Using Autumn Hawk Watch to Track Raptor Migration and to Monitor Populations of North American Birds of Prey[1]

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Abstract

Raptors are secretive, area-sensitive predators whose populations can be logistically difficult and financially prohibitive to monitor. Many North American populations of raptors are migratory however, and on migration raptors are frequently counted at traditional migration watchsites. Experiences at Hawk Mountain Sanctuary (HMS) and elsewhere suggest that long-term migration counts can be used to monitor regional populations of raptors. Hawkwatchers have collected count data on standardized Hawk Migration of North America (HMANA) Daily Report Forms since the mid-1970s. In 1998 HMS, HMANA, the National Audubon Society, and the Lab of Ornithology at Cornell University began Internet-based data entry of migration watchsite counts at the BirdSource website. By autumn 2002, the *Autumn Hawk Watch* web page was collecting and displaying daily count reports from 66 watchsites in three Canadian provinces, 26 United States, and in Mexico, Costa Rica, and Bolivia. *Autumn Hawk Watch* provides participants and interested parties with near real-time maps and tables that document the movements of raptor migration across the Americas each autumn. The web page also captures count data for later use in monitoring raptor populations, and provides HMANA with timely summaries of each count, which are published in the HMANA *Journal of Hawk Migration Studies*.

Key Words: Autumn Hawk Watch; Hawk Migration Association of North America; Hawk Mountain Sanctuary; Internet; migration monitoring; raptors.

Introduction

Raptors are wide-ranging and often secretive predatory birds, many of whose populations are logistically difficult and financially prohibitive to survey and monitor (Bildstein 1998). One particularly cost-effective method for monitoring populations of these birds is to sample regional and even continental populations at traditional migratory bottlenecks and concentration points (Zalles and Bildstein 2000). An incipient network of raptor migration watchsites (i.e., lookout points typically situated on mountain-tops, coastal plains, river valleys, and lakesides and other migration "leading lines") exists in North America, and during the past 70 years migrants have been counted on a regular or irregular basis at more than 1,800 short-term or permanent watchsites (McCarty et al. 2000).

Although most raptor migration watchsites are in the northeastern United States, the recent addition of season-long migration counts at sites in Gulf Coast Texas (Smith et al 2001) and Mexico (Zalles and Bildstein 2000), and in Caribbean slope Costa Rica (Bildstein, pers. obs.), together with the establishment of an array of watchsites in the western United States in the 1980s (Smith and Hoffman 2000), has created a potentially effective network for assessing regional and continental populations of migratory birds of prey. Since the mid 1970s, most migration data have been collected using Hawk Migration Association of North America (HMANA) Daily Report Forms, or "green sheets." As such, much of the information collected at these sites is compatible and regional and continental assessments of population change are possible. Unfortunately, most of this information is not available in electronic format in a single database, making broad-scale, multi-site analyses difficult. However, monitoring numbers of migrating hawks at single migration watchsites has been used to great effect (e.g., Carson 1962, Newton 1979, Kerlinger 1989, Bednarz et al 1990, Zalles and Bildstein 2000, Mueller et al. 2001), and the use of data from networks of sites holds great promise. The establishment of several North American-style, season-long count efforts in Mesoamerica and the Caribbean Basin in the past 10 years, for example, increases the potential for tracking world populations of three species, Mississippi Kite (*Ictinia mississippiensis*), Broad-winged Hawk (*Buteo platypterus*), and Swainson's Hawk (*B. swainsoni*), as well as continental populations of a fourth species, Swallow-tailed Kite (*Elanoides forficatus*) (Zalles and Bildstein 2000, Bildstein and Zalles 2001).

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Here we (1) report several examples of how a single-site, long-term migration watchsite database has been used to track changes in raptor populations and migration behavior, and (2) describe a new webpage that uses the power of the Internet to capture, analyze, and display the results of counts at a network of migration watchsites across North and Central America.

The Conservation Potential of Migration Watchsite Count Data

Hawk Mountain Sanctuary (HMS) was founded in 1934 by conservationist Rosalie Edge to stop the shooting of thousands of migrating raptors along the Kittatinny Ridge in the central Appalachian Mountains of eastern Pennsylvania, 120 km northwest of Philadelphia, Pennsylvania. In late September 1934, Hawk Mountain's Maurice Broun began counting migrating raptors from what was then called Observation Rocks. Although Broun's counts were initiated primarily to document the numbers of raptors being "saved" at the Sanctuary, so as to enlist financial support for the conservation effort, it quickly became apparent that a series of annual counts would enable conservationists to monitor regional populations of birds of prey. Today, Hawk Mountain maintains the longest and most complete record of raptor migration in the world (Bildstein and Compton 2000).

One of the first conservation uses of the Hawk Mountain long-term database was an analysis of annual ratios of juvenile and adult Bald Eagles (*Haliaeetus leucocephalus*) seen at Hawk Mountain before and after the widespread use of DDT in mid-20th Century North America. A bimodal pattern in the seasonal timing of the flight of Bald Eagles at Hawk Mountain, with a major movement in late August-early September, and a second smaller movement peaking in mid-November, suggested that although both "southern" and "northern" birds migrated at the site, most of the birds were southern Bald Eagles nesting in Florida. In 1952, a concerned Maurice Broun began commenting on a substantial decline in the ratio of juvenile-to-adult Bald Eagles at the site, which began in the late 1940s and, thereafter, remained low through the 1950s, 1960s, and mid-1970s (Bildstein 1998). A decade after Broun reported the shift, Rachel Carson used the same database in *Silent Spring* to support her arguments for the impact of organochlorine pesticides on populations of Bald Eagles and other species of predatory birds (Carson 1962).

Particularly notable is that the same database, which now extends into the 21st Century, was also used to track the eventual recovery of Bald Eagle populations following bans on DDT in Canada and the United States in the early 1970s. Even more remarkable is that shifts in overall numbers of Bald Eagles seen at the site lagged declines and subsequent increases in the ratios of juvenile-to-adult birds by 5 to 10 years, exactly as expected if the shifts in ratios of age classes reflected shifts in reproductive success in the monitored population (Bildstein 1998).

A more recent example of the utility of the HMS database involves its use, together with counts from other migration watchsites and information from additional geographically explicit databases. Beginning in the 1980s and extending into the early 1990s, many migration watchsites in the northeastern United States began reporting substantial declines in numbers of Sharp-shinned Hawks (*Accipiter striatus*). The declines were especially notable at coastal watchsites, where flights consisted largely of juvenile individuals. Although initial reports of the decline were accompanied by suggestions of natural population cycling or shifts in wintering range, by the early 1990s additional reports became more ominous, and included suggested links to widespread habitat or prey-base loss induced by acid precipitation or declines in populations of Neotropical songbird migrants (Viverette et al. 1996).

To test the hypothesis that the declines resulted from northward shifts in wintering areas of the regional population, researchers at Hawk Mountain compared migration count data from the Sanctuary and Cape May Point, New Jersey with those from National Audubon Society Christmas Bird Counts (CBCs) north and south of the two migration watchsites. The analysis of CBCs conducted from 1979 through 1989 revealed that numbers of Sharp-shinned Hawks seen on CBCs north of the two migration count sites increased substantially whereas numbers seen on CBCs south of the two watchsites had not. The results support the shift-in-migration behavior hypothesis (i.e., migratory short-stopping). That Cape May Point counts declined more abruptly than those at Hawk Mountain may reflect the fact that the Sharp-shinned Hawk flight at the former site consists almost entirely of juvenile individuals, whereas that at the latter includes many more adults. Juveniles are more likely to modify their migration patterns in light of changed environmental conditions than are adults (Berthold 1993).

Although the reason for the shift in behavior remains uncertain, the change coincided with a series of particularly mild winters, as well as with increases in the numbers of backyard birdfeeders in northeastern North America. Sharp-shinned Hawks rank above domestic cats (*Felis catus*) as the number one predator of birds at backyard birdfeeders (Dunn and Tessaglia 1994), and the growing number of bird feeders in the northeastern United States together with milder winters may have combined to produce the shift (Viverette et al. 1996).

This latter example suggests the utility of migration counts in documenting shifts in migratory behavior, as well as in documenting changes in overall population, and also highlights the importance of using count data in conjunction with other geographically explicit databases such as the Christmas Bird Count.

Realizing the Conservation Potential of Migration Watchsite Count Data Using *Autumn Hawk Watch*

HMANA was founded in 1974 when it became clear (1) that large numbers of individuals were starting to count raptors on migration, (2) that it was important to organize the wealth of information derived from those counts, and (3) that there was a need to develop a standard field sheet to collect these data. The plan was to distribute count data to the public and the scientific community, and to improve techniques to monitor populations of birds of prey (Roberts 2001). Today, cooperators at several hundred watchsites across the continent report their results to HMANA each year, contributing this information to a growing archive of more than 80,000 standardized daily report forms (DRFs). Most of the counts are reported in the HMANA journal every year (*fig. 1*).

In 1996, HMS partnered with HMANA and began cataloging and archiving the DRFs. In an effort to make the data more available to potential users, as well as to speed the summarization and analyses of the data, in 1998 HMANA, HMS, the National Audubon Society (NAS), and the Laboratory of Ornithology at Cornell University (CLO) created the *International Broad-winged Hawk Survey*. The *Survey* enabled hawkwatchers from North to South America to enter counts of migrating Broad-winged Hawks into a web-based data set and to view their collective results in near real-time animated maps of "waves" of these raptors migrating across North America. In 1999 the web page (now called *Autumn Hawk Watch*) was expanded to include all species of diurnal raptors migrating in North America, as well as information on weather conditions.

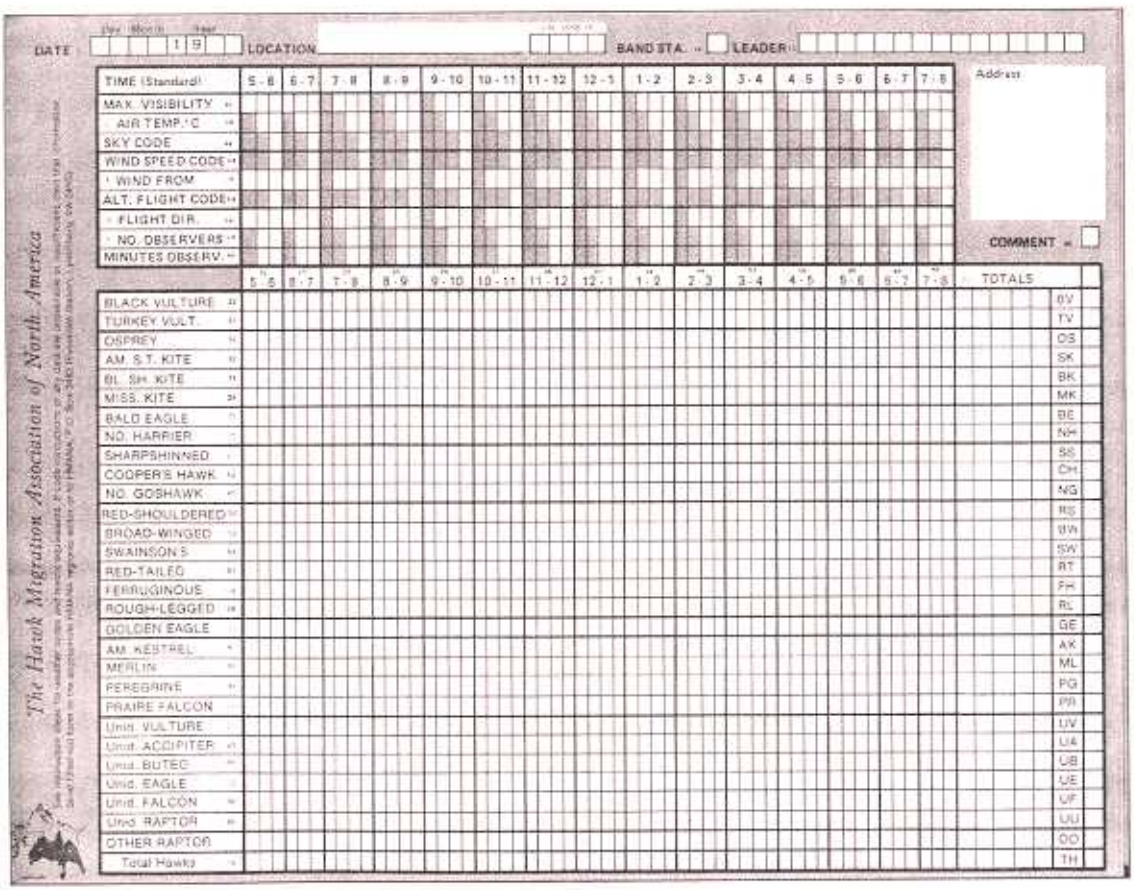

Figure 1—The Hawk Migration Association of North America daily report form, a "green sheet."

In order to simplify the transition for hawkwatchers from a paper to an electronic archive, the *Autumn Hawk Watch* data entry web page was designed after the DRF and uses the same codes for weather variables already familiar to hawkwatchers. After data entry, watchsite coordinators can print summaries of daily counts for their site, and users of *Autumn Hawk Watch* can view and print counts from all watchsites, making the timely entry of count data by each watchsite coordinator essential to the value of the web page to other users.

To enhance the educational impact of the raw count data, and to track the migration as it happens, *Autumn Hawk Watch* generates a series of animated maps for 29 raptor species showing the abundance of migrants recorded at each watchsite over 1-day, 5-day, or 10-day intervals throughout the entire count period, generally running from August to December, and also creates cumulative, static maps and tables by species over 5-day or 10-day periods, or for the entire count period (*fig. 2*). Users also can view counts from a single watchsite, shown in tabular format for a specific date or over 5-day periods (*fig. 3*).

The effectiveness of the *Autumn Hawk Watch* database toward realizing the potential to track raptor populations is tied to ensuring accuracy of data entry and helping project coordinators to control data quality for their watchsite. To reduce errors made during data entry, CLO and HMS fulfill administrative functions within *Autumn Hawk Watch*, such as maintaining regional checklists of migratory raptors, placing count limits on each species based on geographic regions and time of year, and alerting users if they report unusual sightings of a species or enter counts exceeding the limits. Another important feature of *Autumn Hawk Watch* is its ability to accept sporadic or even anecdotal data. Thus, single days of observation at an individual site, or even partial days of observation, can be accepted and archived in the geographically explicit database for future use. Since many watchsites are operated strictly on a part-time or volunteer basis, this type of information is important because it builds a base on which to expand further monitoring efforts.

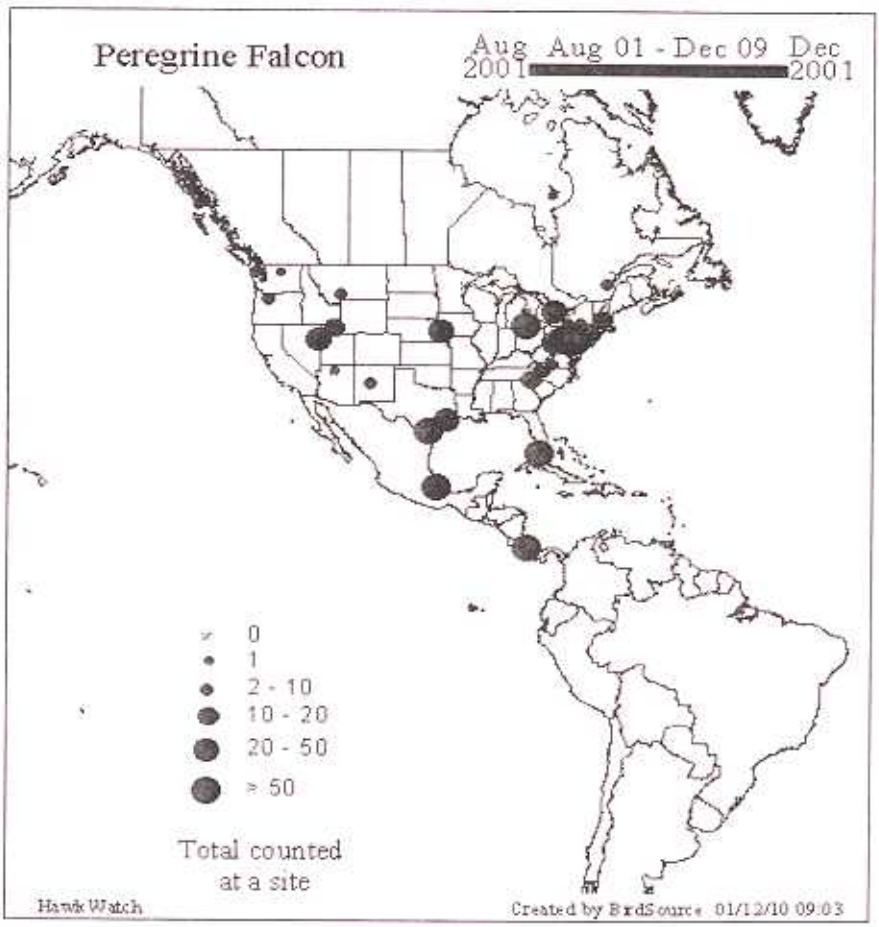

Figure 2—Autumn Hawk Watch map showing counts of Peregrine Falcons (*Falco peregrinus*) from 1 August to 9 December 2001 at all watchsites.

Species	for 10-26	for 10-27	for 10-28	for 10-29	for 10-30	for 10-31	10-26 to 10-31	Total count up to 10-31
Black Vulture *Coragyps atratus*	0	0	2	0	2	0	4	28
Turkey Vulture *Cathartes aura*	6	20	10	3	32	0	71	240
Osprey *Pandion haliaetus*	2	1	0	0	0	0	3	573
Bald Eagle *Haliaeetus leucocephalus*	0	3	1	0	1	0	5	112
Northern Harrier *Circus cyaneus*	5	18	6	1	2	1	33	194
Sharp-shinned Hawk *Accipiter striatus*	40	201	25	7	10	2	285	4664
Cooper's Hawk *Accipiter cooperii*	12	50	17	0	10	1	90	820
Northern Goshawk *Accipiter gentilis*	0	4	13	0	4	1	22	30
Red-shouldered Hawk *Buteo lineatus*	1	17	49	16	12	1	96	180
Broad-winged Hawk *Buteo platypterus*	0	0	0	0	0	0	0	3842
Red-tailed Hawk *Buteo jamaicensis*	52	579	521	68	123	3	1346	2158
Golden Eagle *Aquila chrysaetos*	3	5	8	2	1	0	19	35
American Kestrel *Falco sparverius*	3	0	1	0	0	0	4	580
Merlin *Falco columbarius*	3	2	0	0	0	0	5	170
Peregrine Falcon *Falco peregrinus*	0	0	0	0	0	0	0	34
raptor sp. *Falconiformes*	2	9	0	2	0	0	13	121
Total	**129**	**909**	**653**	**99**	**197**	**9**	**1996**	**13781**

Figure 3—Table generated by the Autumn Hawk Watch web page showing counts of migrant raptors over a 5-day period (26 to 31 October 2001) and total count for the season for Hawk Mountain Sanctuary.

Results from the first four years of the *Autumn Hawk Watch* project indicate that the long-range plans to organize hawk migration data, to make the data more accessible, and to improve techniques to monitor raptor populations are being accomplished. Overall, 99 different watchsites in five countries in North, Central, and South America entered data into the *Autumn Hawk Watch* database in at least one year from 1999 to 2002. Fifty-one watchsites participated in 1999, 53 in 2000, 58 in 2001, and 66 in 2002. In 2001, 53 watchsites were in North America and five were in Central America (*fig. 4; tables 1, 2*). The watchsites averaged 57 days of observation (3333 total days) in 2001, mostly between 26 August and 1 November. (Although impressive, these numbers represent but a fraction of the vast amount of effort expended each year by hawk-watchers in North and Central America.) *Autumn Hawk Watch* tracked the movements of 28 species of raptors in 2001. Most data entry was performed by cooperators at each site; however 16 watchsites provided electronic copies or field sheets of counts to HMS, which then entered the data into the *Autumn Hawk Watch* database. Data entry by watchsite cooperators increases both the accuracy and timely entry of data, and the website works best when participants directly enter their own data. All count data appearing on the website also are published in the HMANA *Journal of Hawk Migration Studies*.

By 2002, count data were reported from three Canadian Provinces, 26 United States, Mexico, Costa Rica, and Bolivia. Fifty-two percent of the sites were in northeastern North America, and more than one-quarter of all sites were in either Pennsylvania or Connecticut. Geographic distribution reflects the numbers of watchsites available. Currently, more participation is needed from the western and, particularly, the central flyways of North America, including the entire Mississippi River corridor.

Conclusions

The long-term goal of *Autumn Hawk Watch* is to advance the ability of ornithologists and amateur hawkwatchers to monitor continental populations of raptors efficiently and to allow rapid information transfer. The *Autumn Hawk Watch* website is designed to accommodate data for 200 known watchsites in North, Central, and South America, with the potential to add any number of new watchsites. Currently, data can be entered from 1998 to the present, and planned entry of historical DRFs from the archive will enhance the expanding database. In addition to the benefits to the hawkwatching and scientific communities, *Autumn Hawk Watch* has the potential for broadening the general public's knowledge of and exposure to the timing, geography, and extensiveness of hawk migration in the Americas.

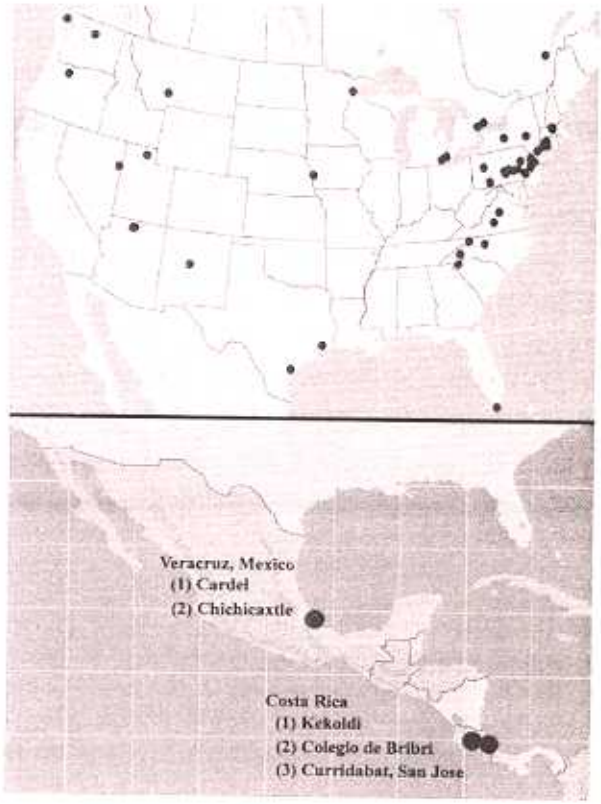

Figure 4—Watchsite locations

Acknowledgments

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Table 1—*Number of watchsites participating in* Autumn Hawk Watch *per year.*

Year	United States	Canada	Mexico	Costa Rica	Bolivia	Total
1999	38	4	2	7	-	51
2000	43	5	2	1	2	53
2001	48	5	2	3	-	58
2002	57	6	1	2	-	66

Table 2—Autumn Hawk Watch *participants, 1999-2002.*

Continent State, country, or province	Watch site	Continent State, country, or province	Watch site
North America: United States			
Arizona	Lipan Point, Grand Canyon	Massachusetts	Blueberry Hill
	Yaki Point, Grand Canyon		Bolton Flats
			Mount Watatic
Connecticut	Bent-of-the-River Sanctuary		Wachusett Mountain State Reservation
	Briggs Hill		Mohonk Preserve
	Chestnut Hill		
	Flat Hill		
	Flirt Hill	Michigan	Southeastern Michigan Raptor Research
	Good Hill		
	Heritage Village		
	Huntington State Park	Minnesota	Hawk Ridge Nature Reserve
	Johnnycake Mountain Farm		
	Lighthouse Point	Montana	Bridgers Mountains
	Maltby Lakes		
	Osborne Hill	Nevada	Goshute Mountains
	Quaker Ridge		
	Torrington Middle School	New Hampshire	Little Round Top
Florida	Curry Hammocks	New Jersey	Cape May Point
			Kittatinny Mountain Raptor Banding Station
Idaho	Lucky Peak		Montclair Hawk Lookout
Illinois	Illinois Beach State Park		Picatinny Peak
			Picatinny Peak – The Domes
Iowa	Hitchcock Nature Area		Raccoon Ridge
	MacBride Nature Recreation Area		Scotts Mountain
Louisiana	Northern Shore of Lake Calcasieu		Sunrise Mountain, Stokes State Forest
Maine	Acadia National Park		Wildcat Ridge Hawkwatch
	Harpswell Peninsula/Casco Bay		
		New Mexico	Manzano Mountains

Table 2 *(continued).*

Continent State, country, or province	Watch site	Continent State, country, or province	Watch site
North America: United States (contd.)			
New York	Central Park	Pennsylvania (contd.)	Waggoner's Gap
	Chestnut Ridge Hawk Watch		Jacks Mountain
North Carolina	Chambers Mountain	South Carolina	Caesar's Head
	Mahogany Rock Mountain		Tibwin Plantation
	Mount Pisgah		
	Pilot Mountain State Park	Texas	Hazel Bazemore Hawk Watch
			Smith Point
Oregon	Bonney Butte		
		Utah	Wellsville Mountains
Pennsylvania	Allegheny Front-Central City		
	Bake Oven Knob	Vermont	Putney Mountain
	Brady's Bend		
	Hawk Mountain Sanctuary	Virginia	Candler Mountain
	Little Gap		Kiptopeke State Park
	Militia Hill		Rockfish Gap
	Rocky Ridge County Park		Snickers Gap
	Rose Tree Park		
	Second Mountain	Washington	Chelan Ridge
	Stone Mountain		
North America: Canada			
British Columbia	Rocky Point Bird Observatory	Ontario (contd.)	Holiday Beach Migration Observatory
			Iroquois Shoreline Raptor Watch
Ontario	Cranberry Marsh		St.-Anne-de-Beaupré
	Hawk Cliff		
	High Park	Quebec	St.-Anne-de-Beaupré
Central and South America			
Bolivia	Concepción	Costa Rica (contd.)	Matina
	Viru-Viru		Puerto Viejo Sarapiqui
			Sixaola
Costa Rica	Bordon		Valle La Estrella
	Colegio de Bribrí		
	Curridabat, San Jose	Mexico	Cardel
	E.A.R.T.H.		Chichicaxtle
	Kéköldi		