FALL 2019 RAPTOR MIGRATION STUDY IN THE BRIDGER MOUNTAINS, MONTANA

(Photo by Kyle Dudgeon)

Sacajawea Audubon Society, Bozeman, MT
&
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INTRODUCTION

The Bridger Mountains Hawk Watch Project in southwestern Montana is an ongoing effort to monitor long-term population trends of raptors using this portion of the Rocky Mountain Flyway (Omland and Hoffman 1996, Hoffman and Smith 2003, Smith et al. 2008a). Fred Tilly first documented this concentrated autumn raptor flyway in the Bridgers in 1987. As a result of Tilly's discovery, HawkWatch International (HWI) initiated a partial-season count at Tilly's original observation point in 1991, with standardized, full-season annual monitoring commencing in 1992. Beginning in 2009, Montana Audubon (MA) took the lead in funding and coordinating these annual counts. In 2017, primary responsibility for conducting the count was transferred to Sacajawea Audubon Society (SAS, Audubon chapter based in Bozeman, MT). HWI has continued to partner with either MA or SAS each year beginning in 2009, primarily to assist in compiling the data and preparing the tables and graphs for each year's annual report.

This flyway is renowned for large numbers of migrating Golden Eagles (see Appendix A for scientific names of all raptor species observed at this site). To date, 18 raptor species have been documented migrating along the Bridger Ridge, with total autumn counts each year ranging between 2,000 and 3,500 migrants. This report summarizes count results for the 2019 season, the 28th consecutive full-season autumn count of migratory raptors at this site.

The Bridger Project is one of eight long-term, annual fall migration counts conducted or co-sponsored by HWI in North America in Fall 2019. In Montana, a total of five annual full-season counts were conducted previously, but in 2019 the Big Belt Mountains' site had only partial-season coverage, and no count was conducted at Nora Ridge. Instead, Raptor View Research Institute conducted an informal count from the trapping blind at their Rogers Pass banding site (approximately 4 km northeast of the Nora Ridge count site). In addition, a new full-season count was initiated at Cut Bank, MT this fall. (The count at this new site yielded 859 migrant raptors of 17 species in 431.5 hours of observation between 1 September and 15 November.)

The primary objective of scientific raptor monitoring efforts in the Bridgers is to document long-term population trends in western North America (Hoffman et al. 2002, Hoffman and Smith 2003, Smith et al. 2008a & b). Raptors serve as important biological indicators of ecosystem health (Bildstein 2001), and long-term monitoring of migrating raptors along concentrated mountaintop flyways (such as the Bridgers) is an efficient, cost-effective method for assessing regional population status and trends of multiple raptor species (Zalles & Bildstein 2000, Bildstein et al. 2008).

STUDY SITE

The Bridger Mountains is an isolated, relatively narrow range that is oriented primarily along a north–south axis. From Sacajawea Peak (2,950 m elevation) the range extends southward for 40 km before ending at Bozeman Pass, 20 km east of Bozeman, Montana. Consistent westerly winds collide with Bridger Ridge's steep west slope, creating predictable orographic lift, thereby attracting a notable abundance and diversity of southbound migrant raptors each fall. The observation site is a helicopter-landing platform atop the Bridger Bowl Ski Area at an elevation of 2,610m (45° 49.022' N, 110° 55.778' W; Fig. 1). The site is situated within the Custer Gallatin National Forest on the crest of Bridger Ridge, about 25 km northeast of Bozeman and 3 km north of Saddle Peak. The helicopter pad is a 5m x 5m concrete platform located approximately 50m north of a ski patrol hut. The Observation Point (OP) is accessed by walking up a primitive dirt road on the east-facing slope of the Bridgers for 4 km (610m

rise in elevation) to the top of the Bridger Bowl Ski Area (designated as "Bridger Lift"), then continuing uphill a few hundred meters along a narrow footpath to the crest of Bridger Ridge, and finally continuing north for 50m to the observation site.

METHODS

Since this project's inception, two well-qualified observers have conducted standardized daily counts of migrating raptors from a designated observation site from late August through late October-early November. In 2019 AR returned to the Bridger Hawk Watch as one of two primary observers (his 3rd consecutive season). AR was accompanied by a second observer (Kyle Dudgeon – "KD") from the first official day of the count (27 August) through 30 September (excepting foul weather days during this period).

Daily observations (weather permitting) were conducted from 27 August through 30 October. Counts typically began at 0900 and ended at 1700 Mountain Standard Time (MST). Observations were aided by 10 X 42 Nikon Monarch 7 binoculars (AR), and Zeiss 10 X 42 Terra ED binoculars (KD). Distant individuals were identified with a 20-60X 86mm Vortex Razor HD spotting scope mounted on a Benro Mach 3 Tripod. The use of a spotting scope allowed for aging a greater proportion of Golden Eagles during the late afternoon hours, when the position of the sun made aging backlit birds extremely difficult. Local volunteers Paulette Epple, Bob Smith and Matt Keefer frequently contributed full days to the hawk watch effort (as did several other expert local birders; see Acknowledgments for a complete list of our 2019 volunteer observers).

The observation site was accessed daily by the observers, either by hiking 4km (with a 610m elevation gain) from the lower parking area, or from the newly-constructed ski patrol hut on the ridge near the observation site, which often served as overnight lodging for the official observers.

As in several previous years, two owl decoys were again employed in 2019 to attract passing migrant raptors; both were elevated about 4m above the ground to increase their visibility to passing raptors. A nearby owl was situated 5m directly to the north of the observation point; it was fastened to a pole which was secured to an upside-down ski patrol sign. This sign was wedged into the rimrock, and large rocks were piled atop the sign which served as a stable base. This set-up also provided easy access to take down the near owl. A more distant owl was situated 600m to the north, at the far (north) end of "Tilly Peak" atop a metal pole that is part of Bridger Bowl's ridge access system. The far owl was erected on 23 August and remained in place until 29 October. The near-owl was erected on 27 August and remained up until the final day of the count (30 October). The near owl was removed to accommodate helicopter landings on 2 and 4 September.

Sharp-shinned Hawk stooping on owl decoy *(K. Dudgeon Photo)*

This year a portable makeshift blind was set up to help conceal the observers from passing migrants (Fig. 1). Downed trees, plywood, a cot and camp table were all covered in camouflage fabric. The

downed trees were held in place with large rocks for stability, and to help break up the silhouette of the observers. This blind likely increased the number of migrants actively harassing our nearby owl decoy.

Figure 1. Portable blind to conceal observers from migrating raptors. (*Photo: Michael Paul Jones)*

The identical protocol used for all western hawk watch sites to conservatively count southbound Turkey Vultures was followed. Specifically, if one or more vulture(s) was detected flying in a southerly direction, only to be seen flying back north shortly thereafter, these individuals were excluded from the day's count.

The observers routinely recorded the following data each day:

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 various age, sex, and color-morph distinctions, and the two-letter codes used for each species).

2. Hour of passage for each migrant; e.g., the 0900-0959 H, etc. (MST).

3. Wind speed and direction, air temperature, percent cloud cover, predominant cloud type(s), precipitation (and type), visibility and a subjective assessment of thermal lift conditions (i.e., excellent, good, fair & poor), assessed every hour on the half-hour.

4. Predominant direction, altitude, and horizontal distance of the migratory flight from the observation

point for each hour.

5. Total minutes observed, and the mean number of observers present during each hour.

6. A subjective visitor-disturbance rating (high, moderate, low, none) was determined for each hour.

7. Observation start and end times for the observers.

In 2019 paper data sheets were used for recording all data in 2019. Hourly raptor count totals were posted on hawkcount.org at the conclusion of the count season. Daily and seasonal Bridger raptor count totals were also posted daily on BBHW website's home page (bmmhw.blogspot.com). Daily and seasonal Bridger raptor count totals were also periodically posted on Sacajawea Audubon Society's website's home page (sacajaweaaudubon.org).

Calculation of "adjusted" (to standardize sampling periods for each raptor species) passage rates (migrant raptors counted per 100 hours of observation) and analysis of trends, updated through 2019, generally followed Hoffman and Smith (2003), using standard linear and quadratic regression statistical techniques. In comparing 2019 data (for each species) with annual means and 95% confidence intervals for all previous seasons, we determined significance when the 2019 value fell outside the 95% confidence interval of the associated mean for the1992-2018 passage rates.

RESULTS AND DISCUSSION

OBSERVATION EFFORT AND WEATHER SUMMARY:

In 2019 the observers conducted counts on 52 of 65 possible days between 27 August and 30 October, for a total of 349.8 observation hours. Total observation hours were 1% below the 1992-2019 mean of 356 (± 21.5) hours. Since 2009 the count has typically run from about 1 September through 5 November, but beginning in 2017 the count start date was advanced 5-6 days to 26-27 August to account for the possibility of a progressively earlier raptor migration, presumably due to climate change (Filippi-Codaccioni et al. 2010, Therrien et al. 2017). This same time frame for the start of the count was followed in 2019; however, the end date was shortened to 30 October, due to severe weather conditions (heavy snowfall and extreme cold) atop the Bridgers.

Inclement weather and/or difficult access prevented observations on 13 days during the 2019 season. In addition, poor weather reduced the total daily observation period to less than four hours on eight additional days. In 2019, the official observers resided atop the Bridger Ridge, providing opportunities to count during brief breaks in inclement weather during long-lasting storms. On seven days the count was started earlier or extended slightly later (hourly observation effort for the 2019 season is provided in Appendix C and at hawkcount.org).

The 2019 season saw multiple long-lasting storms that generally obscured the ridge due to persistent, low-lying clouds, and rain or snow, greatly limiting visibility. These storms occurred 20 - 21 September, 28 September – 1 October and 20 – 21 October. In addition, brief one-day storms occurred on 11 September, and 4, 9, 26 and 28 October.

The first day in which no count was conducted due to inclement weather was on 11 September. (A total of 0.34 inches of rain fell in Bridger Canyon during this weather event.) On 20 September the first prolonged, winter-like storm of the season arrived in the Bridger Range. The storm began with rain in

the morning, but changed to snow by afternoon. By sunset five inches of heavy, wet snow had accumulated at the OP. The approximate snow level was at 7,800 ft elevation on the east side of the ridge. On 21 September an additional 4 inches of snow fell. Heavy snow fell throughout the day. Late in the afternoon the precipitation switched to a wintry mix of graupel, sleet and rain.

During the period 28 September – 1 October, the second major winter storm of the season brought fog and more snow to the Bridger Range. A total of 3.5 inches of fresh snow fell during this storm, and the snow level dropped to 6,500 ft on the east side of Bridger Ridge. The official observer stayed onsite for the majority of this storm, hopeful that it would clear. Unfortunately, stubborn low cloud cover/fog hung on the ridge throughout this 4-day storm.

On 4 October light snow and heavy fog obscured the ridge. Hence, no count was conducted. By the time this storm departed on 5 October, an additional 3.5 inches had accumulated.

On 9 October another winter storm obscured the ridge in fog. This storm started with rain, but upon its conclusion a total of 10 inches of snow had accumulated. This storm brought colder air, dropping the snow level down to the canyon floor.

On 20 – 21 October an additional total of 20 inches of snow fell along the ridge. (Hence, for the remainder of the count season the observer accessed the ridge on skis.)

On 26 October another winter storm brought 4 more inches of snow to Bridger Ridge.

On 28 October the most severe storm of the season descended upon Bridger Ridge. A total of 8 inches of snow fell, and high winds caused the snow to drift, resulting in much deeper snow accumulation in certain areas. There was widespread snow instability beginning near mid-mountain elevations. Hence, the ascent along the trail's upper reaches became quite treacherous. The observer had to carefully select his route to avoid avalanche-prone terrain. The winds were so strong that it took nearly an hour to hike up the last 100m to the hut. (At this point frostbite was a realistic concern, with wind chill dipping to -30F.)

Haze from the McClusky Fire in the Beaverhead – Deerlodge National Forest (to the southwest of the Bridgers) impacted the ridge from the start of the count until 18 September. The 20 – 21 September snowstorm greatly reduced the fire and haze (which had been quite prevalent in the afternoons). Haze from this fire was generally modest, and even at its worst it mostly missed the OP, as the prevailing southwesterly winds generally funneled the smoke to the north through Ross Pass.

FLIGHT SUMMARY:

The fall 2019 raptor migration count tallied 2,579 diurnal raptors of 17 species (Table 1 & Appendices C & D). This is 4% above the 1992-2019 mean of 2,483 (∓ 208). In 2019, species recorded in numbers that were statistically significant and above the long-term mean were: Turkey Vulture, Northern Harrier, Osprey, Sharp-Shinned Hawk, Cooper's Hawk, Broad-winged Hawk, Peregrine Falcon, Prairie Falcon, American Kestrel and Merlin. Raptor species recorded in numbers statistically significant and below the long-term mean were: Bald Eagle, Golden Eagle and Rough-legged Hawk. The 2019 Red-tailed Hawk and Northern Goshawk counts were close to the long-term mean, and thus do not represent a change to the long-term population trend. Finally, the 2019 counts for Swainson's and Ferruginous hawks were higher than the long-term mean; but the extremely low number of birds counted makes the statistical significance of questionable value.

Eagles represented the largest proportion of any raptor group this season, comprising 45% of the total raptor count in 2019 (which is well below the long-term mean; see Fig 7). Accipiters were the next largest raptor group tallied (34%, above the long-term mean for this raptor group; Fig 7), followed by buteos (8% - slightly below the long-term average of 8.6%) and falcons (7.3% - slightly above the long-term average). Harriers, vultures, ospreys and unidentified raptors together comprised only 5% of this season's flight. Of these three species, only Northern Harriers were counted in above-average numbers when compared to the long-term mean. Golden Eagles were the most numerous species, making up 43% of the total count, followed by Sharp-shinned Hawks (19%), Cooper's Hawks (13%), Red-tailed Hawks (6%), American Kestrels (5%), Northern Harriers (4%) and Bald Eagles (2%). The remaining seven species together comprised a total of only 8% of the total raptor flight.

LONG-TERM COUNT TRENDS:

The significant long-term trend for total raptors ($p < 0.001$, Fig. 8a) illustrates an upswing from a low point in 2006, suggesting that migratory raptor populations as a whole have generally been holding their own (since the project's inception) across much of western North America. Smith et al. (2008a) reported trend analyses for data collected through 2005 for most of the long-term migration studies in western North America, including the Bridger Mountains. These and subsequent analyses (reported by the Raptor Population Index or "RPI" project; see http://www.rpi-project. org for updated trend graphs) are based on a more complex analytical approach (see Farmer et al. 2007, and Crewe et al. 2016) than what was reported in Hoffman and Smith (2003) and used herein to present trend analyses through 2019. With few notable exceptions the long-term trend estimates for each species as calculated by this more complex method generally yield similar results to those obtained from the simpler methodology used herein and described more fully in Hoffman and Smith (2003).

The most worrisome trend documented by the Bridger Mountain Hawk Watch over the past 28 count seasons is the significant long-term decline in Golden Eagle passage rates ($p<0.001$; Figs. 8e & f). This trend is consistent with most other long-term Golden Eagle migration counts across western North America (see https://www.birdscanada.org/birdmon/default/popindices.jsp or http://www.rpi-project. org/2016/graphs.php?rsite=592%3AF). However, since 2009 the passage rate of Golden Eagles atop Bridger Ridge has stabilized, suggesting that the long-term decline of this species has arrested in recent years (Fig. 4f). In fact, during the past five years there is actually a slight upward trend (not statistically significant) in passage rates of adult, non-adult, and total Golden Eagles.

Our 2019 Golden Eagle count does dampen our optimism regarding the likelihood of a long-term upswing in the Golden Eagle population trend (especially when considering our encouraging 2017 count of 1,476, the largest Golden Eagle count in the Bridgers since 1999!). This year-to-year variation in Golden Eagle counts atop the Bridgers clearly illustrates why annual, long-term monitoring of raptor populations is critically important to understanding the status and trend of these majestic species. The upcoming 2020 count results will be of particular interest, especially in view of the low counts of Golden Eagles, not only in 2019, but also in 2018, 2015 and 2013.

Causes for this long-term decline in the Golden Eagle passage rate are not fully understood at this time, and thus are not addressed in this report (although ongoing habitat degradation and fragmentation, primarily on the bird's wintering grounds in the western U.S., with a likely concomitant reduction in their favored prey - especially jackrabbits - may be key contributing factors).

We are pleased to report that counts of two accipiter species in 2019 suggest a possible near-term upswing. Sharp-shinned Hawks (497) and Cooper's Hawks (324) were both well above the 27-year mean. (In contrast, Northern Goshawk numbers were slightly below the 27-year mean.)

The upward trajectory in Turkey Vulture counts noted from 2015-2017 was once again observed in 2019, with a total of 15 vultures detected. This count is similar to the above-average numbers recorded in both 2013 and 2016. The 2020 count season will help us to further assess the likely long-term increase in the vulture population passing through this region (although the sample size for migrant vultures in the Bridgers is marginal, at best). However, vulture counts along the Bridger flyway in recent years suggest these birds are continuing to gradually expand their range northward, likely in response to a warming climate (Fig. 8b). This phenomenon has been documented at other long-term Rocky Mountain migration sites as well as sites throughout the Midwest and eastern North America (as documented in hawkcount.org and rpi-project.org). We cautiously predict this positive continent-wide trend in Turkey Vulture abundance will continue for decades to come.

We are pleased to report generally positive count trends over the past 10-15 years along the Bridger flyway for Osprey, Broad-winged Hawk, Red-tailed Hawk, Peregrine Falcon, American Kestrel and Merlin (Figs. 8b, 8d, 8h & 8i).

Peregrine Falcons, Merlins and Broad-winged Hawks have shown significant long-term increases, although we have less confidence in these positive trends due to small sample sizes for these three species (under 15 birds/100 hrs. see Figs. 8d, 8h & 8i). It is notable that eastern North American count trends generally show gradual long-term declines in Broad-winged Hawk counts (Bildstein et al. 2008; rpi-project.org), but an increasing trend over the past 20+ years in the West (Smith et al. 2008). Reason(s) for the apparent Broad-winged Hawk increase in western North America remains unknown.

Continent-wide, Peregrine Falcons are continuing their comeback from historic lows in the early 1970s (Bridger counts reinforce this continentwide trend; Fig. 8i); it is widely known that their decline (from 1946-1975) was caused by the widespread use of DDT throughout the Americas. In the Bridgers, Bald Eagle counts have shown a long-term decline (Fig. 8g), likely due to a trend toward delayed migration of this species in autumn (caused by from climatic warming?). Since Bald Eagles are primarily a late-season fall migrant, further delays in their southward movements due to warming of our climate would result in lower counts, which has been the pattern in the Bridgers and across North America.

Of the remaining eight raptor species, three (Cooper's Hawks, American Kestrels and Northern Harriers) exhibit passage rates exceeding 10 birds/100 hours; none of these show significant long-term count trends in either direction (Figs. 8b, 8c & 8h). Ospreys and Prairie Falcons are all infrequently observed, hence low counts of these species preclude meaningful analyses of trends (Figs. 4b & 4i).

AGE RATIOS:

Overall, immature-to-adult ratios for Golden Eagles in 2019 were about one-third the long-term average (Table 2), suggesting the likelihood that breeding success this year was well below average. Please note that the calculated age-ratios presented in Table 2 do not reflect the actual ratio of first-year birds to adults, since the "immature" category includes the combined totals for subadult, non-adult and first-year (juveniles) age classes (hence, "immature" birds as classified herein range from 4 months to 3.5 years of age). Consequently, the calculated age ratios do not directly measure the current year's breeding success, but rather provide a rough estimate of the combination of adult breeding success and overall survival of juvenile and subadult birds during the previous 3-4 years.

An alternative explanation for the low proportion of younger age classes for Golden Eagles in 2019 is that observations this fall were significantly hampered by poor weather during the seasonal time frame in which a high proportion of young eagles were passing through. Of course, there is the possibility that

both factors were at play in contributing to the remarkably low percentage of juvenile and subadult eagles documented this fall at our Bridger site.

RESIDENT RAPTORS:

This year nine raptor species consistently displayed resident behavior. These included the Turkey Vulture, Sharp-shinned Hawk, Cooper's Hawk, Red-tailed Hawk, Golden Eagle, Bald Eagle, Peregrine Falcon, Prairie Falcon and American Kestrel.

Turkey Vulture – Historically, Turkey Vultures have rarely been documented as residents on the Bridger Ridge. However, in 2016 vulture flocks of 8-12 individuals became more prevalent. In 2019 this trend continued, although flock sizes were generally smaller. On 28 August the largest flock was detected, with seven individuals kettling quite high to the northwest of the OP. This flock moved off to the north. Resident flocks of 4-5 individuals were detected throughout early September until 18 September, when the last resident was observed heading north low over the valley west of Bridger Ridge.

Sharp-shinned Hawk – Resident Sharp-shinned Hawks were regularly seen from the start of the season through 8 October. This represents a two-week earlier departure date for resident Sharp-shinned Hawks compared to 2018. Three immatures and at least one adult were detected. As always, these Sharp-shinned Hawks regularly mobbed both decoy owls as well as migrating raptors. One memorable observation occurred on 31 August, when all three immature Sharp-shinned Hawks were observed harassing a migrating Broad-winged Hawk. As the first thermals began forming in the morning sun along the east face of Tilly Peak, the Broad-winged Hawk was one of the first to take advantage of the rising air currents. As it struggled to gain altitude, it attracted the attention of the three resident immature sharpshins, who frequently interacted among themselves in this location each morning. On this particular morning all three birds harassed the broadwing repeatedly, eventually forcing the hawk to find refuge on a nearby snag. As the thermals became stronger, the Broad-winged Hawk gained the needed altitude to rise above the resident sharpshins. At this point, two of the sharpshins peeled off to the east, while one continued to harass the hawk. Once the hawk took full advantage of the west winds above the ridge, it attacked the smaller sharpie. The sharpie then took cover in the forest. In this instance the resident Sharp-shinned Hawks alerted the observers to the presence of the Broad-winged Hawk (an uncommon migrant).

Cooper's Hawk – Two immatures and one adult Cooper's Hawk were classified as residents this fall. Similar to the Sharp-shinned Hawks, Cooper's Hawks were noted harassing other resident raptors, and hunting the forested slopes near the OP on both sides of the ridge. The last resident was detected on 15 September, three days earlier than their departure date in 2018. (Mid-September is likely the normal departure time for resident Cooper's Hawks in the Bridgers.)

Northern Goshawk – No Northern Goshawks showed resident behavior during this year's count. Northern Goshawks may migrate (or disperse) in any direction, and so with goshawks it wasn't assumed that they were resident just because they were flying north. By following closely to the protocol (used for all HawkWatch International count sites), our migratory Northern Goshawk numbers were more in line with the previous 27-year average. This is in contrast to 2018, when the migrant goshawk count was well below the long-term average.

Red-tailed Hawk – A total of seven resident Red-tailed Hawks were detected during the count. Two immature light-morphs, four adult light-morphs, and one adult dark-morph. All were quite active along

Bridger Ridge, harassing the decoy owls, interacting with each other, and escorting migrants along the ridge. The last remaining resident, an immature light-morph, was last detected on 16 October.

Golden Eagle – Resident Golden Eagles were commonly observed throughout the entire count period. A total of four adults, one immature and one sub-adult were observed. Most of the time we observed two adults (likely a resident pair) patrolling their territory and often performing their characteristic "roller coaster" territorial displays. A subadult was also often seen along the ridge, and later in the season was joined by a second subadult. Near the end of the count these two were seen interacting on the west face of Tilly Peak, and nearly always seemed to disappear to the north. The immature (first-year juvenile) eagle was seen until the end of September, but not after this date.

Bald Eagle – One resident adult Bald Eagle was spotted this year, early in the count season. It was not detected after 5 September, which is a significantly earlier departure date than last year's 16 October final detection date for the resident Bald Eagle.

Peregrine Falcon – In 2019 one immature and two adult Peregrine Falcons were confirmed as residents. These birds hunted the steep slopes and cliff faces around Tilly Peak, and frequently interacted with passing migrant raptors. The immature resident was first spotted on 23 August harassing a Red-tailed Hawk to the north of the OP. On 16 September this immature was again spotted very high above the OP, successfully taking a migrating passerine (high overhead, where the songbird was unable to find cover). (The falcon made it look effortless, reaching forward with one foot to grab the bird.)

Prairie Falcon – On 28 August a resident Prairie Falcon was first seen on its favorite flight line, approaching low on the east side of the OP. On 27 September the observer became aware of the falcon's approach when he heard the bird rapidly passing to the west of the OP. The falcon had spotted several Northern Flickers foraging together on the east side of Tilly Peak. When the falcon made a serious pass through the flock, they all scattered, sounding the alarm. The falcon was unsuccessful in catching its prey. Interestingly, the observers witnessed the resident Prairie Falcon hunting Northern Flickers multiple times on the east side of the ridge. In fact, it was most common to hear the alarm call of the flicker(s) first, and then spot the falcon. This Prairie Falcon was last detected on 17 October, which is two days earlier than last year's departure. (It would appear that this falcon's typical departure date from the Bridger Range is shortly after the middle of October.)

American Kestrel – As was the case in 2018, at least a single male-female pair of American Kestrels was resident on the ridge until 18 September (the exact same departure date as in 2018). These birds were often observed harassing the decoy owls and hunting migrating butterflies and dragonflies from favored perches atop the limestone rimrock south of the OP. No immature kestrels were ever positively identified in 2019; however, groups of three or four kestrels (of unknown age) were spotted early in the count period. This year, with the helipad blind in place, these small falcons repeatedly captivated visitors, stooping repeatedly on the nearby owl decoy.

PUBLIC VISITATION:

Bridger Bowl Ski Area hosts a variety of outdoor activities the Bozeman community regularly engages in, including hiking, trail running, and skiing. Public visitation to our observation site was quite frequent in 2019. Throughout our fall season we welcomed a steady stream of outdoor enthusiasts; weekends on Bridger Ridge were generally bustling with runners, hikers and birdwatchers alike. A total of 280 folks signed our visitation log this season (10 more than 2018).

Figure 2. International Hawk Migration Week banner provided by the Hawk Migration Association of North America (HMANA).

Julie Brown, monitoring site coordinator for Hawk Migration Association of North America (HMANA), provided the Bridger Mountain Hawk Watch with an excellent sign to help us celebrate International Hawk Migration Week (Fig. 2). This continent-wide raptor migration celebration occurs in mid-September annually (14-21 September in 2019). The banner was affixed to a large piece of plywood and was set up daily where the trail crests Bridger Ridge. Since the observers are intensely focused on scanning for migrating raptors, this sign may have helped facilitate valuable public outreach, likely enticing hikers and other non-birders to visit our observation site. The sign worked so well that we elected to display it throughout the entire count season. (It is made of durable, weatherproof material, and we suggest that it be used throughout the migration season every year.)

The 23rd annual Bridger RaptorFest (4 – 6 October, see www.bridgerraptorfest.org/) is organized and run by Bridger Bowl staff as well as community volunteers. This weekend event drew a substantial number of visitors to the Bridger Hawk Watch. As usual, the festival kicked off Friday night at the Ellen Theater in downtown Bozeman. Montana Raptor Conservation Center staff were featured with a live raptor presentation. This was a family-friendly event, and young raptor enthusiasts learned specifically about the Turkey Vulture and Swainson's Hawk. Teresa Aldrich and Nel Thalhamer shared important natural history and conservation information about these two species. A lively Q & A followed, with many excellent questions asked (especially by the young folks in the audience).

The film, Sky Migrations, was also shown. This film has inspired many non-birders to visit the Bridger Mountains Hawk Watch during the past few years, as it features excellent video material from the Goshute Mountains Hawk Watch Project (which our project coordinator, Steve Hoffman, discovered and launched 40 years ago). After the film, AR entertained a brief Q and A about the Bridger Hawk Watch before closing out this RaptorFest kick-off event.

Unfortunately, challenging weather conditions for Saturday's RaptorFest discouraged visitation to the Hawk Watch. However, Sunday's weather was perfect, with bluebird skies and an awesome flight of raptors! A total of 189 migrant raptors were tallied, with an average of 30 raptors per hour passing between 10:00-16:00. Many families hiked up to enjoy the excellent weather, and everyone was excited to see a variety of raptors (and especially several migrating Golden Eagles!). For the children, our resident mountain passerine birds were an added attraction, as the young raptor enthusiasts enjoyed the chance to see chickadees, nuthatches and Clark's Nutcrackers at close range. During the festival, nearly 60 visitors made it up to observe the raptor migration and enjoy the spectacular view. In addition to the raptors and mountain songbirds, many visitors were also excited to view a black bear sow and cub foraging on the west slope of Tilly Peak (Fig. 3) as well as a lone mountain goat (both at safe viewing distances).

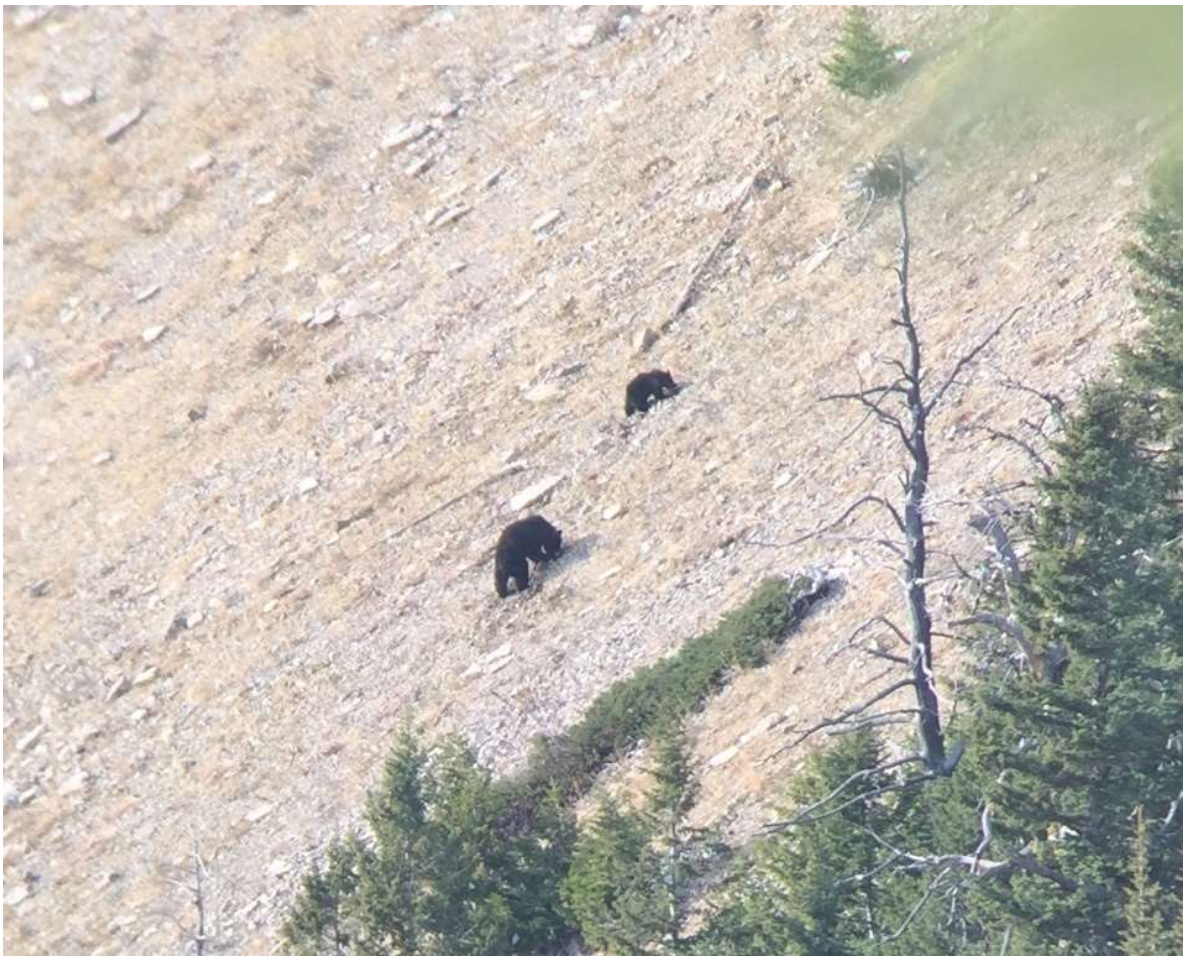

Figure 3. Black bear sow and cub viewed by visitors at the Hawk Watch during the 2019 Bridger RaptorFest.

At festival headquarters (Jim Bridger Lodge), it was estimated that a total of nearly 5,000 visitors attended the weekend's events on Saturday and Sunday (combined). The family-friendly presentations,

children's games and live raptor presentations were well received by festival attendees. Considering that many birding festivals in the United States attract fewer than 500 visitors, the size and scope of this event each year is quite remarkable! The Bridger Mountain Hawk Watch Project is quite fortunate to have this valuable long-term partnership with Bridger Bowl Ski Area and all Bridger RaptorFest organizers. This festival likely does more to generate public awareness of the raptor migration occurring along the Bridger Range than all other publicity and outreach combined throughout the migration season.

Several mass emails were sent out by AR to all visitors who signed our guest log and included their email. These emails were well received, especially since many residents of the area don't have the time or ability to visit the Hawk Watch once deep snow accumulates. Hence, email recipients were pleased to be informed about how the raptor flight was progressing. Keeping in touch with these raptor enthusiasts likely also motivated many repeat visits to the ridge.

Figure 4. The Mountain Belles of Bozeman, MT visited on a spectacular fall day. (*Photo: Michelle Eckhardt*)

Several groups visited the Bridger Mountain Hawk Watch this fall. Michelle Eckhardt of the active outdoor women's group "Mountain Belles" led a group of seven women up to the site on 12 October (a bluebird day!). The group was well prepared to enjoy their time on the ridge. Their timing was impeccable, arriving just as the afternoon flight began. Importantly, a total of 55 migrant raptors came through while they were at the OP. Inviting outdoor groups to enjoy the Bridger raptor migration is highly recommended to further engage Bozeman's community of outdoor and conservation-minded folks in the project.

Steve Hoffman made two trips to the ridge during the season to enjoy the flight (and the view!). Steve's lifelong passion for studying and educating the public about raptor migration provides a rare learning opportunity for both the observers and visiting public during these visits. And, of course, Steve has a keen eye for migrating raptors, having helped launch this and many other raptor count sites throughout the western and southern U.S during the past 40+ years.

OTHER WILDLIFE:

Sitting on a prominent ridgetop for eight hours every day throughout the fall is not only a great way to observe large numbers of diurnal raptors in flight, but also affords opportunities to observe and enjoy many other wildlife species. Several species of mammals along with numerous resident and migrant songbirds were observed throughout the season. Mountain Chickadees, Red-breasted Nuthatches, Clark's Nutcrackers and Steller's Jays were regularly observed near the observation point.

Dragonflies were observed migrating, particularly during the first half of September, and these were often preyed upon by migrating raptors (especially American Kestrels). A resident pair of American Kestrels often perched on the rimrock to the south of the OP and perch-hunted for dragonflies regularly in the afternoon.

Snow Geese were observed moving near the end of the count, with 39 individuals tallied on 29 October (Fig. 6). Canada Geese were recorded as migrants earlier in October, with 8 individuals recorded.

White-throated Swifts were seen in large numbers during the first few weeks of this season's count (until mid-September), with a total of 71 individuals documented (Fig. 6). One afternoon was quite memorable, with a large flock passing very close to the observers.

One Common Loon was detected northwest of the OP, moving from east to west over the high peaks of the Bridger Range. Finally, a single Double-crested Cormorant was observed migrating over in mid-October.

The mountain birds near the OP included the first detection of a Northern Pygmy-Owl on the ridge. On 25 September the resident Mountain Chickadee and Red-breasted Nuthatch vigorously harassed this very small owl, which was often active during daylight hours. Since this small owl often hunts small birds, the mobbing behavior displayed by the songbirds was quite intense. After about 30 minutes of non-stop alarm calls the observers became aware that something was amiss. Even the resident Clark's Nutcracker had joined the fray, attempting to chase away the owl. Eventually the owl moved into the open, on a snag directly west of the OP. The owl then pursued the Clark's Nutcracker. This small owl was heard vocalizing in the vicinity for several more days, mostly during the last few hours of daylight.

Other birds observed along Bridger Ridge included several woodpeckers (Northern Flicker, Hairy Woodpecker and American Three-toed Woodpecker). Most ubiquitous among the resident birds observed from the observation point were corvids: Common Ravens and Clark's Nutcrackers were abundant throughout the study period. Ravens would often interact with the migrating raptors, play among themselves, harass the decoy owls, typically engaging in a vast array of vocalizations and aerial maneuvers. In addition to the resident corvids, this season we saw strong southbound movements of Clark's Nutcrackers, American Crows and Common Ravens (see Fig. 6).

This season the Pygmy Nuthatch was finally fully documented and confirmed in the Bridger Range. According to eBird, this is the first confirmed record for Gallatin County. However, this species was detected by Adam during each of the previous two seasons near the OP. However, without a

photograph the regional eBird reviewers could not accept these observations. Based on this experience, it is suggested that, in the future, if any observers detect a rare bird during the Bridger count, one should first attempt to document the sighting with a photo, and also record detailed notes so these unusual observations can be carefully documented.

Bohemian and/or Cedar Waxwings were seen routinely near the end of the count season in late October (Fig. 6). These large flocks seemed to prefer foraging on the berries of the Common Juniper (*Juniperus communis*).

During the latter half of the season a completely different suite of migrating songbirds, primarily finches, dominated the songbird migration. These included Gray-crowned Rosy-Finch, Cassin's Finch, Red Crossbill, Pine Grosbeak and Pine Siskin (Fig. 6). Impressive movements of Gray-crowned Rosy-Finches were observed primarily in mid-to-late October, with an estimated total of 2,750 individuals moving through. On several occasions the large rosy-finch flocks landed nearby the observation point, providing spectacular views.

Chipmunks (*Neotamias sp.*) and red squirrels (*Tamiasciurus hudsonicus*) were daily visitors to the OP this season (although chipmunk numbers seemed to be markedly down from 2018). Our resident red squirrel was quite active in the area, as always.

A short-tailed weasel (*Mustela erminea*) was observed on the talus slope to the east of the OP later in the season, once snow had accumulated. (The last time it was observed it still had yet to grow its white winter coat.)

A black bear (*Ursus americanus*) sow and cub was noted for several weeks in October near the OP. The cub was frequently seen napping in the tree tops, while the sow was busy foraging, often searching under rocks on the steep slopes of the Bridger Range.

Moose (*Alces alces*) were not spotted this season. However, fresh moose sign was detected near the Alpine Cabin at Bridger Bowl Ski Area. Tracks and droppings were noted in the snow at the beginning of October.

Mountain goats (*Oreamnos americanus*) were active near the OP throughout the entire season. A lone billy goat frequented the OP at night, and in mid-October a larger herd was often observed gathering on the west slope of Tilly Peak; this group numbered 16 individuals, including one kid.

Early in the season a lone coyote (*Canis latrans*) was spotted on the western flank of Tilly Peak. Coyotes were frequently heard howling in the evening on the east side of the ridge near Bridger Bowl Ski Area.

PROJECT PUBLICITY:

Bridger Bowl Hawk Watch received limited publicity in 2019. The project received brief mention during the Bridger Raptor Festival. To enhance the project's visibility throughout the season, AR spent many evenings after the daily counts setting up a project blog. The blog had all the information necessary for visitors to navigate to the ridge, as well as how to prepare adequately for an enjoyable visit. Maps were updated with various hiking options, depending on the visitor's skill level and conditions on the ground. Links to local weather forecasts, the Sacajawea Audubon Society website as well as the Bridger Bowl Ski Area and Bridger RaptorFest websites; websites for HMANA and Wild Birds Unlimited in Bozeman were also included. Many useful links and raptor-related resources were

made available as well. Several of the prior years' Bridger Raptor Project annual reports were also uploaded so anyone interested could look at past data. Helpful articles for the advanced raptor enthusiast were uploaded too, such as the Golden Eagle aging manuscript (authored by Jerry Liguori).

During the count, daily summaries and photos were posted every evening. The blog generated great interest and many visits to the site, and all the wonderful feedback was shared by visitors who appreciated the chance to stay informed about the Bridger season's migration counts. By the end of the season the blog had received nearly 3,500-page views, which is quite encouraging considering the project lasted only 65 days this year. (That is an average of over 50-page views per day for the entire season.) Unfortunately, at the end of the season, due to lack of time for maintenance, the blog was taken down. Public engagement is one of the important stated objectives of this project, with the intended outcome being to help inspire much-needed conservation activism and volunteer support for the project, as well as more general public awareness about this vitally important project.

RECOMMENDATIONS

There is a growing number of studies showing a trend toward earlier fall raptor movements, presumably due to climate change (see Filippi-Codaccioni et al. 2010, Jean-Francois Therrien et al. 2017). The hypothesis is that, with earlier raptor breeding and earlier fledging, and with key prey species perhaps becoming even less abundant during the late summer period (due to increasingly hot, dry conditions), many raptors are initiating their migration earlier (relative to the norm over the past several decades).

This year the wisdom of initiating the Bridger count during the last week of August (for the fourth consecutive season) was not especially well supported by our actual count numbers during the last five days of August. During these five count days we tallied only 85 raptors (3.2% of the seasonal raptor total) of 12 species. It is noteworthy, however, that migrating Golden Eagles were recorded on three of the first five days of the count. Since the timing of migration is likely still in flux (due to long-term global warming phenomena), starting the count even earlier will require further assessment in the years to come.

If future observers have the time and skills to set up and maintain another project-oriented blog, it is highly recommended.

ACKNOWLEDGMENTS

Generous funding for the 2019 field season was provided by USDA Forest Service, Custer Gallatin National Forest (2019 funding facilitated by Forest Biologist Joshua Hemenway), NaturEner USA, a wind energy company active in northern Montana (their critically important 2019 support was facilitated by Steve Laufenberg), Sacajawea Audubon Society (SAS), Bridger Bowl Ski Area (support facilitated by Erin O'Connor), as well as many generous individual contributors. Randy Elliott and Jason Prasek of Bridger Bowl Ski Area provided essential logistic support on the mountain at the beginning and end of the season. Of special importance was full-season access to the Bridger Bowl ski-patrol hut on Bridger Ridge for both overnight lodging and shelter from foul weather. Kathryn Barker and Randy Scarlett of Custer-Gallatin National Forest facilitated appropriate US Forest Service access permits and essential portable toilets.

We especially wish to thank Jerry Buckley & Elisabeth Swanson for providing comfortable in-town lodging for Kyle Dudgeon. Lila Bishop provided lodging for Adam Richardson for a second year. Lila Bishop is a dear friend of Adam's, and he greatly appreciated her company, support and many wonderful meals with her friends and family.

This year the primary observers were able to take days off on poor-weather days, when visibility made counting impossible. This limited the need for volunteer coverage. After KD ended his time as one of the official observers for the project, experienced local raptor watcher Bob Smith signed up to help cover nearly a week's worth of the count during peak migration. Bob Smith is always good company, and well prepared to count under any conditions. Paulette Epple and Matt Keefer also volunteered during critical periods of need, and were rewarded with some extraordinary raptor flights. In addition, Jack Skalicky, Huyen Bui, Cara Priem, Janet Kempf, Vincent Slabe, John Karath, Judy Tsiang and Mikaela Howie all assisted with the count during critical periods this season. Fortunately, with prolonged foul weather making observations extremely limited on 12 days in October, and with the above pool of dedicated volunteers, the Bridger Mountain Hawk Watch was able to maintain its two-observer protocol throughout the season. The Bridger Mountain Hawk Watch would like to sincerely thank all of the volunteer observers (listed above) for their dedicated, timely and enthusiastic expert involvement this season.

We would also like to thank Michael Paul Jones (www.michaelpauljones.com) for his photo that appears in this report. (Michael is a long-time friend of Eric Bendick of Grizzly Creek Films grizzlycreekfilms.com). Eric was up on several occasions to video the migrating raptors for a documentary production about wildlife of the Rocky Mountains.

We also would like to thank Michelle Eckhardt of the Bozeman Chapter of *Mountain Belles* (www.mountainbelles.com) for sharing her group photo for this report. (We hope they will consider making their visit an annual one!).

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Table 1. Species-specific average counts (1992 – 2018) versus 2019 count and historic high counts of fall migrating raptors in the Bridger Mountains, MT.

		1992-2018				All-time Count Records	
	Species	Mean Count	± 95 % CI	2019	% Change	Record Count	Year
	Turkey Vulture	8	± 3	15	88	29	2013
	Osprey	8	± 2	13	62	22	2015
	Northern Harrier	57	± 17	93	63	230	1998
Accipiters							
	Sharp-shinned Hawk	369	± 49	497	35	658	2015
	Cooper's Hawk	183	± 26	324	77	347	1997
	Northern Goshawk	33	± 7	31	-6	96	1992
	ALL ACCIPITERS*	*630*	± *78*	*887*	*41*	*1096*	*2015*
Buteos							
	Broad-winged Hawk	15	± 5	24	60	48	2013
	Swainson's Hawk	4	± 1	7	75	11	1992
	Red-tailed Hawk	143	± 30	145	-2	389	2015
	Ferruginous Hawk	3	± 1	7	230	8	2014
	Rough-legged Hawk	40	± 9	14	-65	96	2015
	TOTAL BUTEOS*	*219*	± *43*	*208*	*-5*	*552*	*2015*
Eagles							
	Golden Eagle	1319	± 109	1101	-17	1871	1996
	Bald Eagle	76	± 9	59	-22	128	2000
	TOTAL EAGLES*	*1400*	± *114*	*1162*	*-17*	*1966*	*1999*
Falcons							
	American Kestrel	84	± 16	117	39	181	2015
	Merlin	14	± 3	25	79	36	2015
	Prairie Falcon	14	± 2	17	21	22	2006
	Peregrine Falcon	14	± 3	27	93	34	2012
	TOTAL FALCONS*	*134*	± *22*	*188*	*40*	*251*	*2015*
	GRAND TOTAL*	**2483**	**± 196**	**2579**	**4**	**3532**	**1998**

*Totals given for each major raptor group (accipiters, buteos, etc.) include all unidentified birds within each raptor group; these numbers are excluded from this Table, but are given in Appendix D.

Juvenile Golden Eagle flying with four Northern Ravens *(K. Dudgeon Photo)*

Table 2. Fall counts by age class and immature[1]: adult ratios for selected species of migrating raptors in the Bridger Mountains, MT: 1992–2018 versus 2019.

	Total and Age-classified Counts						% Unknown Age[2]		Immature[1]: Adult Ratio[3]	
	2019			1992-2019 average						
	Imm[1]	Adult.	Total[4]	Imm[1]	Adult.	Total[4]	1992–2019	2019	1992–2019	2019
Golden Eagle	308	600	1101	614	482	1319	26	17	1.3	0.34
Bald Eagle	30	28	59	28	46	76	4	2	0.6	0.52

[1] Values for the "immature" category represent the combined totals for subadult, non-adult, and immature eagle counts (see Appendix A for eagle age classification scheme).

[2] Percentage "unknown age" represent the proportion of age-unidentified individuals.

[3] For age ratios the long-term mean immature: adult ratio is an average of annual ratios and may differ from the value obtained by dividing long-term total numbers of immatures and adults.

[4]Totals include age-unidentified individuals.

Figure 5. Map showing location of the Bridger Mountains Raptor Migration Project observation site.

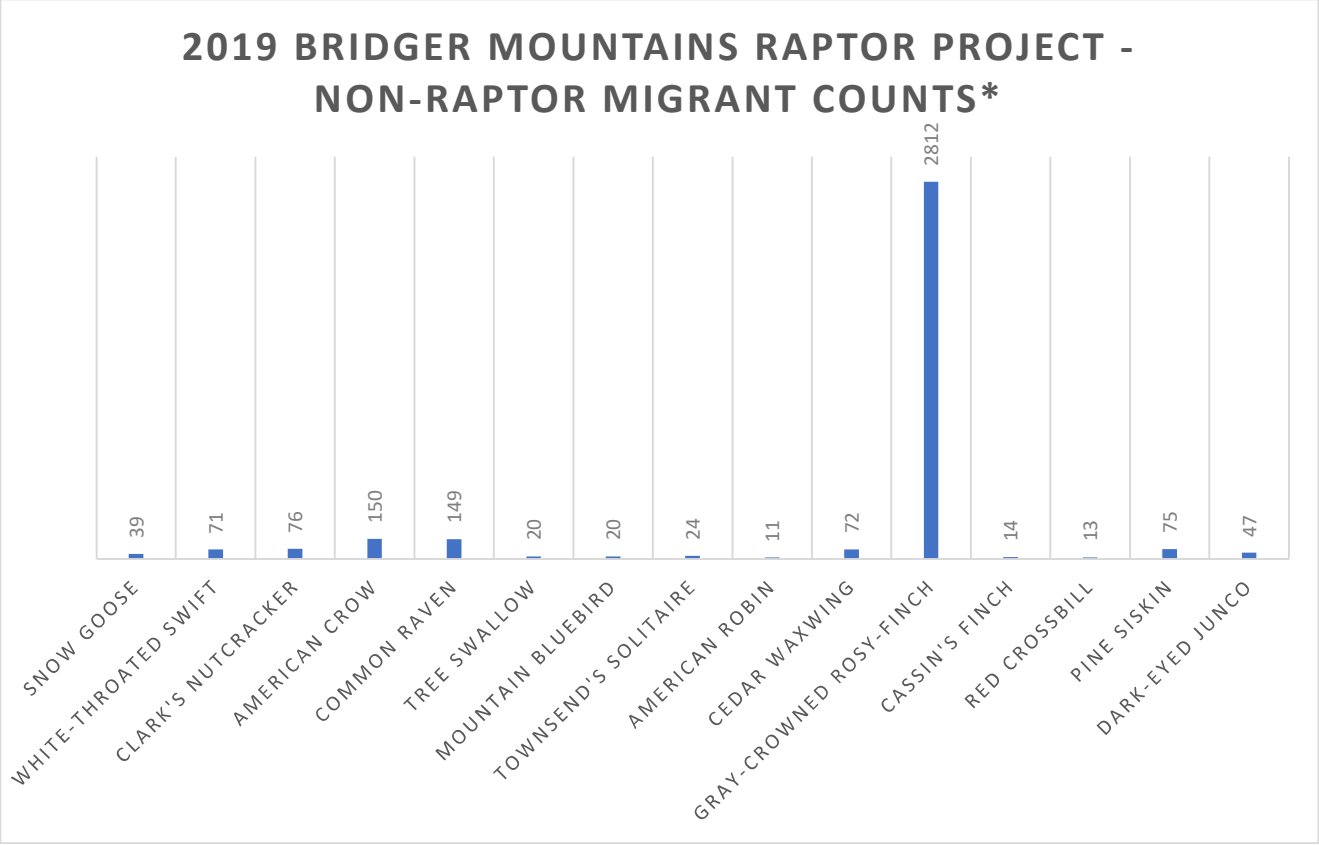


Figure 6. Mjgratory counts of non-raptor bird species atop the Bridger Mountains, Fall 2019.

***** Only species exhibiting migratory behavior and numbering more than 10 individuals are included.

Merlin *(Photo by Kyle Dudgeon)*

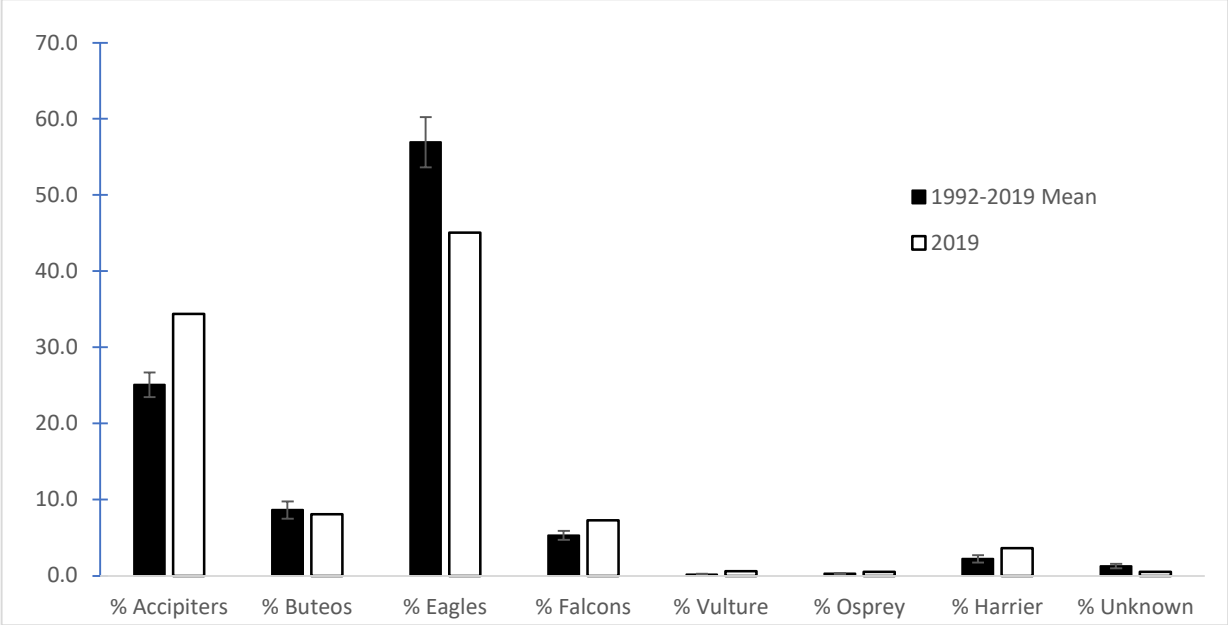


Figure 7. Fall raptor migratory flight composition by major species groups in the Bridger Mountains, MT: 2019 versus 1992-2019 long-term mean. (Note: error bars are one standard deviation.)

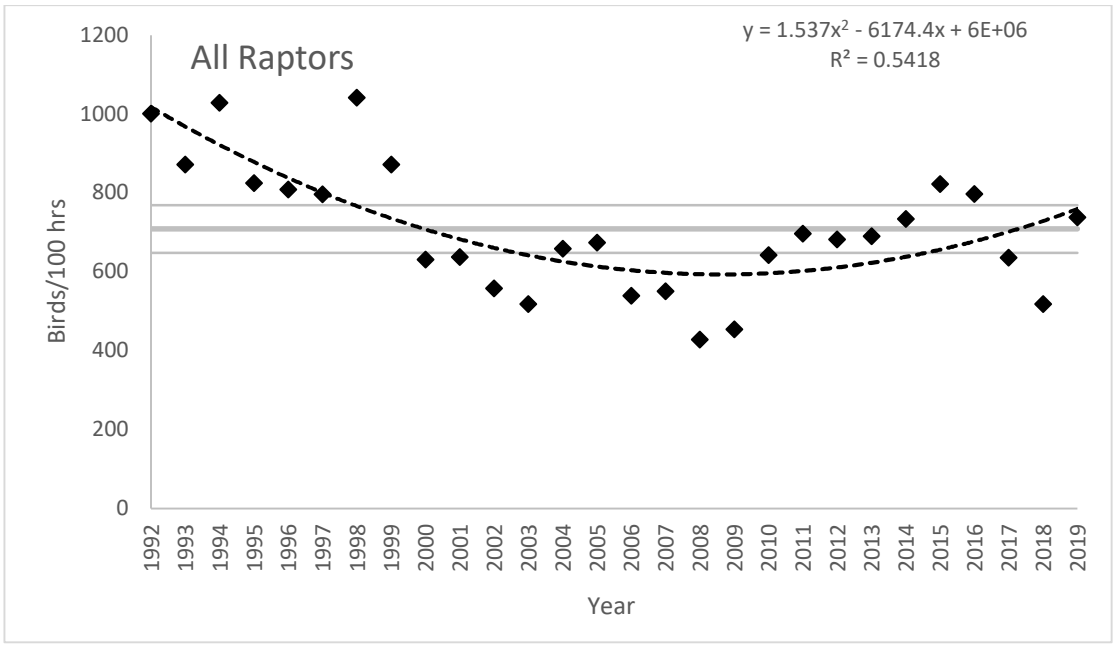


Figure 8a. Effort-adjusted fall migration passage rates for all diurnal raptors in the Bridger Mountains, MT. Dashed line indicates significant ($p < 0.05$) population trend based on quadratic regression. Solid grey lines represent mean (thick) and upper and lower 95% confidence intervals (thin) of historical counts (1992-2019).

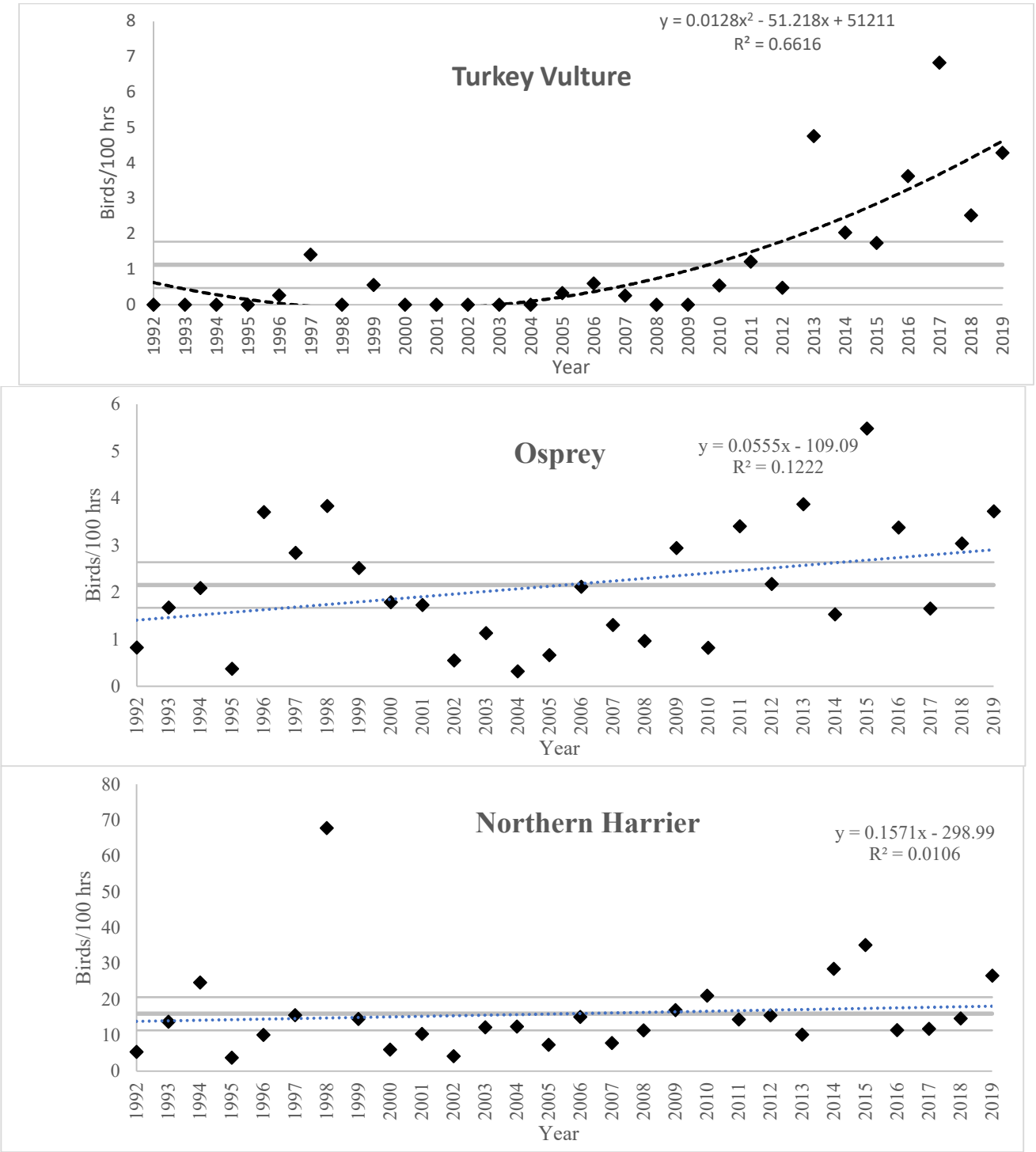
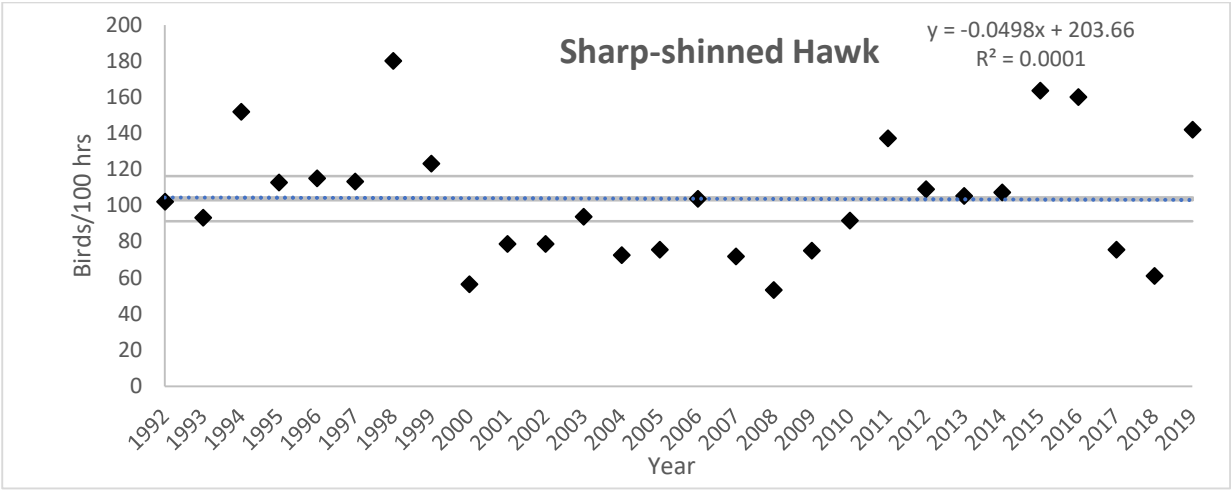
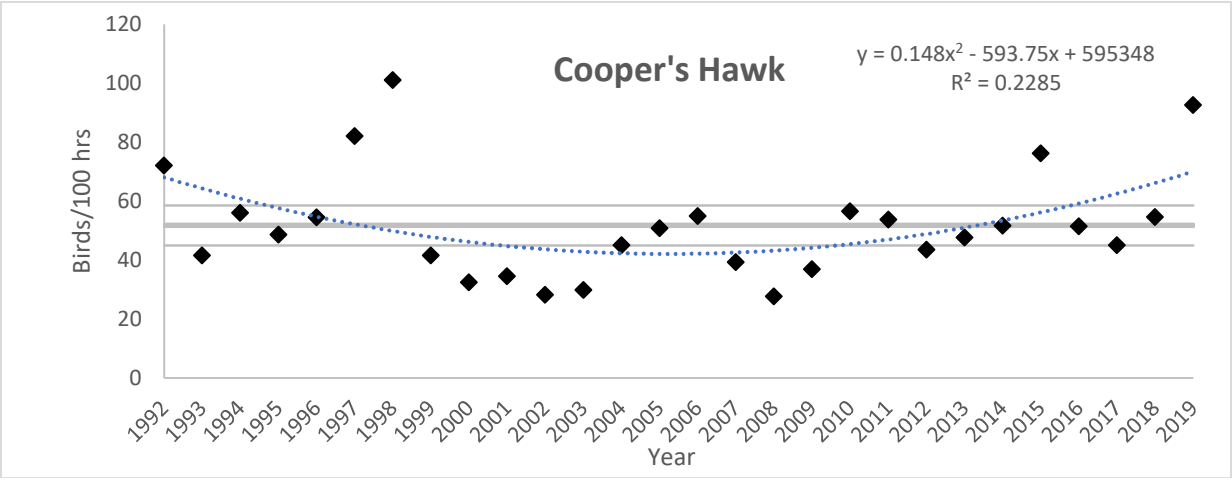


Figure 8b. Effort-adjusted fall migration passage rates for Turkey Vultures, Ospreys and Northern Harriers in the Bridger Mountains, MT. Dashed lines indicate significant ($p < 0.05$) population trend based on quadratic regression. Solid grey lines represent mean (thick) and upper and lower 95% confidence intervals (thin) of historical counts (1992-2019).





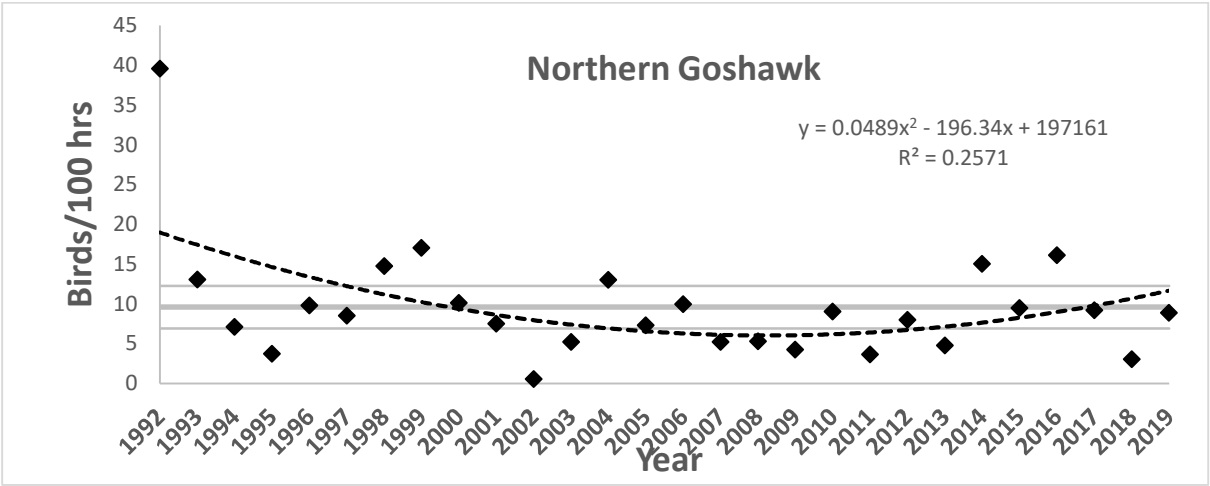


Figure 8c. Effort-adjusted fall migration passage rates for Sharp-Shinned Hawks, Cooper's Hawks and Northern Goshawks in the Bridger Mountains, MT. Dashed line indicates significant ($p < 0.05$) population trend based on quadratic regressions. Solid grey lines represent mean (thick) and upper and lower 95% confidence intervals (thin) of historical counts (1992-2019).

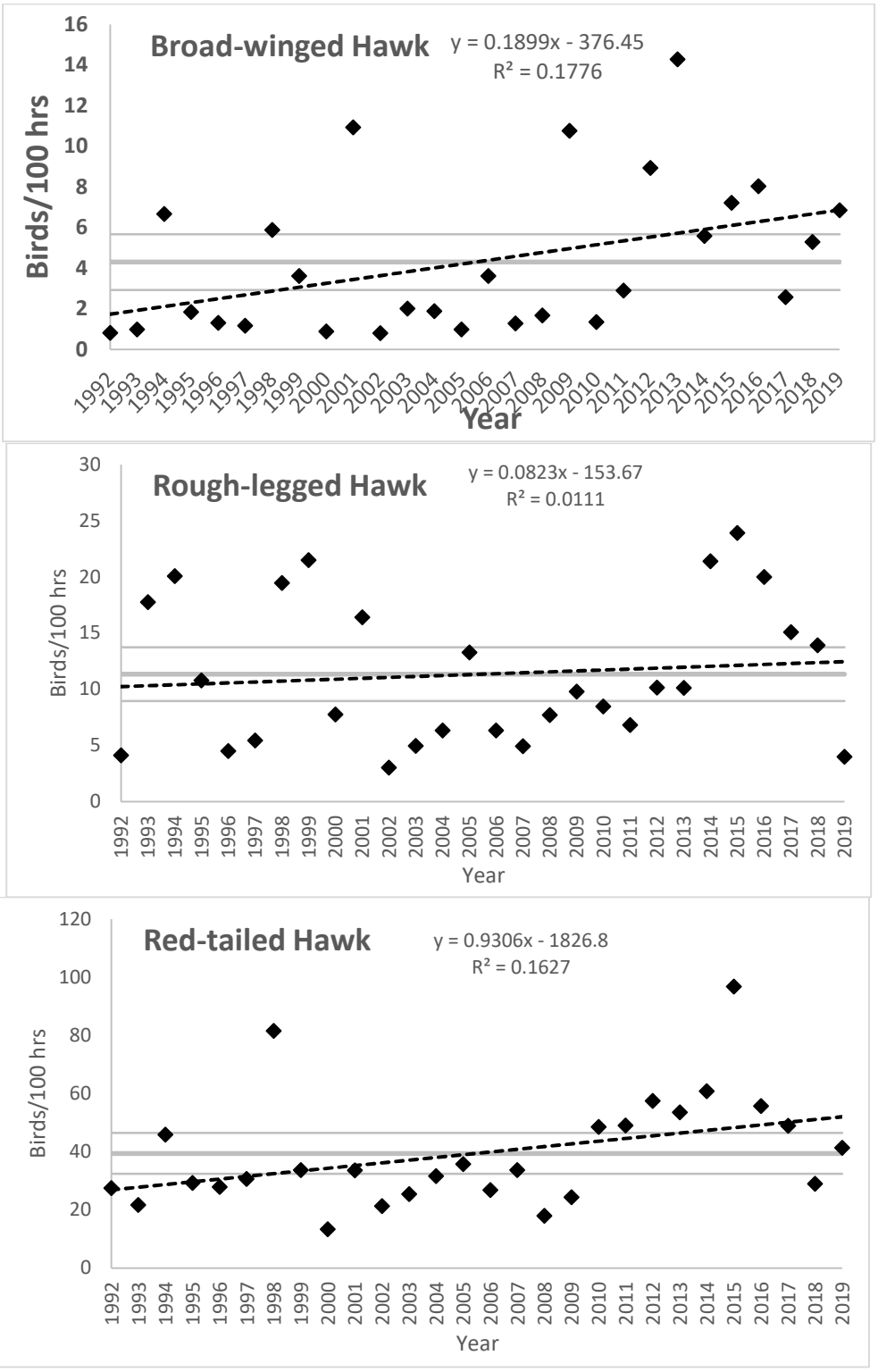


Figure 8d. Effort-adjusted fall migration passage rates for Broad-winged, Rough-legged, and Red-tailed Hawk in the Bridger Mountains, MT. Dashed line indicates significant ($p < 0.05$) population trend based on quadratic (Red-tailed Hawk) and linear (Broad-winged Hawk) regression analyses. Solid grey lines represent mean (thick) and upper and lower 95% confidence intervals (thin) of historical counts (1992-2019).

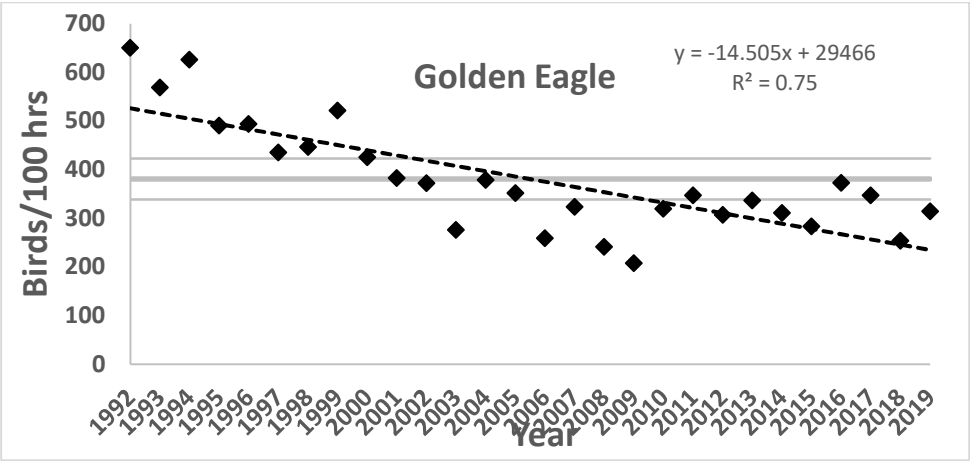
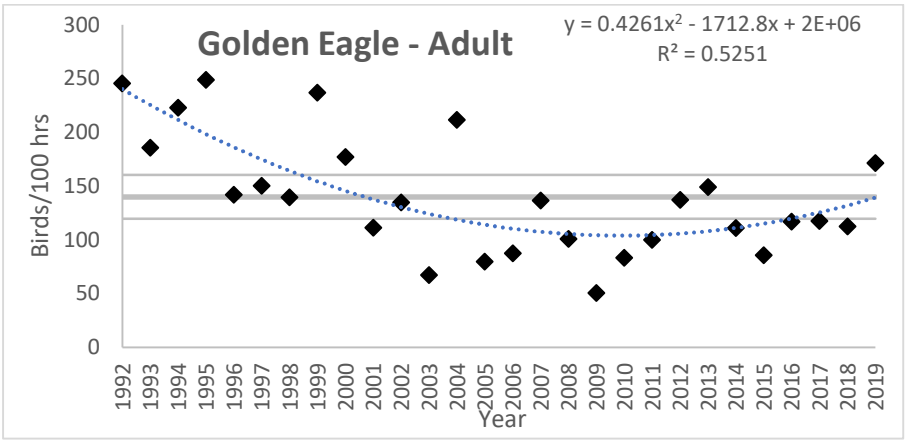


Figure 8e. Effort-adjusted fall migration passage rates for all Golden Eagles in the Bridger Mountains, MT. Dashed line indicates significant ($p < 0.05$) population trend based on quadratic regressions. Solid grey lines represent mean (thick) and upper and lower 95% confidence intervals (thin) of historical counts (1992-2019).



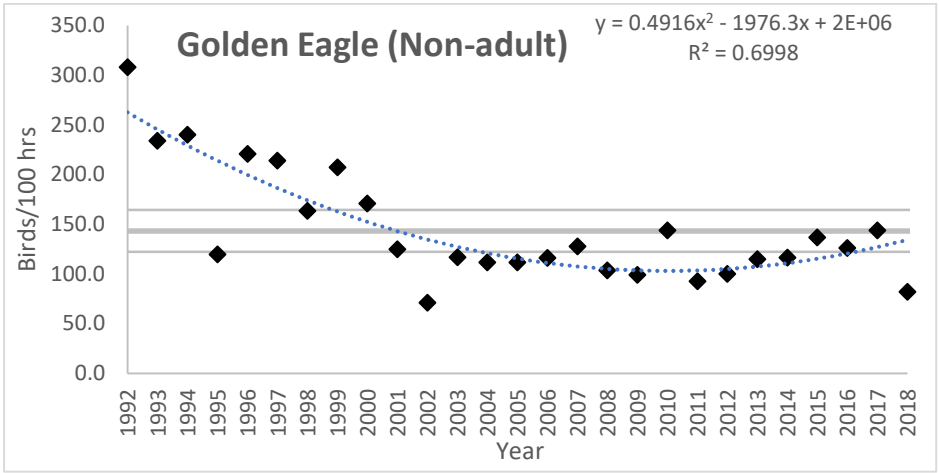


Figure 8f. Effort-adjusted fall migration passage rate comparison for adult vs. non-adult Golden Eagles (includes subadult, immature and non-adult birds) in the Bridger Mountains, MT. Dashed line indicates significant ($p < 0.05$) population trend based on quadratic regressions. Solid grey lines represent mean thick) and upper and lower 95% confidence intervals (thin) of historical counts (1992-2018).

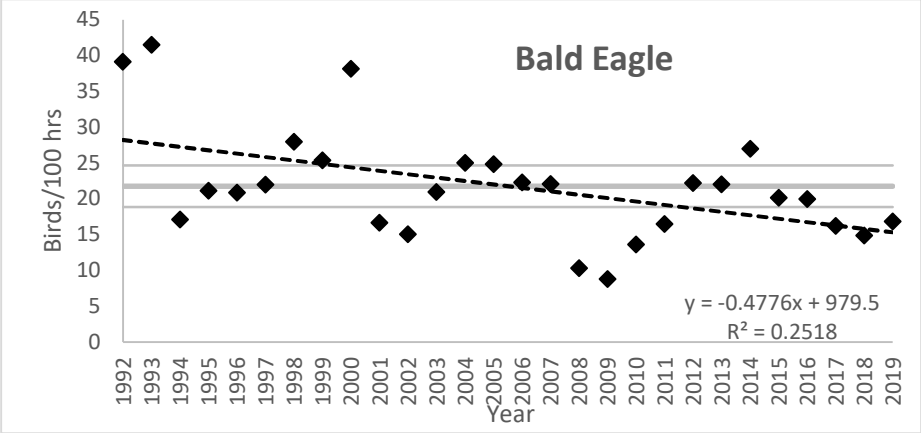


Figure 8g. Effort-adjusted fall migration passage rates for Bald Eagles in the Bridger Mountains, MT. Dashed line indicates significant ($p < 0.05$) population trend based on quadratic regression. Solid grey lines represent mean (thick) and upper and lower 95% confidence intervals (thin) of historical counts (1992-2019).

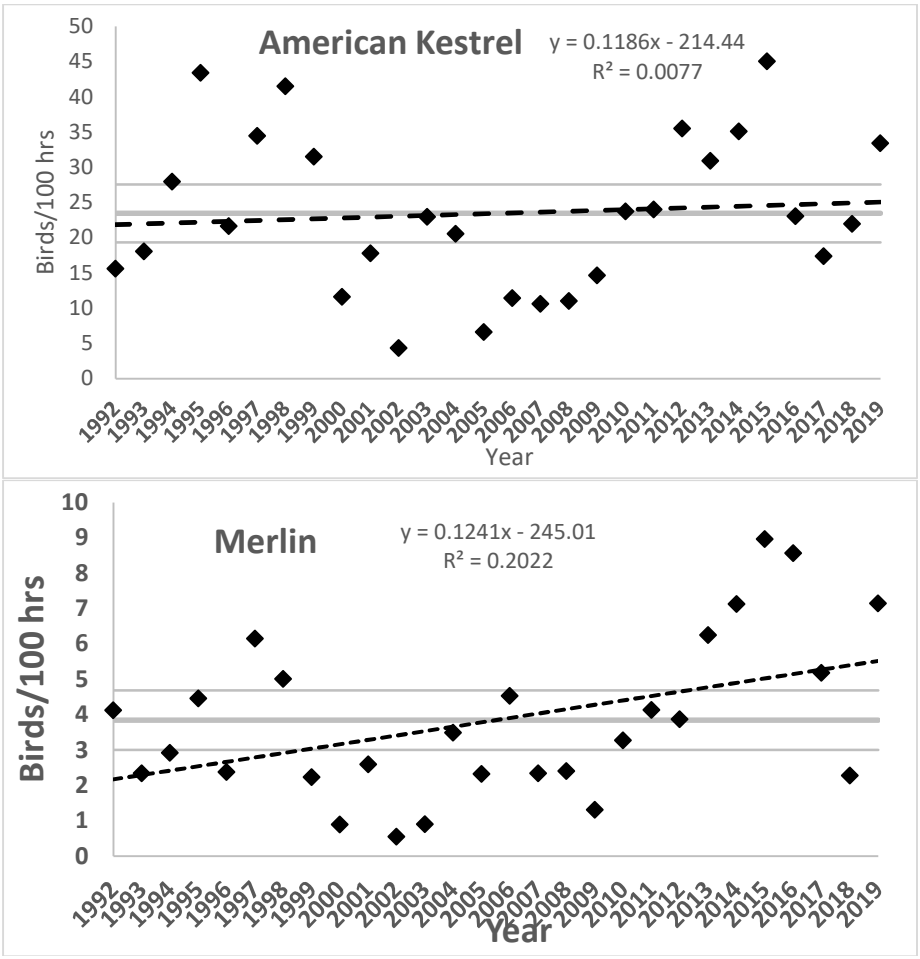
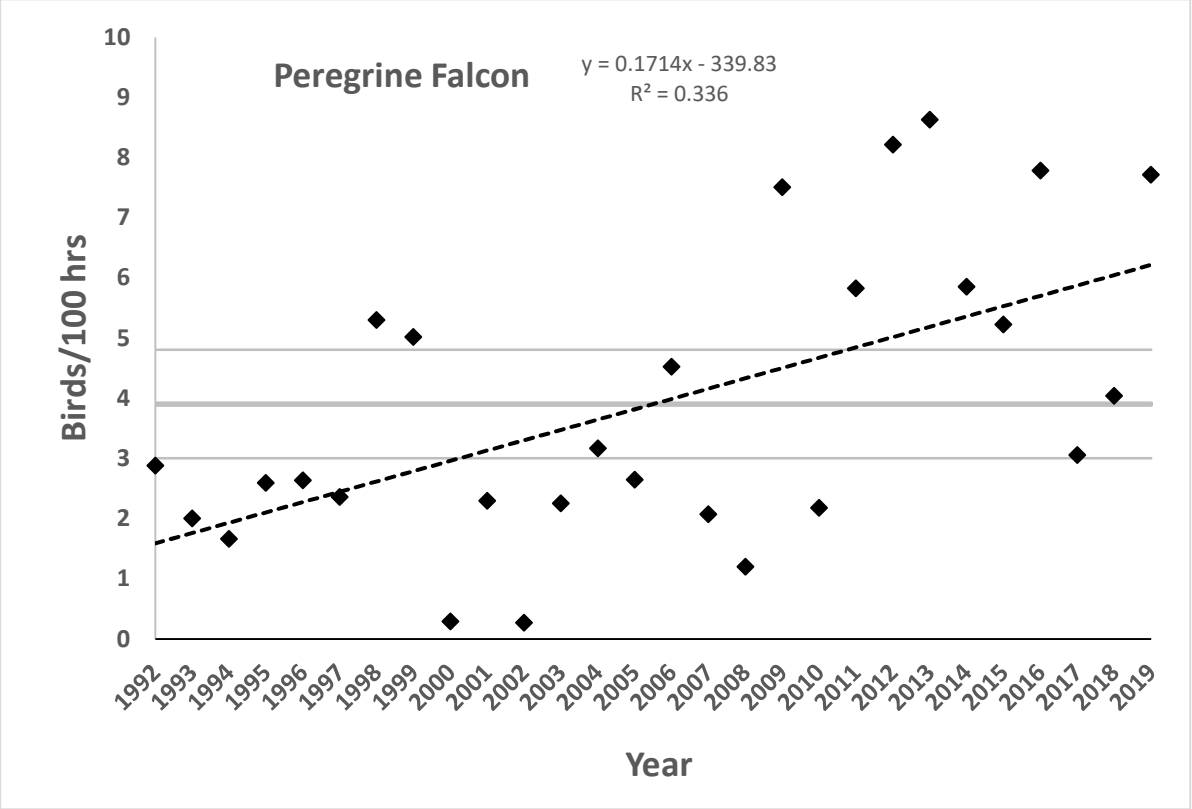


Figure 8h. Effort-adjusted fall migration passage rates for American Kestrels and Merlins in the Bridger Mountains, MT. Dashed line indicates significant ($p < 0.10$) population trend based on quadratic regressions. Solid grey lines represent mean (thick) and upper and lower 95% confidence intervals (thin) of historical counts (1992-2019).



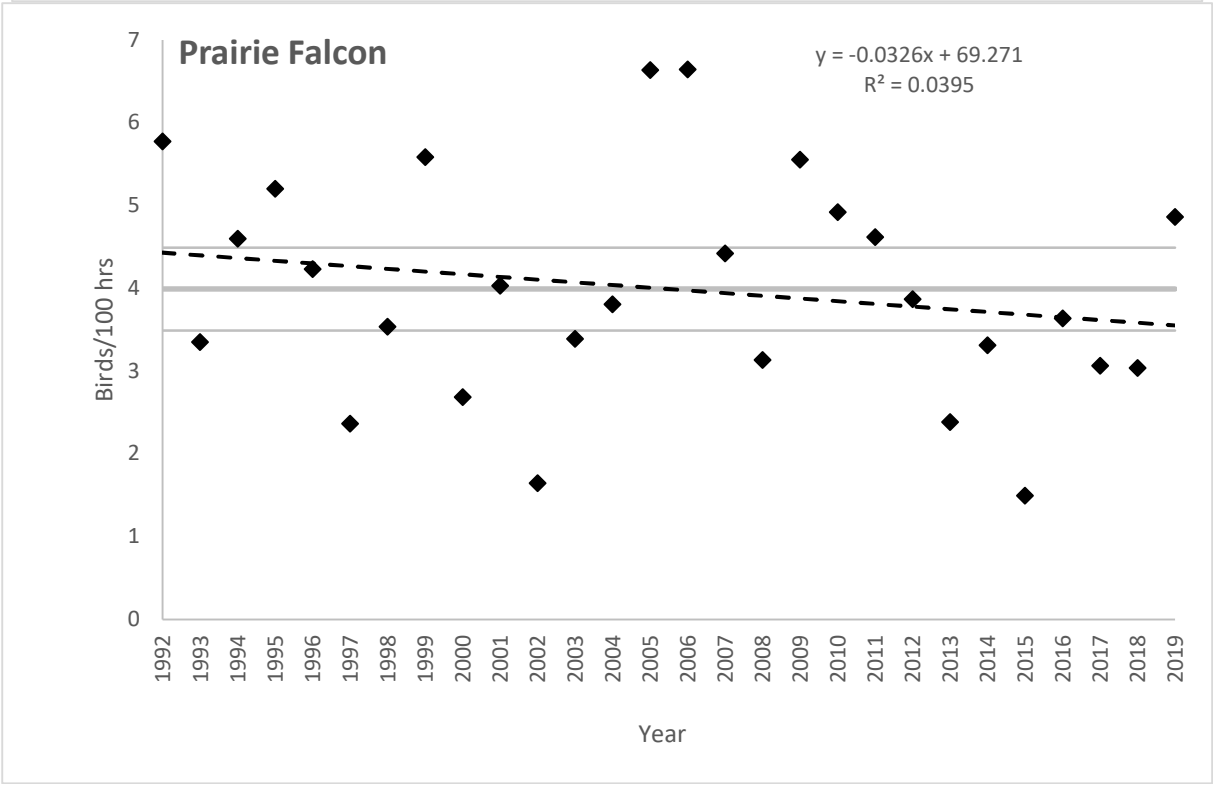


Figure 8i. Effort-adjusted fall migration passage rates for Peregrine and Prairie Falcons in the Bridger Mountains, MT. Dashed line indicates significant ($p < 0.10$) population trend based on quadratic regressions. Solid grey lines represent mean (thick) and upper and lower 95% confidence intervals (thin) of historical counts (1992-2019).

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

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
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
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 peregrines*	PG	A I U	U	NA
Gyrfalcon	*Falco rusticolus*	GY	A I U	U	W G D
Unknown small falcon	*F. sparverius* or *columbarius*	SF	U	U	NA
Unknown large falcon	*F. mexicanus* or *peregrines*	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, 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, G = gray; L = light, W = white; 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 weak 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 usually a dark terminal band on tail; NA = Not adult: unknown age immature/subadult; A = Adult: includes near adult with dark flecks in head and weak dark tail tip, and adult with completely white head and tail; U = Unknown.

Appendix B. A complete history of primary observers for the Bridger Mountains Raptor Migration Project (1991-2019). (Numbers given in parentheses indicate the number of full seasons of previous raptor migration counting experience.)

1991: Variable teams throughout: Kristian Shawn Omland (0), Phil West (1), LisaBeth Daly (2), Craig Limpach (1)
1992: Two observers throughout: Emily Teachout (1), Phil West (2)
1993: Two observers throughout: Adam Kaufman (0), Anne-Marie Gillesberg (0)
1994: Two observers throughout: Chris Gill (0), Stephanie Schmidt (1)
1995: Two observers throughout: Scott Harris (0), Sue Thomas (0)
1996: Two observers throughout: Jason Beason (0), Niels Maumenee (0)
1997: Two observers throughout: Jason Beason (1), Patty Scifres (0)
1998: Two observers throughout: Jason Beason (2), Mike Neal (0)
1999: Two observers throughout: Mike Neal (2), Greg Levandoski (1)
2000: Two observers throughout: Ryan Wagner (1), Tracy Elsey (0)
2001: Two observers throughout: Ryan Wagner (2), Jeff Maurer (4)
2002: Two observers throughout: Matt Proett (0), Marg Lomow (2; half-season), Maureen Essen (0; half-season)
2003: Two observers throughout: Samantha Burrell (0), Carl Bullock (0)
2004: Two observers throughout: Allison Peterson (0), John Bell (0)
2005: Two observers throughout: Corey Michell (0), Beau Fairchild (0)
2006: Two observers throughout: Brian Cook (0), Jamie Granger (0)
2007: Two observers throughout: Jody Vogeler (0), Brenden McGugin (0)
2008: Two observers throughout: Amy Seaman (0), Michaela Hitchcock (0), John Bell (2)
2009: Two observers throughout: Caitlin Kroeger (0), Jason Minné (0)
2010: Two observers throughout: Jamie Hogberg (0), David Laufenberg (0)
2011: Two observers throughout: Brian Connelly (3), John Martineau (0)
2012: Two observers throughout: Bret Davis (0), Kalon Baughan (0)
2013: Two observers throughout: Bret Davis (1), Kalon Baughan (1)
2014: Two observers throughout: Bret Davis (2), Mikaela Howie (0)
2015: Two observers throughout: Andrew Eberly (2), Bridget Bradshaw (1)
2016: Two observers throughout: Bret Davis (5), Jess Cosentino (3)
2017: Two observers throughout: Bret Davis (6), AR (0)
2018: Two observers throughout: AR (1), Bret Davis (7; half-season), Alice Morris (0; half-season)
2019: Two observers throughout: AR (3), Kyle Dudgeon (2)

Appendix C. Daily observation effort and raptor migration counts by species in the Bridger Mountains, MT, Fall 2019. (see Appendix A for species codes).

Date	Hours	TV	OS	BE	NH	SS	CH	NG	BW	RT	RL	SW	FH	GE	AK	ML	PG	PR	UA	UB	UF	UE	UR	TOTAL
8/23	2.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
8/27	8	0	0	0	6	2	1	0	0	6	0	0	0	0	4	0	0	1	1	0	0	1	1	**23**
8/28	8	1	0	0	2	1	2	0	0	1	0	0	0	2	2	2	0	0	0	1	0	0	1	**15**
8/29	8	0	0	0	2	1	2	0	0	3	0	0	0	1	6	1	0	0	0	0	0	0	0	**16**
8/30	8	0	1	0	3	0	0	0	0	0	0	0	1	3	2	0	0	0	0	1	0	0	0	**11**
8/31	8	0	0	0	2	2	8	0	2	1	0	0	0	0	5	0	0	0	0	0	0	0	0	**20**
9/1	8	0	0	2	0	3	3	0	0	4	0	0	0	0	5	1	0	0	0	0	0	0	0	**18**
9/2	6.75	0	0	0	0	3	5	0	0	2	0	0	0	0	3	0	0	0	0	1	0	0	2	**16**
9/3	7.25	0	1	0	7	5	8	0	0	2	0	0	0	3	3	0	1	1	0	0	0	0	0	**31**
9/4	6.25	1	0	0	0	1	2	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	**6**
9/5	8	1	0	1	2	5	5	0	0	2	0	0	0	2	5	1	1	0	0	0	0	0	0	**25**
9/6	4.5	0	0	0	0	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
9/7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
9/8	6	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**2**
9/9	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
9/10	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
9/12	5.25	0	1	1	0	3	5	2	0	5	0	0	2	2	1	3	1	0	0	0	0	0	0	**26**
9/13	8.5	2	2	1	1	12	14	1	0	15	0	0	0	8	10	0	2	0	0	0	0	0	0	**68**
9/14	8	0	2	1	1	11	21	0	0	5	0	0	0	4	5	1	5	1	0	0	0	0	1	**58**
9/15	8	2	2	3	6	29	28	0	0	3	0	0	0	10	7	0	0	1	0	0	1	0	0	**92**
9/16	8	3	0	0	1	31	22	3	1	10	0	2	0	6	3	0	2	1	1	0	0	0	0	**86**
9/17	2.75	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**2**
9/18	8.5	1	0	0	26	47	73	2	6	12	0	1	0	15	31	1	3	2	6	0	0	0	1	**227**
9/19	8	0	0	1	2	3	11	0	1	4	0	0	0	6	1	0	0	1	0	0	0	0	0	**30**
9/22	8.5	2	0	9	5	56	41	1	6	14	0	2	0	27	6	1	2	0	6	2	0	0	2	**182**
9/23	8	2	2	2	2	37	17	2	3	11	0	0	0	21	8	2	4	1	4	0	1	0	0	**119**
9/24	8	0	1	1	0	20	3	0	0	7	0	0	0	8	0	1	3	0	0	1	0	0	0	**45**
9/25	8	0	0	3	1	2	10	0	0	4	0	1	0	12	1	0	1	1	2	0	0	0	0	**38**
9/26	7.5	0	0	0	0	0	1	1	0	1	0	0	0	4	0	0	0	0	0	0	0	0	0	**7**
9/27	4.5	0	0	1	0	2	1	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	**7**
10/2	4	0	0	2	0	3	0	0	0	1	1	0	0	65	0	0	0	0	0	0	0	0	0	**72**
10/3	8	0	0	1	1	1	0	0	0	1	1	0	0	17	0	0	0	0	1	0	0	0	0	**23**
10/5	4.75	0	0	0	0	1	0	0	0	3	0	0	0	6	0	0	1	0	0	0	0	0	0	**11**
10/6	8	0	0	1	2	16	3	2	3	3	0	0	0	151	1	0	0	1	3	1	0	0	2	**189**
10/7	8.5	0	0	2	1	15	3	0	0	2	0	0	0	126	2	4	1	0	1	1	0	0	0	**158**
10/8	7.5	0	1	4	1	94	18	3	1	9	0	1	0	85	5	4	0	2	7	1	0	0	1	**237**
10/10	7	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	**7**
10/11	8.5	0	0	2	1	6	0	2	0	0	0	0	2	45	0	0	0	0	0	0	0	0	0	**58**
10/12	8	0	0	2	1	5	0	2	0	2	0	0	1	40	0	0	0	0	1	0	0	0	1	**55**
10/13	8.5	0	0	0	2	22	5	3	1	4	0	0	0	57	1	1	0	0	1	1	0	1	1	**100**
10/14	8	0	0	1	2	0	2	0	0	3	0	0	0	29	0	0	0	0	0	0	0	0	0	**37**
10/15	8	0	0	2	6	9	4	2	0	1	3	0	1	17	0	1	0	0	0	0	0	0	0	**46**
10/16	8.5	0	0	6	1	16	0	1	0	0	2	0	0	90	0	0	0	1	0	0	0	0	0	**117**
10/17	8	0	0	4	0	11	0	1	0	0	1	0	0	116	0	0	0	0	0	0	0	0	0	**133**
10/18	7.25	0	0	0	1	5	1	1	0	0	0	0	0	21	0	1	0	0	1	0	0	0	0	**31**
10/19	4.5	0	0	1	0	10	0	1	0	1	1	0	0	10	0	0	0	0	0	0	0	0	0	**24**
10/22	6.75	0	0	0	1	0	0	0	0	0	2	0	0	16	0	0	0	0	0	0	0	0	0	**19**
10/23	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
10/24	7.5	0	0	0	0	0	0	1	0	1	2	0	0	39	0	0	0	1	0	0	0	0	0	**44**
10/25	7.5	0	0	4	3	5	0	0	0	1	1	0	0	21	0	0	0	1	0	1	0	0	0	**37**
10/27	4.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
10/29	4.5	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	**1**
10/30	4	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	**5**
TOTAL	**349.75**	**15**	**13**	**59**	**93**	**497**	**324**	**31**	**24**	**145**	**14**	**7**	**7**	**1101**	**117**	**25**	**27**	**17**	**35**	**11**	**2**	**2**	**13**	**2579**

[1] Species code UA is unknown accipiter, UB is unknown buteo, UF is unknown falcon, UE is unknown eagle and UR is unknown raptor. (UA is combined small and large accipiter. UF is combined Unknown Falcon, Small Falcon, and Large Falcon totals.)

Appendix D. Annual observation effort and fall raptor migration counts by species in the Bridger Mountains, MT: 1991–2019.

	1991	1992	1993	1994	1995	1996	1997
Start date	15-Sep	6-Sep	9-Sep	13-Sep	10-Sep	1-Sep	27-Aug
End date	3-Nov	28-Oct	31-Oct	30-Oct	2-Nov	30-Oct	31-Oct
Observation days	32	39	46	36	42	53	62
Observation hours	191.1	242.58	298.50	239.25	269.17	378.25	422.92
Raptors / 100 hours	926.7	1000.1	871.7	1027.8	824.0	808.5	796.1
SPECIES			RAPTOR COUNTS				
Turkey Vulture	3	0	0	0	0	1	6
Osprey	2	2	5	5	1	14	12
Northern Harrier	19	13	41	59	10	38	66
Sharp-shinned Hawk	88	248	279	364	304	436	480
Cooper's Hawk	87	175	124	134	131	206	347
Northern Goshawk	27	96	39	17	10	37	36
Unidentified Accipiter	70	35	27	20	33	51	53
Total Accipiters	272	554	469	535	478	730	916
Broad-winged Hawk	0	2	3	16	5	5	5
Swainson's Hawk	1	11	0	3	2	0	6
Red-tailed Hawk	26	67	65	110	79	106	130
Ferruginous Hawk	3	1	1	1	0	5	4
Rough-legged Hawk	9	10	53	48	29	17	23
Unidentified Buteo	14	8	19	15	18	13	20
Total Buteos	53	99	141	193	133	146	188
Golden Eagle	1280	1579	1699	1500	1322	1871	1844
Bald Eagle	43	95	124	41	57	79	93
Unidentified Eagle	5	2	17	0	25	14	0
Total Eagles	1328	1676	1840	1541	1404	1964	1937
American Kestrel	33	38	54	67	117	82	146
Merlin	2	10	7	7	12	9	26
Prairie Falcon	9	14	10	11	14	16	10
Peregrine Falcon	1	7	6	4	7	10	10
Gyrfalcon	0	0	0	0	0	0	0
Unidentified Falcon	5	3	2	4	2	5	17
Total Falcons	50	72	79	93	152	122	209
Unidentified Raptor	44	10	27	33	40	43	33
Grand Total	1771	2426	2602	2459	2218	3058	3367

Appendix D. (continued)

	1998	1999	2000	2001	2002	2003	2004
Start date	28-Aug	29-Aug	29-Aug	27-Aug	27-Aug	27-Aug	27-Aug
End date	31-Oct	31-Oct	29-Oct	31-Oct	27-Oct	31-Oct	27-Oct
Obs. Days	56	57	52	58	52	64	48
Obs. Hours	339.33	358.24	335.40	347.49	365.84	443.18	316.70
Raptors/100 hrs	1040.9	871.8	630.9	636.3	556.0	517.6	655.2
SPECIES			RAPTOR COUNTS				
Turkey Vulture	0	2	0	0	0	0	0
Osprey	13	9	6	6	2	5	1
Northern Harrier	230	52	20	36	15	54	39
Sharp-shinned Hawk	612	442	190	274	288	416	229
Cooper's Hawk	343	149	109	120	103	132	142
Northern Goshawk	50	61	34	26	2	23	41
Unidentified Accipiter	49	39	35	27	20	33	48
Total Accipiters	1054	691	368	447	413	604	460
Broad-winged Hawk	20	13	3	38	3	9	6
Swainson’s Hawk	2	3	3	0	1	2	0
Red-tailed Hawk	277	121	45	117	78	113	100
Ferruginous Hawk	7	4	1	3	0	1	3
Rough-legged Hawk	66	77	26	57	11	22	20
Unidentified Buteo	13	3	8	6	9	6	18
Total Buteos	385	221	86	221	102	153	147
Golden Eagle	1516	1870	1429	1330	1359	1226	1196
Bald Eagle	95	91	128	58	55	93	79
Unidentified Eagle	15	5	3	2	15	4	2
Total Eagles	1626	1966	1560	1390	1429	1323	1277
American Kestrel	141	113	39	62	16	102	65
Merlin	17	8	3	9	2	4	11
Prairie Falcon	12	20	9	14	6	15	12
Peregrine Falcon	18	18	1	8	1	10	10
Gyrfalcon	0	1	0	0	0	0	0
Unidentified Falcon	8	6	4	3	5	4	15
Total Falcons	196	166	56	96	30	135	113
Unidentified Raptor	28	16	20	15	43	20	38
Grand Total	3532	3123	2116	2211	2034	2294	2075

Appendix D. (continued)

	2005	2006	2007	2008	2009	2010	2011
Start date	27-Aug	27-Aug	27-Aug	27-Aug	6-Sep	28-Aug	2-Sep
End date	31-Oct	29-Oct	29-Oct	31-Oct	31-Oct	1-Nov	4-Nov
Observation days	48	45	56	56	44	54	57
Observation hours	300.83	331.25	384.59	415.49	306.25	366.00	411.42
Raptors / 100 hours	674.8	538.3	550.5	427.7	453.2	641.8	695.9
SPECIES			RAPTOR COUNTS				
Turkey Vulture	1	2	1	0	0	2	5
Osprey	2	7	5	4	9	3	14
Northern Harrier	22	50	30	47	52	77	59
Sharp-shinned Hawk	228	344	277	222	230	336	565
Cooper's Hawk	153	182	151	115	113	207	221
Northern Goshawk	22	33	20	22	13	33	15
Unidentified Accipiter	123	10	29	56	19	87	37
Total Accipiters	526	569	477	415	375	663	838
Broad-winged Hawk	3	12	5	7	33	5	12
Swainson's Hawk	0	0	3	8	4	1	2
Red-tailed Hawk	108	89	130	75	75	178	202
Ferruginous Hawk	2	3	5	1	2	3	2
Rough-legged Hawk	40	21	19	32	30	31	28
Unidentified Buteo	27	2	11	10	10	20	4
Total Buteos	180	127	173	133	154	238	250
Golden Eagle	1061	859	1247	1003	638	1171	1431
Bald Eagle	75	74	85	43	27	50	68
Unidentified Eagle	1	1	0	10	4	1	0
Total Eagles	1137	934	1332	1056	669	1222	1499
American Kestrel	20	38	41	46	45	87	99
Merlin	7	15	9	10	4	12	17
Prairie Falcon	20	22	17	13	17	18	19
Peregrine Falcon	8	15	8	5	23	8	24
Gyrfalcon	0	0	0	0	0	0	0
Unidentified Falcon	53	1	7	10	10	5	2
Total Falcons	108	91	82	84	99	130	161
Unidentified Raptor	54	3	17	38	30	14	37
Grand Total	2030	1783	2117	1777	1388	2349	2863

Appendix D. (continued)

	2012	2013	2014	2015	2016	2017	2018	2019	Mean
Start date	1-Sep	1-Sep	1-Sep	29-Aug	27-Aug	26-Aug	26-Aug	27-Aug	31-Aug
End date	5-Nov	5-Nov	8-Nov	2-Nov	5-Nov	8-Nov	10-Nov	30-Oct	1-Nov
Observation days	58	50	57	55	54	60	52	52	52
Observation hours	414.38	335.76	399.67	401.33	385.2	424.3	395.5	349.8	356.0
Raptors / 100 hours	680.0	688.9	720.4	822.0	798.1	635.5	516.5	737.3	707.6
SPECIES	RAPTOR COUNTS								
Turkey Vulture	2	16	8	7	14	29	10	15	3
Osprey	9	13	6	22	13	7	12	13	8
Northern Harrier	64	34	112	141	44	50	58	93	56
Sharp-shinned Hawk	452	354	422	658	617	321	242	497	365
Cooper's Hawk	180	160	203	306	198	191	216	324	183
Northern Goshawk	33	16	59	38	62	39	12	31	33
Unidentified Accipiter	58	35	66	94	61	45	28	35	36
Total Accipiters	723	565	750	1096	938	596	498	887	589
Broad-winged Hawk	37	48	22	29	31	11	21	24	15
Swainson's Hawk	8	4	2	3	4	5	2	7	3
Red-tailed Hawk	238	180	239	389	215	208	115	145	139
Ferruginous Hawk	4	3	8	6	3	5	2	7	3
Rough-legged Hawk	42	34	84	96	77	64	55	14	41
Unidentified Buteo	12	17	37	29	16	19	16	11	14
Total Buteos	341	286	392	552	346	312	211	208	196
Golden Eagle	1272	1131	1222	1138	1437	1476	1004	1101	1319
Bald Eagle	92	74	106	81	77	69	59	59	76
Unidentified Eagle	12	3	11	2	1	4	11	2	6
Total Eagles	1376	1208	1339	1221	1515	1549	1074	1162	1403
American Kestrel	147	104	138	181	89	74	87	117	84
Merlin	16	21	28	36	33	22	9	25	14
Prairie Falcon	16	8	13	6	14	13	12	17	14
Peregrine Falcon	34	29	23	21	30	13	16	27	14
Gyrfalcon	0	0	0	0	0	0	0	0	0.05
Unidentified Falcon	13	3	7	7	8	6	8	2	8
Total Falcons	226	165	209	251	174	128	132	188	134
Unidentified Raptor	77	28	63	9	30	25	53	13	31
Grand Total	2818	2315	2879	3299	3074	2696	2048	2579	2483