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The RPI Website

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Abstract.—Hawkcount.org is an online database system that provides data submission, reporting, and storage services for hawk migration watchsites. Here, I outline current features of the online database system, implementation details, and plans for future system development.

Hawkcount.org is an online database system that provides count and observation data entry, storage, and reporting services for migration watchsites. This system was implemented in 1999–2000 as a single-site data reporting system for the Holiday Beach Migration Observatory watchsite near Amherstburg, Ontario, Canada. This early version provided functionality related to daily reporting of observed raptor counts at the site. Results were made available immediately on the Holiday Beach web site, and automated e-mail reports were submitted daily to various mailing lists, including the BIRDHAWK list maintained by the Hawk Migration Association of North America (HMANA), regional bird-related mailing lists, and others.

One of the primary goals of the original system involved the simplification of the hawk counters' daily reporting tasks, including eliminating the need to submit hard-copy daily paper forms. Each day, the counter (or other site representative) "reported" the day's results to several places, including a hard-copy daily report form or HMANA "greensheet" to be submitted to HMANA, various e-mail lists, and the Autumn HawkWatch system, an internet-based database system that, as the result of collaboration among Hawk Mountain Sanctuary, the Cornell Lab of Ornithology, and the Hawk Migration Association of North America, provided a database of

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raptor migration counts for numerous watchsites (McCarty and Bildstein 2005). The initial version of the Hawkcount.org system automated these daily tasks. Daily counts could be entered online once. After entry, the system would generate e-mail reports that were sent to various e-mail lists, as well as automatically submit the day's results to the Autumn HawkWatch system by means of an emulated web browser session.

In 2002, the system was expanded to support multiple watchsites. The new multisite system was renamed and made available on the internet as http://Hawkcount.org/.

When the Autumn HawkWatch system was discontinued and taken offline, the Hawkcount.org system continued to provide its established e-mail reporting mechanisms. Recently, automated data transfer to the Avian Knowledge Network at the Cornell Lab of Ornithology has replaced Autumn HawkWatch as second repository for count data entered into Hawkcount.org.

During its first season as a multisite database, Hawkcount.org handled data from six autumn watchsites. By autumn 2006 it was handling data from more than 180 spring and autumn watchsites.

Hawkcount.org Implementation: Hardware and Software

Hawkcount.org currently runs on a single, primary server at a commercial data center in Troy, Michigan. The server provides web service, database service, SMTP (e-mail) service, and other components and services required by the system. Several redundant automated backup servers in various places in the United States maintain daily backup archives of the entire Hawkcount.org system, including all programs and data. In addition, Hawk Mountain Sanctuary maintains a DVD-based archive that is updated every three months. The Hawkcount.org system runs on freely available open-source software. Doing so provides adequate functionality and performance, and at the same time minimizes costs.

The primary Hawkcount.org server is an Intel/AMD x86-64 architecture computer running a modified GNU/Linux operating environment; in the past, the primary server was an x86-32 machine running GNU/Linux, an x86-32 machine running an OpenBSD operating environment, and a Sun SPARC-based machine running an OpenBSD operating environment.

The main server makes use of the Apache web-server package (http://www.apache.org) to provide the base http (web) service. This service receives requests for web pages from the network and launches the parts of the Hawkcount.org application that handle each request.

Hawkcount.org applications and ancillary programs primarily are written in the PHP scripting language (http://php.net/); PHP provides a programming language similar in many respects to C or Perl, but is optimized

for web-based applications. PHP provides convenient access to webpage components such as data forms submitted by hawk counters and environmental data available on websites such as temperature, wind speed, and wind direction, while also providing interoperation with common database platforms, e-mail, and operating-system services such as file system access and shell execution. Currently, PHP version 5 is used. A few Hawkcount.org functions and services are written in the C language instead of PHP. The system uses the MySQL version 5.0 database server (http://mysql.com/) for all observation-related data storage (raw file storage is used for purposes such as error logging and user activity tracking). MySQL provides a relational database server package that understands database commands and queries that follow the standardized SQL (structured query language) format. Data are structured as several interrelated MySQL tables including one that tracks bird-sighting information, a second that tracks observation conditions (weather, observer information, etc.), and a third that tracks overall daily report notes. Other tables unrelated to observed data track application data such as user names, passwords, and site profiles.

A network of automated backup servers in Michigan and Alaska ensure that the unexpected failure of the primary server will not result in permanent data loss. Backup servers run either GNU/Linux or OpenBSD operating environments. Backup images of the entire system (both data and programs) are made nightly through communication of differential data to each of these backup systems: only the day's changes to data and programs are communicated over the internet, but the backup servers use this differential data to reconstruct an entire image of the system at that point in time. Each backup server maintains several months of daily backup images. In the case of complete failure of the main server, the system can be reconstituted with the backup image provided by any one of these redundant backup servers. This backup mechanism has been implemented as Unix shell scripts that make use of the "rdiff" differential file copy program. In addition to backup servers, nightly backup images are also stored on a separate physical hard disk within the primary server. Copies of backup images are periodically written to optical disks and placed in a bank's safe deposit box.

Watchsite Information

In addition to providing current watchsite count data, Hawkcount.org also attempts to serve as an up-to-date directory of North American watchsites by keeping record of site-specific details, including geographic parameters, site descriptions, contact information, and other site-specific attributes. Count summary statistics are calculated and provided on site profile pages.

The stored site-specific information serves several purposes; some of the information is used in the generation of publicly accessible site profiles and details. Other site-specific information controls the behavior of each site's data-entry facilities. Such details include the site's species checklist and details related to weather and flight parameter observation protocols, all of which can be customized. Permission and data-access settings allow each site to control public data accessibility and establish data release conditions.

Data Entry

Daily count data are entered via the web by representatives of each watchsite. Although daily or hourly data can be submitted, hourly data are encouraged. Access to the data-entry functions may be delegated by the user registered as the watchsite's leader. Each day's data entry session begins on a summary page that allows entry of the day's general observation notes, including selection of date, start and end times for the observation period, and general notes about raptor and non-raptor observations, visitors, and predictions for the next day (Fig. 1). The user is then guided through hourly or daily data entry pages. Hourly pages consist of three subsections: (1) a predefined list of qualified observers, (2) hourly flight observations (wind speed, wind direction, temperature, humidity, barometric pressure, cloud cover, visibility, direction of migrating birds' flight, and height of migrating birds' flight; Fig. 2), and (3) hourly counts of each species (Fig. 3). Daily pages follow the format of hourly pages, but without weather and flight parameter fields. Site-specific species checklists speed data entry. Drop menus containing a larger list of raptor species allows temporary addition of these species to the data entry form.

Data also can be imported from Excel spreadsheets. Imported spreadsheets must follow a scheme that defines each row as a count period (typically 1 h). Columns define the date, start and end times, weather parameters, and species counts for a single count period. The import mechanism "learns" about each spreadsheet column layout and can accommodate much variation. However, to encourage consistent input, the system produces template spreadsheets at a user's request. Templates reflect the specific checklist and field order configured for the user's site.

The system also allows data export via Excel spreadsheets for use by the site. Export start and end dates and other data detail options are selected on a web page that produces standardized exported spreadsheets. Special-purpose spreadsheet exports can be implemented to support data requests.

A second type of export generates paper copies of the data as PDF (Portable Document Format) files resembling an expanded version of the HMANA daily report form.

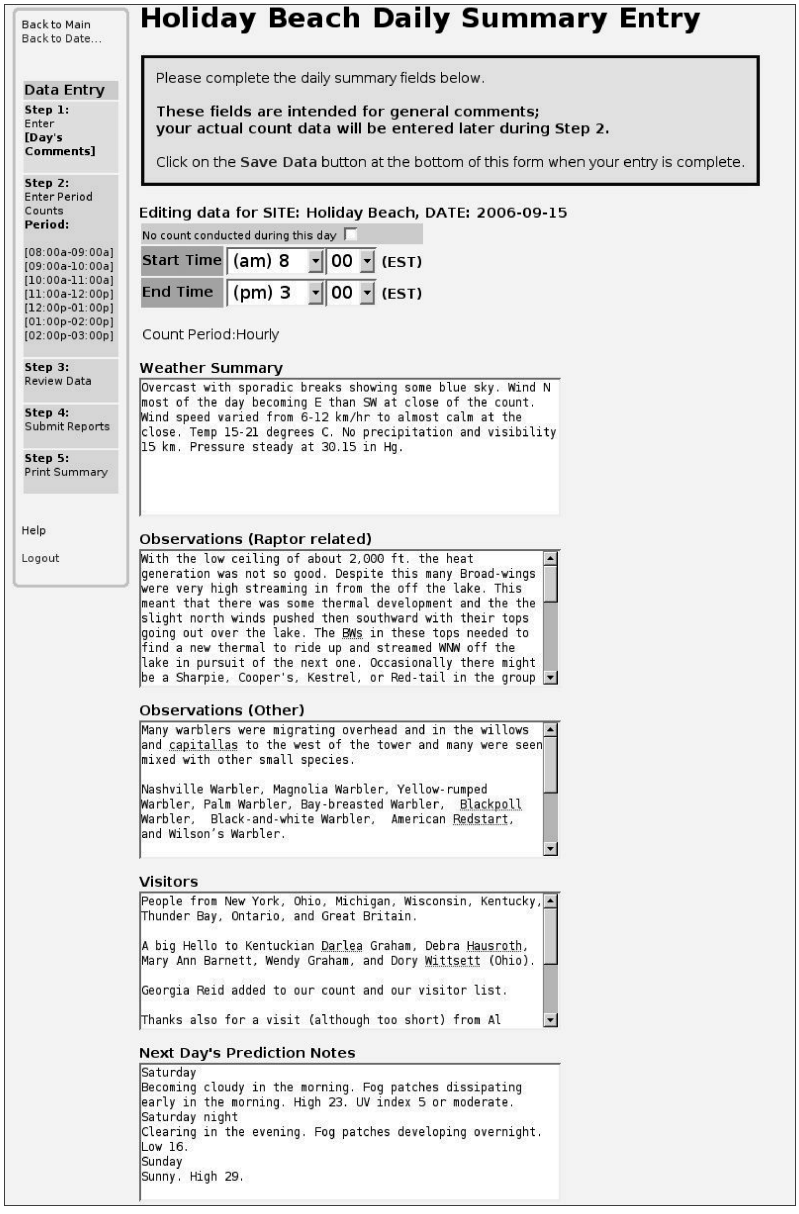


Fig. 1. Example of daily general notes entry on Hawkcount.org web page.

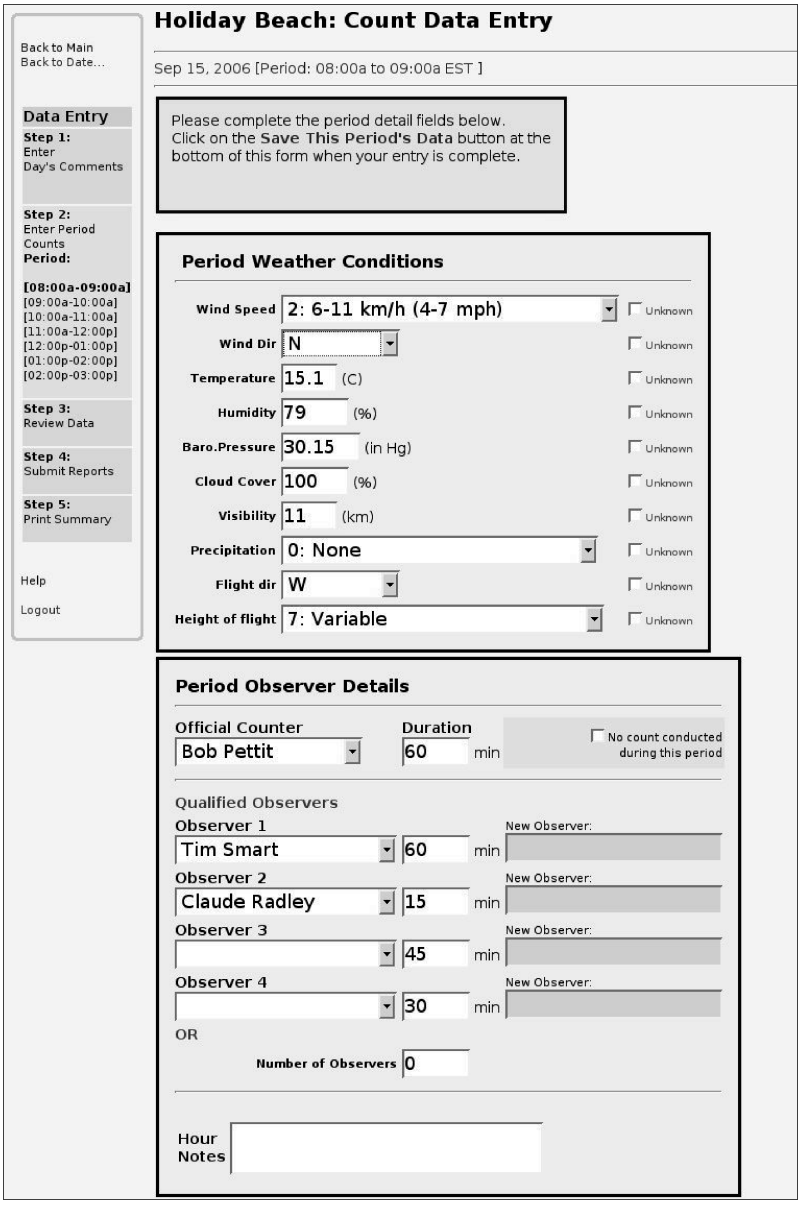
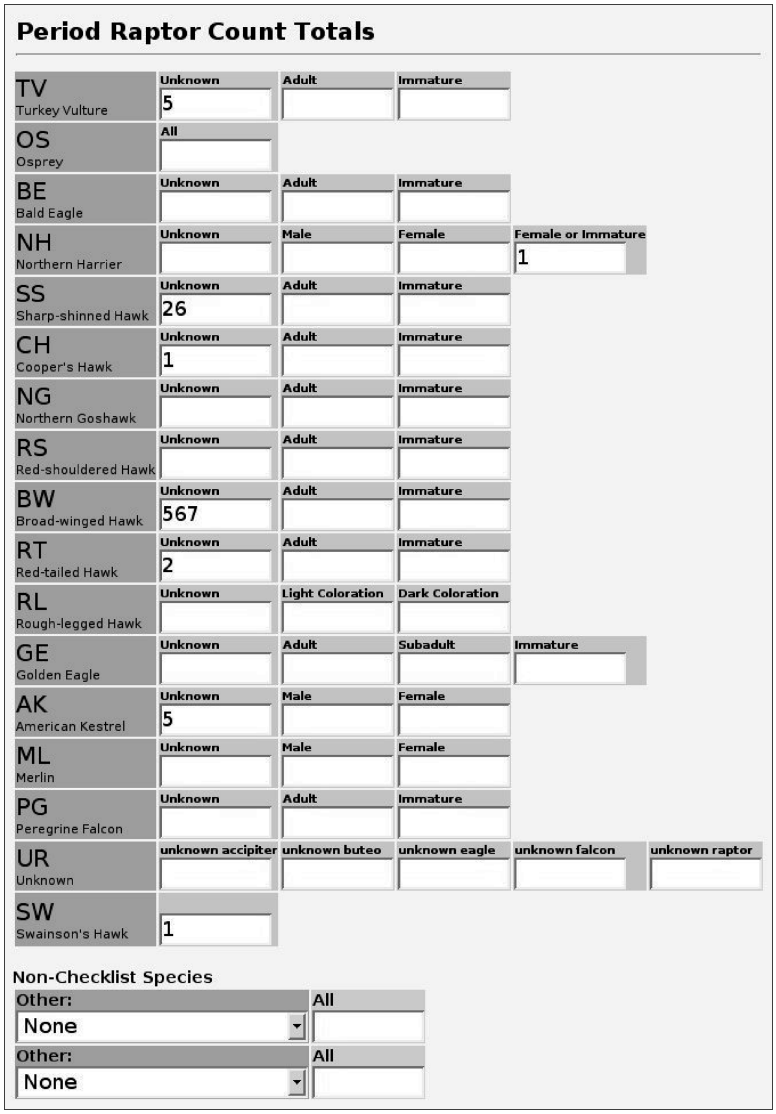


Fig. 2. Example of hourly data entry, including weather and observer information, on Hawkcount.org web page.



Period Raptor Count Totals

TV Turkey Vulture	Unknown: 5	Adult:	Immature:		
OS Osprey	All:				
BE Bald Eagle	Unknown:	Adult:	Immature:		
NH Northern Harrier	Unknown:	Male:	Female:	Female or Immature: 1	
SS Sharp-shinned Hawk	Unknown: 26	Adult:	Immature:		
CH Cooper's Hawk	Unknown: 1	Adult:	Immature:		
NG Northern Goshawk	Unknown:	Adult:	Immature:		
RS Red-shouldered Hawk	Unknown:	Adult:	Immature:		
BW Broad-winged Hawk	Unknown: 567	Adult:	Immature:		
RT Red-tailed Hawk	Unknown: 2	Adult:	Immature:		
RL Rough-legged Hawk	Unknown:	Light Coloration:	Dark Coloration:		
GE Golden Eagle	Unknown:	Adult:	Subadult:	Immature:	
AK American Kestrel	Unknown: 5	Male:	Female:		
ML Merlin	Unknown:	Male:	Female:		
PG Peregrine Falcon	Unknown:	Adult:	Immature:		
UR Unknown	unknown accipiter:	unknown buteo:	unknown eagle:	unknown falcon:	unknown raptor:
SW Swainson's Hawk	1				

Non-Checklist Species

Other: None	All:
Other: None	All:

Fig. 3. Example of hourly species count entry including optional count breakdown based on age, sex, and phase attributes on Hawkcount.org web page.

Data Reporting

The system allows for automatic reporting of entered data to a variety of targets defined by each watchsite, including private e-mail addresses, public mailing lists, and the Avian Knowledge Network (http://

avianknowledge.net/) (Kelling and Stewart 2005), the latter by means of the DiGIR software package (http://digir.sourceforge.org/), which maps incoming XML (eXtensible Markup Language) requests to predefined database queries. Through this latter interaction, portions of the database can be integrated with other major bird monitoring datasets, which are available for broad distribution.

E-mail reports may contain either plain-text or HTML-formatted table summaries of a day's count result. Daily, monthly, and seasonal totals are provided for each species. General observation notes and observer names also are included. Each site defines lists of recipients of such e-mail reports. The system is subscribed to many popular e-mail list servers, including regional birding lists and the BIRDHAWK hawk watching exchange list, allowing sites to elect to have copies of their daily reports sent to these mailing lists.

Public Data Access

Publicly accessible areas of the Hawkcount.org web site allow browsing of participating watchsites' daily results and historical data (for those sites that have opted to allow public access). Site-profile pages provide site details, count statistics, data inventory, contact information, and access to site protocols or other site-specific documents. Summaries of watchsite results are provided in both daily and hourly format. The monthly summary view presents a table that summarizes daily totals for all observed species for the entire selected month (Fig. 4). Additionally, tables providing comparisons with previous years' observations for the same month also can be viewed. The daily summary view provides all details recorded for the day, including hourly count breakdown, observation notes, and weather and flight parameter details.

Each watchsite controls access to their data by means of controls available in their site settings within the system. The controls are based on HMANA data submission and release policies (http://hmana.org/data_policies/policies.php).

Watchsite Participation

During autumn 2006, approximately 80 of 183 active watchsites submitted count data daily. Others submitted data less frequently or via post-season spreadsheets. Overall, the system has been used to report counts of over 50 million raptors since its inception as a multiple-site recording system in 2001.

Holiday Beach
Ontario, Canada
(Site Profile)

Month Summary:Sep, 2006

Date	Obs Hrs	TV	OS	BE	NH	SS	CH	NG	RS	BW	RT	RL	GE	AK	ML	PG	UR	SW	TOTAL
2006-09-01	6	0	2	0	8	3	1	0	0	20	4	0	0	14	0	0		0	52
2006-09-02	7	0	2	0	8	12	0	0	0	8	0	0	0	2	0	0		0	32
2006-09-03	9	0	0	4	12	15	0	0	0	8	1	0	0	10	0	0		0	50
2006-09-04	10	0	2	0	3	2	0	0	0	0	0	0	0	7	0	0		0	14
2006-09-05	3	0	0	0	5	9	0	0	0	2	8	0	0	16	0	1		0	41
2006-09-06	4	0	0	0	1	4	0	0	0	1	0	0	0	5	0	0		0	11
2006-09-07	6	0	4	1	7	3	1	0	0	2	2	0	0	5	0	0		0	25
2006-09-08	5	0	1	0	3	0	0	0	0	0	0	0	0	0	0	1		0	5
2006-09-09	9	13	5	0	19	14	3	0	0	4	10	0	0	48	2	0		0	118
2006-09-10	10	0	8	1	65	300	8	0	0	28	6	0	0	346	6	1		0	769
2006-09-11	10	10	7	18	37	204	15	0	0	1116	31	0	0	45	6	5		0	1494
2006-09-12	6	0	0	0	6	45	0	0	0	0	0	0	0	2	3	0		0	56
2006-09-13	3.5	0	0	0	1	126	0	0	0	0	0	0	0	2	2	0		0	131
2006-09-14	9	0	1	4	20	489	15	0	0	482	8	0	0	223	1	4		0	1247
2006-09-15	7	1	3	0	18	226	12	0	0	549	11	0	0	112	2	1		1	936
Date	**Obs Hrs**	**TV**	**OS**	**BE**	**NH**	**SS**	**CH**	**NG**	**RS**	**BW**	**RT**	**RL**	**GE**	**AK**	**ML**	**PG**	**UR**	**SW**	**TOTAL**
2006-09-16	9.5	5	5	1	21	269	11	0	0	184	8	0	0	39	2	0		0	545
2006-09-17	9	0	4	0	8	301	7	0	0	3	1	0	0	70	3	1		0	398
2006-09-19	5	5	1	0	5	88	4	0	0	1	0	0	0	103	2	1		0	210
2006-09-20	8.5	17	1	0	12	319	8	0	0	1403	7	0	0	127	4	1	1	1	1901
2006-09-21	8.5	9	2	1	32	169	10	0	0	4	6	0	3	56	2	2		0	296
2006-09-22	6.5	42	12	0	2	70	6	0	0	0	0	0	0	9	4	5		0	150
2006-09-23	8.5	0	6	0	7	113	7	0	0	0	0	0	0	12	4	7		0	156
2006-09-24	7	18	4	0	7	303	4	1	0	2	4	0	0	81	3	2	1	0	430
2006-09-25	10	19	5	5	10	217	20	1	0	1	1	0	0	243	7	6		0	535
2006-09-26	8	76	7	8	47	158	16	1	0	1056	17	0	1	24	4	14	3	0	1432
2006-09-27	5	54	4	1	10	161	9	0	0	0	2	0	0	42	12	7		0	302
2006-09-28	5.5	51	0	1	11	251	19	0	0	845	21	0	0	45	1	0	1	0	1246
2006-09-29	8	420	9	6	38	512	3	0	0	1536	12	0	0	60	2	3		0	2601
2006-09-30	9	0	2	0	7	54	5	0	0	0	0	0	0	6	5	3		0	82
Total: Sep 2006	**212.5** hours	740	97	51	430	4437	184	3	0	7255	160	0	4	1754	77	65	6	2	15265
Total: Fall 2006	**212.5** hours	35665	111	124	1195	9814	760	28	492	7730	4248	30	63	2113	122	114	40	3	62652

Fig. 4. Example of open-access monthly count summary on Hawkcount.org web page.

The Future

Development plans for the Hawkcount.org system include improvements in public-data queries, integration of near-real-time statistics and trend analysis, further mapping and GIS integration, improved data import capacity, support of portable data recording devices, and implementation of additional live servers.

Public-data queries will be improved with species- and geographic-specific query ability. Additional statistics and simple trend analyses will

be added to the system. Currently, mapping is included in the site location and profile pages provided by the system by means of the Google Maps API (http://maps.google.com/). Additional mapping ability is anticipated.

Import via additional spreadsheet formats (aside from the current Excel-97 or earlier format limitation) also is anticipated. Hawkcount.org also anticipates support of automated import of data recorded on portable devices, including laptop and handheld computers.

Literature Cited

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Table 1. Hawkcount.org participating watchsites, 2001–2006.

Country	Province or state	Watchsite name
Canada	British Columbia	Kitsilano
		Rocky Point Bird Observatory
	Manitoba	St. Adolphe Hawkwatch
		Whytewold Hawkwatch
	Ontario	Beamer Backup
		Beamer Conservation Area auxiliary sites
		Niagara Peninsula Raptor Watch
		Cranberry Marsh Raptor Watch
		Grimsby Air Park
		Hawk Cliff Hawkwatch
		High Park Hawk Watch
		Holiday Beach Migration Observatory
		Innisfree
		Thunder Cape Bird Observatory
	Québec	Belvédère Raoul-Roy, Parc national du Bic
		Eagle Crossing
		Montreal West Island Hawkwatch
		Observatoire d'oiseaux de Tadoussac
		Plateau de Beaupre
Costa Rica	Talamanca	Kekoldi
Mexico	Veracruz	Tlacotalpan, Veracruz, Mexico
		Veracruz River of Raptors
Panama	Panama	Semaphore Hill (Canopy Tower)
USA	Alaska	Gunsight Mountain
	Arizona	Grand Canyon Raptor Migration Project at Lipan Point
		Grand Canyon Raptor Migration Project at Yaki Point
	California	Borrego Valley
		Lagoon Valley
	Connecticut	Beelzebub Street
		Bent of the River
		Booth Hill
		Botsford Hill
		Briggs Hill
		Chestnut Hill
		East Shore Park
		Flat Hill
		Flint Hill
		Good Hill
		Heritage Village
		Huntington State Park
		Johnycake Mountain
		Larson Sanctuary
		Lighthouse Point Hawk Watch

Table 1. Continued.

Country	Province or state	Watchsite name
USA	Connecticut	Maltby Lakes
		Middle School
		Osborne Hill
		Peak Mountain
		Quaker Ridge
		Southbury Training School Farm
		Taft School
		Taine Mountain
		Whippoorwill Hill
		White Memorial Foundation
	Delaware	Cape Henlopen Hawk Watch
		White Clay Creek State Park - Carpenter Recreation Area
	Florida	Guana Reserve
	Illinois	Illinois Beach State Park
		Lost Mound Refuge
	Iowa	Hitchcock Nature Center
	Maine	Bradbury Mountain State Park
		Cadillac Mountain, Arcadia National Park
	Maryland	Cromwell Valley Park
		Fort Smallwood Park
		Manchester Ridges
		Turkey Point Hawk Watch
		Washington Monument State Park
	Massachusetts	Alander Mountain
		Bare Mountain
		Barre Falls
		Blueberry Hill
		Little River Lookout
		Mount Tom
		Mount Wachusett
		Mount Watatic
		Pilgrim Heights Hawk Watch
		Pinnacle Rock
		Plum Island MA
		Shatterack Mountain
		Tuttle Hill
	Michigan	Meadowbrook Migration Area
		Muskegon Hawkwatch
		Port Huron Hawk Watch
		SMRR- Lake Erie Metropark
		SMRR- Pointe Mouillee State Game Area
		Straits of Mackinaw
		Whitefish Point Bird Observatory
	Minnesota	Hawk Ridge Bird Observatory
		West Skyline Hawk Count

Table 1. Continued.

Country	Province or state	Watchsite name
USA	Montana	Bridger Mountains Raptor Migration Project
	Nevada	Goshute Mountains Raptor Migration Project
	New Hampshire	Interlakes Elementary School
		Little Round Top
		Pack Monadnock Raptor Migration Observatory
		Peter Wood Hill
	New Jersey	Cape May Bird Observatory
		Kittatinny Mountain
		Montclair Hawk Lookout
		NJAMP at Chimney Rock
		NJAMP at Duke Farms
		Picatinny Peak Hawkwatch
		Raccoon Ridge
		Reed's Beach Autumn Hawk Watch
		Sandy Hook Migration Watch
		Scotts Mountain
		Sparta Migration Watch
		State Line Hawkwatch
		Sunrise Mountain
		Wildcat Ridge Hawkwatch
	New Mexico	Manzano Mountains Raptor Migration Project
	New York	Braddock Bay
		Chestnut Ridge Hawk Watch
		Derby Hill Bird Observatory
		Fire Island
		Franklin Mountain Hawkwatch
		Hamburg Hawk Watch
		Hook Mountain
		Kestrel Haven
		Lenoir Wildlife Sanctuary
		Mohonk Preserve
		Mount Peter Hawk Watch
		Ripley Hawk Watch
		Summitville Hawkwatch
	North Carolina	Big Bald
		Bullhead Mountain
		Mahogany Rock
		Mount Pisgah
		Pea Island National Wildlife Refuge
		Phoenix Mountain Hawk Watch
		Pilot Mountain State Park
	Oregon	Bonney Butte Raptor Migration Project
	Pennsylvania	Allegheny Front Hawk Watch
		Audubon's Hawk Watch at Waggoner's Gap

Table 1. Continued.

Country	Province or state	Watchsite name
USA	Pennsylvania	Bake Oven Knob
		Bald Eagle Mountain
		Brady's Bend
		BroadwingSEPT - Buckingham
		BroadwingSEPT - Core Creek
		BroadwingSEPT - Lake Nockamixon
		BroadwingSEPT – Lehigh
		BroadwingSEPT - Peace Valley
		BroadwingSEPT - Pipersville
		BroadwingSEPT – Pleasant Valley
		Cove Mountain
		Hawk Mountain Sanctuary
		Hopewell Fire Tower
		Jack's Mountain Hawk Watch
		Kirkridge
		Lehigh Gap Hawkwatch
		Little Gap
		Meadowood Bird Observatory
		Militia Hill
		Rose Tree Park Hawk Watch
		Second Mountain
		Stone Mountain Hawk Watch
		Tuscarora Summit
		Tussey Mountain Hawkwatch
	South Carolina	Caesars Head Hawk Watch
		Congaree Bluffs
		Trezevant's Landing
	Tennessee	Tara Woods East Collierville
	Texas	Bentsen Rio Grande Valley State Park
		Corpus Christi Raptor Migration Project
		Smith Point Raptor Migration Project
	Utah	Wellsville Mountain Raptor Migration Project
	Vermont	Putney Mountain
	Virginia	Bear Mountain Farm
		Candler Mountain
		Carvins Cove
		College Creek
		Harvey's Knob Overlook
		Hughes River Gap
		Kiptopeke Hawkwatch
		Rockfish Gap Hawk Watch
		Snickers Gap Hawkwatch
	Washington	Chelan Ridge Raptor Migration Project
	West Virginia	Hanging Rock Tower
	Wisconsin	Chequamegon Bay Hawkwatch
		Concordia University