FALL 2014 RAPTOR MIGRATION ANNUAL REPORT: MANZANOS HAWKWATCH, CENTRAL NEW MEXICO

HawkWatch International, Inc.

Salt Lake City, Utah

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INTRODUCTION

The Manzanos HawkWatch in central New Mexico is an ongoing effort to monitor long-term regional population trends of diurnal raptors that migrate through the southern portion of the Rocky Mountain flyway (Hoffman et al. 2002, Hoffman and Smith 2003, Smith et al. 2008a). HawkWatch International (HWI) initiated standardized counts of the autumn raptor migration at the Manzanos in 1985, and began a trapping and banding program in 1990. To date, HWI observers have recorded 18 species of migratory raptors at the site, with counts typically ranging between 4,000 and 7,000 migrants per season. The 2014 season marked the 30th consecutive count and the 25th consecutive season of trapping and banding efforts. This report summarizes the 2014 fall raptor migration season for the Manzanos HawkWatch.

The Manzanos HawkWatch was 1 of 9 long-term, annual migration counts and 1 of 4 migration-banding studies conducted or co-sponsored by HWI in North America during 2014 (Fig.1). The primary objective of these efforts is to track long-term population trends of diurnal raptors in western North America and around the Gulf Coast region (Hoffman and Smith 2003; Smith et al. 2001, 2008a, b). Raptors can serve as important biological indicators of ecosystem health (Bildstein 2001) and long-term migration counts are one of the most cost effective and efficient methods for monitoring the regional status and trends of multiple raptor species (Zalles and Bildstein 2000).

In addition to long-term counting and banding efforts, HWI conducts and supports other studies to further knowledge about the biology of migrating raptors. Some of these efforts include: telemetry work to identify species' ranges, migratory routes and connectivity; and blood and feather sampling to track changes in raptor health and populations (e.g., Hoffman et al. 2002, Lott and Smith 2006, Goodrich and Smith 2008, DeLong and Hoffman 2004, McBride et al. 2004).

Beyond having scientific and conservation value, each site in HWI's migration network offers unique opportunities for the public to learn about raptors and the natural environment. Providing such opportunities is another important component of the Manzanos HawkWatch and outreach efforts here reach hundreds of people from the Albuquerque area, central New Mexico, and beyond each season.

STUDY SITE

The HawkWatch is located in the Manzano Wilderness Area of the Cibola National Forest (Mountainair Ranger District) near Capilla Peak, approximately 56 km south-southeast of Interstate 40 (34°42.25' N, 106°24.67' W; Fig. 2). The observation point sits at an elevation of 2,805 m (9,195 ft) on a northwest-southeast facing outcrop of a limestone ridge. It is reached by walking up a 1.2 km trail from the main road leading up to Capilla Peak (FS 522). The vegetation on the slopes of the ridge consists of Gambel oak (Q*uercus gambelli*), Douglas-fir (*Pseudotsuga menziesii*), White fir (*Abies concolor*), Ponderosa pine (*Pinus ponderosa*), Pinyon pine (*Pinus edulis*), New Mexico locust (*Robinia neomexicana*), and Bigtooth maple (*Acer grandidentatum*).

Two banding stations were operated within 0.25–1 km of the observation point (Fig. 1). **North** station, operated every year since 1990, is located 100 m east and 50 m north of the observation point at an elevation of 2,790 m. **West** station, operated every year since 1991, is located 0.5 km southwest of the observation point at an elevation of 2,684 m.

Many factors make the Manzano Lookout well suited for observing consistent flights of fall migrating raptors. Several mountain ranges to the north serve as leading lines (Bildstein 2006), which cause raptors to funnel into the area. The Manzano Mountains are also a relatively narrow and well-defined north–south range, which creates beneficial updrafts and serves as a distinct flight path for migrating raptors. Capilla Peak provides an excellent source of orographic lift, with two other peaks located 10–15 km north of the observation site also attract southbound migrants that benefit from strong ridge updrafts. The

concentration effect of the Manzano range is further enhanced by the absence of parallel ranges nearby to serve as alternate flight paths.

METHODS

STANDARDIZED COUNTS

Weather permitting; two designated observers conducted standardized daily counts of migrating raptors from late August through late October. Observations typically began between 0800–0900 hrs and ended near 1700 hrs Pacific Standard Time (PST). Visitors occasionally assisted with the count.

Data collection followed standardized protocols used at all HWI migration sites (Hoffman and Smith 2003). The observers routinely recorded the following data:

1. Species, age, sex, and color morph of each migrant raptor, whenever possible and applicable (Appendix B lists common and scientific names for all species, information about the applicability of age, sex, and color morph distinctions, and two-letter codes used to identify species in tables and figures).
2. Hour of passage for each migrant; e.g., the 1000–1059 hrs PST.
3. Wind speed and direction, air temperature, percent cloud cover, predominant cloud type(s), presence of precipitation, visibility, and an assessment of thermal-lift conditions were recorded for each hour of observation on the half hour.
4. Predominant direction, altitude, and distance from the lookout of the flight during each hour.
5. Total minutes observed and the mean number of observers present during each hour (included designated observers plus volunteers/visitors who actively contributed to the count [active scanning, pointing out birds, recording data, etc.] for more than 10 minutes in a given hour), recorded on the hour.
6. A subjective visitor-disturbance rating for each hour, recorded on the hour.
7. Daily start and end times for each official observer.

In comparing 2014 counts against means and 95% confidence intervals for previous seasons, we consider a count value falling outside the 95% confidence interval of the historic site means as significantly different. Linear and quadratic regression was used on effort-adjusted annual passage rates (raptors/100hrs) to identify long-term trends in migrating raptors.

TRAPPING AND BANDING

Similar to the counts, trapping and banding efforts began late August and continued through late October at the two banding stations, generally between 0900–1700 hrs MST (see Appendix F for daily trapping records). Capture devices included mist nets and remotely triggered bow nets. Trappers lured migrating raptors into the capture stations from camouflaged blinds using live, non-native avian lures attached to lines manipulated from the blinds. Unless already banded, all captured birds were fitted with a uniquely numbered USGS Biological Resources Division aluminum leg band. Data collection followed standardized protocols used at all HWI migration-banding sites (Hoffman et al. 2002). All birds are released within 45 minutes of capture.

2014 RESULTS AND DISCUSSION

OBSERVATION EFFORT AND WEATHER SUMMARY

The Manzanos HawkWatch standard season runs 27 August—5 November; in 2014 observers counted on 65 of 71 possible days during this period for a total of 506.62 hours (Appendix C). Weather led to shortened counts (<4 hrs) on 6 days. Weather varies throughout every season, in 2014 based on hourly recording of conditions during observation it was clear 36% of the time, cloudy and/or overcast 34% of the time, hazy 19% of the time, and rainy 10% of the time.

2014 FLIGHT SUMMARY

Overall Flight:

A total of 5,993 migrating raptors representing 17 species were counted in 2014, 12% higher than the site long-term average, but not a statistically significant difference (Table 1). Highlights of the flight included a record high season total for Rough-legged Hawks (3) and the biggest Merlin day ever at the Manzanos HawkWatch with 8 birds counted.

The flight consisted of 50% buteos, 36% accipiters, 6% vultures, 5% falcons, 2% eagles, 0.7% harriers, 0.6% Ospreys, and 0.4% harriers. The relative proportions of buteos was high in 2014 compared to historic values; vultures and Ospreys were counted in proportions similar to historic averages; while accipiters, falcons, eagles, and Northern Harriers made up less than the flight than they typically do (Fig. 2). Swainson's Hawks were the most abundant species (38% of the total), followed by Sharp-shinned Hawks (22%), Cooper's Hawks (13%), Red-tailed Hawks (12%), Turkey Vultures (6%), American Kestrels (3%), and Golden Eagles (2%). The remaining species each accounted for 1% or less of the total count (Table 1).

The following sections summarize the 2014 count relative to historic means at the site, and any statistically significant ($p < 0.05$) population trends based on first and second order regression analysis. HWI only depicts significant trends for species with a historic average count rate greater than or equal to 10 individuals per 100 hours. The rationale is that trends for counts below this point likely do not contain biologically useful information on regional populations—species with counts this low likely have a dispersed migration, another primary migration route, or large portions of the population that are resident. We do include count information in the reports, as occurrences of rarer species are of interest to both managers and the general public, and could represent the beginning of meaningful long-term changes.

Total Flight (Fig.4):

The 1186 raptors counted per 100 hours of observation at the Manzanos HawkWatch in 2014 did not differ significantly from the site average of 1027—the 2014 total flight was average.

Vultures, Osprey, and Harriers (Fig. 5a):

Seasonal counts and effort-adjusted passage rates (raptors/100hrs) were above average for Ospreys, average for Turkey Vultures, and below the historic site average for Northern Harriers. Long-term passage rates for these species are stable (no significant trend over time).

Accipiters (Fig. 5b):

Counts for Sharp-shinned Hawks, Cooper's Hawks and Northern Goshawks all fell below historic averages this past season (Table 1). Passage rates for Cooper's Hawks and Goshawks were also low, but Sharp-shinned Hawk rates were average. Cooper's Hawks are the only accipiter species with a significant trend in passage rates, increasing from 1985 to 1998, but declining in recent years ($F_{2,27} = 7.05$, $r^2 = 0.34$, $p = 0.0043$).

Buteoine Hawks (Fig. 5c):

Crews counted above average numbers of Broad-winged Hawks, Swainson's Hawks, Red-tailed Hawks, and Rough-legged Hawks in 2014; effort-adjusted passage rates for these species were also high. Feruginous Hawk count and passage rate were below average. No long-term trends were found for species with mean passage rates >10 birds/100hrs.

Eagles (Fig.5d):

Golden Eagle counts were low compared to historic site average, but effort-adjusted passage rate did not differ statistically from average (Table 1). Additionally, Golden Eagle passage rates have been stable at the Manzanos HawkWatch over the life of the site. The count and passage rate of Bald Eagles was high in 2014.

Falcons (Fig. 5e):

The Merlin count and passage rate was above average in 2014, while Peregrine Falcon and Praire Falcon counts and rates were average (Table 1). The American Kestrel count and effort-adjusted passage rate were below average, in fact the 200 Kestrels counted in 2014 is an all-time site low for the species at this site (Appendix C). Moreover, regional populations are declining based on fall migration passage rates (slope = -3.064, $r^2 = 0.501$, p = 0.000). Similar declines have been documented for this species across the HWI network and at other count sites. In response, HWI, along with many other North American researchers and Citizen Scientists are working to understand American Kestrel declines both locally and at the continental scale and have partnered under the umbrella of the American Kestrel Partnership (http://kestrel.peregrinefund.org/).

Flight timing:

We examined changes in the timing of fall migration at the Manzanos HawkWatch over the life of the site. Changes in migration phenology in response to global climate change have been documented for a number of plant and wildlife species in some regions. We examined several aspects of the timing of fall migration: the start date for 95% of a year's flight, the end date for 95% of a year's flight, and the median date for the year's flight. We then used linear regression to look for shifts over time in any of these variables for the total flight (all species), Sharp-shinned Hawks, Cooper's Hawks, Red-tailed Hawks, American Kestrels, and Golden Eagles (Fig. 6). The Sharp-shinned Hawk and American Kestrel flights at the Manzanos HawkWatch are lasting longer into the season (95% end date trending later: slope = 0.15, r^2 = 0.21, p=0.013 and slope = 0.27, r2 = 0.26, p= 0.005, respectively). The median passage date for Golden Eagles has shifted later (slope = 0.19, r2 = 0.18, p=0.02), suggesting that more eagles are passing by the site later each year. While these are the only statistically significant (alpha = 0.05) changes in migration timing seen at the Manzanos HawkWatch to date, it is worth noting the overall pattern seen for many species seems to be later migration. Moreover further changes are likely and long-term monitoring efforts such those at the Manzanos and elsewhere are crucial to documenting future changes.

TRAPPING EFFORT

Crews trapped for 55 days (totaling 500.5 hrs) between 28 August and 29 October, and captured 384 raptors of ten different species (Table 2). Both the number of hours trapped and capture totals were low compared to historic site averages (Appendix D). Season highlights from the blind included: the capture of a sub-adult Bald Eagle, a hatch-year male Golden Eagle, and a hatch-year Swainson's Hawk.

ENCOUNTERS WITH PREVIOUSLY BANDED BIRDS

A total of 179 birds banded at Manzano Mountains have been recovered elsewhere and reported to the Bird Banding Laboratory (Fig. 7). During 2014 we received notice of two recoveries: one female Cooper's Hawk that was banded as an adult, and a female Northern Goshawk that was banded as hatch-year, immature (Table 3). The Cooper's Hawk was found dead, cause unknown, but the Northern Goshawk wast reported as being predated, but not by a cat (*Felis catus*). Both were recovered in New Mexico. The Cooper's Hawk was recovered just over a year post banding, and since it was recovered in early November, it is unknown if this bird died during migration, or near it's summer breeding or wintering locations. The Northern Goshawk was recovered almost 9 years post-banding and only 28 km away. This bird was originally banded as an immature so we don't know how far it dispersed from its natal origin, but since it was recovered in early July, it may have been on its summer range

Also during the season the crew recaptured (Appendix D) an adult female Cooper's Hawk that was originally captured at the Manzanos HawkWatch and banded on 26 September, 2006 as a hatch-year bird. Interestingly, the crew noted that the upper mandible was overgrown, and similar looking to a "crossbill." There was no mention of this deformity when the bird was originally banded. In recent years, banders have reported a number of beak deformities, especially from Black-capped Chickadees (*Parus atricapillus*) in south-central Alaska (USGS-Alaska Science Center) but it is rare to see these deformities in the southern U.S. One of the reasons we band birds is to keep track of individual health and assess physiology and morphometrics. The crew also captured a second-year male Cooper's Hawk originally banded elsewhere (Appendix D). This bird also had a strange deformity of a large growth or tumor located on the right side of the bird's face.

SITE VISITATION

During the season, a total of 88 individuals visited the site, primarily from New Mexico. Visitors also traveled from Arizona, Alaska, California, Colorado, Tennessee, and North Carolina. Visitors to the site get to see raptors in flight and in hand prior to release post- banding, learn to identify raptors in flight and also about raptor migration ecology and what banding and counting efforts can tell us about regional raptor populations and the health of the landscapes they use. They also learn about the ecosystems found around the Manzanos HawkWatch and are introduced/reminded about leave no trace outdoor ethics.

2014 FALL MIGRATION ACROSS HWI'S NETWORK

HawkWatch International and partners operated 9 fall count sites in 2014 (Fig. 1). During the 4,884.4 hours of standardized observation we counted 504,905 migrating birds of prey. The power and utility of HWI's network of fall count sites, and long-term monitoring in general, lies in that it allows identification of patterns in regional raptor populations, both over time at a single site and also network-wide. Declines in counts or passage rates for a species or group of species at the regional level can highlight the need for more focused research or management attention at local scales, while increases may indicate the success of management and conservation efforts. While each site in HWI's network varied in terms of individual species or group counts, notable network-wide patterns in 2014 included (Table 4):

- Below average counts for the fall flight at 4 of 9 sites
    - Both Pacific Northwest sites, Commissary Ridge, and Corpus Christi
- Low or average Golden Eagle counts at all network sites--no increases at any site
- Below historic average American Kestrel counts at 6 of 9 sites
- Low Northern Harrier counts at 8 of 9 network sites
- Above average Peregrine Falcon counts at 6 of 9 sites and average counts at the other 3

- Above average Broad-winged Hawk numbers at 6 western sites and below average Broad-winged numbers at Corpus Christi – does this signify a change in the migration pathways for this species?

HWI partners with Hawk Mountain Sanctuary, the Hawk Migration Association of North America (HMANA), and Bird Studies Canada (BSC) to provide western US data for the Raptor Population Index (RPI), a collaborative standardized effort to monitor raptor migration across North America.

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Finally, enormous thanks go to our 2014 field crew: Emily Abernathy, Robert Baez, Olivia DeRugna, Stephen Brenner, Sue Bruner, and Ben Dudek. Without your skill, dedication, and willingness to brave the elements over the course of a long field season these efforts would not be possible.

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Table 1. Historic fall migration counts (mean±95% CI), counts from fall 2014, and site records at the Manzano Mountains, NM.

		1985-2013					All-time Historic Records	
	Species	**Mean Count ± 95 % CI**			**2014**	**% Change**	**Season**	**Daily**
	Turkey Vulture	387	±	85	343	-11	1116 (1998)	256 (2012)
	Osprey	30	±	6	38	27	86 (2003)	26 (2003)
	Northern Harrier	58	±	9	42	-27	133 (1998)	14 (1998)
Accipiters								
	Sharp-shinned Hawk	1470	±	156	1304	-11	2585 (1998)	194 (1996)
	Cooper's Hawk	971	±	126	770	-21	2025 (1998)	239 (1996)
	Northern Goshawk	16	±	3	11	-33	42 (2000)	6 (2x)
	Unidentified accipiter	115	±	20	51	-56	266 (1993)	
	TOTAL ACCIPITERS	2573	±	267	2136	-17	4736 (1998)	
Buteos								
	Red-shouldered Hawk		±					
	Broad-winged Hawk	8	±	2	17	116	19 (2012)	8 (2008)
	Swainson's Hawk	903	±	598	2279	152	7301 (1993)	5006 (1993)
	Red-tailed Hawk	612	±	63	696	14	1151 (1998)	138 (1997)
	Ferruginous Hawk	12	±	2	7	-42	25 (1992)	4 (1991)
	Rough-legged Hawk	1	±	0	3	267	3 (2014)	2 (2013)
	Unidentified buteo	23	±	8	7	-70	106 (2001)	
	TOTAL BUTEOS	1558	±	593	3009	93	7916 (1993)	
Eagles								
	Golden Eagle	115	±	12	103	-11	172 (1994)	19 (1994)
	Bald Eagle	4	±	1	6	70	9 (1994)	2 (10x)
	Unknown eagles	3	±	1	0	-100	9 (2007)	
	TOTAL EAGLES	120	±	12	109	-9	181 (1994)	
Falcons								
	American Kestrel	489	±	65	200	-59	905 (1996)	158 (1993)
	Merlin	29	±	6	37	28	64 (2012)	8 (2014)
	Prairie Falcon	18	±	4	17	-7	58 (1998)	5 (1998)
	Peregrine Falcon	49	±	12	59	20	127 (2002)	14 (2003)
	Unidentified falcon	4	±	2	2	-54	21 (2002)	
	TOTAL FALCONS	590	±	69	315	-47	1033 (1996)	
	Unidentified Raptor	38	±	14	0	-100	142 (1992)	
	GRAND TOTAL	5354	±	729	5993	12	11895 (1993)	5196 (1993)

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Table 2. Capture totals and rates for fall migrating raptors at the Manzanos HawkWatch in central New Mexico: 1991–2013 versus 2014.

	Capture Total		Capture Rate[1]	
Species	1991–2013[2]	2014	1991–2013[2]	2014
Northern Harrier	4 ± 1.3	0	0.5 ± 0.12	0.0
Sharp-shinned Hawk	447 ± 81.0	218	58.0 ± 5.50	43.6
Cooper's Hawk	329 ± 60.4	140	42.8 ± 4.60	28.0
Northern Goshawk	5 ± 1.5	1	0.6 ± 0.21	0.2
Broad-winged Hawk	0.3 ± 0.19	0	0.05 ± 0.031	0.0
Swainson's Hawk	0.3 ± 0.31	1	0.04 ± 0.042	0.2
Red-tailed Hawk	45 ± 9.4	13	5.9 ± 0.85	2.6
Zone-tailed Hawk	0.0 ± 0.09	0	0.003 ± 0.006	0.0
Golden Eagle	4 ± 0.9	1	0.5 ± 0.14	0.2
American Kestrel	30 ± 9.7	2	3.6 ± 0.90	0.4
Merlin	5 ± 1.4	3	0.7 ± 0.19	0.6
Prairie Falcon	3 ± 1.2	0	0.4 ± 0.11	0.0
Peregrine Falcon	5 ± 1.6	3	0.7 ± 0.20	0.6
All Species	877 ± 157.8	386	113.8 ± 10.48	77.1

[1] Captures / 100 station hours.

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

Table 3. Foreign encounters with raptors originally banded at the Manzanos HawkWatch in central New Mexico: 2014.

Band #	Species[1]	Sex	Banding Age[1]	Banding Date	Encounter Date	Encounter Age[2]	Encounter Location	Distance (km)	Status
1075 – 02146	CH	F	AHY	30-Sep-13	19-Nov-14	AHY	Roswell, NM	248	found dead – cause unknown
1807 – 93955	NG	F	HY	03-Oct-05	08-Jul-14	ATY	Torreon, NM	28	found dead – predation (other than cat)

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

[2] HY = hatch year; SY = second year; TY = third year; AHY = after hatch year; ASY = after second year; ATY = after third year.

Table 4. Summary of the 2014 fall flight of migrating raptors across HWI's monitoring network. Values are counts ; green indicates a count significantly higher (outside the 95% confidence interval) than the historic site average, red indicates a count significantly lower than average, and black indicates a count that does not differ from the site average.

	Bonney Butte, OR	Chelan Ridge, WA	Bridger Mtn, MT	Commissary Ridge, WY	Goshute Mts, NV	Yaki Pt, AZ	Lipan Pt, AZ	Manzano Mts, NM	Corpus Christi, TX
	Hours Counted in 2014								
Species	414.5	448.3	392.7	491.3	690	605.6	518.1	505.1	818.8
Black Vulture									228
Turkey Vulture	322	55	8	31	661	*	*	343	57128
Osprey	53	41	6	6	125	58	45	38	211
Northern Harrier	18	75	112	6	145	31	35	42	171
Crested Caracara									1
Common Black Hawk									0
Harris' Hawk									4
Accipiters									
Sharp-shinned Hawk	802	520	422	600	6141	1806	1572	1304	2101
Cooper's Hawk	465	190	203	148	3986	862	599	770	821
Northern Goshawk	53	21	59	4	152	4	2	11	0
Unidentified accipiter	41	64	66	49	42	342	281	51	105
TOTAL ACCIPITERS	1361	795	750	801	10321	3014	2454	2136	3027
Buteos									
Red-shouldered Hawk	2				0				15
Broad-winged Hawk	1	12	22	0	203	28	23	17	370575
Short-tailed Hawk									0
Swainson's Hawk	0	43	2	16	509	59	54	2279	8035
White-tailed Hawk									23
Zone-tailed Hawk									5
Red-tailed Hawk	415	119	239	530	5095	1262	1687	696	159
Ferruginous Hawk	0		8	3	32	12	2	7	6
Rough-legged Hawk	1	5	84	3	19	0		3	0
Unidentified buteo	6	22	37	73	16	28	28	7	22
TOTAL BUTEOS	425	201	392	625	5874	1389	1794	3009	378766
Eagles									
Golden Eagle	59	67	1222	136	230	2	16	103	1
Bald Eagle	38	14	106	108	16	12	7	6	15
Unknown eagles	5	0	11	22	0	0	0	0	0
TOTAL EAGLES	102	81	1339	266	246	14	23	109	16
Falcons									
American Kestrel	10	24	138	64	1730	474	440	200	1016
Merlin	80	42	28	4	110	16	12	37	98
Prairie Falcon	7	8	13	9	43	7	0	17	8
Peregrine Falcon	17	10	23	16	33	18	11	59	237
Aplomado Falcon									0
Unidentified falcon	7	7	7	10	0	5	4	2	8
TOTAL FALCONS	121	91	209	103	1916	520	467	315	1367
Kites									
Hook-billed Kite									0
Swallow-tailed Kite									59
White-tailed Kite									4
Mississippi Kite					1				20032
Unidentified Kites									0
TOTAL KITES									20095
Unidentified Raptor	21	45	63	28	0	19	38	0	157
GRAND TOTAL	2423	1384	2879	1866	19288	5045	4856	5993	461171

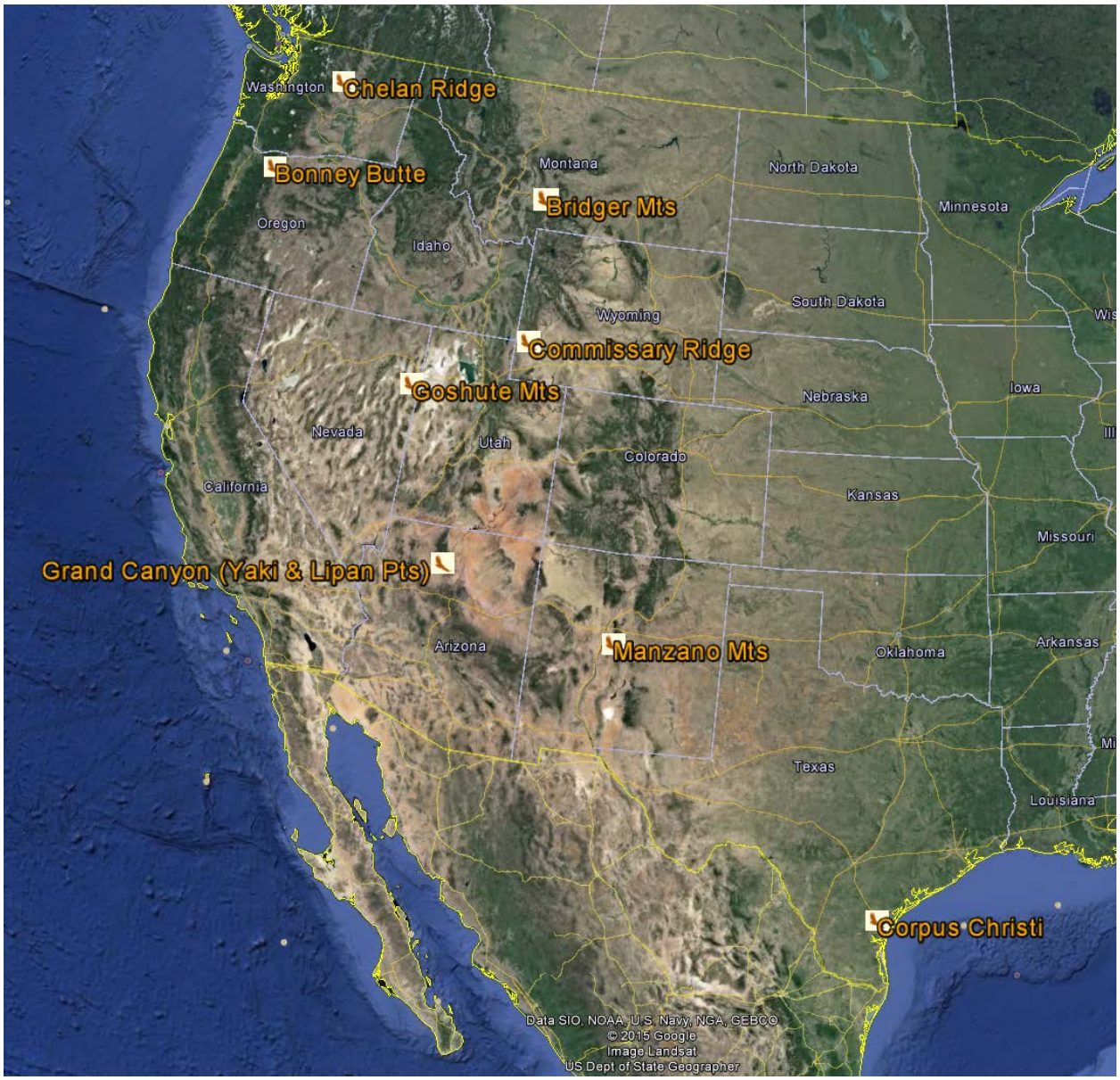

Figure 1. Locations of fall HawkWatch sites operated by HWI and partners.

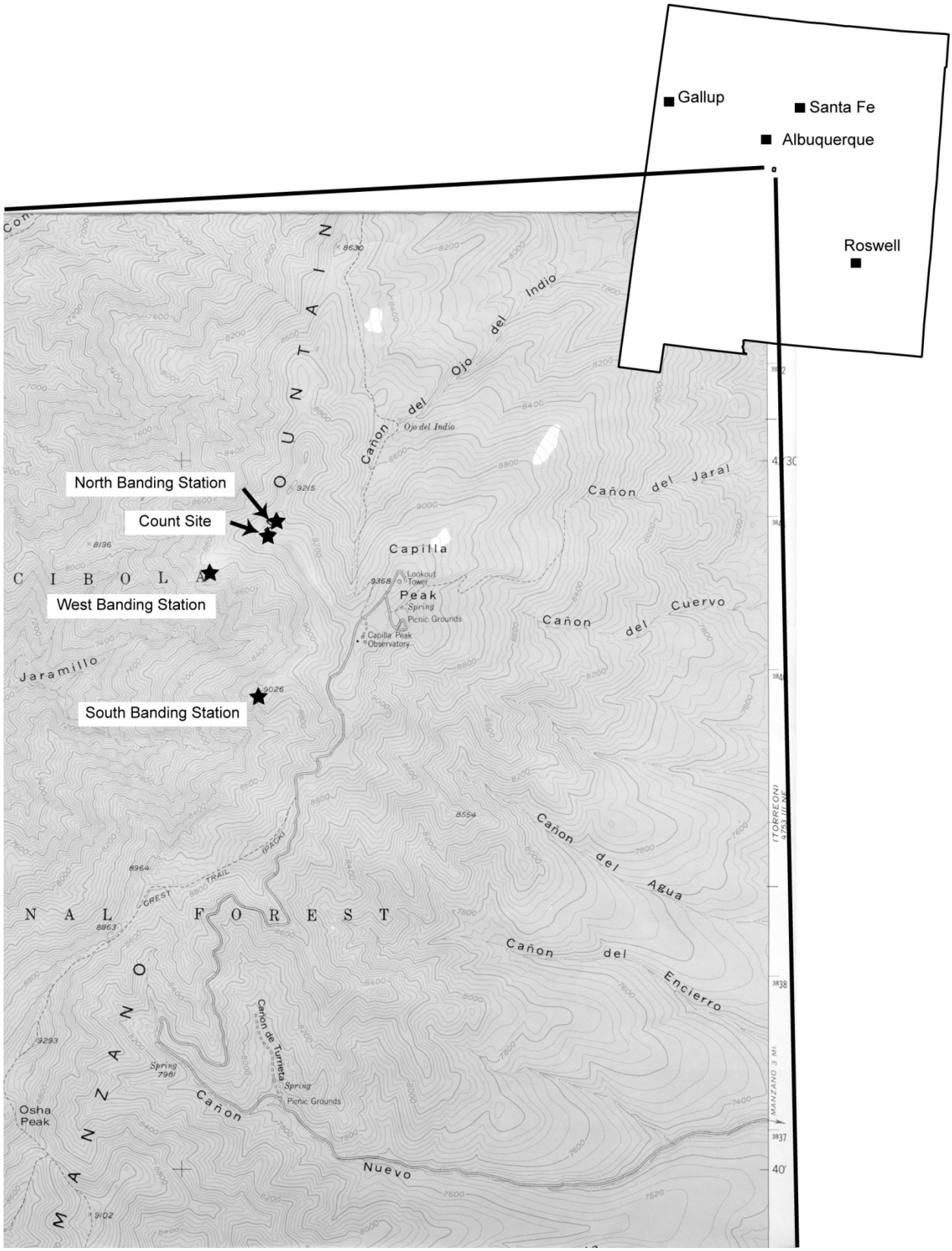

Figure 2. Location of the Manzanos HawkWatch in central New Mexico.

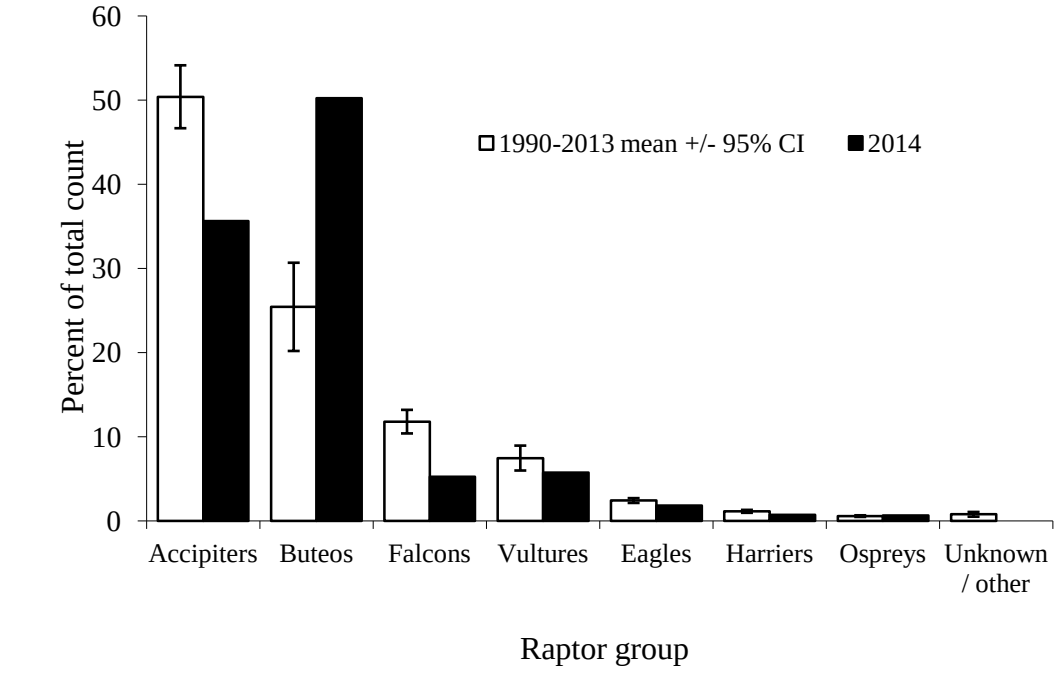

Figure 3. Fall raptor-migration flight composition by major species groups at the Manzanos HawkWatch in central New Mexico: 1985–2013 versus 2014.

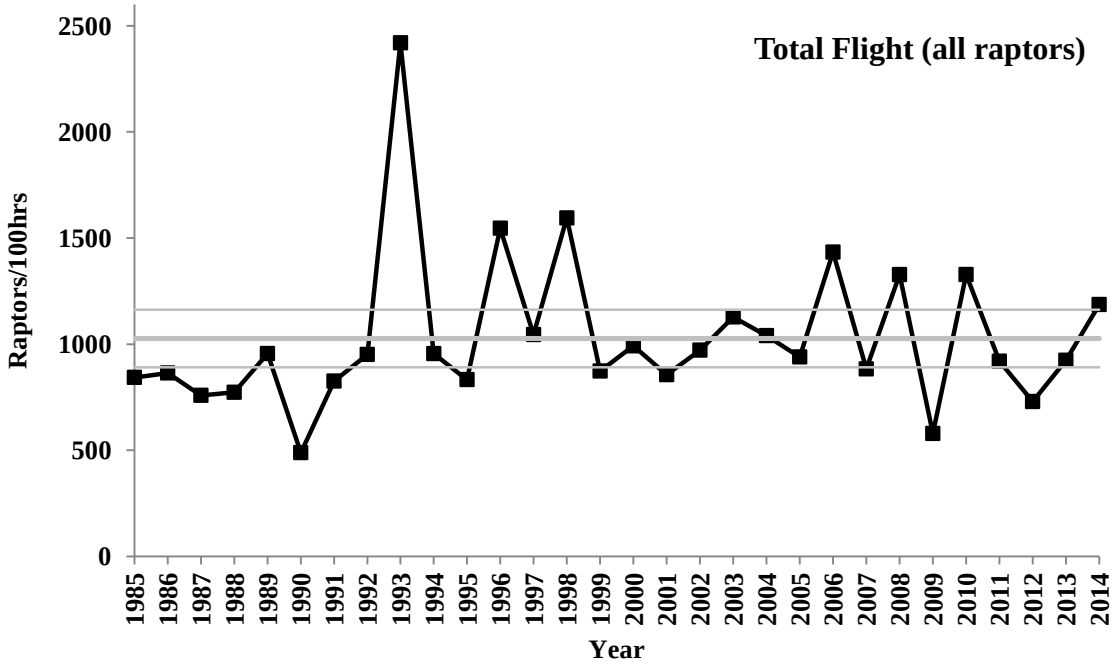

Figure 4. Fall migration passage rates at Manzanos HawkWatch in central New Mexico for all migrating raptors: 1985-2014. Solid grey lines represent mean (thick) and upper and lower 95% confidence intervals (thin) of historic counts (1985-2013) at the Manzanos.

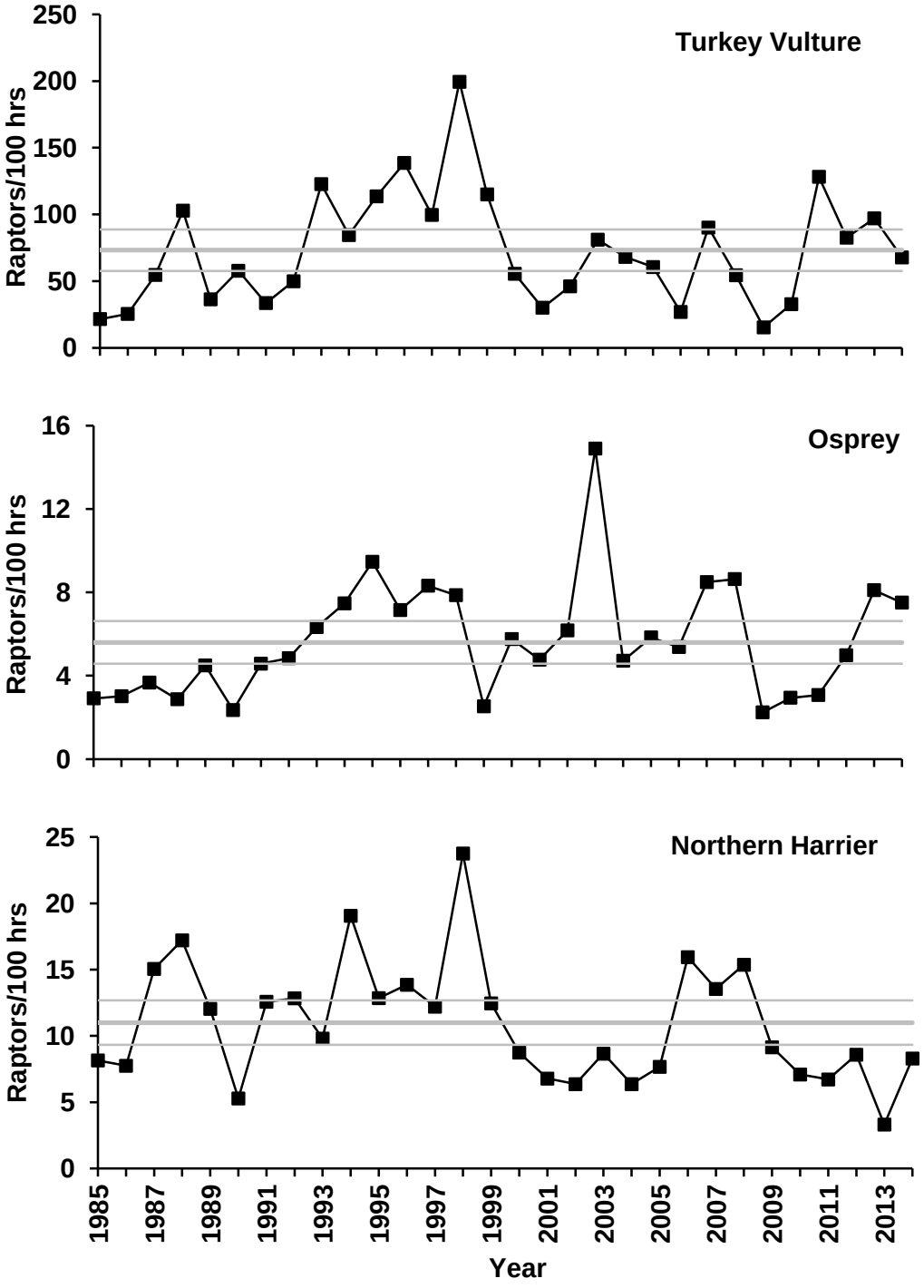

Figure 5a. Effort-adjusted fall-migration passage rates at the Manzanos HawkWatch in central New Mexico for Turkey Vultures, Ospreys, and Northern Harriers: 1985–2014. Solid grey lines represent mean (thick) and upper and lower 95% confidence intervals (thin) of historic counts (1985-2013) at the Manzano Mountains.

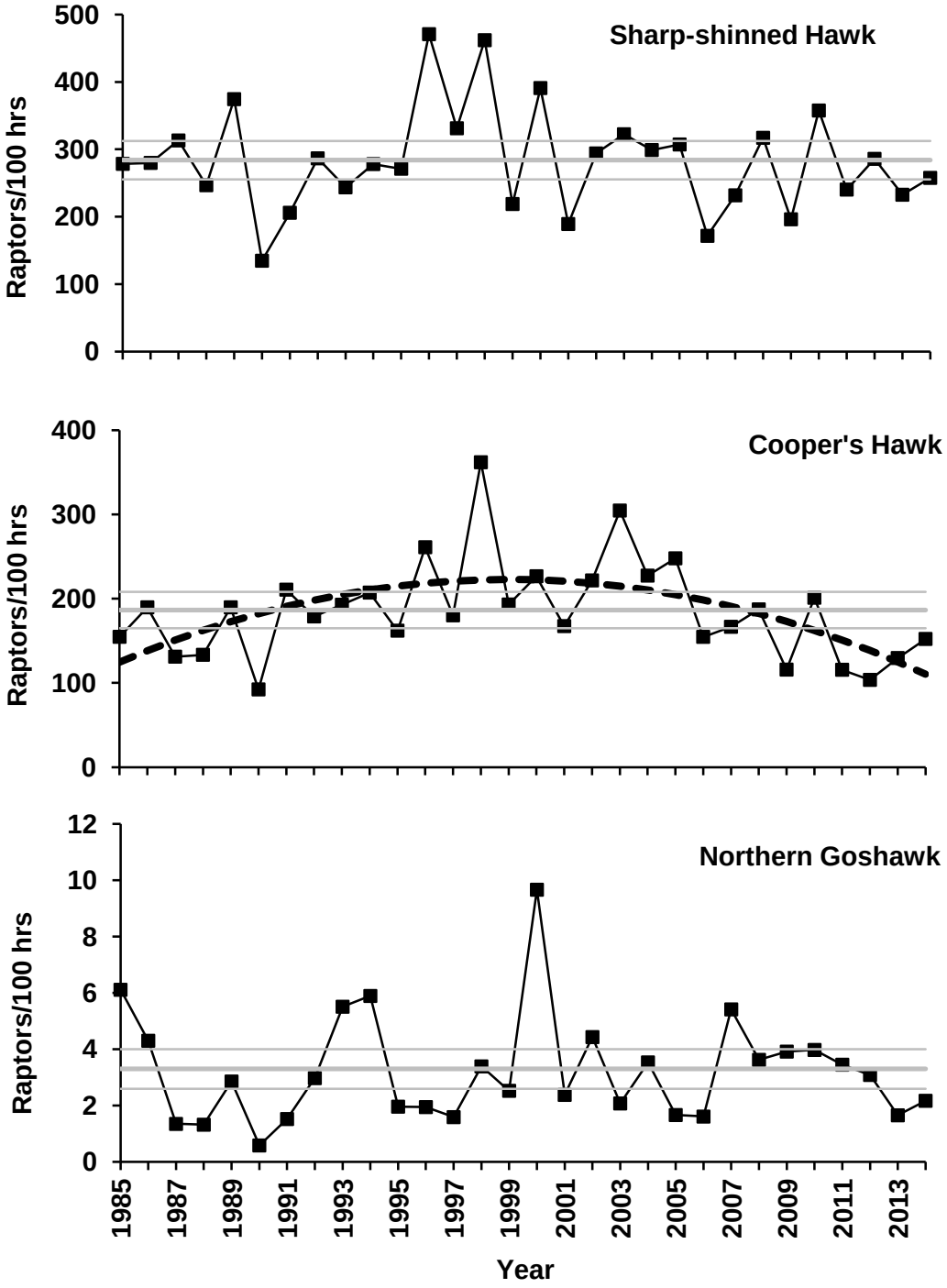

Figure 5b. Effort-adjusted fall-migration passage rates at the Manzanos HawkWatch in central New Mexico for Accipiters: 1985–2014. Dashed lines indicate trends for significant ($p < 0.05$) linear or quadratic regressions. Solid grey lines represent mean (thick) and upper and lower 95% confidence intervals (thin) of historic counts (1985-2013).

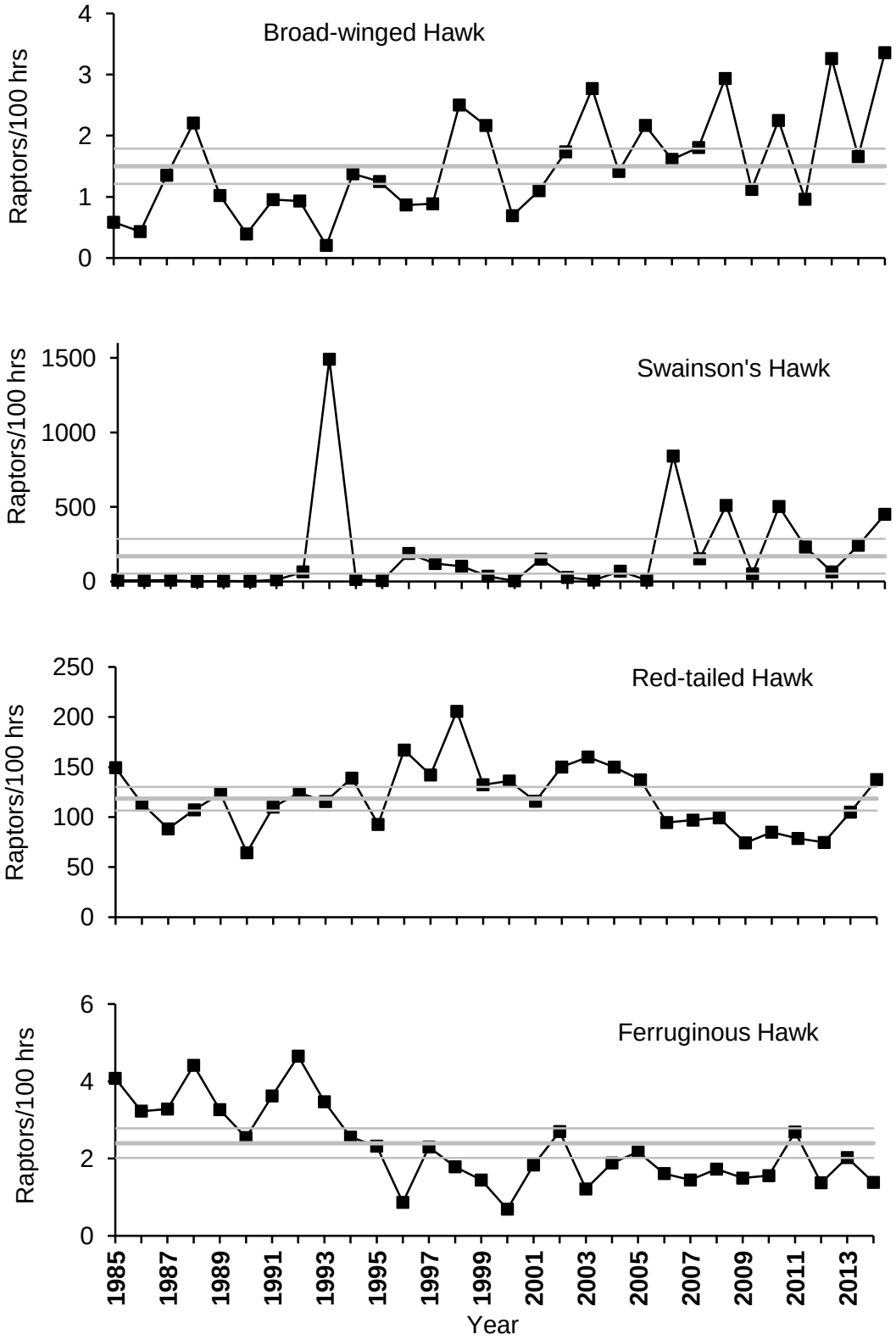

Figure 5c. Effort-adjusted fall-migration passage rates at the Manzanos HawkWatch in central New Mexico for buteoine hawks: 1985–2014. Dashed lines indicate significant ($p < 0.05$) population trends based on linear or quadratic regressions. Solid grey lines represent mean (thick) and upper and lower 95% confidence intervals (thin) of historic counts (1985-2013).

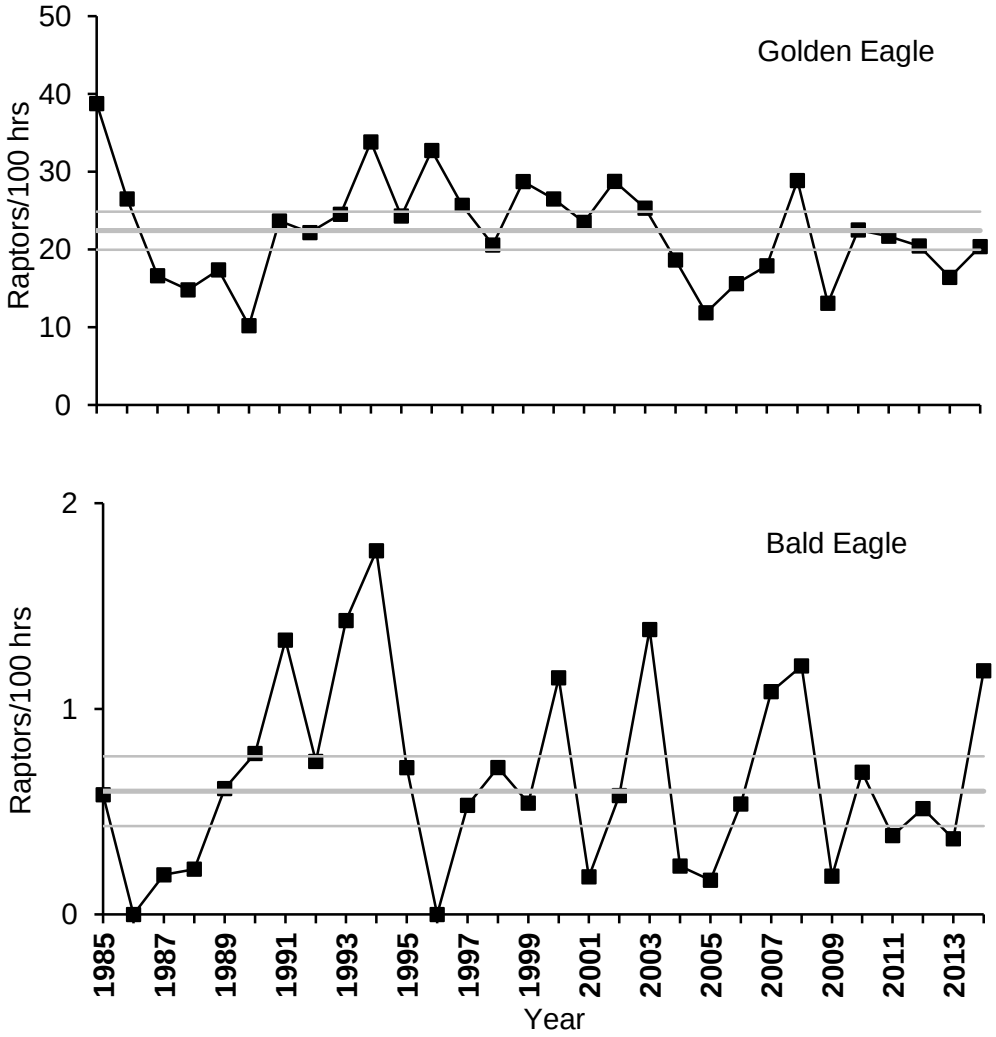

Figure 5d. Effort-adjusted fall-migration passage rates at the Manzanos HawkWatch in central New Mexico for Golden and Bald Eagles: 1985–2014. Solid grey lines represent mean (thick) and upper and lower 95% confidence intervals (thin) of historic counts (1985-2013).

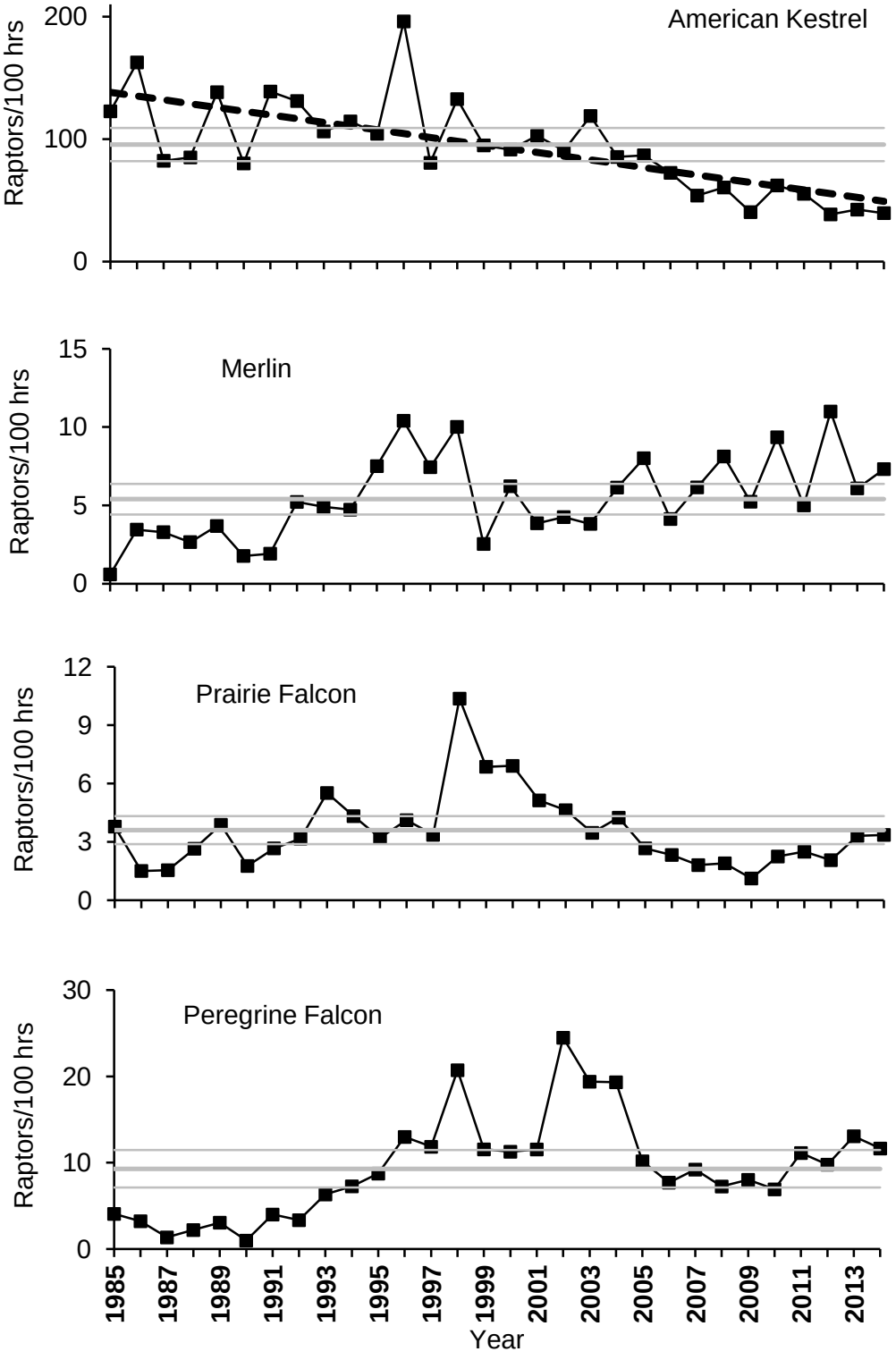

Figure 5e. Effort-adjusted fall-migration passage rates at the Manzanos HawkWatch in central New Mexico for falcons: 1985–2014. Dashed lines indicate significant ($p < 0.05$) population trends based on linear. Solid grey lines represent mean (thick) and upper and lower 95% confidence intervals (thin) of historic counts (1985-2013).

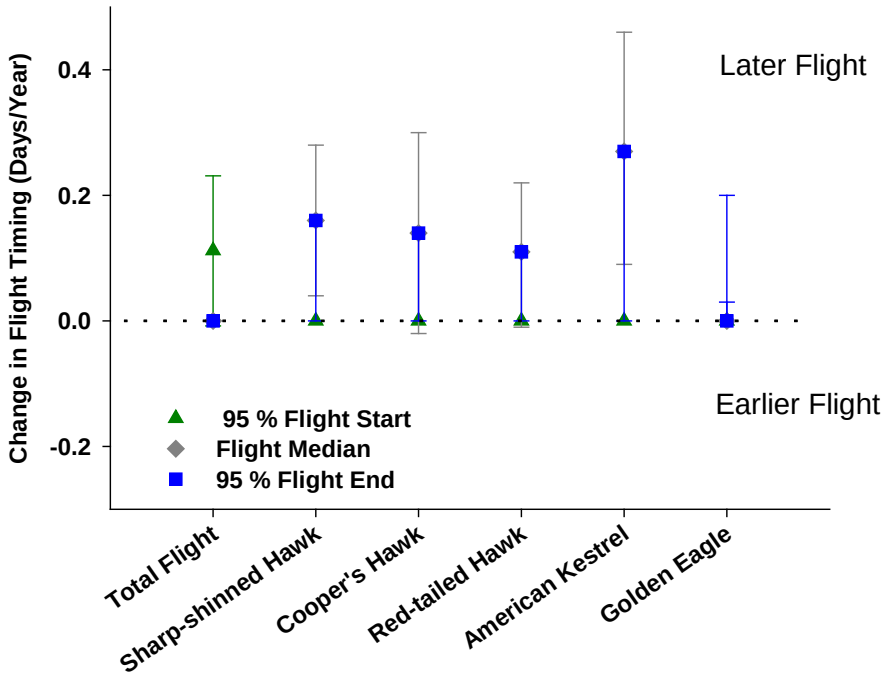

Figure 6. Changes in the timing of fall migration at the Manzanos HawkWatch for the total flight and select individual species. Values represent the slope of regressions on start date, end date, and median passage date over time; error bars represent 95% confidence intervals for estimated slopes.

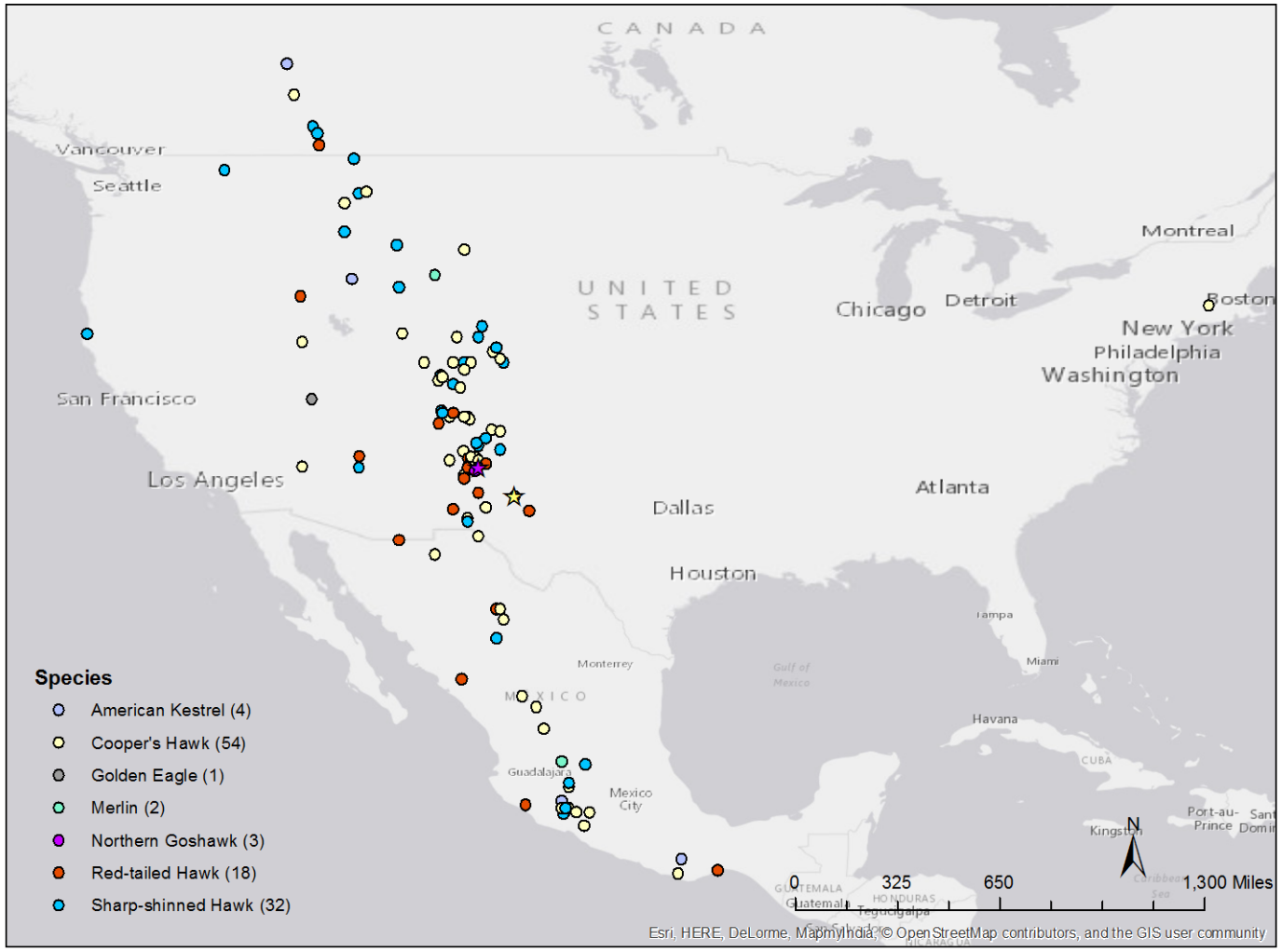

Figure 6. Foreign encounters of raptors banded at the Manzanos HawkWatchin central New Mexico. Circles represent recaptures from 1990 to 2013, stars represent 2014 recoveries.

Appendix A. History of official observer participation at the Manzanos HawkWatch: 1985–2014.

1985 Single observer throughout, shared duty: Gary Cress (0)[1], Jim Daly (1), Allen Hale (1)

1986 Single observer throughout: Jim Daly (2)

1987 Single observer throughout: Jim Daly (3)

1988 Single observer throughout: Gordon Vickrey (1)

1989 Two observers during peak 3/4 of the season, one observer otherwise: Brett Ewald (2), Tim Menard (0)

1990 Two observers during peak 3/4 of the season, one observer otherwise: David Curson (0), Gary Cress (1)

1991 Two observers throughout: Eric Meyer (1), Tylan Dean (0)

1992 Two observers throughout: Eric Meyer (3), Jessie Jewell (0)

1993 Two observers throughout: Jessie Jewell (2), John Haskell (0)

1994 Two observers throughout: Jessie Jewell (4), Jeff Ogburn (1)

1995 Two observers throughout: Jessie Jewell (6), Jeff Ogburn (2)

1996 Two observers throughout: Jessie Jewell (8), Sean O'Connor (3)

1997 Two observers throughout: Jeff Ogburn (4), Sean O'Connor (4)

1998 Two observers throughout: Dan Rossman (1), Lawry Sager (0)

1999 Two observers throughout: Jason Beason (4), Lawry Sager (1)

2000 Two observers throughout: Jorge Canaca (1), Laura Lutz (1)

2001 Two observers throughout: Tim Meehan (1), Carrie Hisaoka (0)

2002 Two observers throughout: Carrie Hisaoka (1), Richard Sim (0)

2003 Two observers throughout: Carrie Hisaoka (2), Tim Hanks (1)

2004 Two observers throughout: Paula Shannon (3), Frank Mayer (2)

2005 Two observers throughout: Tim Hanks (2), Geoff Gould (0)

2006 Two observers throughout: Tim Hanks (3), Greg Levandoski (3)

2007 Two observers throughout: Tim Hanks (4), Aldo Raul Coutreras Reyes (4)

2008 Two observers throughout: Tim Hanks (5), Aldo Raul Coutreras Reyes (5), Roger Grimshaw (1)

2009 Two observers throughout: Kimberly Cullen (1), Amber Wingert (1), Roger Grimshaw (2)

2010 Two observers throughout: Tim Hanks (6+), Russell Seeley (0), Roger Grimshaw (3+)

2011 Two observers throughout: Tim Hanks (7+), Russell Seeley (1), Roger Grimshaw (4+)

2012 Two observers throughout: Robert Baez (3), Ian Dolly (+), Dan D. Tempest (0), Roger Grimshaw (5+), Steve deLaPena (+)

2013 Two observers throughout: Robert Baez (4), Sarah Dudek (0), Ian Dolly (1+), Roger Grimshaw (6+), Steve deLaPena (+)

2014 Two observers throughout: Robert Baez (5), Olivia DeRugna (1), Stephen Brenner (+), Roger Grimshaw (7+), Steve deLaPena (+)

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[1] Numbers in parentheses indicate previous full seasons of observation experience.

Appendix B. Common and scientific names, species codes, and regularly applied age, sex, and color-morph classifications for all diurnal raptor species observed during fall migration at the Manzanos HawkWatch in central New Mexico.

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 accipiter	*Accipiter* spp.	UA	U	U	NA
Broad-winged Hawk	*Buteo platypterus*	BW	A I U	U	D L U
Swanson's Hawk	*Buteo swainsoni*	SW	U	U	D L U
Red-tailed Hawk	*Buteo jamaicensis*	RT	A I U	U	D L U
Ferruginous Hawk	*Buteo regalis*	FH	A I U	U	D L U
Rough-legged Hawk	*Buteo lagopus*	RL	U	U	D L U
Zone-tailed Hawk	*Buteo albonotus*	ZT	A I U	U	NA
Unknown buteo	*Buteo* spp.	UB	U	U	D L U
Golden Eagle	*Aquila chrysaetos*	GE	I, S, NA, A, U[4]	U	NA
Bald Eagle	*Haliaeetus leucocephalus*	BE	I, S1, S2, NA, A, U[5]	U	NA
Unknown eagle	*Aquila* or *Haliaeetus spp.*	UE	U	U	NA
American Kestrel	*Falco sparverius*	AK	U	M F U	NA
Merlin	*Falco columbarius*	ML	AM Br	AM U	NA
Prairie Falcon	*Falco mexicanus*	PR	U	U	NA
Peregrine Falcon	*Falco peregrinus*	PG	A I U	U	NA
Unknown falcon	*Falco* spp.	UF	U	U	NA
Unknown raptor	Falconiformes	UU	U	U	NA

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

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

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

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

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

Appendix C. Annual observation effort and fall raptor migration counts by species at the Manzanos HawkWatch in central NM: 1985–2014.

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Start date	06-Sep	23-Aug	25-Aug	30-Aug	28-Aug	27-Aug	27-Aug	25-Aug	25-Aug	25-Aug
End date	02-Nov	31-Oct	04-Nov	31-Oct	31-Oct	31-Oct	05-Nov	05-Nov	05-Nov	02-Nov
Days of observation	50	63	65	60	63	62	67	70	68	66
Hours of observation	343.33	464.50	517.92	453.08	489.75	510.75	524.58	537.25	489.67	508.75
Raptors / 100 hours	843.2	863.9	758.6	772.3	955.4	494.6	825.6	946.3	2429.2	966.5
SPECIES	RAPTOR COUNTS									
Turkey Vulture	74	118	283	466	178	295	176	268	601	430
Osprey	10	14	19	13	22	12	24	26	31	38
Northern Harrier	28	36	78	78	59	27	66	69	48	97
Sharp-shinned Hawk	956	1300	1622	1118	1834	688	1080	1540	1193	1415
Cooper's Hawk	531	881	679	604	929	471	1105	961	944	1054
Northern Goshawk	21	20	7	6	14	3	8	16	27	30
Unknown accipiter	78	104	119	111	121	133	156	117	266	118
TOTAL ACCIPITERS	1586	2305	2427	1839	2898	1186	2349	2634	2430	2617
Broad-winged Hawk	2	2	7	10	5	2	5	5	1	7
Swainson's Hawk	27	33	44	3	16	9	58	344	7301	67
Red-tailed Hawk	513	527	457	486	604	329	577	667	566	707
Ferruginous Hawk	14	15	17	20	16	13	19	25	17	13
Rough-legged Hawk	0	0	0	1	1	0	0	0	0	0
Zone-tailed Hawk	0	0	0	0	0	0	0	2	0	1
Unknown buteo	21	12	11	16	4	19	30	11	31	22
TOTAL BUTEOS	577	589	536	536	646	372	689	1054	7916	817
Golden Eagle	133	123	86	67	85	52	124	119	120	172
Bald Eagle	2	0	1	1	3	4	7	4	7	9
Unknown Eagle	0	0	0	4	0	4	0	0	0	0
TOTAL EAGLES	135	123	87	72	88	60	131	123	127	181
American Kestrel	421	755	426	385	677	409	728	704	520	582
Merlin	2	16	17	12	18	9	10	28	24	24
Prairie Falcon	13	7	8	12	19	9	14	17	27	22
Peregrine Falcon	14	15	7	10	15	5	21	18	31	37
Unknown falcon	4	0	1	0	3	7	3	1	0	1
TOTAL FALCONS	454	793	459	419	732	437	776	768	602	666
Unknown raptor	31	35	40	76	56	41	120	142	140	71
TOTAL	2895	4013	3929	3499	4679	2526	4331	5084	11895	4917

Appendix C. continued

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Start date	27-Aug	27-Aug	27-Aug	27-Aug	27-Aug	27-Aug	27-Aug	27-Aug	27-Aug	28-Aug
End date	08-Nov	05-Nov	5-Nov	5-Nov	5-Nov	2-Nov	4-Nov	3-Nov	5-Nov	30-Oct
Days of observation	70	59	68	65	70	57	68	65	69	57
Hours of observation	560.00	461.67	565.08	559.58	553.77	434.33	545.47	518.50	577.25	424.08
Raptors / 100 hours	832.9	1545.9	1044.8	1594.2	873.1	991.6	855.8	972.0	1126.4	1039.9
SPECIES	RAPTOR COUNTS									
Turkey Vulture	636	640	563	1116	637	241	164	239	468	289
Osprey	53	33	47	44	14	25	26	32	86	20
Northern Harrier	72	64	69	133	69	38	37	33	50	27
Sharp-shinned Hawk	1519	2174	1872	2585	1212	1698	1032	1524	1861	1268
Cooper's Hawk	907	1205	1018	2025	1069	984	913	1149	1758	964
Northern Goshawk	11	9	9	19	14	42	13	23	12	15
Unknown accipiter	44	147	76	107	51	29	86	202	215	201
TOTAL ACCIPITERS	2481	3535	2975	4736	2346	2753	2044	2898	3846	2448
Broad-winged Hawk	7	4	5	14	12	3	6	9	16	6
Swainson's Hawk	32	867	679	572	194	19	815	139	53	291
Red-tailed Hawk	519	771	803	1151	733	591	632	778	924	636
Ferruginous Hawk	13	4	13	10	8	3	10	14	7	8
Rough-legged Hawk	0	0	0	1	1	0	1	0	0	0
Zone-tailed Hawk	1	0	1	2	0	3	1	1	0	0
Unknown buteo	9	11	3	28	5	2	106	32	30	69
TOTAL BUTEOS	581	1657	1504	1778	953	621	1571	973	1030	1010
Golden Eagle	136	151	145	115	159	115	128	149	146	79
Bald Eagle	4	0	3	4	3	5	1	3	8	1
Unknown Eagle	0	0	0	0	0	1	0	0	1	0
TOTAL EAGLES	140	151	148	119	162	121	129	152	155	80
American Kestrel	584	905	455	742	525	397	560	470	686	362
Merlin	42	48	42	56	14	27	21	22	22	26
Prairie Falcon	18	19	19	58	38	30	28	24	20	18
Peregrine Falcon	49	60	67	116	64	49	63	127	112	82
Unknown falcon	0	1	0	12	2	1	5	21	6	7
TOTAL FALCONS	693	1033	583	984	643	504	677	664	846	495
Unknown raptor	8	24	15	11	11	4	20	49	21	41
TOTAL	4664	7137	5904	8921	4835	4307	4668	5040	6502	4410

Appendix C. continued

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Mean
Start date	27- Aug	27- Aug	27-Aug	27-Aug	27-Aug	27-Aug	27-Aug	27-Aug	27-Aug	27-Aug	26-Aug
End date	5-Nov	5-Nov	5-Nov	5-Nov	5-Nov	4-Nov	4-Nov	5-Nov	4-Nov	03-Nov	2-Nov
Days of observation	69	68	63	69	68	70	68	70	67	65	65
Hours of observation	599.58	566.41	553.58	579.00	535.68	578.00	521.00	582.42	542.92	506.13	520.62
Raptors / 100 hours	937.8	1433.4	883.2	1327.5	577.0	1327.7	919.4	729.4	923.7	1184.1	1027.1
SPECIES							RAPTOR COUNTS				
Turkey Vulture	363	150	499	315	82	189	668	481	527	343	387
Osprey	35	30	47	50	12	17	16	29	44	38	30
Northern Harrier	46	90	75	89	49	41	35	50	18	42	58
Mississippi Kite	–	–	–	–	–	–	1	–	–	–	1
Sharp-shinned Hawk	1842	958	1283	1836	1051	2067	1252	1665	1263	1304	1470
Cooper's Hawk	1486	865	922	1084	620	1162	602	603	703	770	971
Northern Goshawk	10	10	30	21	21	23	18	18	9	11	16
Unknown accipiter	135	127	91	83	118	114	36	73	74	51	115
TOTAL ACCIPITERS	3473	1960	2326	3024	1810	3366	1908	2359	2049	2136	2572
Broad-winged Hawk	13	9	10	17	6	13	5	19	9	17	8
Swainson's Hawk	52	4695	841	2952	274	2906	1204	371	1317	2279	903
Red-tailed Hawk	823	534	537	575	398	491	410	435	570	696	612
Ferruginous Hawk	13	9	8	10	8	9	14	8	11	7	12
Rough-legged Hawk	0	0	0	1	0	0	0	1	2	3	0
Zone-tailed Hawk	1	0	0	0	0	1	4	0	1	1	1
Unknown buteo	33	23	19	11	57	22	10	9	13	7	23
TOTAL BUTEOS	935	5270	1415	3566	743	3442	1647	843	1923	3010	1559
Golden Eagle	71	87	99	167	70	130	113	119	89	103	115
Bald Eagle	1	3	6	7	1	4	2	3	2	6	3
Unknown Eagle	4	1	9	2	4	4	5	0	0	0	1
TOTAL EAGLES	76	91	114	176	75	138	120	122	91	109	120
American Kestrel	520	412	298	350	216	359	288	224	230	200	489
Merlin	48	23	34	47	28	54	26	64	33	37	29
Prairie Falcon	16	13	10	11	6	13	13	12	18	17	18
Peregrine Falcon	61	43	51	42	43	40	58	57	71	59	49
Unknown falcon	13	5	3	4	9	7	5	3	3	2	4
TOTAL FALCONS	658	496	396	454	302	473	390	360	355	315	590
Unknown raptor	37	32	17	12	18	8	5	4	8	0	38
TOTAL	5623	8119	4889	7686	3091	7674	4790	4248	5015	5993	5354

Appendix D. Annual trapping and banding effort and capture totals of migrating raptors by species at the Manzanos HawkWatch in central NM: 1990–2014.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Start date	28-Aug	05-Sep	31-Aug	03-Sep	01-Sep	04-Sep	02-Sep	31-Aug	29-Aug	31-Aug	02-Sep	01-Sep	03-Sep	07-Sep	05-Sep	04-Sep	04-Sep	02-Sep
End date	27-Oct	29-Oct	30-Oct	24-Oct	25-Oct	31-Oct	19-Oct	28-Oct	29-Oct	16-Oct	27-Oct	25-Oct	25-Oct	24-Oct	28-Oct	28-Oct	24-Oct	27-Oct
Blinds in operation	1	3	3	3	3	4	4	4	3	3	3	3	3	2	2	2	2	2
Trapping days	47	54	57	50	48	53	45	54	58	46	50	55	51	45	45	51	48	47
Station days	47	95	131	120	121	136	132	151	165	94	119	145	131	84	84	99	94	105
Station hours	511	693	967	889	926	1041	1030	1211	1352	664	791	1037	957	633	756.15	707.77	677.67	452.97
Captures / 100 stn hrs	47.7	72.4	108.2	100.8	110.7	85.7	137.0	95.0	148.2	115.7	121.7	85.9	135.3	152.7	136.0	163.0	96.5	83.2
SPECIES	RAPTOR CAPTURES																	
Northern Harrier	1	2	2	3	9	2	1	8	14	0	5	7	6	3	0	3	6	3
Sharp-shinned Hawk	124	262	589	430	502	493	778	612	987	321	495	426	635	458	566	562	299	196
Cooper's Hawk	95	195	335	374	353	310	460	427	772	323	330	337	510	400	378	495	280	142
Northern Goshawk	1	7	6	6	7	1	5	3	6	6	16	1	10	1	2	3	3	3
Broad-winged Hawk	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	1	1
Swainson’s Hawk	0	0	0	0	0	0	0	0	0	0	0	1	3	0	0	0	1	0
Red-tailed Hawk	8	18	61	55	83	50	50	46	112	56	76	39	56	38	43	35	35	9
Zone-tailed Hawk	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Golden Eagle	1	3	4	4	4	4	6	4	5	2	4	5	7	8	2	2	1	1
Bald Eagle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
American Kestrel	10	13	42	14	59	28	92	32	75	44	25	56	37	43	18	37	10	9
Merlin	1	0	2	4	1	1	11	6	7	2	8	2	12	3	10	3	2	5
Prairie Falcon	1	1	3	5	3	1	3	5	13	6	3	7	5	4	3	4	4	2
Peregrine Falcon	2	1	2	1	4	2	5	7	12	8	1	10	13	7	5	10	12	6
All Species	244	502	1046	896	1025	892	1411	1150	2006	768	963	891	1295	966	1028	1154	654	377
Recaptures[1]	0	0	1	1	2	2	1	2	4	4	3	2	3	2	2	3	2	0
Foreign recaptures[2]	2	1	1	1	2	0	5	1	2	2	0	0	3	2	0	0	1	0
Foreign encounters[3]	0	2	3	4	7	8	10	11	17	17	9	9	11	9	8	11	9	7

[1] Recaptures in the Manzanos of birds originally banded in the Manzanos.

[2] Recaptures in the Manzanos of birds originally banded elsewhere.

[3] Birds originally banded in the Manzanos and subsequently encountered elsewhere.

Appendix D. continued

	2008	2009	2010	2011	2012	2013	2014	TOTAL	MEAN
Start date	3-Sep	3-Sep	2-Sep	1-Sep	31-Aug	29-Aug	28-Aug		1-Sep
End date	30-Oct	27-Oct	27-Oct	28-Oct	28-Oct	30-Oct	29-Oct		25-Oct
Blinds in operation	2	2	2	2	2	2	2		2.7
Trapping days	56	48	52	46	56	60	55		50.9
Station days	80	61	61	58	76	79	73		94.3
Station hours	586.04	390.25	408.67	397.00	495.25	527.75	500.48		754.2
Captures / 100 stn hrs	104.8	133.8	93.5	80.6	121.6	134.3	76.7		110.0
SPECIES						RAPTOR CAPTURES			
Northern Harrier	4	2	2	2	2	2	0	89	3.7
Sharp-shinned Hawk	315	255	184	171	362	387	218	10627	433.7
Cooper's Hawk	247	201	160	105	171	257	140	7797	319.0
Northern Goshawk	3	8	2	1	2	3	1	107	4.4
Broad-winged Hawk	0	0	0	0	1	0	0	7	0.3
Swainson’s Hawk	0	0	0	0	0	2	1	8	0.3
Red-tailed Hawk	20	34	22	27	41	31	31	1058	43.5
Zone-tailed Hawk	0	0	0	0	0	0	0	1	0.0
Golden Eagle	9	1	1	1	4	3	1	87	3.6
Bald Eagle	0	0	0	0	0	0	1	1	0.0
American Kestrel	4	16	5	8	9	10	2	698	29.0
Merlin	8	2	2	3	8	5	3	111	4.5
Prairie Falcon	1	1	3	0	0	1	0	79	3.3
Peregrine Falcon	3	2	1	2	2	6	3	127	5.2
All Species	614	522	382	320	602	709	384	20798	850.6
Recaptures[1]	1	1	2	1	1	1	1	42	1.7
Foreign recaptures[2]	0	1	0	0	0	0	1	25	1.0
Foreign encounters[3]	7	7	2	1	5	3	1	179	7.2

[1] Recaptures in the Manzanos of birds originally banded in the Manzanos

[2] Recaptures in the Manzanos of birds originally banded elsewhere.

[3] Birds originally banded in the Manzanos and subsequently encountered elsewhere.