

# **Fall 2017 Golden Eagle Migration Survey Big Belt Mountains, Montana**



*(Photo by David Brandes)*

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*Report submitted to:*  
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**March 2018**

# **FALL 2017 GOLDEN EAGLE MIGRATION SURVEY IN THE BIG BELT MOUNTAINS, MONTANA**

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# INTRODUCTION

The majority of North American diurnal raptor species migrate biannually between their breeding and wintering grounds, instinctively following predictable migration routes. During migration, raptors often concentrate along specific geographic features (especially high mountain ridges and coastlines) associated with optimal flying conditions. This provides excellent opportunities for researchers to quantify long-term trends in raptor populations, and for some species assess year-to-year demographic changes. It has been well established that standardized scientific annual counts at established hawk-watch sites are a cost-effective way to track long-term raptor population trends (Zalles and Bildstein 2000, Farmer et al. 2007).

Trends in diurnal raptor populations can serve as a useful barometer of the overall health of their preferred habitat, making them key biological indicators (Bildstein 2001). The monitoring of migratory Golden Eagles in western North America is especially important currently because migration counts suggest long-term declines since the late 1990s (Smith et al. 2008, Sherrington 2017a & b). The Bridger Mountains, located approximately 60 miles south-southeast of the Big Belts (near Bozeman), is a historically significant site for censusing migrant Golden Eagles. Golden Eagle numbers counted along this flyway have declined by 30-40% (Smith et al. 2008, Davis et al. 2017) since standardized scientific counts began in 1992.

Raptor View Research Institute (RVRI), based out of Missoula, first recognized the Big Belt Mountains as a significant migration flyway for Golden Eagles in 2007. Steve Hoffman, founder of HawkWatch International and former Executive Director of Montana Audubon, launched additional exploratory raptor migration counts in the Big Belts in October 2014. On 11 October 2014, Hoffman, Dan Ellison and Jane Fournier documented an incredible 284 migrating Golden Eagles in 6.75 hours of observation. Additional counts in the Big Belts in fall 2014 consistently yielded far greater numbers of migrant Golden Eagles (compared to the Bridgers) on corresponding days. Data from migrating Golden Eagles equipped with satellite transmitters (by RVRI) has shown that a significant number of migrant Golden Eagles, after traversing the length of the Big Belts, redirected their flight path eastward to the Crazy Mountains and thus could not have been tallied at the Bridger Mountains' site. From these findings Hoffman hypothesized that full-season autumn migration counts in the Big Belts could likely contribute substantially to a better understanding of regional long-term trends in Golden Eagle populations along this prominent Rocky Mountain flyway.

In fall 2015, Bret Davis and Ronan Dugan conducted the first standardized raptor migration count in the Big Belts (Davis & Hoffman 2016). From 15 September – 3 November Davis and Dugan camped at Duck Creek Pass and conducted daily migration surveys (weather permitting). Their effort produced astonishing results: 2,630 Golden Eagles were recorded in 352.8 hours of observation, yielding one of the highest Golden Eagle passage rates known in North America (Yates et al. 2001, McIntyre and Lewis 2016, Grayum et al. 2017). The Big Belts also proved to be an active site for many other migrating raptors; remarkably, on 23 September all 17 raptor species known to migrate through the region were recorded – an unprecedented occurrence which, to our knowledge, has never before been documented at any hawk watch site in western North America!

In fall 2016, Ronan Dugan returned as a primary observer. He was joined by biologist and novice hawk-watcher Jeff Grayum to assist with daily counts. Efforts began 15 days earlier than in 2015, with Dugan and Grayum beginning official counts on 1 September. The 2016 season was a collaborative effort among four entities: Montana Audubon, Last Chance Audubon Society,

Montana Fish, Wildlife, and Parks, and the US Forest Service (Helena-Lewis & Clark National Forest), with each organization contributing unique and important roles. This collective effort was christened the **Golden Eagle Migration Survey (GEMS)**. This has continued through 2017 with the support of this highly successful collaboration.

The primary objectives of this long-term study are to:

1. Annually quantify numbers and movement patterns of all diurnal raptor species, especially Golden Eagles, as they pass through the Big Belt Mountains, primarily to assess long-term population trends.
2. Determine the population demographics of Golden Eagles using the Big Belt flyway.
3. Collect daily and regional weather data to help evaluate the migrants' behavioral responses to various weather patterns and how weather factors may influence our counts.
4. Engage local communities by developing public education opportunities to share the science and amazing spectacle of the fall raptor migration in the Big Belts.

## STUDY SITE

The Big Belts is a 75-mile long, northwest-southeast trending ridgeline managed by the Helena – Lewis and Clark National Forest in west-central Montana (Fig. 1). The range is bordered to the west by Canyon Ferry Lake, a 35,181-acre artificial reservoir created by the damming of the Upper Missouri River. To the east of the Big Belts lies Shields Valley and farther east is another string of northwest-southeast trending mountain ranges. Following the Big Belt Mountains toward the south-southeast leads to the Bridger Mountains (Fig. 1), where many of the raptors migrating through the Big Belt Mountains also likely pass.

Strong southwesterly winds typically prevail across the crest of the Big Belts. These consistent winds, combined with the Big Belts' steep west-facing slopes, generate powerful orographic lift, thus providing ideal flying conditions for migrating raptors. The 'lake-effect' of Canyon Ferry Reservoir may enhance the consistency and speed of these westerly winds over the Big Belts. These factors, along with the prominent "leading line" created by the Rocky Mountain Front (which extends to the north well into Canada) make the southern end of the Big Belts a profoundly significant concentration point for migrating raptors in autumn.

During fall 2017, three observation sites were utilized at various elevations on the west slope of the Big Belts (Fig. 2). The primary lookout since the project's inception (including in 2017) is referred to herein as 'Radio Tower West Slope' (RTWS). This site is located along the ridgeline, 1.4 miles south of Duck Creek Pass (N = 46.476962 degrees, W = -111.256572 degrees). It is approximately 200m downslope from the radio communications towers, at an elevation of 8180 feet. In 2015, this site was referred to as "Far Down Hill" upon its establishment as the primary site. This lookout affords exceptionally close views of a relatively high percentage of the migrating raptors, allowing observers to accurately determine species, age and/or sex for a remarkably high proportion of the passing migrants. Access to the observation site from Duck Creek Pass is via a steep, rocky road suitable only for 4-wheel drive, high-clearance vehicles. (Visitors are encouraged to park at Duck Creek Pass and hike 1.4 miles and 900 feet in elevation gain to the observation site.)

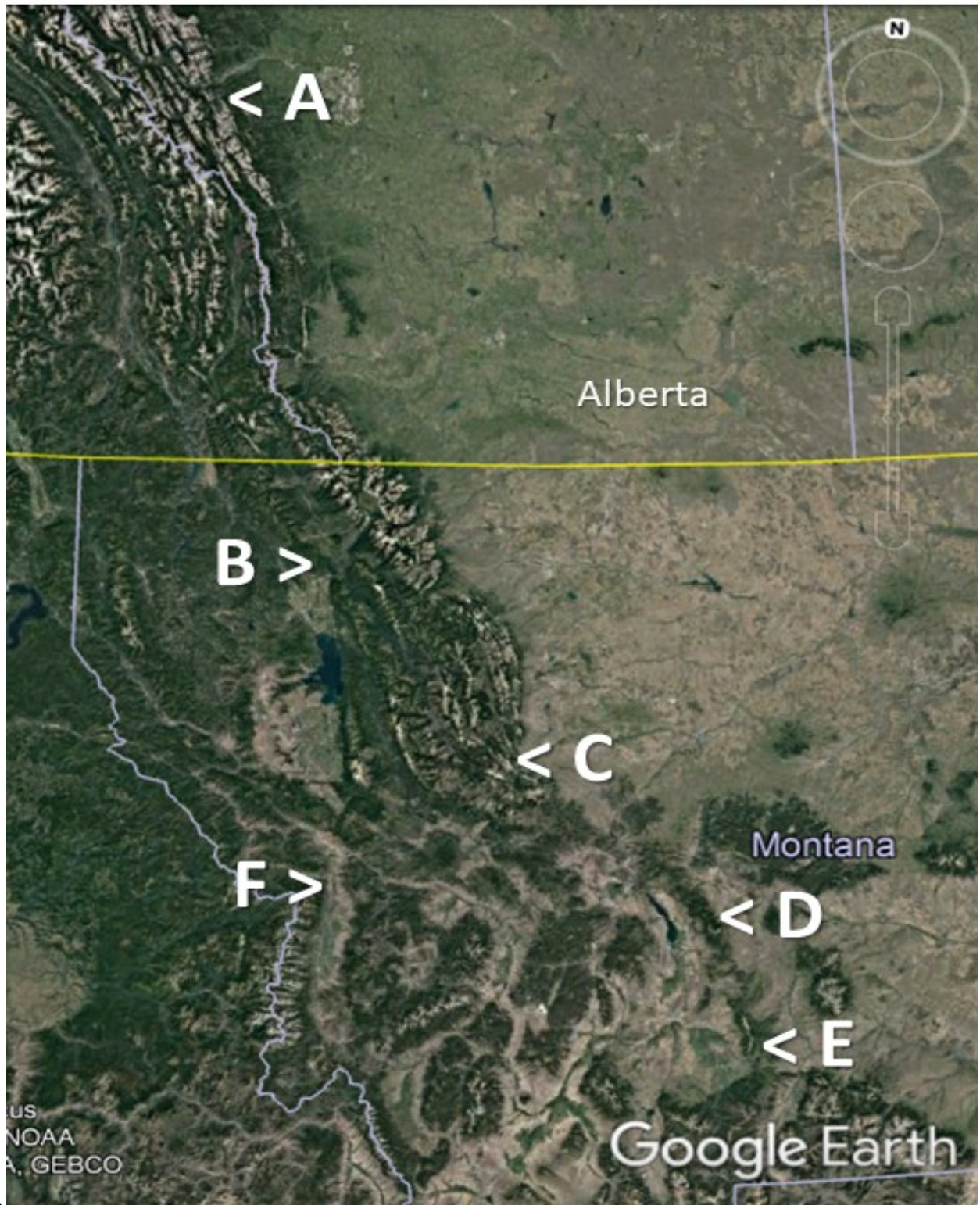
When fog and low cloud cover dramatically reduced visibility at the primary site the observers conducted the official count from a lower elevation, referred to herein as 'Vista Point' (VP). VP is located at an elevation of 7,570 feet, 2.6km north of RTWS and within 40m of Duck Creek Pass

Road (N = 46.497535 degrees, W = -111.268915 degrees). This site is easily accessible by regular passenger vehicles and provided an ideal location to bring field-trip participants unable to make the steep hike to the primary observation site. In 2017 no simultaneous counts were conducted from multiple sites, as was done in previous seasons.

It is important to note that in both 2015 and 2016 a different site was used as a lower, alternative observation site when fog/low cloud cover prevented counting from RTWS. In previous project annual reports (and in hawkcount.org) this site is referred to as 'Saddle Knoll' (SK). SK's location is 0.6km north-northwest of Vista Point at an approximate elevation of 7550 feet (N = 46.502518 degrees, W = -111.273463 degrees). In 2017 this alternative site was moved to Vista Point for two reasons: 1) Ease of access, especially during times of deep snow cover, and 2) Enhanced overall visibility for detecting passing migrants. (VP observation site is especially advantageous for seeing migrants using a more easterly flight path.)

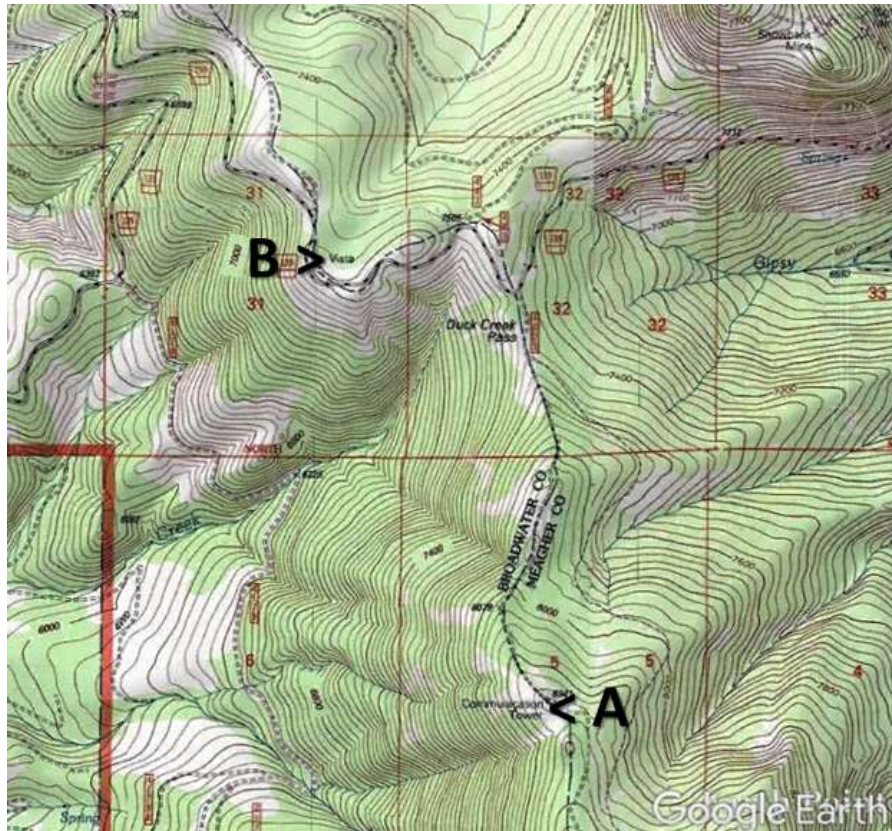
When extreme weather prevented counts from being conducted at both the primary and secondary sites the observers stationed themselves at an even lower elevation along Duck Creek Road, herein referred to as 'Lower Duck Creek Rd' (LDCR). This observation site is on private land (used with landowner permission), located on a grassy saddle west of Duck Creek Pass at an elevation of approximately 6000 feet. This site is mostly suited for detecting only large raptors, due to its considerable distance from the ridgetop (and primary migratory flight path). LDCR was also used sparingly in 2016.





**Figure 1.** Approximate locations of hawk-count sites in Montana, and in Alberta, Canada. A) Mt. Lorette (Alberta); B) Jewel Basin; C) Nora Ridge; D) Big Belts; E) Bridgers; F) MPG Ranch.





**Figure 2:** Locations of public-land observation sites utilized in the Big Belt Mountains during fall 2017: A) Radio Tower West Slope (RTWS – primary site); B) Vista Point (VP – secondary site).

## METHODS

In 2017, Jeff Grayum returned as the primary observer and was joined by biologist and avid birder Hilary Turner (see Appendix B for a complete history of official observers for the GEMS Project). Grayum and Turner once again camped at Duck Creek Pass, but for the first time were provided with a wall tent (equipped with a wood stove). The 2017 count season start date was 15 September, keeping the primary focus on Golden Eagles, whose migration is generally not conspicuous until later in September. The season ended on 31 October with the approach of a severe, prolonged winter storm.

Training in migrant raptor identification of the two official observers was provided by Steve Hoffman at the start of the count to ensure data would be collected accurately. In addition to the official observers, two well-qualified US Forest Service (USFS) employees, Shaun Hyland and Erin Brekstad, substituted twice weekly to provide a weekly day off for Jeff and Hilary. Shaun possesses multiple seasons of raptor migration counting experience as an official observer at HawkWatch International's Chelan Ridge (Washington) site. Both USFS biologists have fulfilled this role as auxiliary observers since the inception of the count, and project organizers were pleased to have them back for a third consecutive year.

Observation hours began regularly at 0900, and on most days concluded at 1700 (MST). During peak Golden Eagle migration the observers often began counting 30-60 minutes earlier in the morning, and continued observing 30-60 minutes later in the evening to ensure that no substantial

migratory flights of Golden Eagles were missed. Data were recorded following standardized protocol established by HawkWatch International. Weather observations were measured using a handheld Kestrel 2500 Weather Station.

A decoy owl was erected at the primary lookout (RTWS) to lure migrating raptors closer to the observers, thereby enhancing the quality of data collected. The decoy was erected approximately 80m downslope from the observers, situated on a prominent dead snag so it would be clearly visible to migrating raptors approaching from the north.

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/scientific names for all species, species-specific applicability of various age, sex, and color morph distinctions, and 2-letter codes used for each species).
2. Hour of passage for each migrant (e.g., the 0900–0959 H, etc - Mountain Standard Time).
3. Wind speed and direction, air temperature, percent cloud cover, predominant cloud type(s), presence of precipitation (and type), visibility, and a subjective assessment of thermal lift conditions (i.e., excellent, good, fair and poor) for each hour of observation (assessed on the half-hour).
4. Predominant direction, altitude, and horizontal distance from the observation point of the migratory flight for each hour.
5. Total minutes observed, and the mean number of observers present during each hour (including official observers plus volunteers/visitors who contributed substantially to the count [actively scanning, pointing out birds, recording data, etc.] for at least 10 minutes in a given hour).
6. A subjective visitor-disturbance rating (high, moderate, low, none) for each hour.
7. Names and contact information for each visitor; observation start and end times for each observer.
8. Presence and behavior of resident raptors, including criteria used to determine resident status.

The method for recording data throughout the 2017 season was expanded from the typical paper datasheets to include in-the-field electronic data entry using an Android Tablet, utilizing the Dunkadoo ([dunkadoo.org](http://dunkadoo.org)) application. HMANA's (Hawk Migration Association of North America) website, [hawkcount.org](http://hawkcount.org), was automatically updated via Dunkadoo at the end of each day. The GEMS migration site on the hawkcount.org website is listed as "Golden Eagle Migration Survey" (GEMS). Hourly raptor count totals and a general summary of the day's events, including weather, were posted on hawkcount.org daily. Regular postings with updates of the count results were also made daily to the project's Facebook page ("Golden Eagle Migration Survey"). The data entered electronically mirrored that recorded on the paper data sheets, precluding the need for data-entry each evening or at the end of the season.

## RESULTS AND DISCUSSION

### **OBSERVATION EFFORT AND WEATHER SUMMARY:**

Observations were conducted on 41 of 47 possible count days between 15 September and 31 October 2017. The first severe winter storm deposited more than 18 inches of snow at camp, creating logistical challenges for the observers on day one, primarily due to difficult access to Duck Creek Pass. The first weather-permitting (partial) day of observation was 16 September at Lower Duck Creek Road (LDCR). On 17 September observations were conducted at VP, and on 18 September the count was conducted throughout the day at the primary site (RTWS), since the storm had left the area. The season ended on 31 October with the approach of a severe winter storm that deposited up to a foot of fresh snow throughout the area.

Inclement weather made observations impossible on six days, including the first scheduled day of the count (15 September). Additionally, there were two days when observations totaled fewer than four hours (Table 1). On six days the observation site had to be moved from RTWS to VP (five days) and to LDCR (one day). On four days counting was conducted entirely at the secondary sites: VP (three days) and LDCR (one day).

**Table 1.** Complete record of inclement weather days in the Big Belt Mountains, Fall 2017.

<b>Date</b>	<b>Count Site (mins)<sup>1</sup></b>
15-Sep.	No count conducted
16-Sep.	LDCR (330)
17-Sep.	VP (330)
19-Sep.	VP (330)
20-Sep.	VP (165) RTWS (135)
22-Sep.	No count conducted
23-Sep.	RTWS (225)
30-Sep.	VP (60) RTWS (255)
1-Oct.	VP (285)
2-3 Oct.	No counts conducted
5-Oct.	LDCR (240) RTWS (105)
12-Oct.	VP (360) RTWS (150)
13-Oct.	VP (90) RTWS (135)
14-Oct.	VP (135) RTWS (264)
22-Oct.	No count conducted
29-Oct.	No count conducted

<sup>1</sup>Count-site is where the count was conducted that day. LDCR=Lower Duck Creek Road; VP=Vista Point; RTWS=Radio Tower West Slope (see Fig. 2 – LDCR is not shown due to its private-land status). Numbers in parentheses gives the total observation minutes at each respective count site.

Haze/smoke from nearby wildfires was present in all of western Montana during the late summer and early fall 2017. Thankfully, storms during the first few days of the count effectively cleared out the smoke in the vicinity of the Big Belts, allowing for generally haze-free viewing throughout the season. Accumulated snow cover was a consistent feature in the Big Belts for the entire season. Multiple storms occurred in both September and October, generally depositing 6 – 8 inches of snow each time. In addition to snow, these storms often brought dense fog and low cloud cover, sometimes preventing observation from RTWS for days at a time. Days when counts were conducted at the secondary sites, or when the count was moved from the primary to secondary sites in midday, were characterized by low cloud cover/fog, but generally without snow or rain.

## **FLIGHT SUMMARY:**

From 15 September – 31 October observations were conducted for a total of 295.0 hours (H). A total of 2,929 migrating raptors of 16 species were recorded (Table 2), yielding an average passage rate of 9.9 raptors/H. Compared with the first two seasons of the count (4,318 total raptors in 2015, and 4,389 in 2016), the 2017 count was exceptionally low. However, Golden Eagle passage rates were quite comparable among all three years (745/100H in 2015; 591/100H in 2016; and 732/100H in 2017). It is important to emphasize that we need many more years of observations before we can do an analysis of long-term trends (10 or more consecutive full-season counts are necessary before statistical count trends can be scientifically assessed). The total flight in 2017 was comprised of 76% eagles, 13% accipiters, 8% buteos, 2% falcons, 1% all other raptors (Northern Harrier, Osprey, and Turkey Vulture), and 1% unknown raptors (Fig. 3).

## **GOLDEN EAGLE:**

The Golden Eagle was by far the most numerous migrant raptor species; observers documented 2,159 Golden Eagles in fall 2017, comprising 74% of all raptor migrants. The average hourly passage rate from 15 September – 31 October was 7.3 Golden Eagles/H. Golden Eagle numbers reached a peak on 16 October, with 359 recorded in 9.8H (36.6/H; a record high for this site). The highest 5-day passage rate for Golden Eagles occurred from 16-20 October (Fig. 4), with a total count of 639 Golden Eagles and a rate of 15.4 Golden Eagles/H.

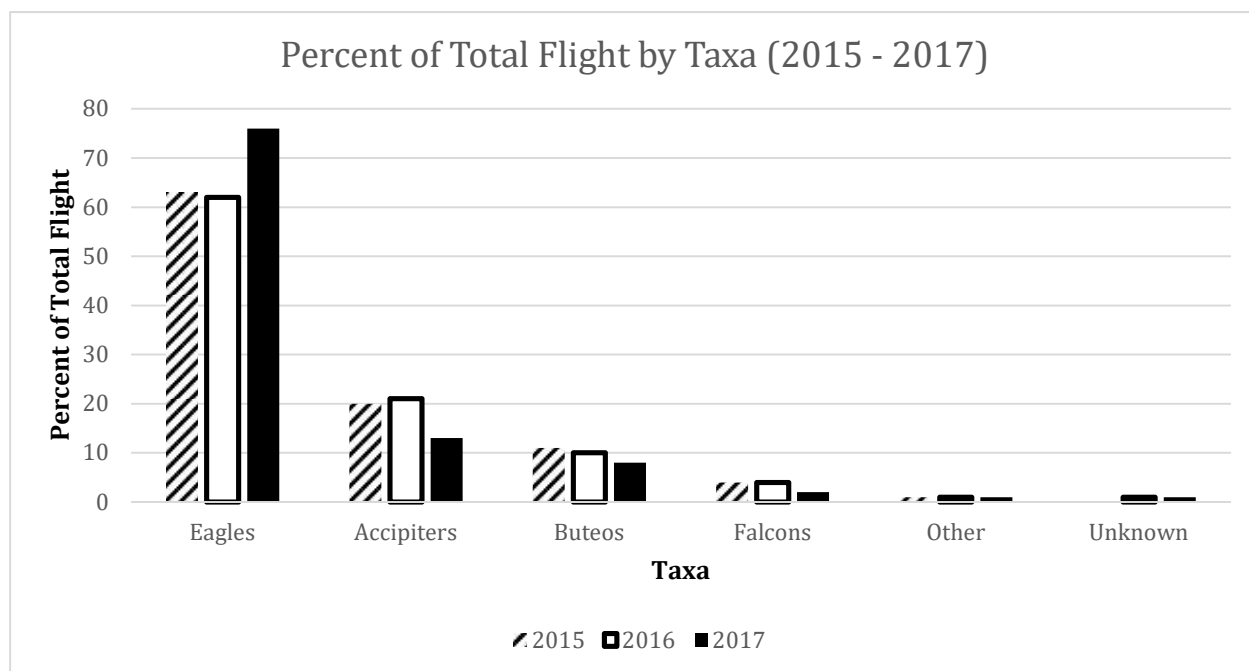
Age-specific data were collected for 74% of all Golden Eagles observed. Due to the difficulty of accurately distinguishing immature (hatch-year) Golden Eagles from older subadults in the field, and for the purposes of this report, the non-adult category includes all birds identified in the field as immature, sub-adults (generally birds that are 1.5-3.5 years of age), or non-adults (see Appendix A). In total, adult birds greatly outnumbered non-adult birds (969 adults counted versus 629 non-adults, see Table 2, Figures 4 & 5). Although long-term demographic data do not yet exist for the Big Belt flyway, the Bridger Raptor Migration Project has been collecting detailed age data on migrating Golden Eagles since 1991, providing a useful comparison for our age-specific observations in the Big Belts (which may provide valuable information on breeding success). In fall 2017 the ratio of non-adult-to-adult Golden Eagles using the Big Belt flyway was 0.65:1. This is well below the 1992-2015 average non-adult-to-adult ratio in the Bridgers (1.1:1), and quite different from the observed ratios in the Bridgers in 2017 (1.1 non-adults to 1 adult). This pattern of age disparity between the two sites is evident throughout the three-year history of the GEMS Project and may suggest age-specific differences in migration routes. At this time we are unable to confidently explain this consistent age-specific disparity between the Bridgers and the Big Belts.

**Table 2.** Flight summary for all migrating diurnal raptor species observed in the Big Belt Mountains, fall 2017. Given are the species' two-letter code, total counted for each species, dates of first and last detections, and "bulk passage dates" (dates for which the middle 80% of the flight passed). Bulk passage dates are calculated only for species with total counts of 10 or more individuals. Data for adult (A) and non-adult (NA) Golden Eagles are given as well as total Golden Eagles. Dashes indicate non-applicable fields.

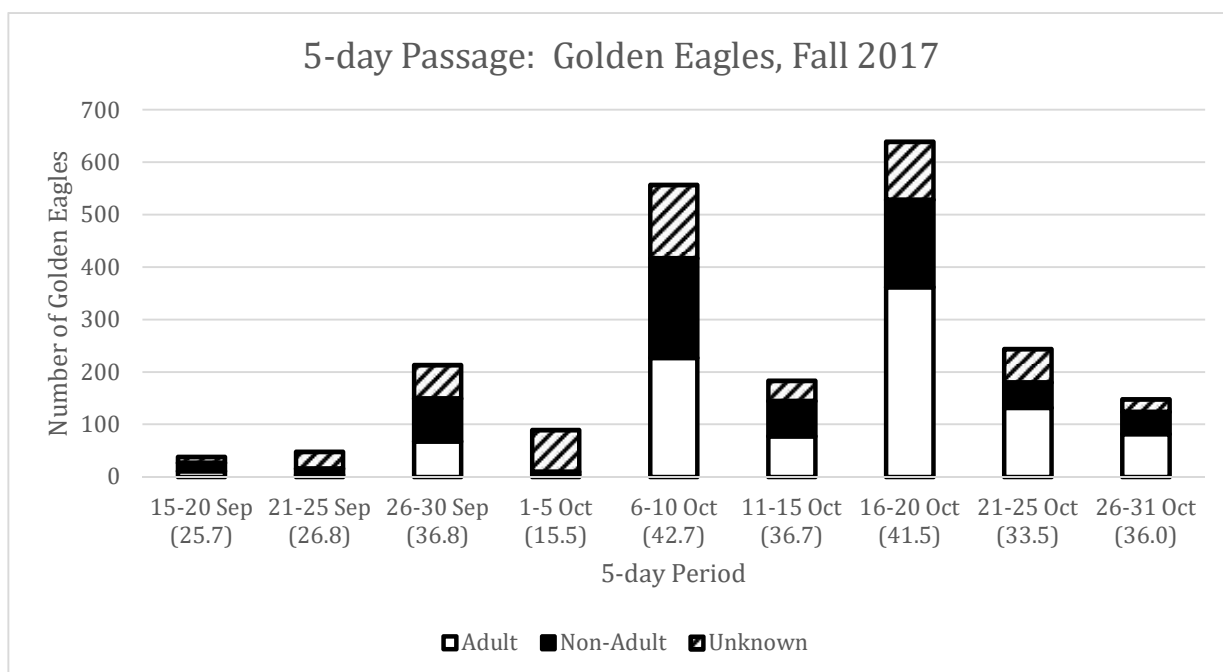
<u>Species</u>	<u>Total</u>	<u>First Observed</u>	<u>Last Observed</u>	<u>Bulk 80% Passage</u>
GE (A)	969	16-Sep	31-Oct	6 – 25 Oct
GE (NA)	629	17-Sep	31-Oct	28-Sep – 24-Oct
GE (total)	2159	16-Sep	31-Oct	29-Sep – 24-Oct
SS	232	18-Sep	30-Oct	27-Sep – 19-Oct
RL	127	29-Sep	30-Oct	9-Oct – 28-Oct
RT	81	16-Sep	30-Oct	24-Sep – 19-Oct
CH	67	18-Sep	24-Oct	27-Sep – 11-Oct
BE	65	17-Sep	31-Oct	29-Sep – 30-Oct
NG	60	19-Sep	31-Oct	25-Sep – 25-Oct
NH	15	17-Sep	19-Oct	21-Sep – 11-Oct
AK	12	27-Sep	17-Oct	28-Sep – 10-Oct
ML	11	17-Sep	21-Oct	29-Sep – 18-Oct
PR	10	17-Sep	23-Oct	17-Sep – 19-Oct
PG	5	18-Sep	6-Oct	-
SW	1	28-Sep	-	-
BW	1	17-Sep	-	-
OS	1	17-Sep	-	-
TV	1	29-Sep	-	-
FH	0	-	-	-

Inexperienced hatch-year raptors are often first to migrate from their breeding grounds as food resources become increasingly scarce (Omland & Hoffman 1996). Furthermore, adult birds often remain on their breeding territory long after the immature birds have initiated their autumn migration (Kochert et al. 2002). In terms of 5-day periods, the Golden Eagle flight flipped from being dominated by non-adult birds to mostly adult birds after 5 October; this pattern became more pronounced as the season progressed (Fig. 5).

The GEMS count recorded the greatest number of Golden Eagles of any raptor migration site in the contiguous United States in fall 2017 (Table 3). As stated earlier, the Big Belts' Golden Eagle numbers has greatly exceeded the Bridger count each year, and should be considered a premier site in the United States for monitoring western Golden Eagle populations. Nora Ridge (R. Domenech, pers. comm.) and Glacier National Park (Yates et al. 2001) are the only other sites in the United States that have recorded migrant Golden Eagle numbers comparable to the Big Belts and Bridgers in a single season. (Please note that a complete, season-long count was not conducted at Nora Ridge in fall 2017 due to severe forest fires in the area.)

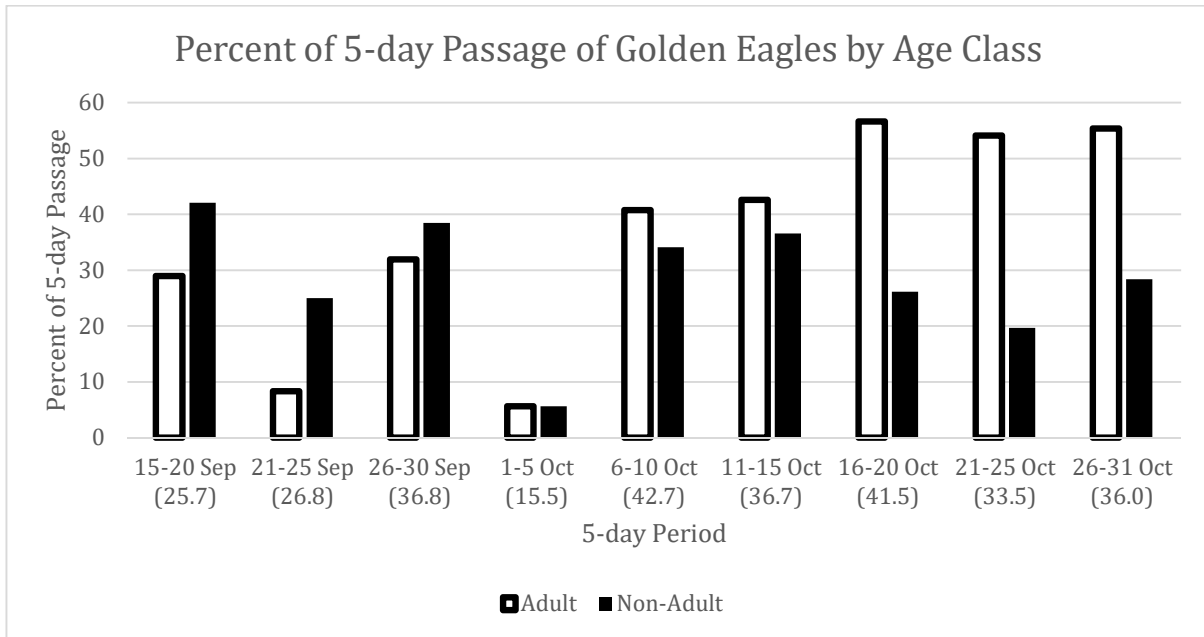


**Figure 3.** Percent of total flight by taxa – fall 2015, 2016 & 2017. ‘Other’ category includes Turkey Vultures, Ospreys, and Northern Harriers. ‘Unknown’ category is comprised of totally unidentified raptors. Both ‘Unknown’ and ‘Other’ categories each made up <1% of the count in all three fall seasons.



**Figure 4.** Five-day passage rates for Golden Eagles in fall, 2017. Given are the numbers of adult, non-adult, and unknown-age Golden Eagles counted during each five-day period. Non-adult category contains all raptors identified as immature, sub-adult, or non-adult (see Appendix A). Total

observation hours during the 5-day periods are shown in parentheses. First and last periods are six days to include the first and last days of the count.



**Figure 5.** Percent of 5-day passage of Golden Eagles by age class in the Big Belt Mountains in fall 2017. All non-adult Golden Eagles (immature, subadults, and non-adults; see Appendix A) were combined to a single non-adult category when calculating non-adult: adult ratios. Total observation hours for each 5-day period are given in parentheses.

The site in Glacier National Park is located at the base of Mt. Brown, along the shore at the upper end of Lake McDonald. Fall counts conducted by National Park Service employees produced astonishing results. In the autumns of 1994, 1995, and 1996 a total of 1,941, 1,730 and 2,249 Golden Eagles were recorded in 81.1, 117.9 and 158.9 observation hours, respectively. It must be stressed that these counts were conducted mostly during peak times of day/season. Also, these counts were conducted in the mid-1990's when other sites (most notably the Bridgers) were experiencing peak numbers of migrant Golden Eagles, suggesting much healthier western Golden Eagle populations at that time.

Mount Lorette (in Alberta; <http://eaglewatch.ca>), consistently counts the greatest number of Golden Eagles of any site in North America, although it must be noted that counts are conducted later in the season and for a far greater number of hours than any other Golden Eagle migration site. Hence the Big Belts typically records the highest passage rate for Golden Eagles (732/100H in 2017, and an average of 679/100H over the three-year period) of any annually-monitored, full-season fall raptor count in North America.

Raptor View Research Institute's research on migrant Golden Eagles includes wing-tagging of migrants at Rogers Pass (150km northwest of the Big Belts). This research enables researchers to collect valuable data on movement patterns (including seasonal and annual variation in the use of specific migration flyways), dispersal patterns and survivorship. In 2017 observers in the Big Belts documented two observations of wing-tagged Golden Eagles. Both were observed on 6 October and



photographed by visiting scientist David Brandes. Dr. Brandes' photos provided confirmation of the tag number on one of the birds (#300). This eagle was originally tagged as an adult female on 21 October 2015. The bird weighed almost 12 pounds, and its blood lead level was classified as "sub-clinical". Unfortunately, we were unable to confirm the tag number for the other wing-tagged eagle that passed that day.

**Table 3.** Comparison of Golden Eagle counts among active North American hawk watches in 2017 that recorded significant numbers of migrating Golden Eagles.

	Mt. Lorette	Bridger Ridge	Big Belts
Start date	20-Sep	27-Aug	15-Sep
End date	15-Nov	8-Nov	31-Oct
Observation days	51	60	41
Observation hours	533	424	295
Golden Eagles	3233	1476	2159
Golden Eagles / 100H	607	348	732

## **RESIDENT RAPTORS:**

Raptors displaying non-migrant behavior were assumed to be year-round residents. Resident behavior included active hunting, prolonged perching, performing territorial displays, and flying in a direction atypical of migration (flying north, east or west). Observers kept a detailed, daily journal of resident bird activity.

Golden Eagle: A pair of Golden Eagles was frequently observed (3-4 times a week) to the northwest of the primary observation site (RTWS). Typical behaviors that identified them as residents included roller-coaster displays, escorting and sometimes harassing migrant Golden Eagles, and flight directions atypical for migrants. The roller-coaster display is a territorial display; it is characterized by an almost vertical, powered flight, followed by tucking their wings at the flight apex and falling into a steep dive before finally opening their wings and swooping back up at the bottom of their dive. This is often repeated several times in succession. One member of the pair was a sub-adult. A second pair of Golden Eagles was observed less frequently (1-2 times a week) southwest of the main observation site, in the direction of the Horseshoe Hills. These birds were seen harassing/escorting migrant birds in addition to flying in a direction atypical of migration. This pair was likely observed less frequently because the observers spent far less time scanning to the south.

Bald Eagle: A pair of adult Bald Eagles was seen regularly throughout the season. These birds were most often classified as residents because of their frequent northward flight pattern. They were not observed making territorial displays or escorting migrant eagles. This suggests the center of their territory was a bit farther from the observation point (perhaps in the vicinity of the subalpine lakes near the southeast terminus of the Big Belts?).

Northern Goshawk: An immature Northern Goshawk was seen regularly throughout the season. This bird was most often identified as resident because it usually flew northward in a manner atypical of migrants. It would occasionally perch in the meadow at the main observation site and sometimes mobbed the decoy owl. An adult Northern Goshawk was also seen regularly at both RTWS and VP. Several times a bird was spotted low against the trees west of RTWS, often catching a thermal and then flying north or east. The adult observed at VP may have been the same bird, but this could not be confirmed. Northern Goshawks are regular breeders in the Big Belts (D. Pengeroth, pers. comm.). It seems likely that the adult Northern Goshawk nests in the area to the west below the radio tower, and the resident immature likely fledged from that nest.

Red-tailed Hawk: An adult light-morph Red-tailed Hawk was commonly seen hunting the ridgeline throughout the season, especially in the early evenings. It was also observed flying north. This bird likely dispersed after mid-October, and Red-tailed Hawks occasionally observed hunting after that date were presumed to be migrants.

## **PUBLIC VISITATION:**

The Big Belts' proximity to Helena, Townsend, and White Sulphur Springs, its relative accessibility (at least in most years?), and the exceptionally close views of migrating raptors make this site suitable for hosting educational field trips. In 2017 the observers enjoyed occasional interactions with guests. Approximately 60 visitors signed our visitor log so they could receive updates about the project and information about Montana Audubon and Last Chance Audubon Society.

Three field trips to the Golden Eagle Migration Survey were organized during the 2017 season. On 28 September Steve Hoffman led a group of four friends from the Cascade-Craig area to the site. The new Director of Montana Audubon, Larry Berrin, joined the group along with Last Chance Audubon Society President Janice Miller. In addition, two raptor identification workshops were held in Helena, and these workshops included field trips to the survey site. The first of these was convened on 22 September and taught by Steve Hoffman, and the second was held on 29 September and taught by Amy Seaman (MT Audubon Director of Bird Conservation). Many of the participants from these two workshops joined field trips to the site on either 30 September or 7 October. The first field trip attracted nine participants. This group was split between the primary site (RTWS) and Vista Point (VP). The 12 participants on the 7 October field trip all remained at the lowest observation site, Lower Duck Creek Road (LDCR), throughout the day where they enjoyed observing somewhat distant migrating raptors.

## **PUBLICITY:**

Once again the GEMS Project received significant news coverage during and shortly after the 2017 season. The *Great Falls Tribune* published an article on 10 October:  
<http://www.greatfallstribune.com/story/news/2017/10/10/snow-cools-early-eagle-migration-but-its-not-over/748285001/> This article was also published in *USA Today* on the same day. A second *Great Falls Tribune* article was published one week later to announce the record Golden Eagle count of 359 birds (documented in the Big Belts on 16 October):  
<http://www.greatfallstribune.com/story/news/2017/10/17/record-golden-eagles-jam-montana-big-belts-super-highway/773969001/> A spring 2017 article (about the fall 2016 GEMS count) was published on April 3<sup>rd</sup> in the *Great Falls Tribune*:

<http://www.greatfallsbtribune.com/story/news/local/2017/04/03/big-belts-nations-flyway-golden-eagles-survey-says/99991826/>

On 2 November the *Helena Independent Record* announced the upcoming Last Chance Audubon membership meeting and program about the Fall 2017 GEMS Project (the program was presented by Hilary Turner on 14 November): [http://helenair.com/news/local/outdoor-briefs-published-thursday/article\\_535aa364-740e-547c-9ebc-0b72deb3fb76.html/](http://helenair.com/news/local/outdoor-briefs-published-thursday/article_535aa364-740e-547c-9ebc-0b72deb3fb76.html/) On 16 November the *Helena Independent Record* also published a summary article about the 2017 GEMS season: [http://helenair.com/lifestyles/recreation/extreme-weather-and-a-record-day-highlight-annual-golden-eagle/article\\_6783d6ef-9c27-530b-adf5-40d4f3cbb5b5.html/](http://helenair.com/lifestyles/recreation/extreme-weather-and-a-record-day-highlight-annual-golden-eagle/article_6783d6ef-9c27-530b-adf5-40d4f3cbb5b5.html/)

Montana Audubon published an article about the GEMS Project in their Fall 2017 newsletter. Finally, the Hawk Migration Association of North America published a summary of the 2016 GEMS season in their Fall 2017 issue of *Hawk Migration Studies* (authored by Steve Hoffman, *With An Eye On Raptors*, pages 17-21, Volume 43, No. 1). Unfortunately, this article is not available online.

## **OTHER AVIAN WILDLIFE:**

Observers spent the duration of the GEMS project season camping in the Big Belt Mountains, and thus witnessed a diverse array of wildlife in addition to the daily flight of migrating raptors. One resident Great Horned Owl was noted around camp throughout the fall. A variety of passerines were fall/winter residents in the Big Belts, and observers enjoyed the daily company of Clark's Nutcrackers, Gray Jays, Black-billed Magpies, Red Crossbills, Pine Grosbeaks, Hairy Woodpeckers, Northern Flickers, Mountain Chickadees, Golden-crowned Kinglets, Red-breasted Nuthatches, Pine Siskins and Townsend's Solitaires. Common Ravens were always present in abundance throughout the fall season. A single individual Common Loon was observed migrating as it flew southwest toward Canyon Ferry Lake on 9 October. One flock of 250 Snow Geese was seen migrating through on 27 October. Also noted on 27 October was a migrating flock of 7 Tundra/Trumpeter swans. One unidentified merganser and a Ring-billed Gull were also seen migrating over the Big Belts. A somewhat unusual observation was a flock of approximately 20 European Starlings seen migrating south on 15 October.

Lots of White-crowned Sparrows migrated through the area early in the season. Lots of Yellow-rumped Warblers also used the ridge as they flew south. Ruby-crowned Kinglets lingered into late September before disappearing. American Robins and Mountain Bluebirds came through in small numbers. A group of 11 American Pipits was observed from Vista Point one day during bad weather. One Horned Lark was seen on another day; it was not known if it was a migrant or local. Lots of migrating American Crows came through the Big Belts as well. Bohemian Waxwings and Gray-crowned Rosy-Finches both migrated over the Big Belts in flocks of 200+ in October. Observations of all bird species were documented on the 'Golden Eagle Migration Survey (GEMS) hawk watch' hotspot on eBird.org (<https://ebird.org/hotspot/L4988893>).

## RECOMMENDATIONS & CLOSING REMARKS

Based on the first three full seasons of study in the Big Belts, we recommend the Golden Eagle Migration Survey be continued annually. There is tremendous value in continuing this standardized, long-term, science-based raptor migration count, with the primary focus on assessing the long-term health and trends of this migratory Golden Eagle population.

We believe strongly the GEMS effort will complement other standardized, long-term raptor migration counts in the region, and recommend ongoing information exchange with Golden Eagle researchers in Alaska, Canada and the western U.S. to gain a better understanding of Golden Eagle movements, population dynamics, and long-term population health. The importance of studying migrant populations of these arctic, sub-arctic, and boreal apex predators in this age of global climate disruption cannot be over-emphasized. Hence, we hope consistent, long-term funding can be secured to continue supporting the GEMS annual fall monitoring effort.

One primary challenge of the GEMS Project is access to the observation site, which is relatively remote. For the 2017 season a wall-tent and wood stove were purchased for the observers. Access to the observers' camp is via a long (10+ mile) forest service road that seldom receives maintenance. From camp to the observation site requires an additional 1.5-mile hike. During years of heavy, persistent snowfall, the observers face many logistical challenges, including breaking camp in deep snow and extreme cold, and safely exiting the site at the end of the season. We recommend the standardized, official end-date for the count be 31 October – hopefully in most years deep snow and prolonged winter weather can be avoided by ending on this date. We also recommend ongoing use of the wall tent, wood stove, and camper to provide some degree of comfort for the observers.

The start-date of the count has varied a bit throughout its three-year history. In 2015 the count began on 15 September; in 2016 it was initiated on 1 September; small numbers of Golden Eagles were observed on most days during those initial two weeks. A total of 98 Golden Eagles were recorded during these first 14 days of observation in 2016 (with a high count of 34). On 12 days during this period the observers recorded fewer than 10. In summary, Golden Eagle counts during the first two weeks of September comprised less than 4% of the total count, but 23% of the total count days.

The GEMS Project is designed to primarily document the Golden Eagle migration, which suggests that a 15 September start date would be appropriate. However, with accelerating climate disruption and a growing body of evidence that these climate changes are already beginning to show alterations in seasonal timing for several raptor species (including some initiating their fall migration earlier - see Filippi-Codaccioni et al. 2010 & Therrien et al. 2017), there is strong rationale for considering an earlier start date.

In addition, it is notable that, in 2017, before camp could be fully set up a major winter storm deposited more than 18 inches of snow at Duck Creek Pass. This made setting up camp especially challenging. To minimize this possibility in the future, and to give the observers time to adjust to the field conditions, establish their routine, and become fully trained to conduct this work, and in

consideration of likely future climate impacts to the seasonal timing of raptor migration along this flyway, we recommend a standardized starting date no earlier than 1 September, and no later than 10 September.

Our partnership with the U.S. Forest Service and Montana Fish, Wildlife and Parks is tremendously beneficial and profoundly appreciated. The funding and logistic support they have provided has been critical to the project's success during these first three years. Their donations of personnel and equipment have also been vital to the project. We encourage expanding existing collaborations as needed, as well as seeking new partnerships other potential partners in the future (e.g., perhaps the Discovery Center in Helena could be recruited to help organize onsite public outreach efforts?).

The utilization of a tablet in the field to enter data via the dunkadoo app was largely effective, thus we recommend it be continued. The degree of distraction from observing introduced by the time required to enter the data on the tablet (in addition to duplicate recording on the paper data sheets) was generally inconsequential. However, there are still a few issues that require addressing. The dunkadoo application needs to more effectively feed the information into hawkcount.org. We found that certain data fields were sometimes either lost or incorrectly reported in hawkcount.org. The Dunkadoo application precludes the need for tedious data entry each evening (or at the end of the season), and may help enhance public interest in the GEMS Project.

Since the project's inception in 2015, the use of multiple observation sites helped us to learn more about the raptor flight through the area under various local weather conditions. Now, after three seasons, this objective has largely been accomplished. Counts of migrating raptors, such as those done at hawk watch sites across the continent, depend heavily on well-controlled, standardized conditions to accurately measure population change over time. One key factor that must be considered is the value of maintaining a single, consistent, standardized observation point. Therefore, we recommend that our primary observation site, Radio Tower West Slope (RTWS), be the sole observation point going forward. On days when severe weather precludes observation from RTWS observations could certainly be made from either secondary site, *but these data should not be incorporated into the standardized data set*. In addition, the standardized count period of 0900 – 1700 MST should be maintained; if observers choose to arrive early or stay late during times of especially active migration, only counts during the standardized time frame should be included in the official count. This is especially important, since in the past how early or late observers have chosen to observe has not been standardized, and frankly has been left up to the whim of the observers. It is important to remember that the purpose of the GEMS count is to obtain a standardized, credible, science-based data set to assess long-term population health and change; it is not to count as many raptors as possible.

A final recommendation is to develop a standardized protocol that takes into account observer safety during times of especially inclement weather. Previously observers have been required to maintain their post as long as conditions were suitable for migrant raptors to be seen. However, conducting the count in the Big Belts has proven to be daunting in times of severe weather. Exceptionally high winds (>70 mph recorded!) and sub-zero wind chills can certainly threaten observer health and safety. Taking into account the difficulty of site access, we suggest specific protocols be established so observers are permitted to avoid extreme conditions when necessary to minimize the risk of frostbite, hypothermia, etc.

During the past three fall seasons the Big Belts' raptor flight has rewarded hundreds of visitors with many close, memorable views of not only Golden Eagles, but many other migrating raptors. When weather conditions are suitable the GEMS Project can provide (for years to come) outstanding, outdoor, experiential opportunities for raptor education, and public awareness and appreciation (not to mention avian photography!).

## **ACKNOWLEDGMENTS**

The 2017 raptor migration study in the Big Belt Mountains (GEMS) was again a successful collaborative effort among four entities: Montana Audubon (MA), Last Chance Audubon (LCAS), Montana Fish, Wildlife, and Parks (FWP), and US Forest Service (USFS; Helena-Lewis & Clark National Forest). The unique contributions and generous funding provided by each of these entities were critical to the success of the project, and deeply appreciated. The project greatly benefited from additional generous financial contributions from the Montana Outdoor Legacy Foundation, Mitch Stocks, two anonymous donors, and a great many individual contributors to Last Chance Audubon (through LCAS's year-end giving campaign) and Montana Audubon – thanks to all for helping us to effectively monitor and conserve these magnificent raptors!

Most importantly, the official GEMS observers: Jeff Grayum, Hilary Turner, Shaun Hyland and Erin Brekstad deserve our heartfelt thanks for their profound dedication, commitment and hard work under extremely difficult field conditions throughout the 2017 season. Without their enthusiasm, expertise and amazing stamina the observers showed throughout this year's especially windy, cold, wintry-like conditions, the GEMS Project would not exist. Jeff's return for a second consecutive season was hugely appreciated, and contributed tremendously to the project's continuity and overall success. Fortunately, both Shaun and Erin returned for a third consecutive season to observe two days each week, allowing Jeff and Hilary to each have one day off every week. In addition to their essential role as official observers, Erin and Shaun were also invaluable members of the GEMS Committee, contributing greatly to project planning, acquisition of necessary camp gear, and fundraising from within the Helena-area community. Shaun's donations of camping supplies, food and cooking expertise were also greatly appreciated!

Every member of the GEMS Committee made unselfish, highly significant contributions, without which this study would not have been possible. Sincere, heartfelt thanks are expressed to: Janice Miller for her capable committee leadership, her hospitality and positive attitude every day; Steve Hoffman for his wealth of knowledge and expertise, as well as his energetic commitment to the project; Bob Martinka for his donation of camping supplies, and assistance in transporting and storing supplies, as well as setting up and breaking down camp; Stephen Turner for camp setup and breakdown, and his untiring efforts to keep the observers stocked with numerous supplies for their safety and well-being. Stephen also secured the storage unit and provided oversight for the cleaning and storage of the tent, stove, and other gear. GEMS also benefited tremendously from Stephen's persistent, pro-active efforts to understand and support the interface with Dunkadoo so we could showcase our observations online to the general public in a timely way; his efforts to update the GEMS website and maintain the project's financial spreadsheet were also profoundly appreciated; Liz Hiltunen for her diligent work publicizing the project and organizing its associated events, as well as her donation of the internet hotspot; Dan Ellison for providing sage advice in support of the committee's deliberations, and for assisting with project field trips; Allison Begley for obtaining essential FWP and Montana Outdoor Legacy Foundation funding for the project; USFS biologist Denise Pengeroth for providing generous cost-share funding and authorizing two USFS seasonal

employees, Shaun Hyland and Erin Brekstad, to serve as official observers two days per week throughout the season.

We wish to express our deepest appreciation to Conrad Evarts for once again loaning his camp trailer to the GEMS Project for use at Duck Creek Pass throughout the entire GEMS season. Cory Llewelyn, USFS District Ranger (Townsend), capably facilitated acquisition of the USFS “Extended Camping Permit” for the project. Pat Grantham and Christian Meny provided essential support for the educational field trips again this year. Jerry Liguori, raptor expert and author of two acclaimed raptor ID books, provided invaluable assistance by promptly viewing photos of passing raptors to confirm species’ identifications. Jay Kolbe, FWP employee in White Sulphur Springs, was instrumental in securing a FWP 4-wheel drive pickup truck for our observers to use for much of the field season. Patty Turner opened her home to the observers during and after the count, including her garage as a place to organize the GEMS gear once the field season ended. She also cooked a great many meals for the observers to take back to camp, which helped sustain them during this exceptionally harsh, cold season. Carl Hiltunen served as an essential authority on setting up and taking down our new canvas tent; he also provided invaluable advice and assistance for all kinds of gear, and made sure the observers had enough propane for the camp-trailer stove, and sufficient fuel for the wood-burning stove.

Finally, the GEMS observers greatly appreciated the timely, informative Golden Eagle migration updates from Mt. Lorette (in Alberta, Canada), reported via email almost daily by Peter Sherrington, Founder and President of the Rocky Mountain Eagle Foundation.

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## APPENDICES

**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 Big Belt Mountains, MT.

COMMON NAME	SCIENTIFIC NAME	SPECIES CODE	AGE <sup>1</sup>	SEX <sup>2</sup>	COLOR MORPH <sup>3</sup>
Turkey Vulture	<i>Cathartes aura</i>	TV	U	U	NA
Osprey	<i>Pandion haliaetus</i>	OS	U	U	NA
Northern Harrier	<i>Circus cyaneus</i>	NH	A I Br U	M F U	NA
Sharp-shinned Hawk	<i>Accipiter striatus</i>	SS	A I U	U	NA
Cooper's Hawk	<i>Accipiter cooperii</i>	CH	A I U	U	NA
Northern Goshawk	<i>Accipiter gentilis</i>	NG	A I U	U	NA
Unknown small accipiter	<i>A. striatus</i> or <i>cooperii</i>	SA	U	U	NA
Unknown large accipiter	<i>A. cooperii</i> or <i>gentilis</i>	LA	U	U	NA
Unknown accipiter	<i>Accipiter</i> spp.	UA	U	U	NA
Broad-winged Hawk	<i>Buteo platypterus</i>	BW	A I U	U	D L U
Swainson's Hawk	<i>Buteo swainsoni</i>	SW	U	U	D L U
Red-tailed Hawk	<i>Buteo jamaicensis</i>	RT	A I U	U	D L U
Ferruginous Hawk	<i>Buteo regalis</i>	FH	A I U	U	D L U
Rough-legged Hawk	<i>Buteo lagopus</i>	RL	U	U	D L U
Unknown buteo	<i>Buteo</i> spp.	UB	U	U	D L U
Golden Eagle	<i>Aquila chrysaetos</i>	GE	I, S, NA, A, U <sup>4</sup>	U	NA
Bald Eagle	<i>Haliaeetus leucocephalus</i>	BE	I, S1, S2, NA, A, U <sup>5</sup>	U	NA
Unknown eagle	<i>Aquila</i> or <i>Haliaeetus</i> spp.	UE	U	U	NA
American Kestrel	<i>Falco sparverius</i>	AK	U	M F U	NA
Merlin	<i>Falco columbarius</i>	ML	AM Br	AM U	NA
Prairie Falcon	<i>Falco mexicanus</i>	PR	U	U	NA
Peregrine Falcon	<i>Falco peregrines</i>	PG	A I U	U	NA
Unknown small falcon	<i>F. sparverius</i> or <i>columbarius</i>	SF	U	U	NA
Unknown large falcon	<i>F. mexicanus</i> or <i>peregrines</i>	LF	U	U	NA
Unknown falcon	<i>Falco</i> spp.	UF	U	U	NA
Unknown raptor	Falconiformes	UU	U	U	NA

<sup>1</sup> Age codes: A = adult, I = immature, Br = brown (adult female or immature), U = unknown age.

<sup>2</sup> Sex codes: M = male, F = female, U = unknown.

<sup>3</sup> Color morph codes: D = dark or rufous, G = gray; L = light, W = white; U = unknown, NA = not applicable.

<sup>4</sup> 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.

<sup>5</sup> 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 official observers for the Golden Eagle Migration Survey in the Big Belt Mountains (2015-2017). Numbers given in parentheses indicate the number of full seasons of previous raptor migration counting experience.

**2015:** Two observers throughout: Bret Davis (4), Ronan Dugan (0)

**2016:** Two observers throughout: Jeff Grayum (0), Ronan Dugan (1)

**2017:** Two observers throughout: Jeff Grayum (1), Hilary Turner (0)

**Appendix C.** Daily observation effort and raptor migration counts by species in the Big Belt Mountains, MT, fall 2017 (see Appendix A for species codes)<sup>1</sup>.

Date	Obs. Hours	TV	OS	BE	NH	SS	CH	NG	BW	RT	RL	SW	FH	GE	AK	ML	PG	PR	UA	UB	UF	UE	UU	Grand Total	Birds per Hour
15-Sep	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
16-Sep <sup>3</sup>	5.5	0	0	0	0	0	0	0	0	1	0	0	0	2	0	0	0	0	0	1	0	0	0	4	0.7
17-Sep <sup>2</sup>	5.5	0	1	1	1	0	0	0	1	1	0	0	0	15	0	1	0	1	0	0	0	1	1	24	4.4
18-Sep	4.2	0	0	0	0	3	1	0	0	1	0	0	0	4	0	0	1	0	0	0	0	0	0	10	2.4
19-Sep <sup>2</sup>	5.5	0	0	0	0	0	1	1	0	3	0	0	0	16	0	0	0	1	0	0	0	0	0	22	4.0
20-Sep	2.3	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
20-Sep <sup>2</sup>	2.8	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	2	0.7
21-Sep	7.3	0	0	0	1	0	0	0	0	1	0	0	0	15	0	0	0	0	0	0	0	0	0	17	2.3
22-Sep	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-Sep	3.8	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0.3
24-Sep	8.0	0	0	0	2	1	0	4	0	2	0	0	0	16	0	0	0	0	0	1	0	0	3	29	3.6
25-Sep	7.8	0	0	0	0	0	1	1	0	1	0	0	0	16	0	0	1	0	0	0	0	0	1	21	2.7
26-Sep	6.8	0	0	0	0	1	3	1	0	0	0	0	0	24	0	0	0	0	2	0	0	0	3	34	5.0
27-Sep	8.0	0	0	4	2	19	8	6	0	11	0	0	0	43	2	0	0	2	4	0	0	0	0	101	12.6
28-Sep	8.5	0	0	0	0	9	6	3	0	11	0	1	0	50	3	0	0	0	3	1	0	0	2	89	10.5
29-Sep	8.3	1	0	5	2	13	17	7	0	11	1	0	0	62	4	2	1	0	7	1	1	0	2	137	16.6
30-Sep	4.3	0	0	0	0	8	1	0	0	3	1	0	0	34	1	1	0	0	0	1	2	1	0	53	12.5
30-Sep <sup>2</sup>	1.0	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
1-Oct <sup>2</sup>	4.8	0	0	1	1	3	1	0	0	1	2	0	0	9	0	0	0	0	1	3	0	1	0	23	4.8
2-Oct	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
3-Oct	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
4-Oct	5.0	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
5-Oct <sup>3</sup>	4.0	0	0	0	1	0	0	1	0	3	0	0	0	80	0	0	0	0	3	2	3	0	3	96	24.0
5-Oct	1.8	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
6-Oct	9.1	0	0	4	1	17	8	1	0	6	3	0	0	147	0	0	2	1	0	0	0	1	0	191	21.0
7-Oct	6.8	0	0	3	0	6	3	0	0	4	1	0	0	148	0	0	0	0	1	0	1	0	1	168	24.6
8-Oct	8.5	0	0	1	0	0	1	0	0	0	2	0	0	18	0	0	0	0	0	2	0	1	3	28	3.3
9-Oct	9.3	0	0	2	1	3	1	1	0	1	3	0	0	184	0	0	0	0	0	0	0	1	1	198	21.4
10-Oct	9.0	0	0	4	0	2	3	3	0	2	15	0	0	60	1	1	0	0	0	1	0	0	0	92	10.2

# Appendix C. (continued)

Date	Obs. Hours	TV	OS	BE	NH	SS	CH	NG	BW	RT	RL	SW	FH	GE	AK	ML	PG	PR	UA	UB	UF	UE	UU	Grand Total	Birds per Hour
11-Oct	9.0	0	0	0	2	39	7	5	0	1	4	0	0	92	0	1	0	0	0	0	0	0	0	151	16.8
12-Oct	2.5	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	2	0.8
12-Oct <sup>2</sup>	6.0	0	0	0	0	0	0	0	0	0	8	0	0	12	0	0	0	1	0	0	0	0	0	21	3.5
13-Oct	2.3	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
13-Oct <sup>2</sup>	1.5	0	0	0	0	0	0	0	0	0	1	0	0	5	0	0	0	0	0	0	0	0	0	6	4.0
14-Oct	4.4	0	0	1	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	16	3.6
14-Oct <sup>2</sup>	2.3	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
15-Oct	8.8	0	0	2	0	3	0	1	0	1	6	0	0	58	0	1	0	1	0	0	0	0	0	73	8.3
16-Oct	9.8	0	0	5	0	16	0	5	0	0	7	0	0	359	0	1	0	0	0	0	0	0	1	394	40.4
17-Oct	9.5	0	0	0	0	23	1	2	0	1	4	0	0	132	1	1	0	1	0	0	1	0	3	170	17.9
18-Oct	8.0	0	0	1	0	18	0	1	0	0	2	0	0	52	0	1	0	0	0	0	0	0	0	75	9.4
19-Oct	9.5	0	0	5	1	27	0	3	0	7	4	0	0	65	0	0	0	1	0	0	0	0	1	114	12.0
20-Oct	4.8	0	0	2	0	4	1	1	0	1	1	0	0	31	0	0	0	0	0	0	0	0	0	41	8.6
21-Oct	8.5	0	0	1	0	0	0	0	0	0	4	0	0	30	0	1	0	0	0	0	1	0	0	37	4.4
22-Oct	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	8.0	0	0	3	0	0	1	1	0	3	27	0	0	84	0	0	0	1	0	0	1	0	2	123	15.4
24-Oct	8.5	0	0	5	0	3	2	3	0	0	8	0	0	66	0	0	0	0	1	0	0	0	1	89	10.5
25-Oct	8.5	0	0	3	0	9	0	5	0	0	1	0	0	64	0	0	0	0	0	0	0	0	0	82	9.6
26-Oct	6.3	0	0	0	0	0	0	0	0	1	1	0	0	6	0	0	0	0	0	0	0	0	0	8	1.3
27-Oct	8.0	0	0	0	0	0	0	0	0	0	4	0	0	3	0	0	0	0	0	0	0	0	0	7	0.9
28-Oct	8.0	0	0	5	0	4	0	3	0	2	14	0	0	42	0	0	0	0	0	0	0	0	0	70	8.8
29-Oct	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	7.8	0	0	2	0	1	0	0	0	1	3	0	0	23	0	0	0	0	0	0	0	0	0	30	3.9
31-Oct	6.0	0	0	5	0	0	0	1	0	0	0	0	0	74	0	0	0	0	0	0	0	0	0	80	13.3
<b>TOTAL</b>	<b>295.0</b>	<b>1</b>	<b>1</b>	<b>65</b>	<b>15</b>	<b>232</b>	<b>67</b>	<b>60</b>	<b>1</b>	<b>81</b>	<b>127</b>	<b>1</b>	<b>0</b>	<b>2159</b>	<b>12</b>	<b>11</b>	<b>5</b>	<b>10</b>	<b>23</b>	<b>13</b>	<b>10</b>	<b>7</b>	<b>28</b>	<b>2929</b>	<b>9.9</b>

<sup>1</sup> Species code UA is combined with Unknown Accipiter, Small Accipiter, and Large Accipiter totals. UF is combined with Unknown Falcon, Small Falcon, and Large Falcon totals.

<sup>2</sup> Count conducted at Vista Point (VP).

<sup>3</sup> Count conducted at Lower Duck Creek Road (LDCR).

**Appendix D.** Annual observation effort and fall raptor migration counts by species in the Big Belt Mountains, MT: 2015–2017.

	2015	2016	2017	Mean
Start date	15-Sep	1-Sep	15-Sep	10-Sep
End date	2-Nov	5-Nov	31-Oct	2-Nov
Observation days	46	60	41	49
Observation hours	352.8	443.4	295.0	363.7
Raptors / 100 hours	1244	974	993	1070
SPECIES	RAPTOR COUNTS			
Turkey Vulture	3	1	1	2
Osprey	9	17	1	9
Northern Harrier	32	45	15	31
Sharp-shinned Hawk	656	673	232	520
Cooper's Hawk	102	116	67	95
Northern Goshawk	85	107	60	84
Unidentified Accipiter	42	38	23	34
Total Accipiters	885	934	382	734
Broad-winged Hawk	29	17	1	16
Swainson's Hawk	2	2	1	2
Red-tailed Hawk	176	203	81	153
Ferruginous Hawk	7	2	0	3
Rough-legged Hawk	215	214	127	185
Unidentified Buteo	29	19	13	20
Total Buteos	458	457	223	379
Golden Eagle	2630	2620	2159	2470
Bald Eagle	104	116	65	95
Unidentified Eagle	3	4	7	5
Total Eagles	2727	2740	2231	2569
American Kestrel	59	83	12	51
Merlin	58	30	11	33
Prairie Falcon	19	15	10	15
Peregrine Falcon	36	28	5	23
Gyr Falcon	0	0	0	0
Unidentified Falcon	8	13	10	10
Total Falcons	180	169	48	132
Unidentified Raptor	14	26	28	23
Grand Total	4318	4389	2929	3879