FALL 2014 RAPTOR MIGRATION REPORT

CORPUS CHRISTI HAWKWATCH, HAZEL BAZEMORE COUNTY PARK, TEXAS

HAWK WATCH INTERNATIONAL

Conserving Raptors and Our Shared Environmen

Salt Lake City, Utah

June 2015

FALL 2014 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 2014 fall raptor migration at HBCP, the 18th straight year of fall counting at this important migration site.

The Corpus Christi HawkWatch was 1 of 9 long-term, annual migration counts conducted or co-sponsored by HWI in North America during 2014. 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 an elevation of 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 2014 marked the seventh 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.

Weather permitting, 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). At this location 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 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. We use linear and quadratic regressions on effort-adjusted annual passage rates (raptors/100hrs) to identify long-term trends in migrating raptors.

2014 RESULTS AND DISCUSSION

OBSERVATION EFFORT AND WEATHER SUMMARY

Corpus Christi HawkWatch's standard season runs 15 August—15 November; in 2014 observers counted from 1 August to 15 November, for a total of 106 days and 812.8 hours--an effort significantly higher than the site averages of 93days and 711.68 hours (Appendix C). We shifted the season start to pick up the flight of early-migrating species, such as the Swallow-tailed Kite and plan to start monitoring on this date going forward. Only one day was was lost due to weather, and one additional day was shortend (≤4 hours). Weather varies throughout every season, in 2014 based on hourly recording of conditionsduring observation it was clear 15% of the time, hazy 90% of the time, overcast 85% of the time, and rainy 7% of the time.

2014 FLIGHT SUMMARY

Overall Flight:

Observers counted 461,171 migrant raptors of 24 different species in 2014, making this a below average year for raptor migration at the Corpus Christi HawkWatch compared to the site long-term average (Table 1); counts have been similarly low since 2008 (Appendix C). Season highlights included the biggest Sharp-shinned Hawk day at the site (340), and the highest seasonal eagle count (16), driven by a record Bald Eagle count (15).

The flight consisted of 82 % buteos, 12% vultures, 4% kites and less than 1% of all other groups, owing to the large proportion of Broad-winged Hawks (91% on average, but only 80% in 2014) comprising the flight (Fig 2a). Removing Broad-winged Hawks from the flight composition (Fig 2b) yields the following proportions: vultures (63%), kites (22%), buteos (9%), accipiters (3%), falcons (2%), and other species (<1%).

The following sections summarize the 2014 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 56,432 raptors counted per 100 hours of observation at the Corpus Christi HawkWatch in 2014 was significantly below site historic average, the third straight season with a below average passage rates for the total flight (Fig 4a). Regression analysis of passage rates indicate long-term declines in the total number of raptors counted each year at Corpus Christi (slope = -4268.8, $r^2 = 0.39$, $p=0.005$). Interestingly, Broad-winged hawks seem to be driving this trend; the total flight exclusive of Broad-winged Hawks had higher than average passage rates in 2014 (11,147 birds/100hrs) and an overall increasing trend based on linear regression (slope = 548.8, $r^2 = 0.7$, $p<0.001$).

Vultures and Osprey (Fig. 5a)

Black Vulture count and passage rate were below the historic site averages for Black Vultures, the third straight season of statistically significant low counts. Despite this, the long-term regional population trend for Black Vultures is stable. Turkey Vulture count and passage rate were high for the site this season and regression analysis on effort-adjusted passage rates shows that regional populations of Turkey Vultures are growing (slope = 358.620, $r^2 = 0.489$, $p = 0.001$). Count and passage for Osprey in 2014 were average compared to historic values and over the long term Osprey passage rates are increasing (slope = 1.163, $r^2 = 0.356$, $p = 0.009$).

Northern Harriers and Kites (Fig. 5b):

Northern Harrier count and passage rate were both below site historic average in 2014; despite this the long-term regional population trend for harriers remains stable. Even with the season beginning early, neither the count nor the passage rate for Swallow-tailed Kites deviate from site historic averages. However, based on 2nd order polynomial regression of effort adjusted passage rates, regional populations of Swallow-tailed Kites have been declining since 2008 ($F_{2,15}=8.35$, $r^2 = 0.53$, $p = 0.003$). Count and passage rate for Mississippi Kites were both significantly above site average and regional populations of this species are increasing (slope = 156.58, $r^2 = 0.62$, $p << 0.0001$).

Crested Caracara and Accipiters (Fig. 5c):

Crested Caracaras are relatively uncommon migrants at the site (Appendix E), and only one was counted in 2014. Sharp-shinned Hawk count and passage rate were above average in 2015 and regional populations of this species are increasing based on linear regression of effort-adjusted passage rates (slope = 8.202, r^2 = 0.398, p = 0.005). The number of Cooper's Hawks counted in 2015 was average for the site, but the effort-adjusted passage rate was low—likely due to the early start date in 2015. Regional populations of Cooper's Hawks are increasing (slope = 6.454, r^2 = 0.337, p = 0.012).

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

Broad-winged Hawks regularly make up 91% of the fall flight, the 370,575 Broad-wings counted in 2014 was significantly low (Table 1), and analyses of effort-adjusted passage rates indicate significant regional population declines (slope = -4748, r^2 = 0.44, p= 0.003). Counts and passage rates for Red-shouldered Hawks, Red-tailed Hawks, and Harris' Hawks were also below historic means; in fact the 15 Red-shouldered Hawks counted matched the lowest count on record and the 4 Harris' Hawks counted set a new low for the species (Appendix E). Counts and passage rates for Swainson's Hawk, White-tailed Hawk, and Zone-tailed Hawk in 2014 were all in-line with historic site averages.

Falcons (Fig. 5f):

Counts for American Kestrels , Merlins, and Peregrine Falcons were all above historic averages in 2014 (Table 1), and both Kestrels and Peregrine Falcon regional populations are increasing based on linear regression of effort-adjusted passage rates (slope = 7.287, r^2 = 0.56, p << 0.001and slope 1.09 r^2 = 0.32, p = 0.015, respectively). 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 and at the continental scale under the umbrella of the American Kestrel Partnership (http://kestrel.peregrinefund.org/). Prairie Falcon counts and passage rates in 2014 were in-line with historic site averages.

VISITOR PARTICIPATION AND PUBLIC OUTREACH

At least 915visitors came to the site to watch and learn about the spectacular fall raptor migration at the Corpus Christi HawkWatch. HWI co-hosted, along with the Caeser Kleberg Wildlife Research Institute, the 2014 annual Raptor Research Foundation meeting held in Corpus Christi, from September 24th through 28th. Participants attending the conference took breaks to check out the local flight throughout the week culminating in a scheduled field trip where 55 visitors comprised of a veritable who's who of raptor researchers spent time on the counting platform. The annual *Celebration of Flight* also took place during that weekend. Unfortunately, weather had an affect on Saturday but those who stuck around during the afternoon on Sunday got a break in the weather and treated to a fantastic Broad-winged Hawk flight; where the observers counted over 21,000 birds! Visitors were also able to experience live raptor programs by Sky Kings Falconry, as well as participate in HWI lectures on HWI history, hawk migration, local raptors of the Coastal Bend, and the ecology and threats that raptors face. Other organized groups included students from the Texas State Aquarium Sea Camp, Rockport Elementary, Texas A&M Community College, and Delmar College; four families participating in the Texas Nature Challenge; and birding groups from the Travis Audubon Society and the Rockport Hummerbird Celebration.

Although many visitors came from Texas, folks from 31 US states and Puerto Rico also visited the HawkWatch. International guests came from the Netherlands, Canada, Mexico, the United Kingdom, Austria, Pakistan, and the United Arab Emirates.

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 2):

- 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 to all of the members of our 2014 field crew: Dane Ferrell, Kevin Georg, and Elizabeth Errickson; 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. Historic fall raptor migration counts (mean ± 95% CI), counts from fall 2014, and site records for the Corpus Christi HawkWatch.

Species	1997-2013 Mean Count ± 95 % CI			2014	% Change	All-time Historic Records Season	Daily
Black Vulture	465	±	164	228	-51	1398 (1999)	254 (1999)
Turkey Vulture	31544	±	9533	57128	81	78587 (2013)	41132 (2013)
Osprey	207	±	36	211	2	351 (2011)	39 (2004)
Northern Harrier	254	±	78	171	-33	614 (2006)	64 (2011)
Crested Caracara	10	±	3	1	-90	21 (2003)	7 (1999)
Common Black Hawk	<1	±		0		1 (2002)	1
Harris' Hawk	14	±	5	4	-72	39 (2006)	5 (2006)
Accipiters							
Sharp-shinned Hawk	1442	±	238	2101	46	2466 (2012)	340 (2014)
Cooper's Hawk	962	±	204	821	-15	1719 (2006)	259 (2006)
Northern Goshawk	0	±	0	0	-100	3 (2007)	2 (2007)
Unidentified accipiter	249	±	39	105	-58	379 (2000)	
TOTAL ACCIPITERS	2654	±	394	3027	14	4146 (2012)	
Buteos							
Red-shouldered Hawk	51	±	13	15	-71	101 (2006)	19 (2012)
Broad-winged Hawk	564886	±	116271	370575	-34	989957 (2004)	520032 (2004)
Short-tailed Hawk	1	±	1	0	-100	4 (2005)	1
Swainson's Hawk	7409	±	3545	8035	8	26093 (2008)	17549 (2012)
White-tailed Hawk	21	±	7	23	10	50 (2008)	5 (2x)
Zone-tailed Hawk	6	±	3	5	-14	22 (2008)	2 (9x)
Red-tailed Hawk	159	±	37	85	0	363 (2006)	58 (2000)
Ferruginous Hawk	4	±	2	6	65	14 (1999)	2 (6x)
Rough-legged Hawk	<1	±		0		4 (1999)	1
Unidentified buteo	93	±	41	22	-76	368 (2001)	
TOTAL BUTEOS	572629	±	116303	378766	-34	1004989 (2004)	
Eagles							
Golden Eagle	2	±	1	1	-43	5 (2013)	1
Bald Eagle	5	±	2	15	200	15 (2014)	3 (2x)
Unknown eagles	<1	±		0		1 (2008)	
TOTAL EAGLES	6	±	2	16	154	16 (2014)	
Falcons							
American Kestrel	768	±	183	1016	32	1381 (2011)	251 (2011)
Merlin	56	±	14	98	74	104 (2012)	18 (2012)
Prairie Falcon	8	±	3	8	0	33 (1999)	5 (1999)
Peregrine Falcon	199	±	37	237	19	317 (2012)	48 (2012)
Aplomado Falcon	0.7	±	1	0	-100	4 (2007)	2 (2x)
Unidentified falcon	31	±	13	8	-74	103 (2000)	
TOTAL FALCONS	1063	±	217	1367	29	1749 (2013)	
Kites							
Hook-billed Kite	<1	±		0		1 (2003)	1 (2003)
Swallow-tailed Kite	88	±	41	59	-33	349 (2008)	58 (2008)
White-tailed Kite	5	±	2	4	-15	14 (2008)	5 (2008)
Mississippi Kite	12859	±	3747	20032	56	27285 (2007)	12261 (2007)
Unidentified Kites	<1	±		0		1 (2008)	
TOTAL KITES	12947	±	3779	20095	55	27454 (2007)	
Unidentified Raptor	680	±	624	157	-77	4376 (1998)	
GRAND TOTAL	622473	±	108833	461171	-26	1030849 (2004)	520351 (2004)

Table 2. 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

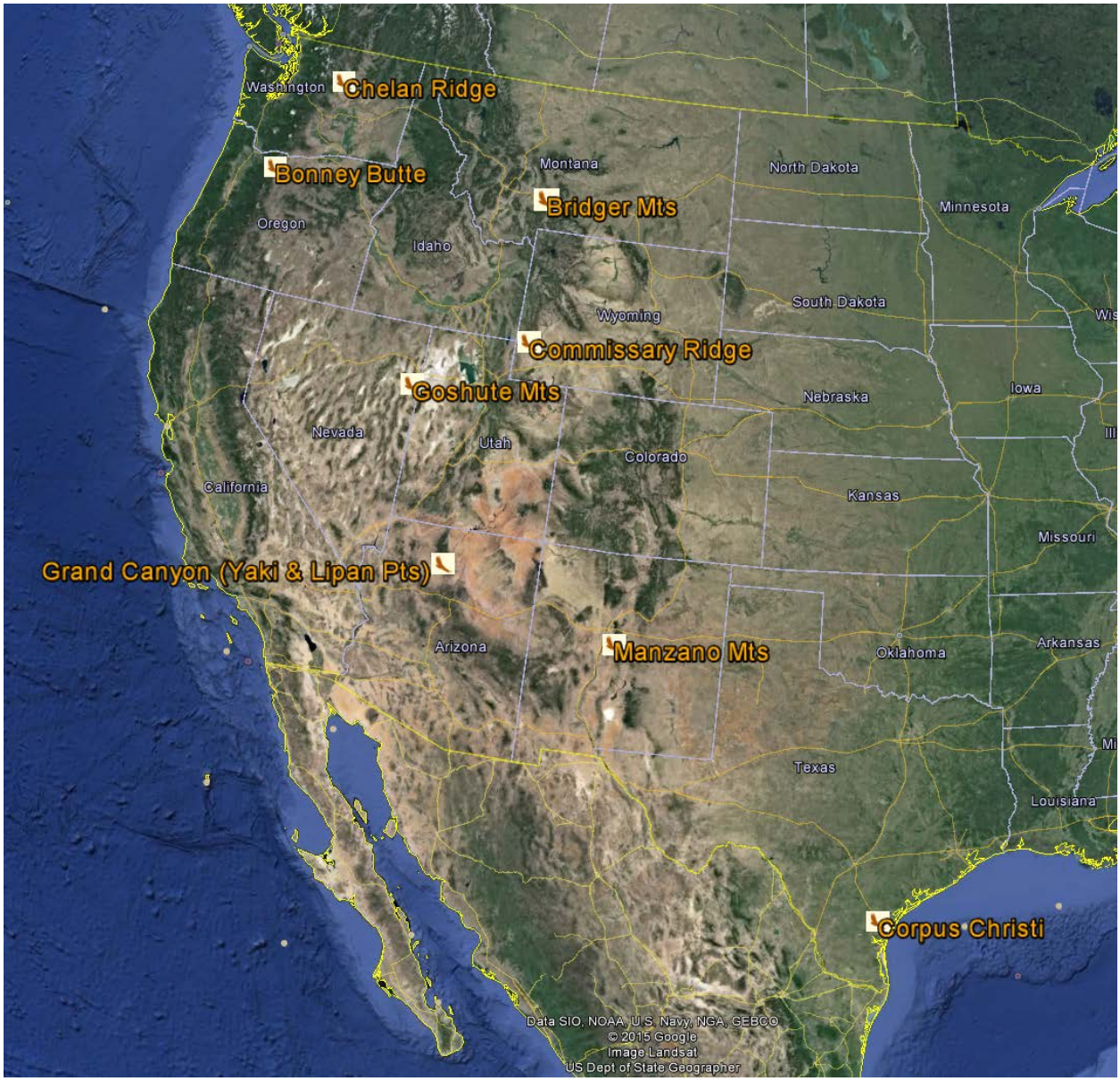


Figure 1. Locations of fall HawkWatch sites operated by HWI and partners.

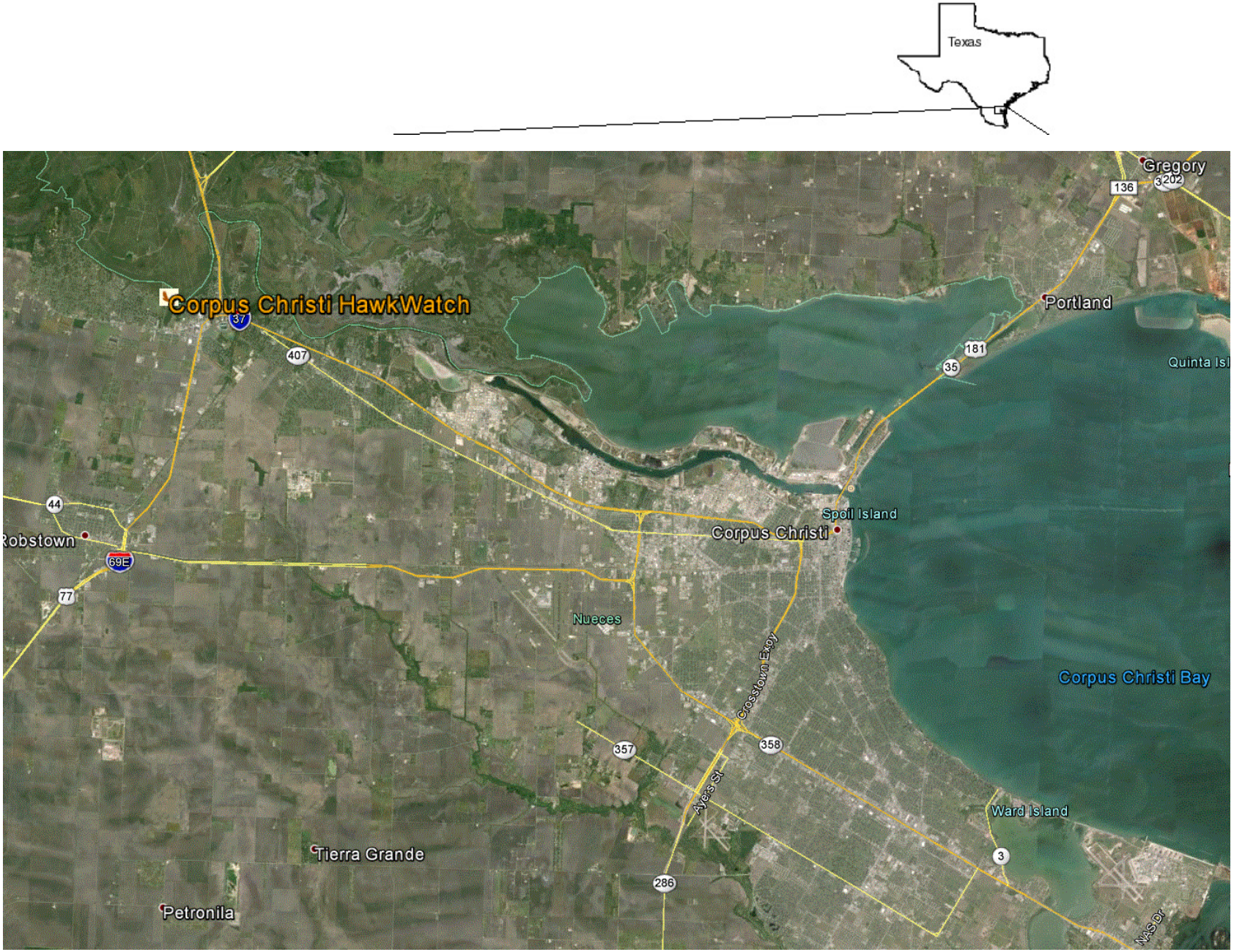
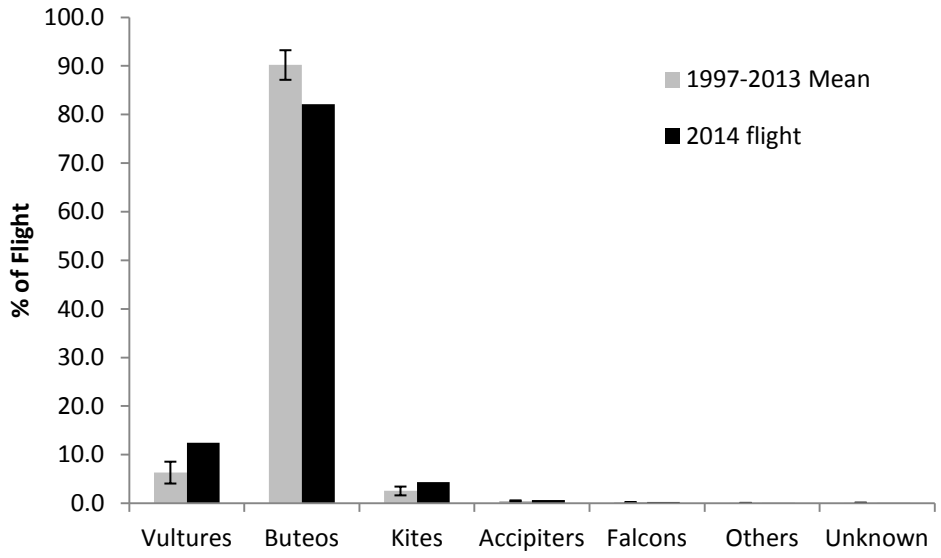


Figure 2. Location of the Corpus Christi HawkWatch, at Hazel Bazemore County Park, TX.

a.



b.

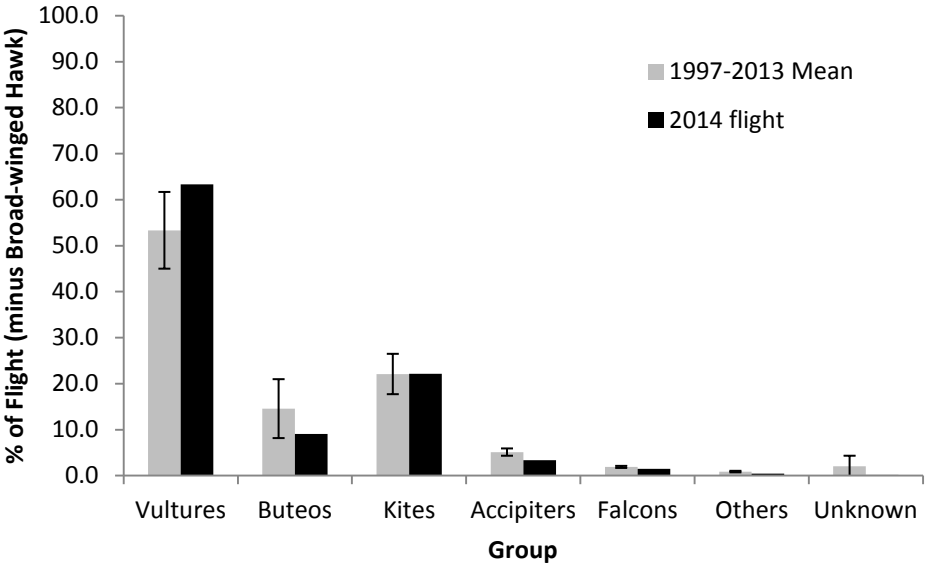


Figure 3. Composition of the fall raptor flight by species group a) with and b) without Broad-winged Hawks at the Corpus Christi HawkWatch, Texas: 1997–2013 versus 2014.

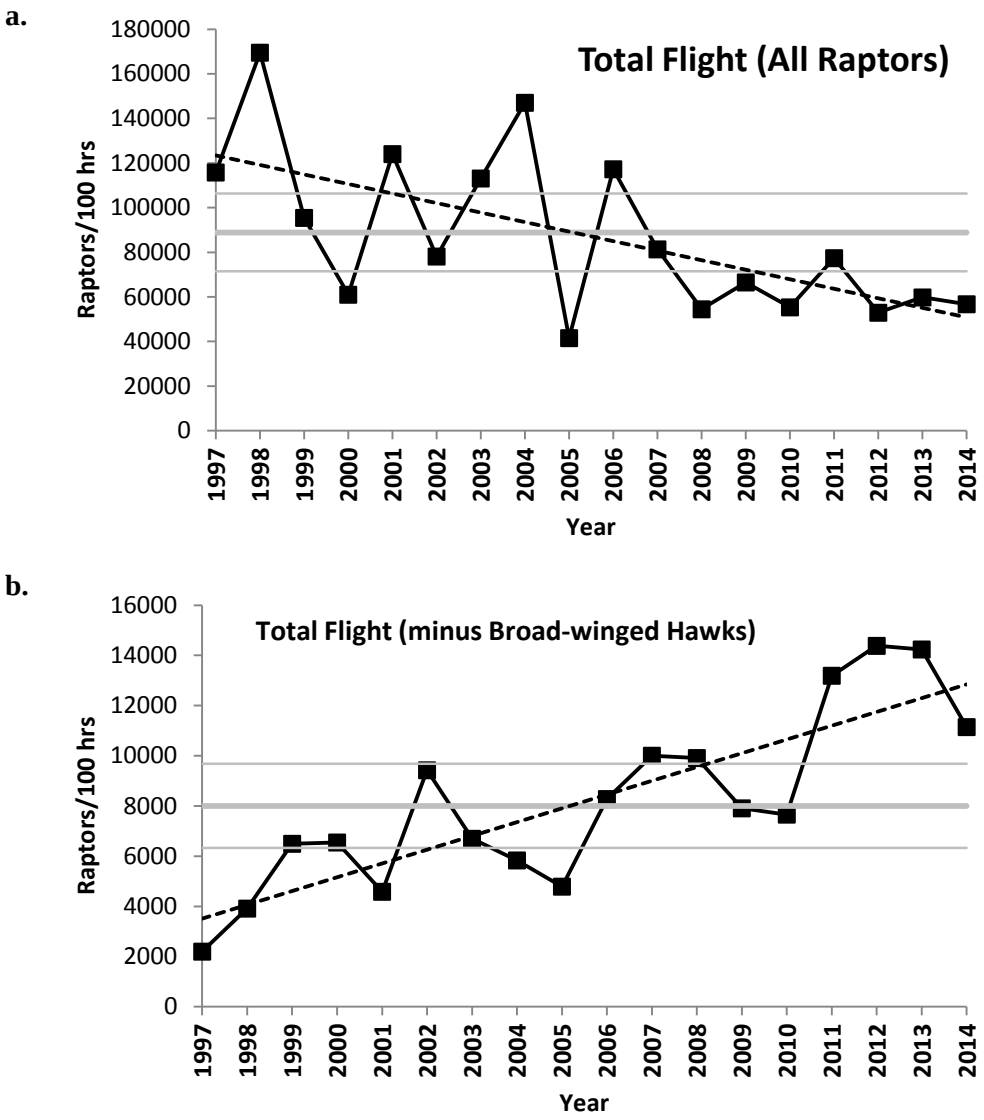


Figure 4. Effort-adjusted fall migration passage rates at the Corpus Christi HawkWatch for a) all migrating raptors counted and b) all migrating raptors counted excluding Broad-winged Hawks: 1997-2014. Solid grey lines represent mean (thick) and upper and lower 95% confidence intervals (thin) of historic counts (1997-2013). Dashed lines indicate significant (alpha=0.05) population trends based on linear regression.

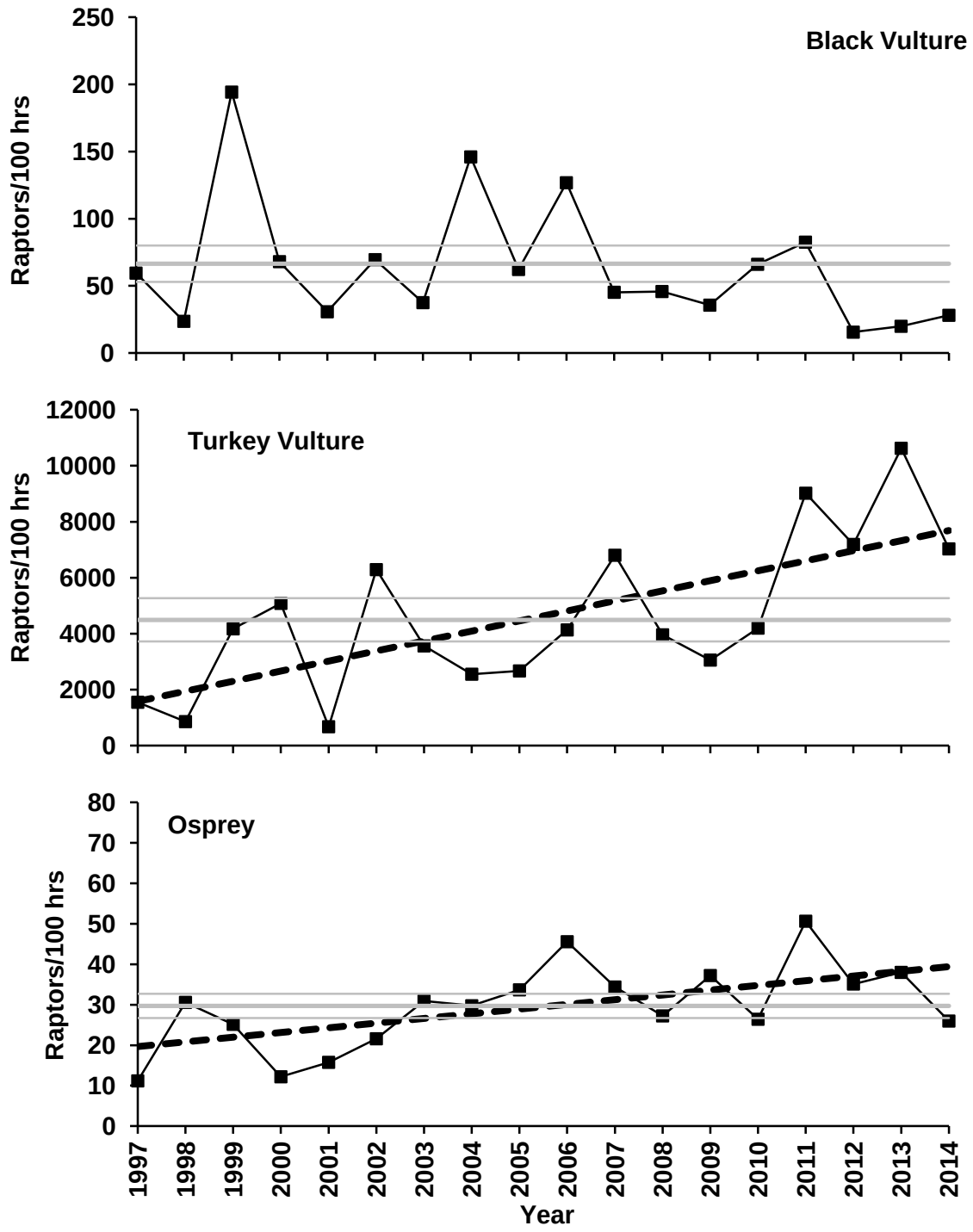


Figure 5a. Fall-migration passage rates for the Corpus Christi HawkWatch, at Hazel Bazemore County Park, TX for Black Vultures, Turkey Vultures, and Osprey: 1997–2014. Dashed lines indicate trends for significant ($p < 0.05$) linear regression. Solid grey lines represent mean (thick) and upper and lower 95% confidence intervals (thin) of historic site counts (1997-2013).

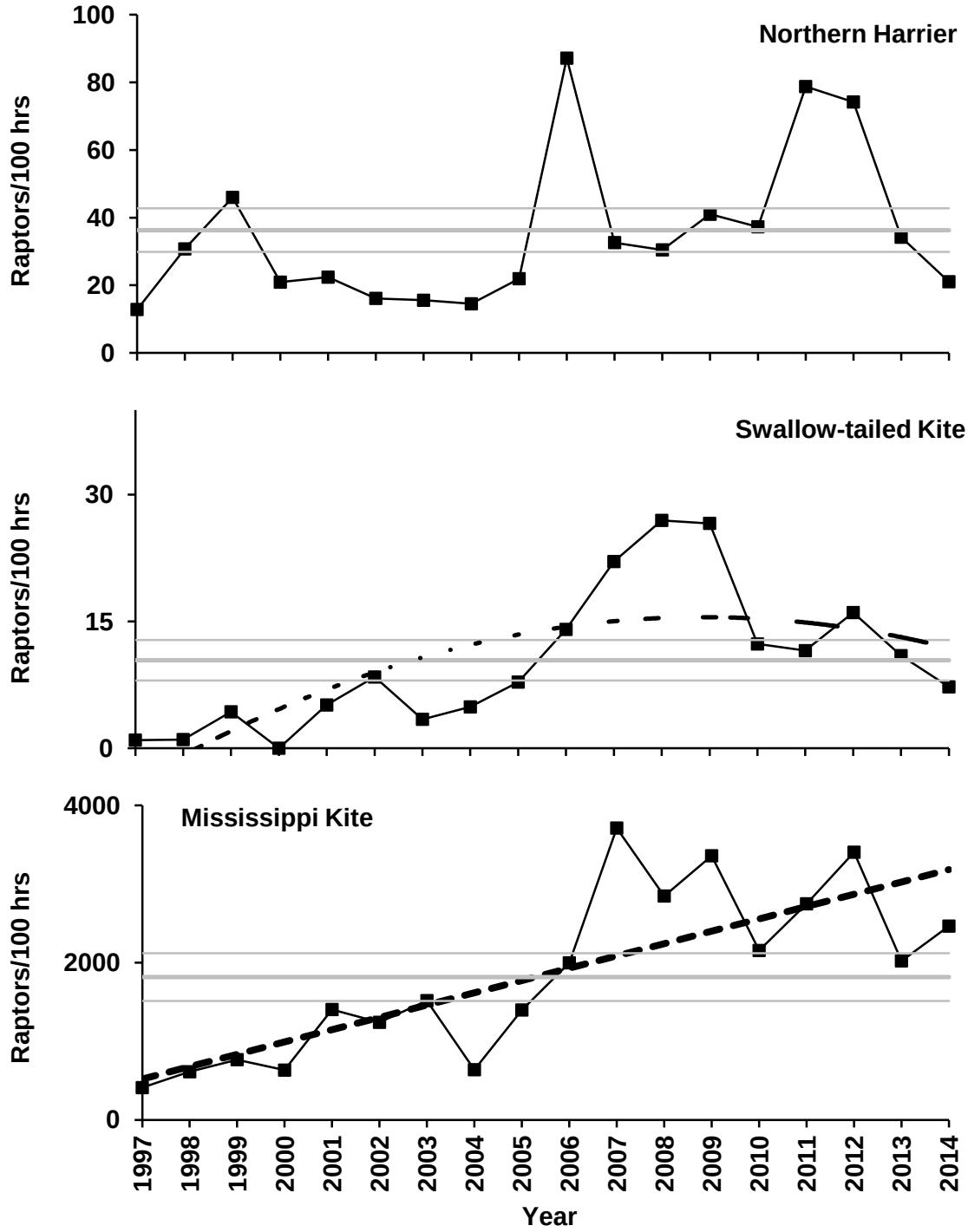


Figure 5b. Fall-migration passage rates for the Corpus Christi HawkWatch, at Hazel Bazemore County Park, TX for Northern Harriers, Swallow-tailed Kites, and Mississippi Kites: 1997–2014. Dashed lines indicate trends for significant ($p < 0.05$) linear or quadratic regression. Solid grey lines represent mean (thick) and upper and lower 95% confidence intervals (thin) of historic site counts (1997-2013).

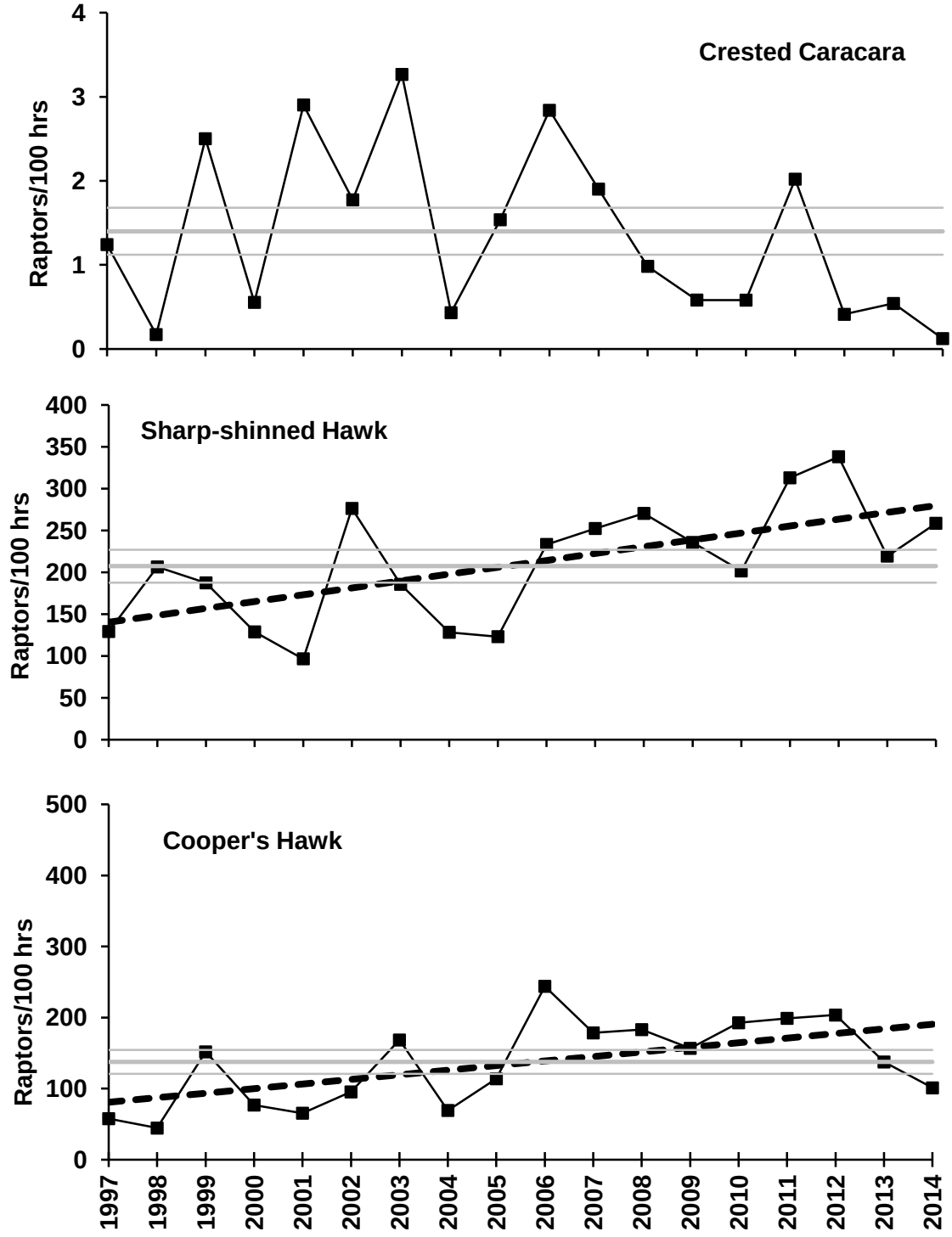


Figure 5c. Fall-migration passage rates for the Corpus Christi HawkWatch, at Hazel Bazemore County Park, TX for Crested Caracara, Sharp-shinned, and Cooper's Hawks: 1997–2014. Dashed lines indicate trends for significant ($p < 0.05$) linear regression. Solid grey lines represent mean (thick) and upper and lower 95% confidence intervals (thin) of historic site counts (1997-2013).

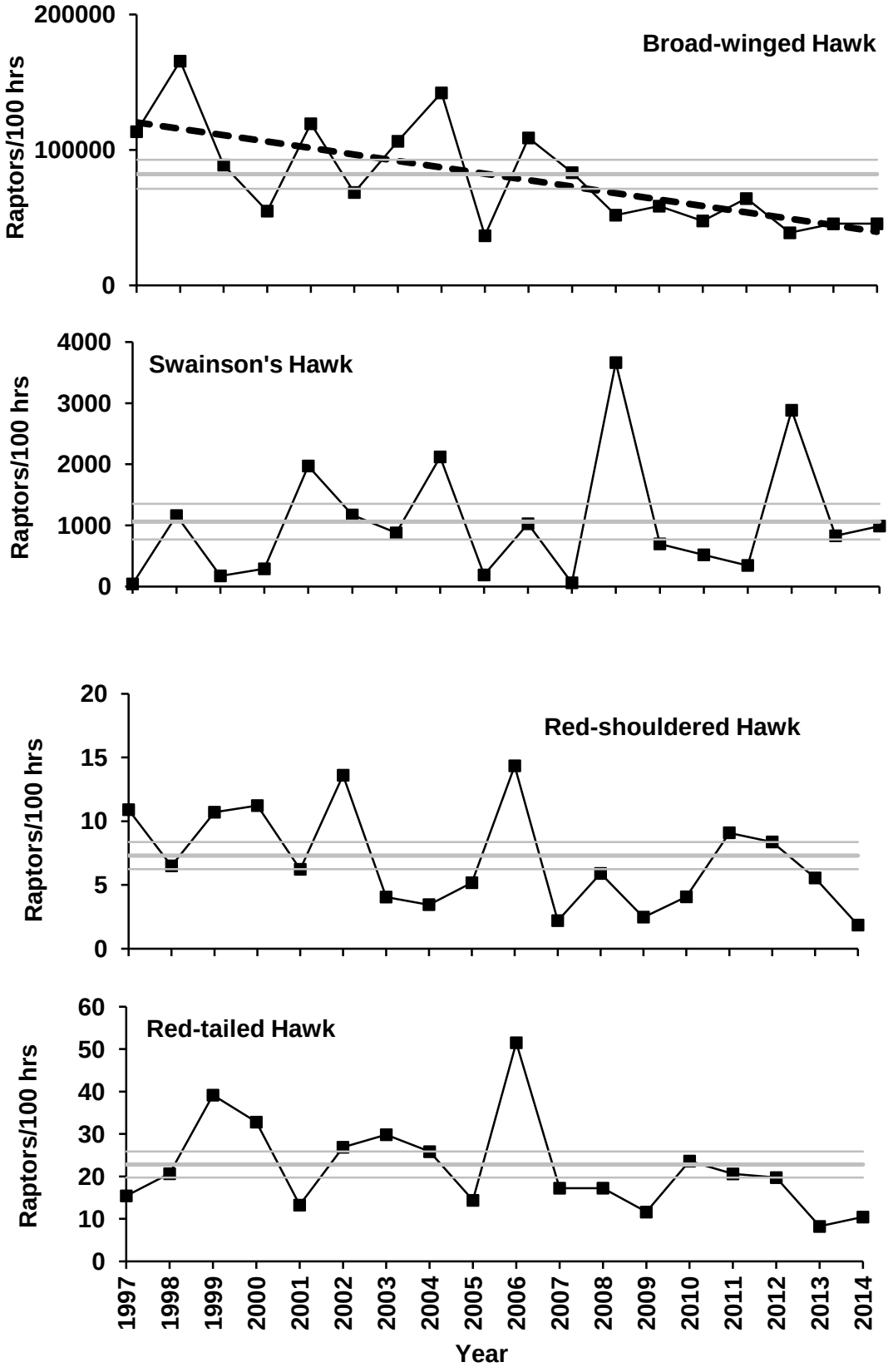


Figure 5d. Fall-migration passage rates for common buteos for the Corpus Christi HawkWatch, at Hazel Bazemore County Park, TX: 1997–2014. Dashed lines indicate trends for significant ($p < 0.05$) linear regression. Solid grey lines represent mean (thick) and upper and lower 95% confidence intervals (thin) of historic site counts (1997-2013).

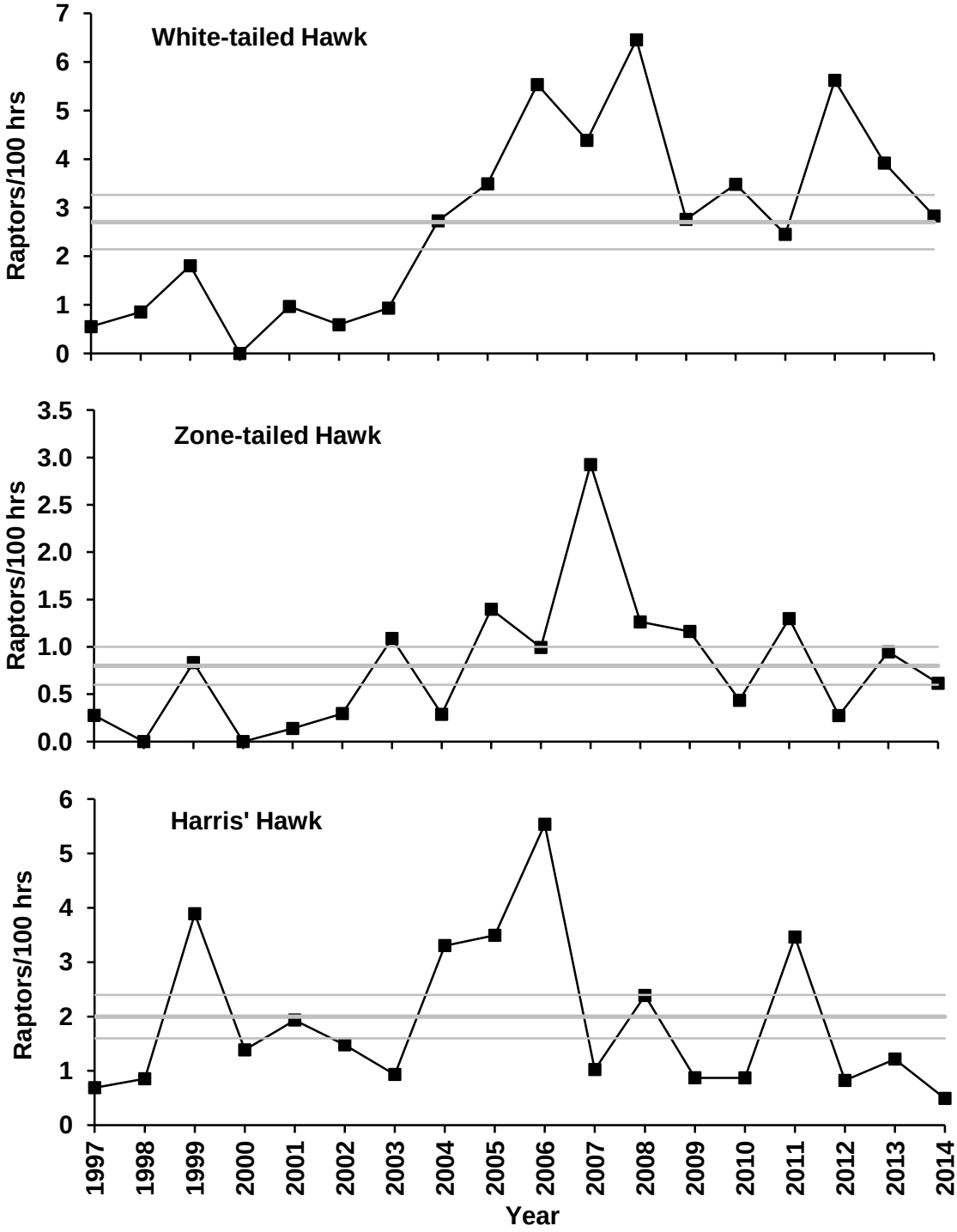


Figure 5e. Fall-migration passage rates for uncommon buteos and Harris's Hawk for the Corpus Christi HawkWatch, at Hazel Bazemore County Park, TX: 1997–2014. Dashed lines indicate trends for significant ($p < 0.05$) linear regression. Solid grey lines represent mean (thick) and upper and lower 95% confidence intervals (thin) of historic counts (1997-2013) at HBCP.

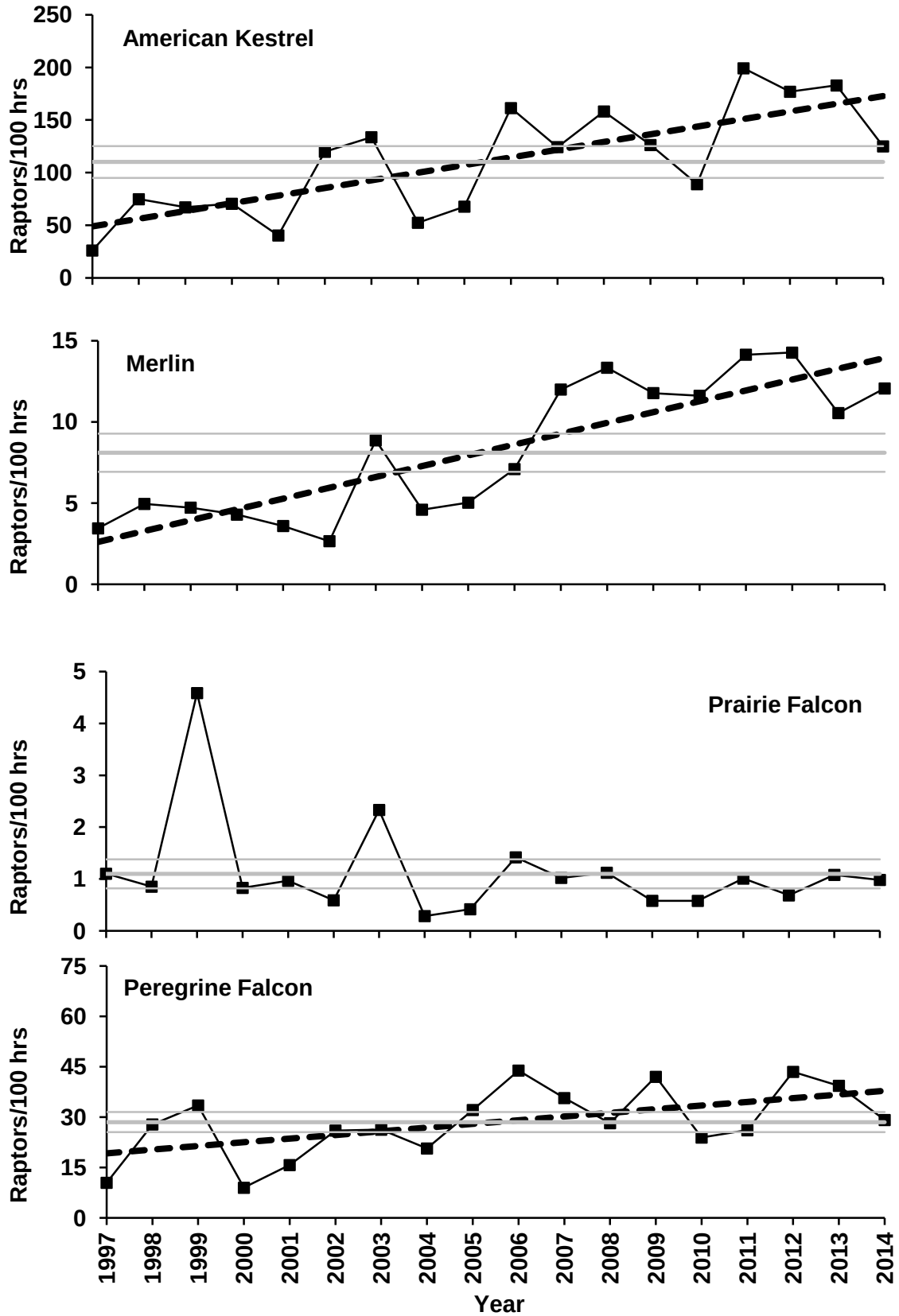


Figure 5f. Fall-migration falcon passage rates for the Corpus Christi HawkWatch, at Hazel Bazemore County Park, TX: 1997–2014. Dashed lines indicate trends for significant ($p < 0.05$) linear regression. Solid grey lines represent mean (thick) and upper and lower 95% confidence intervals (thin) of historic counts (1997-2013).

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: 1997–2014.

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: Elizabeth Errickson (1+), Kevin Georg (8+), Dane Ferrell (13); regularly assisted by other dedicated, local volunteers, especially Libby Even (9) and Bob Creglow (16+).

[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: 1997–2014.

	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: 1997–2014.

	2010	2011	2012	2013	2014	Mean
Start date	15-Aug	15-Aug	15-Aug	10-Aug	01-Aug	12-Aug
End date	15-Nov	15-Nov	15-Nov	15-Nov	15-Nov	14-Nov
Observation days	91	93	93	98	106	93
Observation hours	689.25	693.25	736.08	739.75	812.75	711.68
SPECIES						
Black Vulture	455	572	113	147	228	465
Turkey Vulture	28,926	62,521	52,543	78,587	57,128	31,544
Unidentified vulture	0	0	0	0	0	1
Total vultures	29,381	63,093	52,656	78,734	57,356	32,103
Osprey	182	351	256	281	211	207
Northern Harrier	257	546	542	253	171	254
Common Black Hawk	0	0	0	0	0	<1
Harris's Hawk	6	24	7	9	4	14
Hook-billed Kite	0	0	0	0	0	<1
Swallow-tailed Kite	85	80	117	81	59	88
White-tailed Kite	4	4	4	4	4	5
Mississippi Kite	14,851	19,054	24,825	14,960	20,032	12,859
TOTAL KITES	14,940	19,138	24,946	15,045	20,095	12,947
Sharp-shinned Hawk	1,389	2,169	2,466	1,622	2,101	1,442
Cooper's Hawk	1,328	1,379	1,484	1,017	821	962
Northern Goshawk	0	0	0	0	0	0
Unidentified accipiter	333	156	196	138	105	249
TOTAL ACCIPITERS	3,050	3,704	4,146	2,777	3,027	2,654
Red-shouldered Hawk	28	63	62	41	15	51
Broad-winged Hawk	328,730	445,112	283,755	336,960	370,575	564,886
Short-tailed Hawk	0	0	1	1	0	1
Swainson's Hawk	3,565	2,387	21,019	6,132	8,035	7,409
White-tailed Hawk	24	17	41	29	23	21
Zone-tailed Hawk	3	9	2	7	5	6
Red-tailed Hawk	163	143	148	61	85	159
Ferruginous Hawk	2	2	6	3	6	4
Rough-legged Hawk	0	0	0	0	0	<1
Unidentified buteo	84	70	47	49	22	93
TOTAL BUTEOS	332,605	447,827	305,088	343,292	378,766	572,629
Golden Eagle	2	1	1	5	1	2
Bald Eagle	12	10	7	6	15	5
Unidentified eagle	0	0	0	0	0	<1
TOTAL EAGLES	14	11	8	11	16	6
Crested Caracara	4	14	3	4	1	10
American Kestrel	614	1,381	1,290	1,353	1,016	768
Merlin	80	98	104	78	98	56
Prairie Falcon	4	7	5	8	8	8
Peregrine Falcon	165	181	317	291	237	199
Aplomado Falcon	0	1	0	0	0	1
Unidentified falcon	6	2	6	4	4	31
TOTAL FALCONS	885	1,684	1,734	1,749	1,367	1,063
Unidentified raptor	200	201	254	155	157	680
GRAND TOTAL	381,514	536,555	389,630	442,297	461,170	622,473