## FALL 2015 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 18<sup>th</sup> 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 2015. 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 (27°52'3.0"N, 97°38'30.1"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 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.

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:

- 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 2015 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.

#### 2015 RESULTS AND DISCUSSION

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

Corpus Christi HawkWatch's standard season runs 15 August—15 November; in 2015 observers counted from 1 August to 15 November, for a total of 101 days and 814.75 hours--an effort significantly higher than the site averages of 94 days and 722 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 lost due to weather, and one additional day was shortend ( $\leq$ 4 hours). Weather varies throughout every season, in 2015 based on hourly recording of conditions during observation it was clear 17% of the time, partly cloudy 24% of the time, mostly cloudy 22% of the time, overcast 36% of the time, hazy 78% of the time, foggy 3% of the time, and rainy 5% of the time.

#### **2015 FLIGHT SUMMARY**

#### **Overall Flight:**

Observers counted 660,189 migrant raptors of 25 different species in 2015, making this an average year for raptor migration at the Corpus Christi HawkWatch compared to the site long-term average (Table 1); this was the largest count since 2006 (Appendix C). Season highlights included the highest seasonal Turkey Vulture (170,976) and Merlin counts (117).

The flight consisted of 72 % buteos, 26% vultures, 1% kites and less than 1% of all other groups, owing to the large proportion of Broad-winged Hawks (87% on average, but only 72% in 2015) comprising the flight (Fig 3a). Removing Broad-winged Hawks from the flight composition (Fig 3b) yields the following proportions: vultures (91%), kites (5%), buteos (2%), accipiters (2%), falcons (1%), and other species (<1%).

The following sections summarize the 2015 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 81,030 raptors counted per 100 hours of observation at the Corpus Christi HawkWatch in 2015 was comparable to the historic average (Fig 4a). Regression analysis of passage rates indicate long-term declines in the total number of raptors counted each year at Corpus Christi (slope = -3724, r<sup>2</sup> = 0.35, p=0.008). Interestingly, Broad-winged Hawks seem to be driving this trend; the total flight exclusive of Broad-winged Hawks was considerably higher than average (23,064 birds/100hrs) and set a new record in 2015. It is worth noting this high rate was in strong part due to record high Turkey Vulture counts. Based on linear regression there has been an overall increasing trend in the flight independent of Broad-winged Hawks (slope = 701, r<sup>2</sup> = 0.67, p<0.001).

#### Vultures and Osprey (Fig. 5a)

Black Vulture count and passage rate were below the historic site averages, the fourth 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 set record highs for the site this season and regression analysis on effort-adjusted passage rates suggests that regional populations of Turkey Vultures are growing (slope = 563,  $r^2 = 0.47$ , p = 0.001). Counts of Osprey in 2015 were average compared to historic values but passage rates were the lowest they have been in 7 seasons. Over the long term Osprey passage rates are increasing (slope = .877,  $r^2 = 0.23$ , p = 0.036).

#### Northern Harriers and Kites (Fig. 5b):

Northern Harrier count and passage rate were both below site historic averages in 2015 and were the lowest since 2005 and 2004 respectively; 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 deviated from site historic averages. However, based on  $2^{nd}$  order polynomial regression of effort adjusted passage rates, regional populations of Swallow-tailed Kites have been declining since 2008 ( $F_{2,16}=5.66$ ,  $r^2 = 0.41$ , p = 0.03). Count and passage rate for Mississippi Kites were both significantly below site average and the lowest since 2004. Regional populations of this species are increased between 1997 and 2012, but regression results suggest a decline starting in 2013 ( $F_{2,16}=12.1$ ,  $r^2 = 0.6$ , p = 0.003).

#### Crested Caracara and Accipiters (Fig. 5c):

Crested Caracaras are relatively uncommon migrants at the site (Appendix C), and only four were counted in 2015. Sharp-shinned Hawk counts were above average and passage rate were average in 2015; regional populations of this species are increasing based on linear regression of effort-adjusted passage rates (slope = 7.15,  $r^2 = 0.38$ , p = 0.005). The Cooper's Hawks count and passage rate in 2015 were average for the site. According to 2<sup>nd</sup> order polynomial regression on fall passage rates, regional populations of Cooper's Hawks increased between 1997 and 2006, but have slowly declined since 2010 (F<sub>2,16</sub> = 6.59,  $r^2 = 0.45$ , p = 0.021).

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

Broad-winged Hawks regularly make up 87% of the fall flight, the 472,276 Broad-wings counted in 2015 was consistent with the historic average (Table 1), however, the passage rate was below average. Long term analyses of effort-adjusted passage rates indicate significant regional population declines (slope = -4425,  $r^2 = 0.44$ , p= 0.002). Counts and passage rates for Red-shouldered Hawks, Red-tailed Hawks, Swainson's Hawks, and Harris's Hawks were low compared to site averages; in fact, the 2 Harris's Hawks counted set the lowest count on record for the second consecutive season (Appendix C).

#### Falcons (Fig. 5f):

Counts for American Kestrels and Merlins were above historic averages in 2015 (Table 1) and Kestrel regional populations are increasing based on linear regression of effort-adjusted passage rates (slope = 6.6,  $r^2 = 0.55$ , p < 0.001. 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 low in 2015 compared to historic site averages.

#### VISITOR PARTICIPATION AND PUBLIC OUTREACH

At least 1,025 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* also took place during that weekend and included presentation and time on the counting platform with Jerry Liguori. A last highlight of the *Celebration of Flight* was the presentation of the HWI Lifetime Achievement Award to Joel Simon for his many years of keeping this effort afloat—thank you Joel! 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.

#### 2015 FALL MIGRATION ACROSS HWI'S NETWORK

HawkWatch International and partners operated 8 fall count sites in 2015(Fig. 1). During the 4,252 hours of standardized observation we counted 700,457 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 2015 included (Table 2):

- Above average or average counts at 6 of 8 sites
  - Exceptions were Chelan Ridge and Manzano Mountain sites which had significantly low counts.
- Below average Golden Eagle counts at 6 of 8 sites—only above average count was at Commissary Ridge, WY
- Below historic average American Kestrel counts at 6 of 8 sites
- Significantly low counts of all accipiter species at both Pacific Northwest sites
- Significantly high Turkey Vulture counts at 5 of 7 sites where counted (record set at 3 sites: Chelan Ridge, Goshute Mountains, and Corpus Christi-where 170,976 were counted!)
- Above average or average Broad-winged Hawk numbers at all sites with record numbers at 3 sites (Chelan Ridge, Goshute Mountains, and Yaki Point).

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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		1997	-201	14		All-time Historic Records			
	Species	Mean Cour	nt ±	95 % CI	2015	% Change	Season	Daily	
	Black Vulture	452.2	±	156.8	186	-58.9	1,398 (1999)	254 (1999)	
	Turkey Vulture	32965.7	±	9409.9	170976	418.6	170,976 (2015)	41132 (2013)	
	Osprey	207.1	±	33.8	194	-6.3	351 (2011)	39 (2004)	
	Northern Harrier	249.6	$\pm$	74.4	169	-32.3	614 (2006)	64 (2011)	
	Crested Caracara	9.4	±	3.3	4	-57.6	21 (2001)	7 (1999)	
	Common Black Hawk	<1	±		0		1 (2002)	1	
	Harris's Hawk	13.7	$\pm$	4.7	2	-85.4	39 (2006)	5 (2006)	
Accipiters									
-	Sharp-shinned Hawk	1478.7	±	235.3	1914	29.4	2,466 (2012)	340 (2014)	
	Cooper's Hawk	954.4	±	192.5	1094	14.6	1,719 (2006)	259 (2006)	
	Northern Goshawk	0.4	±	0.4	0	-100.0	3 (2007)	2 (2007)	
	Unidentified accipiter	241.1	±	40.2	69	-71.4	379 (2000)		
	TOTAL ACCIPITERS	2674.6	+	373.3	3077	15.0	4,146 (2012)		
Buteos							, ,		
	Red-shouldered Hawk	49.1	±	12.8	23	-53.1	101 (2006)	19 (2012)	
	Broad-winged Hawk	554091.1	+	111644.2	472276	-14.8	989,957 (2004)	520.032 (2004)	
	Short-tailed Hawk	0.8	+	0.5	2	140.0	4 (2005)	1	
	Swainson's Hawk	7443.6	+	3343 3	2941	-60.5	26 093 (2008)	17549(2012)	
	White-taile Hawk	21.1	+	65	43	104.2	50 (2008)	5(2x)	
	Zone_tailed Hawk	5.8	- +	2.5	13	125.0	22 (2007)	$\frac{3(2x)}{2(9x)}$	
	Red_tailed Hawk	155.3	- +	85.0	68	-56.2	363 (2006)	58 (2000)	
	Ferruginous Hawk	3.8	- -	1.6	08	-50.2	14(1999)	2(6x)	
	Pough lagged Hawk	J.0	<u>+</u>	1.0	4	5.9	4(1999)	2 (0X)	
	Unidentified butes	<1 20.1	<u>+</u>	20.1	0	80.0	4(1999)	1	
		09.1 561050 7	±	59.1 111665 A	9 175270	-69.9	1 004 080 (2004)		
Fogles	IOTAL BUTEOS	501656.7	Ŧ	111003.4	475579	-13.4	1,004,989 (2004)		
Lagies	Coldan Fagla	17	-	0.6	2	16.1	5 (2013)	1	
	Bald Eagle	5.6	- -	2.0	14	1/8 0	15(2013)	$\frac{1}{3(2\mathbf{v})}$	
	Unknown aaglas	J.0	- -	2.0	14	140.9	13(2014) 1(2008)	J(2X)	
	TOTAL EACLES	<1 6 9	±	2.2	0	124.1	1(2008) 16(2014)		
Folgong	IOTAL EAGLES	1007 2014	Ξ	2.2	10	134.1	10 (2014)		
r alcolis	American Kestrel	791.6	-	174.5	1171	40.8	1 281 (2011)	251 (2011)	
	American Kesuer	/01.0 59.6	± .	1/4.5	11/1	49.0	1,301 (2011) 117 (2015)	231(2011) 18(2012)	
	Merini Dalida Falazza	58.0	±	14.1	117	99.0 50.0	117 (2015)	18 (2012)	
	Prairie Falcon	8.0	±	3.2	4	-50.0	33 (1999)	5 (1999)	
	Peregrine Faicon	201.1	±	34.8	146	-27.4	317 (2012)	48 (2012)	
	Aplomado Falcon	<1	±	0.5	0	-100.0	4 (2007)	2(2x)	
	Unidentified falcon	29.6	±	12.5	11	-62.9	103 (2000)		
	TOTAL FALCONS	1079.6	±	207.3	1449	34.2	1,749 (2013)		
Kites									
	Hook-billed Kite	<1	±		0		1 (2003)	1 (2003)	
	Swallow-tailed Kite	86.5	±	39.0	89	2.9	349 (2008)	58 (2008)	
	White-tailed Kite	4.7	±	1.5	5	7.1	14 (2008)	5 (2008)	
	Mississippi Kite	13257.3	±	3618.0	8506	-35.8	27,285 (2007)	12,261 (2007)	
	Unidentified Kites	<1	±		0		1 (2008)		
	TOTAL KITES	13343.8	±	3646.6	8600	-35.6	27,454 (2007)		
	<b>Unidentified Raptor</b>	650.6	±	591.4	137	-78.9	4,376 (1998)		
	GRAND TOTAL	613511.8	+	104101.0	660189	7.6	1.030.849 (2004)	520,351 (2004)	

Table 1.	Historic fall ra	ptor migration coun	ts (mean ± 95% CI)	, counts from fall 2015	, and site records for the	Corpus	Christi HawkWatch
				/	/		

Table 2. Summary of the 2015 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 count. *In 2015 HWI monitored migration for 4,252 hrs and counted 700,457 birds*.

	Bonney Butte,	Chelan Ridge,	Bridger Mtn,	Commissary	Goshute Mts,		Manzano	Corpus
	OR	WA	MT	Ridge, WY	NV	Yaki Pt, AZ	Mts, NM	Christi, TX
	-			Hours Counted	d in 2015			
Species	365.7	338.8	399.1	532.5	679.8	568.3	553.4	814.8
Black Vulture								186
Turkey Vulture	494	*81*	5	90	*1102*		292	*170976*
Osprey	67	28	*22*	39	162	*75*	30	194
Northern Harrier	24	73	141	*64*	239	55	51	169
Crested Caracara								4
Common Black Hawk								0
Harris' Hawk								2
Accipiters								
Sharp-shinned Hawk	964	367	*655*	1321	6769	2209	1420	1914
Cooper's Hawk	226	179	306	526	4418	1538	<b>469</b>	1094
Northern Goshawk	19	15	38	48	100	3	3	0
Unidentified accipiter	44	41	94	71	43	*728*	39	69
TOTAL ACCIPITERS	1253	602	*1093*	1966	11330	*4478*	1931	3077
Buteos								
Red-shouldered Hawk	1	0	0	0	0	0	0	23
Broad-winged Hawk	4	*16*	29	30	*336*	*47*	18	472276
Short-tailed Hawk								2
Swainson's Hawk	1	14	2	202	*2856*	138	388	2941
White-tailed Hawk								43
Zone-tailed Hawk							1	13
Red-tailed Hawk	614	139	*382*	1070	*6988*	*1723*	384	68
Ferruginous Hawk	0	0	6	3	21	8	2	4
Rough-legged Hawk	1	35	*96*	11	11	0	0	0
Unidentified buteo	3	30	29	47	15	68	16	9
TOTAL BUTEOS	624	234	*544*	1363	*10227*	*1984*	809	475379
Eagles								
Golden Eagle	56	60	1134	*359*	170	1	43	2
Bald Eagle	78	*16*	81	169	15	11	1	14
Unknown eagles	1	1	2	9	0	0	1	0
TOTAL EAGLES	135	77	1217	537	185	12	45	16
Falcons								
American Kestrel	8	16	*180*	189	1881	595	267	1171
Merlin	69	34	*36*	19	73	10	37	*117*
Prairie Falcon	4	7	6	11	37	6	5	4
Peregrine Falcon	12	7	21	8	45	9	23	146
Aplomado Falcon								0
Unidentified falcon	7	2	7	11	1	17	3	11
TOTAL FALCONS	100	66	*250*	238	2037	637	335	1449
Kites								
Hook-billed Kite								0
Swallow-tailed Kite								89
White-tailed Kite								5
Mississippi Kite								8506
Unidentified Kites								0
TOTAL KITES								8600
Unidentified Raptor	7	31	9	12	0	49	7	137
GRAND TOTAL	2704	1192	3281	4309	25282	*7290*	3500	660189



Figure 1. Locations of fall HawkWatch sites operated by HWI and partners (symbols with borders represent sites that conducted banding in 2015).



Texas

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



Figure 3. Composition of the fall raptor flight by species group a) with and b) without Broadwinged Hawks at the Corpus Christi HawkWatch, Texas: 1997–2014 versus 2015.



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: 1997-2015. Solid grey lines represent mean (thick) and upper and lower 95% confidence intervals (thin) of historic counts (1997-2014). 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: 1997–2015. 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 (1997-2014).



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: 1997–2015. 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 (1997-2014).



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: 1997–2015. 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 (1997-2014).



Figure 5d. Fall-migration passage rates for common buteos for the Corpus Christi HawkWatch, at Hazel Bazemore County Park, TX: 1997–2015. 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 (1997-2014).



Figure 5e. Fall-migration passage rates for uncommon buteos and Harris's Hawk for the Corpus Christi HawkWatch, at Hazel Bazemore County Park, TX: 1997–2015. 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 (1997-2014).



Figure 5f. Fall-migration falcon passage rates for the Corpus Christi HawkWatch, at Hazel Bazemore County Park, TX: 1997–2015. 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 (1997-2014).

		Species			Color
Common Name	Scientific Name	Code	Age <sup>1</sup>	Sex <sup>2</sup>	Morph <sup>3</sup>
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	MFU	NA
Hook-billed Kite	Chondrohierax uncinatus	HK	AIU	AM AF U	DLU
Swallow-tailed Kite	Elanoides forficatus	SK	U	U	NA
White-tailed Kite	Elanus leucurus	WK	U	U	NA
Mississippi Kite	Ictinia mississippiensis	MK	AIU	U	NA
Unknown kite	see above	UK	U	U	NA
Sharp-shinned Hawk	Accipiter striatus	SS	AIU	U	NA
Cooper's Hawk	Accipiter cooperii	СН	AIU	U	NA
Northern Goshawk	Accipiter gentilis	NG	AIU	U	NA
Unknown accipiter	Accipiter spp.	UA	U	U	NA
Common Black Hawk	Buteogallus anthracinus	CB	AIU	U	NA
Harris's Hawk	Parabuteo unicinctus	HH	AIU	U	NA
Red-shouldered Hawk	Buteo lineatus	RS	AIU	U	NA
Broad-winged Hawk	Buteo platypterus	BW	AIU	U	DLU
Short-tailed Hawk	Buteo brachyurus	ST	U	U	DLU
Swainson's Hawk	Buteo swainsoni	SW	U	U	DLU
White-tailed Hawk	Buteo albicaudatus	WT	AIU	U	NA
Zone-tailed Hawk	Buteo albonotatus	ZT	AIU	U	NA
Red-tailed Hawk	Buteo jamaicensis	RT	AIU	U	DLU
Ferruginous Hawk	Buteo regalis	FH	AIU	U	DLU
Rough-legged Hawk	Buteo lagopus	RL	U	U	DLU
Unknown buteo	Buteo spp.	UB	U	U	DLU
Golden Eagle	Aquila chrysaetos	GE	$A S I NA U^4$	U	NA
Bald Eagle	Haliaeetus leucocephalus	BE	A S2 S1 I NA U <sup>5</sup>	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	MFU	NA
Merlin	Falco columbarius	ML	AM Br	M U	NA
Prairie Falcon	Falco mexicanus	PR	U	U	NA
Peregrine Falcon	Falco peregrinus	PG	AIU	U	NA
Aplomado Falcon	Falco femoralis	AF	AIU	U	NA
Unknown falcon	Falco spp.	UF	U	U	NA
Unknown raptor	Falconiformes	UU	U	U	NA

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

 $^{1}$  A = adult, I = immature (HY), Br = brown (adult female or immature), U = unknown age.

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

<sup>3</sup> D = dark or rufous, L = light, U – unknown, NA = not applicable.

<sup>4</sup> 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.

<sup>5</sup> 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: 1997–2015.

**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+).

**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+).

<sup>&</sup>lt;sup>1</sup> 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: 1997–2015.

	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							
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: 1997–2015.

	2010	2011	2012	2013	2014	2015	Mean
Start date	15-Aug	15-Aug	15-Aug	10-Aug	01-Aug	1-Aug	11-Aug
End date	15-Nov						
Observation days	91	93	93	98	106	101	94
Observation hours	689.25	693.25	736.08	739.75	812.75	814.75	722.43
			SPEC	IES			
Black Vulture	455	572	113	147	228	186	438
Turkey Vulture	28,926	62,521	52,543	78,587	57,128	170,976	40,229
Unidentified vulture	0	0	0	0	0	0	<1
Total vultures	29,381	63,093	52,656	78,734	57,356	171,162	40,751
Osprey	182	351	256	281	211	194	206
Northern Harrier	257	546	542	253	171	169	245
Common Black Hawk	0	0	0	0	0	0	<1
Harris's Hawk	6	24	7	9	4	2	13
Hook-billed Kite	0	0	0	0	0	0	<1
Swallow-tailed Kite	85	80	117	81	59	89	82
White-tailed Kite	4	4	4	4	4	5	5
Mississippi Kite	14,851	19,054	24,825	14,960	20,032	8,506	13,007
TOTAL KITES	14,940	19,138	24,946	15,045	20,095	8,600	13,094
Sharp-shinned Hawk	1,389	2,169	2,466	1,622	2,101	1,914	1,502
Cooper's Hawk	1,328	1,379	1,484	1,017	821	1,094	962
Northern Goshawk	0	0	0	0	0	0	0
Unidentified accipiter	333	156	196	138	105	69	232
TOTAL ACCIPITERS	3,050	3,704	4,146	2,777	3,027	3,077	2,713
Red-shouldered Hawk	28	63	62	41	15	23	48
Broad-winged Hawk	328,730	445,112	283,755	336,960	370,575	472,276	549,785
Short-tailed Hawk	0	0	1	1	0	2	1
Swainson's Hawk	3,565	2,387	21,019	6,132	8,035	2,941	7,207
White-tailed Hawk	24	17	41	29	23	43	21
Zone-tailed Hawk	3	9	2	7	5	13	6
Red-tailed Hawk	163	143	148	61	85	68	151
Ferruginous Hawk	2	2	6	3	6	4	4
Rough-legged Hawk	0	0	0	0	0	0	<1
Unidentified buteo	84	70	47	49	22	9	85
TOTAL BUTEOS	332,605	447,827	305,088	343,292	378,766	475,379	557,320
Golden Eagle	2	1	1	5	1	2	2
Bald Eagle	12	10	7	6	15	14	5
Unidentified eagle	0	0	0	0	0	0	<1
TOTAL EAGLES	14	11	8	11	16	16	7
Crested Caracara	4	14	3	4	1	4	9
American Kestrel	614	1,381	1,290	1,353	1,016	1,171	802
Merlin	80	98	104	78	98	117	62
Prairie Falcon	4	7	5	8	8	4	8
Peregrine Falcon	165	181	317	291	237	146	198
Aplomado Falcon	0	1	0	0	0	0	1
Unidentified falcon	6	2	6	4	4	11	22
TOTAL FALCONS	885	1,684	1,734	1,749	1,367	1,449	1,100
Unidentified raptor	200	201	254	155	157	137	624
GRAND TOTAL	381,514	536,555	389,630	442,297	461,170	660,189	616,051