FALL 2016 RAPTOR MIGRATION REPORT

CORPUS CHRISTI HAWKWATCH, HAZEL BAZEMORE COUNTY PARK, TEXAS

HAWK WATCH INTERNATIONAL

Conserving Raptors and Our Shared Environment

Salt Lake City, Utah

August 2017

FALL 2016 RAPTOR MIGRATION REPORT
CORPUS CHRISTI HAWKWATCH, HAZEL BAZEMORE COUNTY PARK, TEXAS

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INTRODUCTION

The Corpus Christi HawkWatch in southern Texas is an ongoing effort to monitor long-term regional trends in raptor populations using the Gulf Coast migratory flyway (Smith et al. 2001, 2008a). HawkWatch International (HWI), in partnership with Nueces County Parks and Recreation, Texas Parks and Wildlife Department, and local volunteers began standardized annual counts of the fall raptor migration at Hazel Bazemore County Park (HBCP) near Corpus Christi in 1997. Prior to this, local volunteers conducted shortened, peak-season counts at this "Coastal Bend" site each year between 1988 and 1996 following protocols of the Hawk Migration Association of North America (HMANA; see the Dec 1997 issue of Hawk Migration Studies for a summary of those efforts). Since HWI established full-season counts at the site in 1997, we have documented 30 species of raptors migrating through the project area with annual counts ranging between 445,000 to more than 1,000,000 migrants each fall. The spectacular Broad-winged Hawk flight comprises 88–98% of the total count annually. Other species of note seen at the Corpus Christi HawkWatch each year include sizeable flights of Mississippi and Swallow-tailed Kites, and an occasional Aplomado Falcon. This report summarizes the 2016 fall raptor migration at the Corpus Christi HawkWatch, the 20th straight year of fall counting at this important migration site.

The Corpus Christi HawkWatch was 1 of 8 long-term, annual migration counts conducted or co-sponsored by HWI in North America during 2016. The primary objective of these efforts is to track long-term regional population trends of diurnal raptors in western North America and around the Texas Gulf Coast (Hoffman and Smith 2003; Smith et al. 2001, 2008 a, b). The Corpus Christi HawkWatch falls within the Tamaulipan Brushlands and Gulf Coast bird conservation regions, the Gulf Coast Joint Venture, and the Coastal Prairies Partners in Flight region. Raptors can serve as important biological indicators of ecosystem health (Bildstein 2001) and long-term migration counts can be a cost effective and efficient method for monitoring regional population status and trends of multiple raptor species (Zalles and Bildstein 2000).

Beyond having scientific and conservation value, all of HWI's migration studies offer unique opportunities for the public to learn about raptors and the natural environment. Providing such opportunities is another important component of the Corpus Christi HawkWatch and outreach efforts here reach hundreds of people from the Texas Gulf Coast and beyond each season.

STUDY SITE

The nine-county area surrounding Corpus Christi is also known as the Coastal Bend and includes: Aransas, Refugio, San Patricio, Nueces, and Kleberg counties along the coast, and Goliad, Bee, Live Oak, and Jim Wells counties to the west. The Gulf Coast in Texas runs from the northeast to the southwest between the Louisiana border and Corpus Christi Bay, and then shifts to a more north–south direction from there into Mexico. Hazel Bazemore County Park (HBCP) is approximately 27 km west of Corpus Christi Bay near the town of Calallen (27º52'3.0"N, 97º38'30.1"W; Figure 1). This geographic location is ideal for monitoring the autumn raptor migration through the region. Past records show that this is a major migration path for Broad-winged Hawks (Rappole and Blacklock 1985).

The Corpus Christi HawkWatch sits at 28 m above mean sea level, the highest elevation along the coast in a four-county area. The park is located on the southern bank of the Nueces River at a horseshoe bend where the river changes from a southeast to north–northwest flow. Fall 2015 marked the eighth season for the viewing platform centered atop the grassy area that previously served as the central viewshed. The deck can hold up to 150 people, affords a sweeping 180° viewscape, and includes a backside ramada for shade. Visibility is clear to the west, north, and east, but trees and topography at a similar elevation restrict the southern view. The Nueces River bottomlands feature a transitional riparian forest. Characteristic plants include hackberry (*Celtis* spp.), Mexican ash (*Fraxinus berlandieriana*), anacua (*Ehretia anacua*), black persimmon (*Diospyros texana*), chittimwood (*Bumelia lanuginosa*), and cedar elm (*Ulmus crassifolia*). Many species of raptors use this forested area for nocturnal roosting during migration (Rappole and Blacklock 1985). Open farmland predominates to the north and south, open ranchland to the west. Corpus Christi Bay, which is an industrial and urbanized area, lies to the east.

METHODS

STANDARDIZED COUNTS

Weather permitting, two designated observers, relieved or supplemented by other trained staff and volunteers, conduct standardized daily counts of migrating raptors from the observation platform. Observers assign specific roles to other volunteers and visitors taking part in the count to maximize count accuracy and enhance the quality of the count. Counters are responsible for counting large flights of raptors, usually Broad-winged Hawks. Spotters are responsible for scanning the sky for both large flights and single raptors, and notifying the counters of their sightings. Other individuals are responsible for scanning through large flights of Broad-winged Hawks and noting occurrences of other species. Additional volunteer assignments include keeping up with the visitor log, taking weather observations when the primary observer is too busy with counts, and serving as data recorder on busy days.

Observations usually begin by 0800 H and end by 1600 H Central Standard Time (CST). Data gathering and recording follows standardized protocols used at all HWI migration sites (Hoffman and Smith 2003). Observers routinely record the following data:

1. Species, age, sex, and color morph of each migrant raptor, whenever possible and applicable (Appendix A lists common and scientific names for all species, information about the applicability of age, sex, and color morph distinctions, and two-letter codes used to identify species in some tables and figures). Observers generally tally raptors by species and not sex or age class, because the demands of counting during peak flight periods usually precluded paying close attention to details other than species identification.
2. Hour of passage for each migrant; e.g., the 1000–1059 H CST.
3. Wind speed and direction, air temperature, percent cloud cover, predominant cloud type(s), presence or of precipitation, visibility, and an assessment of thermal-lift conditions, recorded for each hour of observation on the half hour.
4. Predominant direction, altitude, and distance from the lookout of the flight during each hour.
5. Total minutes observed and the mean number of observers present during each hour (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 2016 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. We use linear and quadratic regressions on effort-adjusted annual passage rates (raptors/100hrs) to identify long-term trends in migrating raptors.

2016 RESULTS AND DISCUSSION

OBSERVATION EFFORT AND WEATHER SUMMARY

Corpus Christi HawkWatch's standard season runs 15 August—15 November; in 2016 observers counted from 1 August to 15 November for the second consecutive season, for a total of 107 days and 856.3 hours—a record high effort for the site (averages of 94 days and 722 hours, Appendix C). We shifted the season start to better document the flight of early-migrating species, such as the Swallow-tailed Kite and plan to start monitoring on this date going forward. Weather shortened the count on three days (≤4 hours). Weather varies throughout every season, in 2016 based on hourly recording of conditions during observation it was clear 15% of the time, partly cloudy 24% of the time, mostly cloudy 22% of the time, overcast 39% of the time, hazy 90% of the time, foggy 2% of the time, and rainy 5% of the time.

2016 FLIGHT SUMMARY

Overall Flight:

The Corpus Christi HawkWatch crew counted 682,126 migrant raptors of 23 different species in 2016, making this an average year for raptor migration compared to the site long-term average (Table 1); this was the largest count since 2006 (Appendix C). Season highlights included the largest Mississippi Kite flight in site history (35,219), and the most Swallow-tailed Kites counted since 2009.

The flight consisted of 87 % buteos, 6 % vultures, 5 % kites and less than 1 % of all other groups, owing to the large proportion of Broad-winged Hawks (87% on average, including 2016) comprising the flight (Fig 3a). Removing Broad-winged Hawks from the flight (Fig 3b) yields the following proportions: vultures (51%), kites (40%), buteos (3%), accipiters (3%), falcons (1%), and other species (<1%).

The following sections summarize the 2016 count relative to historic means at the site, and any statistically significant ($p < 0.05$) regional 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 very 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 (Figure 4):

The 79,660 raptors counted per 100 hours of observation at the Corpus Christi HawkWatch in 2016 was comparable to the historic average (Fig 4a). Regression analysis of passage rate indicates long-term decline in the total number of raptors counted each year at Corpus Christi (slope = -3293.6, $r^2 = 0.32$, $p=0.009$). Interestingly, Broad-winged Hawks seem to be driving this trend; the total flight exclusive of Broad-winged Hawks was average (10,265 birds/100hrs) in 2016. Based on linear regression there has been an overall increasing trend in the flight independent of Broad-winged Hawks (slope = 620, $r^2 = 0.61$, $p<0.001$).

Vultures and Osprey (Fig. 5a)

The crew counted Black Vultures at a clip below the site average for the fifth straight season. Despite this, the long-term regional population trend for Black Vultures remains stable. Turkey Vulture count and passage rate were average this season after setting all-time highs in 2015; and regression analysis on effort-adjusted passage rates suggest that regional populations of Turkey Vultures are growing (slope = 481, $r^2 = 0.40$, $p = 0.003$). Counts of Osprey in 2016 were average compared to historic values but passage rate was the lowest since 2002. Regression results suggest declining Osprey passage rates since 2011 ($F_{2,17} = 4.98$, $r^2 = 0.37$, $p = 0.039$).

Northern Harriers and Kites (Fig. 5b):

We documented below average numbers of Northern Harriers in 2016, with the lowest count and passage rate since 2005 and 2004, respectively; despite this the long-term regional population trend for harriers remains stable. Despite an early start to the season, Swallow-tailed Kite count and passage rate were below average; and binomial regression of effort adjusted passage rates suggest regional populations of Swallow-tailed Kites have been declining since 2008 ($F_{2,17}=5.6$, $r^2 = 0.4$, $p = 0.03$).

We documented record numbers of Mississippi Kites in 2016 (count= 35,219, passage rate= 4113 birds/100hr). Increasing regional populations are suggested by regression results (slope= 135, $r^2 = 0.52$, $p < 0.001$).

Crested Caracara and Accipiters (Fig. 5c):

Crested Caracaras are relatively uncommon migrants at the site (Appendix C), and only five were counted in 2016. The Corpus crew observed an above average count and passage rate of Sharp-shinned Hawk in 2016; regional populations of this species are increasing based on linear regression of effort-adjusted passage rates (slope = 6.7, $r^2 = 0.39$, $p = 0.003$). The Cooper's Hawk count was in line with the site average and the passage rate was below average in 2016. According to binomial regression on fall passage rates, regional populations of Cooper's Hawks increased between 1997 and 2006, but have slowly declined since 2010 ($F_{2,17} = 7.03$, $r^2 = 0.45$, $p = 0.017$).

Buteoine and Near-Buteoine Hawks (Figs. 5d and 5e):

Broad-winged Hawks regularly make up 87% of the fall flight, the 594,222 Broad-wings counted in 2016 was consistent with the historic average (Table 1); and despite being the highest seen since 2007, the passage rate was below average. Long-term analyses of effort-adjusted passage rates suggest significant regional population declines (slope = -3913.5, $r^2 = 0.39$ $p = 0.003$). In 2016 we recorded below average counts and passage rates for Red-shouldered Hawks, Red-tailed Hawks, Swainson's Hawks, and Harris's Hawks; in fact, the 44 Red-tailed Hawks counted set a new low count for the Corpus Christi HawkWatch (Appendix C).

Falcons (Fig. 5f):

The 810 American Kestrels counted by the team in 2016 is in line with the historic average (Table 1); and linear regression of effort-adjusted passage rates suggest Kestrel regional populations are increasing (slope = 5.4, $r^2 = 0.43$, $p = 0.002$. Interestingly the increasing trend for American Kestrels here contrasts with those found at most other HWI sites in the western US where the species is declining. Based on findings at those sites and other regional monitoring sites across North America, HWI scientists, along with many other North American researchers and Citizen Scientists have collaborated to understand Kestrel declines locally (www.hawkwatch.org/kestrels) and at the continental scale under the umbrella of the American Kestrel Partnership (http://kestrel.peregrinefund.org/).

Both Peregrine Falcon and Prairie Falcon counts and passage rates were average in 2016 compared to historic site averages.

VISITOR PARTICIPATION AND PUBLIC OUTREACH

At least 849 visitors came to the site to watch and learn about the spectacular fall raptor migration at the Corpus Christi HawkWatch. The annual *Celebration of Flight* included presentation and time on the counting platform with HWI Conservation Biologist, Neil Paprocki. Other organized groups included students from the Texas State Aquarium Sea Camp, Rockport Elementary, Texas A&M Community College, and Delmar College.

2016 FALL MIGRATION ACROSS HWI'S NETWORK

HawkWatch International and partners operated 8 fall count sites in 2016 (Fig. 1). During the 4,341 hours of standardized observation, we counted 714,248 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 2016 included (Table 4):

- Below average Kestrel numbers at 5 of 8 sites (no sites w/ above average counts).

- Below average counts for Prairie Falcons and Osprey at 5 of 8 sites and 4 of 8 sites, respectively.

- Above average Merlin counts at 5 of 8 sites, only exception was Manzanos with a count below average (this site had second lowest overall (all raptors) count in 32-yr history)

- Above average counts at Bridger, Commissary, and Grand Canyon for second year in a row overall and for most species.

- Below average counts for Red-tailed Hawks at 4 of 8 sites, including a record low at Corpus Christi; above average counts at 3 sites.

- Record highs for:
    - Golden Eagles at Commissary (only network site w above average Golden Eagle count)
    - All falcons except Kestrels and Northern Harriers at the Grand Canyon
    - Bald Eagles at Chelan Ridge
    - Mississippi Kites at Corpus Christi (shattered previous record of 27,285)

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 to all of the members of our 2016 field crew: Dane Ferrell, Kevin Georg, Matt Mills, and Earl Johnson; our local site coordinators: Libby Even and Joel Simon; and to Beth Hoekje for education and outreach efforts throughout the Coastal Bend area. Without your skill, dedication, neck-strength, and willingness to brave the bugs, humidity, and heat over the course of a long and intense season these efforts would not be possible.

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Table 1. Average fall raptor migration counts (± 95% CI), counts from fall 2016, and site records for the Corpus Christi HawkWatch.

Species	1997-2015 Mean Count ± 95 % CI	2016	% Change	All-time Historic Records Season	Year	Daily
Black Vulture	438 ± 151	140	-68	1398	1999	254 (1999)
Turkey Vulture	40229 ± 16790	45293	13	170976	2015	41132 (2013)
Osprey	206 ± 32	187	-9	351	2011	39 (2004)
Northern Harrier	245 ± 71	158	-36	614	2006	64 (2011)
Crested Caracara	9 ± 3	5	-45	21	2001	7 (1999)
Common Black Hawk	<1 ±	0		1	2002	1
Harris' Hawk	13 ± 5	5	-62	39	2006	5 (2006)
Accipiters						
Sharp-shinned Hawk	1502 ± 227	2159	44	2466	2012	340 (2014)
Cooper's Hawk	962 ± 183	824	-14	1719	2006	259 (2006)
Northern Goshawk	0 ± 0	0	-100	3	2007	2 (2007)
Unidentified accipiter	232 ± 42	64	-72	379	2000	
TOTAL ACCIPITERS	2696 ± 356	3047	13	4146	2012	
Buteos						
Red-shouldered Hawk	48 ± 12	15	-69	101	2006	19 (2012)
Broad-winged Hawk	549785 ± 105942	594222	8	989957	2004	520032 (2004)
Short-tailed Hawk	1 ± 0	0	-100	4	2005	1
Swainson's Hawk	7207 ± 3196	2255	-69	26093	2008	17549 (2012)
White-taile Hawk	21 ± 7	22	4	50	2008	5 (2x)
Zone-tailed Hawk	6 ± 2	7	14	22	2007	2 (9x)
Red-tailed Hawk	151 ± 85	44	-71	363	2006	58 (2000)
Ferruginous Hawk	4 ± 2	2	-47	14	1999	2 (6x)
Rough-legged Hawk	<1 ±	0		4	1999	1
Unidentified buteo	85 ± 38	24	-72	368	2001	
TOTAL BUTEOS	557307 ± 106001	596591	7	1004989	2004	
Eagles						
Golden Eagle	2 ± 1	0	-100	5	2013	1
Bald Eagle	6 ± 2	9	56	15	2014	3 (2x)
Unknown eagles	<1 ±	0		1	2008	
TOTAL EAGLES	7 ± 2	9	23	16	2014	
Falcons						
American Kestrel	802 ± 170	810	1	1381	2011	251 (2011)
Merlin	62 ± 15	83	35	117	2015	18 (2012)
Prairie Falcon	8 ± 3	7	-10	33	1999	5 (1999)
Peregrine Falcon	198 ± 33	224	13	317	2012	48 (2012)
Aplomado Falcon	<1 ± 0	0	-100	4	2007	2 (2x)
Unidentified falcon	29 ± 12	10	-65	103	2000	
TOTAL FALCONS	1099 ± 200	1134	3	1749	2013	
Kites						
Hook-billed Kite	<1 ±	0		1	2003	1 (2003)
Swallow-tailed Kite	82 ± 37	152	85	349	2008	58 (2008)
White-tailed Kite	5 ± 1	13	178	14	2008	5 (2008)
Mississippi Kite	13007 ± 3457	35219	171	35219	2016	12261 (2007)
Unidentified Kites	<1 ±	0		1	2008	
TOTAL KITES	13094 ± 3484	35384	170	35384	2016	
Unidentified Raptor	624 ± 562	172	-72	4376	1998	
GRAND TOTAL	615969 ± 98587	682126	11	1030849	2004	520351 (2004)

Table 2. Summary of the 2016 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. Asterisks denote a record high or low count. *In 2016 HWI monitored fall migration for 4,451.7 hrs and counted 713,979 birds.*

	Bonney Butte, OR	Chelan Ridge, WA	Bridger Mtn, MT	Commissary Ridge, WY	Goshute Mts, NV	Yaki Pt, AZ	Manzano Mts, NM	Corpus Christi, TX
	Hours Counted in 2016							
Species	**366**	**421**	**381.8**	***573.8***	**698.5**	**600.8**	**553.5**	**856.3**
Black Vulture								140
Turkey Vulture	596	63	14	59	370		214	45293
Osprey	66	*16*	13	22	54	70	22	187
Northern Harrier	12	82	44	52	211	*68*	30	158
Crested Caracara								5
Common Black Hawk								0
Harris' Hawk								5
Accipiters								
Sharp-shinned Hawk	1146	490	616	1487	3204	1667	892	2159
Cooper's Hawk	362	196	198	536	1960	1255	466	824
Northern Goshawk	24	13	62	45	27	10	9	0
Unidentified accipiter	43	74	60	66	656	377	94	64
TOTAL ACCIPITERS	1575	773	936	2134	5847	3309	1461	3047
Buteos								
Red-shouldered Hawk	0	0		0	*3*	0	0	15
Broad-winged Hawk	4	8	31	25	91	37	8	594222
Short-tailed Hawk								0
Swainson's Hawk	0	6	4	96	180	59	149	2255
White-tailed Hawk								22
Zone-tailed Hawk							3	7
Red-tailed Hawk	344	151	212	1183	3128	1510	421	*44*
Ferruginous Hawk	0	0	3	8	9	10	5	2
Rough-legged Hawk	3	28	77	11	20	0	0	0
Unidentified buteo	25	35	16	37	102	60	22	24
TOTAL BUTEOS	376	228	343	1360	3533	1676	608	596591
Eagles								
Golden Eagle	66	87	1434	*476*	139	4	95	0
Bald Eagle	83	*18*	78	230	10	8	2	9
Unknown eagles	*11*	0	1	11	5	1	0	0
TOTAL EAGLES	160	105	1513	*717*	154	13	97	9
Falcons								
American Kestrel	9	26	88	167	893	496	237	810
Merlin	108	34	33	31	42	*22*	17	83
Prairie Falcon	2	6	14	5	11	*11*	13	7
Peregrine Falcon	17	9	30	13	26	*19*	35	224
Aplomado Falcon								0
Unidentified falcon	4	2	4	2	*43*	*33*	9	10
TOTAL FALCONS	140	77	169	218	1015	581	311	1134
Kites								
Hook-billed Kite								0
Swallow-tailed Kite								152
White-tailed Kite								13
Mississippi Kite								*35219*
Unidentified Kites								0
TOTAL KITES								*35384*
Unidentified Raptor	2	30	34	18	185	*71*	6	172
GRAND TOTAL	**2927**	**1374**	**3066**	**4580**	**11369**	**5788**	**2749**	**682126**

Figure 1. Locations of fall HawkWatch sites operated by HWI and partners (symbols with borders represent sites that banded in 2016).

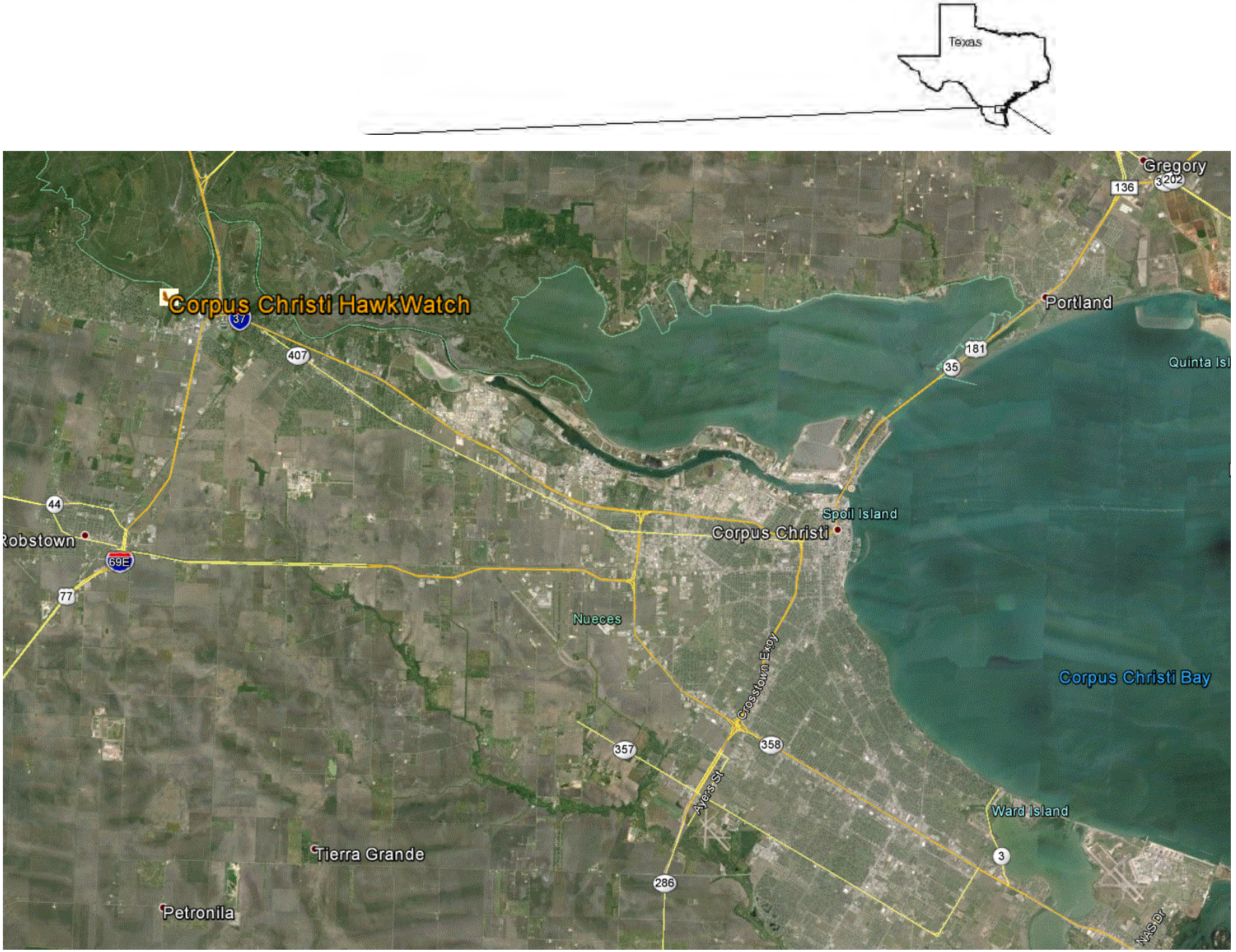
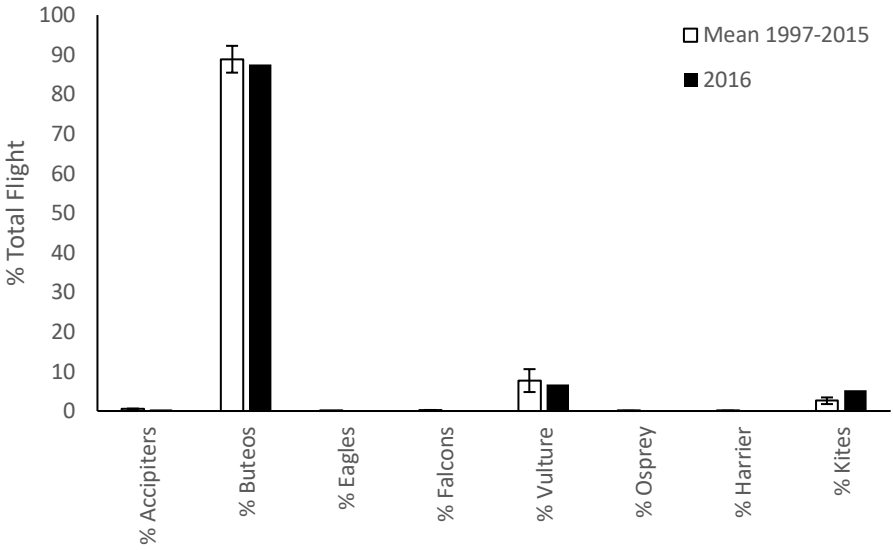


Figure 2. Location of the Corpus Christi HawkWatch, at Hazel Bazemore County Park, TX.

a.



b.

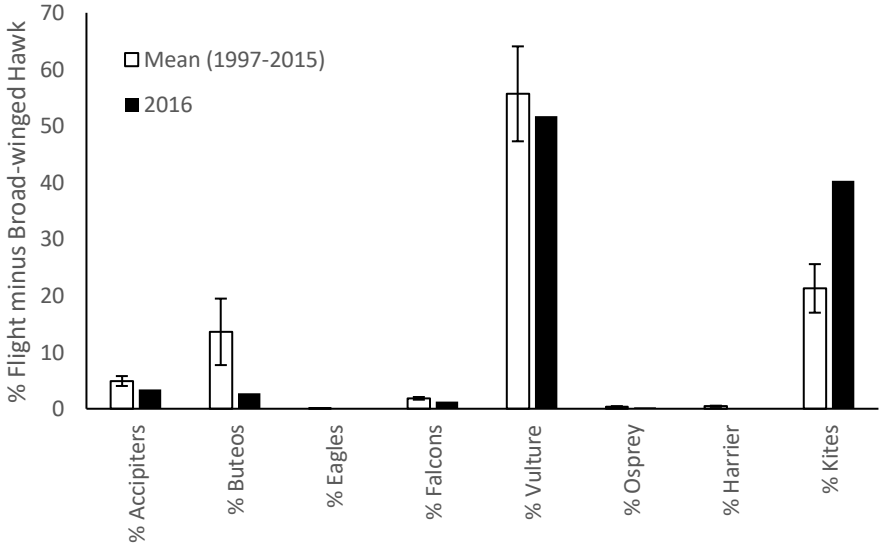


Figure 3. Composition of the fall raptor flight by species group a) with and b) without Broad-winged Hawks at the Corpus Christi HawkWatch, Texas: 1997–2015 versus 2016.

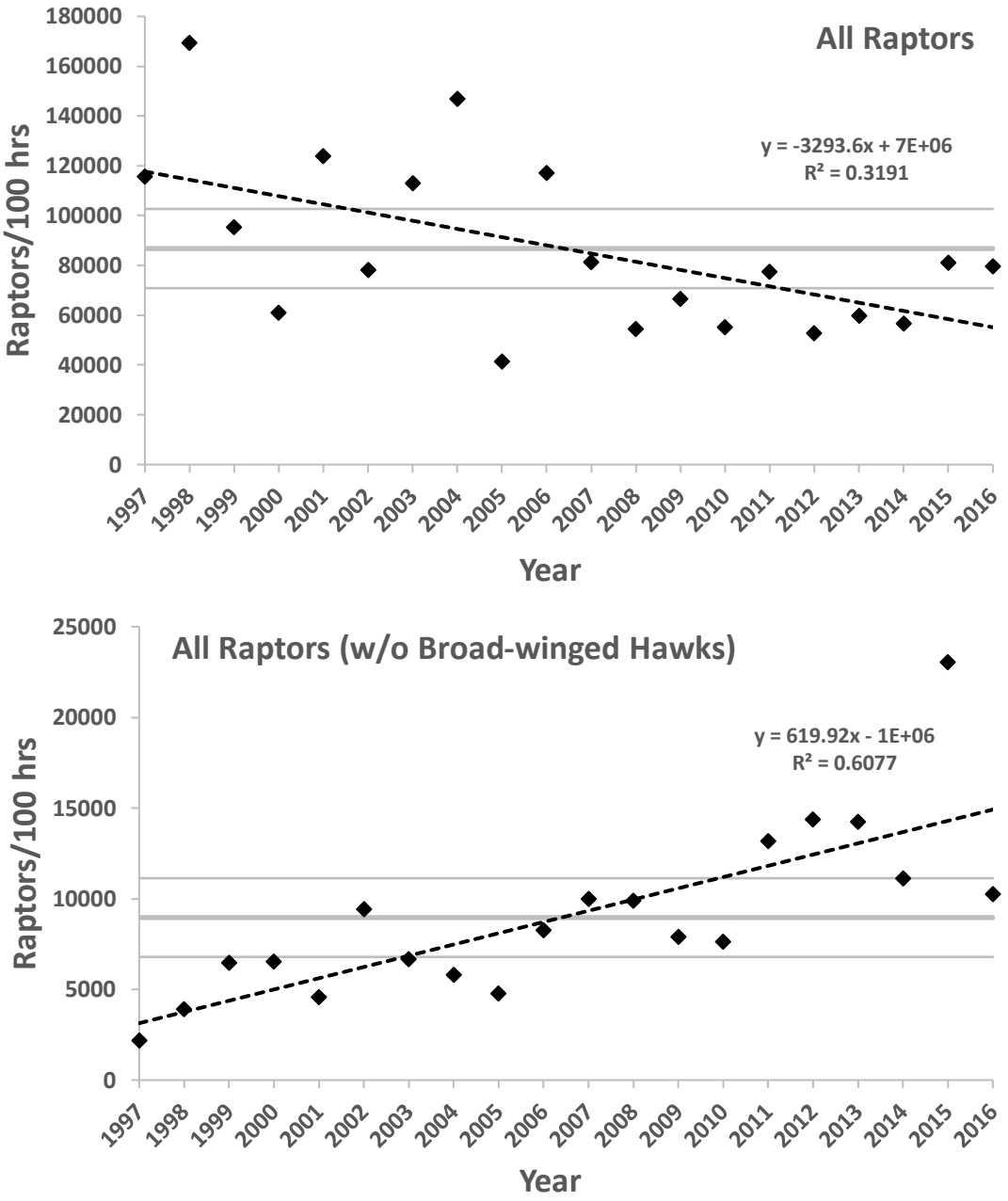


Figure 4. Effort-adjusted fall migration passage rates at the Corpus Christi HawkWatch for a) all migrating raptors counted and b) all migrating raptors counted excluding Broad-winged Hawks: 1997-2016. Solid grey lines represent mean (thick) and upper and lower 95% confidence intervals (thin) of historic counts (1997-2015). Dashed lines indicate significant (alpha=0.05) population trends based on linear regression.

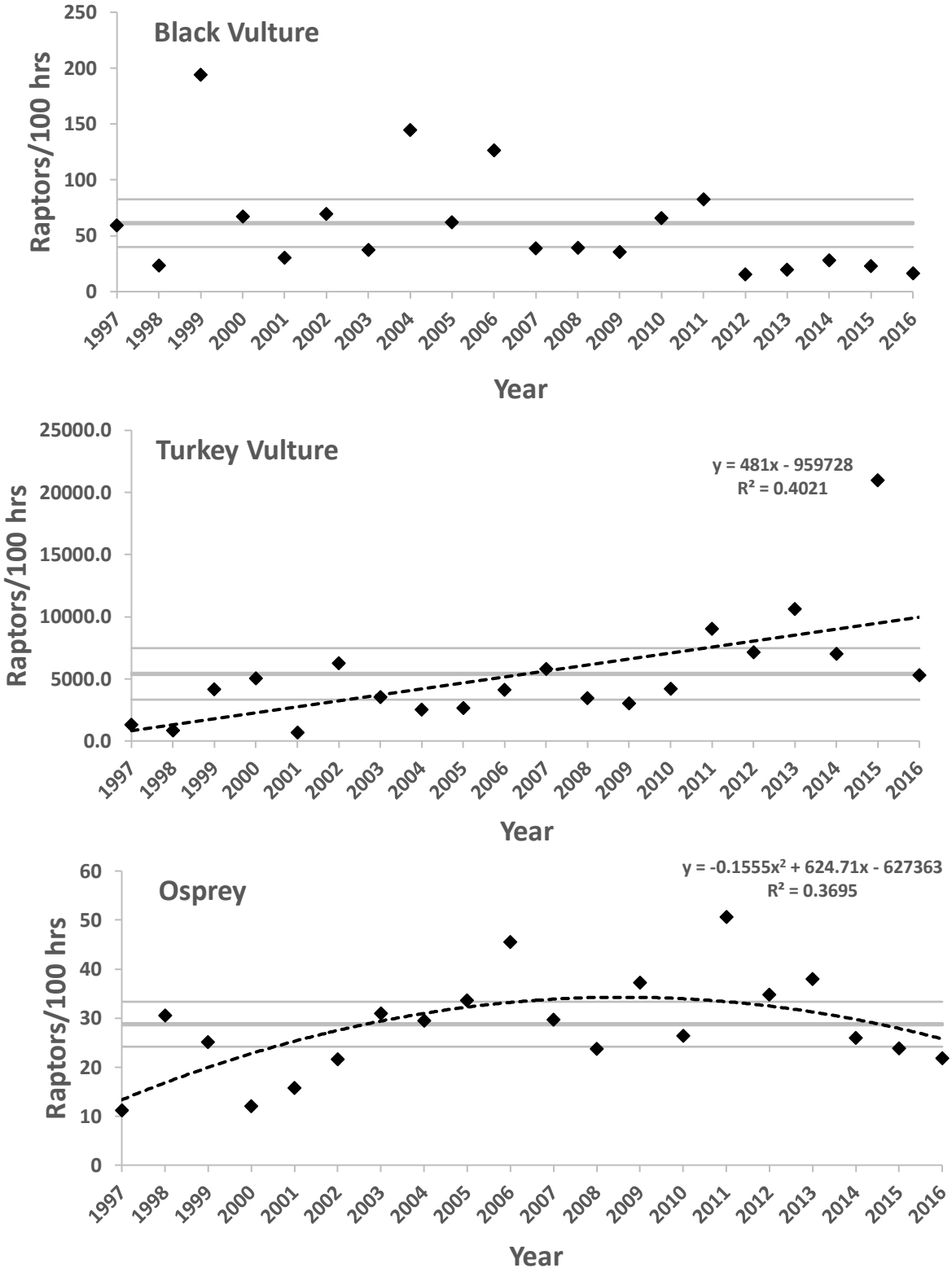


Figure 5a. Fall-migration passage rates for the Corpus Christi HawkWatch, at Hazel Bazemore County Park, TX for Black Vultures, Turkey Vultures, and Osprey: 1997–2016. Dashed lines indicate trends for significant ($p < 0.05$) linear or binomial regression. Solid grey lines represent mean (thick) and upper and lower 95% confidence intervals (thin) of historic site counts (1997-2015).

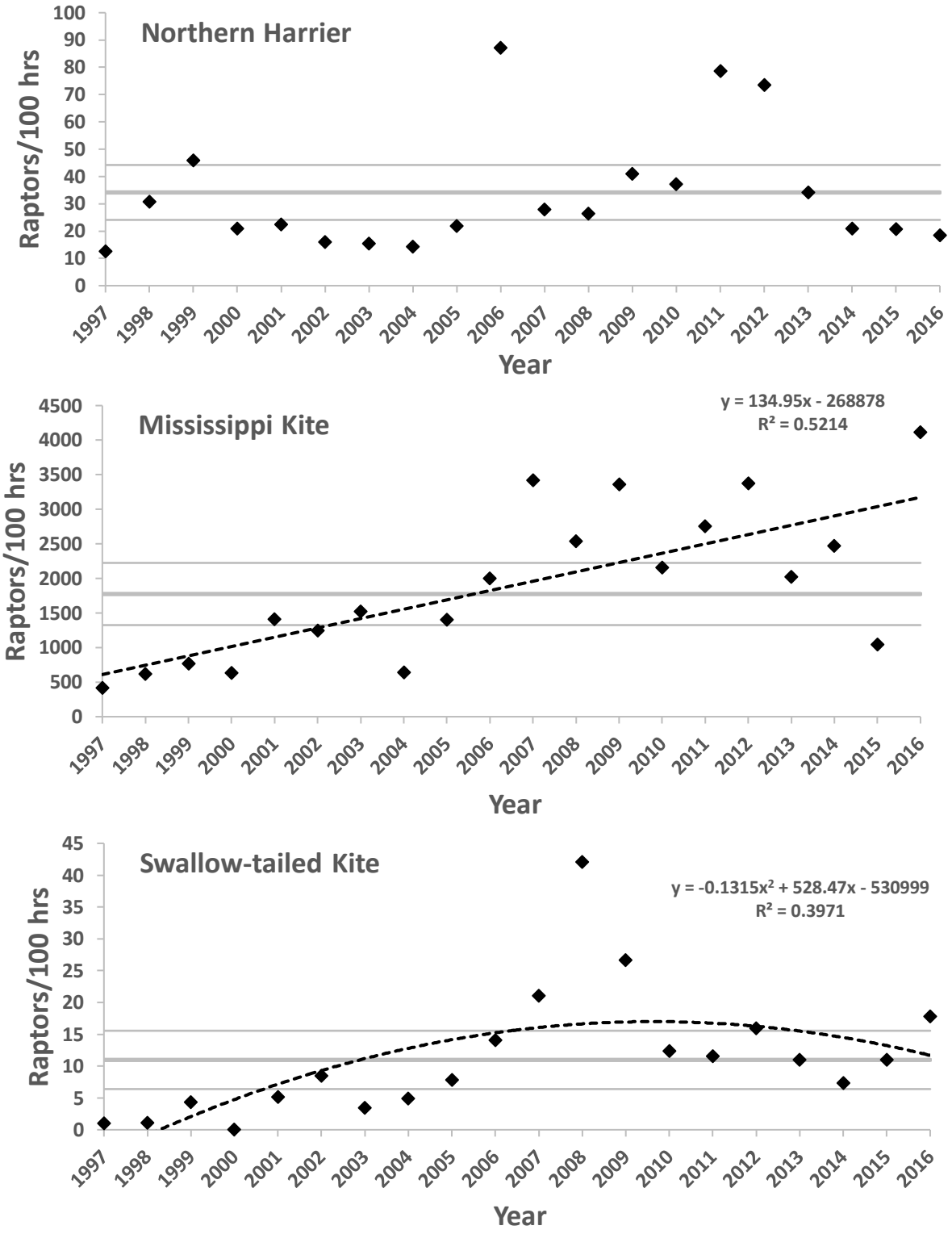


Figure 5b. Fall-migration passage rates for the Corpus Christi HawkWatch, at Hazel Bazemore County Park, TX for Northern Harriers, Swallow-tailed Kites, and Mississippi Kites: 1997–2016. Dashed lines indicate trends for significant ($p < 0.05$) linear or binomial regression. Solid grey lines represent mean (thick) and upper and lower 95% confidence intervals (thin) of historic site counts (1997-2015).

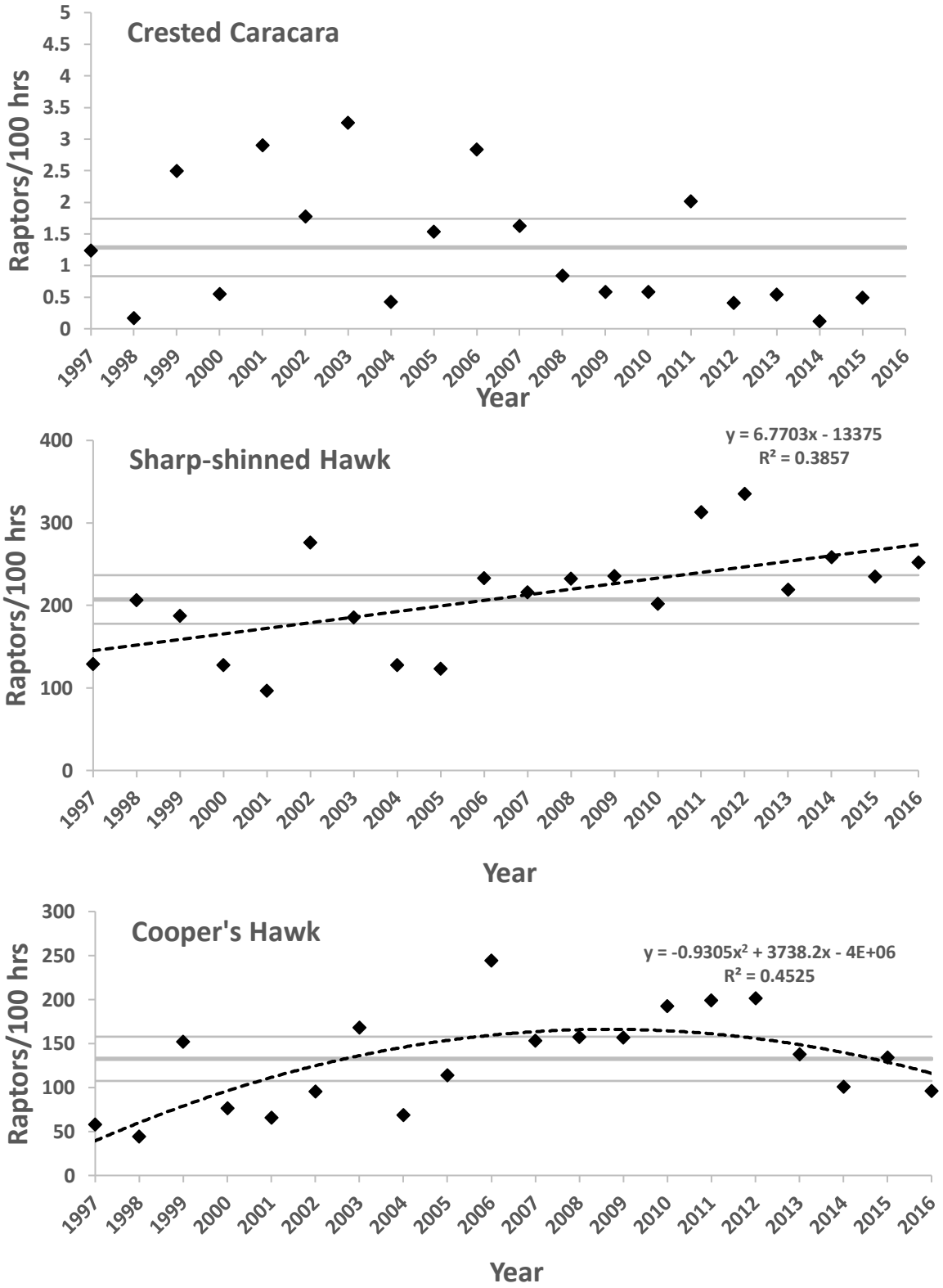


Figure 5c. Fall-migration passage rates for the Corpus Christi HawkWatch, at Hazel Bazemore County Park, TX for Crested Caracara, Sharp-shinned, and Cooper's Hawks: 1997–2016. Dashed lines indicate trends for significant ($p < 0.05$) linear regression. Solid grey lines represent mean (thick) and upper and lower 95% confidence intervals (thin) of historic site counts (1997-2015).

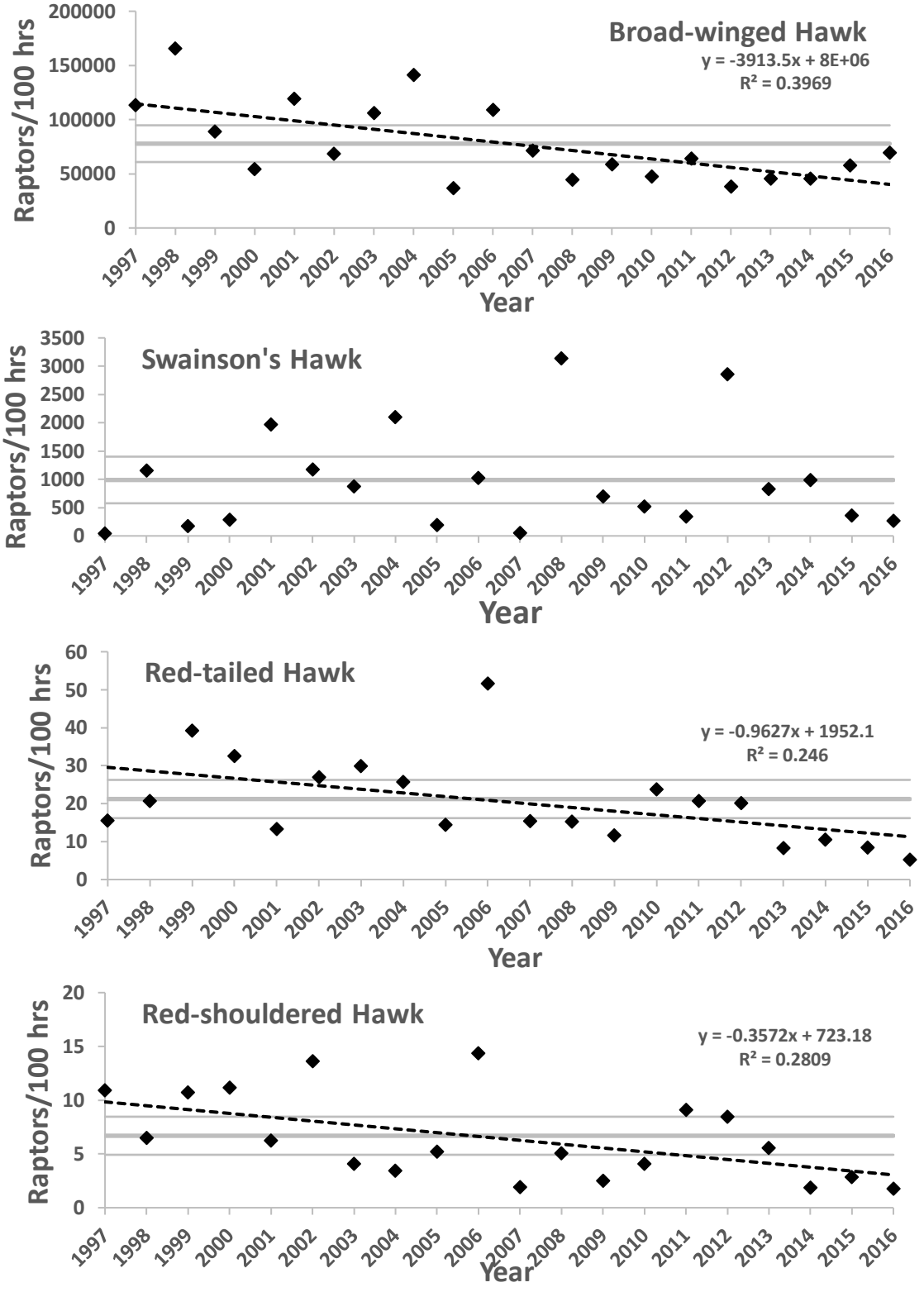


Figure 5d. Fall-migration passage rates for common buteos for the Corpus Christi HawkWatch, at Hazel Bazemore County Park, TX: 1997–2016. Dashed lines indicate trends for significant ($p < 0.05$) linear regression. Solid grey lines represent mean (thick) and upper and lower 95% confidence intervals (thin) of historic site counts (1997-2015).

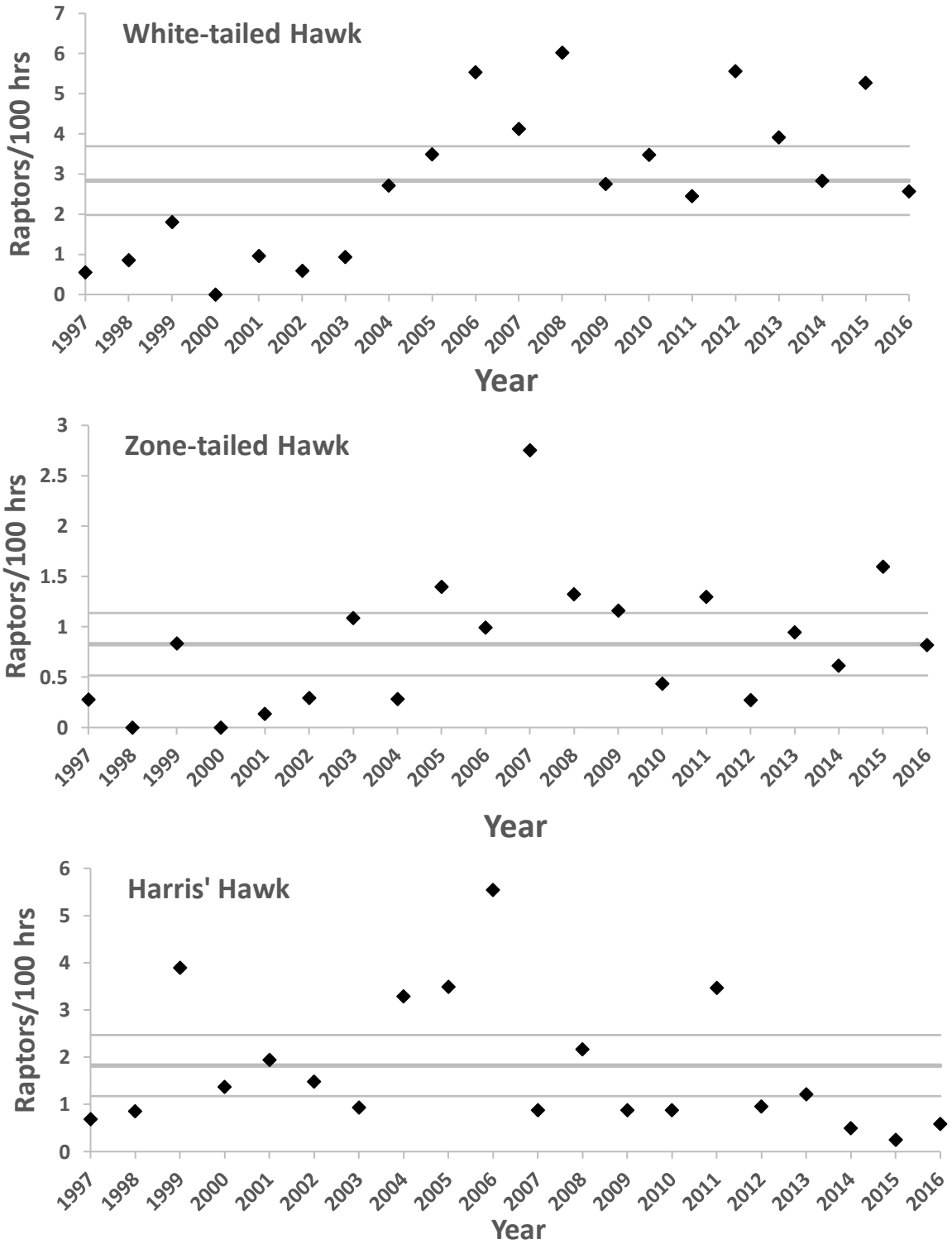


Figure 5e. Fall-migration passage rates for uncommon buteos and Harris's Hawk for the Corpus Christi HawkWatch, at Hazel Bazemore County Park, TX: 1997–2016. Solid grey lines represent mean (thick) and upper and lower 95% confidence intervals (thin) of historic counts (1997-2015).

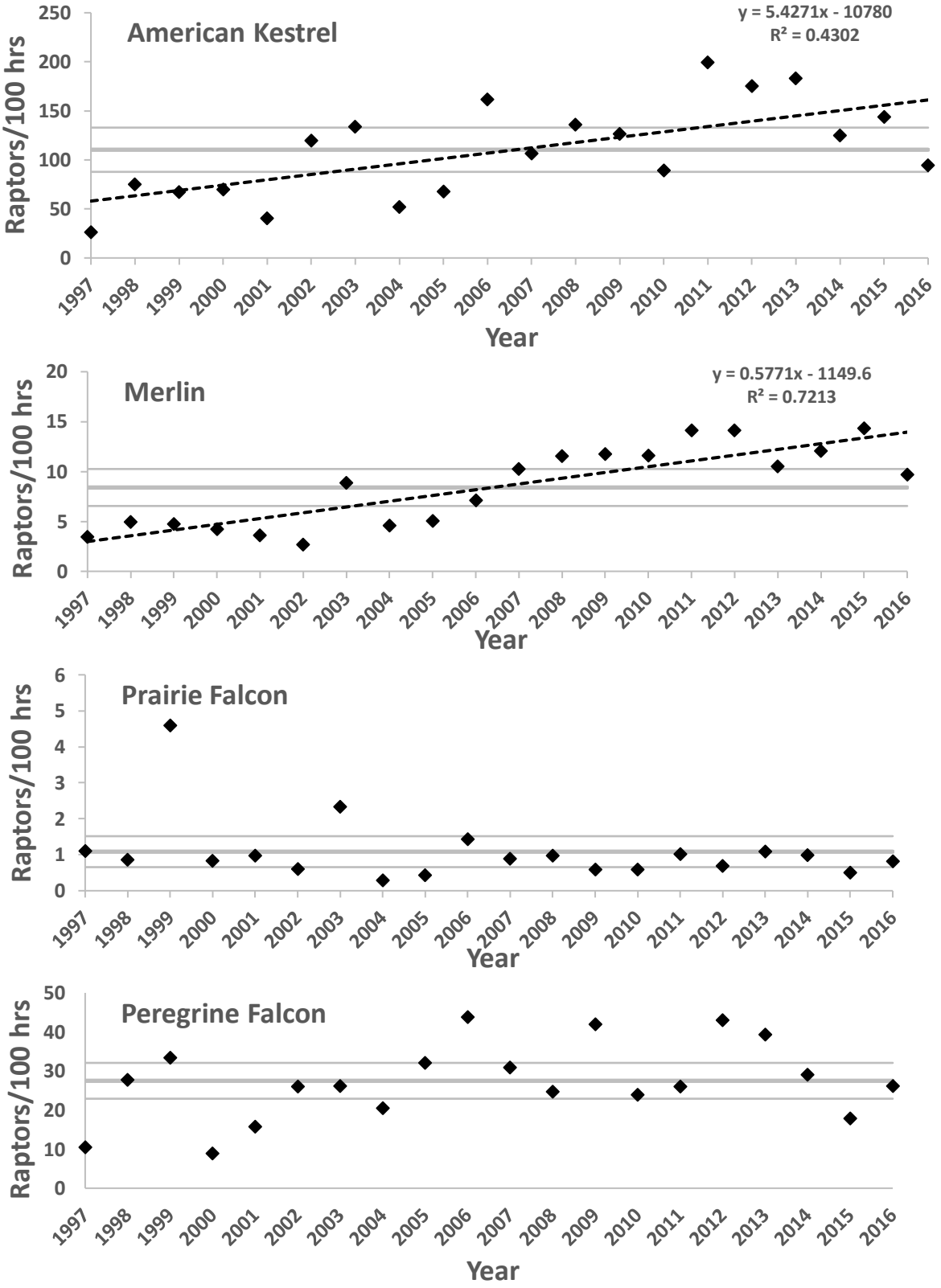


Figure 5f. Fall-migration falcon passage rates for the Corpus Christi HawkWatch, at Hazel Bazemore County Park, TX: 1997–2016. Dashed lines indicate trends for significant ($p < 0.05$) linear regression. Solid grey lines represent mean (thick) and upper and lower 95% confidence intervals (thin) of historic counts (1997-2015).

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

Common Name	Scientific Name	Species Code	Age[1]	Sex[2]	Color Morph[3]
Black Vulture	*Coragyps atratus*	BV	U	U	NA
Turkey Vulture	*Cathartes aura*	TV	U	U	NA
Unknown vulture	see above	UV	U	U	NA
Osprey	*Pandion haliaetus*	OS	U	U	NA
Northern Harrier	*Circus cyaneus*	NH	A I Br U	M F U	NA
Hook-billed Kite	*Chondrohierax uncinatus*	HK	A I U	AM AF U	D L U
Swallow-tailed Kite	*Elanoides forficatus*	SK	U	U	NA
White-tailed Kite	*Elanus leucurus*	WK	U	U	NA
Mississippi Kite	*Ictinia mississippiensis*	MK	A I U	U	NA
Unknown kite	see above	UK	U	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
Common Black Hawk	*Buteogallus anthracinus*	CB	A I U	U	NA
Harris's Hawk	*Parabuteo unicinctus*	HH	A I U	U	NA
Red-shouldered Hawk	*Buteo lineatus*	RS	A I U	U	NA
Broad-winged Hawk	*Buteo platypterus*	BW	A I U	U	D L U
Short-tailed Hawk	*Buteo brachyurus*	ST	U	U	D L U
Swainson's Hawk	*Buteo swainsoni*	SW	U	U	D L U
White-tailed Hawk	*Buteo albicaudatus*	WT	A I U	U	NA
Zone-tailed Hawk	*Buteo albonotatus*	ZT	A I U	U	NA
Red-tailed Hawk	*Buteo jamaicensis*	RT	A I U	U	D L U
Ferruginous Hawk	*Buteo regalis*	FH	A I U	U	D L U
Rough-legged Hawk	*Buteo lagopus*	RL	U	U	D L U
Unknown buteo	*Buteo* spp.	UB	U	U	D L U
Golden Eagle	*Aquila chrysaetos*	GE	A S I NA U[4]	U	NA
Bald Eagle	*Haliaeetus leucocephalus*	BE	A S2 S1 I NA U[5]	U	NA
Unknown eagle	*Aquila* or *Haliaeetus spp.*	UE	U	U	NA
Crested Caracara	*Caracara cheriway*	CC	U	U	NA
American Kestrel	*Falco sparverius*	AK	U	M F U	NA
Merlin	*Falco columbarius*	ML	AM Br	M U	NA
Prairie Falcon	*Falco mexicanus*	PR	U	U	NA
Peregrine Falcon	*Falco peregrinus*	PG	A I U	U	NA
Aplomado Falcon	*Falco femoralis*	AF	A I U	U	NA
Unknown falcon	*Falco* spp.	UF	U	U	NA
Unknown raptor	Falconiformes	UU	U	U	NA

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

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

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

[4] Golden Eagle age codes: I = immature, first-year bird, bold white wing patch visible below (small patch may be visible above), bold white in the tail, no molt; S = subadult, white wing patch variable or absent, obvious white in the tail, molt or tawny bar on upper wing visible; NA = not adult, unknown age immature/subadult, obvious white in wing or tail, but rest of plumage not adequately observed; A = adult, no obvious white on wing or tail; U = plumage not adequately observed to make an age determination.

[5] Bald Eagle age codes: I = immature, first-year bird, dark breast and tawny belly; S1 = young subadult, Basic I and II plumages, light belly or upside-down white triangle on the 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 tip to tail (may be hard to see in field) and adult with pure white head and tail; U = plumage not adequately observed to make an age determination.

Appendix B. History of official observer participation at the Corpus Christi HawkWatch: 1997–2016.

1997: Two observers throughout: Glenn Swartz (6 partial at this site) and Joel Simon (0), regularly assisted by several other dedicated volunteers.

1998: Two observers throughout: Glenn Swartz (1 plus 6 partial at this site) and Joel Simon (1), regularly assisted by several other dedicated volunteers.

1999: Three observers throughout: Joel Simon (2), Fernando Rincon (1), and Ryan Wagner (0), regularly assisted by several other dedicated volunteers.

2000: Rotating team working two at a time except during peak Broad-winged Hawk flight when all three worked together: Scott Rush (2), Beth Hahn (1), and Jo Creglow (several partial at this site), regularly assisted by several other dedicated volunteers.

2001: Rotating team working two at a time except during the peak Broad-winged Hawk flight when all three worked together: Greg Greene (limited experience in Idaho), Devin Taylor (0), and Karen Johnson (0), regularly assisted by several other dedicated volunteers.

2002: Rotating team working two at a time except during the peak Broad-winged Hawk flight when all three worked together: Joel Simon (3), Vicki Simon (regular volunteer on project since 1997), Kirsten McDonnell (2), Paul Sweet (0), regularly assisted by several other dedicated volunteers.

2003: Rotating team working two at a time except during the peak Broad-winged Hawk flight when all three worked together: Joel Simon (4), Ricardo Perez (0, but relevant experience in PA and El Salvador), Taylor Ellis (0, but relevant experience in FL), regularly assisted by several other dedicated volunteers.

2004: Rotating team working two at a time except during the peak Broad-winged Hawk flight when all three worked together: Joel Simon (5), Dane Ferrell (2), Scott Loss (1), regularly assisted by several other dedicated volunteers.

2005: Rotating team working two at a time except during the peak Broad-winged Hawk flight when all three worked together: Joel Simon (6), Dane Ferrell (4), Brian Bielfelt (1), regularly assisted by several other dedicated volunteers.

2006: Rotating team working two at a time except during the peak Broad-winged Hawk flight when all three worked together: Joel Simon (7), Dane Ferrell (5), Libby Even (1), regularly assisted by several other dedicated volunteers.

2007: Rotating team working two at a time except during the peak Broad-winged Hawk flight when all three worked together: Joel Simon (8), Dane Ferrell (6), Libby Even (2), regularly assisted by several other dedicated volunteers.

2008: Three-person team working two at a time throughout the season, plus two additional full-time counters from mid-September through mid-October: Full-season—Dane Ferrell (7), Leslie Parks (0), Libby Even (3); peak-season—Kevin Georg (2+), Bob Baez (0); regularly assisted by other dedicated, local volunteers, especially Joel Simon (9) and Bob Creglow (10+).

2009: Three-person team working two at a time throughout the season: Libby Even (4), Kevin Georg (3+), Dane Ferrell (8); regularly assisted by other dedicated, local volunteers, especially Bob Creglow (11+).

2010: Three-person team working two at a time throughout the season: Libby Even (5), Kevin Georg (4+), Dane Ferrell (9); regularly assisted by other dedicated, local volunteers, especially Bob Creglow (12+).

2011: Three-person team working two at a time throughout the season: Libby Even (6), Kevin Georg (5+), Dane Ferrell (10); regularly assisted by other dedicated, local volunteers, especially Bob Creglow (13+).

2012: Three-person team working two at a time throughout the season: Celia Benitez Gil (+), Kevin Georg (6+), Dane Ferrell (11); regularly assisted by other dedicated, local volunteers, especially Libby Even (7) and Bob Creglow (14+).

2013: Three-person team working two at a time throughout the season: Celia Benitez Gil (1+), Kevin Georg (7+), Dane Ferrell (12); regularly assisted by other dedicated, local volunteers, especially Libby Even (8) and Bob Creglow(15+).

2014: Three-person team working two at a time throughout the season: Libby Errickson (1+), Kevin Georg (8+), Dane Ferrell (13); regularly assisted by other dedicated, local volunteers, especially Libby Even (9) and Bob Creglow (16+).

2015: Three-person team working two at a time throughout the season: Erik Bruhnke (2+), Kevin Georg (9+), Dane Ferrell (14); regularly assisted by other dedicated, local volunteers, especially Libby Even (10) and Bob Creglow (17+).

2016: Four-person team, 3 on obs, 1 on outreach: Dane Ferrell (15), Kevin Georg (10+), Matt Mills (0), and Earl Johnson (0); assisted by other dedicated volunteers, especially Libby Even (11) and Bob Creglow (18+)

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[1] Numbers in parentheses indicate the number of previous full seasons of experience counting migratory raptors.

Appendix C. Annual observation effort and fall raptor migration counts by species at the Corpus Christi HawkWatch: 1997–2016.

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Start date	15-Aug	15-Aug	14-Aug	15-Aug	15-Aug	15-Aug	15-Aug	15-Aug	15-Aug	15-Aug	1-Aug	1-Aug	15-Aug
End date	15-Nov	15-Nov	15-Nov	15-Nov	15-Nov	15-Nov	15-Nov	15-Nov	15-Nov	15-Nov	15-Nov	15-Nov	15-Nov
Observation days	89	83	90	91	93	89	86	93	92	93	106	107	92
Observation hours	725.00	585.50	719.75	728.58	723.50	676.50	643.00	701.00	715.75	704.50	798.75	830.42	688.00
							SPECIES						
Black Vulture	431	138	1,398	491	222	470	241	1,016	445	893	309	326	245
Turkey Vulture	9,629	5,011	30,027	36,690	4,870	42,536	22,900	17,759	19,090	29,115	46,503	28,530	21,018
Unidentified vulture	0	0	0	0	0	0	0	9	0	0	0	0	0
Total vultures	11,652	5,149	31,425	37,181	5,092	43,006	23,141	18,766	19,535	30,008	46,812	28,856	21,263
Osprey	81	179	181	88	114	146	199	207	241	321	237	197	256
Northern Harrier	93	180	331	153	162	109	100	101	157	614	223	219	282
Common Black Hawk	0	0	0	0	0	1	0	0	0	0	0	0	0
Harris's Hawk	5	5	28	10	14	10	6	23	25	39	7	18	6
Hook-billed Kite	0	0	0	0	0	0	1	0	0	0	0	0	0
Swallow-tailed Kite	7	6	31	0	37	57	22	34	56	99	168	349	183
White-tailed Kite	4	6	6	2	2	2	1	2	9	8	1	14	7
Mississippi Kite	2,974	3,584	5,513	4,569	10,155	8,394	9,753	4,441	10,004	14,073	27,285	21,050	23,114
TOTAL KITES	2,985	3,596	5,550	4,571	10,194	8,453	9,776	4,477	10,069	14,180	27,454	21,413	23,304
Sharp-shinned Hawk	936	1,208	1,348	929	698	1,869	1,193	892	880	1,643	1,725	1,927	1,621
Cooper's Hawk	418	260	1,092	555	473	645	1,083	483	815	1,719	1,222	1,308	1,078
Northern Goshawk	0	0	1	0	0	1	0	0	0	2	3	0	0
Unidentified accipiter	308	316	310	379	298	108	344	252	174	290	217	264	149
TOTAL ACCIPITERS	1,662	1,784	2,751	1,863	1,767	2,649	2,620	1,627	1,869	3,654	3,167	3,499	2,848
Red-shouldered Hawk	79	38	77	81	45	92	26	24	37	101	15	42	17
Broad-winged Hawk	823,602	970,025	640,258	396,774	864,355	464,772	684,815	989,957	263,101	767,730	569,839	370,088	403,192
Short-tailed Hawk	0	0	2	0	0	0	0	1	4	2	1	2	1
Swainson's Hawk	300	6,790	1,246	2,085	14,260	7,912	5,633	14,751	1,347	7,225	412	26,093	4,792
White-tailed Hawk	4	5	13	0	7	4	6	19	25	39	33	50	19
Zone-tailed Hawk	2	0	6	0	1	2	7	2	10	7	22	11	8
Red-tailed Hawk	112	121	282	237	96	182	192	180	103	363	122	126	80
Ferruginous Hawk	1	0	14	1	1	2	1	2	5	8	3	8	3
Rough-legged Hawk	1	0	4	0	0	0	0	0	0	0	0	0	0
Unidentified buteo	18	25	62	215	368	80	71	53	34	79	67	105	154
TOTAL BUTEOS	824,124	977,009	641,992	399,403	879,147	473,057	690,757	1,005,012	264,691	775,593	570,521	396,543	408,272
Golden Eagle	1	0	4	1	1	1	2	1	2	2	1	2	3
Bald Eagle	0	2	4	0	2	1	1	3	4	5	7	10	1
Unidentified eagle	0	0	1	0	0	0	0	0	0	0	0	1	0
TOTAL EAGLES	1	2	9	1	3	2	3	4	6	7	8	13	4
Crested Caracara	9	1	18	4	21	12	21	3	11	20	13	7	4
American Kestrel	189	438	483	509	292	811	860	365	485	1,137	850	1,127	869
Merlin	25	29	34	31	26	18	57	32	36	50	82	96	81
Prairie Falcon	8	5	33	6	7	4	15	2	3	10	7	8	4
Peregrine Falcon	76	163	241	65	114	176	169	144	230	309	247	205	289
Aplomado Falcon	0	0	1	0	0	0	1	0	1	1	4	2	2
Unidentified falcon	14	39	92	103	41	16	33	7	5	15	2	9	2
TOTAL FALCONS	312	674	884	714	480	1,043	1,163	554	761	1,526	1,207	1,455	1,264
Unidentified raptor	220	4,376	3,874	506	837	98	133	89	35	135	120	211	110
GRAND TOTAL	841,139	992,950	687,015	444,484	897,519	528,540	727,900	1,030,849	297,375	826,058	649,762	452,414	457,607

Appendix C (continued). Annual observation effort and fall raptor migration counts by species at the Corpus Christi HawkWatch: 1997–2016.

	2010	2011	2012	2013	2014	2015	2016	Mean
Start date	15-Aug	15-Aug	15-Aug	10-Aug	01-Aug	1-Aug	1-Aug	11-Aug
End date	15-Nov	15-Nov	15-Nov	15-Nov	15-Nov	15-Nov	15-Nov	15-Nov
Observation days	91	93	93	98	106	101	107	94.65
Observation hours	689.25	693.25	736.08	739.75	812.75	814.75	856.3	729.12
				SPECIES				
Black Vulture	455	572	113	147	228	186	140	423
Turkey Vulture	28,926	62,521	52,543	78,587	57,128	170,976	45,293	40,483
Unidentified vulture	0	0	0	0	0	0	0	<1
Total vultures	29,381	63,093	52,656	78,734	57,356	171,162	45,433	40,985
Osprey	182	351	256	281	211	194	187	205
Northern Harrier	257	546	542	253	171	169	158	241
Common Black Hawk	0	0	0	0	0	0	0	<1
Harris's Hawk	6	24	7	9	4	2	5	13
Hook-billed Kite	0	0	0	0	0	0	0	<1
Swallow-tailed Kite	85	80	117	81	59	89	152	86
White-tailed Kite	4	4	4	4	4	5	13	5
Mississippi Kite	14,851	19,054	24,825	14,960	20,032	8,506	35,219	14,118
TOTAL KITES	14,940	19,138	24,946	15,045	20,095	8,600	35,384	14,209
Sharp-shinned Hawk	1,389	2,169	2,466	1,622	2,101	1,914	2,159	1,534
Cooper's Hawk	1,328	1,379	1,484	1,017	821	1,094	824	955
Northern Goshawk	0	0	0	0	0	0	0	0
Unidentified accipiter	333	156	196	138	105	69	64	224
TOTAL ACCIPITERS	3,050	3,704	4,146	2,777	3,027	3,077	3,047	2,729
Red-shouldered Hawk	28	63	62	41	15	23	15	46
Broad-winged Hawk	328,730	445,112	283,755	336,960	370,575	472,276	594,222	552,007
Short-tailed Hawk	0	0	1	1	0	2	0	1
Swainson's Hawk	3,565	2,387	21,019	6,132	8,035	2,941	2,255	6,959
White-tailed Hawk	24	17	41	29	23	43	22	21
Zone-tailed Hawk	3	9	2	7	5	13	7	6
Red-tailed Hawk	163	143	148	61	85	68	44	145
Ferruginous Hawk	2	2	6	3	6	4	2	4
Rough-legged Hawk	0	0	0	0	0	0	0	<1
Unidentified buteo	84	70	47	49	22	9	24	82
TOTAL BUTEOS	332,605	447,827	305,088	343,292	378,766	475,379	596,591	559,283
Golden Eagle	2	1	1	5	1	2	0	2
Bald Eagle	12	10	7	6	15	14	9	6
Unidentified eagle	0	0	0	0	0	0	0	<1
TOTAL EAGLES	14	11	8	11	16	16	9	7
Crested Caracara	4	14	3	4	1	4	5	9
American Kestrel	614	1,381	1,290	1,353	1,016	1,171	810	803
Merlin	80	98	104	78	98	117	83	63
Prairie Falcon	4	7	5	8	8	4	7	8
Peregrine Falcon	165	181	317	291	237	146	224	199
Aplomado Falcon	0	1	0	0	0	0	0	1
Unidentified falcon	6	2	6	4	4	11	10	21
TOTAL FALCONS	885	1,684	1,734	1,749	1,367	1,449	1,134	1,102
Unidentified raptor	200	201	254	155	157	137	172	601
GRAND TOTAL	381,514	536,555	389,630	442,297	461,170	660,189	682,126	619,355