0	0	0	0	0	1	24	5.3
25-Oct	8.25	0	0	0	4	1	0	0	0	0	0	0	37	1	2	0	6	20	0	0	0	0	0	0	0	0	0	71	8.6
26-Oct	7.25	0	0	0	2	0	0	0	0	0	0	0	6	0	0	1	3	6	3	0	0	0	0	0	0	0	3	24	3.3
27-Oct	7.75	0	0	0	5	1	1	0	0	0	0	0	11	0	0	0	20	31	1	0	0	0	0	0	0	0	0	70	9.0
28-Oct	0.00	No observations – inclement weather																										
29-Oct	0.50	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	0	0.0
30-Oct	0.00	No observations – inclement weather																										
31-Oct	0.00	No observations – inclement weather																										
Total	322.67	97	11	32	675	409	21	78	6	16	8	82	823	6	5	17	352	233	10	258	9	6	3	0	0	2	38	3197	9.9

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