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A NEW RAPTOR MIGRATION MONITORING SITE IN THE FLORIDA KEYS: COUNTS FROM 1999–2004

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ABSTRACT.—The narrowing of the Florida Peninsula into the Florida Keys concentrates large flights of migrating raptors en route to southern wintering grounds each fall. Between 1999 and 2004, HawkWatch International (HWI) conducted standardized daily counts of migrant raptors from 15 September to 13 November at Curry Hammock State Park in the middle Keys. Average annual counts for the eight most common species were: Broad-winged Hawk (*Buteo platypterus*; 3893); Sharp-shinned Hawk (*Accipiter striatus*; 3300); American Kestrel (*Falco sparverius*; 2800); Peregrine Falcon (*F. peregrinus*; 1908); Osprey (*Pandion haliaetus*; 1171); Northern Harrier (*Circus cyaneus*; 568); Merlin (*F. columbarius*; 554); and Cooper's Hawk (*A. cooperii*; 545). Counts were comparable to or greater than totals from each of nine sites representative of the major raptor migration corridors within the Nearctic-Neotropical migration system. Given the unique geographic position of the Florida Keys in the southeastern U.S. where no other major concentrations of migratory raptors occur, long-term counts at Curry Hammock will be important for monitoring North American raptor population trends. Counts of migrating Peregrine Falcons at this site may be of particular importance, because more costly monitoring efforts at breeding sites will decrease over time now that peregrines are no longer listed as an Endangered Species.

KEY WORDS: *Peregrine Falcon*; Falco peregrinus; *Endangered Species*; *monitoring*; *population trends*.

UN NUEVO SITIO DE MONITOREO DE MIGRACIÓN DE RAPACES EN LOS CAYOS DE LA FLORIDA: CONTEOS REALIZADOS ENTRE 1999 Y 2004

RESUMEN.—El estrechamiento de la Península de la Florida hacia los cayos de ese estado concentra los vuelos de muchas rapaces migratorias que cada otoño se dirigen a sus sitios de invernada en el sur. Entre 1999 y 2004, HawkWatch International (HWI) realizó conteos estandarizados de rapaces migratorias diariamente entre el 15 de septiembre y el 13 de noviembre en el Parque Estatal Curry Hammock, en los cayos medios. Los promedios anuales de los conteos de las especies más comunes fueron: *Buteo platypterus*, 3893; *Accipiter striatus*, 3300; *Falco sparverius*, 2800; *F. peregrinus*, 1908; *Pandion haliaetus*, 1171; *Circus cyaneus*, 568; *F. columbarius*, 554; *A. cooperii*, 545. Los conteos fueron comparables a, o mayores que, los totales de cada uno de nueve sitios representativos de los principales corredores de migración de rapaces del sistema migratorio Neártico-Neotropical. Debido a la posición geográfica singular de los cayos de la Florida en el sureste de los Estados Unidos, donde no existen otras concentraciones importantes de rapaces migratorias, los conteos a largo plazo realizados en Curry Hammock probablemente serán importantes para monitorear las tendencias de las poblaciones norteamericanas de rapaces. Los conteos de los individuos migrantes de *F. peregrinus* realizados en este lugar podrían ser de especial importancia debido a que los esfuerzos de monitoreo más costosos realizados en las áreas de cría se harán menos comunes con el tiempo, ahora que esta especie ya no se considera amenazada.

[Traducción del equipo editorial]

Each fall, millions of diurnal raptors migrate south from temperate breeding areas to wintering areas in the southern United States, Mexico, the Caribbean, Central America, and South America (Heintzelman 1986, Kerlinger 1989). Many of these raptors are counted each fall at hawkwatches situated along the major migration corridors across North America. During the breeding season and winter, many raptor species occupy remote habitats and large home ranges, making their populations difficult and costly to monitor (Fuller and Mosher 1987, Dunn 2005). During fall migration, however, raptors become conspicuous and numerous at locations where their flights are concentrated due to topographic or geographic features (Mueller and

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Berger 1967, Hoffman 1985, Heintzelman 1986). Consequently, long-term counts at a network of hawkwatch sites across North America have been proposed as an efficient and cost-effective means for monitoring the status and trends of raptor populations (Bednarz and Kerlinger 1989, Titus et al. 1990, Smith and Hoffman 2000) and raptor migration count data have figured prominently in comprehensive reviews of the status of raptor populations in Canada (Kirk and Hyslop 1998) and for all of North America (Fuller 1996).

The continental status of Peregrine Falcon (*Falco peregrinus*) populations has been reviewed several times in the past forty years (Hickey 1969, Cade et al. 1988, Enderson et al. 1995), most recently in the context of the proposed removal of the *anatum* subspecies from the United States Fish and Wildlife Service (USFWS) list of Endangered and Threatened Species (Millsap et al. 1998). The *tundrius* subspecies was removed from the Endangered Species list in 1994 (Swem and Ambrose 1994) and the *anatum* subspecies was removed in 1999 (Mesta 1999). Now that North American Peregrine Falcons will no longer receive Endangered Species level research attention, monitoring of peregrine populations will be critical to ensure that populations remain stable or continue to show increasing trends (Millsap et al. 1998, U.S. Fish and Wildlife Service 2003), particularly if falconry take of migrant peregrines is approved by the USFWS (B. Millsap pers. comm.).

Migration monitoring data are particularly important for species where more than a third of the species' breeding range or most of a species' wintering range occurs outside the coverage of major monitoring programs such as the Breeding Bird Survey or Christmas Bird Count (Dunn et al. 2005, Hussell and Ralph 2005). This is true for a number of migrant raptor species that have large breeding populations in boreal or arctic regions where regular survey efforts would be cost-prohibitive for long-term monitoring (Bart and Ralph 2005, Dunn 2005). Migration count data were used to document Peregrine Falcon population declines during the DDT era (Carson 1962, Mueller et al. 1988) and Enderson (1969) suggested that peregrine populations could be effectively monitored by a network of count sites at locations where flights of migrant peregrines concentrate along the Atlantic and Gulf of Mexico coasts. Migration count data from the Florida Keys and elsewhere should provide valuable data to evaluate the overall long-term status and trends of Peregrine Falcon populations at a fraction of the cost of short-term breeding season monitoring programs (U.S. Fish and Wildlife Service 2003).

Some of the major raptor migration concentration points in the Nearctic-Neotropical migration system, such as the coastlines of the Great Lakes, northern Appalachian ridges, and major peninsulas along the North Atlantic coast, have been known for many years (Heintzelman 1986, Kerlinger 1989); however, other major sites have been documented more recently (Smith and Hoffman 2000). Long-term counts at well-established sites in the upper Midwest and the northeastern U.S.A. have produced information on population trends for raptors breeding to the north of these sites in the U.S. and Canada (Bednarz et al. 1990, Hussell and Brown 1992) and major raptor migration count sites in western North America have documented population trends for western raptor populations since the mid-1980s (Hoffman and Smith 2003). In the mid-1990s, standardized counts were initiated at several major migration concentration points along the western Gulf of Mexico, spanning from Smith Point, Texas to Veracruz, Mexico, where flights of more than five million raptors have been observed in a single season (Smith and Hoffman 2000, Ruelas Inzunza et al. 2000, Smith et al. 2001). Raptor migration counts in Costa Rica that began in 2000 have begun to quantify the enormous concentration of migrant raptors that has long been known to occur across the Mesoamerican land corridor (Smith 1980, Porras-Penaranda et al. 2004). Using data from single-day counts in October over several years, Hoffman and Darrow (1992) suggested that the Florida Peninsula may be a raptor migration corridor of continental significance and that the Florida Keys represent the largest concentration point along this corridor. This was confirmed by two years of full season counts by Brashear and Stoddard (2001), which documented high count totals for Peregrine Falcons and seven other species. These short-term counts were conducted from private property, which was not conducive to the development of a long-term raptor migration monitoring site (Brashear and Stoddard 2001).

In autumn 1999, HawkWatch International (HWI) initiated its first full-season count of migrating raptors in the middle Florida Keys at Curry Hammock State Park. This count was designed to document long-term trends in Peregrine Falcon populations as well as population trends for the seven other common diurnal raptor species. Because the Florida Keys are situated near the southern end

of the breeding distributions of most North American raptor populations, potential source areas for Florida Keys migrants are vast, and mostly unknown. I summarize 6 yr of raptor migration count data from Curry Hammock State Park to document the magnitude and timing of raptor migration through the Florida Keys. I also compare Curry Hammock count totals with nine other raptor migration count sites across North and Central America to place raptor migration through the Florida Keys in the context of the major raptor migration concentration points within the Nearctic-Neotropical migration system and to demonstrate the particular importance of these counts for monitoring long-term trends in Peregrine Falcon populations.

METHODS

Study Site. The Florida Keys are an approximately 170-km-long island chain that trends northeast to the southwest from the southern tip of the Florida peninsula (Fig. 1). The Curry Hammock hawkwatch was located in the middle Florida Keys at Curry Hammock State Park, on Little Crawl Key, just northeast of the town of Marathon at 24°44.50′N, 80°59.00′W. Earlier, simultaneous counts at multiple locations throughout the Florida Keys demonstrated that the flight path of migrant raptors tends to be most concentrated in the middle Keys due to the relatively narrow landmass and the lack of alternative overland routes that are formed by strings of offshore islands in both the Upper and Lower Keys (Hoffman and Darrow 1992). HWI chose Curry Hammock State Park as the hawkwatch location based on the combination of its favorable location in the middle Keys and open public access, which has allowed us to develop a complementary environmental education program.

For 6 km in either direction from the Curry Hammock hawkwatch, the middle Keys are typically less than 1 km wide (range 0.1–2 km in width). Birds that travel over land or slightly offshore within this area are often visible to the naked eye. We assumed that nearly all birds flying in the area of Curry Hammock State Park were detectable by binoculars, regardless of distance or direction from the hawkwatch. To qualitatively test this assumption, pairs of observers made simultaneous observations from both the north end of Long Point Key and the hawkwatch platform on Little Crawl Key on two different days when the primary flight line was well offshore of Long Point Key to the north (Fig. 1). This was the greatest distance from the Curry Hammock hawkwatch platform that we ever observed migrating raptors in this part of the Florida Keys. Observers at the hawkwatch communicated numbers and species of migrating birds they saw to observers on Long Point Key by radio in real time. Although many of these birds were nearly 2.5 km from the hawkwatch, birds were still easily detectable with binoculars and identifiable with a 30× spotting scope, suggesting that regardless of the daily flight path (which shifts with local weather conditions), migrant raptors were detectable from the hawkwatch platform.

The hawkwatch was on the elevated deck of a park restroom. The area around the hawkwatch had been cleared of vegetation in preparation for a development project that never came to fruition and observers had a relatively unobscured view of the sky in all directions. The vegetation surrounding the hawkwatch was mostly native grasses and mixed small native trees; primarily Red Mangrove (*Rhizophora mangle*) or Buttonwood (*Conocarpus erectus*). Observers standing on the deck at the hawkwatch could see over most of these trees; however, some trees to the north and west of the site made detection of distant low-flying birds difficult. Consequently, observers scanned this area more frequently, particularly on windy days when birds were most likely to fly low. This ''blind spot'' may have resulted in undercounting some species that often migrate at low altitudes through the Florida Keys, particularly Merlins (*F. columbarius*).

Count Period. Previous full-season counts of migrating raptors in the Florida Keys by Brashear and Stoddard (2001) began as early as 5 August. Data from these counts indicated limited passage of most species before 15 September or after 13 November. Exceptions included small numbers of Swallow-tailed Kites (*Elanoides forficatus*) and Ospreys (*Pandion haliaetus*) in August and early September. In this study, two official observers conducted standardized daily counts of migrating raptors at Curry Hammock State Park between 15 September and 30 October, 1999, and between 15 September and 13 November each year from 2000–04. The shorter count period in 1999 was due to limited start-up funds.

Daily counts were conducted from 0800–1600 Eastern Standard Time (EST). Previous counts by Brashear and Stoddard (2001) indicated low numbers of observations after 1600 EST on most days. However, occasional, large, late-afternoon flights (mostly by American Kestrels [*F. sparverius*], Ospreys, and Northern Harriers [*Circus cyaneus*]), were observed. To reduce the chance of missing these late-afternoon flights, observers employed the ''15-min rule,'' and stayed open for an additional 15 min if more than 10 southbound birds were counted during the last 15 min of the count. Thus, if more than 10 southbound birds were counted between 1545–1600, observers continued observations until the first 15-min period went by with fewer than 10 southbound migrants observed.

Observers. Two primary observers conducted the daily count each year. All observers had at least one full season of experience as a primary hawk counter at another migration site in North America and were capable of identifying migrant raptors in flight prior to being hired in the Florida Keys. Each primary observer worked 5–6 d per wk. On their days off, another similarly qualified observer filled in as a primary observer. At the beginning of each season, new observers were trained in count data collection protocols, ensuring that scanning routines, flight-line coverage, and counting, recording, and data entry protocols were consistent among years. Observer experience and quality remained fairly consistent across all 6 yr of the count.

Count and Data Collection Protocols. Observers used high quality 8–10× binoculars to spot and identify migrating raptors. Wide-angle 30× spotting scopes were used to assist in the identification of distant birds. Dunne et al. (1988), Wheeler and Clark (1995), and Clark and Wheeler (2001) served as primary identification references. Both observers scanned the sky regularly with naked eyes,

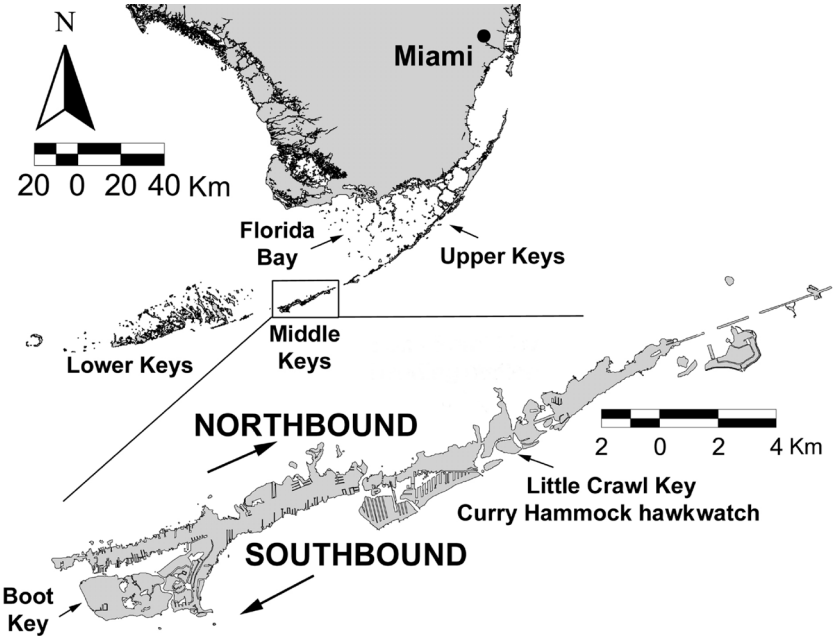

Figure 1. Map of south Florida and the Florida Keys. Detailed inset map at bottom shows the Middle Keys near the Curry Hammock hawkwatch.

dividing the sky into quadrants of responsibility depending on the flight patterns of the day. Observers systematically scanned more distant areas with binoculars once every 1–2 min.

Observers recorded the species and flight direction of each migrant raptor seen from the watch site. Migrants following the Keys from the northeast to southwest were classified as southbound and migrants traveling southwest to northeast were classified as northbound (Fig. 1). Multiple-tab clickers were used to tally sightings for common species on busy days, minimizing the amount of time spent looking away from the sky while recording data. Hourly totals for each species were transferred from the clickers to the datasheets at the end of each hour. Mechanical hand clickers were used to count individuals in large flocks (200–800 individuals). Observers were conscious of the potential to count resident raptors as migrants and care was taken to follow the flight paths of common resident or wintering species well to the south or north of the count site before each bird was recorded as a migrant. Resident Ospreys were common around the hawkwatch in all years and Bald Eagles (*Haliaeetus leucocephalus*) were regular around the hawkwatch in some years. Individual resident Bald Eagles were identifiable by unique plumages. Resident Ospreys frequently vocalized as migrants passed through, simplifying their identification as residents; however, because they were so common as residents, observers spent additional time ensuring that migrant Ospreys continued to fly well past the hawkwatch and out of site to the south. Nonetheless, some resident Ospreys may have been counted as migrants. After the fall 2000 season, observers stopped counting the large flocks of Turkey Vultures (*Cathartes aura*) that move throughout the Florida Keys in late fall and early winter (Darrow 1983), because the flight direction of these flocks was often difficult to determine and observers frequently observed the same flock of vultures heading north and south several times on the same day.

Count Totals. Count totals are represented in tables and figures as southbound, net, or percent northbound sightings. Southbound totals best represent the total number of birds that migrate into the Middle Keys each fall, regardless of their final wintering destination. Southbound totals include both the birds that continue to the south of the hawkwatch and the birds that head south past the watch site and later reverse the direction of their flight, passing by the hawkwatch again on their way north. Net totals represent southbound observations minus northbound observations for each species. Therefore, net totals reflect the number of individuals that continue past the count site to either winter in the lower Keys or continue their migration through the Caribbean. Some species with a high percentage of northbound sightings (such as Broad-winged Hawks [*Buteo platypterus*] and Swainson's Hawks [*B. swainsoni*]) may move back and forth through the Keys more than once during the migration period and are thus likely to be counted more than once as they repeatedly pass the hawkwatch. For these two species, net totals may be closer to the true number of birds that pass through the Middle Keys than southbound totals.

I compared southbound totals from the Florida Keys for the 6 yr between 1999–2004 with count totals from other major raptor migration sites in North America for this same range of years (unless otherwise noted in Table 3). I selected nine raptor migration sites for comparison that are representative of the major regions where flights of

migrating raptors are known to concentrate during fall in North America (Heintzelman 1986, Kerlinger 1989, Smith and Hoffman 2000). Each of these sites met the four following criteria: (1) count data were available for 1999–2004 (see Table 3 for one exception); (2) standard data collection protocols were employed for this range of years; (3) the count period at each of these sites encompassed the full migration period for each of the eight common species included in comparisons; and (4) permission was obtained to present count totals in this paper for this comparison. In some cases, counts from multiple sites within a single region (e.g., the Appalachian Mountains, the Great Lakes, or the North Atlantic Coast) were available, but data from only a single representative site for each region were included in this comparison. Other sites within these same regions typically have similar species compositions and relatively similar count totals. Annual count totals from count sites were obtained from the Hawk Migration Association of North America's online database (www.hawkcount.org), websites for individual hawk migration sites, or directly from count site coordinators (see Table 3).

Passage Dates. Average median and bulk passage dates of raptors through the Florida Keys were calculated for all species with more than 20 southbound sightings per year using daily totals for each of the years between 2000–04. Data from 1999 were not included in these calculations because this season ended 14 d earlier than the other five seasons. Bulk passage dates were the range of dates between which the central 80% of the entire season's southbound total for each species passed through the Florida Keys (i.e., the first date is the date by which 10% of the season's cumulative sightings have been made and the last is the date by which 90% of the season's cumulative sightings have been made).

RESULTS

Observation Effort. Observation dates varied slightly across the six years of this study (CV = 8%). Some of this variation is related to different start dates among years (see Methods) and the rest is due to different amounts of full-day closures among years due to mandatory hurricane evacuations. In 2004, the start date for the count was delayed 4 d due to a mandatory evacuation of the Florida Keys for Hurricane Ivan. Observations were cancelled for one full day five different times between 1999–2004. Other than these five within-season full-day closures due to hurricanes or extreme weather, daily counts were rarely suspended for more than 1 hr due to rain and observers continued to count migrants during light to moderate rains. The number of hours of observation per day varied only slightly among years (range 6.8–8.4 hr/d).

Count Totals. Between 1999–2004, observers counted an average southbound total (excluding Turkey Vultures) of 15 036 raptors (CV = 10%) of 16 different species (Table 1). Eight raptor species comprised 98% of all southbound observations. Broad-winged Hawks were the most abundant raptor observed, followed by Sharp-shinned Hawks (*Accipiter striatus*), American Kestrels, Peregrine Falcons, Ospreys, Northern Harriers, Merlins, and Cooper's Hawks (*A. cooperii*; Table 1). Six species were uncommon during fall migration, averaging 11–84 observations per yr. These were: Swainson's Hawks, Short-tailed Hawks (*B. brachyurus*), Mississippi Kites (*Ictinia mississippiensis*), Red-shouldered Hawks (*B. lineatus*), Bald Eagles, and Swallow-tailed Kites. Two species averaged fewer than two sightings per year: Red-tailed Hawks (*B. jamaicensis*), and Black Vultures (*Coragyps atratus*). Observers counted 11 932 southbound Turkey Vultures in 2000, the only year when this species was counted during their peak migration into the Florida Keys.

Species abundance ranks for net totals differed from those for southbound totals (Table 1). Most notably, net totals for Broad-winged Hawks were much lower than southbound totals, reflecting the high proportion of northbound sightings for this species. Sharp-shinned Hawks and American Kestrels had the highest net totals of all species (Table 1). Net totals were also high for Peregrine Falcons, Broad-winged Hawks, Ospreys, Northern Harriers, Merlins, and Cooper's Hawks. A net total of 3720 Turkey Vultures were counted in 2000, suggesting that only a small percentage of the 11 932 Turkey Vultures observed heading south at Curry Hammock continued their migration to the south of the Florida Keys. Northbound birds comprised 21% of all observations across all years of the count (Table 1). For species with more than 500 observations per year, this ranged from a high of 35% in Broad-winged Hawks to a low of 4% for American Kestrels and Northern Harriers.

Seasonal Timing of Migration. Fall raptor migration through the Florida Keys took place within a relatively short time frame from mid-September through early November. However, the timing of migration within this window varied among years and daily counts varied considerably within each season. Each fall, there was a large number of days (47–70% of d per yr) with very low counts, <1% of the entire season's total. Conversely, infrequent and large, single-day flights often accounted for a large percentage of the entire season's total. In the 6 yr between 1999–2004, the 5 d with the highest count totals within each season accounted for between 32–47% of the total annual count for all species combined.

The seasonal timing of raptor migration through the Florida Keys varied among species (Table 2).

Table 1. Southbound and net count totals (and percentage of northbound sightings) for the raptor migration count at Curry Hammock State Park, Florida Keys, FL, 1999–2004.

	Yearly Southbound Totals						1999–2004 South		1999–2004 Net		Mean Annual
Species	1999	2000	2001	2002	2003	2004	Mean	CV	Mean	CV	% North
Black Vulture		2									
Turkey Vulture[a]	2800	11 932									
Osprey	937	1093	983	1657	1431	925	1171	26	1070	27	8
Swallow-tailed Kite	6	4	17	8	21	10	11	60	11	60	0
Mississippi Kite	22	13	57	14	14	7	21	86	21	88	2
Bald Eagle	11	17	19	21	15	14	16	22	10	52	28
Northern Harrier	786	527	741	451	531	371	568	29	542	29	4
Sharp-shinned Hawk	4741	4547	3697	1856	2195	2764	3300	37	2819	34	11
Cooper's Hawk	424	839	335	289	348	1036	545	57	466	59	12
Red-should. Hawk	33	35	7	1	5	12	16	95	10	104	27
Broad-winged Hawk	3286	2984	3535	5194	5237	3121	3893	27	1703	58	35
Short-tailed Hawk	16	27	38	37	16	38	29	37	18	52	24
Swainson's Hawk	31	146	109	36	44	137	84	63	33	95	29
Red-tailed Hawk	2		5	2	1	1	2	75	1	64	19
American Kestrel	3631	3029	4338	1825	2130	1849	2800	37	2675	38	4
Merlin	834	522	581	609	459	317	554	31	475	25	11
Peregrine Falcon	1569	1894	1432	2001	2858	1695	1908	27	1790	27	6
Unidentified raptors	226	127	36	77	149	98	119	55	104	54	11
Total (no vultures)	16 555	15 804	15 930	14 078	15 454	12 395	15 036	10	11 746	16	21

[a] Observers stopped counting Turkey Vultures at the end of the 2000 season.

Mississippi Kites, Ospreys, and Merlins were early season migrants and Short-tailed Hawks and Swainson's Hawks were late season migrants. Among the common species, annual passage dates were fairly predictable, and median passage dates showed less annual variation than peak passage dates (Table 2). Bulk (80%) passage took place over a relatively small number of days for some species (e.g., Peregrine Falcons, Sharp-shinned Hawks, and American Kestrels; Table 2) and was more protracted for other species (e.g., Cooper's Hawks and Northern Harriers; Table 2).

Table 2. Median, peak, 80% bulk passage dates, and high single-day southbound counts for all diurnal migrant raptor species with more than 20 southbound sightings per yr at Curry Hammock State Park, Florida Keys, FL, 2000–04.

			No. of		Median		Peak		Single	High
Species	80% Passage Dates		Days	SD	Date	SD	Date	SD	Day High	Count Date
Osprey	21 Sep	18 Oct	27	10	1 Oct	4	8 Oct	11	340	1 Oct 2001
Mississippi Kite	18 Sep	7 Oct	19	6	23 Oct	6	23 Sep	8	23	16 Sep 2001
Northern Harrier	26 Sep	5 Nov	39	7	14 Oct	8	18 Oct	7	150	18 Oct 1999
Sharp-shinned Hawk	5 Oct	26 Oct	21	5	16 Oct	1	15 Oct	4	873	18 Oct 1999
Cooper's Hawk	28 Sep	28 Oct	29	9	13 Oct	4	11 Oct	7	127	4 Oct 2002
Broad-winged Hawk	29 Sep	30 Oct	31	7	11 Oct	4	10 Oct	7	883	16 Oct 2004
Short-tailed Hawk	13 Oct	7 Nov	25	3	26 Oct	7	25 Oct	9	9	21 Oct 2004
Swainson's Hawk	20 Oct	8 Nov	20	5	31 Oct	6	28 Oct	9	40	9 Nov 2001
American Kestrel	4 Oct	26 Oct	22	3	13 Oct	5	13 Oct	8	966	1 Oct 2001
Merlin	22 Sep	19 Oct	27	9	3 Oct	2	1 Oct	5	91	30 Sep 2003
Peregrine Falcon	26 Sep	17 Oct	20	5	3 Oct	2	7 Oct	8	521	1 Oct 2003
Eight common species	28 Sep	26 Oct	28	4	12 Oct	2	12 Oct	6	2590	18 Oct 1999

Table 3. Mean count totals (1999–2004 unless otherwise specified in footnotes) for 10 major raptor migration count sites within the Nearctic-Neotropical migration system for the eight species of diurnal raptors that are common during fall migration in the Florida Keys.

Site	Region	Osprey	Northern Harrier	Sharp-shinned Hawk	Cooper's Hawk	Broad-winged Hawk	American Kestrel	Merlin	Peregrine Falcon
Hawk Ridge, MN[1]	W. Great Lakes	387	564	16 758	179	70 968	2370	181	67
Holiday Beach, ON[2]	E. Great Lakes	89	761	10 194	455	27 016	2155	73	45
Hawk Mt., PA[3]	Appalach. Mtns	652	225	3948	740	7314	514	132	49
Cape May Pt., NJ[4]	N. Atlantic Coast	1987	1390	17 226	3426	1204	6592	1672	903
Smith Point, TX[5]	N. Gulf Coast	65	329	2639	1118	46 816	1404	62	92
Florida Keys, FL[6]	**Florida Peninsula**	**1171**	**568**	**3300**	**545**	**3893**	**2800**	**554**	**1908**
Goshute Mtns, NV[7]	Mountain West	119	191	5046	3201	77	2298	42	17
Manzano Mtns, NM[8]	Rocky Mtns	34	42	1433	1140	9	500	22	83
Veracruz, Mexico[9]	S. Gulf Coast	3090	357	3612	2587	1 946 389	6657	149	754
Kekoldi, Costa Rica[10]	Mesoamerica	1071	7	20	19	531 326	8	51	1384

[1] Hawk Ridge Bird Observatory, unpublished data for counts 15 Aug–30 Nov. Data acquired from http://www.hawkridge.org
[2] Holiday Beach Migration Observatory, unpublished data for counts 1 Sep–29 Nov. Data acquired from http://www.hbmo.org
[3] Hawk Mountain Sanctuary, unpublished data for counts 15 Aug–30 Nov. Data provided by Christopher J. Farmer.
[4] NJ Audubon Society, unpublished data, 1 Sep–30 Nov. Data acquired from: http://www.njaudubon.org/Sightings/cmhw25.html for 1999–2001 and http://hawkcount.org/index.php for 2002–04.
[5] Smith et al. (2001) and HawkWatch International, unpublished data, 15 Aug–15 Nov. Data provided by Jeff P. Smith.
[6] HawkWatch International, this study.
[7] Hoffman and Smith (2003) and HawkWatch International, unpublished data, 15 Aug–5 Nov. Data provided by Jeff P. Smith.
[8] Hoffman and Smith (2003) and HawkWatch International, unpublished data, 27 Aug–3 Nov. Data provided by Jeff P. Smith.
[9] Pronatura A.C. Veracruz, Hawk Mountain Sanctuary, and HawkWatch International, unpublished data, 20 Aug–20 Nov, Cardel and Chichicaxtle sites combined.
[10] Porras-Penaranda et al. (2004), 7 Sep–15 Dec in 2000 and 3 Sep–30 Nov in 2001. Totals for 2000–01 only.

Comparisons with Other Migration Count Sites. Count totals for many species in the Florida Keys were comparable to totals from nine other hawk migration count sites representative of the major known hawk migration concentration points in North America (Table 3). Mean annual Florida Keys count totals for Peregrine Falcons were considerably higher than counts in any other region of North America. Totals in the Florida Keys for Ospreys, American Kestrels, and Merlins were second only to north Atlantic coast hawkwatches (represented here by Cape May) in the United States and Canada. Florida Keys count totals for Northern Harriers were similar to totals from several of the other major concentration points for this species in North America. In the southern U.S., count totals for Sharp-shinned Hawks were higher than the other major coastal concentration point at Smith Point on the upper Texas coast. Count totals for Cooper's Hawks in the Florida Keys were lower than totals from many other sites, reflecting the position of this site near the southern limit of their wintering range in the eastern U.S. Count totals for Broad-winged Hawks in the Florida Keys, although substantial, did not come close to rivaling the large concentrations of this species counted at many other locations, particularly those along the west side of the Gulf of Mexico.

DISCUSSION

The Florida Keys are a migration concentration point of similar magnitude to other major, well-known raptor migration sites in North America, such as Cape May, New Jersey, Hawk Mountain, Pennsylvania, or the Goshute Mountains, Nevada. Count totals for Peregrine Falcons in the Florida Keys were considerably higher than totals from any other site in North America. If continued for the long term, raptor migration counts in the Florida Keys will provide high-quality, cost-effective data for monitoring Peregrine Falcon population trends and population trends for seven other common spe-

cies of diurnal migrant raptors. The value of any given raptor migration count site for monitoring long-term population trends may be evaluated relative to: (1) the number of raptors counted at that site compared with the size of the breeding population that is to be monitored (Bart and Ralph 2005); (2) the coefficient of variation of annual counts, which contributes to statistical power to estimate long-term trends (Lewis and Gould 2000); and (3) the geographic representation (i.e., source areas) of migrants that are counted each year at that site. In each of these categories, long-term counts at Curry Hammock State Park can provide important data for monitoring North American raptor population trends.

White et al. (2002) summarized estimates of the number of breeding Peregrine Falcon pairs in North America as 5650–7000. This estimate included the U.S.A., Canada, Greenland, and Mexico. Previous migration banding and telemetry data suggested that individuals of the *pealei* subspecies and individuals of the *anatum* subspecies in the Pacific Northwest, Rocky Mountains, Southwestern U.S., and Mexico most likely do not migrate through the Florida Keys (White et al. 2002). Thus, the potential source population for Florida Keys migrant Peregrine Falcons may be defined as all individuals of the *tundius* or *anatum* subspecies from Alaska, Canada, Greenland, or the U.S.A. east of the Mississippi River (referred to hereafter as the ''boreal and eastern U.S. population''). The boreal and eastern U.S. population was estimated as 3434–4360 pairs by White et al. (White et al. 2002). Given these breeding population estimates and recent productivity estimates of 1.3–2.5 young per pair (White et al. 2002), I calculated that approximately 7345–17 500 young peregrines are produced in North America each year (which includes 4464–10 900 within the boreal and eastern U.S. population). White et al. (2002) suggested that there was approximately one nonbreeding adult ''floater'' per breeding pair. Therefore, by combining breeding adults, adult floaters, and young-of-the-year, I estimated that total Peregrine Falcon population size in North America peaks at 24 295–38 500 individuals at the end of each breeding season and the boreal and eastern U.S. population peaks at 14 765–23 982. From the population estimates above and our mean annual count of 1908 peregrines, it appears that approximately 5.0–7.9% of all North American Peregrine Falcons (and 8.0–12.9% of all boreal and eastern U.S. peregrines) were counted in the Florida Keys each fall. Similarly robust population estimates do not exist for other species of diurnal raptors.

For the eight common migrant species in the Florida Keys, annual coefficients of variation for counts ranged from 26%–37% (with the exception of Cooper's Hawks, which had a CV of 57%). These CVs were lower than those for many of the raptor migration site and species combinations reported in Lewis and Gould (2000) and counts for seven of the eight common migrant species in the Florida Keys also met the statistical power criteria for monitoring long-term trends (80% power to detect a 50% decline over 20 years with a level of significance of 0.10, using a two-tailed test) that was suggested by Bart et al. (2004). One possible reason for the relatively low CVs of annual counts observed in the Florida Keys is that raptors in the Florida Keys may remain detectable regardless of wind direction at this site because the landmass is so narrow and raptors that are following the island chain can be seen offshore in either direction, regardless of which direction they are drifting offshore due to local winds. In contrast, coastal sites in areas with alternate inland routes may only detect raptors on days where wind conditions concentrate the flight of migrating raptors along the shore. On days with on-shore winds at other locations, many other sites may not detect raptors as their flight-lines shift inland. Thus, a reduced effect of wind direction on detectability may play a part in the relatively low CVs of annual counts in the Florida Keys.

Data from the Florida Keys will contribute to the Raptor Population Index (RPI), a collaborative effort by HWI, Hawk Migration Association of North America, Hawk Mountain Sanctuary, and several other partners that is designed to pool data from a network of raptor migration count sites to estimate population trends for North American raptors (MacLeod 2004). Given the large volume of raptor migration and the unique geographic position of the Florida Keys (far to the south and east of the other major hawkwatch locations in North America), count data from Curry Hammock State Park will provide important data to RPI. The far southern location of this site relative to the breeding distributions of all eight common migrant species ensures that counts in the Florida Keys will contribute population trend data for at least some individuals that are not counted at northern hawkwatch sites during fall migration, thus improving the spatial coverage of this continental network of raptor migration count sites designed to document North American raptor population trends.

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