RED-SHOULDERED HAWK AND SPRING WOODPECKER SURVEY

1990-2006 Final Report

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EXECUTIVE SUMMARY

The Red-shouldered Hawk (*Buteo lineatus*) is a rare to locally uncommon breeding bird in Ontario (Austen and Cadman 1994, Austen et al. 1994, James 1991, Sutherland 1994). It was classified as a species of Special Concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 1983, but was subsequently classified as Not at Risk in 2006 based on an updated status report (COSEWIC 2006). The Red-shouldered Hawk and Spring Woodpecker Survey was initiated in 1990 with the primary goal of assessing population trends of Red-shouldered Hawks in Ontario. Data on other forest raptors and five species of woodpeckers were also gathered.

In 2007, based on mutual consent between Bird Studies Canada and the Ontario Ministry of Natural Resources, the Red-shouldered Hawk and Spring Woodpecker Survey was discontinued. There were a number of factors that influenced this decision including declining participation rates in recent years, the limited extent of this survey relative to the breeding ranges of woodpecker species detected, the limited range of the Red-shouldered Hawk in Ontario.

From 1991-2006, more than 180 survey teams participated in the survey; a total of 142 survey routes were established in Ontario, 119 of which were run at least once. Over the duration of the survey, it was estimated that volunteers committed at least a 4860 hours to the Red-shouldered Hawk and Spring Woodpecker Survey (assuming a 5 hour commitment per survey-year). This corresponds to over 2 years of volunteer time.

Data from the Red-shouldered Hawk and Spring Woodpecker Survey, and from the Ontario Breeding Bird Atlas suggest that the Red-shouldered Hawk population is stable and that it has expanded north in Ontario. Data from Hawk Watch stations in eastern North America also indicate a stable or increasing population. These results suggest that there is sufficient quality and quantity of habitat in Ontario to maintain this species. Woodpecker population trends from this survey, the Breeding Bird Survey and from the atlas also show stable or increasing populations.

The Red-shouldered Hawk and Spring Woodpecker data made an important contribution to the downlisting of the species, and allowed researchers to generate an updated population estimate (COSEWIC 2006). The data were also incorporated into the 2nd Breeding Bird Atlas and thus contributed greatly to assessing changes in distribution of hawks and woodpeckers in Ontario. The survey data have been used extensively by the Ontario Ministry of Natural Resources to develop habitat models and guidelines for Red-shouldered Hawks and Pileated Woodpeckers. Although the survey has ended, we anticipate that the data will continue to be used by researchers and biologists.

Thanks to all of the volunteers who participated in the survey from 1990-2006. Each of you made an important contribution to bird conservation in Ontario!

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INTRODUCTION

The Red-shouldered Hawk (*Buteo lineatus*) was once the most common hawk in southern Ontario, but due to a dramatic continent-wide decline in the last century (Crocoll 1994), this species is now considered a rare to locally uncommon breeding bird in Ontario (Austen and Cadman 1994, Austen et al. 1994, James 1991, Sutherland 1994). The Red-shouldered Hawk was classified as a species of Special Concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in April 1983. In April 2006, the species was down-listed to Not at Risk based on an updated status report, which reported that recent Red-shouldered Hawk population trends were either stable or increasing throughout most of its range (COSEWIC 2006).

Approximately 1% of the North American Red-shouldered Hawk population breeds in Canada (COSEWIC 2006), and roughly 90% of Ontario Red-shouldered Hawk breeding records are from the Great Lakes – St. Lawrence Forest Region, with a few additional breeding sites in the Carolinian and Southern Boreal forests. Red-shouldered Hawks breed in a broad array of forest types, including bottomland hardwood, riparian areas, flooded deciduous swamps, and upland mixed-wood forest. They are area sensitive and prefer extensive, contiguous, mature to old-growth forest tracts with variable amounts of understory (Crocoll 1994). Typically, Red-shouldered Hawks require canopy closure of 70% or greater for successful reproduction (see Naylor et al. 2004), and are sensitive to changes in forest structure following timber harvesting (Crocoll 1994). For example, Red-shouldered Hawks may be displaced or out-competed by the larger Red-tailed Hawk (*Buteo jamaicensis*), which may benefit from reduced canopy closure following timber management (Bryant 1986).

The dependence of Red-shouldered Hawks on large, mature forest tracts raised the concern that timber management practices might negatively affect this species. Consequently, Red-shouldered Hawks were included as a representative species in Condition 30 (b) of the Ontario Ministry of Natural Resources' (OMNR) Provincial Wildlife Population Monitoring Program. This program identifies species that may be affected by forest management practices and should therefore be monitored for population trends (Ministry of Natural Resources 2004).

Several woodpecker species (Northern Flicker, Yellow-bellied Sapsucker, Hairy Woodpecker and Pileated Woodpecker) are also listed as representative species in Condition 30 (b) because of their dependence on habitat features that are apt to be modified through certain logging practices. All four woodpecker species rely on snags; all but Northern Flicker require mature or over-mature forest stands; and Yellow-bellied Sapsuckers and Pileated Woodpeckers require large tracts of undisturbed forest for breeding. These species are not adequately monitored by bird surveys such as the Breeding Bird Survey because of their secretive nature in June (McLaren 1993). The detection of woodpeckers is better in late April and early May, when Red-shouldered Hawk breeding surveys are performed (Peterjohn et al. 1994).

In 1990, the Red-shouldered Hawk and Spring Woodpecker Survey was initiated by Bird Studies Canada as part of the Ontario Birds at Risk (OBAR) program, and in cooperation with the OMNRs' Wildlife Assessment Program (now Terrestrial Assessment Program). The primary objective of the survey was to monitor population trends of Red-shouldered Hawks, Pileated Woodpeckers and Yellow-bellied Sapsuckers, and to determine whether forest management practices were affecting these species. The study area was restricted to deciduous or mixed forest habitat in central Ontario, the core breeding range of the Red-shouldered Hawk.

In 2006, based on mutual consent between Bird Studies Canada and the Ontario Ministry of Natural Resources, the Red-shouldered Hawk and Spring Woodpecker Survey was discontinued. There were a number of factors that influenced this decision, including: declining participation rates in the survey in recent years, the limited extent of this survey relative to the breeding ranges of woodpecker species detected, the limited range of the Red-shouldered Hawk in Ontario, and the fact that the Red-shouldered Hawk was no longer considered to be at risk in Canada.

This report summarizes results of the survey (1991-2006) and discusses the status of Red-shouldered Hawks and the five woodpecker species in Ontario. Annual indices and trends were calculated for numbers of Red-shouldered Hawks from 1991–2006, and for the five most frequently encountered woodpecker species for the period 1992–2006 (1996-2006 for non-target species). Volunteer participation in the survey and the reasons for discontinuing the survey are outlined.

METHODS

The Red-shouldered Hawk and Spring Woodpecker Survey is a volunteer-based, roadside survey that uses playback calls to elicit responses from Red-shouldered Hawks. Passive acoustic and visual observations of other raptor and woodpecker species are also recorded. The survey methods were proposed by Szuba (1990), and were further tested and modified by Callaghan (1990) and Austen (1991).

Prior to the survey, each surveyor was given a participant's kit containing: a 1:50,000 scale topographic map of their survey route; stop descriptions of their survey route; a participant's guide with survey instructions; a training tape or CD with examples of hawk calls and woodpecker calls and drumming; a broadcast tape or CD with Red-shouldered Hawk calls; data forms (survey form, bird data form, stop description form); a dashboard sign; and a tax-relief form.

Survey routes were located along secondary roads that passed through as much deciduous woodland as possible. Each route consisted of 20 survey stations spaced 1 km apart, for a total route length of 19 km. All routes were surveyed once annually between 17 April- 7 May, which is the pre-incubation period for Red-shouldered Hawks in Ontario and, thus, when the highest response rate to call playback is expected. Each year, new surveyors were asked to scout their

route prior to their survey to establish survey stations and determine proper spacing based upon their vehicle's odometer. If a potential survey station was located in an unsuitable location (e.g., no forest within 500 m, adjacent to a house or urban area), surveyors were instructed to move their stop an additional 500 m and assess the new location. This process was repeated until 20 suitable survey stations were found. All surveyors were asked to mark locations of their survey stations on 1:50,000 scale topographic maps and to complete a form describing the location and general habitat at each stop. Surveyors who took over an existing route were asked to use the same stops as the previous surveyor.

Surveyors were asked to survey their route within 30 minutes after sunrise on mornings with a minimum of 1.6 km visibility, wind speed less than 13 km/h, and no persistent precipitation. If the weather changed or exceeded any of these limitations during the survey, surveyors were asked to use their best judgement as to whether to complete the survey or stop and return at a later date to re-do the entire survey.

When surveying a route, a single surveyor usually made all observations, but a second person often accompanied the surveyor to record data. At the beginning and end of each survey, the surveyor recorded route, time and weather conditions. At each station, surveyors played a pre-recorded cassette tape or CD consisting of six sets (20 seconds each) of Red-shouldered Hawk calls interspersed with 40 seconds of silence. Surveyors placed the broadcast unit on a towel on the roof of their vehicle with the speaker facing one side of the road. The speaker was rotated 180° after each broadcast call interval, so that three sets of calls were broadcast to each side of the road. After the 5:20 minute broadcast period, the surveyor remained at the station for a final two-minute listening period before moving to the next station. The number of adult, immature, and unknown-age raptors seen or heard, and the number of woodpeckers seen, heard calling or drumming were recorded at each stop. Surveyors were also asked to record additional noteworthy observations, especially of species at risk.

WOODPECKER PROTOCOL DEVELOPMENT

Since the beginning of the survey, there were several changes in the method of woodpecker data collection. In 1992, surveyors began to record observations of Pileated Woodpecker and Yellow-bellied Sapsucker (the two target species). In 1995, surveyors began to record all woodpecker species observed and whether they could identify the target species by sight, call and/or drumming. In 1996, surveyors began submitting their identification skills for the non-target woodpecker species, and a 30-minute training tape with examples of hawk calls and woodpecker calls and drumming was distributed to help improve surveyor identification skills. To encourage surveyors to report all woodpecker species, the data form was redesigned in 1996.

BROADCAST EQUIPMENT AND TAPE QUALITY

When the survey began in 1990, BSC provided volunteer surveyors with one of two types of

broadcast equipment:

> (1) Car stereo set. Yamaha YCR-340 or YCR-325 car cassette decks (16 units) with Yamaha-6920 bookshelf speakers or a horn speaker, or
> (2) Portable cassette player. Sanyo MCD-S750 (29 units) or Fisher PH-W3300 (1 unit) portable CD/cassette player equipped with a horn speaker in place of the manufacturer's speakers.

Some surveyors continued to use these units, but since their distribution, many units began to function inadequately and their use was discontinued. Although standardization of broadcast equipment is ideal to minimize differences in power output levels among surveys, the cost of providing broadcast units to all surveyors became prohibitive. Thus, most surveyors used their own equipment for surveys, even though differences in power output levels may have affected hawk responses.

The quality of the broadcast tape also changed over time. From 1991 to 1994, surveyors used the same broadcast tape until new tapes were produced in 1995. Although the new tapes contained the same recordings as the old tapes, they were louder and of better quality, especially because at least some of the old tapes apparently deteriorated during the previous four years of use. Regardless, tapes were again re-used from 1995-1997, but since 1998, new tapes were distributed annually to prevent sound deterioration. Although we tried to keep the volume and quality of the tapes similar to those released in 1995, there was some annual variation in tape quality.

To minimize the effect of tape or equipment differences, surveyors were encouraged to test their broadcast equipment each year to ensure their broadcast unit met our guidelines (Red-shouldered Hawk call audible and recognizable at 500 metres).

ROUTE SELECTION

Initially, either the survey coordinator or the surveyors selected survey routes in suitable Red-shouldered Hawk habitat, regardless of whether hawks were known to occur along those routes. The number of routes increased slowly from 1990 to 1993 and in 1994 the survey underwent a major expansion (37 new routes). During this expansion, a stratified random route selection protocol was introduced, based upon map grid squares. Data from the first Ontario Breeding Bird Atlas (Cadman et al. 1987) and the Ontario Rare Breeding Bird Program (Austen et al. 1994) were used to determine the number of 10 km x 10 km atlas squares (defined by the Universal Transverse Mercator (UTM) grid) in each 100 km x 100 km block that had breeding Red-shouldered Hawks reported within them since 1981. The number of routes per block was assigned proportional to the number of squares in that block that had hawk records. In each block, the starting point for each route was placed in a square that was randomly selected from among those known to contain Red-shouldered Hawks. The actual route location was then

determined based upon the availability of suitable secondary roads that were accessible in early spring. The route did not necessarily remain in the chosen square, although it was required to remain at least 3 km from any other route. Not all of the randomly selected routes were surveyed because of the absence of volunteer surveyors in certain locations, and from 1995-2001, a number of new routes were established in locations selected largely by the surveyors.

In 2002, a route randomization strategy was adopted for all new routes, to ensure that trends observed along the selected routes were representative of those in the region as a whole. This was accomplished by first dividing the province into 1:250,000 blocks on a topographic map, then by sub-dividing each block into east and west, such that each sub-block measured 1° latitude x 1° longitude. Sub-blocks south of 43° latitude or north of 47° latitude were excluded because they were outside the Red-shouldered Hawk's normal breeding range in Ontario. Blocks that were less than 1/3 covered by land or less than 1/3 within the political boundaries of Ontario were also excluded.

Of the sub-blocks located within the 43-47° latitude range, those with insufficient survey coverage were identified by first overlaying all of the starting points for existing routes on the grid. If the sub-block was more than 50% covered by land, minimum coverage was set at four routes per degree block; if the sub-block was 33-50% covered by land, minimum coverage was set at two routes per degree block. If sub-blocks had insufficient route coverage, routes were randomly selected within those sub-blocks by first dividing those 1° sub-blocks into 16 cells (1 cell=1:50,000 topographic map) and then randomly selecting a cell (or cells) from the sub-block. If the randomly selected cell had no suitable habitat or suitable roads, then another cell was randomly selected until an appropriate cell was identified. In some cases, entire blocks were eliminated due to unsuitable habitat. Once appropriate cells were selected, a random point was selected within that cell and the nearest road to that point was selected as the starting point for the new survey route.

A total of 19 random starting points for routes were selected using this methodology. Volunteers who were assigned to random routes were asked to scout the area ahead of time to ensure that the habitat and road were suitable. There were seven new routes assigned and surveyed in 2005, but no new routes assigned in 2006.

DATABASE STRUCTURE

The Red-shouldered Hawk database was originally maintained in Paradox but was converted to Microsoft Access in 2002 to be compatible with scannable data forms. The main database structure is comprised of 11 tables, each prefixed with rsha_. The contents of the various database tables, pertinent queries, and relationships are summarized below.

DATABASE TABLE CONTENTS

1. **route**: basic route information including route number, route name, nearest town, modification, current status, and current surveyor information.
2. **modif_routes**: information pertaining to what year route modifications occurred.
3. **surveyors**: contact information for past and present surveyors.
4. **surveys**: survey information describing date surveyed, start and end times, weather conditions, surveyor ID.
5. **stations**: station specific data including an odometer reading of distance to each station, and the time each station was surveyed.
6. **coordinates**: geographic information for each route: closest town, station specific coordinates (UTM, Lat/Long, Map Number), and written stop descriptions provided by surveyors.
7. **id_wp**: information for each route/year combination on whether the surveyor was unable to identify any of the woodpecker species based on categories of 'Call', 'Sight', or 'Drumming'. These data were used to identify routes with surveyors who were confident in their identifications, and were available from 1995 onwards for Pileated Woodpecker and Yellow-bellied Sapsucker, and from 1996 onwards for remaining woodpecker species.
8: **equipment_test**: annual information describing type and sound quality of surveyor broadcast equipment.
9. **data_hawk**: hawk observations (including unidentified Accipiters and unidentified Buteos) by station, including species and numbers in each age class (adult, immature or unknown).
10. **data_wp**: woodpecker observations (including unidentified woodpeckers) by station, including species, total number of individuals, and those detected by drumming only.
11. **waitinglist**: list of names, addresses, and contact information for volunteers interested in participating.

QUERIES

The "Yearly_routes_per_constituent" query allows the user to view route and surveyor history. This cross tabulation query displays how many times a route was surveyed in each year and by whom. This query is very useful when a volunteer calls with questions about his/her route because it allows the user to view the entire route history while on the phone.

RELATIONSHIPS

"Surveys" is the main header table in the database and is linked to four tables, each containing survey specific information: Stations, Route, Equipment_test, and Id_wp. "Stations" is further linked to "Data_hawk" and "Data_rsha", while "Route" is further linked to "Coordinates" and "Modif_routes".

Referential integrity is enforced to ensure that all relationships between related tables are valid. This means that all records in the primary table must also be found in the related table. For example, information contained in the "Stations" table must also be found in "Surveys".

DATA ANALYSIS

ANNUAL INDICES AND TRENDS

To estimate how Red-shouldered Hawk and woodpecker numbers in 2006 compared with previous years, we used the Poisson modelling approach of Link and Sauer (1997, 1998) to calculate annual indices controlling for differences among routes (SAS 2001; Proc Genmod). We did not adjust for potential over-dispersion in the data relative to a Poisson model. This approach was used to provide annual indices for Red-shouldered Hawks and the five most commonly encountered woodpecker species. We also used this approach to estimate if there was any average long-term change in Red-shouldered Hawk and woodpecker indices, by using routes as covariates and treating year as a continuous variable. This assumed that the populations changed by the same proportion every year (i.e. exponentially). However, models assuming linear change are not necessarily appropriate for populations with large annual fluctuations in size.

Data from 1991 to 2006 were included in Red-shouldered Hawk analyses. Data from 1990 were excluded because the duration of the listening period and the volume of the broadcast tape both changed substantially after 1990. To calculate trends for the two target woodpecker species, data from 1992-2006 were used; for non-target species, data from 1996-2006 were used. Trend analyses for Pileated Woodpecker and Yellow-bellied Sapsucker were restricted to surveys for which the surveyor was able to identify the species by call, sight and drumming. Data collected prior to 1995 were included for the two target species regardless of surveyor identification skills. For all other woodpecker species, birds recorded based on drumming alone were excluded because many surveyors could not confidently identify individuals to species in this way.

Results presented here include only surveys for which at least 18 stops were completed along a survey route. For this report, we did not exclude routes on the basis of inappropriate survey dates or time of day, but such screening may be considered in the future.

RED-SHOULDERED HAWK FALL MIGRATION INDICES

Trends in annual indices for Red-shouldered Hawks at six hawk watch sites (Hawk Mountain, Pennsylvania; Cape May, New Jersey; Waggoners Gap, Pennsylvania; Montclair, New Jersey; and Lighthouse Point, Connecticut) are presented as a comparison to the trend in breeding Red-shouldered Hawks in Ontario. Data were obtained from the Raptor Population Index (http://www.rpi-project.org). The Raptor Population Index (RPI) project is a partnership between the Hawk Migration Association of North America, Hawk Mountain Sanctuary, and HawkWatch International. Annual indices from Hawk Watch stations are the natural logarithm of the Red-shouldered Hawk annual index, expressed as mean hawks per observation day in the Red-shouldered Hawk migration window.

CHANGES IN RED-SHOULDERED HAWK AND WOODPECKER DISTRIBUTION AND ABUNDANCE

To examine whether the distribution of Red-shouldered Hawks and woodpeckers in Ontario have changed over the last 20 years, the number of Ontario Breeding Bird Atlas squares that recorded each species in the first Atlas (1981-1985) were compared to the number of Atlas squares that recorded each species in the second Atlas (2001-2005). A map of Red-shouldered Hawk distribution was also examined to determine whether the species had expanded northward as suggested by Badzinski (2004). Regions that were used to assess breeding bird changes in Ontario are shown in Figure 1. To further investigate population trends of woodpeckers in Ontario, Breeding Bird Survey data were also examined for three time periods: 1968-2005, 1981-2005, 1995-2005 (Downes et al. 2005).

Figure 1 – Regions that were used to assess change in breeding birds between the first (1981-1985) and second atlas (2001-2005).

RESULTS

VOLUNTEER PARTICIPATION (1991-2006)

In 2006, 101 routes were assigned to volunteer surveyors, 56 (55%) of which were surveyed by 50 volunteers. Of those volunteers, 47 volunteer pairs surveyed a single route, 2 surveyed two routes and one team surveyed five routes. Of the 56 routes surveyed, 53 had at least 18 stops completed and were used for analyses. The locations of all routes surveyed since 1990 are shown in Figure 2.

From 1991-2006, 187 surveyors and 111 assistants participated in the survey. A total of 142 survey routes were established in Ontario throughout the duration of the survey, 119 of which were run at least once (Appendix A). Of these, two routes (4 and 8) were run every year by the same dedicated surveyors (Ron Weir, Roy Jenkins). Routes 5, 7 and 11 were run in 14 of the 16 years thanks to the efforts of Chris Risley, Margaret McLaren, Reider Westerhoff, and Donald Kerr. Routes 16, 46 and 60 were run 11 times (by Peter Mansfield, Brian Naylor, and Brian Tuttle) and routes 45, 69 and 74 were run in 10 different years (by Stan Fairchild, Simon Lunn, and Ann Balmer). Twenty-seven volunteers participated in the survey eight or more times and 164 volunteers surveyed from one to seven times. Bob Knudsen surveyed the most routes since he joined the survey in 1998; surveying eight different routes in the Sault Ste. Marie area.

The number of routes surveyed has been very stable since 1999 (~55 routes/year). However, the proportion of routes assigned that were completed declined every year. In the last few years, participation rates remained at around 55%.

Over the duration of the survey, it was estimated that volunteers committed at least 4860 hours to the Red-shouldered Hawk and Spring Woodpecker Survey (assuming a 5-hour commitment per survey-year). This corresponds to 608 person days, which is more than 2 work years of time.

SURVEY CONDITIONS

In 2006, only one route was surveyed outside of the recommended time period (17 April - 7 May). This route was surveyed on 11 May. Three routes were surveyed outside of the appropriate time of day (within one half hour of sunrise). Starting temperatures for survey routes ranged from –6º C to 13ºC, and ending temperatures ranged from 1ºC to 22ºC. All surveys except three were initiated with wind conditions of four or less on the Beaufort scale, and with little or no precipitation. Cloud cover varied considerably among surveys.

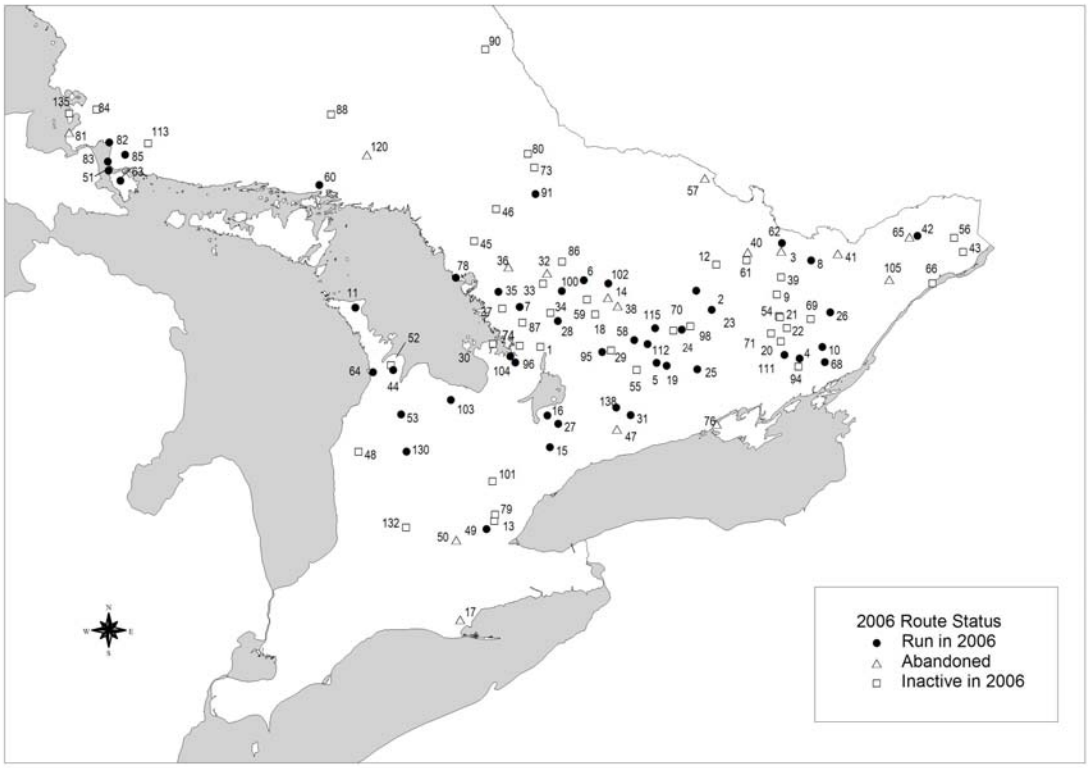

Figure 2 – Distribution and status of Red-shouldered Hawk and Spring Woodpecker survey routes in 2006.

RED-SHOULDERED HAWKS

In 2006, 153 Red-shouldered Hawks were reported along 35 of the 53 completed survey routes (67%; Figure 3), for a mean of 2.89 hawks per route (Table 1). The proportion of routes recording Red-shouldered Hawks was the same as in 2006, but the mean hawks per route increased slightly compared to 2005 (2005: 67% of routes recorded hawks; mean 2.65 hawks per route). Mean hawks observed per route was below the long term average of 3.73.

Annual indices and trends. Annual indices of Red-shouldered Hawks varied considerably among years, but have shown little overall change from 1998-2006 (Figure 4). The index declined gradually from 1991 to 1994, with a statistically significant decline in 1992. This was followed by a significant increase in 1995. From 1995-1997, population indices declined again, followed by a significant increase in 1998. There was no significant change in the Red-shouldered Hawk population index between 1998 and 2002. Between 2002 and 2003, the population index declined significantly, but has remained stable since then.

Overall, from 1991 to 2006, Red-shouldered Hawks did not show a significant long-term trend in

annual population indices (Figure 4; slope = -0.6% per year, 95% Confidence Interval: -1.6 to 0.4%, $p = 0.3$).

Red-shouldered Hawk fall migration indices. Fall migration indices for Red-shouldered Hawks from four of the six Raptor Population Index Program Hawk Watch Sites showed no significant change (Table 3). Two stations (Montclair, Lighthouse Point) showed significant increases in fall migration indices (1.3%, 3.3% respectively).

Changes in Red-shouldered Hawk distribution in Ontario. With the exception of the Carolinian zone, Breeding Bird Atlas data showed that the Red-shouldered Hawk population increased and expanded its range in Ontario. During the first atlas, this species was recorded in 384 squares; whereas the second atlas detected the species in 518 squares (Table 2; Figure 5). The largest increase was detected in the Southern Shield, where the number of squares recording the Red-shouldered Hawk increased from 179 to 268. Simcoe-Rideau experienced a smaller increase, and there was a small decrease in the number of squares reporting the Red-shouldered Hawk in the Carolinian zone.

The northern range of the Red-shouldered Hawk in southern Ontario shifted north by 38 km as compared to the first atlas (Breeding Bird Atlas 2006). Given that the southern edge did not change, this means that the species has expanded northward. In the regions of Sudbury, Parry Sound, Spanish, and Lake of the Woods, the majority of squares that reported the Red-shouldered Hawk in the second atlas, did not record the species during the first. Atlas data also show that the Red-shouldered Hawk's Ontario range shifted west and disappeared from many squares in eastern Ontario.

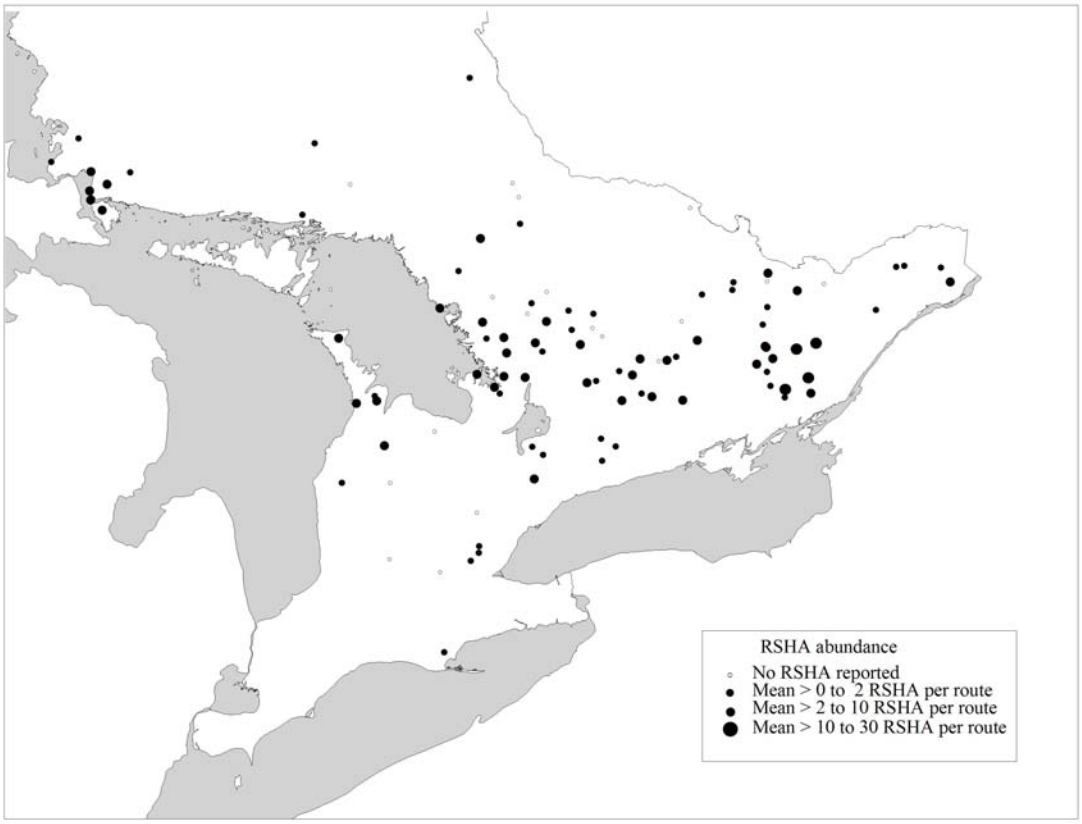

Figure 3 - Mean number of Red-shouldered Hawks recorded by Red-shouldered Hawk and Spring Woodpecker Survey volunteers from 1991-2006

OTHER RAPTORS

Eleven other raptor species were recorded during the Red-shouldered Hawk surveys in 2006 (Table 1). Next to the Red-shouldered Hawk, Turkey Vulture was the second most common raptor species recorded by surveyors in 2006 (mean: 1.30 birds/route), followed by Broad-winged Hawk (mean: 0.77 birds/route) and Red-tailed Hawk and Ospreys (mean: 0.19 birds/route). The mean number of individuals recorded per route was below the long-term average for seven raptor species in 2006 (Table 1). In 2006, numbers of American Kestrels were at their lowest level since the survey began.

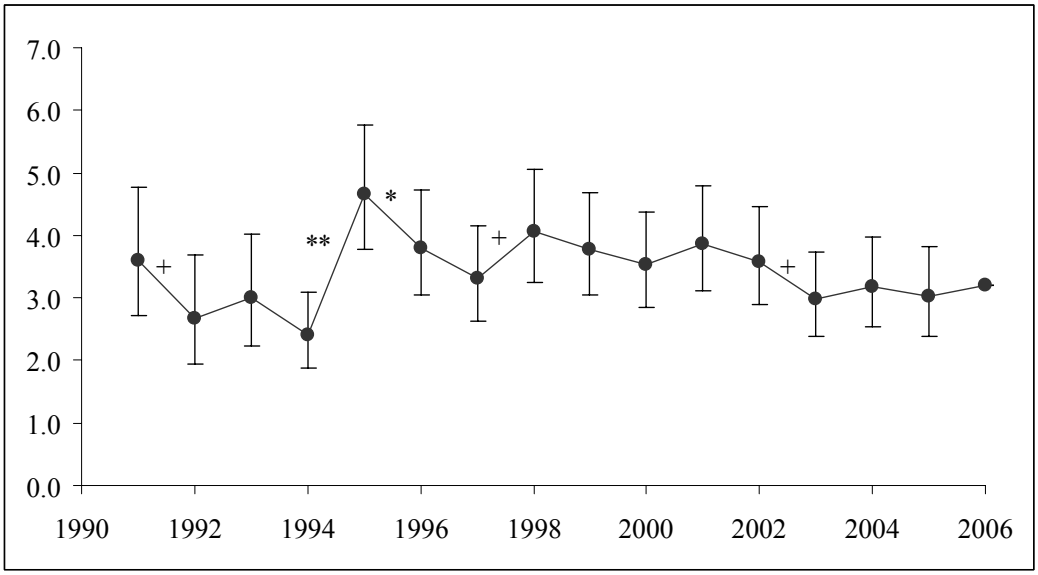

Figure 4 – Estimated annual indices for Red-shouldered Hawk counts from 1991-2006 derived from a generalized linear model assuming Poisson residuals and a log-link function. 95% confidence limits refer to differences from 2006, which was chosen as the baseline year. Year-to-year comparisons based on post-hoc contrasts were significantly different as marked: + p<0.10, * p<0.05, ** p<0.01.

Table 1 - Mean number of raptors per route on Red-shouldered Hawk and Spring Woodpecker surveys from 1991-2006. Only routes with at least 18 stops were included in analyses.

Species	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Mean
Red-shouldered Hawk	5.13	3.38	3.94	2.24	4.69	4.76	4.08	4.62	3.96	3.96	3.51	3.34	3.04	3.44	2.65	2.89	3.73
Turkey Vulture	3.00	1.81	1.82	1.18	1.56	2.66	1.98	2.33	2.12	2.44	2.25	1.90	1.38	1.85	1.29	1.30	1.93
Broad-winged Hawk	0.93	1.25	1.12	0.57	0.48	0.56	0.58	0.74	0.75	0.93	1.23	1.05	1.07	0.71	0.69	0.77	0.84
Red-tailed Hawk	0.33	0.81	0.12	0.31	0.21	0.29	0.38	0.10	0.46	0.28	0.25	0.12	0.22	0.42	0.25	0.19	0.30
American Kestrel	0.27	0.31	0.24	0.25	0.08	0.22	0.15	0.14	0.15	0.24	0.23	0.41	0.18	0.21	0.14	.08	0.21
Northern Harrier	0.47	0.31	0.06	0.25	0.25	0.29	0.08	0.21	0.25	0.13	0.10	0.28	0.15	0.21	0.14	0.17	0.21
Osprey	0.07	0.31	0.18	0.18	0.02	0.34	0.08	0.29	0.13	0.35	0.15	0.19	0.20	0.13	0.04	.19	0.18
Sharp-shinned Hawk	0.27	0.13	.	0.12	0.10	0.22	0.25	0.12	0.04	0.11	0.11	0.05	0.04	0.21	0.10	0.04	0.13
Merlin	.	.	.	0.02	0.02	0.07	0.03	0.07	0.10	0.06	0.02	0.12	0.07	.	0.16	.09	0.07
Rough-legged Hawk	0.07	.	.	.	0.06	.	.	.	.	0.06	0.07	0.16	0.04	0.02	.	.	0.07
Cooper's Hawk	.	.	0.12	0.04	0.10	0.07	0.05	.	0.04	0.02	0.07	0.03	0.04	0.08	0.02	.06	0.06
Northern Goshawk	0.07	.	.	.	0.08	0.15	0.05	0.02	0.02	0.04	0.07	0.03	0.02	0.06	0.02	.06	0.05
Bald Eagle	.	.	.	.	.	.	.	.	.	.	.	0.03	.	0.02	.	.02	0.02
Peregrine Falcon	.	.	.	.	.	.	.	.	.	.	0.02	0.03	.	0.02	0.02	.	0.02
Unknown Buteos	0.33	0.13	0.59	0.22	0.08	0.12	0.10	0.05	0.21	0.06	0.23	0.07	0.07	0.19	0.04	0.13	0.16
Unknown Accipiters	0.07	0.13	0.12	0.04	.	0.12	0.05	0.02	0.04	0.04	0.02	.	0.04	0.08	0.02	0.08	0.06
Number of routes	15	16	17	51	52	41	40	40	52	54	62	57	55	47	51	53	

BIRD STUDIES CANADA
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Table 2 - Number of Breeding Bird Atlas squares in which Red-shouldered Hawks were observed (possible, probable or confirmed) in the first atlas (1981-1985) and the second atlas (2001-2005). Red-shouldered Hawk and Spring Woodpecker Survey data were included in the second atlas.

	Ontario	Carolinian	Simcoe-Rideau	Southern Shield	Northern Shield
First atlas	384	20	184	179	1
Second atlas	518	19	228	268	3

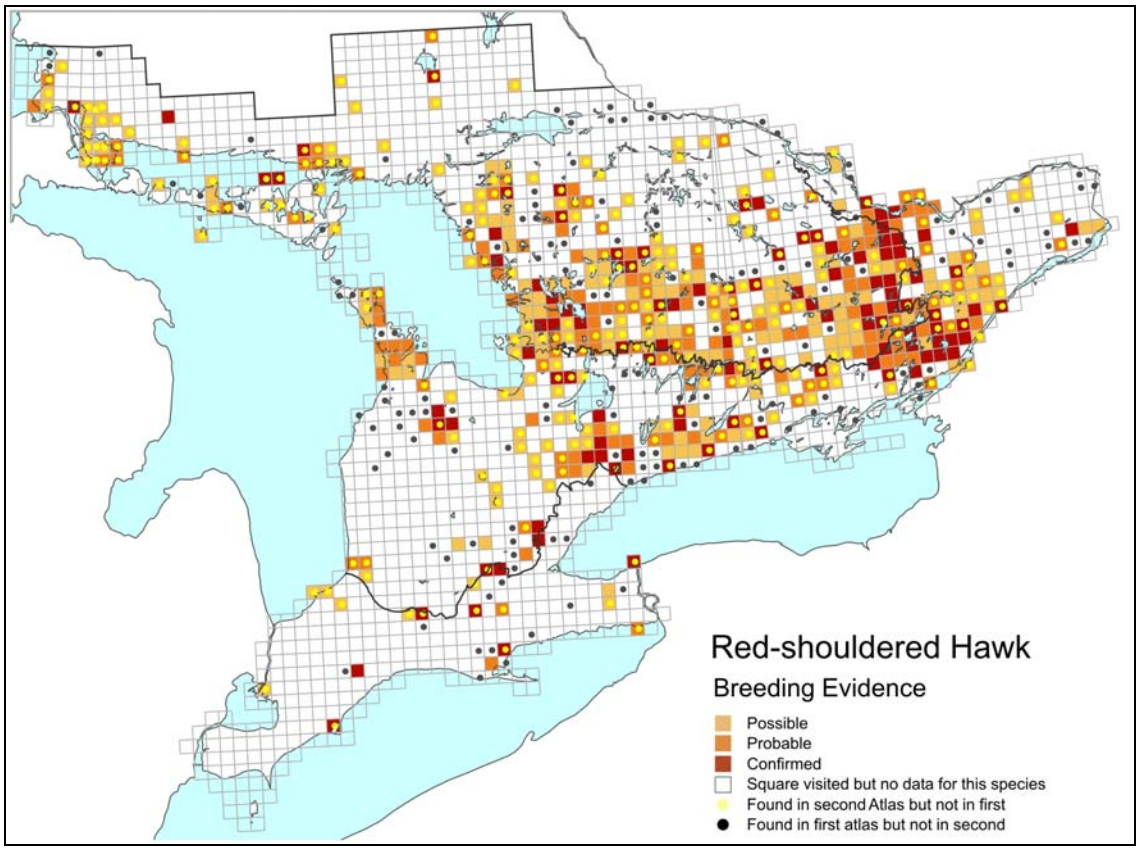

Figure 5 – Change in distribution of Red-shouldered Hawks between the first (1981-1985) and second (2001-2005) breeding bird atlases in Ontario.

Table 3 - Calculated trend (% change/yr) in Red-shouldered Hawk fall migration population indices from 1974-2004 (1976-2004 for Cape May) for six Raptor Population Index Program Hawk Watch Sites. Hawk Watch Site annual indices represent the natural logarithm of the Red-shouldered Hawk annual index, expressed as mean hawks per observation day in the Red-shouldered Hawk migration window. Significant trends are shown in bold.

Hawk Watch Site	Trend	*P*
Holiday Beach, Ontario	-1.31	0.23
Hawk Mountain, Pennsylvania	-0.57	0.11
Cape May, New Jersey	-0.31	0.65
Waggoners Gap, Pennsylvania	0.47	0.83
Montclair, New Jersey	**1.32**	**0.04**
Lighthouse Point, Connecticut	**3.32**	**0.0001**

WOODPECKERS

In addition to the two target woodpecker species (Pileated Woodpecker and Yellow-bellied Sapsucker), three other woodpecker species were commonly recorded during 2006 surveys: Northern Flicker, Downy Woodpecker and Hairy Woodpecker (Table 4). Red-bellied Woodpeckers were reported twice in 1997, 2002 and 2005, three times in 1999 and five times in 2006. Red-headed Woodpeckers were recorded three times in 1997, 1999, and 2000; twice in 2002; and once in 2005.

Annual indices and trends. Population indices for Pileated Woodpecker and Yellow-bellied Sapsucker have shown the largest annual fluctuations of the five commonly observed woodpecker species (Figure 6). Population indices for Pileated Woodpecker increased significantly between 1994 and 1995 and reached population highs in 1997, 1999, 2003, and again in 2005. This species experienced significant population index declines in 1998, 2000, 2002, 2004 and 2006.

Table 4 – Number of each woodpecker species recorded on 2006 Red-shouldered Hawk and Spring Woodpecker Surveys (N=51 routes), as well as the number of routes on which each species was recorded and the mean number of birds per route. Drum Only is the number of woodpeckers recorded on the survey that were identified by drumming alone.

Species	Birds	Routes	Mean per route	Drum Only
Yellow-bellied Sapsucker	871	44	17.4	601
Northern Flicker	378	50	7.6	45
Downy Woodpecker	201	44	4.6	103
Hairy Woodpecker	135	43	2.7	59
Pileated Woodpecker	99	34	1.9	40
Red-bellied Woodpecker	5	2	0.1	0
Red-headed Woodpecker	0	0	0	0
Unknown Woodpecker	100	21	2.0	95

Yellow-bellied Sapsuckers steadily increased between 1993 and 1995, but declined significantly between 1996 and 1997. This species then showed a significant increase in 1999, decline in 2000, increase in 2002, decline in 2003 and 2004, and then increased to a population high in 2005. Yellow-bellied Sapsuckers declined significantly in 2006. Overall, between 1992 and 2006, both Pileated Woodpeckers and Yellow-bellied Sapsuckers appear to have increased in number. Breeding Bird Survey trends also show increases for these species over all three time periods, with the highest increases in the last 10 years (Table 5).

Downy and Hairy Woodpeckers displayed very similar population trends between 1996 and 2003 (Figure 6). Both species increased steadily and significantly from 1996 to 1998 and leveled off between 1998 and 2003. However, Hairy Woodpeckers showed a slight increase in 2004, a significant decline in 2005, and a non-significant decline in 2006. Downy Woodpeckers, on the other hand, have been very stable since 2004. Downy and Hairy Woodpeckers both showed positive population trends from the Breeding Bird Survey (Table 5). However, Hairy Woodpeckers were increasing at a higher rate than were Downy Woodpeckers.

Northern Flicker population indices have been fairly stable over the duration of the survey, despite a significant increase between 1998 and 1999 and a significant decline in 2003 and 2005. Breeding Bird Survey data show significant declines for Northern Flicker in Ontario for 1981-2005 and 1968-2005 and a non-significant increase for 1995-2005 (Table 5).

Table 5 – Population trends for five woodpecker species recorded on Breeding Bird Survey Routes in Ontario.

Species	1995-2005	1981-2005	1968-2005
Downy Woodpecker	2.9	0.9	1.9+
Hairy Woodpecker	5.9*	2.3*	3.0*
Northern Flicker	2.2	-1.6*	-1.3*
Pileated Woodpecker	9.1*	2.8	6.1*
Yellow-bellied Sapsucker	6.5*	2.2+	2.2

+P<.0.1;*P<0.05

Changes in woodpecker distribution in Ontario. Data from the Red-shouldered Hawk and Spring Woodpecker Survey showed that the distribution of each woodpecker species varied across Ontario (Figure 7). Breeding Bird Atlas showed an increase in Pileated Woodpeckers in all regions of Ontario, with the biggest increase observed in the Northern Shield (59% increase, effort adjusted; Table 6). Yellow-bellied Sapsuckers showed a large increase in the Carolinian Forests (first atlas: 36 squares; second atlas: 69 squares), and showed smaller increases in Simcoe-Rideau, Southern Shield, and Northern Shield. Sapsuckers showed a small decline in the Hudson Bay Lowlands (disappearing from 4 squares). The large increase in the number of squares reporting Yellow-bellied Sapsuckers in the southern part of the province suggests a southern range expansion.

During the second atlas, Downy and Hairy Woodpeckers were both reported in more squares in the southern and northern shield. However, after correcting for effort, both species showed little overall change in distribution between the first and the second breeding bird atlases. Northern Flicker showed an increase in the number of squares recording the species, but after correcting for effort, little change was apparent. The exception was the Carolinian Zone, where effort adjusted data show a -9% decline (Table 6).

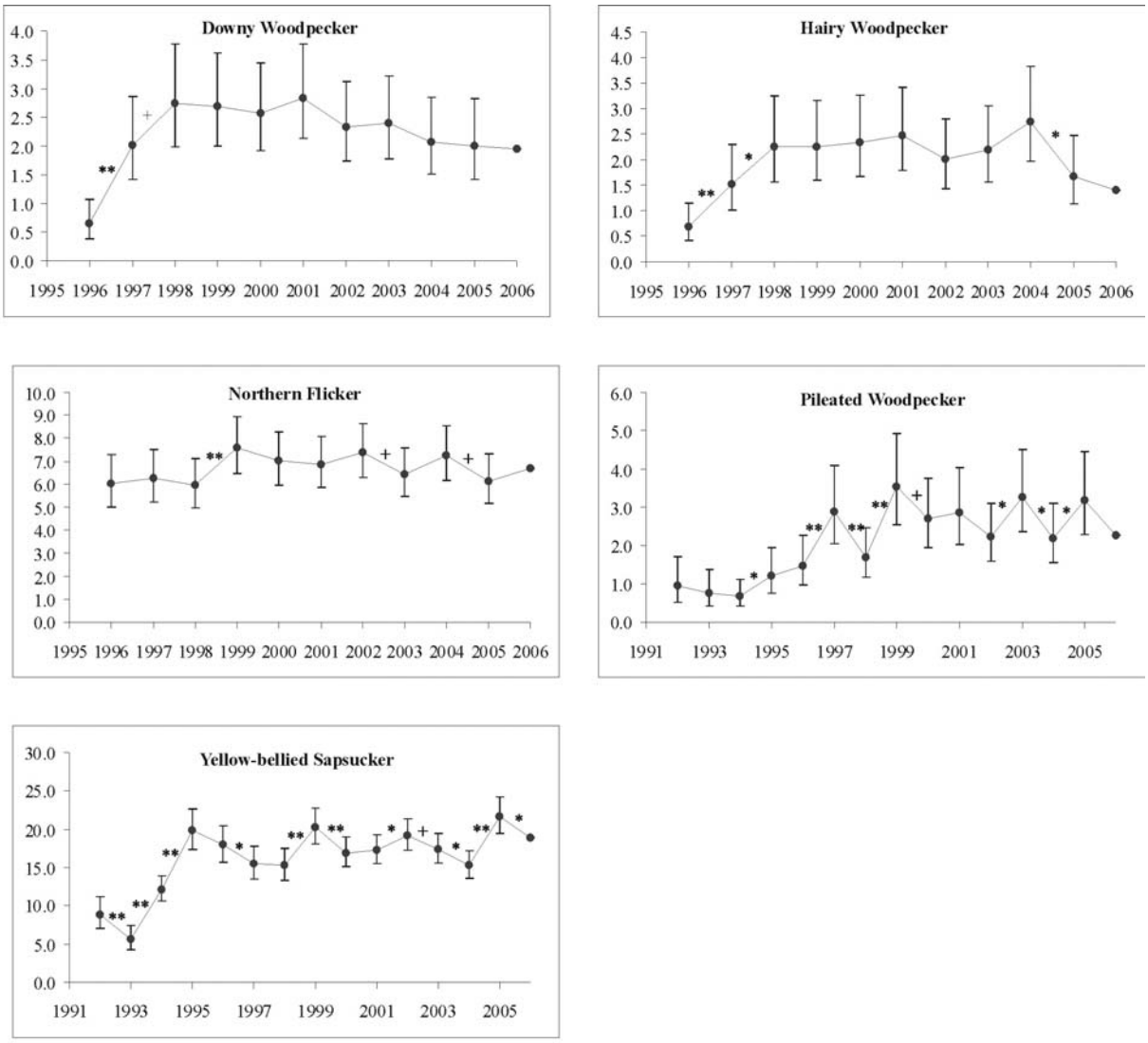

Figure 6 – Annual population indices for five woodpecker species detected regularly during the survey. Indices were calculated using generalized linear regression with Poisson residuals and a log-link function. 95% confidence limits of estimates refer to deviations from the 2006 value. Observations from surveyors who were not confident in their identifications were excluded from analyses. Year-to-year comparisons based on post-hoc contrasts were significantly different as marked: + p<0.10, * p<0.05, ** p<0.01.

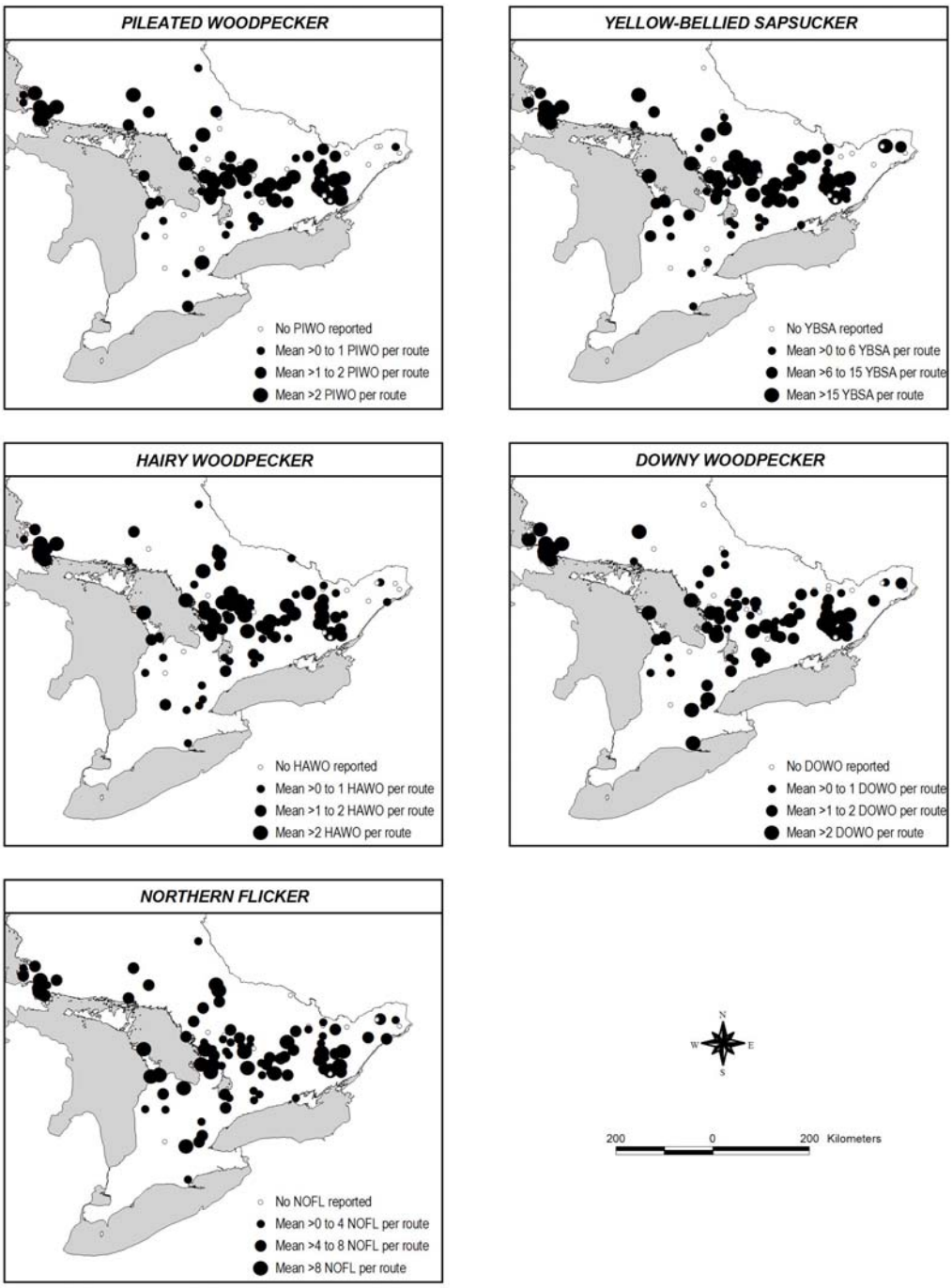

Figure 7 - Mean number of Pileated Woodpecker, Yellow-bellied Sapsucker, Hairy Woodpecker, Downy Woodpecker, and Northern Flicker recorded by Red-shouldered Hawk and Spring Woodpecker Survey volunteers from 1995-2005.

Table 6 - Number of Breeding Bird Atlas squares in which woodpecker species were observed (possible, probable or confirmed) in the first atlas (1981-1985) and the second atlas (2001-2005). Red-shouldered Hawk and Spring Woodpecker Survey data were included in the second atlas.

Downy Woodpecker		**Ontario**	**Carolinian**	**Simcoe-Rideau**	**Southern Shield**	**Northern Shield**	**Hudson Bay Lowlands**
No. squares with breeding evidence	First atlas	1,882	269	701	682	220	10
	Second atlas	2,229	275	720	750	479	5
% squares with breeding evidence (effort adjusted)	First atlas	41.1%	87.7%	86.1%	77.6%	44.0%	8.7%
	Second atlas	41.9%	87.7%	84.3%	80.6%	48.5%	1.9%
Proportional difference (effort adjusted)		2%	0	-2%	4%	10%	**-78%**
Hairy Woodpecker		**Ontario**	**Carolinian**	**Simcoe-Rideau**	**Southern Shield**	**Northern Shield**	**Hudson Bay Lowlands**
No. squares with breeding evidence	First atlas	1,906	226	682	710	255	33
	Second atlas	2,436	233	717	786	652	48
% squares with breeding evidence (effort adjusted)	First atlas	49.5%	67.2%	78.5%	84.2%	52.7%	23.8%
	Second atlas	51.5%	61.2%	78.8%	92.0%	55.8%	22.8%
Proportional difference (effort adjusted)		4%	-9%	0	**9%**	6%	-5%
Northern Flicker		**Ontario**	**Carolinian**	**Simcoe-Rideau**	**Southern Shield**	**Northern Shield**	**Hudson Bay Lowlands**
No. squares with breeding evidence	First atlas	2,425	274	739	789	539	84
	Second atlas	3,037	276	743	805	1086	127
% squares with breeding evidence (effort adjusted)	First atlas	79.1%	97.9%	97.4%	97.9%	87.2%	50.1%
	Second atlas	78.8%	88.7%	94.6%	97.0%	88.1%	48.9%
Proportional difference (effort adjusted)		0	**-9%**	-3%	-1%	1%	-2%
Pileated Woodpecker		**Ontario**	**Carolinian**	**Simcoe-Rideau**	**Southern Shield**	**Northern Shield**	**Hudson Bay Lowlands**
No. squares with breeding evidence	First atlas	1,434	91	514	626	195	8
	Second atlas	2,151	131	658	762	585	15
% squares with breeding evidence (effort adjusted)	First atlas	29.7%	17.1%	45.3%	70.1%	34.2%	5.7%
	Second atlas	43.8%	22.7%	63.2%	87.1%	54.5%	5.9%
Proportional difference (effort adjusted)		**48%**	**33%**	**39%**	**24%**	**59%**	4%
Yellow-bellied Sapsucker		**Ontario**	**Carolinian**	**Simcoe-Rideau**	**Southern Shield**	**Northern Shield**	**Hudson Bay Lowlands**
No. squares with breeding evidence	First atlas	1,553	36	506	734	256	21
	Second atlas	2,178	69	593	792	707	17
% squares with breeding evidence (effort adjusted)	First atlas	43.2%	6.8%	60.5%	89.2%	49.9%	14.8%
	Second atlas	42.3%	12.8%	68.0%	92.3%	50.3%	7.0%
Proportional difference (effort adjusted)		-2%	**90%**	**12%**	**4%**	1%	**-53%**

DISCUSSION

VOLUNTEER PARTICIPATION

From 1991-2006, there has been tremendous long-term commitment by Red-shouldered Hawk and Spring Woodpecker surveyors. An accumulated total of 2+ years of volunteer time is truly impressive. Congratulations to each and every one of you for a job well done!

Although the number of routes run each year has been very stable since 1999, efforts to increase the number of routes run were unsuccessful. In recent years we established new routes in Ontario in order to increase the power of the survey to detect Red-shouldered Hawk population changes, but these routes were often not run. Each year, we ensured that as many routes as possible were assigned to surveyors (usually close to 100%) and we encouraged surveyors to complete their route as assigned. In the last few years, close to 100 routes were assigned to volunteers. Despite these efforts, the participation rate remained low and we saw no resultant increase in the number of routes for which we received data.

SURVEY POWER

Whittam and Francis (1999) estimated that 65 routes were required to detect a 20% change in numbers of Red-shouldered Hawks between two years (α=0.05, β=0.80). Although the number of routes assigned each year was sufficient to meet this goal, the number of routes completed often fell short. In addition, not all routes were run every year, which further reduces the power of the survey to detect population change.

Although the Red-shouldered Hawk Survey may not have been able to detect short-term changes in Red-shouldered Hawk populations, the number of routes surveyed was sufficient to detect a 20% change over 10 or more years. For this reason, we can reasonably assume that population trends of Red-shouldered Hawks derived from this survey are accurately reflecting true population change.

RED-SHOULDERED HAWK TRENDS AND DISTRIBUTION

Red-shouldered Hawk population indices in Ontario were relatively stable from 1991 to 2006, despite minor fluctuations and two significant increases in 1995 and 1998. The increases in 1995 and 1998 might have been due to better tape quality during those years, when new tapes were issued (Francis 1999). Since then, new tapes were issued annually, and Red-shouldered Hawk population indices have remained relatively stable, with the exception of a significant decline in 2003. From 2004-2006, annual indices remained near the level recorded in 2003.

Despite these and other minor fluctuations in the central Ontario Red-shouldered Hawk population, the relative stability in the estimated annual indices from 1991 to 2005 suggests that

there is sufficient habitat in central Ontario to maintain the present Red-shouldered Hawk population, even though the population remains small and depressed relative to its historic abundance in this area. Overall trends in annual indices calculated for six Raptor Population Index program hawk watch sites also showed either no change or significant positive trends.

Data from the first and second Breeding Bird Atlases show that with the exception of the Carolinian zone, the Red-shouldered Hawk population has increased and expanded its range in Ontario. In the regions of Sudbury, Parry Sound, Spanish, and Lake of the Woods, the majority of squares that reported the Red-shouldered Hawk in the second atlas, did not record the species during the first. Atlas data also show that the Red-shouldered Hawk's Ontario range shifted west and disappeared from many squares in eastern Ontario, particularly in the Cornwall region. Local declines were also reported for Long Point, Toronto, and Prince Edward County regions.

In 2006, the Committee on Endangered Wildlife in Canada (COSEWIC) reassessed the status of the Red-shouldered Hawk in Canada, and determined that it is Not at Risk. The Red-shouldered Hawk had previously been classified as Special Concern in 1983. The updated status report for Red-shouldered Hawks (COEWIC 2006) drew upon data from the Red-shouldered Hawk and Spring Woodpecker Survey, Breeding Bird Survey, migration monitoring, breeding bird atlases, Christmas Bird Count and checklist programs. This comprehensive assessment concluded that the Red-shouldered Hawk population in Canada has been relatively stable or increasing throughout most of its range over the past 10 and 20 years.

Overall, results suggest that the Ontario Red-shouldered Hawk population is not currently experiencing long-term deleterious effects that could be related to forest management activities in central Ontario. Naylor et al. (2004) found that the province's current forest management guidelines for Red-shouldered Hawks (28 hectare area-of-concern to protect nesting areas) appear to be effective, because nesting areas protected by the guidelines experienced similar rates of activity and breeding success as nests in uncut forest stands. However, the lack of extensive, contiguous mixedwood forests in southwestern Ontario might be a factor influencing the apparent northward expansion of Red-shouldered Hawks in Ontario. This species also avoids areas of intensive human use (Helferty et al. 2002). Thus, the continued expansion of urban areas and ever-increasing cottage development in prime Red-shouldered Hawk breeding habitat in central Ontario are potential threats to the Ontario population.

OTHER FOREST RAPTORS

Although the survey was primarily designed to collect data on Red-shouldered Hawks, many other raptors were also recorded during surveys. These data show little change in raptor numbers throughout the duration of the survey. According to Breeding Bird Atlas data, most diurnal forest raptors are increasing in Ontario. Reductions in DDT and other organochlorines, as well as less persecution of raptors have contributed to these population increases. Maturation of forests in parts of Ontario as well as increasing forest cover in eastern North America have also had a

positive impact on forest raptors.

WOODPECKER POPULATION TRENDS AND DISTRIBUTION

The two target woodpecker species, Pileated Woodpecker and Yellow-bellied Sapsucker, have increased from 1992-2005, although this was largely driven by increases that occurred in early years of the survey (1992-1997). Long-term monitoring data from the Breeding Bird Survey also show significant increases for both of these species in Ontario. Effort-adjusted breeding bird atlas data show significant province-wide increases for Pileated Woodpecker but not for Yellow-bellied Sapsucker. Atlas data do show, however, that sapsuckers have expanded in southern Ontario. These data suggest that habitat quantity and quality within the survey area is sufficient to maintain the current population levels of these two woodpecker species. It is important to remember, however, that the study area represents a relatively small portion of these species' ranges in Ontario.

Red-shouldered Hawk Survey data show that Downy Woodpecker, Hairy Woodpecker and Northern Flicker population indices have remained relatively stable since the late 1990s. BBS data for the last 20 years show significant declines for Northern Flicker and a non-significant increase over the last 10 years. Downy Woodpeckers showed small increases, whereas a significant increase was documented for Hairy Woodpecker. Breeding Bird Atlas data show little overall change for these species. These trends also suggest that present habitat quantity and quality are sufficient to maintain these species at their current population levels.

All woodpecker species were found throughout the study area, but the areas of highest densities were not necessarily the same for all species. The most abundant woodpecker species were Yellow-bellied Sapsucker and Northern Flicker. At the time of the survey, both of these species may still be migrating, so counts likely included both residents settled on territories and unsettled migrants, resulting in higher population estimates than would be recorded during the breeding season. Downy Woodpecker, Hairy Woodpecker and Pileated Woodpecker are year-round residents. Hence, all three of these species were presumably settled on breeding territories at the time of the survey.

DISCONTINUATION OF THE RED-SHOULDERED HAWK AND SPRING WOODPECKER SURVEY

In 2006, based on a mutual decision between Bird Studies Canada and the Ontario Ministry of Natural Resources, it was decided that the Red-shouldered Hawk and Spring Woodpecker Survey would be discontinued. There were a number of factors that influenced this decision. First, declining participation rates in recent years resulted in decreased survey power. This means that with the current number of routes we were unable to detect large annual changes in the Red-shouldered Hawk population. Second, the survey covered only a small portion of the woodpecker species breeding ranges because it was restricted to the core breeding range of the

Red-shouldered Hawk in Ontario. In addition, it was felt that sufficient data had been gathered to accurately assess the population status of the Red-shouldered Hawk in Ontario. Population monitoring of the Red-shouldered Hawk will continue via other bird monitoring programs such as migration monitoring, breeding bird atlases and checklist programs.

The Red-shouldered Hawk and Spring Woodpecker Survey data made an important contribution to the down-listing of the Red-shouldered Hawk, and allowed researchers to generate an updated population estimate (COSEWIC 2006). The data were also incorporated into the 2nd Breeding Bird Atlas and thus contributed greatly to assessing changes in distribution of hawks and woodpeckers in Ontario. The survey data have been used extensively by the Ontario Ministry of Natural Resources to develop habitat models and guidelines for Red-shouldered Hawks and Pileated Woodpeckers. Although the survey has ended, we anticipate that the data will continue to be used by researchers and biologists.

ACKNOWLEDGMENTS

Many, many thanks to all the dedicated volunteer surveyors who collected data throughout the duration of the survey. More than 180 volunteers (see below) participated in the survey and collectively contributed over 2 person years of time! Your dedication and commitment made an important contribution to understanding and conserving Red-shouldered Hawks in Ontario. Thanks to everyone for a job well done. We hope that you will continue to participate in other Citizen Science programs in the future.

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Chris Farmer, North American Monitoring Coordinator, Hawk Mountain Sanctuary, calculated the annual indices and trends for the Raptor Population Index program watch sites included in this report. Thanks to those watch sites (Holiday Beach, Waggoners Gap, Montclair, Hawk Mountain, Lighthouse Point and Cape May) for providing the data necessary to calculate indices and trends. Thanks to the volunteers and partners of the Ontario Breeding Bird Atlas (Bird Studies Canada, Canadian Wildlife Service, Ontario Field Ornithologists, Ontario Ministry of Natural Resources, and Ontario Nature) for providing Atlas data, and to Andrew Couturier and Peter Blancher for GIS analyses. Thanks also to the Breeding Bird Survey (BBS) volunteers for collecting data that were included in the report and to the Canadian Wildlife Service for BBS program coordination and data analysis.

Peter Burke produced the Red-shouldered Hawk illustrations used throughout the report and Charles Francis wrote the original SAS programs used to analyze data. Funding for this project

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RED-SHOULDERED HAWK AND SPRING WOODPECKER SURVEYORS (1991-2006)

The following people volunteered their time to collect data for the Red-shouldered Hawk Survey. Thanks to these Citizen Scientists as well as to their assistants. Your efforts are greatly appreciated!

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APPENDIX A ***- Route number, name, latitude and longitude for all routes that have been run at least once, with the numbers of hawks detected each year it was surveyed. AB indicates that the route has been abandoned. Cells containing '.' indicate that the route was not run (or the data were not reported) in that year.***

Route	Route Name	Status	Lat	Long	# RSHA detected by year														
					91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06
1	Sparrow Lake		44 48'	79 23'	14	.	.	4	17	5	2	2	6	5	.	.	2	.	.	.
2	Cashel		44 58'	77 29'	6	2	0	1	5	2	.	0	2	2	5	.	4	9	.	11
3	Ashdad	AB	45 21'	76 39'	0	0	0	.	.	.	.	.	.	.	.	.	.	.	.	.
4	Canoe Lake		44 30'	76 35'	22	21	20	22	30	33	29	29	35	32	36	34	31	29	31	21
5	Big Cedar Lake		44 35'	78 08'	2	2	0	0	2	.	1	1	2	2	3	0	1	1	0	1
6	Livingstone Lake		45 17'	78 52'	0	2	0	1	.	.	.	2	7	0	0	0	1	0	0	1
7	Foreman		45 07'	79 35'	8	13	9	1	10	5	4	7	.	3	1	4	5	4	6	.
8	White Lake		45 16'	76 20'	6	2	2	3	4	6	5	4	4	3	4	3	2	3	2	2
9	Lavant		45 02'	76 45'	1	1	0	1	0	.	.	.	4	5	3	1	0	.	1	4
10	Opinicon Lake		44 35'	76 19'	10	5	15	11	12	10	9	20	20	23	22	18	27	20	25	17
11	Brinkmans Corners		45 11'	81 24'	3	0	0	0	1	0	1	.	0	1	1	2	0	1	1	.
12	Quadeville		45 19'	77 23'	0	1	0	0	1	.	.	1	.	.	0	.	0	.	.	.
13	Mountsberg		43 27'	80 01'	0	0	0	0	.	.	1	.	.	.	.	.	.	.	.	.
14	Kennisis Lake	AB	45 08'	78 37'	0	0	.	0	0	.	.	.	.	.	.	.	.	.	.	.
15	Maple		44 00'	79 22'	5	4	4	0	4	4	2	1	5	8	1	1	5	6	6	.
16	Brown Hill		44 15'	79 22'	.	1	0	0	2	2	4	.	0	1	.	.	2	1	1	.
17	Norfolk		42 42'	80 27'	.	0	1	0	0	.	.	2	1	1	0	0	.	.	0	.
18	Minden		44 59'	78 45'	.	.	11	6	13	3	.	2	.	0	.	0	0	.	.	.
19	Belmont-Methuen		44 34'	78 02'	.	.	5	.	4	0	2	4	4	9	3	2	2	3	3	3
20	Parham		44 39'	76 45'	.	.	.	1	0	4	1	3	3	1	0	.	2	.	.	5
21	Ardoch		44 52'	76 45'	.	.	.	3	9	7	4	6	4	2	2	.	.	.	.	.
22	Sharbot Lake		44 46'	76 41'	.	.	.	3	9	11	.	.	.	5	3	.	8	.	.	.
23	Myers Cave		45 11'	81 24'	.	.	.	4	16	.	9	.	4	.	.	.	0	0	1	.
24	Steenburg Lake		44 50'	77 50'	.	.	.	5	5	6	.	10	4	12	5	.	1	9	3	3
25	Vansickle		44 30'	77 42'	.	.	.	3	5	.	.	3	3	0	4	7	5	6	6	0
26	Otty Lake		44 50'	76 12'	.	.	.	12	21	11	10	17	18	10	.	10	.	4	.	.
27	Zephyr		44 11'	79 15'	.	.	.	2	1	0	.	3	.	1	.	2	2	2	.	0
28	Uffington		44 59'	79 11'	.	.	.	0	2	1	0	3	0	0	3	1	0	1	2	2
29	Union Creek		44 43'	78 37'	.	.	.	1	.	.	.	.	.	0	.	.	.	.	.	.
30	Farlain Lake		44 50'	79 54'	.	.	.	5	7	2	0	2	1	.	3	3	7	.	0	.
31	Cavan		44 12'	78 28'	.	.	.	.	3	0	.	.	1	1	1	2	1	1	.	.
32	Ifracombe	AB	45 21'	79 16'	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	0
33	Beatrice		45 17'	79 18'	.	.	.	.	0	0	.	.	0	.	0	0	.	.	1	.
34	Fraserburg		45 03'	79 15'	.	.	.	3	5	.	.	.	0	.	1	.	.	.	.	0
35	Humphrey		45 15'	79 49'	.	.	.	1	.	.	.	.	.	3	.	.	.	3	.	.
36	Broadbent	AB	45 26'	79 41'	.	.	.	0	.	.	.	.	.	.	.	.	.	.	.	.
37	Twelve Mile Bay		45 04'	79 48'	.	.	.	1	.	7	.	.	0	3	0	1	2	.	2	5
38	Harburn	AB	45 04'	78 31'	.	.	.	0	.	.	.	.	.	.	.	.	.	.	.	.
39	Flower Station		45 09'	76 41'	.	.	.	0	4	.	.	1	0	.	.	.	1	.	.	.
40	Esmonde	AB	45 23'	77 01'	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.
41	Manion Corners	AB	45 18'	76 02'	.	.	.	0	.	.	.	.	.	.	.	.	.	.	.	.
42	Lemieux		45 21'	75 08'	.	.	.	.	0	.	.	.	.	.	.	0	0	1	0	0
43	Glenroy		45 11'	74 39'	.	.	.	0	8	.	3	.	.	.	.	.	.	.	.	.

Appendix A continued.

Route	Route Name	Status	Lat		Long		# RSHA detected by year															
							91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06
44	Charles Lake		44	43'	81	2'	.	.	.	0	2	1	1	1	.	.	.	.	.	.	1	0
45	Waubamik		45	39'	80	2'	.	.	.	2	3	.	1	2	1	0	2	.	2	.	0	.
46	Commanda		45	53'	79	46'	.	.	.	4	1	1	3	.	1	7	1	2	2	.	0	2
47	Pontypool	AB	44	6'	78	38'	.	.	.	0	0	0	.	.	0	1	0	.	.	.	.	.
48	Kinlough		44	4'	81	26'	.	.	.	0	2	0	0	0	0	0	.	.	.	.	.	0
49	Beverly Swamp		43	24'	80	6'	.	.	.	0	1	1	0	0	0	.	.	0	0	0	0	0
50	Wrigley's Corners	AB	43	20'	80	26'	.	.	.	0	.	.	.	0	0	.	.	.	.	.	.	.
51	St. Joseph Island		46	19'	84	7'	.	.	.	2	5	7	3	.	7	5	11	8	2	4	.	9
52	Mountain Lake		44	41'	81	1'	.	.	.	2	4	6	5	3	2	1	1	.	.	3	3	.
53	Mooresburg		44	20'	80	58'	.	.	.	2	2	6	3	5	2	0	4	3	4	0	2	2
54	Burke Settlement		44	51'	76	44'	.	.	.	3	6	6	7	.	.	.	.	.	.	.	.	.
55	Buckhorn		44	33'	78	21'	.	.	.	3	1	4	.	.	.	.	.	.	.	.	.	.
56	Greenfield		45	18'	74	44'	.	.	.	0	2	.	.	.	.	.	.	1	0	.	.	0
57	Petawawa	AB	45	59'	77	25'	.	.	.	.	0	.	.	.	.	.	.	.	.	.	.	.
58	Catchacoma		44	42'	78	25'	.	.	.	.	.	.	.	.	2	3	.	.	.	1	3	0
59	Pine Springs		45	8'	78	51'	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.
60	Fox Lake Road		46	9'	81	44'	.	.	.	.	0	0	0	0	2	1	0	4	2	4	4	4
61	Two Island Lake Ro		45	19'	77	2'	.	.	.	.	0	0	.	2	.	.	0	.	.	.	.	.
62	Burnstown		45	25'	76	38'	.	.	.	.	9	7	8	10	8	3	5	4	1	6	3	3
63	Koshkawong		46	14'	83	59'	.	.	.	.	5	8	9	.	10	7	12	7	7	5	.	6
64	Sauble- Howdenvale		44	40'	81	15'	.	.	.	.	0	7	5	9	7	7	8	9	4	5	.	3
65	Limoges	AB	45	21'	75	13'	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.
66	Ingleside		44	58'	75	2'	.	.	.	.	0	.	0	.	0	.	0	.	0	.	.	0
68	Dog Lake		44	28'	76	19'	.	.	.	.	.	.	7	4	7	5	.	.	.	2	1	.
69	Christie Lake		44	48'	76	25'	.	.	.	.	.	17	16	12	11	7	12	15	9	.	5	9
70	Glen Alda		44	50'	77	55'	.	.	.	.	.	0	0	.	.	.	.	.	.	.	.	2
71	Mountain Grove		44	44'	76	51'	.	.	.	.	.	5	.	.	6	5	4	.	.	.	.	.
72	Unmentionable	AB	44	4’	77	44’	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.
73	Wasi Lake Circle		46	11'	79	19'	.	.	.	.	.	0	0	.	0	.	.	.	.	.	.	.
74	Big Chute		44	48'	79	37'	.	.	.	.	.	.	3	4	2	4	5	3	8	6	4	2
76	Renderville Road	AB	44	4'	77	33'	.	.	.	.	.	.	0	.	.	.	.	0	.	.	.	.
77	Southwest Elgin	AB	42	34’	81	33’	.	.	.	.	.	.	.	.	0	.	.	.	.	.	.	.
78	Killbear		45	22'	80	16'	.	.	.	.	.	.	3	9	7	7	.	5	.	2	.	.
79	Hilton Falls		43	30'	80	0'	.	.	.	.	.	.	2	1	0	1	0	0	0	.	.	2
80	Trout Lake		46	18'	79	22'	.	.	.	.	.	.	.	0	0	.	.	.	.	.	.	.
81	Red Rock Road	AB	46	36'	84	33'	.	.	.	.	.	.	.	1	0	0	.	.	.	.	.	.
82	Echo Bay		46	32'	84	6'	.	.	.	.	.	.	.	4	2	0	6	3	0	0	.	2
83	Laird		46	23'	84	7'	.	.	.	.	.	.	.	4	1	2	5	3	2	2	.	0
84	Robertson Lake		46	46'	84	16'	.	.	.	.	.	.	.	.	.	0	1	1	.	.	.	0
85	Gordon Lake		46	26'	83	55'	.	.	.	.	.	.	.	.	.	5	5	4	2	2	.	.
86	Limberlost Rd		45	26'	79	5'	.	.	.	.	.	.	.	.	.	.	0	.	.	.	.	.
87	Torrance-Southwood		44	59'	79	34'	.	.	.	.	.	.	.	.	.	6	3	3	4		.	.5
88	Whitefish-Cartier		46	42'	81	34'	.	.	.	.	.	.	.	.	.	2	0	1	0	.	.	.
89	Six Mile Lake		44	55’	79	43’	.	.	.	.	.	.	.	.	.	.	2	.	2	0	.	.
90	Nipissing Road		47	8'	79	46'	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.
91	Trout Creek		45	58'	79	18'	.	.	.	.	.	.	.	.	.	1	0	0	.	1	1	3
92	Rain Lake Road		45	35’	78	58’	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.
94	Sydenham		44	28'	76	36'	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.

Appendix A continued.

Route	Route Name	Status	Lat		Long		# RSHA detected by year															
							91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06
95	Burnt River		44	42'	78	43'	.	.	.	.	.	.	.	.	.	.	3	7	2	2	0	3
96	Moonstone		44	41'	79	41'	.	.	.	.	.	.	.	.	.	.	5	3	0	0	2	.
98	Ormsby		44	51'	77	44'	.	.	.	.	.	.	.	.	.	.	0	1	0	.	1	.
100	Lake of Bays		45	13'	79	7'	.	.	.	.	.	.	.	.	.	.	4	3	.	0	0	1
101	Terra Cotta		43	46'	80	1'	.	.	.	.	.	.	.	.	.	.	0	0	.	.	.	0
102	Haliburton Forest		45	14'	78	35'	.	.	.	.	.	.	.	.	.	.	1	2	0	0	.	.
103	Eugenia/Ravenna		44	25'	80	24'	.	.	.	.	.	.	.	.	.	.	0	.	.	0	0	0
104	Sturgeon River Val		44	44'	79	44'	.	.	.	.	.	.	.	.	.	.	6	4	0	2	1	0
105	Kemptville	AB	45	3'	75	30'	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.
111	Depot Lakes		44	33'	76	44'	.	.	.	.	.	.	.	.	.	.	3	0	2	1	.	.
112	Anstruther/Chandos		44	44'	78	13'	.	.	.	.	.	.	.	.	.	.	3	3	.	1	3	5
113	Carpenter Lake Rd		46	31'	83	40'	.	.	.	.	.	.	.	.	.	.	0	1	.	.	.	.
114	Killarney HW 637		46	0’	81	26’	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3
115	Kawartha Highlands		44	51'	78	7'	.	.	.	.	.	.	.	.	.	.	.	0	2	10	4	.
120	Massey	AB	46	22'	81	12'	.	.	.	.	.	.	.	.	.	.	.	0	.	.	.	.
122	Noganosh Lake		45	52’	80	22’																0
124	Whitney		45	25'	78	8'	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	4
125	McArthur Mills	AB	45	7'	77	38'	.	.	.	.	.	.	.	.	.	.	.	.	.	0	.	.
127	Aberdeen		45	31'	74	39'	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	.
129	Merrickville		44	50'	75	49'	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0
130	Mildmay		44	2'	80	55'	.	.	.	.	.	.	.	.	.	.	.	0	.	0	0	.
132	Milverton		43	27'	80	58'	.	.	.	.	.	.	.	.	.	.	.	.	0	.	.	.
135	Goulais Bay		46	48'	84	32'	.	.	.	.	.	.	.	.	.	.	.	0	.	.	0	.
137	Ferguson Corners		44	59'	77	17'	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	.
138	Mount Horeb		44	16'	78	37'	.	.	.	.	.	.	.	.	.	.	.	1	1	2	2	1
139	N of Apsley		44	47'	77	53'	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	3
140	Millbridge		44	43'	77	38'	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1
141	Brighton		44	6'	77	52'	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	.