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Jean Gauthier, Mark Dionne, Céline Maurice, Josée Potvin, Michael D. Cadman and Daniel Busby

Québec Region, 2007
Canadian Wildlife Service
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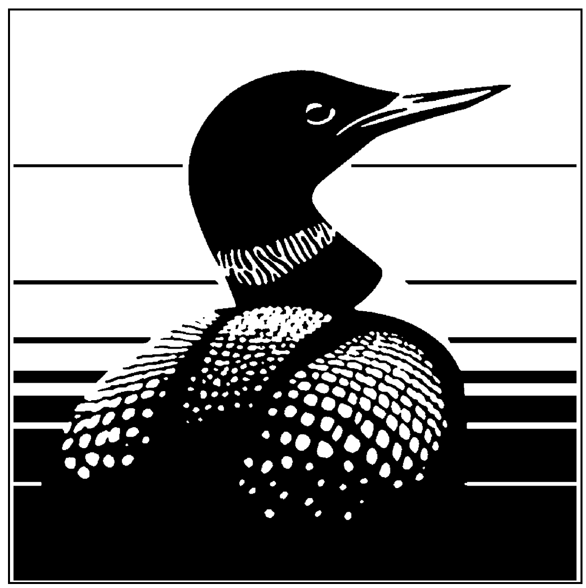

Technical Report Series No. 477

Environnement Canada / Environment Canada
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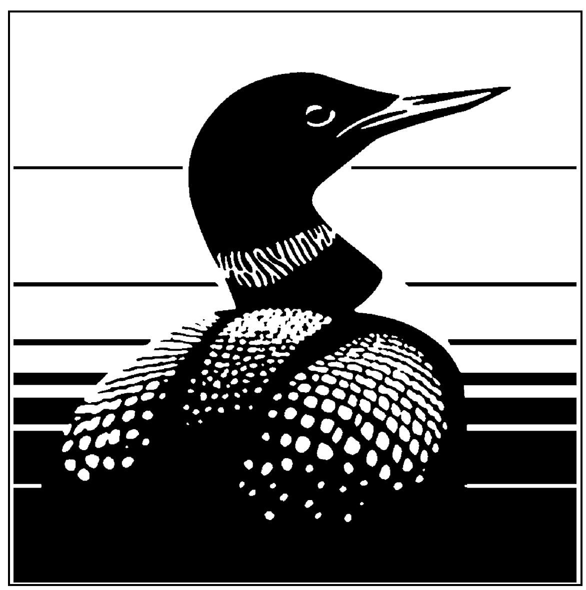

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ABSTRACT

The Chimney Swift (*Chaetura pelagica*) is an aerial insectivorous bird that forages exclusively on the wing. The species is part of the long distance neotropical migrant's group. The breeding range of the Chimney Swift is largely limited to eastern North America below the 49th parallel. Approximately 26% of the species' breeding range is in Canada. The Chimney Swift winters mainly in the upper Amazon River drainage basin in South America, however, very little information on this subject is available.

Before the arrival of Europeans in North America, the Chimney Swift primarily used hollow trees (snags and cavity trees), and to a lesser extent caves and crevices in rock cliffs. Nowadays, the Chimney Swift is associated with built-up areas (urban, suburban and rural areas), where it mainly uses chimneys for nesting and roosting.

The Chimney Swift population is in decline throughout its breeding range and the situation seems to have worsened in recent years. All available data (Breeding Bird Survey [BBS], Breeding Bird Atlases, historical roost data, "Étude des populations d'oiseaux du Québec" [ÉPOQ] data and the Québec Chimney Swift Survey Program) point in the same direction. The most serious factor causing this decline seems to be the dwindling number of its main nesting sites, which are traditional masonry chimneys.

The growing use of electric and gas heating, new construction standards and materials and fire prevention bylaws and measures (metal chimney flue, spark arresters, chimney hats and protective fencing against nuisance animals) have reduced the number of traditional chimneys available to swifts. Based on population viability analyses, between 40 and 60% of mature birds must reproduce successfully in order to maintain the population level.

In 2005, the Canadian Chimney Swift population was estimated at about 4,000 breeding pairs. The rate at which chimneys are being converted is increasing and hardly any suitable nesting sites will remain in 20 years, but in fact, the issue may be decided in the next 5 to 10 years. However, simple and inexpensive conservation measures exist which could help the species on a short and long term basis. These include the creation of a traditional chimney stewardship program, building artificial chimneys and, above all, changing forestry practices in order to maximize the number of suitable hollow trees.

RÉSUMÉ

Le Martinet ramoneur (*Chaetura pelagica*) est un oiseau insectivore strictement aérien, faisant partie des migrateurs néotropicaux de longue distance. L'aire de nidification de cette espèce est en grande partie limitée à la partie orientale des États-Unis et du Canada, en dessous du 49° de latitude nord. Environ 26 % de son aire de nidification se trouve au Canada. Le Martinet ramoneur hiverne principalement en Amérique du Sud, dans le bassin supérieur de l'Amazone, mais il existe très peu d'information au sujet de l'écologie de cet oiseau dans ces régions.

Avant l'arrivée des Européens en Amérique du Nord, le Martinet ramoneur utilisait principalement des gros arbres creux, mais aussi des grottes et des crevasses rocheuses. Aujourd'hui, l'espèce est principalement associée aux zones urbaines, périurbaines et campagnardes où elle utilise majoritairement les cheminées pour nicher et passer la nuit (dortoir).

La population du Martinet ramoneur est en déclin à travers toute son aire de nidification, et la situation semble s'être aggravée au cours des dernières années. Toutes les données disponibles (le Relevé des oiseaux nicheurs [RON], l'Atlas des oiseaux nicheurs, les données historiques de dortoirs, Étude des populations d'oiseaux du Québec [ÉPOQ] et le programme d'inventaire du Martinet ramoneur au Québec) abondent dans ce sens. La cause primaire de ce déclin semble être le manque de ses principaux sites de nidification, à savoir les cheminées traditionnelles en maçonnerie, et leur disparition. La disparition de cet habitat essentiel pour l'espèce s'explique par la conversion des bâtiments aux nouvelles technologies de chauffage, par l'utilisation de nouveaux matériaux de construction pour les cheminées ainsi que par l'établissement de règlements et de normes en matière de protection et de prévention contre les incendies favorisant la fermeture, la modification et la destruction de ce type de cheminée. Selon les modèles de viabilité des populations réalisées, entre 40 et 60 % des oiseaux reproducteurs doivent se reproduire afin de maintenir la population.

En 2005, au Canada, on estimait la population de Martinets ramoneurs à près de 4 000 couples reproducteurs. Au rythme actuel de la disparition des sites de nidification, on estime que dans une vingtaine d'années, au plus, il ne restera plus aucune cheminée pour le martinet. La grande majorité de celles-ci auront disparu d'ici 5 à 10 ans, particulièrement celles utilisées pour la nidification. Il existe, cependant, des mesures de conservation simples et peu onéreuses permettant d'aider l'espèce à court et long terme. Parmi ces recommandations, il y a la création d'un programme d'intendance afin de conserver les cheminées adéquates existantes, la création d'habitats artificiels (privés ou touristiques) et surtout, la modification de nos pratiques forestières afin de maximiser la quantité d'arbres à cavité de fortes dimensions.

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1. Classification

The Chimney Swift belongs to the genus *Chaetura*, which includes nine other species unique to the Americas (Chantler 1999; AOU 2002). There are three other species of swifts in Canada, namely Vaux's Swift (*Chaetura vauxi*), the only other *Chaetura* swift in North America; the Black Swift (*Cypseloides niger*); and the White-throated Swift (*Aeronautes saxatalis*). All three are restricted to the western half of the country (Godfrey 1986). The Chimney Swift could constitute a super-species along with the Vaux's Swift and the Chapman's Swift (*Chaetura Chapmani*) (AOU 1998). The distribution of the Chapman's Swift is limited to the northern part of South America (Marín 1997). *Chaetura* swifts belong to the Chaeturini tribe, which in turn is part of the subfamily Apodinae, family Apodidae, order Apodiformes. The Chimney Swift is considered a monotypic species (Chantler 1999).

2. Morphological characteristics

Often mistaken for a swallow, the Chimney Swift is readily distinguished by its cigar-shaped body (seems to lack a tail because it is so short), its long narrow pointed wings, its silhouette bowed slightly backward, its characteristic call and its quick jerky flight. Based on Schnell and Hellack's work (1978), Chimney Swifts fly at speeds varying between 29 and 58 km/h. This small bird is 12 to 14 cm long (Chantler 1999) with a wingspan of 29 to 31 cm (Snow and Perrins 1998). It reaches a weight of approximately 21 g (Chantler 1999). Its short, square tail is made up of 10 rectrices. The rachides of the rectrices extend 5 to 7 mm beyond the feather tips, giving the tail a spiny appearance and enabling the bird to cling onto vertical surfaces (Lack 1956). This characteristic is unique to the *Chaetura* genus. The Chimney Swift also possesses a small and strong mobile hallux oriented on the posterior side, which also helps it to cling onto vertical structures (Lack 1956; Collins 1983; Sibley and Ahlquist 1990). This apodidae is not very well adapted to walking, and therefore needs to fly to get in and out of roosting and nesting cavities. The wings are long and narrow, with 10 greatly elongated primaries and very short secondaries. They are much longer than the tail when they are folded in. Upper parts are dark sooty brown, slightly chatoyant, palest on the rump, and blackish on the wings; the abdomen is dark like the back, turning to brownish grey, and sometimes white on the throat (Godfrey 1986). The Chimney Swift does not exhibit any sexual dimorphism (Fischer 1958). Juvenile plumage is similar to the adult's. Smaller size and a spiny tail distinguish it from the Black Swift and the White-throated Swift. It is very similar to Vaux's Swift, but its somewhat larger size and darker under parts facilitate identification when the bird is in hand.

3. Biology

Chimney Swifts also possess the capability to become torpid (temporary poikilotherm) when the temperature is cold (Ramsey 1970). Their body temperature can drop to about 5°C and the bird becomes still. When the outdoor temperature increases, the bird's body temperature rises back quickly (Ramsey 1970). This adaptation allows birds to remain in their refuge when conditions are unfavourable. This behaviour also prevents high energetic costs (foraging and thermoregulation) when few flying insects are available.

3.1 Breeding

The main studies on the breeding biology of the Chimney Swift were carried out by Ralph Dexter (1944-1983) at Kent State University in Ohio and by Richard B. Fischer (1939-1953) in New York State. The information on reproduction in this section originates primarily from the work of these two researchers.

Breeding behaviour

During summer Chimney Swifts may be seen in large numbers entering a chimney for roosting. It is, however, a solitary breeder and only one nest is built per site (chimney, tree hollow, air shaft, etc.) (Fischer 1958; Dexter 1969, 1974, 1991). Although several chimneys from a building may each host a nesting pair (Dexter 1969), the swift is not a true colonial bird (Fischer 1958). Swifts form a loose colony in which each pair uses and defends a different nesting structure. At Ohio's Kent State University, Dexter (1969) even noted that the birds tended not to nest in an air shaft if it was adjacent to one already occupied by a pair. The only exception reported in the literature is of two nests inside the same barn (Fischer 1958). The presence of two pairs in one location is doubtless explained in this case by the building's large size in comparison to a chimney. It is difficult to believe that there could be more than one nest in a given chimney considering a pair's aggressiveness towards other swifts when nesting is advanced (CWS, unpublished data). On rare occasions, a site may be used for both nesting and roosting: Zammuto and Franks (1978) observed a chimney used as a roost by 40 or so birds that also hosted a nest.

Fidelity

Chimney Swifts normally mate for life and are monogamous (Dexter 1992). Adults have a very strong tendency to return to the previous year's nesting site (Fischer 1958; Dexter 1992). Swifts retain the same mate as long as both return to the nesting site each year (Dexter 1971). However, if one of the birds does not return, the remaining one will mate with another individual. Dexter (1992) recorded a mate fidelity rate of 84% (294 pairs) between 1945 and 1983, and 96% of these pairs occupied the same air shaft that they had used the previous year. Pairs typically build their nest in the same spot on the wall from one year to the next (Dexter 1969). This phenomenon was also observed in Québec at two sites during six consecutive years (CWS, unpublished data).

Mating

Chimney Swifts do not generally breed before their second year (Dexter 1981a), but it has been shown that some individuals can breed during their first summer (Dexter 1952a, 1981b, 1985; Fischer 1958; Kyle and Kyle, unpublished data). However, broods from one year-old birds are usually smaller then those of older birds (Dexter 1981b). Courtship primarily takes place in the air and consists of pair chase and flight, with the birds engaging in "V-ing" and gliding together for short distances (Fischer 1958). It was long believed that swifts copulated while in flight, but that is not true. They copulate inside the nesting site, hanging onto the vertical surface (Dexter 1950; Fischer 1958) or in the nest (C. Garneau, unpublished data). Chimney Swifts are generally single-brooded in northern latitudes (Baichich and Harrison 1997). There have been reports of two broods per year for some pairs in Texas (Kyle and Kyle, unpublished data).

Nest

The nest is made of small dead twigs from tree tops that the swift snaps off with its feet while in flight (MacNamara 1918; Shelley 1929; Fischer 1958; Zammuto and Franks 1981a) or, very rarely, using its beak (Fischer 1958). Before setting off for the nesting site, it transfers the twigs to its beak (Fischer 1958). With its glutinous saliva, the swift fastens the twigs to the vertical surface and to each other to form a half-saucer nest like. Saliva glands swell up prior to nesting, probably to increase saliva production for nest building (Sibley and Ahlquist 1990). Male and female build the nest together, which takes approximately 18 days, but can take up to 30 (Fischer 1958). Poor weather conditions can slow down nest construction. The birds continue to add twigs and saliva to the nest until the eggs begin to hatch (Fischer 1958). Dexter (1969) observes that the average depth from the chimney top was 6.1 m in 400 nests studied in Ohio. Most of the time, they were attached to the chimney's south and west walls. Swifts do not normally reuse nests built the previous year as most fall down over the fall or winter (Dexter 1969). Those that do survive are often in poor condition and the birds destroy them the following year (Dexter 1981a). However, if a nest is in good condition, it can be reused (Amadon 1936; Dexter 1978, 1981a) even for four consecutive years (C. Garneau, unpublished data). This is often the case with nests constructed in sheltered locations, such as under an overhang (Dexter 1981a) or inside a building (Dexter 1962). The old nest is then often repaired, and the birds add twigs and saliva to solidify it (Fischer 1958; Dexter 1978; Cink and Collins 2002; C. Garneau, pers. comm.).

Egg laying and incubation

Egg laying begins when the nest is half built (Fischer 1958) and the female usually lays one egg every second day (Dexter 1950). Four eggs (2-6) are laid on average and the young hatch after 19 to 21 days of incubation (Fischer 1958), which is done by both parents. Similar clutch sizes have been observed on two nests eight years in a row in Québec from 1998 to 2005 (Table 1), and in Texas between 1989 and 2002 (Kyle and Kyle, unpublished data) which also correspond to other existing data (Appendix 2). Sometimes more than two adults can be found at a nesting site, as extra-parental co-operation is well established for this species. It is fairly common for one or two non-breeding swifts to join up with a breeding pair during the nesting season to help incubate the eggs and feed the young (Dexter 1952a). These "helpers" are usually males in their first summer (Dexter 1992). Out of 117 breeding flocks studied over a period of 14 years from 1953 to 1983, Dexter (1992) noted 98 pairs (83.8%), 17 threesomes (14.5%) and two foursomes (1.7%). A group of five birds including three helpers, and another of six birds, one pair with four helpers, were observed at one nest on one occasion in a 30-year period (1944 to 1974) (Dexter 1974). There is no evidence that these helpers increase breeding success, in spite of aid given during the nesting period (Dexter 1981b). There have also been a few cases where an additional bird joined a pair for a brief period before nesting began (Dexter 1952a). These "wanderers" left the site quickly after finding a mate (Dexter 1952a; 1982).

3.2 Demographic parameters

Hatching

Hatching success is high in this species. Fischer (1958) obtained a figure of 89.5%. This result is also similar to the 90% obtained from an artificial chimney set in Lévis near Québec City between 1998 and 2006 (Table 1) and in Texas from 1989 to 2002 (Kyle and Kyle, unpublished data; Appendix 2). The featherless nestlings are blind at birth. During the first week, the parents feed them by regurgitation. They then bring them small pellets of insects. The insects seldom exceed 5 mm in length (Fischer 1958). As early as their second day, nestlings crawl to the side of the nest to defecate outside; in doing so one sometimes falls off and dies. During the first week, the young are fed by regurgitation approximately every 16 to 24 minutes; as they get older, they eat more frequently (Zammuto *et al*. 1981). The period between feedings can vary according to the weather conditions. For instance, the parents normally spend more time away from the nest looking for insects when it is raining, very hot or very windy as insects are harder to find under these conditions (Zammuto *et al*. 1981). Young Chimney Swifts grow rapidly and their eyes normally open on the 15th or 16th day (Fischer 1958). Clutch size seems to determine when the young will leave the nest. The larger the brood, the faster they will leave the nest because of the lack of space. In the case of a brood with four or five young, they will leave the nest at around 14 days, even if their eyes are not yet open; smaller broods remain an average of 19 days (Fischer 1958). The young swifts cling then to the wall next to the nest. They groom and stretch their wings before making short flights from one wall to the next where parents continue to feed them.

Fledglings and juveniles

Nestlings make their first flight outside the nesting structure on the 30th day after hatching (Fischer 1958). Fledging success is high (86%) and a mean of two to three young are produced (Fischer 1958; Dexter 1950, 1951, 1956, 1960, 1968, 1979, 1986). Cink (unpublished data) recorded a fledging success of 69% (Cink and Collins 2002). Fledging success in Québec is similar (Table 1). Once fledglings have left the nesting site, they are no longer fed by their parents (Fischer 1958). After the first flight, the young return occasionally to the nesting site during the day and on a regular basis to spend the night with their parents during the first week (Fischer 1958). The family then breaks up and the members visit other sites, increasing the numbers at certain roosts (Fischer 1958). Juvenile swifts can show poor return rates following the hatch year, reaching only 10.8% as observed in New York by Fisher (1958).

Survival and longevity

The various species of swifts generally have a relatively high survival rate (Chantler and Driessens 2000), frequently above 80% (Lack and Collins 1985). Based on numerous banding data collected across North America between 1920 and 1956, the annual adult survival rate was about 63% (Henny 1972). This rate is similar to the one (73 ±7 %) calculated with banding data from Paul and Georgean Kyle's Chimney Swift project in Texas between 1989 and 2002 (unpublished data). Data from Kyle and Kyle also permitted an estimate of the survival rate for juveniles (78.8± 21.9%) which was not significantly different from the adults (see section 10, Appendix 1 for methodology). This rate is particularly high considering that the Chimney Swift makes long transcontinental migrations. Mortality is highest in the first year after hatching (Chantler and Driessens 2000). With such a high survival rate for birds of such a small size, it is not surprising that swifts live to an old age. The record for known Chimney Swift longevity is 14 years (Dexter 1979). The species' average longevity is 4.6 years (Dexter 1969). All known demographic parameters are presented in Appendix 2.

Table 1. Summary of breeding data from two nests in Québec over eight consecutive years

Year	Site	Structure	Eggs	Hatching	Fledging
1998	Lévis	Artificial Chimney	4	4	3
1999	Lévis	Artificial Chimney	4	4	3
2000	Lévis	Artificial Chimney	5	5	5
2001	Lévis	Artificial Chimney	5	5	4
2002	Lévis	Artificial Chimney	4	4	4
2003	Lévis	Artificial Chimney	5	?	3
2004	Lévis	Artificial Chimney	0	0	0
2005	Lévis	Artificial Chimney	3	3	3
1998	Scotstown	Well	3	3	3
1999	Scotstown	Well	5	4	4
2000	Scotstown	Well	5	5	5
2001	Scotstown	Well	5	?	4
2002	Scotstown	Well	0	0	0
2003	Scotstown	Well	4	4	3
2004	Scotstown	Well	4	4	3
2005	Scotstown	Well	4	3	3

3.3 Feeding habits

Chimney Swifts are diurnal foragers but there have been reports of feeding activity extending into dusk (Cottam 1932; Godfrey 1986). This species feed exclusively on insects and spiders, which are mainly caught during flight (Chantler 1999). However, they do occasionally catch insects on foliage in the tree tops (Fischer 1958; Zammuto and Franks 1979a) or on water surfaces (MacBriar 1963). They eat a wide variety of small insects, primarily Diptera, Homoptera, Hymenoptera, Hemiptera, Coleoptera, Ephemeroptera and Plecoptera (Fischer 1958; Fudge 1998). Chimney Swifts also take advantage of certain massive insect emergences that occur, such as swarming Ephemera and ants (Fischer 1958). Stinging insects are avoided (Chantler and Driessens 2000). Swifts typically feed in small groups (Kaufman 1996). They often forage at high altitudes in fair weather (Godfrey 1986; Snow and Perrins 1998; Chantler and Driessens 2000), but tend to fly lower to follow insects during threatening or rainy weather (Godfrey 1986; Kaufman 1996; Chantler and Driessens 2000). There is one mention of Chimney Swifts feeding on fruits (Latham 1920). Adults bring food to the nestlings in the form of small pellets of insects mixed with saliva that they carry in their distended throats (Fischer 1958; Chantler and Driessens 2000). A beakful can contain up to 200 insects (Chantler 1999). Chimney Swifts also regurgitate small balls containing undigested insect matter, such as capsules, feet, antennae and elytra (Duke 1977). To drink, they skim close to the water, touching the surface lightly with their bills (Whittemore 1981; Godfrey 1986).

The Chimney Swift eats thousands of insects per day (Kyle and Kyle 2004). The species could also act as biological control against flying insects that carry human transmittable diseases. The Chimney Swift generally forages between 20-150 metres over cities and buildings, 2-8 m over forest and grassland, 4-8 m over shrubby pastures and orchards, and 1-4 m over farmyards, rivers, pond and reservoirs (Cink and Collins 2002), which encompasses flight altitudes of certain mosquitoes like those which can carry the West Nile virus. Certain species from the Apodiforme order, like the African Palm Swift (*Cypsiurus parvus*), could help control certain insect species known to cause epidemics in humans (Thirumurthi and Krishna Doss 1980).

3.4 Behaviour

Chimney Swifts are among the most aerial species and spend most of the day on the wing. Swifts outside the breeding season or non-breeders during the breeding season can spend almost 17 hours daily flying. When the temperature is fair, they sometimes fly so high as to be mere specks in the sky with only their call, a rapid sharp staccato chit-chit-chit, at times running together into a prolonged chittering, betraying their presence. Their quick, jerky flight consists of series of alternating wing beats followed by short glides.

Chimney Swifts are extremely gregarious when not breeding; they feed and roost in huge numbers (Chantler and Driessens 2000; Snow and Perrins 1998). During migration, they congregate in flocks of thousands at roosting sites along their migration route (Groskin 1945; Michael and Chao 1973). Roosts are also used in the summer. The number of birds found at summer roosts is high in the spring and then decreases as pairs scatter to find nesting sites nearby. Numbers in the spring can vary considerably because some birds do not nest nearby and they use the roost as a stopover site during their migration (Appendix 3B). During the summer, only non-breeding birds use the roost every night. As the season advances, swift numbers come back up as adults that have lost their brood and parents with young join unpaired adults and immature birds that occupied the roosts during summer (Dexter 1991). The number of swifts dwindles again at the end of the summer when the birds undertake their fall migration, with northern roosts emptying first. Appendix 3B shows how numbers of Chimney Swifts fluctuate in a typical summer roost, during the nesting season. Summer roosts are somewhat like a community centre for birds that fail to reproduce and numbers fluctuate less than migration roosts (Zammuto and Franks 1979b). It is even possible to estimate the proportion of non-breeders and juveniles birds for certain roosts (Appendix 3A). Table 2 summarizes information for summer roosts in Québec (n=26) that have sufficient data (minimum of 10 observations spread across the breeding season) to estimate the proportion of non-breeders and juveniles. Only roosts exhibiting a typical pattern can be used for estimating such numbers. The presence of a predator or chimney renovation can disrupt typical abundance patterns in a roost, even causing birds to abandon the place. Appendix 3 also describes the methodology used by volunteers to monitor a roost and to estimate the proportion of non-breeders and juveniles.

Roosts are easy to identify because of swifts' distinctive behaviour. On fine evenings, before sunset, they gradually close in on a chimney, flying in what appears to be a random manner. However, as the time to enter approaches, the birds form a tighter group and begin to swirl around the chimney while chittering and then, as if on cue, they vanish inside, rather like a puff of smoke in reverse. They may enter the chimney all together in one movement or in small groups. In the latter case, the birds still in flight continue to swirl around, attracting other nearby swifts with their calls, until the last individual rushes in. Sometimes the birds enter the chimney directly without displaying this behaviour, usually at small roosts or when the birds are entering late. Just before they go into the roost, they raise their wings to break their flight and then let themselves literally drop inside.

In fine weather, the birds enter their roosts 10 minutes after sunset on average (Shaffer 1998) and leave the next day about 11 minutes before sunrise (Zammuto and Franks 1981b). Since the sun sets a little earlier on each summer evening, the swifts' entrance follows more or less the same schedule (Zammuto 1978; Shaffer 1998). It is also known that the swifts' time of entry after sunset is negatively correlated with light intensity (Michael and Chao 1973; Zammuto 1978; Zammuto and Franks 1981b). Climatic factors, such as temperature, windspeed and precipitation influence their roost entrance and exit behaviours. The birds leave the roosts a little later and enter a little earlier on cold, rainy and windless days (Zammuto 1978; Zammuto and Franks 1981b). On cold rainy mornings, the swifts often leave the roost and then return (Zammuto and Franks 1981b), probably due to a shortage of flying insects. Temperature, precipitation and wind are climate variables known to affect the abundance of airborne insects (Zammuto and Franks 1981b).

Chimney Swifts' behaviour at nesting sites is different from their behaviour at their roosts. At a nesting site, the birds enter the chimney directly very quickly and discreetly. Adults observed repeatedly coming out and going into a chimney during the day (every five to 15 minutes in general) indicates a nesting site (e.g., a pair trying to build a nest or feed their young). Nesting adults do not generally venture far away from their nest, spending about 50% of their time within 0.5 km of their site (Cink and Collins 2002). Fisher (1958) observes that Chimney Swifts can forage up to 8 km from their nest. The closely related Vaux's Swift spends about 5% of its time within 5 km of its nest (Bull and Beckwith 1993).

The daily flight behaviour of non-breeding Chimney Swifts (failed breeders and first years) seems to differ considerably from those of breeding individuals. They leave the summer roost at dawn and returning at dusk. If we take into account the flight speed of this species (46 km/h) and the fact that they can fly almost 17 hours a day, they can travel 750 km in one day. However, the distance travelled from their summer roost is unknown. A Chimney Swift was observed travelling about 30 km along the Saint-Maurice River in Québec during the third week of June (J. Gauthier, CWS, pers. obs.). All known data from similar species indicate that non-breeding birds may venture far from their roost. White-throated Swifts have been reported about 15 km away from their roost, while Black Swifts have been seen as far as 40-120 km away from their roosting site (Lowther and Collins 2002). Tree Swallows (*Tachycineta bicolour*) and Cliff Swallows (*Hirundo pyrrhonota*) have been observed as far as 60 km from their roosts (Robertson *et al.* 1992; Brown and Brown 1995). This high mobility comes into play when considering the capacity of certain survey methods, such as point counts, to estimate bird population for large geographic areas. The flight behaviour of such birds resembles those of birds of prey, making point counts method inadequate for estimating bird density.

Table 2. Roosting site results from the Québec Chimney Swift Survey Program between 1998 and 2005. Methodology for estimating non-breeders and juveniles along with raw data are available in Appendix 3

Roost (city)	Year	Non-breeders (%)	Juveniles (%)
Mont-Laurier	1999	37.9	56.1
Mont-Laurier	2000	1.2	40.4
Mont-Laurier	2002	35.9	55.1
Montmagny	2001	45.5	60.0
Montmagny	2003	39.3	56.8
Montmagny	2004	70.4	75.3
Montmagny	2005	50.2	62.6
Saint-Jovite	2003	51.2	63.2
Saint-Jovite	2004	36.1	55.2
Sainte-Agathe-des-Monts	2002	17.2	46.7
Sainte-Agathe-des-Monts	2004	54.8	65.3
Sainte-Agathe-des-Monts	2005	48.1	61.4
Saint-Hyacinthe	2004	18.4	47.1
Saint-Hyacinthe	2005	57.8	67.1
Saint-Raymond	1999	50.3	62.6
Saint-Raymond	2005	21.7	48.6
Hull	2005	39.6	57.0
Laval	2005	31.1	52.8
Shawville	2005	0.0	40.0
Squatec	2005	27.0	50.9
Saint-Georges	1999	24.2	49.7
Saint-Georges	2000	24.7	49.9
Saint-Georges	2004	20.1	47.8
Saint-Georges	2005	23.2	49.2
Old-Québec City	2004	51.0	63.1
Old-Québec City	2005	20.4	48.0
Mean ± Std. Dev.		34.5 ± 17.3	55.1 ± 8.5

4. Distribution

4.1 Breeding grounds

The breeding range of the Chimney Swift is largely limited to eastern North America (United States, Canada) below the 49th parallel (Chantler 1999; Chantler and Driessens 2000; Cink and Collins 2002) (Figure 1). It occasionally breeds in southern California and possibly Arizona (Sibley and Monroe 1990; Chantler and Driessens 2000). Approximately 26% of the species' breeding range is located in Canada.

In Québec, the Chimney Swift is considered a migratory breeder (Cyr and Larivée 1995; Lemieux and Robert 1995; David 1996). It nests in the southern part of the province, except for Anticosti Island and the Magdalen Islands (where it is an accidental visitor), to the northwest as far as the Abitibi region, and on the Upper North Shore in the northeast (Lemieux and Robert 1995; David 1996). It was not reported breeding north of the 49th parallel during atlassing for the Breeding Bird Atlas (Lemieux and Robert 1995). The most northerly Atlas records are from Saint-Maurice-de-Dalquier in the Abitibi region, the La Mothe Reservoir in the Saguenay–Lac-Saint-Jean region and Forestville on the Upper North Shore (Lemieux and Robert 1995). Swifts have been reported at Matamec and Harrington Harbour on the Middle and Lower North Shores, but there are no Atlas records (Lemieux and Robert 1995). The swift may also be an accidental visitor in regions well north of its known breeding range. One was seen in Digges Sound, near the 60th parallel in the extreme northwestern tip of Québec, in August 1980 (Gaston *et al.* 1985).

In Ontario, the Chimney Swift breeds as far north as the 49th parallel (Peck and James 1983; Helleiner 1987). The most northerly record is of birds in the vicinity of Pickle Lake (51.4° latitude north) (Helleiner 1987), but no nesting was confirmed. Historical records suggest that it formerly occupied much the same range as it does today, at least in the southern part of the province (Helleiner 1987). Data from the second Atlas of Breeding Birds of Ontario (2005) suggests that the species range of distribution is similar to what it was in the first Atlas, however, presence is parcelled up (Cadman *et al*., in prep.).

According to the Atlas of the Breeding Birds of the Maritime provinces (Erskine 1992), the Chimney Swift breeds in most regions of New Brunswick and Nova Scotia, including Cape Breton Island. However, the species is rare in regions adjoining the Northumberland Strait. Based on observations by Godfrey (1986), Chantler and Driessens (2000) reported that the Chimney Swift breeds on Prince Edward Island. However, Erskine (1992) mentions that few individuals were observed during the Maritime provinces atlas surveys. Breeding is described as probable but unconfirmed in that province.

Montevecchi and Tuck (1987) classify the Chimney Swift as a transient breeder in Newfoundland. However, it possibly breeds in the southwestern part of the province (Godfrey 1986; Sibley and Monroe 1990). There are numerous records of its occurrence at Codroy, but there is no breeding evidence (Godfrey 1986).

The Chimney Swift has been recorded breeding in southern Manitoba around Winnipeg, Dauphin, Saint-Laurent, Indian Bay, Steinbach, Portage-la-Prairie and Selkirk (Godfrey 1986; Cleveland *et al.* 1988; Manitoba Museum of Man and Nature 1998; Taylor *et al.* 2003). According to the Atlas of Saskatchewan Birds (Smith 1996), the Chimney Swift is limited to the east central part of the province. It is a confirmed breeder in Nipawin and individuals have been recorded in Raymore, Fort Qu'Appelle, Langenburg and most recently in Regina and Estevan (A. R. Smith, CWS, pers. comm.). The birds probably migrate via southern Manitoba as they are rarely seen in southern Saskatchewan (Smith 1996). The Atlas of Breeding Birds of Alberta makes no mention of the Chimney Swift (Semenchuk 1992), although Tyler (1940) reports that two birds were observed in Edmonton on May 17, 1897.

The Chimney Swift is classified as a hypothetical species in British Columbia, because either no records have ever been published or they have been reported by only a single observer (Campbell *et al*. 1990).

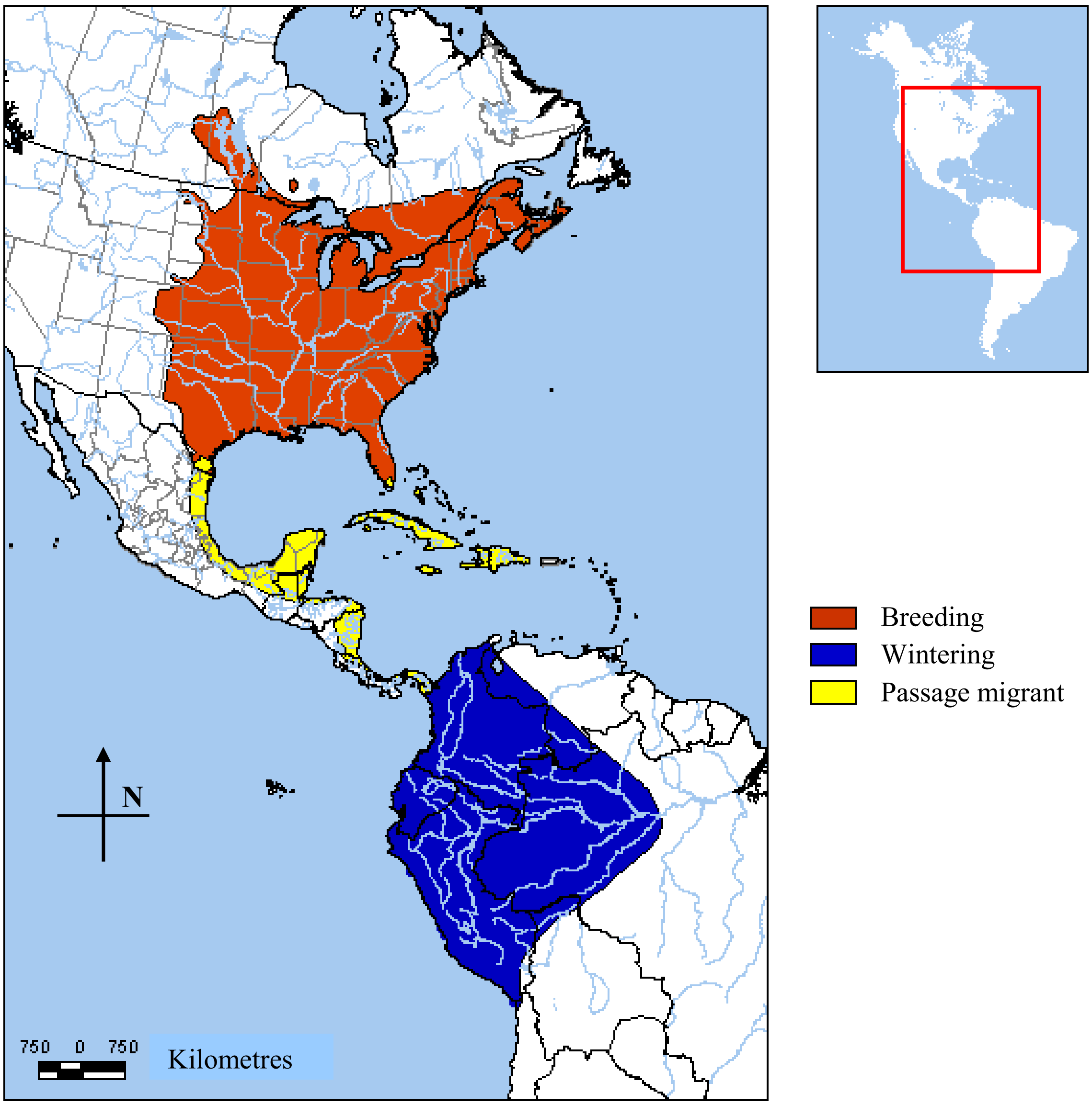

Figure 1. Chimney Swift range of distribution (*Chaetura pelagica*). © 2005 NatureServe, 1101 Wilson Blvd. 15th floor, Arlington, Virginia 22209, U.S.A. All rights reserved. 28 September, 2005. This figure was modified to include a portion of mideastern Saskatchewan which is in the species range

In the United States, the Chimney Swift has been recorded as a breeder in all states east of the Rockies, in the eastern part of some of the large western states (Wyoming, Montana, Colorado and New Mexico) and in California, for a total of 42 states. Table 3 lists the status and abundance of the species in each state. The swift's presence is considered rare to very uncommon in California (Garrett and Dunn 1981; Small 1994; Chantler and Driessens 2000; Cink and Collins 2002). The first reference to the Chimney Swift in California dates back to 1930, when a specimen was collected (Huey 1960). Most records are from the southern part of this state (Small 1974), mainly in Los Angeles County, but also in Santa Barbara, Ventura and San Diego counties (Garrett and Dunn 1981). The birds are observed in the summer and during migration. The swift is casual in the interior (Garrett and Dunn 1981). Opinions are divided on the species' status in California, with some authors classifying it as a transient (Small 1974, 1994) or a regular summer visitant (Garrett and Dunn 1981), while others consider it a sporadic breeder since there is a record of breeding in California (Sibley and Monroe 1990; Chantler and Driessens 2000): a nest containing three young was found on August 2, 1976 in Ventura (Garrett and Dunn 1981). Since it is probable that other instances of nesting have occurred, the status of sporadic breeder seems more appropriate.

4.2 Wintering grounds

The Chimney Swift's winter range is located in the upper Amazon basin of South America (Figure 1), mainly in Peru (Snow and Perrins 1998; Cink and Collins 2002). It is found in western and northeastern Peru (Chantler 1999). It is also regularly observed from November to April on the Pacific coast, between Trujillo and Lima to Mollendo (Plenge 1974), Arequipa (Johnson 1972) to the southwest and Tacna in the far south (Hughes 1988). It has been observed once in Cuzco (Fjeldså and Krabbe 1986). Its winter range also extends into southern (Bloch *et al*. 1991) and northeastern Ecuador (Pearson 1980; Chantler 1999), northwestern Brazil (Chantler 1999) and northern Chile (Demetrio 1993; Chantler 1999). Since 1987, groups of Chimney Swifts have been observed on a regular basis in December and January in Chile's Calama valley (23° of latitude south) in the western Andes, in the northern part of the country (Demetrio 1993). The Chimney Swift's exact winter range is still somewhat unclear today and is probably more extensive than is thought (Chantler 1999; Figure 1). It was discovered relatively recently—in 1944, bands from 13 swifts killed in northeastern Peru (Yanayaco River) in November 1943 were recovered, allowing one of the species' wintering sites to be located for the first time (Coffey Jr. 1944; Lincoln 1944). There is one mention of large numbers of *C. pelagica* wintering in Guatemala (Wenzel 1928). There have been a few Chimney Swift spring sightings in Venezuela and Colombia, however the species is considered transient in those areas (Meyer de Schauensee and Phelps 1978; Hilty and Brown 1986).

Table 3. Status and abundance of the Chimney Swift in the United States

State	Status	Abundance	Reference(s)
Alabama	Migrant breeder	Unknown	Vaughan 1994
Arizona	Possible sporadic migrant breeder	--	Sibley and Monroe 1990; Chantler and Driessens 2000
Arkansas	Migrant breeder	Common	James and Neal 1986
California	Sporadic migrant breeder	Rare to uncommon	See text
Colorado	Migrant breeder	Regular	Bailey and Niedrach 1965; Kingery 1998
Connecticut	Migrant breeder	Uncommon breeder Common migrant	Zeranski and Baptist 1990
Delaware	Migrant breeder	Fairly common	Hess 2000
Florida	Migrant breeder	Unknown	Kale and Maehr 1990
Georgia	Migrant breeder	Common	Haney *et al*. 1986
Idaho	Absent	--	Larrison 1981
Illinois	Migrant breeder	Common	Bohlen 1989
Indiana	Migrant breeder	Abundant	Keller *et al*. 1986
Iowa	Migrant breeder	Common	Fleckenstein 1996
Kansas	Migrant breeder	Common in the central and eastern part	Thompson and Ely 1989
Kentucky	Migrant breeder	Common	Palmer-Ball 1996
Louisiana	Migrant breeder	Unknown	Clisby 1931
Maine	Migrant breeder	Unknown	Adamus 1987
Maryland	Migrant breeder	Common	Zucker 1996
Massachusetts	Migrant breeder	Common and widespread	Veit and Petersen 1993
Michigan	Migrant breeder	Common to abundant	Dexter 1991
Minnesota	Migrant breeder	Abundant	Janssen 1987
Mississippi	Migrant breeder	Common	Turcotte and Watts 1999
Missouri	Migrant breeder	Common	Robbins and Easterla 1992
Montana	Migrant breeder	Unknown	Montana Dept. Fish, Wildlife and Parks 1998
Nebraska	Migrant breeder	Regular	Ducey 1988
Nevada	Absent		Alcorn 1988
New Hampshire	Migrant breeder	Common	Sutcliffe 1994
New Jersey	Migrant breeder	Common and largely distributed	Walsh *et al*. 1999
New York	Migrant breeder	Common	Bull 1985; Sibley 1988
New Mexico	Migrant breeder	Unknown	DeGraaf and Rappole 1995

State	Status	Abundance	Reference(s)
North Carolina	Migrant breeder	Abundant	Potter *et al*. 1980
North Dakota	Migrant breeder	Fairly common to common	Fargo 1975
Ohio	Migrant breeder	Common	Peterjohn and Rice 1991
Oklahoma	Migrant breeder	Common	Baumgartner and Baumgartner 1992
Oregon	Absent	--	Gilligan *et al.* 1994
Pennsylvania	Migrant breeder	Common	Mulvihill 1992
Rhode Island	Migrant breeder	Relatively common	Enser 1992
South Carolina	Migrant breeder	Common	Post and Gauthreaux 1989
South Dakota	Migrant breeder	Uncommon and limited	Peterson 1995
Tennessee	Migrant breeder	Common	Nicholson 1997
Texas	Migrant breeder	Unknown	Johnsgard 1979; DeGraaf and Rappole 1995
Utah	Visitor	Unusual	Bailey and Niedrach 1965
Vermont	Migrant breeder	Common	Norse and Kibbe 1985
Virginia	Migrant breeder	Common	Anonymous 1989
West Virginia	Migrant breeder	Fairly common to common	Hall 1983
Washington	Absent	--	Smith *et al*. 1997
Wisconsin	Migrant breeder	Common	Robbins 1991
Wyoming	Migrant breeder	Rare	Atlas of Birds in Wyoming 1997

5. Movements and migration

The Chimney Swift is a species that migrates in flocks, during the day and over long distances (Coffey Jr. 1936; Tyler 1940; Whittemore 1981; Chantler 1999). Table 4 shows the list of countries where it has been observed in migration and its relative abundance. Between the late 1920s and the early 1950s, swift banding was a very popular activity, particularly in the United States and Ontario, where thousands of migrating birds were caught every year (Coffey Jr. 1936, 1937, 1943; Peters 1937; Green 1940; Lowery 1943; Ganier 1944; Bowman 1952). Banding made it possible to study the species' migration pattern in detail.

There have been a few reports of migrating birds in Venezuela and Colombia in the spring (Chantler and Driessens 2000). During the spring migration, birds head northward, following the Caribbean coast of Panama and Costa Rica. From mid-March to mid-May, but mainly in April, swifts are spotted on the Atlantic coast of Honduras as far east as the Mexican border (Howell and Webb 1995). Most of the Chimney Swifts observed in Panama were on the Caribbean coast (Ridgely and Gwynne 1989). Olson (1993) observed a number of birds migrating in April in

Panama's Bocas del Toro archipelago. Swifts have also been spotted flying north over the Caribbean and the Gulf of Panama (Ridgely and Gwynne 1989). Whittemore (1981) says that the birds follow the coast of Mexico and Texas to reach their breeding area, without citing any information sources. However, this is contradicted by the observation of hundreds of Chimney Swifts arriving in Texas on March 29, 1999, from the Gulf of Mexico (Kyle and Kyle 2000) and the scarcity of observations on the coast of Mexico. Despite the long distance involved, it seems that Chimney Swifts do cross the Gulf of Mexico to reach the continent. In spring 1999, the first swifts arrived in southern Texas during the week of March 11 (Kyle and Kyle 2000). Bowman (1952) provides a map of spring migration movements in North America.

Most Chimney Swifts arrive in Québec in the last two weeks of May (David 1996; CWS, unpublished data). The earliest record of a swift was on April 15, 1951, in Richelieu (David 1996: CWS, unpublished data). Swifts arrive in Southern Ontario at the end of April and in mid-May in the most northern areas (Cink and Collins 2002). The earliest mention of swift in this province is April 10 (Speirs 1985). In New Brunswick and probably all of the Maritimes, swift have been reported as early as April 22 (Squires 1976). After breeding, Chimney Swifts leave Québec early, most of them by the end of August (David 1996). However, one individual was spotted as late as October 18, 1981 in Pointe-au-Père, near Rimouski (Larivée 1993). Since 1999, various roosts have been monitored from May to September, which provides CWS with accurate data on the time period when birds are present in the different regions of Québec. In the most northern regions of the Laurentians (Mont-Laurier, Saint-Jovite), in La Malbaie and Sainte-Perpétue (L'Islet), swifts leave the roosts at the end of July. In the Québec City area, the last residents depart between August 17 and 21. Further south, in Saint-Georges-de-Beauce and Mascouche, the birds begin their migration in the first few weeks of August. Swifts in the Montreal area and the Eastern Townships head off in early September while in southern Ontario in London area swifts may still be seen at the beginning of October. In the Maritimes, swifts are gone by September 18 (Squires 1976); some swifts have been seen as late as November 10 (Tuft 1986), although this sighting could be a storm fallout (see section 8.7).

During the fall migration, the swifts converge on the Mississippi Valley (in the area of Baton Rouge, Louisiana) from the northern United States and Canada (Lowery 1943; Ganier 1944; Bowman 1952). This has been demonstrated by the capture of birds banded in Nova Scotia and caught in Memphis (Coffey Jr. 1943) and Nashville (Ganier 1944), birds banded in New Brunswick and caught in Nashville (Ganier 1944), and birds banded in Kingston, Ontario, and caught in Nashville (Ganier 1944), Memphis (Coffey Jr. 1936) and Baton Rouge (Lowery 1943). Chimney Swifts form big migrating flocks and stop to roost overnight in large chimneys on their way south. The number of birds increases as they get farther south, reaching thousands of individuals in the Gulf States (Texas, Louisiana, Mississippi).

Table 4. Status and abundance of the Chimney Swift in Central America and the Caribbean

Country	Status	Abundance	Reference(s)
Panama	Passage migrant	Common on the Caribbean coast	Wetmore 1968; Ridgely and Gwynne 1989
Costa Rica	Passage migrant	Common on the Caribbean coast	Stiles and Skutch 1989
Honduras	Passage migrant	Uncommon to common (Lowlands and North Shore islands)	Monroe 1968
Cuba	Passage migrant	Very rare	Raffaele *et al*. 1998; Llanes Sosa and Pérez Mena 2000
Cayman Islands	Passage migrant	Rare	Bradley 1985
Bahamas	Passage migrant	Uncommon; mainly observed in the northern area (New Providence Island, Eleuthera and Exuma)	Buden 1987; Buden and Sprunt 1993; Raffaele *et al.*1998
Bermuda	Visitor	Uncommon	Amos 1991
Haiti	Passage migrant	Very rare	Raffaele *et al.* 1998
Dominican Republic	Passage migrant	Very rare	Raffaele *et al.* 1998
Netherlands Antilles	Visitor	Exceptional (two sightings: Aruba and Bonaire)	Voous 1983; Stotz *et al*. 1996
Jamaica	Passage migrant	Very rare	Raffaele *et al.* 1998
Virgin Islands	Passage migrant	Very rare	Raffaele *et al.* 1998
Guatemala	Wintering?	Unknown	Wenzel 1928

Most of the swift population then crosses over the Gulf of Mexico; it does not seem to follow the coast of Texas or pass over Florida (Lowery 1943). If swifts had followed the Texas coast, the number of banded swifts caught there would have been very high, while in fact it was rather low (Lowery 1943). It appears that a relatively small percentage of the Chimney Swift population flies over Florida in the fall and spring (Lowery 1943). Lowery (1943) suggests that if Florida was on the major migration route, most of the birds banded in Louisiana and Tennessee would have also been found in that state, whereas only one of the swifts banded in Baton Rouge and Memphis had actually been caught in Florida. In addition, it seems improbable that swifts banded as far east as Nova Scotia, New Brunswick and New England would be caught as far west as Baton Rouge if there were a migration route through Florida (Lowery 1943). If this route was used more often, there would be more records of swifts in the Caribbean than there are – they are, in fact, fairly rare (Table 4). From the Mississippi Valley swifts then cross the Gulf of Mexico, pass over the Yucatan Peninsula, and then fly along the Atlantic coast of Central America

(Howell and Webb 1995). Chimney Swifts are common on the Caribbean coast of Costa Rica and Panama in October and November (Ridgely and Gwynne 1989; Stiles and Skutch 1989). They do not appear to migrate along the coast of Mexico, as reports of the species are rare (Howell and Webb 1995). The swifts reach Lima, Peru in early November of each year (Plenge *et al.* 1989).

The Chimney Swift is an exceptional visitor on the Galápagos Islands (Chantler 1999) and in Greenland (Tyler 1940; Alstrom and Colston 1991; Snow and Perrins 1998). The species has also been reported accidentally in Western Europe, four times in Great Britain (McLaren 1981; Etcheberry 1982; Williams 1986; Alstrom and Colston 1991; Byrne and Graves 1992) and on the Canary Islands during the fall period (Chantler 1999). Such reports can be linked to storms and hurricanes, which can carry birds off course. See section 8.7 for more details.

6. Habitat

6.1 Breeding grounds

The Chimney Swift spends most of the day on the wing foraging for insects and returning to the ground only to breed and roost. As a result, it is difficult to associate the species with only a single type of habitat, and its presence in a particular area largely depends on the availability of suitable nesting sites (DeGraaf and Rappole 1995) and the abundance of insects (Kaufman 1996). For nesting and roosting, the Chimney Swift looks for a dark, sheltered spot with vertical surfaces to grip onto and attach its nest (Fischer 1958). Before the arrival of European settlers, the Chimney Swift was associated with old-growth forests, when large hollow trees (snags and cavity trees) were abundant and thus their main source of nesting and roosting sites. Nowadays, the Chimney Swift is found mainly in built-up areas (cities, towns and villages) (Chantler 1999; Cink and Collins 2002). Its presence in forested areas has become marginal because large hollow trees are now scarce (see *Forested areas* below).

The Chimney Swift is often seen near bodies of water because of the abundance of its main food source, insects (Sibley 1988, Sibley and Monroe 1990; Chantler 1999; Cink and Collins 2002). The species is often observed feeding over rivers and flood plains in Kentucky (Palmer-Ball 1996). Many other authors have reported Chimney Swift foraging over wetlands (MacBriar 1963; Norse and Kibbe 1985; Ridgeley and Gwynne Jr. 1989; Sutcliff 1994; Wakeley and Roberts 1994; Vallianatos 2000). Two studies reveal that three of the five main insect orders consumed by this species are associated with wetlands (Fisher 1958; Fudge 1998). These results are in accordance with those of Lack (1973), who studied the diet of the Common Swift (*Apus apus*). Del Hoyo *et al*. (1999) suggested that swifts in general are found close to water especially when breeding, because the young cannot travel as far as the parents. The proximity of nesting and roosting sites inventoried during the Québec Chimney Swift Survey Program (1998-2002) revealed that 95% of these (140/147) were located less than 1,000 m from a body of water (Figure 2). In another study not directly pertaining to the subject (Zammuto 1978), data revealed that 18 out 19 nests (95%) were located less than 1,000 m from a body of water. Methodologies used to estimate the distance of Chimney Swift nesting sites from bodies of water in both cases are presented in Appendix 4.

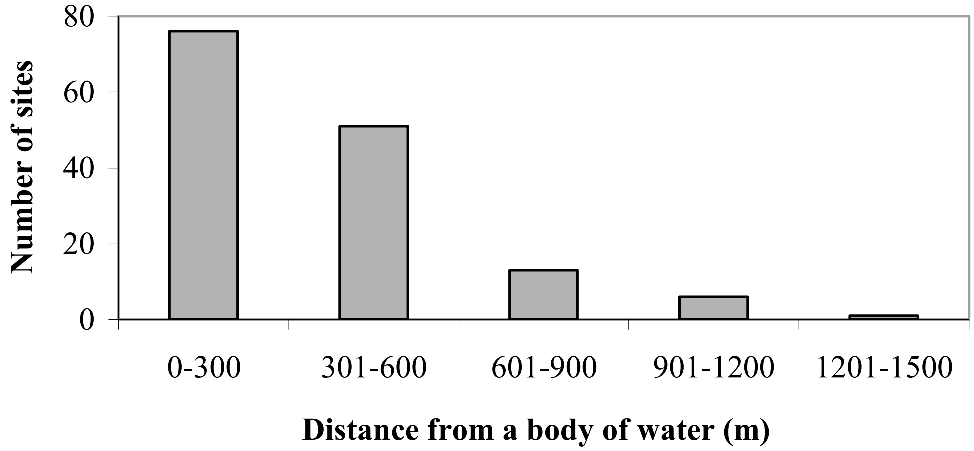

Figure 2. Distance of breeding and roosting sites from the closest body of water for all known sites in Québec between 1998 and 2002 (n=147). Methodology is presented in Appendix 4

Forested areas

Prior to European settlement, Chimney Swift nested and roosted mainly inside hollow trees (living or dead) and sometimes on cave walls and inside rocky crevasses (Chamberlain 1891; Dionne 1906; Tyler 1940; Coffey Jr. 1944; Lack 1956; Fisher 1958; Fargo 1975; Godfrey 1986; Tuft 1986; Erskine 1992). Hollow trees can be used as a nesting site or as a roost. There is much evidence leading to the conclusion that the hollow trees required by this species are of large diameter (> 50 cm diameter at breast height or DBH). In 1985, a Balsam Poplar (*Populus balsamifera*) used by swifts in the Rimouski area had a DBH of 60 cm (Bélanger 1985). In 2001 and 2005, two nests were found in maple trees of the same size in Saint-Pamphile-de-L'Islet and Tourville respectively (CWS, unpublished data). Tumer *et al*. (1984) observed Chimney Swifts entering and exiting a tree with a 52 cm DBH. Blodgett and Zammuto (1979) discovered a nest in a tree which had a diameter of 50 cm at nest height. Many other authors mention that Chimney Swifts were present in large diameter trees, without further details on their dimensions (Hofslund 1958; Cottrille 1956; Whittemore 1981; Ferguson and Ferguson 1991; Jackson 1997). The Vaux's Swift (*Chaetura vauxi*), an Allopatric species (Lack 1956), also requires large hollow trees for nesting and roosting. Twenty-one trees containing Vaux nests in Oregon had a mean DBH of 67.5 cm (Bull and Collins 1993). These trees, following an injury or in their old age, rot from the inside and form a natural chimney. The tree may also be alive and well, as was the case with the Sugar Maple Tree (*Acer saccharum*) in Saint-Pamphile-de-L'Islet. The tree contained a Chimney Swift nest inside and was still producing ample quantities of sap water (CWS, unpublished data). Birds usually enter the tree by an opening at the top (broken crown or branch, woodpecker hole).

The swift can also nest in cavities abandoned by the Pileated Woodpecker (*Dryocopus pileatus*), although this is rare (Cameron 1949; Hofslund 1958; Cotrille 1956 *in* Dexter 1991; Wittemore 1981). Such cavities could be attractive because of their dimension. Such cavities are twice the size of those created by the second biggest primary cavity nesters, the Northern Flicker (*Colaptes* *auratus*) (Bonar 2000). Because Chimney Swifts enter and leave their cavities by flight, a minimum cavity size could be required.

Flocks of swifts have also been observed roosting on tree trunks in the southern United States during migration. It is possible that birds choose this solution when there are no other appropriate sites available (Spendelow 1985), when their usual sites become unavailable suddenly – e.g., when there is smoke in a chimney (Campbell and Campbell 1944), or because of sudden poor weather conditions that force them to seek shelter elsewhere (Arvin 1982).

Today, most authors agree that Chimney Swifts mainly nest in built-up areas (urban, suburban and rural), as natural nesting sites have become scarce (MacNamara 1918; Coffey Jr. 1936; Lack 1956; Fisher 1958; Johnsgard 1979; Bull 1985; Norse and Kibbe 1985; Sibley 1988; Peterjohn and Rice 1991; Sutcliffe 1994; Fleckenstein 1996; Snow and Perrins 1998; Cink and Collins 2002). Chimneys are the main structure used in built-up areas for nesting and roosting. Some Chimney Swifts still continue to nest in hollow trees in isolated forested areas (Fischer 1958; Helleiner 1987; Sutcliffe 1994), but reports of such behaviour are now very rare (Norse and Kibbe 1985; Chantler 1999) and the number of swifts breeding in these areas probably represents a small fraction of the population. The availability of nesting sites can be a limiting factor for certain bird species which use cavity trees (Sedgeley 2001). After reviewing existing literature on cavity nesting birds, Newton (1994) concluded that the availability of cavity trees was the main factor limiting bird populations on their breeding grounds. In New York State, Sibley (1988) noted that almost all of the swift records during work on the Atlas of Breeding Birds of New York State were in cities or towns. In Ohio, Beissinger and Osborne (1982) observed that Chimney Swift population density is five times higher in cities and towns than in forested areas. In Rhode Island and Tennessee, the highest densities of swifts were found in urban areas (Enser 1992; Nicholson 1997). In southern Michigan, Vermont and Kentucky, the majority of Chimney Swift observations made during Breeding Bird Atlases were in built-up areas (Dexter 1991; Norse and Kibbe 1985; Palmer-Ball 1996).

The first Ontario Breeding Bird Atlas reported a similar situation (Heillener 1987). Based on data from the second Ontario Breeding Bird Atlas (Cadman *et al*. in prep.), only 4% of the survey squares where the Chimney Swift was present had no housing agglomeration (n=275) (Figure 3). Survey squares without agglomerations represent 13% of the total squares considered complete in terms of survey effort (n=2090). In Québec, based on the Breeding Bird Atlas, the situation is similar; the proportion of survey squares with the presence of Chimney Swifts was about twice as high when an agglomeration was present (Gauthier and Aubry 1995) (Figure 4). Chimney Swift occurrence in squares without agglomeration seems higher in Québec, however, the data were collected about 15 years earlier and forested habitats have changed considerably since then. Nowadays, the situation in forested areas in Québec is probably quite similar to the one observed in Ontario.

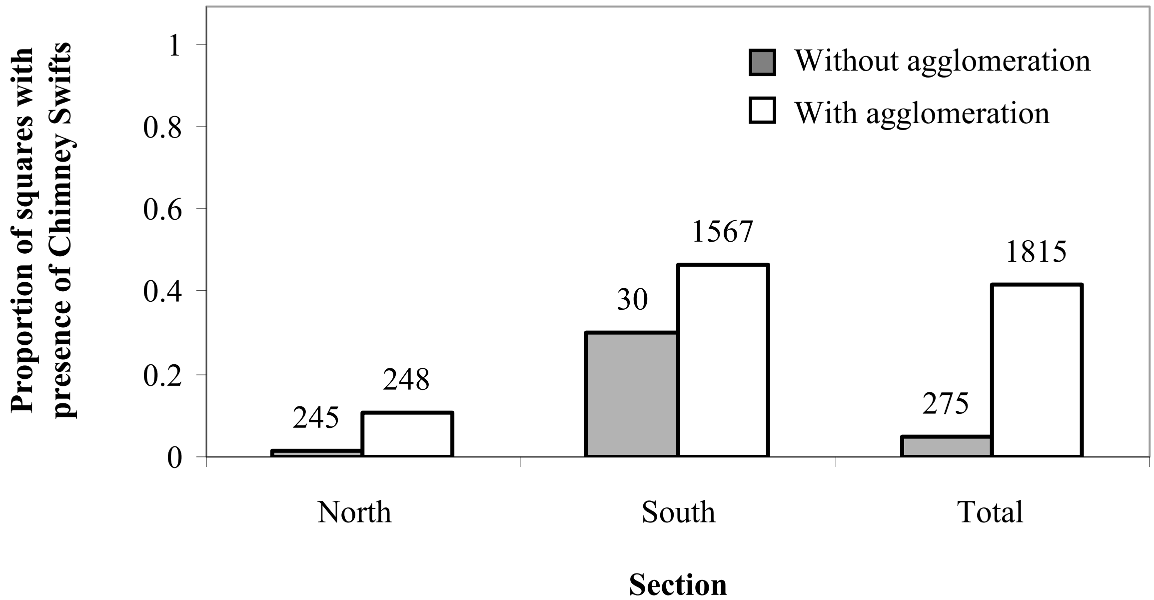

Figure 3. Proportion of completed survey squares from the Ontario Breeding Bird Atlas (2005) in which Chimney Swifts were present, for different sections of the province. Survey squares are divided according to the presence or absence of an agglomeration within a 12-km radius of the observation. The numbers above the columns equal the total number of survey squares in each category. The methodology is presented in Appendix 5

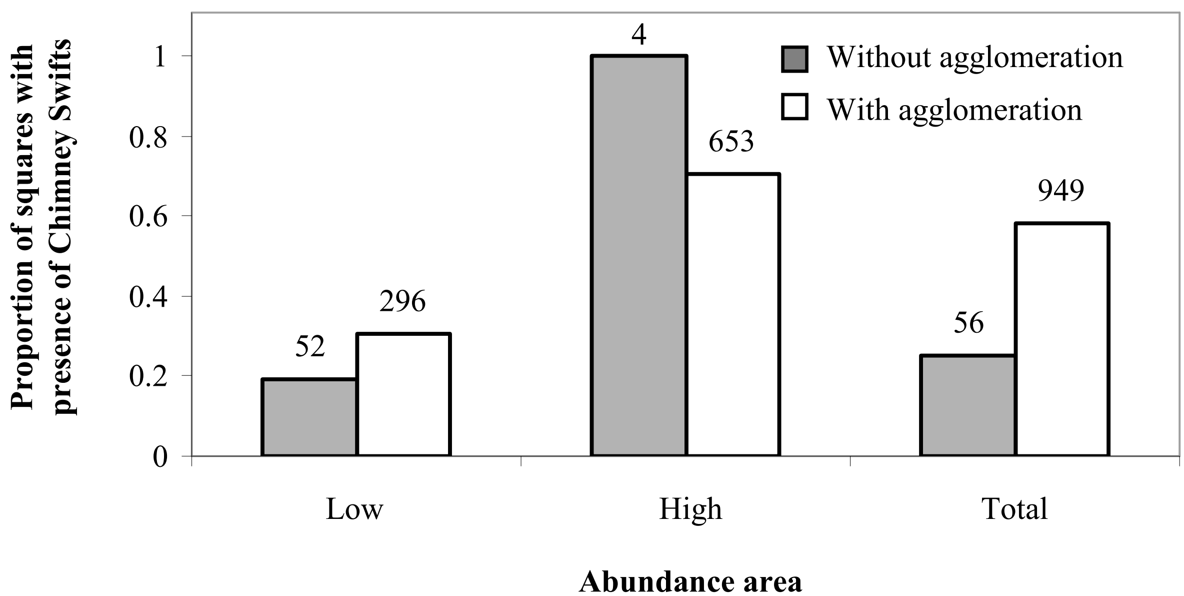

Figure 4. Proportion of completed survey squares from the Québec Breeding Bird Atlas (1995) in which Chimney Swifts were present, for different abundance areas of the province. Survey squares are divided according to the presence or absence of an agglomeration within a 12-km radius of the observation. The numbers above the columns equal the total number of survey squares in each category. The methodology is presented in Appendix 5

In 1958, Fischer said that the number of reports of swifts nesting in hollow trees had fallen considerably since the 1920s. Blodgett and Zammuto (1979) noted that barely 10 nests in hollow trees had been reported in the previous hundred years. Our literature review found only 27 reports of hollow tree nests in the United States between 1840 and 1991 (Audubon 1840; Ridgway 1874; Daniel 1902; Coffey Jr. 1944; Ganier and Clebsch 1946; Ganier 1962; Fargo 1975; Blodgett and Zammuto 1979; Hall 1983; Bull 1985, 1991; Robbins 1991; Ferguson and Ferguson 1991; Robbins and Easterla 1992; Nicholson 1997). In Canada, Peck and James (1983) reported only one such nest in Ontario. In the Maritimes, there are no records of nesting in a hollow tree for New Brunswick, but there are 10 for Nova Scotia (A. J. Erskine, CWS, pers. comm.). However, most of these sightings are from the same nesting site, observed over several consecutive years. In Québec, three hollow tree nesting cases have been recorded under the Québec Nesting Record Scheme, one in 1964 in Labelle (Desgranges 1964) and another in 1985 near Rimouski (Bélanger 1985). Since the beginning of the Québec Chimney Swift Survey in 1998, two other cases of hollow tree nesting have been reported in Saint-Pamphile-de-L'Islet and Tourville, in 2001 and 2005 respectively. Swifts have also been observed flying over old forest habitats in 2000 (F. Morneau, CWS, pers. comm.), 2002, 2004 and 2005 (CWS, unpublished data). The 2002, 2004 and 2005 observations were part of a Chimney Swift survey done in old-growth forests, where swifts were seen in three out of seven sites visited. See Appendix 6 for details on these surveys.

Nowadays, the scarcity of large-diameter hollow trees certainly goes a long way towards explaining the lack of Chimney Swift observations in forested areas. Intensive forest clearing began during the colonial period for agriculture, construction and heating purposes. Clearing increased in the 18th century as the logging industry developed rapidly. Ever since, large trees, like those used by the Chimney Swift, have been systematically removed in Canada and the United States. Today, there are only small isolated fragments of old-growth and primary forests where such trees are abundant (Davis 1993; Leverett 1996; Drushka 2000). Many studies on historical archives and old surveyor reports confirm that trees were bigger and older during settlement (Leverett 1996), and therefore forests contained more large hollow trees.

Modern day forestry practices do not help Chimney Swifts to establish nesting sites in forested areas. Indeed, although the general forest cover in North America seems plentiful, forestry practices mostly favour short harvest rotation, removal of dead trees and improvement thinning. As an example, maximum DBH guidelines for saw timber production is 45-60 cm (Gilbert and Jensen 1958; Leak *et al*., 1969; Hansen and Nyland 1986; Reed and Mroz 1997) and 40-45 cm for fibre production (Gilbert and Jensen 1958; Hansen and Nyland 1986). Wood clearing and modern day forestry practices limit the presence of large hollow trees potentially suitable for Chimney Swift nests and roosts in forests under exploitation (Conner *et al.* 1975; Cline *et al*. 1980; McComb and Nobel 1980; Mannan and Meslow 1984; Zarnowitz and Manuwal 1985; Runde and Capen 1987; Moorman *et al*. 1999; Sedgeley 2001).

Old-growth forests are considered essential for certain cavity nesting bird species (Haney and Schaadt 1996). In Canada, very little old-growth or primary forest is left. In the Maritimes, national inventories reveal that 1-5% at most of existing forest cover is 100 years and older, however, actual old growth in certain areas is less, based on preliminary field sampling (Mosseler *et al*. 2003). Loo and Ives (2003) confirmed that very few forests in the Maritimes escaped human impact after the arrival of the Europeans. In Ontario there is only a little old growth left (LandOwner Resource Centre 1999). Suffling *et al*. (2003) cited the Forestry Resource Inventory when he stated that there were 1,475 ha of old growth left in 1978 in the southern part of the province. In 1986, only 0.07% of the territory was classified as old growth (over 120 years old) (Larson *et al*. 1999). In the northern and central part of Ontario, the proportion of old growth is higher, reaching 23% on Crown land and 28% in provincial parks and nature reserves (O-DNR 2002). In Québec, the Department of Natural Resources identifies 49 old-growth stands (6,664 ha in total) that are in the process of validation (N. Villeneuve, Québec Department of Natural resources and Wildlife, pers. comm.). Out of the 49 old-growth forests identified, seven are classified as ecological reserves and are thus protected. They are the Rivière-du-Moulin, Tantaré, Lake Malakisis, Tapani, Rolland-Germain, Grands-Ormes and Boisé-des-Muir ecological reserves. The old-growth forests in these reserves represent 1,395 ha or 20.9% of the total area of the old-growth forests identified (Q-DNRWP 1996). These old-growth forests often have in common old trees exceeding 200 years of age and large DBH (> 80 cm) (Villeneuve 1994). According to the third 10-year wood inventory (1991-2000), less than 0.3% of trees on public and private land in southern Québec had a DBH larger than 50 cm (among those with a DBH of 10 cm or more). Among these trees (>50 cm DBH), only a fraction contain a cavity of adequate size for the swift's wingspan (Daniel Demers, Forest Inventory Section, Québec Department of Natural Resources and Wildlife, pers. comm.).

In the northeastern United States, only 0.4% of the forest cover is old-growth or primary forest (Davis 1996). The US Department of Agriculture Forest Service (1977) stated that less than 8% of the 116 billion trees in this area had a DBH over 23 cm. Among these trees, not all had cavities, making them potentially available for cavity nesting birds.

Forestry practices favour certain tree species which are less sensitive to cavity development. Also, foresters are often required to eliminate hollow trees for safety and productivity purposes. For example, in Québec, the provincial Department of Natural Resources policy makes it mandatory to eliminate snags in logged areas (Q-DNRWP 1998). The forest labour code is often used to justify snag removal under the threat of accidents to forestry workers. Municipalities in built-up areas in Canada also have bylaws requiring that dead and diseased trees be cut down, even if they do not pose a potential danger. A direct consequence of all these actions is a reduction in the potential number of natural sites available to the Chimney Swift. As an example, in Ontario, campaigns for the preservation of hollow trees on Crown land confirm the scarcity and necessity of such trees, essential for many animal species, including the Chimney Swift (O-DNR 2001). Such campaigns have already been carried out in many American states.

It has been shown that the Vaux's Swift, an allopatric species on Canada's West Coast, is also vulnerable to the loss of old-growth forest. Indeed, recent declines in Vaux's Swift populations' distribution range have been documented where mature forest is dwindling (Bull and Collins 1993). The Vaux's Swift is still considered a forest bird species and is associated with old forests. A positive association was found between the Vaux's Swift and old-growth forests (Manuwal and Huff 1987). Like the Chimney Swift, the closely related Vaux's Swift also nests and roosts in chimneys. However, this species is still found more frequently using large hollow trees (Bull and Collins 1993). In 1957, R. Pough stated that the Vaux's Swift had just started to make the transition from hollow tree nesting to chimney nesting that the Chimney Swift made several years ago. There are probably more large hollow trees in British Columbia because of different tree species which reach larger sizes (e.g., Douglas fur *pseudotsuga menziesii*), milder climate and a longer yearly growth period. Forests in Western Canada are also older compared with the eastern ones, reflecting less disturbance (e.g., logging) (NRCan 2001, 2004).

In terms of habitat protection, Nova Scotia aims at conserving 8% of its Crown forest land in order to achieve and maintain old-growth conditions (NS-DNR 2004). For New Brunswick, the goal is 19% of Crown land. (D. Beaudette, New Brunswick Department of Natural Resource, pers. comm.). In Ontario, current silvicultural guidelines include the maintenance of six large, live cavity trees or potential cavity trees in every hectare of managed forest in Crown land (Naylor *et al*. 1996, O-DNR 2000, 2001). However, cavity trees are defined as having a healthy crown and are not necessarily suitable for Chimney Swifts, which tend to use trees that are chimney-like and largely hollow with an open top. In Québec, 5 to 10 large decaying trees per hectare are to be maintained on privately owned tolerant deciduous forests during thinning cuts. These trees are usually greater than 35 cm in DBH (Q-DNRW 2003). On public land, measures that will take effect in 2008 propose that 5 to 10 trees greater than 20 cm in DBH should be maintained per hectare. One riparian band (20 m wide) out of five should also be left intact while selective cuts will be allowed on the others (Q-DNRW, in prep.). It is, however, easy to imagine that for economic reasons, larger trees will be cut and that only those close to 20 cm in DBH will be left, which are inadequate for Chimney Swift nesting.

Built-up areas

Faced with a rapid decline of natural sites, Chimney Swifts rapidly adopted artificial structures (chimneys, barns, wells, silos, etc.) for nesting and roosting (MacNamara 1918; Coffey Jr. 1936; Lack 1956; Fisher 1958; Johnsgard 1979; Bull 1985; Norse and Kibbe 1985; Sibley 1988; Peterjohn and Rice 1991; Sutcliffe 1994; Fleckenstein 1996; Snow and Perrins 1998; Cink and Collins 2002). The Chimney Swift is now mostly found in built-up areas, where nesting sites are more abundant (Cink and Collins 2002), suggesting that this species might have become human dependent in order to maintain a sufficient amount of nesting sites. Moreover, competition among species for cavity trees left in their natural environment is high, which does not favour Chimney Swifts breeding in forested areas (see section 8.4).

Among the artificial structures preferred by the Chimney Swift, masonry chimneys are the most abundant and by far the most frequently used. In Québec, the Chimney Swift Survey program (1998-2005) revealed that 98.5% of known sites (270/274) (active, abandoned or closed) were traditional masonry chimneys, made out of mortar and bricks or other porous materials. These types of chimneys were mostly built before the 1960s. Therefore, Chimney Swifts are observed more often in old districts where these chimneys are more abundant. Modern buildings often have chimneys that are prefabricated or contain a metal flue inside. Such chimneys are inadequate for Chimney Swifts because the inside surface is smooth, preventing the birds from clinging onto or attaching a nest on the inside.

Chimney Swifts discovered that traditional chimneys offered similar conditions (vertical rugged surfaces, darkness and shelter against wind, cold and predators) to those provided by hollow trees (Tyler 1940). The swifts appear to have adopted chimneys quite early on since they were first spotted in such structures in Maine in 1672 (Palmer 1949). Coffey Jr. (1944) mentioned that swifts began using chimneys in 1808. At the beginning of the 19th century, Audubon (1840) had already observed the widespread use of chimneys for nesting. He even commented that the species once nested in trees in western Kentucky, implying that the use of natural sites was already a phenomenon of the past by that time. In the same period, Wilson (1812) observed that nesting was already limited solely to chimneys in western Pennsylvania. In 1918, MacNamara also reported that the vast majority of swifts were nesting in chimneys.

Chimney Swifts choose unused chimneys to build their nests or roost, but a moderate amount of heat does not appear to harm them in large chimneys (J. Gauthier, CWS, pers. obs.). Little is known about the factors that contribute to the swifts' decision to choose one chimney over another, but the fact that a chimney is unused during the breeding period is probably one of them. Chimney inside temperature also seems to play a role. During the Québec Chimney Swift Survey Program, the temperature inside a few masonry chimneys occupied by swifts was measured (Table 5). Methodology for these experiments is presented in Appendix 7A. The data shows that the temperature inside a chimney fluctuated very little compared to the outdoor temperature. Marín (1997) noted the same phenomenon in a natural cave in southern California where Black Swifts nested. Segeley (2001) noted a similar phenomenon in hollow trees used by bats. Tyler (1940) reports that the chimneys most frequently occupied were unused, connected to the basement of a building and provided a flow of warm air. Bowman (1952) gives an example of such a chimney in Kingston, Ontario, adding that the flow of warm air made the chimney particularly attractive to swifts, especially on cool nights in April and May. In Lévis, Québec, during a cold day in spring 1998, swifts attracted by recorded bird calls chose a chimney connected to a house over an artificial chimney made out of wood, which did not retain heat (CWS, unpublished data). In Québec and in their northern breeding range, swifts look for sites where the ambient temperature remains relatively constant and where some heat is present. Results in Table 5 support this conclusion. The internal temperature of insulated artificial chimneys fluctuates less than in artificial chimneys without insulation. The temperature variations measured in insulated artificial chimneys resemble those of traditional masonry chimneys (Table 5). In Québec, Chimney Swifts not only look for sites with fairly stable temperatures, but also with a minimum temperature. It was possible, by an experiment (n=3), to determine a threshold temperature at which swifts depart from a chimney (see Appendix 7B for details). A threshold temperature of about 13°C seems to be required by Chimney Swifts in these northern latitudes. Certain large hollow trees also offer this minimal temperature required by swifts (Sedgeley 2001; CWS, unpublished data).

In addition to chimneys, the swift can nest and roost in air shafts, silos, wells, inside barns, tobacco curing sheds, abandoned buildings and large concrete sewer pipes (M. Robert, CWS, pers. comm.; Fischer 1958; Bull 1985; Dexter 1991). Inside buildings, the birds generally build their nests above the floor in the darkest corners (Fischer 1958) where the heat tends to accumulate.

Table 5. Mean temperatures ± SD (°C) (daily, day, night) inside and outside two chimney types. Maximum and minimum daily temperatures are also presented. See Appendix 7 for methodological details

Chimney type	Traditional			Artificial						
Location	Saint-Raymond	Mont-Mégantic	La Malbaie	Saint-Augustin	Cap Tourmente					
Height (m)	?	?	?	6.1	2.4	2.4	6.1	6.1	6.1	6.1
Insulation	NA	NA	NA	No	No	Yes	No	Yes	No	Yes
Period (1999)	6 Jul. to 14 Sept.	8 Jul. to 14 Aug.	19 Jul. to 21 Sept.	13 Jul. to 3 Aug.	7 Jul. to 27 Aug.	7 Jul.to 27 Aug.	7 Jul. to 12 Oct.	7 Jul. to 27 Aug.	7 Jul. to 12 Oct.	7 Jul. to 27 Aug.
Chimney temperature (°C)										
Mean ± SD	21.7 ± 1.8	19.8 ± 3.7	18.4 ± 2.5	23.0 ± 5.5	20.6 ± 5.5	19.5 ± 4.3	16.9 ± 6.2	19.6 ± 4.8	16.7 ± 6.0	19.1 ± 4.6
Maximum	25.0	28.8	24.4	35.4	35.0	30.0	31.0	31.0	30.3	30.3
Minimum	17.4	12.6	9.4	9.7	9.2	10.3	-1.9	9.2	-1.9	9.7
Day mean ± SD	22.1 ± 1.8	22.4 ± 3.6	20.0 ± 2.4	30.0 ± 3.5	27.4 ± 4.2	24.3 ± 3.5	22.0 ± 5.9	25.0 ± 4.0	21.4 ± 5.4	23.8 ± 3.8
Night mean ± SD	21.4 ± 1.8	17.4 ± 2.9	17.2 ± 2.6	16.8 ± 3.0	14.8 ± 2.8	15.3 ± 2.7	12.0 ± 5.0	14.5 ± 3.0	12.0 ± 5.0	14.5 ± 3.1
Mean daily difference ± SD	0.7 ± 0.4	5.0 ±2.3	2.8 ± 1.1	13.2 ± 4.0	12.6 ± 4.0	9.0 ± 3.3	10.1 ± 4.1	10.5 ± 4.0	9.4 ± 3.9	9.3 ±3.8
Outdoor temperature (°C)										
Mean ± SD	18.6 ± 4.4	15.9 ± 4.3	16.6 ± 4.5	21.6 ± 4.2	18.8 ± 4.3	18.8 ± 4.3	16.4 ± 5.6	18.8 ± 4.3	16.4 ± 5.6	18.8 ± 4.3
Maximum	30.3	27.6	28.6	30.3	29.8	29.8	29.8	29.8	29.8	29.8
Minimum	7.2	5.9	5.7	9.7	8.4	8.4	-2.2	8.4	-2.2	8.4
Day mean ± SD	23.5 ± 3.7	19.4 ± 4.2	20.8 ± 4.1	24.9 ± 3.3	23.6 ± 3.7	23.6 ± 3.7	21.2 ± 5.4	23.6 ± 3.7	21.2 ± 5.4	23.6 ± 3.7
Night mean ± SD	13.8 ± 2.8	12.6 ± 3.4	12.1 ± 3.0	15.2 ± 2.6	14.0 ± 2.6	14.0 ± 2.6	11.8 ± 4.2	14.0 ± 2.6	11.8 ± 4.2	14.0 ± 2.6
Mean daily difference ± SD	9.8 ± 3.7	6.8 ± 2.0	8.6 ± 3.2	9.7 ± 3.4	9.5 ± 3.1	9.5 ± 3.1	9.3 ± 3.3	9.5 ± 3.1	9.3 ± 3.3	9.5 ± 3.1

6.2 Wintering grounds

The Chimney Swift's winter range in South America consists of river-edge forest, edge of tropical lowland evergreen forest and second-growth scrub (Rappole *et al*. 1983; Stotz *et al.* 1996). It also frequents irrigated farmland and suburban and city centre zones (Hughes 1988). On the Peruvian coast, the swift regularly occurs at altitudes of 2,500 m, and sometimes 3,000 m (Hughes 1988). It roosts in chimneys, crevices, caves (Fjeldså and Krabbe 1990) and hollow trees (snags and cavity trees) that are plentiful in the Amazon forest (Whittemore 1981). The discovery of their wintering grounds in 1944 proves that the species uses hollow trees as roosting sites in South America (Brackbill 1950). The region where some banded swifts were captured by local people in a hollow tree is located in the middle of the jungle where such trees are common. However, the Chimney Swift's winter habitat preferences are still not very well known (Stotz *et al*. 1996; Cink and Collins 2002).

7. Population trends

7.1 United States

Breeding Bird Survey (BBS)

In the United States, although the swift is considered common in almost all the states where it breeds (Table 3), the population has also declined by 1.6% per year since 1966, according to the BBS (Table 6). Of the 38 states for which data are available, 16 (42%) show a significant ($P < 0.05$) downward trend for the 1966-2005 period (Sauer *et al.* 2006). No trend data are available for New Mexico, Arizona and California, because too few Chimney Swifts have been detected on BBS routes in those states. Within states (n=11) showing a significant decrease for the two considered periods (1966-2005 and 1980-2005), all (100%) saw the decline accelerate in the last 25 years, or the 1980-2005 period (Table 6). Sauer *et al*. (2006) caution that the trends in Colorado, Illinois, Indiana, Kentucky, Michigan, Rhode Island, South Dakota, Tennessee, Virginia and West Virginia must be considered carefully because the data are deficient in a number of ways (e.g., small number of birds per route and fewer than five routes sampled). Rodriguez (2002) re-analyzed the 1966-1993 BBS figures in order to study changes in the range of distribution for significantly declining bird species. During this period, the Chimney Swift had suffered a 21% decline in abundance while its distribution range had decreased by 32.2%.

Breeding Bird Atlases

A number of authors from many Breeding Bird Atlases have also reported a population decline in their states: Palmer-Ball (1996) in Kentucky, Hess (2000) in Delaware and Mulvihill (1992) in Pennsylvania. In Connecticut, Zeranski and Baptist (1990) noted that the species began to decline in the 1960s and 1970s. The Driftwood Wildlife Association (2000), a Texas organization that is conducting research projects on the Chimney Swift, reported that the population had been shrinking since the mid-1980s. Sibley (1988) also reported a significant decline in the number of swifts in New York State, particularly in New York City and area. In Ohio, Peterjohn and Rice (1991) reported that the Chimney Swift was widespread, but that the population decline had become obvious in many parts of the state in the 1980s. In Colorado, Kingery (1998) observed that the species had been less and less evident in recent years. The population drops in New Hampshire and Maryland have led authors to declare that the species should be monitored in the next few years and that a follow-up should be carried out (Sutcliffe 1994; Zucker 1996).

Table 6. Chimney Swift population trends in the United States expressed as % of change per year, based on Breeding Bird Survey results (Sauer *et al.* 2006). N represents the number of survey routes used in the analysis

Region	Period			
	1966-2005		1980-2005	
	Index (%/year)	N	Index (%/year)	N
North America	-1.6 *	2,144	-2.5 *	2,019
United States	-1.6 *	1,996	-2.5 *	1,903
Alabama	-1.5 *	100	-2.8 *	99
Arkansas	-0.6	35	-2.0 *	34
Colorado	-15.0	5	-9.0	5
Connecticut	-0.2	18	-1.2	18
Delaware	-2.0 *	13	-1.2	13
Florida	-1.2	67	-1.7	65
Georgia	-1.1	66	-2.0 *	65
Illinois	-2.5 *	98	-3.6 *	98
Indiana	-2.8 *	59	-3.8 *	59
Iowa	-1.9	38	-3.1 *	37
Kansas	-0.8	53	-1.8	52
Kentucky	-2.4 *	48	-4.9 *	45
Louisiana	-1.2 *	62	-2.6	57
Maine	-2.5 *	58	-2.6	55
Maryland	-1.6 *	64	-0.7	62
Massachusetts	-1.8	25	-1.0	23
Michigan	+0.1	66	-0.7	60
Minnesota	-1.3	47	-2.5	42
Mississippi	-1.8	34	-1.0	32
Missouri	-1.5	63	-2.2 *	61
Nebraska	-2.0	30	-4.4	29
New Hampshire	-1.9	25	-2.9 *	24
New Jersey	-3.0 *	36	-2.1	31
New York	-1.7 *	111	-1.0	102
North Carolina	-0.5	81	-1.0	75
North Dakota	+11.3	5	+10.2	5
Ohio	-0.7	78	-1.6 *	77
Oklahoma	-3.1 *	53	-3.3 *	52
Pennsylvania	-0.6	118	-0.3	106
Rhodes Island	-11.2 *	4	-12.6 *	3
South Carolina	-1.2	38	-2.0	34
South Dakota	+1.1	5	-1.8	5
Tennessee	-2.0 *	47	-3.2 *	46
Texas	-2.4 *	127	-3.4 *	124
Vermont	-2.4	24	-0.3	21
Virginia	-1.3 *	55	-1.4 *	50
West Virginia	-1.6 *	56	-2.5 *	53
Wisconsin	-0.6	83	-1.8 *	83

* P <0.05

7.2 Canada

Breeding Bird Survey

According to the BBS, the Canadian Chimney Swift population experienced a significant decline ($P < 0.05$), on the order of -8.2% annually, between 1968 and 2004 (Downes *et al*. 2006) (Table 7). When this annual decline is cumulated for the entire survey period using the procedure described on the Web site of the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2005), we obtain a 95.4% drop in the Chimney Swift population for that period.

Table 7. Chimney Swift population trends in Canada and for various provinces and periods. The results are expressed as a % of change per year, based on Breeding Bird Survey results (Downes *et al*. 2006). N represents the number of survey routes used in the analysis

Region	1968-1994	N	1968-1998	N	1968-2004	N	1989-1998	N	1994-2004	N
Canada	-4.9 *	157	-7.4 *	133	-8.2 *	206	-11.4 *	65	-1.6	121
Québec	--		--		-5.3 *	57	--		+7.1	35
Ontario	--		--		-9.0 *	82	--		-9.9 *	52
New Brunswick	--		--		--		--		--	
Nova Scotia	--		--		--		--		-4.2	16

* $P < 0.05$

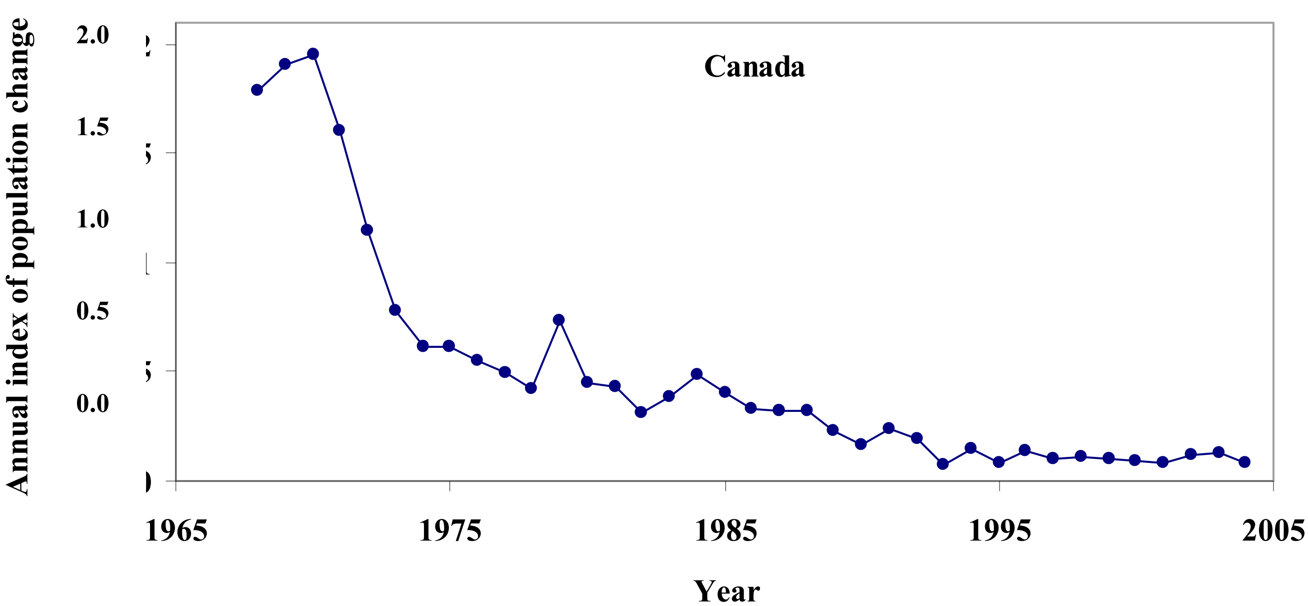

Figure 5. Chimney Swift annual index of population change in Canada, based on Breeding Bird Survey results (1968-2004) (Downes *et al*. 2006)

The situation has deteriorated, since the decline was -4.9% between 1968 and 1994 (Downes and Collins 1996) and -7.4% for the 1968-1998 period (Dunn *et al*. 2000). Although the situation seems to have improved in the 1994-2004 analysis (Downes *et al*. 2006) (Table 7), the trend is not significant. In 2000, Dunn *et al*. placed the Chimney Swift in the category of species with consistently negative trends. The annual abundance indicator (the total number of swifts observed on all routes in a given region and year divided by the total number of listening points), calculated using BBS data, has declined steadily since 1968 (Downes *et al*. 2006) (Figure 5). The result clearly shows that the Canadian population is experiencing an overall decline. This decline can be observed in all provinces where BBS data are available (Figure 6).

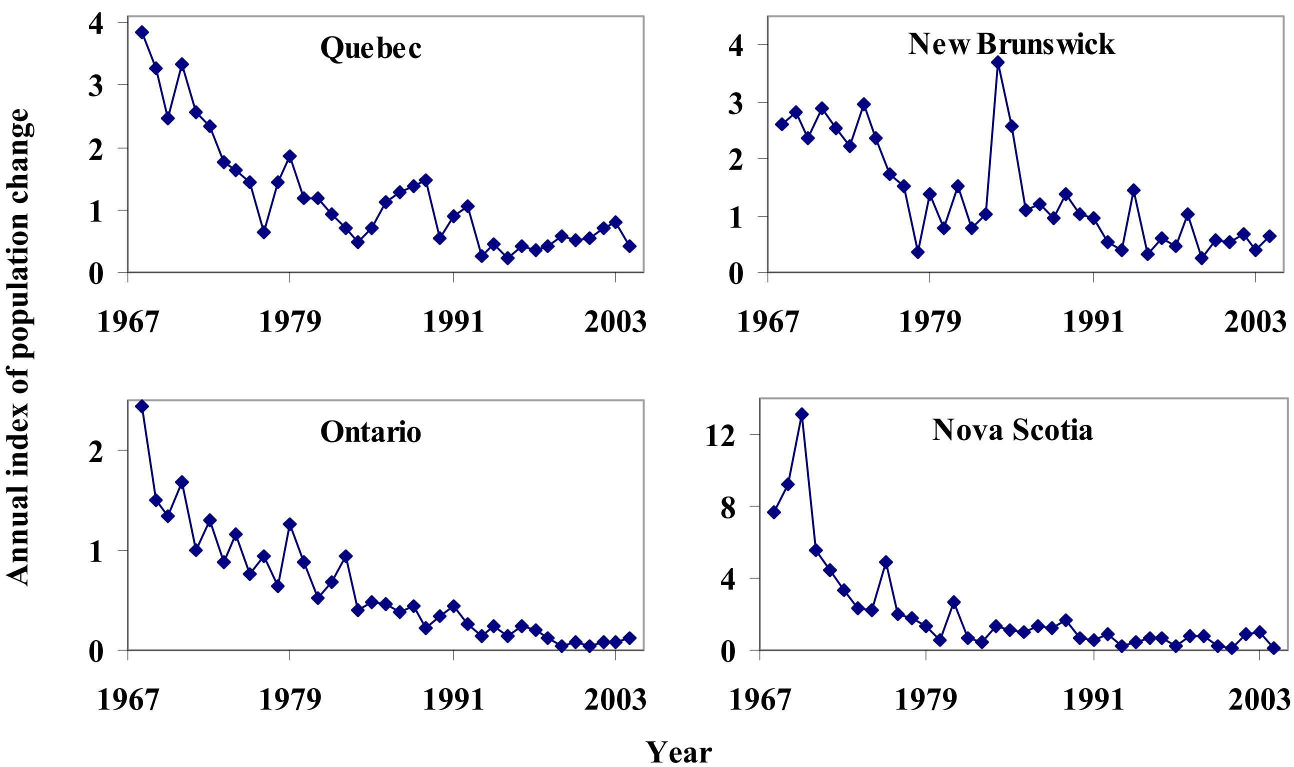

Figure 6. Chimney Swift annual index of population change in four Canadian provinces, based on Breeding Bird Survey results (1968-2004) (Downes *et al*. 2006)

Still according to BBS data (1966-2004) (Table 7), the Québec Chimney Swift population is declining by -5.3% annually. Since 1994, the downward trend seems to have reversed, however, the trend is not statistically significant under an α level of 0.05. This positive trend could be the result of a few good years, giving a short-term increase. It could also be a consequence of a limited number of routes in the province (n=35) or an estimate biased by short time intervals (discussed later). It is always best to consider trends that cover the longest time periods. The swift population remains low and a bad year could dramatically affect the numbers in this province. The population trend in Ontario (1968-2004) shows a significant decline (-9.0% annually) (Table 7). The situation seems to have deteriorated in recent years (1994-2004), reaching -9.9% annually. In the 2002 BBS analysis, the New Brunswick and Nova Scotia populations were experiencing an annual decline of -6.3% and -7.8% (1968-2002) respectively (Downes *et al*. 2003). No data are available for Prince Edward Island.

These BBS analyses also raise some questions relative to the degree of precision of trends in relation to the duration of the considered period. Dunn *et al*. (2000) suggested a negative annual trend of -15.2% for the Chimney Swift between 1994 and 1998, while Downes *et al*. (2003) calculated -0.3% for the 1993-2002 period. Even though the two periods overlap, the addition of a few years to the analysis changes the trend results considerably. However, the longer the time interval, the more precise the trend estimate will be. This statement is based on the flight behaviour of the Chimney Swift, which resembles that of birds of prey, in relation to the methodology of the BBS. The BBS survey consists of 50 stops spaced 0.8 km apart along each survey route. Breeding Chimney Swifts spend most of their day feeding at high altitudes and can forage 8 km away from the nest (Fisher 1958). Unpaired swifts can travel much further (see section 3.4 on behaviour). Therefore, one bird can be counted as often as 10 times on one route, overestimating its presence for that route. If, by chance, many of these biases occur during a survey period, the annual abundance index could be biased in a positive direction. However, the longer the time period under consideration, the less chance there is of many extreme values biasing the overall trend.

Breeding Bird Atlases

Recent data collected for the second Ontario Breeding Bird Atlas (Figure 7) indicate a decrease of 45% of the Chimney Swift distribution range since the first Atlas survey (1981-1985) (Cadman *et al*., in prep.). The species has not been reported in 430 well-covered 10-km squares in which it was detected during the first atlas, though it has been reported in 114 new squares compared to the first Atlas. Of the 184 species reported in more than 100 10-km squares during the first atlas, the Chimney Swift is among species showing the largest proportional decline (M. D. Cadman, CWS, pers. comm.).

After the sharp decline in the Ontario Chimney Swift's range of distribution was observed, a subsample (n=200) of the 1995 survey squares of the Atlas of Breeding Birds of Québec (Gauthier and Aubry 1995) was inventoried in the summer 2004 to see if a reduction had also occurred in Québec. Results showed that the range of distribution declined significantly, by 33% between 1989 and 2004 ($p<0.0001$). See Appendix 8 for methodology and analysis.

According to Erskine (1992), the Chimney Swift population in the Maritime provinces has declined markedly in the last 30 years. They are less numerous in Prince Edward Island and New Brunswick than in the past. A. Erskine (CWS, pers. comm.) also says that the species has been less frequently observed and has even disappeared from certain areas since the publication of the Atlas of Breeding Birds of the Maritime provinces in 1992.
In the Atlas of Saskatchewan Birds, Smith (1996) classifies the Chimney Swift as uncommon in Saskatchewan. However, historical data suggest that the species was once more widespread in the province than it is today. In Manitoba, the situation is similar; swifts were more abundant before (Taylor 2003). There is no information on population trends for this species in Newfoundland.

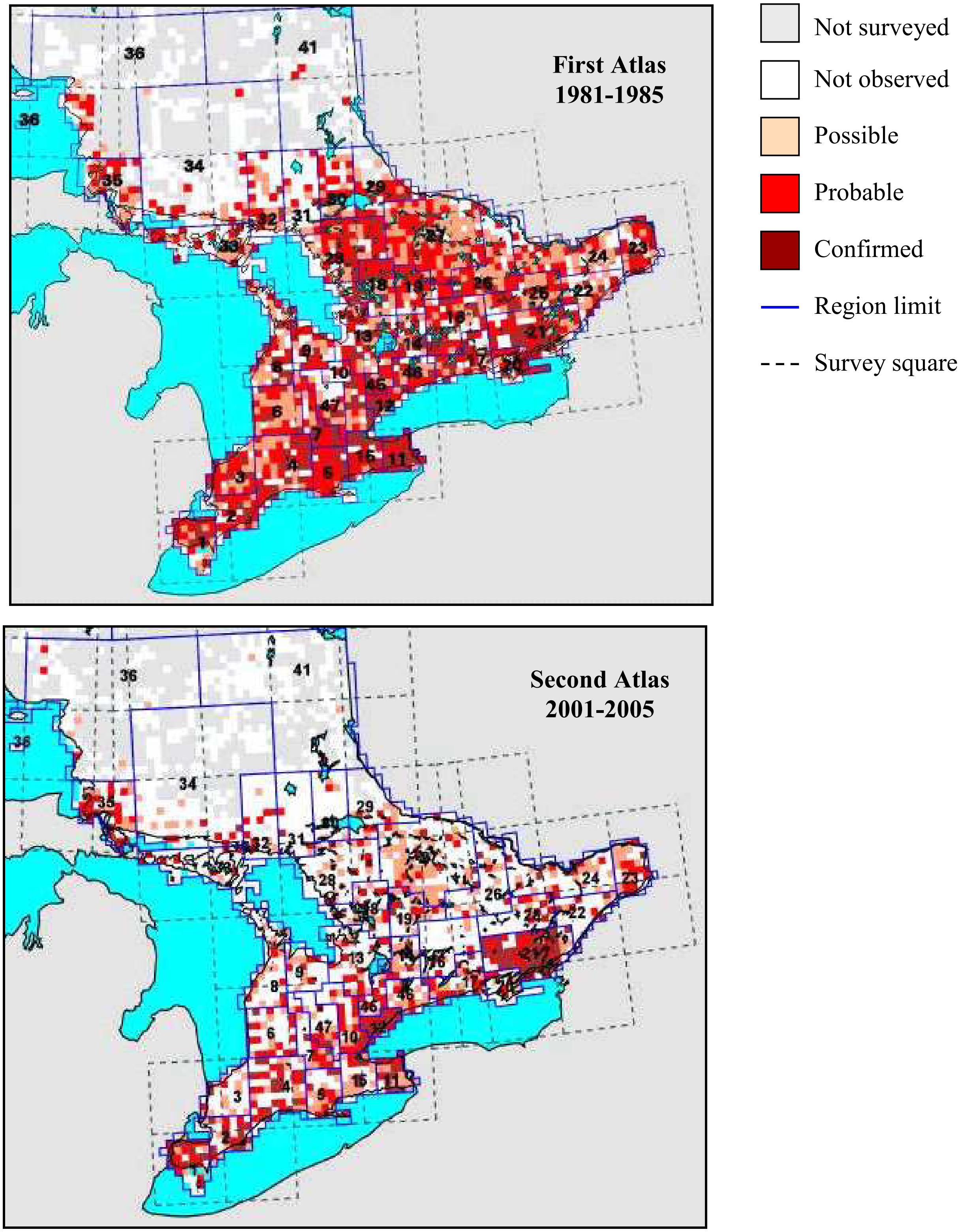

Figure 7. Chimney Swift breeding evidence in southern Ontario recorded during the first and second Breeding Bird Atlas of the province (2001-2005). The map was created by Bird Studies Canada® October 2005

Historical roosts

In Québec there are Chimney Swift historical data for three roosts, located at least 200 km apart, in Saint-Raymond, Arvida (Jonquière) and La Pocatière. At all three sites, data confirm the downward trend observed with the BBS and Atlases. The first roost is located in Saint-Raymond, 50 km west of Québec City. Swifts are occupying the chimney of a former convent that has been converted into a senior citizens' residence. This chimney, which benefits from a legal protection for swifts required by the previous owner is still being used by the birds. In 1981, approximately 1,200 swifts were counted, while 234 were counted in 2002 and 112 in 2005 (Figure 8). Their numbers have thus fallen 91% in 24 years, or 3.7% per year.

The second roost is in Arvida (part of the city known as Saguenay). Chimney Swift numbers declined dramatically from 1958 to 1999 (Figure 8). Observations made between 1958 and 1986 were related to a roost in a supermarket chimney in Carré Davis, the downtown shopping district. For the 1988-1997 observations, the exact location was not specified, but there is every reason to believe that it refers to the same chimney since Chimney Swifts exhibit strong site fidelity (Fischer 1958; Dexter 1992). The number of swifts frequenting this area of town has dramatically fallen in the last 40 years (Figure 8). There were approximately 1,000 birds in the late 1950s (Browne 1967), a few hundred in the early 1980s, a few dozen at the end of the 1980s and barely 15 since 1991. The population has dropped 99% in 42 years (2.4%/year). The supermarket chimney where the large roost was located in 1958 was capped in fall 1998. The chimney was still available as a roost before that date, but that did not prevent the number of swifts from declining. A follow-up visit in summer 1999 confirmed this decline. No more than 11 birds were observed entering the chimney of a school in the same area. Since a roost usually draws birds from a large perimeter, this number can be taken as indicative of the population in this area of the town, since the observers searched it systematically over one entire summer. Including historical data, the species was reported in at least 40 different locations in the Saguenay–Lac Saint-Jean region between 1971 and 1997 (Savard 1999) and in six or seven municipalities annually in the 1980s (Savard 2000). However, in the summer of 1999, despite the observers' efforts, swifts were spotted in only three municipalities (Jonquière, La Baie and Roberval) (Savard 2000). The species seems to have completely deserted Chicoutimi (Saguenay), where it had been present in the past (Savard 2000).

The third roost is located at the François Pilote Museum in La Pocatière in the Lower St. Lawrence region. The chimney is as old as the building, which was built in 1925, but is no longer used for heating. The roost has hosted Chimney Swifts since 1940 and has been protected by a religious community since then (Tanguay 1964-65). Although the chimney is still available, the number of swifts using it has declined significantly since the late 1950s (Figure 8). It is very possible that the number of birds present in 1957 was over 500, because the observer was only able to witness the start of flocking (R. McNeil, Professor of Ornithology at the University of Montreal, pers. comm.). Only two were seen entering the chimney in 2000, down from the 1,200 birds observed in 1958, a drop of over 99.8% in 43 years (2.3%/year). No swifts were observed in 2002. In 2005, two Chimney Swifts were seen at the site. Since 2000 this site seems to have become a nesting site. Twenty years ago in the Rimouski region, during the Breeding Bird Atlas survey period, 100 or so swifts were regularly seen in flight; today, just over 20 can be observed after much effort (J. Larivée, responsible for compiling the Étude des populations d'oiseaux du Québec data, pers. comm.).

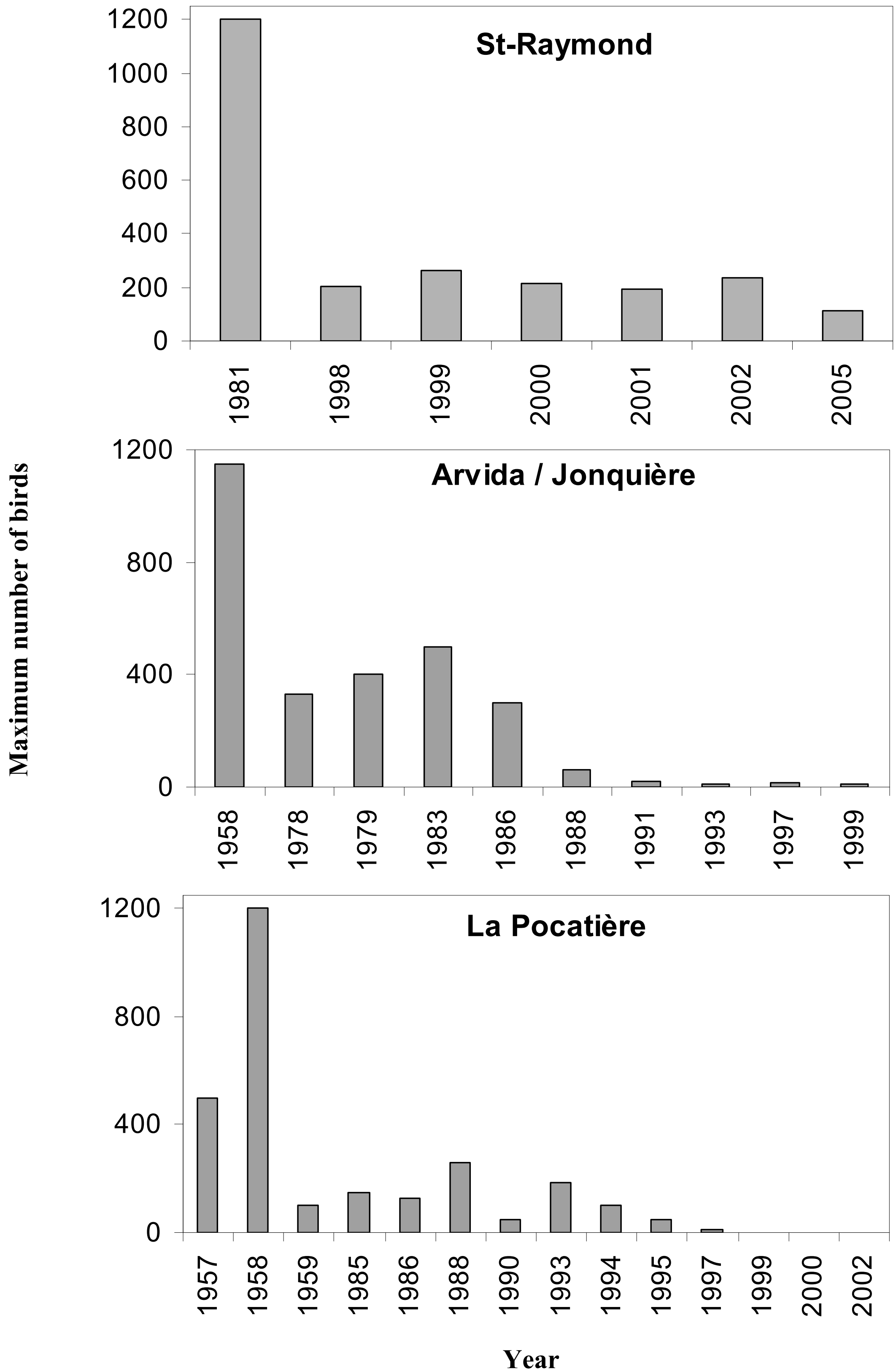

Figure 8. Maximum number of Chimney Swifts in time at three historical roosting sites in Québec

There are also some historical data for three major roosts in Nova Scotia (Figure 9). At the beginning of 1990, Chimney Swifts had almost deserted the University Hall roost (Acadia University). The numbers of birds at the two other sites showed considerable variation over the years, with no clear trend. Chimney Swift numbers at the Robie Tufts Nature Centre (RTNC) chimney in Wolfville peaked in 1989, but then seem to have declined, even though this site was transformed into an interpretive centre in 1990 to protect this important roost in Nova Scotia.

Étude des populations d'oiseaux du Québec (ÉPOQ)

Breeding Bird Survey data are not alone in showing a negative trend in Québec. For the 1969-1989 period, stability and abundance indicators using ÉPOQ file data show a significant drop (Cyr and Larivée 1995).

7.3 Wintering grounds

Population trends in the Chimney Swift's winter range are unknown (Cink and Collins 2002).

8. Causes of population decline and other threats

8.1 Habitat loss

Disappearance of traditional masonry chimneys

One of the main causes of the decline in the North American Chimney Swift population seems to be the reduction in the number of suitable nesting sites (Kyle and Kyle 1996, 2000; Cink and Collins 2002), which affects the species' reproduction capabilities. Nowadays, because the species is mainly found in built-up areas (see section 6.1, *Forested areas*), the reduction and the potential scarcity of nesting sites is related to them. Bull and Hohmann (1993) conclude that the availability of nesting and roosting sites was the main limiting factor for a similar species, the Vaux's Swift. In built-up areas, the Chimney Swift nests mainly in traditional chimneys (see section 6.1, *Built-up areas*). In Canada and United States, we have seen a general decline in the number of chimneys available to swifts in built-up areas. Some authors (Sutcliffe 1994; Fleckenstein 1996; Hess 2000; Cink and Collins 2002) consider this decrease to be a major cause of the population's significant decline. The availability of cavities is the limiting factor for cavity nesting birds on the breeding grounds (Newton 1994).

The potential number of traditional chimneys adequate for Chimney Swift nesting has been decreasing for many years. In the past 50 years, the development of new heating technologies, construction standards and fire prevention measures have led to the modification, closing or destruction of a high proportion of suitable chimneys. One only needs to pay attention to building roofs in order to realize that traditional masonry chimneys are now very rare. These chimneys are disappearing rapidly from old districts, where they were once abundant, and are practically absent from new development areas built after the 1960s.

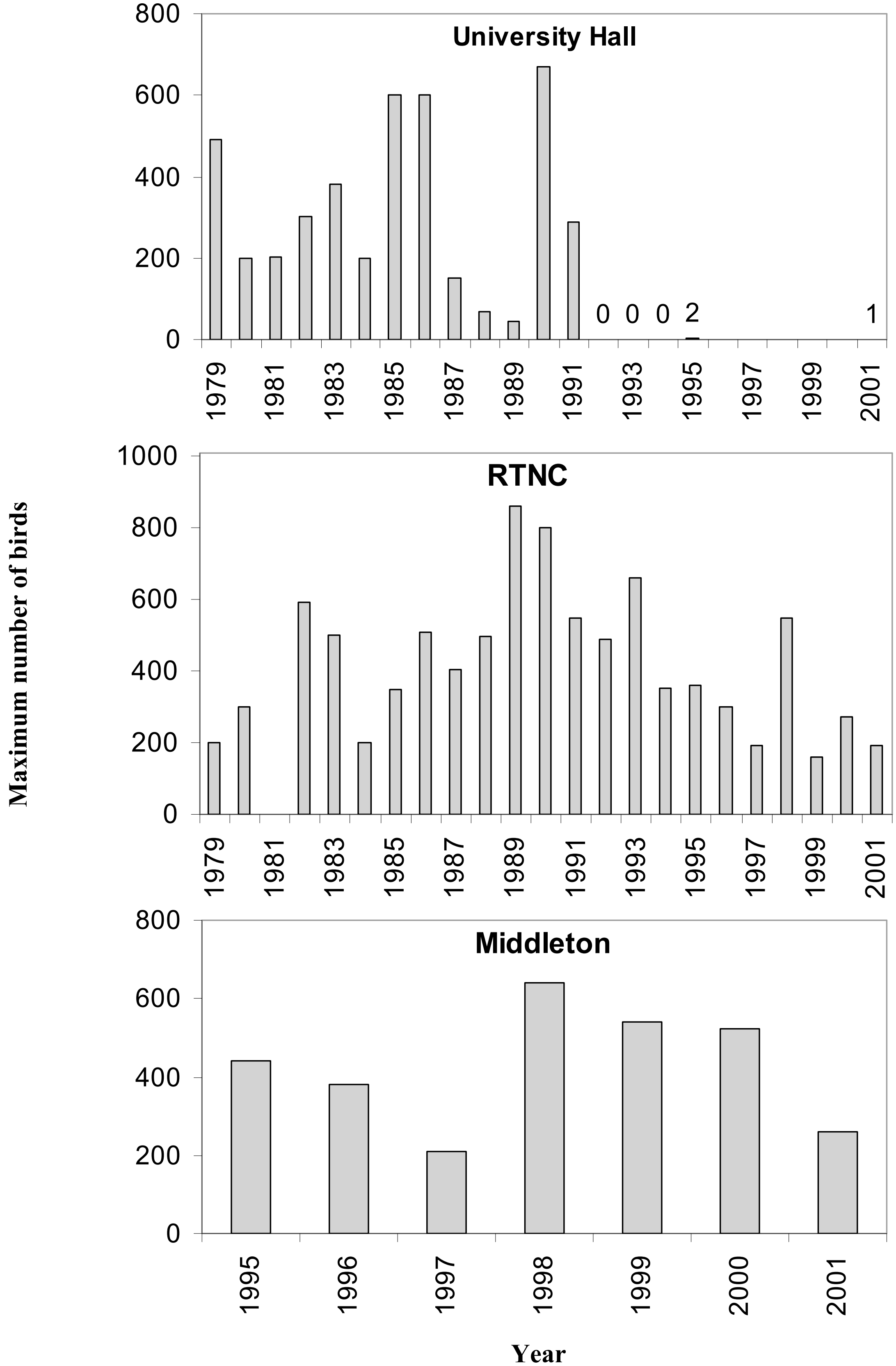

Figure 9. Maximum number of Chimney Swifts over time at three historical roosting sites in Nova Scotia

The growing use of electric heating starting in the 1950s was the beginning of the end for this artificial habitat. Buildings using this type of energy no longer need or have chimneys, which are either capped (closed) or destroyed at the end of their useful life. Chimneys kept on old buildings have to be modified in order to meet new construction standards (Canadian Building Code) to prevent fire hazards. Standards and measures to avoid fire hazards include the use of prefabricated chimneys made out of metal or the installation of metal flues inside a chimney, rendering these sites unsuitable for Chimney Swifts because the sides are too slick for a bird to cling onto or to attach its nest. These chimneys are also often quite small in diameter (< 30 cm), which can turn them into fatal traps for birds that dare to venture inside because they are unable to get out. The recent arrival of gas also increased the conversion of traditional chimneys. Insurance companies strongly "encourage" building owners to adopt such practices by either dramatically increasing insurance costs or refusing to insure owners who do not comply. Heating companies also encourage owners to adopt these new materials and practices to avoid problems related to traditional chimneys when using high performance low combustion stoves. These stoves increase the amount of creosote accumulation (product of combustion) inside the chimney which, in contact with water, creates harmful acids that affect the mortar and bricks of traditional chimneys. Over time, the chimneys' structural materials become frail and crumble, letting the wind pass through and leading to fire risk. Metal chimneys were created in part to respond to this threat.

Other practices include the installation of spark arresters, chimney hats against rain or screens for nuisance animals (raccoons, squirrels), which are often required by municipal bylaws, making potentially suitable chimneys no longer accessible for Chimney Swifts.

In order to evaluate the situation of this critical habitat for Chimney Swifts in Québec, an investigation was carried out on the availability of suitable chimneys. Chimneys were grouped in four categories: industrial, commercial (including government and apartment buildings), residential and religious (churches, church rectories, convents and schools).

Industrial chimneys offer very few suitable sites for Chimneys Swift. The number of industries that possess masonry chimneys is low. When industries are still in service, their chimneys are often in use, making them unavailable for the birds. If not in service, chimneys become abandoned and remain suitable only temporarily. These chimneys degrade rapidly when no longer in use since combustion deposits (creosote) mixed with rain water create powerful acids that destroys the chimney mortar, creating cracks and crevasses in the structure. At this point, cold air circulates inside, reducing the ambient temperature during cold days and making the site less suitable for nesting Chimney Swifts, which look for sites with warm, constant temperatures (see section 6.1). Once the mortar becomes too degraded, these chimneys also become a safety hazard and have to be destroyed. Restoration and repairs have to be carried out early and most often are very expensive. These factors partially explain the difficulty in conserving the large traditional chimneys of industrial buildings.

The situation is fairly similar for traditional chimneys of commercial, government and apartment buildings. However, most of these buildings no longer have such chimneys, as the majority have already been converted with new materials and standards and, therefore, are not suitable for swifts (Public Works and Government Services Canada, Société immobilière du Québec, pers. comm.).

Based on our consultations, chimneys of residential buildings built before 1960 are at least 75% already unavailable to swifts (pers. comm.: P. Allard, restoration adviser for the Giroux-Maçonnex Briques et Pavés for 25 years; M. Gaillardetz, President and Engineer, Terra Cota Company; fire departments of Montreal and Québec City, and the Professional Wood Heating Association). According to M. Gaillardetz (Company President), the Terra Cota Company (main chimney flue tile supplier in North America for over 100 years) has been out of business since 2001 due to new materials being used for chimney construction, mainly stainless steel, which resists corrosion better. This high percentage of unavailable chimneys is easily confirmed by simple observations in cities and rural areas. Of the 25% left, about 60% have a diameter of 28 cm or less (M. Labrècque, chimney sweep and builder, pers. comm.), making them less preferred by swifts since they have a mean wingspan of 30 cm and enter and leave the chimney by flight. A study revealed that dimensions of chimneys used by Vaux's Swift varied between 32.5 and 54.5 cm in diameter (Lewis *et al*. 2002) (also see section 6.1 on *Forested areas* for discussion on minimal cavity size requirements). This tendency towards a reduction in chimney diameter is also confirmed by M. Gaillardetz, who states that new technologies (low combustion stove) require chimneys with a smaller internal diameter. The Terra Cota Company showed a dramatic increase in sales of the the 20-cm chimney flue tile (with a diagonal opening of close to 28 cm) during the 1990s, from 20% to 80% in less than 10 years.

All experts agree that the majority of chimneys of industrial, commercial, government, and residential buildings and houses in Canada are unavailable or unsuitable for Chimney Swifts. Based on the rate at which suitable chimneys are disappearing and on expert opinions, most of remaining suitable chimney will no longer be available for the birds in the next 5 to 10 years. Although no thorough analyses on the situation are available, the coherence and constancy of expert agreement is striking.

Last but most important are chimneys in churches, church rectories, convents and neighbouring schools built before 1960. Many of these religious buildings constructed before 1960 have impressive traditional mortar chimneys with adequate dimensions, and contrary to residential chimneys, these are more resistant. Data from the Québec Chimney Swift Survey Program reveal that chimneys in religious buildings were the ones most often used by the birds. Since 1998, 57% of known Chimney Swift sites (n=274) were chimneys of these types (Table 8). When considering only roosts, the proportion reaches 79%. These results seem to reflect a greater availability of suitable chimneys in religious buildings. This can be explained by the fact that they are abundant and available to swifts and very solidly built in most cases. Because of a decreasing number of devotees, the precarious financial state of church administration due to their large numbers, and high operating costs, these chimneys are likely to be repaired or modified after the other kinds of chimneys. Consequently, the availability of sites in religious buildings is higher than in the other types of buildings already mentioned. When chimneys in religious buildings are ultimately repaired or modified, there can be a negative impact on swifts. According to Dr. R. Pleau of the architecture department at Laval University, such chimneys have an average lifespan of 60 years before repairs are needed, because of the high quality of mortar used. These chimneys were built stronger than residential chimneys. Therefore, although there are many more residential and commercial chimneys, there seem to be more suitable chimneys in religious buildings.

In light of this, a study on church and church rectory chimneys was conducted in Québec in 2000. Parishes (n=239) were selected randomly among those established prior to 1960 and located in the Chimney Swift area of distribution (n=1,540). The survey was conducted over the phone and questions were then asked in order to estimate the proportion of church and church rectory chimneys that were still available for Chimney Swifts and also to document the reasons why some chimneys were no longer available. Approximately 35.4% of chimneys (131/370) in the selected parishes were no longer available to swifts. The diocese with the highest rate of closure was Montreal, where 54% of church and church rectory chimneys had been closed (Table 9). The most common reason for the chimneys' unavailability was the installation of a spark arrester, a hat or protective fencing (Table 10).

Table 8. Classification of known sites from the Québec Chimney Swift Survey Program (1998-2005), based on building type.

Building type	**Number of sites (%)**		
	Roost	**Nesting site**	**Total**
Church	25 (41)	48 (23)	73 (27)
School	18 (29)	35 (16)	53 (19)
Church rectory	2 (3)	14 (7)	16 (6)
Convent	3 (5)	10 (5)	13 (5)
Commercial building	10 (16)	53 (25)	63 (23)
Residential	0 (0)	52 (24)	52 (19)
Factory	3 (5)	0 (0)	3 (1)
Other	0 (0)	1 (<1)	1 (<1)
Total	61	213	274

Table 9. Proportion of church and church rectory chimneys not available to Chimney Swifts in different dioceses in Québec

Diocese	**Number of parishes selected**	**Number of chimneys sampled**	**Number of non-available chimneys (%)**
Montreal	36	50	27 (54)
Saint-Jérôme, Joliette	20	32	17 (53.1)
Québec	33	43	22 (51.1)
Chicoutimi, Baie-Comeau	22	40	15 (37.5)
Nicolet, Trois-Rivières	24	39	14 (35.9)
Sherbrooke	13	20	7 (35.0)
Valleyfield, Saint-Jean-sur-Richelieu, Saint-Hyacinthe	37	53	14 (26.4)
Amos, Rouyn-Noranda	13	18	4 (22.2)
Gaspé, Rimouski and Sainte-Anne-de-la-Pocatière	36	54	8 (14.8)
Mont-Laurier, Gatineau-Hull	15	21	3 (14.3)
Total	249	370	131 (35.4)

Table 10. Summary of modifications made to church and church rectory chimneys in Québec rendering them unsuitable to Chimney Swifts

Modifications	Number of chimneys (%)
Presence of a spark arrester, screen or chimney hat	66 (50.4)
Metal flue inside chimney	23 (17.5)
Prefabricated Chimney	17 (13.0)
Closed off chimney	16 (12.2)
Destroyed chimney	9 (6.9)

If the last traditional chimneys of religious buildings were constructed in 1960 and the maximum lifespan of these chimneys made out of bricks and mortar is 60 years (Dr. R. Pleau, Professor, Department of Architecture, Laval University), very few traditional chimneys will be left (not renovated, closed or destroyed) by 2020. However, many of them will have disappeared before that time. According to Simard (1998), Québec's religious heritage (architecture, landscape, furnishings and archives) is threatened and has become increasingly impoverished and degraded over the past few years. Churches, non-governmental organizations and public authorities have decided to take action. Accordingly, the Québec government, through its support program for the restoration of religious heritage, has invested $101.5 million since 1995 for the restoration of this heritage, particularly in church renovations (Québec's Department of Communication and Culture (Q-DCC) 2000). Under the program, 18 churches underwent major restoration work in 2000 (Q-DCC 2000). In half of these cases, the roofs were repaired and chimneys were modified or renovated at the same time. These renovations are not likely to benefit the Chimney Swift. As a result, the rate of closure of church and church rectory chimneys could be quicker than expected. At that point, the Chimney Swift will face a severe shortage of nesting and roosting sites. Although chimneys forming the church, church rectory and school complexes are probably not the only nesting sites available to these birds, they probably represent the majority of them. Chimneys from such complexes are probably the last to be renovated, closed or destroyed, because they are publicly owned and require major investments.

Aside from the efforts being deployed in Québec, there are no other quantitative data on the proportion of suitable chimneys for the Chimney Swift elsewhere in Canada. However, there is every reason to believe that the situation is similar in the rest of Canada and also in the United States, because of normal structure degradation, new heating technologies, new construction materials and standards, fire prevention measures and bylaws, and insurance companies' incentives. Everywhere in North America, the majority of traditional chimneys will eventually disappear. However, chimneys located in more northern latitudes will disappear at a faster rate because of harsh weather. A similar structure will wear down quicker in the north because of frequent freezing and thawing of water that infiltrates the structure. This phenomenon could explain Rodriguez's conclusion (2002) that the Chimney Swift is experiencing a stronger decline at the edge of its distribution range than in the centre, where numbers are higher.

Chimney traps

Beside the reduction in the number of potentially accessible chimneys, there is also another threatening phenomenon called "chimney traps." These chimneys contain a small diameter metal flue lining inside and nothing at the top preventing birds from entering. Swifts that venture inside become trapped because the flue lining is too small for them to spread their wings and they cannot cling to the sides and climb out because of the smooth surface. Rescue operations have been carried out for several years in a row in Lévis to pull out swifts trapped inside a chimney of this type (C. Garneau, pers. comm.). In Québec, there are municipal laws in some areas that require homeowners to put spark arresters over their chimneys. These caps prevent Chimney Swifts from entering "chimney traps." Unfortunately, not every homeowner obeys this law. Stricter enforcement of the law could easily eliminate the threat posed by such chimneys, for which the magnitude of the effect is unknown. This type of chimney has been built for the last 40 years, but we do not know what proportion of chimneys in general they represent. The rate at which swifts were trapped in Lévis indicates that a number of swifts may suffer the same tragic end.

Chimney sweeping during breeding

The use of fossil fuels for heating, especially in the beginning, was not very efficient and dangerously soiled chimneys. Because this phenomenon often caused fires, many cities in North America resorted to systematic chimney sweeping during summer, which often coincided with the Chimney Swift's breeding period. Chimney sweeping during summer was also cheaper has it corresponded with the sweepers' slow period of the year. Until the early 1990s, large cities like Montreal still underwent this type of systematic sweeping during breeding period, which could have impacted swift populations. Nowadays, many traditional chimneys potentially suitable for swifts are still being systematically swept every summer to prevent fires. Such practice has been confirmed by many professional sweepers.

In Texas, the Driftwood Wildlife Association has partnered up with the National Chimney Sweep Guild in order to educate professional chimney sweeps about the Chimney Swift's plight and promote chimney maintenance outside of the breeding period (Kyle and Kyle 1999).

Disappearance of old abandoned buildings

The Chimney Swift can also nest inside abandoned and old farm buildings (Cink and Collins 2002). It is possible that the species has been affected by the disappearance of farm buildings as farmland has been abandoned or modernized in the last few decades. Because of the need to increase productivity, many small farms were converted into large industrial farms in which silos and barns were renovated and became inaccessible to swifts. Some authors (Mulvihill 1992; Kyle and Kyle 2000) also mention that old abandoned buildings are increasingly rare. They are often demolished for reasons such as aesthetic concerns, legal liability, safety and health. Municipalities continue to collect taxes on these abandoned buildings, and this does not encourage owners to keep them. Finally, land development plans often impose legal limits on this type of building to avoid problems.

8.2 Public misconceptions of this species

Public misconceptions of the species have resulted in building owners' intolerance for swifts nesting in their chimneys. They erroneously evoke the fear of birds carrying nuisance insects to justify their intolerance (Thompson et Ely 1989), but they mostly mention fire risks as the reason for preventing Chimney Swifts from using their chimneys. However, such risks are nonexistent. Roosting swifts cling to the inside chimney walls at night and leave in the morning, while nesting swifts build only one minuscule nest per site (approximately 10 cm long and 5 X 7.5 cm wide (Fischer 1958)). The nest is made of small twigs and often falls to the bottom of the chimney at the end of the season. As a result, there is no possibility of the nest blocking the chimney and causing a fire. Poor chimney maintenance is a much greater danger. Educating building owners is thus essential to ensuring that nesting and roosting sites are conserved. However, it must be recognized that the rearing of Chimneys Swift can be quite noisy, forcing homeowners to intervene. Also, some people confuse swifts with more problematic bird species such as the European Starling (*Sturnus vulgaris*), which prompts them to act. They can also be misidentified as bats, which have a bad reputation and could also carry rabies. As a result, in many villages in Québec at least, people take actions to prevent any chimney intrusion and theirefore eliminate the fear of contamination.

8.3 Insecticides

Most of the studies conducted on the impacts of pesticides in various environments report pesticide-induced changes in birdlife food resources (Avian Effects Dialogue Group 1994). Insectivorous birds are particularly vulnerable to agricultural and forest pesticides, which can significantly reduce insect prey populations. The reduced abundance of insects as well as the changes in diet composition and quality have been related to reduced survival, growth and reproduction among birds (Avian Effects Dialogue Group 1994).

The arrival of the West Nile Virus generated eradication programs in specific areas in Canada, using pesticides. In North America, the practice of spraying pesticides to control insects in cities and towns is becoming increasingly popular. A study on the impact of spreading these products on lawns showed a significant negative correlation between nest productivity of the American Robin (*Turdus migratorius*) and the number of properties treated with chlorpyrifos during the previous two years (Décarie and DesGranges 1990). The declining abundance of earthworms caused by the pesticide explained the negative impact in this case.

During migration, swifts forage on the wing for airborne insects, which are called air plankton. It is known that pesticides can be transported over long distances in the air (Poissant 1999). A number of these have relatively high volatility, which means they evaporate quickly after being sprayed and dispersed in the atmosphere (Poissant and Koprivnjak 1996). Chimney Swifts could be indirectly affected by these products, which cause an impoverishment of the air plankton (populations of flying insects). Since the Chimney Swift depends mainly on insects for its subsistence, it is vulnerable to any reduction in the availability of its prey caused by pesticide apllications. Erskine (1992) expressed concern about aerial spraying against spruce budworm (*Choristoneura fumiferana*), which has taken place in New Brunswick since 1952 and may have reduced flying insect populations below the level needed to support earlier swift numbers recorded in that province.

In addition, insects that survive contact with these products become contaminated, and when eaten by swifts contaminate them too. In Christmas tree plantations, Rondeau and DesGranges (1991) showed that the ingestion of insects contaminated with organophosphates (diazinon and dimethoate) was the main cause of mortality of Song Sparrow (*Melospiza melodia*) nestlings at these sites. Chantler (1999) reports that high concentrations of DDE, a degradation product of DDT, have been found in the Guam Swiftlet (*Aerodramus bartschi*), another member of the Apodinae family. It has been proven that DDT, by making egg shells thinner, reduces breeding success in a number of birds of prey (Blus *et al.* 1995). Chantler (1999) also points out that pesticides could pose a risk to this family, considering the position of swifts in the food chain and their extended longevity. Sick (1993), in *Birds of Brazil*, states that various species of swifts are in decline, as are swallows and nightjars, all of them probably victims of the unrestricted use of pesticides. In Ontario, similar trends were observed in other aerial foragers such as swallows and nightjars, which suggest that something may be happening to their food supply, namely insects (M. D. Cadman, CWS, pers. comm.). This hypothesis could also partially explain the trend observed in the swift population.

Although it is highly probable that the various pesticides being used do affect swifts, by either reducing the quantity of insects available or contaminating them, no reliable information is available to confirm this hypothesis. On the other hand, the recent fecundity and survival rates calculated for swifts in Québec and Texas (Kyle and Kyle, unpublished data) are comparable to those observed between 1930 and 1950 (section 3.2 and Appendix 2), which suggest that the effect of pesticide spraying on this species is potentially similar now to what it was then. However, the emergence of new illnesses carried by biting insects such as mosquitoes has caused pesticide spraying to increase in many cities and suburbs in recent years.

8.4 Competition

There is an interspecific competition with swift species for nesting cavities (Lack and Collins 1985). Disputes over the occupation of nesting sites have been reported between Black Swifts (*Apus apus*) and European Starlings (*Sturnus vulgaris*).

In forested areas, not only are large hollow trees rare (see section 6.1, *Forested areas*), but it seems that cavity size could also act as a factor limiting site suitability (Bonar 2000). The Pileated Woodpecker could be a key species in the production of suitable cavities for secondary cavity nesters such as the Chimney Swift (Bonar 2000). Bonar (2000) also lists 38 species of vertebrates that use secondary cavities and could therefore potentially compete with the Chimney Swift for these sites.

Among birds species competing for cavities are: the Turkey Vulture (*Cathartes aura*), the Great Horned Owl (*Bubo virginianus*), the Long-Eared Owl (*Asio otus*), the Eastern Screech Owl (*Otus asio*), the Northern Hawk-owl (*Surnia ulula*), the Barred Owl (*Strix varia*), the Northern Saw-whet Owl (*Aegolius acadicus*), the Hooded Merganser (*Lophodytes cucullatus*), the Wood Duck (*Aix sponsa*), the Common Goldeneye (*Bucephala clangula*), the Pileated Woodpecker, the Northern Flicker and the House Sparrow (*Passer domesticus).* Many of these species could compete and dislodge the Chimney Swift from a site, given the scarcity of natural sites and the swift's small size. An artificial site created for the Chimney Swift was occupied by Chimney Swifts only after the Northern Flicker pair had abandoned the premises (Whittemore 1981).

Competition with mammals could also threaten the Chimney Swift in its natural sites. One example was reported for Vaux's Swift, where the birds were forced to abandon their roost in a hollow tree when an American black bear (*Ursus americanus)* had moved in (Bull 1991). The Raccoon (*Procyon lotor*), the Grey Squirrel (*Sciurus carolinensis*), the Red Squirrel (*Tamiasciurus hudsonicus*), the Northern Flying Squirrel (*Glaucomys sabrinus*) and the American Marten (*Martes americana*) could also force swifts out of a site as well as posing a threat to eggs and nestlings. Wasps and bats could also compete with Chimney Swifts for such sites.

In urban areas, the European Starling, the House Sparrow, the Raccoon, and the Gray Squirrel are probably the main competitors for chimneys.

Intraspecific competition between adult Chimney Swifts could take on greater importance as suitable nesting sites become increasingly scarce. Intense competition could exclude birds from breeding due to a lack of available sites, but it could also affect the breeding success of the few lucky pairs, given the extra time required to defend and maintain their territory.

8.5 Accidents

Swifts roosting in a chimney do on occasion die from asphyxiation or are burned when the chimney is in use during cold weather (Deane 1908). This situation can cause the death of a large number of birds in one fell swoop. In Illinois, Musselman (1931) reported that 3,000 to 5,000 swifts died in a chimney in October.

At Lake Springfield, Illinois, Bohlen (1989) found 100 dead swifts killed by cars on a cold, rainy spring day when the birds were flying very low to catch insects.

The Chimney Swift can also be victim of collisions with skyscrapers and communication towers, however, reports concerning this species are rare. Fatal Light Awareness Program (FLAP) data on birds picked up after colliding with skyscrapers in downtown Toronto show that Chimney Swifts account for only 0.06% of the birds killed between 1993 and 1995 (Evans Ogden 1996). Similar results have been found in the case of communication towers. In a compilation of results from 47 US and Canadian studies on mortality resulting from collisions with communication towers, only 0.02% of the birds killed were swifts (Shire *et al*. 2000). The main reason for these results is that the species is a diurnal migrant, unlike the majority of birds killed, which migrate during the night (Evans Ogden 1996; Shire *et al*. 2000).

8.6 Predation

When nesting in hollow trees, the eggs or nestlings may be destroyed by a raccoon (Ferguson and Ferguson 1991). The American Red Squirrel and the Grey Squirrel can also carry out some predation, as these species are known for eating eggs and nestlings when given the opportunity (Banfield 1977; Beaudin and Quintin 1983). Deer Mice (*Peromyscus maniculatus*) are also known to eat bird eggs. Certain passerine birds like the Common Grackle (*Quiscalus quiscula*), the Grey Jays (*Perisoreus canadensis*) and the Blue Jays (*Cyanocitta cristata*) can also prey on bird eggs. In urban areas, raccoons and the Grey Squirrel are considered to be the most important predators of eggs and nestlings. Raccoons and squirrels are also becoming more and more abundant in southern Ontario and Québec. Cink (1990) reported one case of four Chimney Swift nestlings preyed upon by a Black Rat Snake (*Elaphe obsoleta obsoleta*) in a chimney in Kansas.

The Chimney Swift's very rapid and erratic flight often saves it from birds of prey, but cases have been reported of individuals that were caught close to roosts by an American Kestrel (*Falco sparverius*) (Laskey 1944), a Merlin (*Falco columbarius*) (Tyler 1940; Wolford 1997; M. Renaud, pers. comm.) and a Sharp-shinned Hawk (*Accipiter striatus*) (Tyler 1940). These took advantage of the fact that swifts had to slow down just before entering the chimney and caught them. Merlins have invaded Québec urban centres in recent years and their increasing number of attacks against swifts is surely related to this phenomenon. The presence of such a predator had an impact on a Chimney Swift's roost in the Saint-Jovite church in 1999 (M. Renaud, pers. comm.). During the period when the Merlin was present, swifts had almost completely abandoned the roost. When this occurs, the birds have to find another home, something that is not easy given the increasing scarcity of suitable sites. Despite these observations, according to Lack (1973), predators are responsible for only a small proportion of swift mortality.

8.7 Meteorological conditions

Weather conditions can have a direct impact on birds, depending on the species' physiological tolerance, or an indirect one resulting from environmental changes that affect the availability of food, habitat structure and relationships between organisms (Hayworth and Weathers 1984).

According to Walker (1944), the Chimney Swift's greatest single enemy is the weather. In addition to affecting the number of insects available, Chantler (1999) says that temperature and precipitation also have a major impact on swifts' breeding success. When the temperature drops below 13°C or rain is abundant, insects fly very little or not at all (Finlay 1976). This temperature also corresponds to the threshold at which Chimney Swifts will leave a site to find a better refuge (see section 6.1, *Built-up areas*). Precipitation can kill birds indirectly. A steady drenching rain for two or three days may clear the air of insects resulting in a lack of food supply, making birds subject to starvation (Walker 1944). Cold, rainy weather in northern Europe is known to cause considerable mortality in swift and swallow populations (Elkins 1988). In Massachusetts, Forbush (1927, 1929) noted that the death of thousands of Chimney Swifts at the bottom of a chimney came following several days of cold weather and rain. In La Pocatière (Québec), 109 birds were found dead in the chimney of the François Pilote Museum on May 23, 1990; they apparently died due to low temperatures and snow (Aubry *et al.* 1990). The bad weather observed in 1990 also apparently killed many Chimney Swifts in the province of Nova Scotia (Wolford 1997). The Chimney Swift looks for nesting or roosting sites with a minimal inside temperature and having less fluctuation than the outside (see section 6.1). However, when the temperature inside a chimney goes below a threshold (13°C), swifts leave the site, possibly looking for a better one even though conditions remain unfavourable. In such a situation, if no better sites are available, birds will remain at their site.

Heavy rain can also detach nests from chimney walls on occasion, which often destroys the eggs and nestlings (Dexter 1952b; 1960; 1981a). However, the young do sometimes survive and climb back up the wall, where the parents continue to feed them (Dexter 1952b; 1960; 1985).

Hurricanes that occur during the fall migration period and move up the Atlantic Coast can also cause events of mass mortality. On October 15, 2005, Hurricane Wilma, which started its course in the Caribbean Ocean, passed through the Yucatan Peninsula and southern Florida, moved up the Atlantic Coast and died down in open water east of the Maritime provinces on October 26, 2005 (Figure 10). Wilma registered a strong depression, resulting in a Category 5 hurricane on the Saffir-Simpson Scale with record-breaking wind gusts (National Hurricane Center 2005). During this time, thousands of birds, among them many Chimney Swifts (>2,000), were brought back up the Atlantic Coast from their migration staging areas. Many Chimney Swifts ended up in the Maritime provinces and many died from direct and indirect causes related to the hurricane. Swifts had been observed in Nova Scotia, late after the breeding season, however, the mean departure date for migration is September 7 (Tuft 1986). At this time of the year, Chimney Swifts are reported in the southern United States, Costa Rica and Panama (Lowery 1943; Stiles and Skutch 1989; Ridgeley and Gwynne 1989). Preliminary analysis of the 2006 data from the Québec Chimney Swift Survey Program indicates that the population has declined by almost 50% compared to the previous year, possibly due to Hurricane Wilma (Dionne *et al*., in prep.).

During this event, at least 700 Chimney Swifts were been found dead (D. Busby, CWS, pers. comm.). The number of swifts that perished in this event is potentially greater, as many may have died offshore as the hurricane passed. Some swifts were seen as far as Sable Island (NS), Saint-Pierre and Miquelon, and even Great Britain and Spain. Swifts have been observed in these areas before, but in small numbers mainly as transients or vagrants (McLaren 1981; Etcheberry 1982; Byrne and Graves 1992).

Many of the Chimney Swift casualties were the result of birds using active chimneys at this time of year. However, it seems that some birds died of exhaustion after being “caught” in the hurricane. Two swifts which were found dead in Grand Manan (NB) had lost 30-35% of their body weight (B. Dalzell, Fundy Bird Observatory, pers. comm.). Many other birds, which were carried back to the Maritimes by the hurricane, may have suffered the same fate. At this time of the year, temperatures are cold and as a result, thermoregulation costs are high while flying insects are scarce. Adding to that the energy lost while caught in the hurricane, it is probable that a number of these birds may not have been able to make the trip back to their wintering grounds as a result of poor body condition. A portion of birds probably died offshore but the extent of these casualties cannot be accounted for.Many birds may have also perished from direct hurricane action in the form of ascending winds. Indeed, powerful hurricanes such as Wilma can generate ascending winds of up to 200 km/h (Ahrens 1999). Birds caught in these winds would be propelled to high altitudes and freeze instantaneously.

Similar effects of hurricanes on birds have been observed before. Tuft (1986) discusses a similar event which occurred in 1924 and brought back many terns and gulls. In 1968, Hurricane Gladys also brought back terns and gulls, along with some Chimney Swifts (Mills 1969). In 1969, it was Bonnie’s turn (Anonymous 1998), however it seems that none have had the same impact as Wilma. The impact of a hurricane on migrating birds probably depends on many factors: hurricane strength, frequency of hurricanes, timing, and hurricane trajectory in relation to bird migration (location). Wilma was not only a powerful hurricane which hammered the Atlantic Coast at the right place and time, but it was also the tenth hurricane (or tropical storm) in the month of September alone, and others followed (National Hurricane Center 2005). Moreover, Tropical Storm Alpha started at about the same time and eventually joined Wilma's trajectory, which potentially contributed to the devastating effect of Wilma (Figure 10).

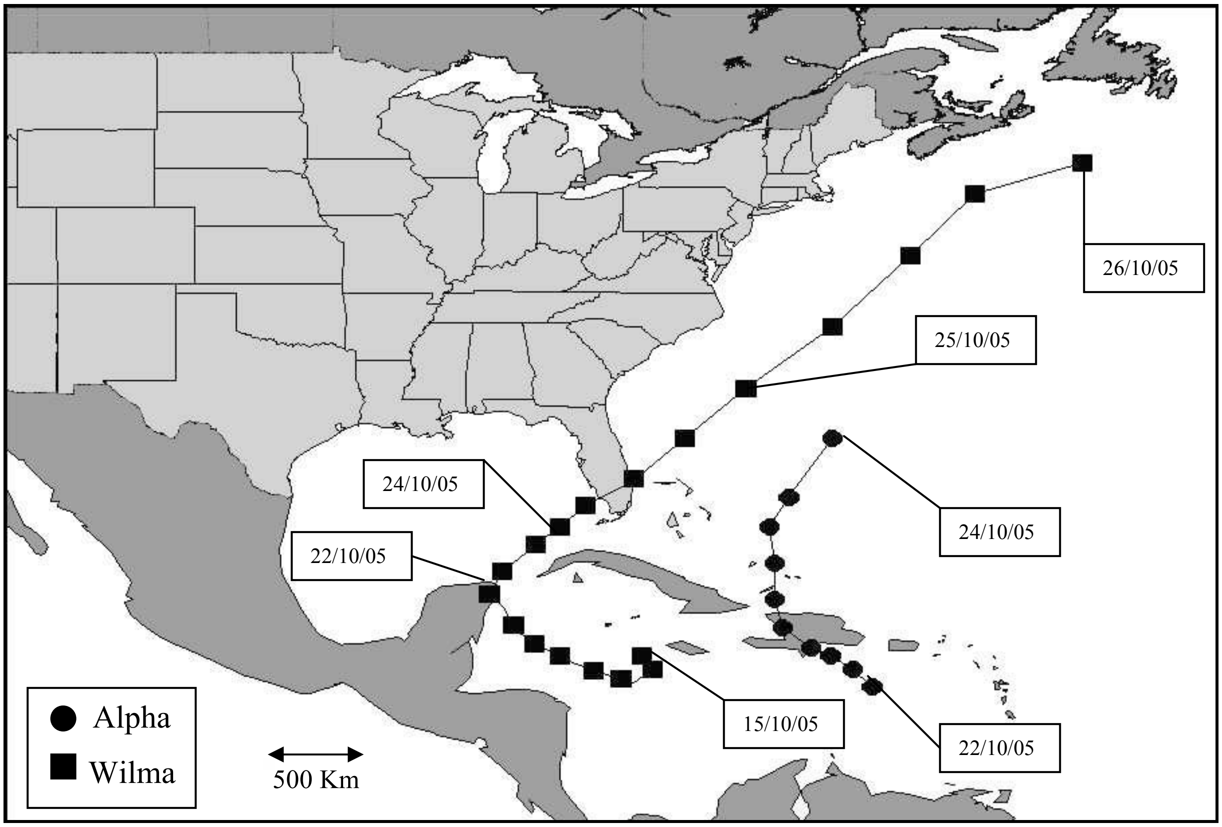

Figure 10. Trajectory of the eye of Hurricane Wilma and Tropical Storm Alpha, which occurred in October 2005. Data were provided by the Canadian Hurricane Center (2005)

Climate changes will undoubtedly have consequences on birdlife. In a study on the evaluation of Québec breeding birds' vulnerability to climate change, Morneau *et al.* (1998) observed that of the 13 most climate-sensitive species, most of them were insectivorous neotropical migrants. The Chimney Swift was one of the 71 vulnerable species identified. Climate warming could result in greater climate fluctuations, which would in turn translate into an increase in the frequency of temperature extremes such as very cold springs or summers. These conditions could be catastrophic for aerial foragers like Chimney Swifts, swallows and nightjars. Extreme temperatures during winter time could also accelerate the degradation of the last remaining traditional chimneys available to Chimney Swifts. During periods of warm weather and rain, water could infiltrate the chimney mortar. The water could then cause considerable damage once it freezes back again, eroding the chimney's structure. The 1998 ice storm in the Montreal region caused much damage to stone and brick structures.

Climate change could also have an impact on the frequency, intensity and trajectories of hurricanes. Stronger and more frequent hurricanes could hit the Atlantic Coast during the bird migration period and cause direct and indirect events of mass mortality, like the one observed in 2005. According to the National Oceanic and Atmospheric Administration (NOAA) (2005), the mean number of storms (tropical storm and hurricane) since 1995 is higher than the previous period (1970-1994). Also, 2005 is a record year in terms of number of storms, number of hurricanes and number of severe hurricanes (categories 4-5 on the Saffir-Simpson scale). This phenomenon may affect an increasing number of birds during their migration south.

8.8 West Nile Virus

The Chimney Swift appears on the list of birds which have been found dead and tested positive for the West Nile Virus in the United States (Centers for Disease Control and Prevention, Division of Vector-Born Infectious Diseases 2003). There have been no cases of infection in Canada and the species is not on the list of birds selected for testing. The increase in insecticide spraying in response to this disease could also adversely affect insectivorous birds including the Chimney Swift (see section 6.4).

8.9 Migration and wintering grounds

Since the Chimney Swift makes use of hollow trees in its South American winter range, the species is threatened by intensive logging and fires in the Amazon forest. In addition, after forests are cleared to create farmland, large quantities of pesticides are often used to control insects that are harmful to farm crops and humans. In some countries, very harmful pesticides banned in North America, such as DDT, are still being used. These products may be having a significant impact on the Chimney Swift, but no data are available on this subject.

Hunting Chimney Swifts is prohibited in North America and appears to be practically nonexistent. However, swifts are a supplemental food source of South American indigenous peoples, as shown by the fate of 13 banded swifts killed by forest inhabitants in Peru in 1943 (Lincoln 1944; Brackbill 1950).

There is very little information on the threats that Chimney Swifts encounter during migration and on the wintering grounds. Rappole and McDonald (1994) conclude in a general way that many neotropical migrants were in decline as a result of habitat change on their wintering grounds. In response to this conclusion, Latta and Baltz (1997) agree that habitat loss or modification on the bird's wintering grounds could limit their survivorship. However, the extent of this phenomenon is unknown and very few studies have demonstrated it. Also, it is very difficult to dissociate factors in population decline on the wintering grounds from those on the breeding grounds. Latta and Baltz (1997) also argue that many of the predictions formulated by Rappole and McDonald (1994) to justify their conclusions could also be explained by factors occurring during migration.

9. Population size in Canada

9.1 Québec

Québec Chimney Swift Survey Program

The Chimney Swift Survey Program mainly covers high-potential habitats, i.e., old neighbourhoods built before 1960 (see Appendix 9 for program methodology). These neighbourhoods contain most of the suitable chimneys, still available for Chimney Swifts. Therefore, the tallied population represents the majority of Chimney Swifts present in the province.

From 1998 to 2005, old neighbourhoods from 331 parishes in Québec were visited during the roosting and breeding periods (see Appendix 9). These parishes represent 21.5% of those established before 1960 which are in the distribution range of the Chimney Swift (n=1540), and therefore, 21.5% of the high-potential habitats. Including the parishes that were inventoried in the study of chimneys in religious buildings (n=199; see section 8.1), the total reaches 530 parishes, which represent 34% of the total high-potential habitat.

In reality, however, survey effort and coverage is much greater, for various reasons:

1. All sightings in the ÉPOQ (Études des populations d'oiseaux du Québec) data base since 1956 were verified, but the effort related to these observations was not tallied. ÉPOQ contains over 2.78 million bird sightings (all species included) located in 3,791 different areas across Québec. These observations were made by birdwatchers during official birding trips and everyday activities when birds are observed.

2. In terms of remaining high-potential habitat (66%) based on data collected during the study of chimneys in religious buildings in 2000, 35% of the chimneys in religious buildings are unavailable to swifts (see section 8.1; Table 9). Since 80% of roost sites may be found in these types of chimneys (see Table 8), there are very few parishes left susceptible to hosting major roosts which could contribute significantly to the swift population.

3. Also, many parishes where visited by volunteers during the Québec Chimney Swift Survey Program, but when there were no swifts, these visits were most often not reported and therefore the effort was not tallied.

4. Chimney Swifts and the Survey Program have benefitted from impressive media coverage reaching not only birdwatchers, but also the public at large, making it unlikely that large undiscovered roosts have gone unnoticed. During the seven years of the program, information about the species and the survey program has been broadcast twice in a popular radio show that airs across the province (*Radio-Canada*). Information was also published twice (once as a full page story) in the Sunday bird chronicle of the widely read newspaper *La Presse*, which has a circulation of about 200,000. Finally, articles and advertisements (including front and back covers) were also published in the *Québec Oiseaux* magazine. This magazine has a circulation of about 15,000 and is also

distributed to ornithology clubs in the province (n=30), reaching 6,000 members. The Canadian Wildlife Service also gave presentations on the subject to these clubs across the province.

5. Over the past eight years, members of ornithology clubs and program volunteers have been asked to participate in the survey. They then received yearly result updates and reports. Birdwatchers know where swift roosts are located in their town and surrounding areas.

6. The roosting behaviour of swifts is quite spectacular and they rarely go unnoticed to birders and the general public. In 2005, following media coverage, a toll free number was available in order to facilitate information exchanges and reports from the public to the CWS on potential swift sites and other relevant information.

Taking into account all the following information: survey coverage and effort, the swift's high detectability during roosting, the fact that population estimates seem to level off even though effort and coverage increases (see below), the fact that the mean size of new roosts discovered decreases over time, the fact that nesting sites represent an increasing proportion of new discovered sites, and the fact that, in 2000, 35% of the chimneys of religious buildings (which constitute 80% of roosts) were unavailable, it would be very surprising to find new important roosts. In other words, a roost with 500 birds would not have gone unnoticed and, even if many small roosts (50 birds) had gone unnoticed, it would take a lot to significantly increase Chimney Swift numbers in Québec.

Figure 11 shows all the parishes, with or without the presence of Chimney Swifts, that were visited between 1998 and 2005. Besides 2001 and 2003 when effort was at its lowest, coverage and effort increased over time. Although coverage and effort increased, new sites were not found at the same rate and the tallied swift population seemed to level off (Figure 12). These results are supported by the fact that the mean size of new roosts discovered decreased over time (Figure 13). The results also show, as expected, that the largest and most important roosts were discovered first. This is also confirmed by the fact that among new swift sites discovered, more and more nesting sites were found compared to roosts (Figure 14). This difference also seems to be increasing over time. All these results suggest that a majority of the roosting sites and, therefore, a majority of the Chimney population in Québec, have been tallied. Although many nesting sites have not been discovered, these will not significantly increase estimates of the Chimney Swift population for the province.

All existing data from the Québec Chimney Swift Survey Program are presented in Table 11. A maximum of 4,700 swifts were counted in 2005. However, since all known sites were not visited that year (except closed sites), the count from the closest previous year was used to estimate numbers at unvisited sites. These were then added to give a maximum cumulated number (estimated + real) of 5,600 Chimney Swifts (or 2,800 pairs), adults and juveniles included, for all known sites in Québec for 2005. Preliminary analysis of the 2006 data indicates that the population has declined by almost 50% compared to 2005, potentially as a result of the Wilma hurricane (Dionne *et al.*, in prep.). The extensive monitoring of roosting sites provided data enabling us to estimate the proportion of juveniles in the population (Table 2, Appendix 3). Based on these figures, about 55.1% of the tallied population during the breeding season (or 3,080) are juveniles (hatch-year birds) and therefore, there are about 2,520 adults or 1,260 breeding pairs in the province of Québec.

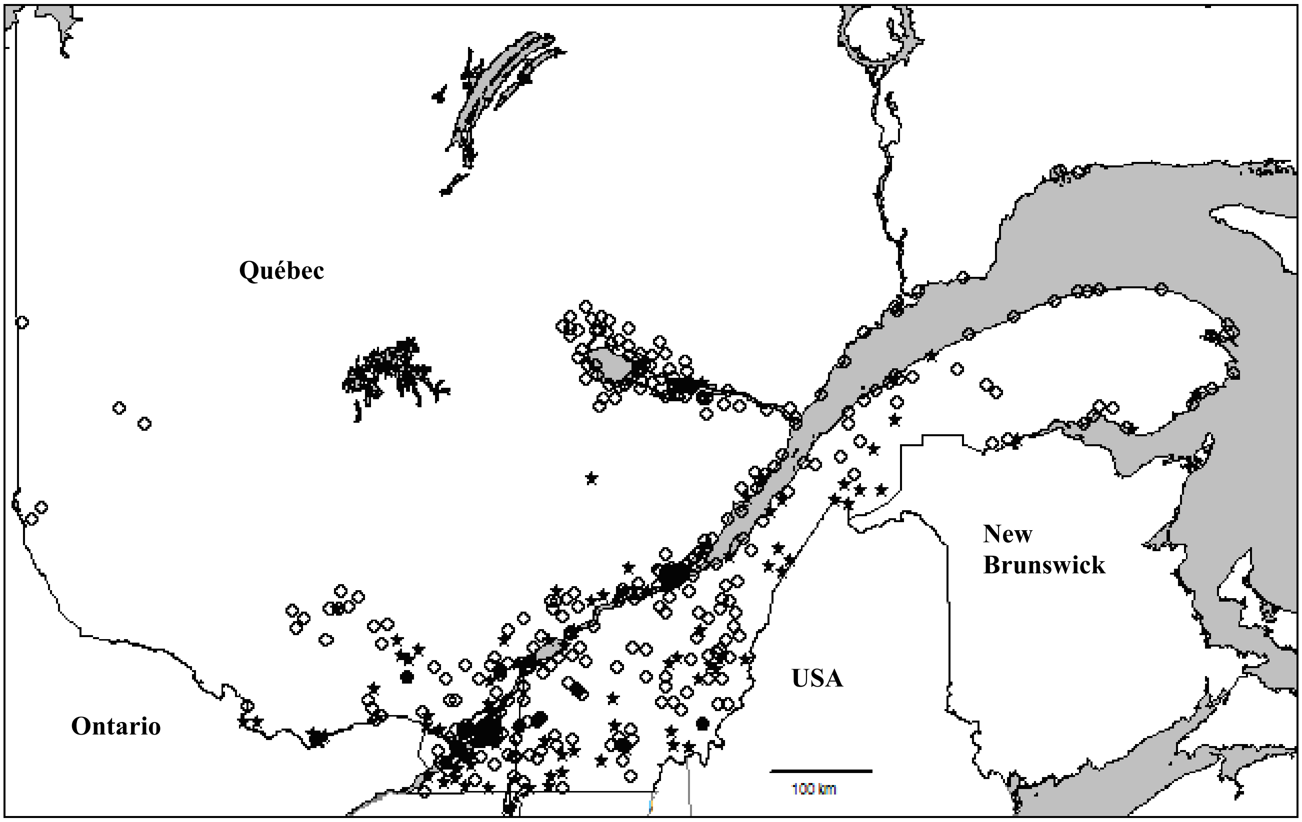

Figure 11. Distribution of parishes surveyed during the Québec Chimney Swift Survey Program between 1998 and 2005 and during the chimney survey of religious buildings in 2000. Empty circles represent parishes where no swifts were detected, while full stars indicate parishes with a known Chimney Swift site (nest or roost), active, abandoned or closed.

Table 11. Québec Chimney Swift Survey Program activity summary between 1998 and 2005. The table shows the number of sites visited per year, along with the number of nest sites and the corresponding bird counts. Sites are divided by type (roost, nest or undetermined). The number of birds represents the maximum number of birds counted at each site during a particular year. See Appendix 9 for details on the methodology. Cumulated sites include some that are either closed or abandoned

	Roost				Nest site				Undetermined*				Total			
	Visited		New		Visited		New		Visited		New		Visited		Cumulated	
Year	# Sites	# Birds	# Sites	# Birds	# Sites	# Birds	# Sites	# Birds	# Sites	# Birds	# Sites	# Birds	# Sites	# Birds	# Sites	# Birds
1998	15	1426	15	1426	12	38	12	38	1	6	1	6	28	1470	28	1470
1999	24	3475	17	1771	31	83	28	69	1	10	1	10	56	3568	71	3904
2000	16	3695	6	779	27	69	19	43	2	11	2	11	45	3775	92	4835
2001	11	2115	3	488	22	83	15	51	1	7	1	7	34	2205	106	4030
2002	22	3523	9	495	43	123	32	98	3	22	3	22	68	3668	134	4466
2003	19	3951	4	342	28	89	14	39	1	4	1	4	48	4044	146	5355
2004	29	2825	12	441	60	135	40	80	10	68	9	65	99	3028	194	4153
2005	46	4418	17	751	103	240	62	140	4	27	3	16	153	4685	258	5599

* Undetermined: Certain nesting sites have “helpers,” therefore, it becomes difficult to distinguish such sites from a small roost.

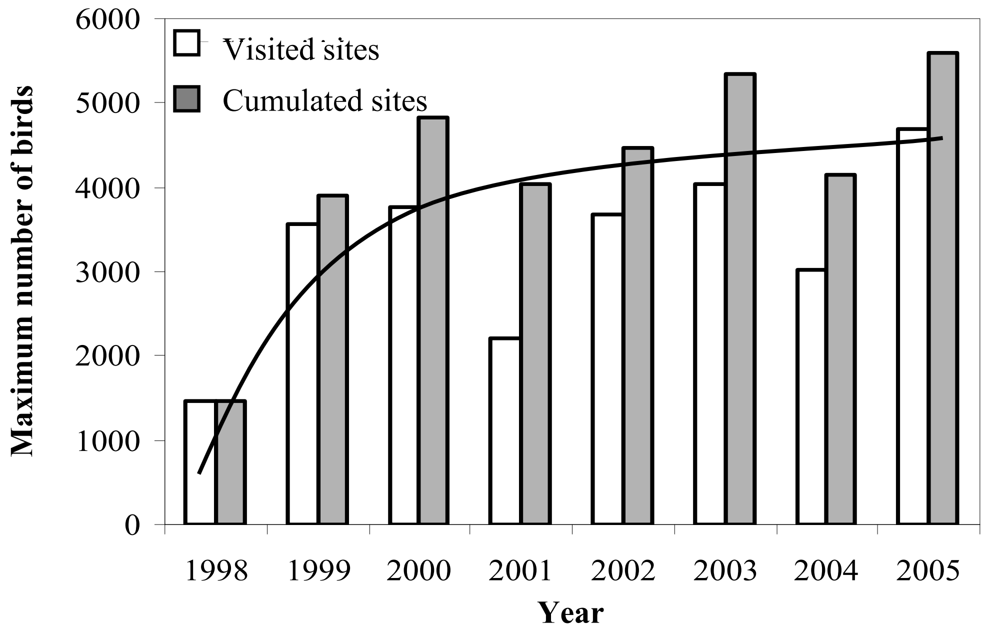

Figure 12. Results of the Québec Chimney Swift Survey Program (1998-2005). The number of birds represents the maximum count observed at each site. Visited sites are sites surveyed at least once during the year. Cumulated sites represent the total of visited sites and known sites that were not visited during the season. In order to estimate the number of birds at a known site which was not visited on a given year, the maximum annual count from the closest previous year was used as an estimate for the current year

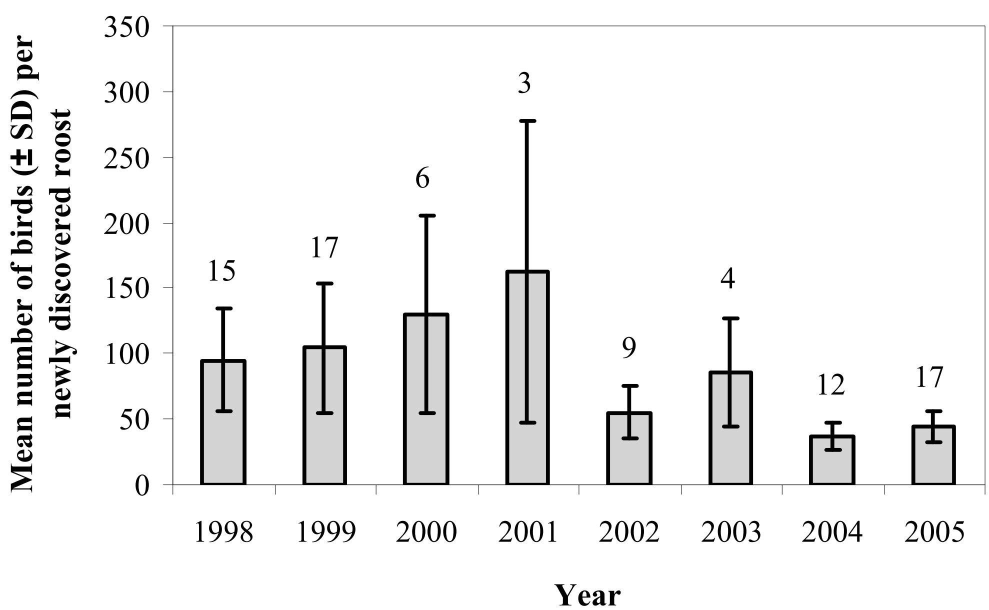

Figure 13. Mean annual number of Chimney Swifts (± SD) observed at newly discovered roosts during the Québec Chimney Swift Survey Program (1998-2005). The mean was calculated from maximum counts at each site. Numbers above the columns represent the amount of newly discovered roosts per year

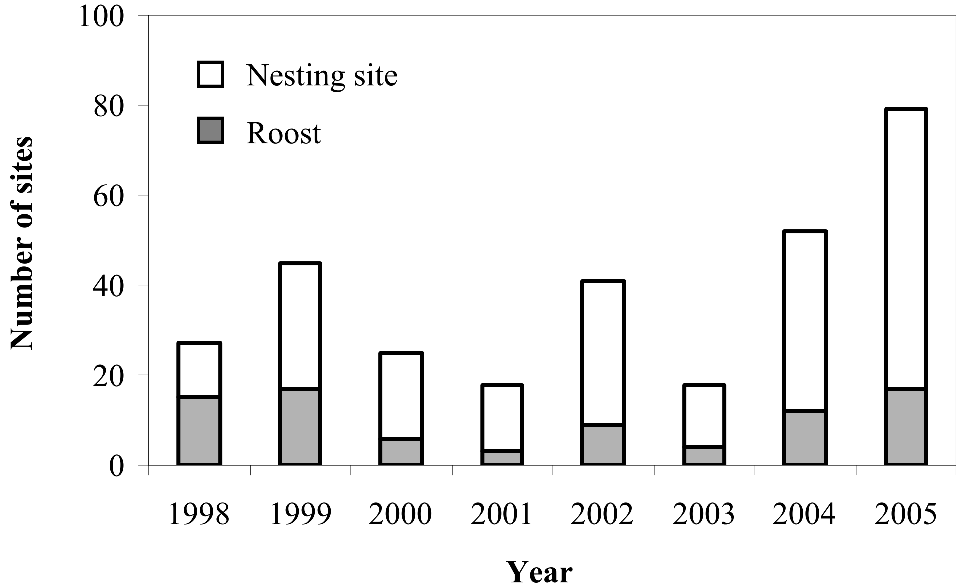

Figure 14. Number of newly discovered sites (roosts and nesting sites) each year during the Québec Chimney Swift Survey Program (1998-2005)

9.2 Ontario

Data from the first Ontario Breeding Bird Atlas (1981-1985; Helleiner 1987) were used to estimate the Chimney Swift population in the province at between 14,505 and 132,692 pairs, including some juveniles. Using an extrapolation method described in the Maritimes Breeding Bird Atlas (Erskine 1992), a total of 17,500 pairs was generated for Ontario in 1985 (M. D. Cadman, CWS, pers. comm.). No abundance estimates were done during the second Atlas (2001-2005; Cadman *et al*. in prep.), however, since the species presence in the survey squares decreased by 45% compared to the first Atlas (see section 7.2), we estimate the population to be 9,625 pairs (17,500*0.55). Considering that 55% of the population is composed of juveniles, as in Québec, there are about 4,331 breeding pairs. This figure is probably an overestimation as it yields a breeding pairs to building ratio about 2.9 times higher than in Québec (see Appendix 10). The estimate of the Chimney Swift population in Québec relies on an extensive survey and is considered reliable. Therefore, it would be very surprising to see such a difference between these two provinces when the situation of available chimneys (closing, modification and destruction of suitable chimneys) is more than likely the same, relatively speaking.

Another means of estimating the Chimney Swift population in Ontario is to apply the Ontario downward trend from the BBS (-9.0%; Table 7, 1968-2004 period) to the abundance estimate in the first Breeding Bird Atlas (17,500 pairs) for the period ranging between 1985 and 2004. This total yields about 3,155 pairs, including juveniles. Omitting juveniles (55%), we are left with about 1,420 breeding pairs. This result is proportionally similar to the Québec result. If the pair to building ratio in Ontario was exactly the same as in Québec, there would be about 1,494 breeding pairs in Ontario (see Appendix 10). The estimate of 1,494 breeding pairs is therefore retained for Ontario.

The first Ontario Breeding Bird Atlas (Helleiner 1987) describes bird abundance (17,500 birds) in terms of breeding pairs, however surveys mainly took place during June and July. Considering Chimney Swifts can start nesting at the end of May and rear their eggs in about 45 days, juveniles are present in the sky from mid July and therefore, a proportion of young is counted in the total number. Many surveys also continued until early August when all juveniles are able to fly, thus increasing the number juveniles counted. Therefore, all estimates should be corrected to obtain the number of breeding individuals. The proportion of juveniles from Québec (55%; Table 2) was used to correct totals from Ontario. This figure represents the maximum number of juveniles which can be found in total from Ontario.The same correction was applied to figures from the Maritimes Breeding Bird Atlas.

A similar survey program to the one in Québec was implemented in Ontario in 2004. It is known as *Swiftwatch*. At this point, only a few roosts in the city of London have been identified and they are being monitored during fall migration. More precise population estimates will eventually be available.

New data and analysis on population estimates by Peter Blanchard, not presented in this report, are available in the following document: COSEWIC. 2007. Unsolicited COSEWIC status report on the Chimney Swift *Chaetura pelagica* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. v + 48 pp.

9.3 New Brunswick and Nova Scotia

In the Maritimes, very little data on population abundance are available. The Maritime Breeding Bird Atlas estimated the Chimney Swift population at 20,000 ± 3,000 breeding pairs (NB: 12,000 ± 2,300; NS: 8,500 ± 1,900) for the 1986-1990 period (Erskine 1992). These results reflect an overestimation, which is due to the method employed; abundance of the different birds species was classified on a logarithmic scale (1; 2-10; 11-100; 101-1,000, etc.)

When the observed BBS downward trend (1968-2002) for each province (NB: -6.3%; NS: -7.8%) (Downes *et al*. 2003) is applied to the 1990-2004 period, a total of 7,552 pairs is obtained for 2004. As was the case in Ontario, these estimates include a certain proportion of juveniles. If we consider that, as in Québec, 55% of the population is composed of juveniles, we obtain a total of 3,398 breeding pairs in the Maritimes. These figures yield a breeding pair to building ratio 9.8 times greater than the one in Québec (see Appendix 10). Because the situation of available chimneys is probably very similar to the one in Québec, these figures are clearly an overestimation.

Figure from the Maritimes are therefore considered unreliable, and because no other information is available, we are forced to use the Québec breeding pair to building ratio to estimate population in the Maritimes (Appendix 10). Figures from Québec are considered reliable and the availability of traditional chimneys is more than likely similar. With this method, we get 345 breeding pairs, however this total is fairly low, so we increased it to 450 breeding pairs.

9.4 Other provinces

A maximum of 15 swifts were observed in Prince Edward Island during field work for the Maritimes Breeding Bird Atlas (Erskine 1992). No estimate exists for Newfoundland. The species is considered transient (Montevecchi and Tuck 1987), however, it is possible that swifts breed in the southwestern part of the province (Godfrey 1986; Sibley and Monroe 1990). In Saskatchewan, the situation is similar. Swifts are uncommon during summer and there are no quantitative data (Smith 1996). In Manitoba, the swift seems more common, however no estimate of the population is available. A group of about 200 swifts was seen in Winnipeg in 1980. A generous total of 450 breeding pairs is estimated for these populations located at the edge of the species' Canadian distribution range.

In summary, considering that a maximum of 55% of the tallied population consists of juveniles, a total estimate of about 3,700 breeding pairs is obtained for all of Canada (Québec: 1,260; Ontario: 1,494; NB and NS: 450; other provinces: 450). On the basis of other data (Dexter 1969), the proportion of juveniles in a population could be lower. Twenty five years of banding activities revealed that 46% of a resident population was composed of juveniles (207/448). Based on this figure, the number of Chimney Swifts in Canada could reach 4,400 breeding pairs. The population level could also be lower today (2006) as a result of Hurricane Wilma, which caused considerable mortality in 2005 (Dionne *et al*., in prep.).

These results contrast heavily with those presented in documents such as: "Wild Species 2000: The General Status of Species in Canada" published by the Canadian Endangered Species Conservation Council (CESCC) in 2001 and "The North American Landbird Conservation Plan" by Rich *et al*. (Partners in Flight) in 2004. Indeed, on the basis of CESCC (2000), the Chimney Swift is ranked number four in Canada and is therefore considered secure. According to Rich *et al*. (2004), there are about 15 million Chimney Swifts in North America. Considering that Canada represents 26% of the species' distribution range, and assuming that the species is evenly distributed, there should be around 3.9 million Chimney Swifts in Canada.

It is important to remind readers that the information and classification presented by the two previous documents comes originally from exercises which were designed in the 1980s. These exercises were originally developed by Bird Life International and their purpose was to compare birds amongst themselves in order to determine priority species, i.e., which species are in the most precarious state and need urgent action. These exercises were not designed to assign individual ranks or to estimate accurate population levels by species, but to compare species on a relative scale. Not all the specific information about a particular species was included in these exercises, making them useful for specialized species with restricted habitat and distribution compared to more generalist and widely distributed species like the Chimney Swift. These documents are updated at regular intervals in order to include new information. The main source of information used to produce population estimates is BBS data. However, the purpose of these data is to detect trends in bird populations from year to year (Bystrack 1981). In order to determine continental bird populations, densities have to be generated from the BBS stops on the surveys routes (point counts) and then these results extrapolated to the species breeding range. Density estimates generated from point counts can give poor results if factors that influence the count are not standardized or removed (Dawson 1981). Point counts can also be ineffective at estimating density for birds that exhibit similar flight behaviour as birds of prey (cover large territories). Because these results are extrapolated to a larger territory, the error can be multiplied. In general, it is also difficult to use BBS data, which are roadside point counts, to generate abundance estimates for a species all across its breeding range (Bart *et al*. 1995).

9.5 Situation before European settlement

Many authors have mentioned without any real evidence that Chimney Swifts increased dramatically with the arrival of European settlers because of the multitude of new nesting cavities provided by chimneys of the buildings being put off (Tyler 1940; Norse and Kibbe 1985; Dexter 1991; Kaufman 1996; Zucker 1996; Chantler and Driessens 2000; Cink and Collins 2002). Chimneys and other manmade structures were supposedly much more abundant and available than the hollow trees (snags and cavity trees) available before settlement, thus increasing the number of nesting and roosting sites. These new nesting sites were rapidly adopted by swifts and would have contributed to a significant increase in Chimney Swift numbers.

However, this hypothesis seems closer to a popular misconception than a potential explanation of the facts. First, the state of the Chimney Swift population in North America prior to European settlement is unknown, so speculations of a possible increase with colonization are difficult to verify. Second, a study by Graber and Graber (1963) has often been cited to support the hypothesis that the Chimney Swift benefitted from colonization. Graber and Graber (1963) noted an increase in Chimney Swift density in Illinois between 1906-09 and 1956-59 and attributed these results to an increasing population and development. However, these results do not reflect the situation before and during colonization; they represent an urbanization process which was already well on its way: 10 of the 14 million acres of forest had been cut down during the 19th century and by 1900, 33 of the 36 million acres that constitute Illinois had already been modified (Graber and Graber 1963). Also, Todd (1940) concludes that the Chimney Swift population prior to settlement was at least as abundant as after settlement.

Because Chimneys Swift numbers prior to settlement are unknown, other ways are needed to estimate population change before and after settlement. The number of potential nesting sites could give some indication of the population level before and after the arrival of European settlers. Newton (1994) concludes that the availability of cavity trees was the main limiting factor for cavity nesting bird populations on their breeding grounds. In other words, if the Chimney Swift population dramatically increased following the arrival of Europeans and their chimneys, then these new nesting sites would have had to be more abundant then natural nesting sites prior to settlement (hollow trees). Therefore, potential Chimney Swift nesting sites were estimated before and after arrival of Europeans. To do this, we compared the potential number of suitable hollow trees prior to settlement with the potential number of suitable chimneys in 1900 in the Chimney Swift area of distribution. Forested areas were generally dominated by primary and old-growth forest before settlement, since the impact of Aboriginal people was believed to be minimal.

During the 18th and 19th centuries, settlers in North America relied heavily on wood for construction, heating and exports. If we add to this the amount of cleared forests for agriculture purposes, few accessible forest areas including old-growth forests have escaped human activity (Leverett 1996; Drushka 2000). Moreover, by 1900 many of the states in the Chimney Swift range of distribution had been logged extensively to make space for agricultural fields and urban development, and to meet the needs of a growing logging industry (Dyer 2001; Mosseler *et al*. 2003). Chimneys were probably already the main nesting sites for Chimney Swifts at that time. At the end of the 19th century, forest covered only 20 to 30% of the landscape of Massachusetts, Connecticut and Rhodes Island (Leverett 1996). By 1850, 50% of southern New England and Pensylvannia's forest cover had disappeared (Dunwiddie *et al*. 1996). Between 1880 and 1920, the majority of forests south of the Appalachians had also disappeared (Frothingham 1931). In 1878, forest cover in Ohio represented only 20% of its original level (Leue 1886; Gordon 1969).

In order to estimate the density of chimneys after the great deforestation period (19th century), we took the total population in a given area, divided it by the number of people in a typical family, and then divided the result by the total surface area in question. In this way, chimney density was calculated for 17 states (CI, DE, GA, KY, ME, MD, MS, NH, NJ, NY, NC, PA, RI, SC, TE, VT, VA) in 1900. At that time, electricity was not yet used for heating and every household possessed at least one chimney. These states were chosen because they are part of the Chimney Swift's central breeding distribution, but also because information is available on historical forest cover and current old-growth snag density. The total population of those states (33,891,905; U.S. Census Bureau 2004) is divided by four (conservative figure used to estimate the number of households); this result is divided by the total area size (111,869,870 ha; U.S. Census Bureau 2004) and the total is multiplied by two (assuming that every residential building had two chimneys), yielding an estimate of 0.152 chimneys/ha. Assuming that every house possessed two large chimneys is also very conservative, as it is generally recognized that only rich families had large houses with two chimneys, one of which was available to swifts in early summer while the other was used for cooking all year long.

To obtain an estimate of the density of potentially suitable hollow trees in primary and old-growth forest before settlements, we must refer to the modern literature on old-growth remnants in eastern North America. McGee *et al*. (1999) found an average of 18 snags (at least 50 cm DBH) per hectare in old-growth deciduous forests in New York State. Goodburn and Lorimer (1998) found similar results for old-growth deciduous forests in Wisconsin and Michigan (20 snags/ha > 45cm DBH).

A comparison of chimney density (0.152/ha) with the density of large hollow trees found in old-growth relics from similar regions (18-20 snags/ha) shows a large discrepancy. With such figures, old-growth deciduous forests would have needed to cover 470,720 ha, or less than 1% of the total area in question, for the number of large hollow trees to be equivalent to the number of chimneys in 1900. This difference suggests that the European settlements dramatically decreased the potential number of nesting sites, rather than dramatically increased the Chimney Swift population. Even though old-growth forests did not cover 100% of the land prior to colonization, and snag densities varied with geographical location and stand composition, the magnitude of the observed difference between chimneys and large hollow trees is too large for Chimney Swifts to have profited from settlement. Even though not every suitable hollow tree was occupied by Chimney Swifts, for different reasons (e.g., competition), the same reasoning also applies to chimneys. As an example, many houses, if not the majority, had only one chimney, which was often not available for the birds as it was used all summer long for cooking. Also, when Chimney Swifts arrived from the south, many chimneys were probably still being used for heating. Also, the specialists we consulted mentioned that many chimneys during that time were smaller in diameter than the bird's wingspan (30 cm), which made them less suitable for the birds. There may have been competition for these sites with other species. It may be possible to obtain a better estimate of potentially suitable chimneys at that time by consulting archives, historical architects and Statistics Canada regarding the number of households, professions, earnings, heating methods used and their conversion rate in time.

In Canada (Maritimes, Ontario and Québec), all available data suggest that the situation was quite similar. The number of households, and therefore, chimneys, was less than in the United States, but logging activities and land clearing to serve the colony and its English empire was of the same order (Historical Atlas of Canada 1990). In the Maritimes, few forests escaped human influence after the arrival of the Europeans (Loo and Ives 2003). In southern Ontario, almost all old-growth stands were eliminated for agriculture and logging purposes (Suffling *et al*. 2003). The situation was practically the same in Québec, where logging activities during this great deforestation period went well beyond the inhabited areas of the St. Lawrence River (Desponts 1995).

All known data indicate that settlement considerably reduced that number of potential nesting sites for the species. In brief, chimneys were not constructed at the same rate as large hollow trees were cleared. The speed at which Chimney Swifts made the transition from hollow trees to chimneys could also be an indication of the population level prior to intense deforestation. The more birds there were, the faster they would have found new habitats. This assumption is supported by V. Baily, who stated in 1887 that the species was abundant in forested areas of Pembina (North Dakota) where no chimneys were present, and nested in hollow trees (Fargo 1975). At the beginning of the 19th century, Audubon (1840) had already observed the widespread use of chimneys for nesting. However, it is also possible that Chimney Swifts switched to chimney as a result of more favourable conditions compared to hollow trees (e.g., predation, competition, temperature). McCafferty *et al*. (2001) found that Barn Owls reduced their metabolic energy production by 21% when using a barn as a roost, compared to 10% when using a hollow tree. Further experiments are required to investigate all possible hypotheses.

10. Extinction risk

Intensive banding programs during the first half of the 20th century allowed researchers to acquire extensive demographic data on the Chimney Swift. These data enabled us to construct a stage base matrix models with probabilistic outputs. This type of modeling is frequently used in population viability analyses (PVA) to evaluate the threats faced by populations of species and their risks of extinction under different management scenarios (Akçakaya 2002).

Most of the data used in this PVA was collected prior to 1950, and therefore may not representative of the current situation. However, thanks to the *Driftwood Wildlife Association* and their Chimney Swift Research Program, it was possible to obtain recent mark recapture data from Texas between 1989 and 2002 (Kyle and Kyle, unpublished data). These data not only made it possible for us to estimate an annual juvenile (HY) survival rate for the first time, but also to estimate a new adult (AHY) annual survival rate, the first since the 1946-56 period (Henny 1972). Survival rates where calculated with the *Program Mark* (version 4.1) software, following the method presented by Cooch and White (2001) (see Appendix 1 for more details). Survival rates and recapture probabilities were either constant or varied in time for HY and AHY age groups. A total of 31 models were built with different combinations of these parameters. Modeling assumptions include: open population, no cohort effect, the same adult annual survival rate for birds of different ages over one time period, and the age at which a bird was banded does not affect its recapture probability. Based on the analysis, the juvenile annual survival rate (0.788±0.219) does not differ significantly from the adult annual survival rate (0.727±0.072). Results, however, suggest that adult annual mortality is less variable. Also, based on confidence intervals (95%), the adult annual survival rate is similar to those calculated by Henny (1972) for three former periods: 1920-35 (0.630±0.013), 1936-45 (0.627±0.009) and 1946-56 (0.630±0.011). Lack of modern data did create some model likelihood problems, but proper adjustments were made and the method used remains the most sensible and robust method for estimating survival rates (Akçakaya 2000).

Ramas Metapop (version 4.0) software was used to create the different PVA models (see Appendix 11 for more details on the methodology), following the method established by Akçakaya (2000). The adult annual survival rate retained for all models was the one calculated by Henny (1972) for the 1920-35 period (0.630±0.013). This value covers the largest time period and was estimated with data from all over the bird's breeding range in Canada and the USA. The juvenile annual survival rate used is the only known rate and was previously calculated with *Program Mark* (version 4.1) software (0.788±0.219). Fecundity estimates for first year birds (1Y) and adults at least 2 years of age (2+Y) varied in relation to the mean number of young fledged per year (maximum and minimum values based on the literature) and to the proportion of swifts successfully reproducing in both age groups (1Y and 2+Y). Appendix 2 presents all available demographic data.

By changing the proportion of swifts that successfully breed in both age groups, it was possible to analyze the effect of a limited amount of nesting sites on the extinction risk for this species. Figure 15 shows the extinction probabilities for Chimney Swifts over the next 100 years in relation to the proportion of breeding birds that are at least 2 years old (2+Y). This relationship was calculated for three different proportions of 1Y birds successfully reproducing: 0%, 25% and 50%. Models were run with the maximum and minimum mean number of young fledged per year from the literature. The proportion of 1Y birds successfully reproducing did not exceed 50% because, although Chimney Swifts are capable of reproducing at one year of age, they generally do not breed before the age of 2 years (Fisher 1958, Dexter 1981a). The model parameters, structure, assumptions and fecundity estimates are shown in Appendix 11. About 40 simulations were carried out using the different parameter combinations.

When considering a situation where only 50% of 1Y breed, the minimum proportion of breeding 2+Y birds needed to avoid an extinction risk of 10% or higher in the next 100 years varies between 15 and 35 %. If only 25% of 1Y birds reproduce, then this threshold increases from 25 to 45%. Finally, if only swifts of at least two years of age reproduce, a minimum of 40 to 60% of them need to breed in order to maintain viable levels of population. These results not only show how a decrease in the availability of nesting sites (or successful reproduction) may influence the viability of the Chimney Swift population, but also the possible effects of habitat enhancement measures on this species (e.g., building artificial chimneys).

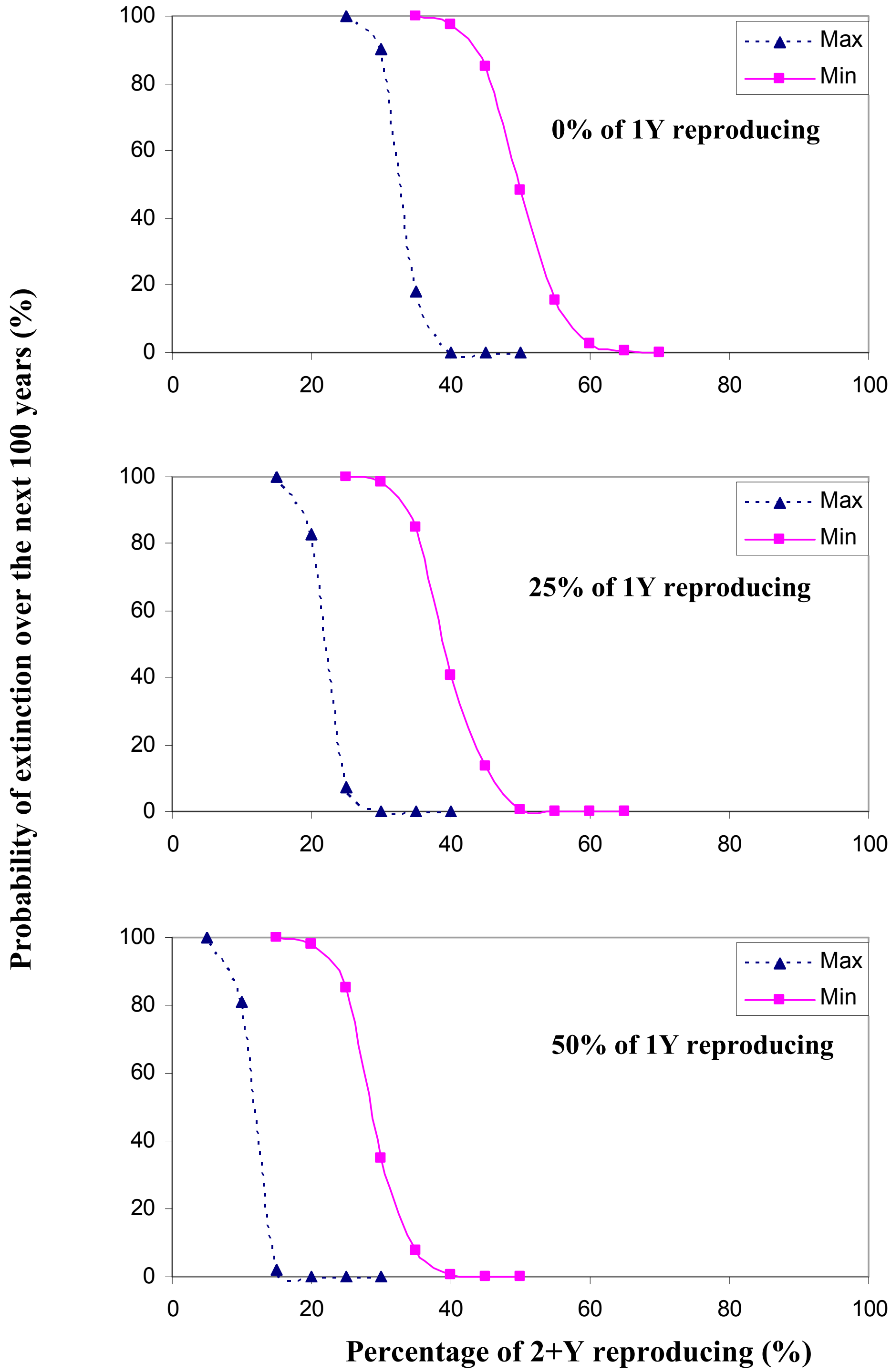

Figure 15. Chimney Swift extinction probability over the next 100 years in relation to the number of adult birds at least two year of age (2+Y) which successfully reproduce. The different probabilities were calculated in relation to the proportion of one year-old birds (1Y) that successfully reproduce (0%, 25% and 50%) and to the numbers of fledged young per year (min and max). Results were generated using *Ramas Metapop Version 4.0*. Details of these analyses are available in Appendix 11

In Québec, the number of nesting sites already seems to be insufficient to allow every couple to nest. Thanks to the Québec Chimney Swift Survey Program, it was possible to estimate the number of adult birds that do not successfully reproduce every year. Data from 26 summer roosts revealed that an average of 35% of AHY adults did not reproduce (Table 2). If we consider the minimum number of young fledged per year along with 0% of 1Y reproducing, the extinction risk in the next 100 years is over 0%. The number of nesting sites seems insufficient to the point where there are probably very few one year-old birds that breed. Indeed, one year-old birds are probably less competitive than older birds at finding a mate and defending a nest site. The models used are conservative because the initial population size used in the models is higher than the one estimated in section 9. The proportion of one year-old birds is also potentially higher than the 10% used here. An adjustment of these parameters would increase the probability of extinction for the different models.

If we consider the rate at which critical nesting habitat (traditional chimneys) are disappearing, the probability of extinction will increase considerably in the coming years. By the year 2020, there will practically be no more suitable chimneys available.

11. Proposed conservation measures

Inform concerned groups

As the species' main nesting sites will soon almost completely disappear in Canada, it is essential to conserve all known sites. In order to keep these traditional chimneys available for Chimney Swifts, everyone concerned, including home and building owners, insurance companies, fire department services, chimney sweeps, bricklayers, architects, engineers and heating specialists, must be informed of the situation and the importance of keeping these chimney available to swifts. Immediate collaboration is needed to stop the closure of existing sites and avoid chimney sweeping or repairs during the birds' breeding season. Owners must also be informed that Chimney Swifts do not pose a fire hazard like other species, as their nests are too small. This proactive approach, as opposed to a legislative one, would involve no costs.

Inform birdwatchers

Every ornithology club in the various regions must be informed of the situation. Many birdwatchers are homeowners and such information could lead them to develop personal projects (e.g., artificial chimneys, maintain a traditional chimney available). Also, birders are members of a community and often have the credibility to inform and convince other homeowners in their neighbourhoods to maintain chimneys and avoid disruption during breeding.

Traditional chimney stewardship program

This measure is the next logical step after informing homeowners. A stewardship program could be set up to help owners maintain their traditional chimneys and, at the same time, secure nesting sites and roosting sites.

Restore original habitat

Because many, if not most, Chimney Swift nesting sites will eventually disappear in built-up areas, conservation of this species requires the restoration and conservation of the birds' original nesting habitat in forested areas, which consists of large hollow trees (>50cm DBH). In order to maintain and increase the number of nesting sites in forested areas, legislation must be adopted on forestry practices. These measures include the conservation of a certain number of hollow trees per hectare in logging areas, the abolition of selective cuts in riparian habitats, and the favouring of certain tree species over others because of rapid growth (e.g., aspen, poplar, birch, etc.).

Create artificial habitat

The main factor that threatens the Chimney Swift population is the loss of nesting and roosting habitat as a result of the modification, closure and destruction of traditional type chimneys. Therefore, it is important to develop measures to maintain the species numbers, such as the creation of artificial nesting sites (e.g., artificial chimneys). These structures are not meant to replace existing suitable chimneys, but rather to provide additional nesting sites. Since 1999, the Canadian Wildlife Service has been designing and testing artificial chimneys. The *Driftwood Wildlife Association* has also designed and tested artificial nesting sites and books have been published on the subject, with information on the species and on how to build artificial structures, and advice on how to attract and maintain birds at a site (Kyle and Kyle 2004). However, certain modifications are necessary for this book to be useful in more northern latitudes (e.g., provide a heat source). More research and collaboration between CWS and Ornithology association members are necessary in order to adapt the available practices to specific regions.

Develop Chimney Swift interpretation centres with some important roosting sites

There are a few examples of Chimney Swift roosting sites converted into interpretation centres. Not only can visitors admire the bird's spectacular behaviour as it enters the roost at dusk, but they also learn about the species. The Blomidon Naturalists Society created such a centre in Wolfville, Nova Scotia, which is used as a roost by as many as 800 birds. In Fredericton, New Brunswick, a chimney at the University campus used by swifts as a roost benefits from protection by the institution (*Friends of the Chimney Swift* 1995). This well-known site is frequented by many visitors. In Québec, two roost sites are protected by private owners, one in Mont-Laurier and the other in Saint-Georges-de-Beauce. In Texas, the *Driftwood Wildlife Association* protects two chimneys in a building which are used for nesting. It has also installed a video camera which transmits images on the Internet all through the breeding season. The association also gives information to the public on Chimney Swift rehabilitation and publishes a journal, the *Chimney Swift Nest Site Research Project*.

Legal protection

In the United States and Canada, the Chimney Swift is only protected by the Migratory Birds Convention Act, 1994, which prohibits the hunting, possession and/or sale of migratory birds and their disturbance during the breeding period. The Chimney Swift is not considered threatened or endangered as it does not appear on the World Conservation Union's list (IUCN 1996), the

Canadian endangered species list (COSEWIC 2006), the US Endangered Species Act list (U.S. Fish and Wildlife Service 2006) or any provincial lists. The Chimney Swift is considered a Moderate Priority Species on the Partners in Flight Watchlist, and as one of 90 species ranked in the highest tiers of conservation concern (Carter *et al*. 1996). However, this classification is not based on any real scientific evidence and is nothing more than a subjective opinion by ornithologists. The objective of this opinion was to achieve a quick, relative and global evaluation of the different bird species (discussed in section 9).

The Chimney Swift does not receive any known form of protection in its winter range. Stotz *et al*. (1996) believe that the conservation priority for this species is low in the Neotropics. However, these authors acknowledge the fact that their wintering range and habitat preferences are poorly known, which is why the Chimney Swift is also classified at a medium level of research priority.

In addition to any conservation measures applied, the Chimney Swift requires a legal designation of its status by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). A legal designation would create a credible basis for informing communities and homeowners of the situation, along with securing minimal funding to pursue and expand researches. Based on IUCN and COSEWIC criteria (2001), the species should be at least designated as threatened. The main reasons for this classification are that the Canadian population is under 10,000 adult individuals (5,000 breeding pairs), the population is declining by 8.2% annually (1968-2004), and the species area of occupancy has declined by 33% in Québec (between 1989 and 2004) and by 45% in Ontario (between 1985 and 2005). The principal cause of these declines (loss of nesting sites) seems to be known and reversible.

12. Conclusion

In the past, the Chimney Swift was considered a common and abundant species in eastern North America. In 1943, Lowery stated that this species was one of the most well-known birds on the continent. Today, even though the Chimney Swift is present in most areas where it was once abundant, the population has declined dramatically since the 1950s. DeGraaf and Rappole (1995) state that although the species is still fairly common, it is declining all across its breeding range. As it is often the case, birdwatchers were the first to sound the alarm. Now, looking back at the situation with existing information and data, scientists and wildlife managers are starting to recognize the gravity of the situation. All existing information, including field observations from birders, BBS, Breeding Bird Atlases, diverse authors and conservation organisms (e.g., *Driftwood Wildlife Association*), is converging toward a common conclusion: the Chimney Swift population is decreasing at an alarming rate. Based on our analysis, the probability of extinction in Canada over the next 100 years could be above 0%.

The reasons for the strong Chimney Swift decline are numerous and not always well defined. For example, threats occurring during migration and on the wintering grounds are practically unknown, even though habitats are changing considerably in these areas. However, the factors affecting this species on their breeding grounds are better understood and it seems that the scarcity and loss of suitable nesting sites is the main factor explaining the decline in the Chimney Swift population. Human-related factors seem to have had two main impacts on the Chimney Swift population since colonial times. First, the great forest clearing period which occurred after

European settlement dramatically reduced the number of suitable nesting sites in forested areas by cutting down large hollow trees (snags and cavity trees). During that time, swifts made a transition towards built-up areas in new, but less abundant nesting sites that offered similar conditions: traditional type chimneys. The species is now rarely observed in forested areas and is mainly found in built-up areas, presumably because there are more suitable nesting sites. However, in the last 30 years or so, humans have also reduced the number of suitable nesting sites in built-up areas by modifying, closing and destroying chimneys used by the species. The development of new heating technologies, construction materials and standards and fire prevention measures and bylaws have caused a dramatic decrease in the number of suitable chimneys. The disappearance of traditional masonry chimneys reduces the breeding potential of the species, which in turn affects its population size. In some regions, the number of suitable nesting sites is probably insufficient for maintaining viable population levels. In about 20 years at most, most traditional chimneys will have reached the limit of their life expectancy and will no longer be available for Chimney Swifts. However, most traditional chimneys will have disappeared in the next five to 10 years. Climate change could increase temperature extremes and hurricanes during the fall migration, which constitute a major threat for this bird and the chimneys they use (e.g., Hurricane Wilma in 2005).

Because most of the Chimney Swift nesting habitat in built-up areas will eventually disappear, it is necessary to restore the species habitat in forested areas. Drastic changes must be made in forestry practices in order to increase the number of suitable cavity trees for the Chimney Swift, which other cavity-dependent species would benefit from too. In built-up areas, it is imperative to maintain already known sites and potential sites by stopping the closure of chimney access. The construction of artificial nesting structures could also contribute to species conservation in built-up areas. In addition to any conservation measures, conservation of the Chimney Swift requires legal recognition of its status in order to secure funding for research and conservation measures and to raise awareness among all concerned parties in order to bring about the collaboration of as many people as possible to save this species. In a large country with a low population density like Canada, Conservation and monitoring of threatened species is dependent on the precious help of informed, organized and motivated groups of volunteers.

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14. References

ADAMUS, P. R. 1987. Atlas of Breeding Birds in Maine, 1978-1983. Maine Department of Inland Fisheries and Wildlife, The Maine Audubon Society. 366 p.

AHRENS, C. D. 1999. Meteorology Today: An Introduction to Weather, Climate, and the Environment. Sixth edition. Brooks/Cole, Pacific Grove, USA. 528 p.

AKÇAKAYA, H. R. 2000. Population viability analyses with demographically and spatially structured models. *Ecological Bulletin* 48: 23-38.

AKÇAKAYA, H. R. 2002. RAMAS Metapop: Viability analysis for stage-structured metapopulations (Version 4.0). Applied Biomathematics, Setauket, New York. 159 p.

ALCORN, J. R. 1988. The Birds of Nevada. Fairview West Publishing, Fallon. 418 p.

ALSTROM, P. and P. COLSTON. 1991. A Field Guide to the Rare Birds of Britain and Europe. Harper Collins, London.

AMADON, D. 1936. Chimney Swifts nesting in a barn. *The Auk* 53: 216-217.

AMOS, E. J. R. 1991. A Guide to the Birds of Bermuda. Warwick. 206 p.

ANONYMOUS. 1989. Virginia's Breeding Birds: An Atlas Workbook. Virginia Society of Ornithology. 227 p.

ANONYMOUS. 1998. Hurricane Bonnie on Sable Island, Nova Scotia. *Birder's Journal* 7 (5): 254.

AMERICAN ORNITHOLOGISTS' UNION (AOU). 1998. Check list of North American Birds. Seventh edition. American Ornithologists' Union, Washington, DC. 829 pp.

AMERICAN ORNITHOLOGISTS' UNION (AOU). 2002. Forty-third Supplement to the American Ornithologist's Union Check list of North American birds. *The Auk* 119 (3): 897-906.

ARVIN, J. C. 1982. South Texas Region: Goatsuckers through woodpeckers. *American Birds* 36 (5): 872.

ATLAS OF BIRDS, MAMMALS, REPTILES AND AMPHIBIANS IN WYOMING. 1997. Wyoming Game and Fish Dept., Nongame Program, Lender. 192 p.

AUBRY, Y., M. GOSSELIN and R. YANK. 1990. The Spring Season: Québec Region. *American Birds* 44 (3): 392-394.

AUDUBON, J. J. 1840. Birds of America, Vol. 1. New York and Philadelphia, published by the author. 256 p.

AVIAN EFFECTS DIALOGUE GROUP. 1994. Assessing pesticide impacts on birds, final report of the avian effects dialogue group, 1988-1993. Resolve, Center for Environmental Dispute Resolution, Arlington, 156 p.

BAICHICH, P. J. and C. J. O. HARISSON. 1997. A Guide to the Nests, Eggs and Nestlings of North American Birds. Academic Press, San Diego.

BAILEY, A. M. and R. J. NIEDRACH. 1965. Birds of Colorado. Vol 2. Denver Museum of Natural History.

BANFIELD, A. W. F. 1977. Les mammifères du Canada. Second edition. Laval University Press and Toronto University Press, Sainte-Foy. 406 p.

BART, J., M. HOFSCHEN and B. G. PETERJOHN. 1995. Reliability of the Breeding Bird Survey: Effects of restricting surveys to roads. Short communication and Commentaries, *The Auk* 112 (3): 758-761.

BAUMGARTNER, F. M. and A. M. BAUMGARTNER. 1992. Oklahoma bird life. University of Oklahoma Press, Norman and London. 443 p.

BEAUDIN, L. and M. QUINTIN. 1983. Mammifères terrestres du Québec, de l'Ontario et des Maritimes. Michel Quintin Edition, Waterloo. 301 p.

BEISSINGER, S. R. and D. R. OSBORNE. 1982. Effects of urbanization on avian community organization. *Condor* 84: 75-83.

BÉLANGER, M.-A. 1985. Fiche de nidification 19389. Fichier de nidification des oiseaux du Québec, Musée national des sciences naturelles, Musées nationaux du Canada.

BLOCH, H., M. K. POULSEN, C. RAHBEK and J. F. RASMUSSEN. 1991. A survey of the mountain forest avifauna of the Loja province, southern Ecuador. International Council for Bird Preservation Study Report No. 49, Zoological Museum, University of Copenhagen, 168 p.

BLODGETT, K. and R. M. ZAMMUTO. 1979. Chimney Swift nest found in hollow tree. *Wilson Bulletin* 91 (1): 154.

BLOMIDON NATURALISTS SOCIETY. 1998. http://www.dal.ca/~stanet/database/blomidon.html.

BLUS, L. J. 1995. Organochlorine Pesticides. *In*: Handbook of Ecotoxicology, D. Hoffmann, B. A. Rattner, G. A. Burton Jr. and J. Cairns Jr. (editors), CRC Press, Boca Raton, Florida.

BOHLEN, H. D. 1989. The Birds of Illinois. Indiana University Press, Bloomington and Indianapolis. 221 p.

BONAR, R. L. 2000. Availability of Pileated Woodpecker cavities and use by other species. *Journal of Wildlife Management* 64 (1): 52-59.

BOWMAN, R. I. 1952. Chimney Swift banding at Kingston, Ontario from 1928 to 1947. *The Canadian Field-Naturalist* 66: 151-164.

BRACKBILL, H. 1950. The man who turned in the first chimney swift bands from Peru. *The Migrant* 21: 17-21.

BRADLEY, P. 1985. Birds of the Cayman Islands. P. E. Bradley, Georgetown. 245 p.

BROWN, C. R. and M. B. BROWN. 1995. Cliff Swallow (*Hirundo pyrrhonota*). *In*: The Birds of North America, No. 149, A. Poole and F. Gill (editors). The Academy of Natural Science, Philadelphia; The American Ornithologists' Union, Washington, D. C.

BROWNE, P. 1967. Status of birds, Lake St. John Region, Québec. *The Canadian Field-Naturalist* 81 (1): 50-62.

BUDEN, D. W. 1987. The Birds of the Southern Bahamas. B. O. U. Checklist No. 8, British Ornithologists' Union, London, 119 p.

BUDEN, D. W. and A. SPRUNT. 1993. Additional observations on the birds of Exumas, Bahama Islands. *Wilson Bulletin* 105: 514-518.

BULL, E. L. 1991. Summer roosts and roosting behavior of Vaux's Swifts in old-growth forests. *Northwestern Naturalist* 72 (2): 78-82.

BULL, E. L. and R. C. BECKWITH. 1993. Diet and Foraging Behavior of Vaux's Swifts in Northeastern Oregon. *Condor* 95 (4): 1016-1023.

BULL, E. L. and C. T. COLLINS. 1993. Vaux's Swift (*Chaetura vauxi*). *In*: The Birds of North America, No. 77, A. Poole and F. Gill (editors). The Academy of Natural Science, Philadelphia; The American Ornithologists' Union, Washington, D. C.

BULL E. L. and J. E. Hohmann. 1993. The association between Vaux's Swifts and old-growth forests in northeastern Oregon. *Western Birds* 24: 38-42.

BULL, J. 1985. Birds of New York State. Comstock Publishing Associates, a division of Cornell University Press, Ithaca and London.

BYRNE, R. W. and J. A. GRAVES. 1992. Chimney Swift in St. Andrews: a first for Scotland ? *Scottish Birds* 16: 219-222.

BYSTRACK, D. 1981. The North American Breeding Bird Survey. *In*: Estimating Numbers of Terrestrial Birds, Studies in Avian Biology 6: 34-41. C. J. Ralph and J. M. Scott (editors). The Cooper Ornithological Society, Lawrence, Kansas. 630 p.

CADMAN, M. D., P. F. J. EAGLES and F. M. HELLEINER (editors). 1987. Atlas of the Breeding Birds of Ontario. Federation of Ontario Naturalists, Long Point Bird Observatory, University of Waterloo Press. 617 p.

CAMERON, A. W. 1949. Chimney Swift's nest in a woodpecker cavity. *The Canadian Field-Naturalist* 63: 114.

CAMPBELL, E. K. and D. CAMPBELL. 1944. Swifts roost upon bark of large tree. *The Migrant* 15 (3): 52-53.

CAMPBELL, R. W., N. K. DAWE, I. McTAGGART-COWAN, J. M. COOPER, G. W. KAISER and M. C. E. McNALL. 1990. The Birds of British Columbia, Vol. 2, Nonpasserines, Diurnal Birds of Prey through Woodpeckers. Royal British Columbia Museum, Canadian Wildlife Service, Victoria. 636 p.

CARTER, M., G. FENWICK, C. HUNTER, D. PAHLEY, D. PETIT, *et al*. 1996. Watchlist 1996: For the future. *Audubon Field Notes*. 50: 239-240.

CENTERS FOR DISEASE CONTROL AND PREVENTION, Division of Vector-Born Infectious Diseases 2003. http://www.cdc.gov/ncidod/dvbid/westnile/birdspecies.htm

CHAMBERLAIN, M. 1891. Chimney Swift. *In:* Popular Handbook of the Ornithology of the United States and Canada, Vol. 1, *The Land Birds*. Little, Brown, and Company, Boston.

CHANTLER, P. 1999. Family Apodidae (swifts). *In:* Handbook of the Birds of the World, Vol. 5, Barn-Owls to Hummingbirds, pp. 388-417. Del Hoyo, J., Elliott, A. and Sargatal, J. (editors). Lynx Edition, Barcelona. 760 p.

CHANTLER, P. and G. DRIESSENS. 2000. Swifts: A Guide to the Swifts and Treeswifts of the World. Second edition. Yale University Press, New Haven and London. 272 p.

CINK, C. L. 1990. Snake predation on Chimney Swift nestlings. *Journal of Field Ornithology* 61 (3): 288-289.

CINK, C. and C. T. COLLINS. 2002. Chimney Swift (*Chaetura pelagica*). *In*: The Birds of North America, No. 646, A. Poole and F. Gill (editors). The Academy of Natural Science, Philadelphia; The American Ornithologists' Union, Washington, D. C.

CLEVELAND, N. J., S. EDIE, G. D. GRIEEF, G. E. HOLLAND, R. F. KOES, J. W. MAYNARD, W. P. NEILY, P. TAYLOR and R. TKACHUK. 1988. Birder's Guide to Southeastern Manitoba. Manitoba Naturalists Society, Winnipeg. 91 p.

CLINE, S. P., A. B. BERG and A. M. WIGHT. 1980. Snag characteristics and dynamics in Douglas–fir forests, western Oregon. *Journal of Wildlife Management* 44: 773-786.

CLISBY, A. S. 1931. The Birds of Louisiana. Bulletin No 20. Department of Conservation, State of Louisiana, New Orleans, 598 p.

COCHRAN, W. G. 1977. *Sampling techniques*. Third edition. John Wiley and Sons, New York, NY. 428 p.

COFFEY, B. B. Jr. 1936. Chimney Swift migration at Memphis. *The Migrant* 7: 78-82, 96-98.

COFFEY, B. B. Jr. 1937. Swift banding at Memphis – sixth season. *The Migrant* 8: 70-72.

COFFEY, B. B. Jr. 1943. Swift notes at Memphis. *The Migrant* 14: 52-53.

COFFEY, B. B. Jr. 1944. Winter home of Chimney Swift discovered in northeastern Peru. *The Migrant* 15 (3): 37-38.

COLLINS, C. T. 1983. A reinterpretation of pamprodactyly in swifts; a convergent grasping mechanism in vertebrates. *The Auk* 100: 735-737.

CANADIAN ENDANGERED SPECIES CONSERVATION COUNCIL (CESCC). 2001. Wild Species 2000: The General Status of Species in Canada. Ottawa: Public Works and Government Services Canada.

COMMITTEE ON THE STATUS OF ENDANGERED WILDLIFE (COSEWIC). 2005. Population decline formula. http://www.cosewic.gc.ca/eng/sct2/sct2_7_e.cfm.

COMMITTEE ON THE STATUS OF ENDANGERED WILDLIFE (COSEWIC). 2006. Canadian Species at Risk, August 2006. http://www.cosewic.gc.ca/eng/sct0/rpt/rpt_csar_f.pdf

CONNER, R. N., R. G. HOOPER, H. S. CRAWFORD and H. S. MOSBY. 1975. Woodpecker nesting habitat in cut and uncut woodland in Virginia. *Journal of Wildlife Management* 39: 144-150.

COOCH, E. and G. WHITE. 2001. Program Mark, Analysis of Data from Marked Individuals: A gentle introduction. Second edition.

COTTAM, CLARENCE. 1932. Nocturnal habits of the Chimney Swift. *The Auk* 49 (4): 479-481.

COTRILLE, BETTY DARLING. 1956. Chimney Swift apparently nesting in Pileated Woodpecker hole in live tree. *Jack-Pine Warbler* 34 (1): 30-31.

CYR, A. and J. LARIVEE. 1995. Atlas saisonnier des oiseaux du Québec. Presses de l'Université de Sherbrooke, Société de loisir ornithologique de l'Estrie, Sherbrooke. 711 p.

DANIEL, J. W. 1902. Summer birds of the Great Dismal Swamp. *The Auk* 19: 15-18.

DAVID, N. 1980. État et distribution des oiseaux du Québec. Cahiers d'ornithologie Victor-Gaboriault no. 3. Club des ornithologues de Québec.

DAVID, N. 1996. Liste commentée des oiseaux du Québec. Association québécoise des groupes d'ornithologues, Montréal. 169 p.

DAVIS, M. B. 1993. Old Growth in the East: A Survey. Wild Earth, Richmond, Vermont. 150 p.

DAVIS, M. B. 1996. Extant and Location. *In*: Eastern Old-Growth Forests: Prospects for Rediscovery and Recovery. Edited by Mary Bird Davis. Island Press, Washington, 383 p.

DAWSON, D. G. 1981. The usefulness of absolute ("Census") and relative ("Sampling" or "Index") measures of abundance. *In*: Estimating Numbers of Terrestrial Birds, Studies in Avian Biology 6: 554-558. C. J. Ralph and J. M. Scott (editors). The Cooper Ornithological Society, Lawrence, Kansas, 630 p.

DEANE, R. 1908. Curious fatality among Chimney Swifts. *The Auk* 25: 317-318.

DÉCARIE, R. and J.-L. DESGRANGES. 1990. Effets physiologiques et comportementaux du traitement des pelouses au Chlorpyriphos sur le Merle d'Amérique (*Turdus migratorius*). G.R.E.B.E. INC. pour Environnement Canada et Dow Chemical Inc. Série de rapports techniques numéro 105. Service canadien de la faune, région du Québec, 82 p.

DeGRAAF, R. M. and J. H. RAPPOLE. 1995. Neotropical migratory birds: Natural History, Distribution and Population Change. Comstock Publishing Associates, a division of Cornell University Press, Ithaca and London. 676 p.

DEL HOYO, J., A. ELLIOTT AND J. SARGATAL (editors). 1999. Handbook of the Birds of the World, Vol. 5. Barn-owls to Hummingbirds. Lynx Edition, Barcelona. 760 p.

DEMETRIO, L. 1993. Aclaraciones sobre la presencia del Vencejo de Chimenea (*Chaetura pelagica*) en el valle de Calama. *Boletin informativo, Unión de Ornitólogos de Chile* 15: 16-17.

DESGRANGES, J.-L. 1964. Fiche de nidification 476. Fichier de nidification des oiseaux du Québec, Musée national des sciences naturelles, Musées nationaux du Canada.

DESPONTS, M. 1995. L'influence humaine sur l'environnement. *In*: Gauthier, J. and Y. Aubry (editors.). 1995. The Breeding Birds of Québec: Atlas of the Breeding Birds of Southern Québec. Association québécoise des groupes d'ornithologues, Province of Québec Society for the Protection of Birds, Canadian Wildlife Service, Environment Canada, Québec Region, Montréal. 1295 pages.

DEXTER, R. W. 1950. Six-year diary of two Chimney Swifts. *Bird-Banding* 21: 99-104.

DEXTER, R. W. 1951. Diary of five Chimney Swifts. *Ohio J. Sci.* 51: 42-46.

-------. 1952a. Extra-parental cooperation in the nesting of Chimney Swifts. *Wilson Bulletin* 64: 133-139.

-------. 1952b. Hazardous nesting of the Chimney Swift. *The Auk* 69: 289-293.

-------. 1956. The returns of banded Chimney Swifts at Kent, Ohio, in 1954 and 1955. *Bird Banding* 27 (2): 83-84.

-------. 1960. Storm damage and renesting behavior by the Chimney Swift. *The Auk* 77 (3): 352-354.

-------. 1961. Unusual nesting behavior of Chimney Swifts. *Wilson Bulletin* 73 (1): 87-89.

-------. 1962. Attempted reuse of old nest by Chimney Swift. *Wilson Bulletin* 74 (3): 284-285.

-------. 1968. Thirteen-year breeding history of a chimney swift. *The Ohio Journal of Science* 68 (6): 273-276.

-------. 1969. Banding and nesting studies of the Chimney Swift, 1944-1968. *Ohio Journal of Science* 69: 193-213.

-------. 1971. Shift of mates during nesting of Chimney Swifts. *Bird-Banding* 42: 125.

-------. 1974. Unusually large numbers of Chimney Swifts at a nest. *Bird-Banding* 45: 365.

-------. 1978. Chimney Swifts use same nest for five consecutive years. *Bird-Banding* 49: 278.

-------. 1979. Fourteen-year life history of a banded Chimney Swift. *Bird-Banding* 50: 30-33.

-------. 1981a. Chimney Swifts reuse ten year-old nest. *North American Bird Bander* 6: 136.

-------. 1981b. Nesting success of Chimney Swift related to age and the number of adults at the nest, and the subsequent fate of the visitors. *J. Field Ornithology* 52: 228-232.

-------. 1982. Wandering Chimney Swifts. *North American Bird Bander* 7: 156-157.

-------. 1985. Nesting history of a banded hermaphroditic Chimney Swift. North American *Bird Bander* 10: 39.

-------. 1986. Postscript on the life history of certain banded Chimney Swifts. *North American Bird Bander*, 11 (4): 132-133.

DEXTER, R. W. 1991. Chimney Swift. *In*: The Atlas of Breeding Birds of Michigan, pp. 254-255. R. Brewer, G. A. McPeek and R. J. Adams (editors). Michigan State University Press, East Landing. 594 p.

-------. 1992. Sociality of Chimney Swifts (*Chaetura pelagica*) nesting in a colony. *North American Bird Bander* 17: 61-64.

DIONNE, C. E. 1906. Les oiseaux de la province de Québec. Dussault et Proulx, Québec, viii + 414 p.

DOWNES, C. M. and B. T. COLLINS. 1996. The Canadian Breeding Bird Survey, 1966-1994. Canadian Wildlife Service Progress Note 210.

DOWNES, C. M., B. T. COLLINS and M. DAMUS. 2003. Canadian Bird Trends Web site Version 2.1. Migratory Birds Conservation Division, Canadian Wildlife Service, Hull, Québec.

DOWNES, C. M., B. T. COLLINS and M. DAMUS. 2006. Canadian Bird Trends Web site Version 2.1. Migratory Birds Conservation Division, Canadian Wildlife Service, Hull, Québec.

DRIFTWOOD WILDLIFE ASSOCIATION. 2000. *North American Chimney Swift Nest Site Research Project.* http://www.concentric.net/~dwa/index.html

DRUSHKA, K. 2000. Canada's Forests: A History. Forest History Society, McGill-Queens University Press. 162 p.

DUCEY, J. E. 1988. Nebraska birds, breeding status and distribution. Simons-Boardman Books, Omaha. 148 p.

DUNN, E. H., C. M. DOWNES and B. T. COLLINS. 2000. The Canadian Breeding Bird Survey, 1967- 1998. Canadian Wildlife Service Progress Note 216.

DUKE, G. E. 1977. Pellet egestion by a captive Chimney Swift (*Chaetura pelagica*). *The Auk* 94: 385.

DUNWIDDIE, P., D. FOSTER, D. LEOPOLD and R. T. LEVERETT. 1996. Old-growth forests in southern New England, New York and Pennsylvania. *In*: Eastern Old-Growth Forests: Prospects for Rediscovery and Recovery. Edited by Mary Bird Davis. Island Press, Washington. 383 p.

DYER, J. M. 2001. Using witness trees to assess forest change in southeastern Ohio. *Canadian Journal of Forestry Research* 31: 1708-1718.

ELKINS, N. 1988. Weather and Bird Behaviour. Second edition. T & A D Poyser, Calton. 239 p.

ENSER, R. W. 1992. The Atlas of Breeding Birds in Rhode Island. Rhode Island Department of Environmental Management. 206 p.

ERSKINE, A. J. 1992. Atlas of the Breeding Birds of the Maritime provinces. Nimbus Publishing Limited, The Nova Scotia Museum. 270 p.

ETCHEBERRY, R. 1982, Les oiseaux de Saint-Pierre et Miquelon, Paris, O.N.C. 78 p.

EVANS OGDEN, L. J. 1996. Collision course: the hazards of lighted structures and windows to migrating birds. World Wildlife Fund Canada, Fatal Light Awareness Program, Toronto. 46 p.

FARGO, N. D. 1975. Breeding Birds of North Dakota. North Dakota State University. 295 p.

FERGUSON, J. and S. FERGUSON. 1991. Chimney Swift choose hollow oak tree for nesting site. *The Migrant* 64 (4): 97-98.

FINLAY, J. C. 1976. Some effects of weather on Purple Martin activity. *The Auk* 93: 231-244.

FISHER, R. B. 1958. The breeding biology of the Chimney Swift, *Chaetura pelagica* (Linnaeus). New York State Museum and Science Service, Bulletin Number 368, 141 p.

FJELDSÅ, J. and N. KRABBE. 1986. Some range extensions and other unusual records of Andean birds. *Bulletin of the British Ornithologists' Club* 106: 115-124.

FJELDSÅ, J. and N. KRABBE. 1990. Birds of the High Andes. Zoological Museum, University of Copenhagen, Apollo Books, Svendborg, Denmark.

FLECKENSTEIN, J. 1996. Chimney Swift. *In* The Iowa Breeding Bird Atlas, pp. 200-201. L. S. Jackson, C. A. Thompson and J. J. Dinsmore (editors). University of Iowa Press, Iowa City. 484 p.

FORBUSH, E. H. 1927. Birds of Massachusetts and Other New England States. Part 2. Massachusetts Department of Agriculture Publication.

FORBUSH, E. H. 1929. Birds of Massachusetts and Other New England States. Part 3. Massachusetts Department of Agriculture Publication.

FROTHINGHAM, E. H. 1931. Timber Growing and Logging Practice in the Southern Appalachian Region. USDA Forest Service Technical Bulletin No. 250, Washington DC. 93 p.

FUDGE, S. 1998. Dietary analysis of the Chimney Swift (*Chaetura pelagica*) at UNB campus. Atlantic Cooperative Wildlife Ecology Research Network, undergraduate thesis, University of New Brunswick. 22 p.

FRIENDS OF THE CHIMNEY SWIFT. 1995. Chimney Swifts: home to roost in Fredericton. http://fan.nb.ca/fan/info/recreation/birdwatching/swifts.html

GANIER, A. F. 1944. Maps showing Chimney Swift migration. *The Migrant* 15: 44, 47, 50.

GANIER, A. F. 1962. The Red-Cockaded Woodpecker in Tennessee. *The Migrant* 33 (2): 40-45.

GANIER, A.F. and A. CLEBSCH. 1946. Breeding birds of the Unicoi Mountains. *The Migrant* 17: 53-59.

GARRETT, K. and J. DUNN. 1981. Birds of Southern California: Status and Distribution. Los Angeles Audubon Society, Los Angeles. 408 p.

GASTON, A. J., D. K. CAIRNS, R. D. ELLIOT and D. G. NOBLE. 1985. A Natural History of Digges Sound. Canadian Wildlife Service. Technical Report Series No. 46, 65 p.

GAUTHIER J. and Y. AUBRY (editors). 1995. The Breeding Birds of Québec: Atlas of the Breeding Birds of Southern Québec. Association québécoise des groupes d'ornithologues, Province of Québec Society for the Protection of Birds, Canadian Wildlife Service, Environment Canada, Québec Region, Montréal. 1295 pages.

GILBERT, A. M. and V. S. JENSEN. 1958. A Management Guide for Northern Hardwoods in New England. U.S. Forest Service Research Station Paper NE-112.

GILLIGAN, J., M. SMITH, D. ROGERS and A. CONTRERAS. 1994. Birds of Oregon, Status and Distribution. Cinclus Publications, McMinnville. 330 p.

GOODBURN, J. M. and C. G. LORIMER. 1998. Cavity trees and coarse woody debris in old-growth and managed northern hardwood forest in Wisconsin and Michigan. *Canadian Journal of Forest Research* 28: 427-438.

GODFREY, W. E. 1986. The Birds of Canada. Revised edition. Canadian Museum of Nature, Ottawa. 650 p.

GORDON, R. B. 1969. The natural vegetation of Ohio in pioneer days. *Bulletin of the Ohio Biological Survey, New Series* 3 (2).

GRABER, R. R., and J. W. GRABER. 1963. A comparative study of bird populations in Illinois, 1906-1909 and 1956-1958. *Illinois Natural Historical Survey Bulletin* 28: 383-528.

GREEN, W. R. 1940. Banding of Chimney Swifts (*Chaetura pelagica*) in the region of Chattanooga, Tennessee. *Bird-Banding* 11: 37- 56.

GROSKIN, H. 1945. Chimney Swifts roosting at Ardmore, Pennsylvania. *The Auk* 62: 361-370.

HALL, G. A. 1983. West Virginia Birds, Distribution and Ecology (Special Publication of Carnegie Museum of Natural History), No 7. Carnegie Museum of Natural History, West Virginia Department of Natural Ressources, Pittsburgh. 180 p.

HANEY, J. C., P. BRISSE, D. R. JACOBSON, M. W. OBERLE and J. M. PAGET. 1986. Annotated Checklist of Georgia Birds. Occasional Publication No. 10, Georgia Ornithological Society. 49 p.

HANEY, J. C. and C. P. SCHAADT. 1996. Functional roles of eastern old growth in promoting forest bird diversity. *In*: Eastern Old-Growth Forests: Prospects for Rediscovery and Recovery. Edited by Mary Bird Davis, Island Press, Washington. 383 p.

HANSEN, G. D. and R. D. NYLAND. 1986. Effect of diameter distributions on the growth of simulated uneven-aged sugar maple stand. *Canadian Journal of Forest Research*. 17: 1-8.

HAYWORTH, A. M. and W. W. WEATHERS. 1984. Temperature regulation and climatic adaptation in Black-billed and Yellow magpies. *Condor* 86: 19-26.

HELLEINER, F. M. 1987. Chimney Swift. *In*: Atlas of the breeding birds of Ontario, pp. 226-227. M. D. Cadman, P. F. J. Eagles and F. M. Helleiner (editors). Waterloo University Press, Waterloo. 617 p.

HENNY, C. J. 1972. An analysis of the population dynamics of selected avian species with special reference to changes during the modern pesticide era. Bureau of Sports Fisheries and Wildlife, Washington, USA. 99 p.

HESS, G. K. 2000. Birds of Delaware. University of Pittsburgh Press, Pittsburgh.

HILTY, S. L. and W. L. BROWN. 1986. A Guide to the Birds of Colombia. Princeton University Press.

HISTORICAL ATLAS OF CANADA. 1990. Volume III. University of Toronto Press, Canada. 199 p.

HOFSLUND, P. B. 1958. Chimney Swift nesting in an abandoned Pileated Woodpecker hole. *Wilson Bulletin* 70 (2): 192.

HOWELL, S. N. G. and S. WEBB. 1995. A Guide to the Birds of Mexico and Northern Central America. Oxford University Press, Oxford.

HUEY, L. M. 1960. Notes on Vaux and Chimney Swifts. *Condor* 62: 483.

HUGHES, R. A. 1988. Nearctic migrants in southwest Peru. *Bulletin of the British Ornitologists' Club* 108: 29-43.

JACKSON, J. A. 1997. Sky sweeper. *Birder's World* 11 (3): 16-20.

JAMES, D. A and J. C. NEAL. 1986. Arkansas Birds, their Distribution and Abundance. The University of Arkansas Press, Fayetteville. 402 p.

JANSSEN, R. B. 1987. Birds in Minnesota. University of Minnesota Press, Minneapolis, for the James Ford Bell Museum of Natural History. 352 p.

JOHNSGARD, P. A. 1979. Birds of the Great Plains, Breeding Species and their Distribution. University of Nebraska Press, Lincoln and London. 539 p.

JOHNSON, A. W. 1972. Supplement to the Birds of Chile and adjacent regions of Argentina, Bolivia and Peru. Buenos Aires. 116 p.

KALE, H. W. and D. S. MAEHR. 1990. Florida's Birds. Pineapple Press, Sarasota. 288 p.

KAUFMAN, K. 1996. Lives of North American birds. Houghton Mifflin Company, Boston and New York. 675 p.

KELLER, C. E., S. A. KELLER and T. C. KELLER. 1986. Indiana Birds and their Haunts: A Checklist and Finding Guide. Indiana University Press, Bloomington. 206 p.

KINGERY, H. E. 1998. Colorado Breeding Bird Atlas. Colorado Bird Atlas Partnership, Colorado Division of Wildlife.

KYLE, P and G. KYLE. 1996. Chimney Swift nest site research project. *Sialia* 18 (4): 123-125.

KYLE, P and G. KYLE . 1999. Providing and maintaining nesting habitat for Chimney Swifts, a guide for homeowners. Driftwood Wildlife Association, Texas Parks and Wildlife. Fact sheet. http://www.tpwd.state.tx.us/huntwild/wild/birding/pif/chimney_swift/new_nesting/

KYLE, P and G. KYLE. 2000. North American Chimney Swift Nest Site Research Project. Driftwood Wildlife Association. http://www.concentric.net/~dwa/index.html

KYLE, P and G. KYLE. 2004. Building Chimney Swift Towers. First edition. Texas A & M University Press, College Station, USA. 87p.

LACK, D. 1956. A review of the genera and nesting habits of swifts. *The Auk* 73 (1): 1-32.

LACK, D. 1973. Swifts in a Tower. Chapman and Hall, London. 239 p.

LACK, D. and C. T. COLLINS. 1985. Swifts. *In*: A Dictionary of Birds, pp. 572-574. B. Campbell and E. Lack (editors), Buteo Books, British Ornithologist's Union, Vermillion., 670 p.

LANDOWNER RESOURCE CENTRE. 1999. Extension Notes: The Old-Growth Forests of Southern Ontario. Queens's Printer for Ontario. Manotick, Ontario. 8 p.

LARRISON, E. J. 1981. Birds of the Pacific Northwest, Washington, Oregon, Idaho and British Columbia. The University Press of Idaho. 337 p.

LARIVÉE, J. 1993. Chronobiologie des oiseaux du Bas-Saint-Laurent. Club des ornithologues du Bas-Saint-Laurent.

LARSON, B.M., J. L RILEY, E. A. SNELL AND H. G. GODSCHALK. 1999. The Woodland Heritage of Southern Ontario: A study of ecological change, distribution and significance. Federation of Ontario Naturalists, Don Mills. 262 p.

LASKEY, A. R. 1944. Winter recovery of a Nashville Chimney Swift. *The Migrant* 15: 42-43.

LATHAM, R. 1920. Unusual habits of Chimney Swift. *The Auk* 37: 132-133.

LATTA, C. S. and M. E. BALTZ. 1997. Population limitation in Neotropical migratory birds : comments on Rappole and McDonald (1994). *The Auk* 114 (4): 754-762.

LEAK, W. B., D. S. SOLOMON and S. M. FILIP. 1969. A silvicultural guide for northern hardwoods in the Northeast. U.S. Forest Service Research Paper NE-143.

LEBRETON, J.-D., K. P. BURNHAM, J. CLOBERT and D. R. ANDERSON. 1992. Modelling survival and testing biological hypotheses using marked animals: a unified approach with case studies. *Ecological Monograph* 62: 67-118.

LEMIEUX, G. and M. ROBERT. 1995. Martinet ramoneur, pp. 630-633 *In*: Gauthier, J. and Y. Aubry (editors.). 1995. The Breeding Birds of Québec: Atlas of the Breeding Birds of Southern Québec. Association québécoise des groupes d'ornithologues, Province of Québec Society for the Protection of Birds, Canadian Wildlife Service, Environment Canada, Québec Region, Montréal. 1295 pages.

LEUE, A. 1886. Ohio State Forestry Bureau, First Annual Report. Colombus OH.

LEVERETT, R. 1996 Definition and History. *In*: Eastern Old-Growth Forests: Prospects for Rediscovery and Recovery. Edited by Mary Bird Davis, Island Press, Washington. 383 p.

LEWIS, J. C., M. WHALEN and R. L. MILNER. 2002. Washington Dept. Fish & Wildlife's priority habitat and species management recommendations. Volume IV: Birds. Vaux's Swift *Chaetura vauxi*.

LINCOLN, F. C. 1944. Chimney Swift's winter home discovered. *The Auk* 61: 604-609.

LLANES SOSA, A. and E. E. PÉREZ MENA. 2000. Primera captura del Vencejo de chimenea (*Chaetura pelagica*) (Aves: Apodidae) para Cuba. *El Pitirre* 13 (1): 15.

LOO, J. AND N. IVES. 2003. The Acadian forest: Historical conditions and human impacts. *The Forestry Chronicle* 79 (3): 462-474.

LOWERY, G. H. Jr. 1943. The dispersal of 21,414 Chimney Swifts banded at Baton Rouge, Louisiana, with notes on probable migration routes. *The Louisiana Academy of Science* 7: 56-74.

LOWTHER, P.E., and C.T. COLLINS. 2002. Black Swift (*Cyseloides niger*). *In:* The Birds of North America, No. 676. A. Poole and F. Gill (editors). The Academy of Natural Science, Philadelphia; The American Ornithologists' Union, Washington, D.C.

MACBRIAR, WALLACE N. JR. 1963. Chimney Swift gathering insects off the surface of a pond. *Wilson Bulletin*, 75 (4): 458.

MACNAMARA, C. 1918. The Chimney Swift. *The Ottawa Naturalist* 32: 39-42.

MANNAN, R. W. and E. C. MESLOW. 1984. Bird populations and vegetation characteristics in managed and old-growth forests, north-eastern Oregon. *Journal of Wildlife Management* 48: 1219-1238.

MANITOBA MUSEUM OF MAN AND NATURE. 1998. The birds of Manitoba online. http://www.chin.gc.ca/exhibitions/birds/mmmn/english/a_chimney_swift_data.html

MARÍN, M. 1997. Some aspects of the breeding biology of the Black swift. *Wilson Bulletin* 109 (2): 290-306.

McCAFFERTY, D. J., J. B. MONCRIEFF and I. R. TAYLOR. 2001. How much energy do barn owls (*Tyto alba*) save by roosting? *Journal of Thermal Biology* 26: 193-203.

McCOMB, W. C. and R. E. NOBLE. 1980. Effects of single-tree selection cutting upon sang and natural cavity characteristics in Connecticut. *Transactions of the Northeastern Section of the Wildlife Society* 37: 50-57.

McGEE, G. G., D. J. LEOPOLD and R. D. NYLAND. 1999. Structural characteristics of old-growth, maturing and partially cut northern hardwood forests. *Ecological Applications* 9 (4): 1316-1329.

McLAREN, I.A. 1981. The birds of Sable Island. *Proceedings of the Nova Scotia Institute of Science* 31: 1-84.

MEYER DE SCHAUENSEE, R. and W. H. PHELPS, Jr. 1978. A Guide to the Birds of Venezuela. Princeton University Press.

MICHAEL, E. D. and W. H. CHAO. 1973. Migration and roosting of Chimney Swifts in east Texas. *The Auk* 90: 100-105.

MILLS, E. L. 1969 Hurricane "Gladys" and its ornithological effect on the Maritime provinces. *Nova Scotia Bird Society Newsletter* 11 (1): 6-16.

MONROE, B. L. Jr. 1968. A distributional survey of the birds of Honduras. *Ornithological Monographs* No. 7, American Ornithologists' Union.

MONTANA DEPARTMENT OF FISH, WILDLIFE AND PARKS. 1998. A list of Montana birds. Montana Department of Fish, Wildlife and Parks. http://www.npwrc.usgs.gov/resource/othrdata/chekbird/r6/montana.htm

MONTEVECCHI, W. A. and L. M. TUCK. 1987. Newfoundland birds: exploitation, study, conservation. Publications of the Nuttall Ornithological Club, No. 21, Cambridge, 273 p.

MOORMAN, C. E., K. R. RUSSELL, G. R. SABIN and D. C. GUYNN JR. 1999. Snag dynamics and cavity occurrence in the South Carolina Piedmont. *Forest Ecology and Management* 118: 37-48.

MORNEAU, F., D. LAMBERT, M. ST-GEORGES and J.-L. DESGRANGES. 1998. Évaluation de la vulnérabilité des oiseaux nicheurs du Québec au changement climatique. G.R.E.B.E. inc. pour Environnement Canada. Série de rapports techniques numéro 299. Service canadien de la faune, Région du Québec, 50 p.

MOSSELER, A., J.A. LYNDS and J. E. MAJOR. 2003. Old-growth forests of the Acadian region. National Research Council of Canada Scientific Press. Environ Rev./Dossiers Environ. 11(S1): S47-S77.

MULVIHILL, R. S. 1992. Chimney Swift. *In*: Atlas of Breeding Birds in Pennsylvania, pp. 174-175. D. W. Brauning (editor). University of Pittsburgh Press, Pittsburgh and London. 484 p.

MUSSELMAN, T. E. 1931. Disasters to swifts. *Bird Lore* 33: 397.

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA). 2005. Climate of 2005: Atlantic Hurricane Season. National Climatic Data Center, November 10, 2005. http://www.ncdc.noaa.gov/oa/climate/research/2005/hurricanes05.html

NATURAL RESOURCES CANADA (NRCan). 2001. The State of Canada's Forests 1999-2000. http://www.nrcan-rncan.gc.ca/cfs-scf/national/what-quoi/sof/sof00/overview_e.html.

NATURAL RESOURCES CANADA (NRCan). 2004. The State of Canada's Forests 2002-2003. http://www.nrcan-rncan.gc.ca/cfs-scf/national/what-quoi/sof/sof03/overview_e.html.

NAYLOR, B., J. A. BAKER, D. M. HOGG, J. G. MCNICOL, W. R. WATT. 1996. Forest Management Guidelines for the Provision of Pileated Woodpecker Habitat, Version 1.0. Ontario Department of Natural Resources. Queen's Printer for Ontario. Toronto.

NICHOLSON, C. P. 1997. Atlas of the Breeding Birds of Tennessee. University of Tennessee Press, Knoxville.

NEWTON, I. 1994. The role of nesting sites in limiting the numbers of hole-nesting birds : A review. *Biological Conservation* 70: 265-276.

NORSE, W. J. and D. P. KIBBE. 1985. Chimney Swift. *In*: The Atlas of Breeding Birds of Vermont, p. 148-149. S. B. Laughlin and D. P. Kibbe (editors). University Press of New England, Hanover and London. 456 p.

NOVA SCOTIA DEPARTMENT OF NATURAL RESOURCES (NS-DNR). 2004. Nova Scotia Government. http://www.gov.ns.ca/natr/forestry/planresch/oldgrowth/index.htm

OLSON, S. L. 1993. Contributions to avian biogeography from the archipelago and lowlands of Bocas del Toro, Panama. *The Auk* 110 (1): 100-108.

ONTARIO DEPARTMENT OF NATURAL RESOURCES (O-DNR). 2000. A Silvicultural Guide to Managing Southern Ontario Forests, Version 1.1. Government of Ontario. Queen's Printer for Ontario, Toronto. 648 p.

ONTARIO DEPARTMENT OF NATURAL RESOURCES (O-DNR). 2001. Forest Management Guide for Natural Disturbance Pattern Emulation, Version 3.1 Government of Ontario. Queen's Printer for Ontario, Toronto. 40 p.

ONTARIO DEPARTMENT OF NATURAL RESOURCES (O-DNR). 2002. State of the Forests Report, 2001. Government of Ontario. Queen's Printer for Ontario. Toronto.

PALMER, R. S. 1949. Maine birds. *Bulletin of the Museum of Comparative Zoology*, Vol. 102, Cambridge.

PALMER-BALL, B. L. 1996. The Kentucky Breeding Bird Atlas. University Press of Kentucky.

PEARSON, D. L. 1980. Bird Migration in Amazonian Ecuador, Peru and Bolivia. *In*: Migrant Birds in the Neotropics: Ecology, behavior, distribution and conservation, pp. 273-283. A. Keast and E. S. Morton (editors). Symposium held at the Conservation and Research Center, National Zoological Park, Smithsonian Institution, 27-29 October 1977. Smithsonian Institution Press, Washington, D. C.

PECK, G. K. and R. D. JAMES. 1983. Breeding Birds of Ontario, Nidiology and Distribution, Vol. 1: Nonpasserines. Royal Ontario Museum, Toronto. 321 p.

PETERJOHN, B. G. and D. L. RICE. 1991. The Ohio Breeding Bird Atlas. The Ohio Department of Natural Resources, Division of Natural Areas and Reserves, Columbus. 416 p.

PETERS, H. S. 1937. Chimney Swift banding in Alabama during the fall of 1936. *Bird-Banding* 8: 16-24.

PETERSON, R. A. 1995. The South Dakota Breeding Bird Atlas. The South Dakota Ornithologists' Union.

PLENGE, M. A. 1974. Notes on Some Birds in West-Central Peru. *Condor* 76: 326-330.

PLENGE, M. A., T. A. PARKER III, R. A. HUGHES and J. P. O'NEILL. 1989. Additional notes on the distribution of birds in West-Central Peru. *Le Gerfaut* 79: 55-68.

POISSANT, L. 1999. Le lindane, du champs de maïs à l'atmosphère. http://www.qc.ec.gc.ca/atmos/lindane/

POISSANT, L. and J.-F. KOPRIVNJAK 1996. Fate and atmospheric concentrations of α- and γ-hexachlorocyclohexane in Québec, Canada. *Environmental Science and Technology* 30: 845-851.

POST, W. and S. A. GAUTHREAUX, Jr. 1989. Status and distribution of South Carolina birds. Contributions from the Charleston Museum No. 18, Charleston. 83 p.

POTTER, E. F., J. F. PARNELL and R. P. TEULINGS. 1980. Birds of the Carolinas. The University of North Carolina Press, Chapel Hill. 408 p.

POUGH, R. H. 1957. Audubon Western Bird Guide. Garden City, NY: Doubleday.

QUÉBEC DEPARTMENT OF COMMUNICATION AND CULTURE (Q-DCC). 2000. Patrimoine religieux: cet été le Québec devient la terre aux cent chantiers. Communiqué du Ministère de la Culture et des communications. Government of Québec. http://www.mcc.gouv.qc.ca/nouveau.htm

QUÉBEC DEPARTMENT OF NATURAL RESOURCES, WILDLIFE AND PARKS (Q-DNRWP). 1996. Biodiversité du milieu forestier. Government of Québec, Québec City. 152 p.

QUÉBEC DEPARTMENT OF NATURAL RESOURCES, WILDLIFE AND PARKS (Q-DNRWP). 1998. Règlement sur les normes d'intervention dans les forêts du domaine public. L.R.Q., c. F-4.1, a. 171. Government of Québec, Québec City. 44 p.

QUÉBEC DEPARTMENT OF NATURAL RESOURCES AND WILDLIFE (Q-DNRW). 2003. Manuel d'aménagement forestier. Fourth edition. Government of Québec, Québec City. 245 p.

RAFFAELE, H., J. WILEY, O. GARRIDO, A. KEITH and J. RAFFAELE. 1998. A Guide to the Birds of the West Indies. Princeton University Press, Princeton.

RAMSEY, J. J. 1970. Temperature changes in Chimney Swift (*Chaetura pelagica*) at lowered environmental temperatures. *Condor* 72: 225-229.

RAPPOLE, J. H., E. S. MORTON, T. E. LOVEJOY and J. L. RUOS. 1983. Neartic avian migrants in the neotropics. U.S. Fish and Wildlife Service, Washington, D. C.

RAPPOLE, J. H. and M. V. McDONALD. 1994. Cause and effect in population declines of migratory birds. *The Auk* 111(3): 652-660.

REED, D. D. and G. D. MROZ. 1997. Rate of sawtimber volume and value growth of individual sugar maple trees in managed, uneven-aged stands in the Lake States. *Northern Journal of Applied Forestry* 14: 78-83.

RICH, T. D., C. J. BEARDMORE, H. BERLANGA, P. J. BLANCHER, M. S. W. BRADSTREET, G. S. BUTCHER, D. W. DEMAREST, E. H. DUNN, W. C. HUNTER, E. E. IÑIGO-ELIAS, J. A. KENNEDY, A. M. MARTELL, A. O. PANJABI, D. N. PASHLEY, K. V. ROSENBERG, C. M. RUSTAY, J. S. WENDT, T. C. WILL. 2004. Partners in Flight: North American Landbird Conservation Plan. Cornell Lab of Ornithology, Ithaca, NY.

RIDGELY, R. S. and J. A. GWYNNE Jr. 1989. A Guide to the Birds of Panama with Costa Rica, Nicaragua and Honduras. Second edition. Princeton University Press, Princeton.

RIDGWAY, R. 1874. On local variations in the notes and nesting habits of birds. *American Naturalist* 8: 197-201.

ROBBINS, M. B. and D. A. EASTERLA. 1992. Birds of Missouri, their Distribution and Abundance. University of Missouri Press, Columbia and London. 399 p.

ROBBINS, S. D. 1991. Wisconsin birdlife, population and distribution past and present. The University of Wisconsin Press, Madison, 702 p.

ROBERTSON, R. J., B. J. STUTCHBURY and R. R. COHEN. 1992. Tree swallow (*Tachycineta bicolor*). The Birds of North America, No. 11. A. Poole and F. Gill (editors). The Academy of Natural Science, Philadelphia; The American Ornithologists' Union, Washington, D.C.

RODRIGUEZ, J. P. 2002. Range contraction in declining North American bird populations. *Ecological Applications*. 12 (1): 238-248.

RONDEAU, G. and J.-L. DESGRANGES. 1991. Effets des arrosages du diazinon (Basudin), du diméthoate (Cygon) et du savon insecticide (Safer TM) sur la faune avienne dans les plantations de sapins de Noël. Foresterie intégrée du Québec inc. pour Environnement Canada. Série de rapports techniques numéro 141. Service canadien de la faune, région du Québec, 54 p.

RUNDE, D. E. and D. E. CAPEN. 1987. Characteristics of northern hardwood trees used by cavity-nesting birds. *Journal of Wildlife Management* 51: 217-223.

SAUER, J. R., J. E. HINES, I. THOMAS, and J. FALLON. 2006. The North American Breeding Bird Survey, Results and Analysis 1966-2005. Version 2003.1, USGS Patuxtent Wildlife Research Center, Laurel, MD.

SAVARD, M. 1999. Le Martinet ramoneur au Saguenay-Lac-Saint-Jean, état des observations. *Le Harfang* 22 (2): 26-33.

SAVARD, M. 2000. Le déclin du Martinet ramoneur au Saguenay-Lac-Saint-Jean. *In*: Le point sur le Martinet ramoneur, p. 30. *Le Harfang* 23 (1): 28-32.

SEDGELEY, J. A. 2001. Quality of cavity microclimate as a factor influencing selection of maternity roosts by a tree-dwelling bat, *Chalinolobus tuberculatus*, in New Zealand. *Journal of Applied Ecology* 38: 425-438.

SEMENCHUK, G. P. 1992. The Atlas of Breeding Birds of Alberta. Federation of Alberta Naturalists, Edmonton, 390 p.

SHAFFER, F. 1998. Suivi du Martinet ramoneur à la cheminée du 225 Grande Allée à Québec en 1997. Internal report, Canadian Wildlife Service, 20 p.

SHELLEY, L. O. 1929. Twig gathering of the Chimney Swift. *The Auk* 46: 116.

SHIRE, G. G., K. BROWN and G. WINEGRAD. 2000. Communication Towers: A Deadly Hazard to Birds. American Bird Conservancy, Washington, D. C. 23 p.

SIBLEY, S. C. 1988. Chimney Swift. *In*: The atlas of breeding birds in New York State, pp. 220-221. R. F. Andrle and J. R. Carroll (editors). Cornell University Press, Ithaca. 551 p.

SIBLEY, S. C. and J. E. AHLQUIST. 1990. Phylogeny and Classification of Birds: A Study in Molecular Evolution. Yale University Press. New Haven and London. pp. 391-401.

SIBLEY, C. G. and B. L. MONROE Jr. 1990. Distribution and Taxonomy of Birds of the World. Yale University Press, New Haven and London.

SICK, H. 1993. Birds in Brazil: A Natural History. Princeton University Press, Princeton, 703 p.

SIMARD, J. 1998. Le patrimoine religieux au Québec: exposé de la situation et orientations. Ministère de la Culture et des Communications, Government of Québec, 55 p.

SMALL, A. 1974. The Birds of California. Winchester Press, New York.

SMALL, A. 1994. California Birds: Their Status and Distribution. Ibis Publishing Company.

SMITH, A. R. 1996. Atlas of Saskatchewan Birds. Canadian Wildlife Service, Natural History Society, Regina. 456 p.

SMITH, M. R., P. W. MATTOCKS and K. M. CASSIDY. 1997. Breeding birds of Washington state: location data and predicted distributions. Seattle Audubon Society Publications in Zoology No. 1. Washington Cooperative Fish and Wildlife Research Unit, Washington University, Seattle. 538 p.

SCHNELL, GARY D. and JENNA J. HELLACK. 1978. Flight speeds of Brown Pelicans, Chimney Swifts, and other birds. *Bird-Banding* 49 (2): 108-112.

SNOW, D. W. and C. M. PERRINS. 1998. The Birds of the Western Palearctic. Oxford University Press, Oxford. 1008 p.

SPENDELOW, P. 1985. Starvation of a flock of Chimney Swifts on a very small caribbean island. *The Auk* 102: 387-388.

SQUIRES, W. A. 1976. The Birds of New Brunswick. Monographic series No. 7. Second edition. The New Brunswick Museum, Saint John, N.B. 221 p.

STILES, F. G. and A. F. SKUTCH. 1989. A Guide to the Birds of Costa Rica. Cornell University Press.

STOTZ, D. F., J. W. FITZPATRICK, T. A. PARKER III and D. K. MOSKOVITS. 1996. Neotropical Birds, Ecology and Conservation. The University of Chicago Press, Chicago. 478 p.

SUFFLING, R., M. EVANS and A. PERERA. 2003. Presettlement forest in southern Ontario: Ecosystems measured through a cultural prism. *The Forestry Chronicle* 79 (3): 485-501.

SUTCLIFFE, S. M. 1994. Chimney Swift. *In*: Atlas of Breeding Birds in New Hampshire, pp. 122-123. C. R. Foss Editor, Arcadia.

TANGUAY, R. 1964-65. Les oiseaux des comtés de Kamouraska, l'Islet et Montmagny, P. Q. *Le Naturaliste Canadien*, Vol. XCI (12), Dec. 1964 and Vol. XCII (1), January 1965 and No. 2 February 1965.

TAYLOR, P. 2003. The Birds of Manitoba. P. Taylor Editor. Manitoba Avian Research Committee/Manitoba Naturalist Society. Winnipeg, MN. 504p.

THIRUMURTHI, S. and D. KRISHNA DOSS. 1980. A note on the feeding habits of swift (Apodidae: apodiforme). *Journal of the Bombay Natural History Society* 78: 378-379.

THOMPSON, M. C. and C. ELY. 1989. Birds in Kansas. University of Kansas, Museum of Natural History, Lawrence. 404 p.

TODD, W. E. C. 1940. Birds of Western Pennsylvannia. University of Pittsburgh Press, Pittsburgh, PA.

TUFT, R.W. 1986. Birds of Nova Scotia. Third edition. Nimbus Publishing and the Nova Scotia Museum. Halifax, NS. 478 p.

TUMER, C., J. HILL, AND D. W. JOHNSTON. 1984. Chimney Swift nesting in a hollow tree. *Raven* 55: 12.

TURCOTTE, W. H. and D. L. WATTS. 1999. Birds of Mississippi. Mississippi Department of Wildlife, Fisheries and Parks.

TYLER, W. M. 1940. *Chaetura pelagica,* Chimney Swift. *In*: Life Histories of North American Cuckoos, Goatsuckers, Hummingbirds, and their Allies, pp. 271-293. Bent, A. C. (editor). Part 2. Bulletin 176, Smithsonian Institution, United States National Museum, Washington (reprinted by Dover Publications Inc., New York).

THE WORLD CONSERVATION UNION (IUCN). 2001. http://www.redlist.org/info/categories_criteria2001.html.

U.S. CENSUS BUREAU. 2004. http://quickfacts.census.gov/qfd/

U.S. DEPARTMENT OF AGRICULTURE FOREST SERVICE. 1977. Gen. Tech. Rep. SE-14, p. 76-89. U.S. Department of Agriculture and Forest Services, South East. For. Esp. Stn., Asheville, NC.

U.S. FISH AND WILDLIFE SERVICE. 2006. *Threatened and Endangered Wildlife and Plants.* http://www.fws.gov/Endangered/wildlife.html.

VALLIANATOS, MARY. 2000. Marsh monitoring report reveals the ups and downs of marsh birds and amphibians. *Long Point Bird Observatory* 32 (3): 3.

VAUGHAN, R. 1994. Birder’s guide to Alabama and Mississippi. Gulf Publications.

VEIT, R. R. and W. R. PETERSEN. 1993. Birds of Massachusetts. Natural History of New England Series, Massachusetts Audubon Society. 514 p.

VILLENEUVE, N. 1994. Les écosystèmes forestiers exceptionnels au Québec. Rapport présenté à la Direction de l’environnement forestier, ministère des Ressources naturelles, Dessau Environnement ltée, Saint-Romuald, 41 p.

VOOUS, K. H. 1983. Birds of the Netherlands Antilles. De Walburg Pers, 327 p.

WAKELEY, J. S. AND ROBERTS, T. H. 1994. Army Engineer Waterways Experiment Station, Vicksburg, MS Avian Distribution Patterns Across the Cache River Floodplain, Arkansas. Non Paid ADAS, 53p. Prepared in Collaboration with Tennessee Technological Univ., Cookeville.

WALKER, W. M. 1944. Some habits of the Chimney Swift. *The Migrant* 15: 45, 46, 51-52.

WALSH, J., V. ELIA, R. KANE and T. HALLIWELL. 1999. Birds of New Jersey. New Jersey Audubon Society, Bernardsville.

WENZEL, WALTER. 1928. Überwinternde Massen von Chaetura pelagica (L.) in Guatemala. [C. pelagica wintering in quantities in Guatemala.] *Ornith. Monatsber*. 36 (3): 76-77.

WETMORE, A. 1968. The Birds of the Republic of Panama. Part 2.- Columbidae to Picidae. Smithsonian Miscellaneous Collections, Vol. 150. Smithsonian Institution Press, Washington. 605 p.

WHITTEMORE, M. 1981. Chimney Swifts and their Relatives. Nature Books Publishers, Jackson, 168 p.

WILLIAMS, L. P. 1986. Chimney Swift: New to the western palearctic. *British Birds* 79: 423-426.

WILSON, A. 1812. American Ornithology, Vol. 5. Philadelphia, Bradfort and Inskeep. 122 p.

WOLFORD, J. 1997. 1996 Wolfville chimney swifts and merlins. *Nova Scotia Birds* 39 (2): 41-43.

ZAMMUTO, R. M. 1978. Seasonal activity of the Chimney Swift (*Chaetura pelagica*) population in Macomb, Illinois. Master's thesis, Western Illinois University, Macomb, Illinois. 106 p.

ZAMMUTO, R. M. and E. C. FRANKS. 1978. Forty adult Chimney Swifts at an active nest. *Bird-Banding* 49: 278-279.

-------. 1979a. Chimney Swifts apparently feeding near surfaces of lawns and from trees. *Inland Bird Banding* 51 (4): 73-73.

-------. 1979b. Trapping flocks of Chimney Swifts in Illinois. *Bird-Banding* 50 (3): 201-209.

-------. 1981a. Chimney Swift twig-gathering behavior. *Inland Bird Banding* 53: 7.

-------. 1981b. Environmental effects on roosting behavior of Chimney Swifts. *Wilson Bulletin* 93 (1): 77-84.

ZAMMUTO, R. M., E. C. FRANKS and C. R. PRESTON. 1981. Factors associated with the interval between feeding visits in brood-rearing Chimney Swifts. *Journal of Field Ornithology* 52 (2): 134-139.

ZARNOWITZ, J. E. and D. A. MANUWAL. 1985. The effects of forest management on cavity-nesting birds in northwestern Washington. *Journal of Wildlfe Management*. 49 (1): 255-263.

ZERANSKI, J. D. and T. R. BAPTIST. 1990. Connecticut Birds. New England University Press, Hanover, London. 328 p.

ZUCKER, E. E. 1996. Chimney Swift. *In*: Atlas of the Breeding Birds of Maryland and the District of Columbia, pp. 196-197. C. S. Robbins and E. A. T. Blom (editors). University of Pittsburgh Press, Pittsburgh. 479 p.

Appendix 1. Details of methodology used to estimate Chimney Swift survival rates with mark-recapture data from the *Driftwood Wildlife Association* (Kyle and Kyle, unpublished data) and *Program Mark Software Version 4.1*. The general procedure described in Cooch and White (2001) was used to create and select the different models.

List of models tested. Models are classified in order of their likelihood based on the AIC. (Lebreton *et al*. 1992).

Nb.	Models	Details
1	{Φ(.) p(.)}	Constant survival rate; constant recapture probability
2	{Φ(g) p(.)}	Banding effect on survival rate different between age groups; constant recapture probability
3	{Φ(a2-c/c) p(.)}	Age group effect on constant survival rates; constant recapture probability
4	{Φ(.) p(a2-c/c)}	Constant survival rate; age group effect on constant recapture probabilities
5	{Φ(g) p(a2-c/c)}	Banding effect on survival rate; age group effect on constant recapture probabilities
6	{Φ(a2-c/c) p(a2-c/c)}	Age group effect on constant survival rates; age group effect on constant recapture probabilities
7	{Φ(.) p(t)}	Constant survival rate; time varying recapture probability
8	{Φ(t) p(.)}	Time varying survival rate; constant recapture probability
9	{Φ(g) p(t)}	Banding effect on survival rate different between age groups; time varying recapture probability
10	{Φ(a2-c/c) p(t)}	Age group effect on constant survival rates; time varying recapture probability
11	{Φ(t) p(a2-c/c)}	Time varying survival rate; age group effect on constant recapture probabilities
12	{Φ(a2-t/c) p(.)}	Age group effect on survival rates (time varying / constant); constant recapture probability
13	{Φ(.) p(a2-c/t)}	Constant survival rate; age group effect on recapture probabilities (constant / time varying)
14	{Φ(a2-c/t) p(.)}	Age group effect on survival rates (constant / time varying); constant recapture probability
15	{Φ(.) p(a2-t/c)}	Constant survival rate; age group effect on recapture probabilities (time varying / constant)
16	{Φ(g) p(a2-c/t)}	Banding effect on survival rate different between age groups; age group effect on recapture probabilities (constant / time varying)
17	{Φ(a2-c/c) p(a2-c/t)}	Age group effect on constant survival rates; age group effect on recapture probabilities (constant / time varying)
18	{Φ(a2-c/c) p(a2-t/c)}	Age group effect on constant survival rates; age group effect on recapture probabilities (time varying / constant)
19	{Φ(g) p(a2-t/c)}	Banding effect on survival rate different between age groups; age group effect on recapture probabilities (time varying / constant)
20	{Φ(t) p(t)}	Time varying survival rate; time varying recapture probability
21	{Φ(a2-t/c) p(t)}	Age group effect on survival rates (time varying / constant); time varying recapture probability
22	{Φ(a2-t/t) p(.)}	Age group effect on time varying survival rates; constant recapture probability
23	{Φ(t) p(a2-c/t)}	Time varying survival rate; age group effect on recapture probabilities (constant / time varying)
24	{Φ(a2-c/t) p(t)}	Age group effect on constant survival rates; time varying recapture probability
25	{Φ(.) p(a2-t/t)}	Constant survival rate; age group effect on time varying recapture probabilities
26	{Φ(t) p(a2-t/c)}	Time varying survival rate; age group effect on recapture probabilities (time varying / constant)
27	{Φ(a2-c/c) p(a2-t/t)}	Age group effect on constant survival rates; age group effect on time varying recapture probabilities
28	{Φ(g) p(a2-t/t)}	Banding effect on survival rate different between age groups; age group effect on time varying recapture probabilities
29	{Φ(a2-t/t) p(t)}	Age group effect on time varying survival rates; time varying recapture probability
30	{Φ(t) p(a2-t/t)}	Time varying survival rate; age group effect on time varying recapture probabilities
31	{Φ(a2-t/t) p(a2-t/t)}	Age group effect on time varying survival rates; age group effect on time varying recapture probabilities

Φ: Survival rate
p: Recapture probability
.: Constant
t: Varies in time
g: Banding effect
a2: Two age groups

Appendix 1. Details of methodology used to estimate Chimney Swift survival rates (continued)

In order to determine how well the data fits the models under consideration, a bootstrapping procedure was carried out (n=1,000). These analyses helped determine that the original data were overdispersed compared to the data generated by simulation. A correction factor (*c-hat*) was therefore calculated in order to correct for overdispersed data and generate more reliable parameter estimates. The most conservative method was used to calculate *c-hat* (Cooch and White 2001):

$$c\text{-}hat = \frac{\text{Sum of squares of the observed variance}}{\text{Degree of liberty}} \div \text{Mean simulated } c\text{-}hat\text{'s} = 2{,}96$$

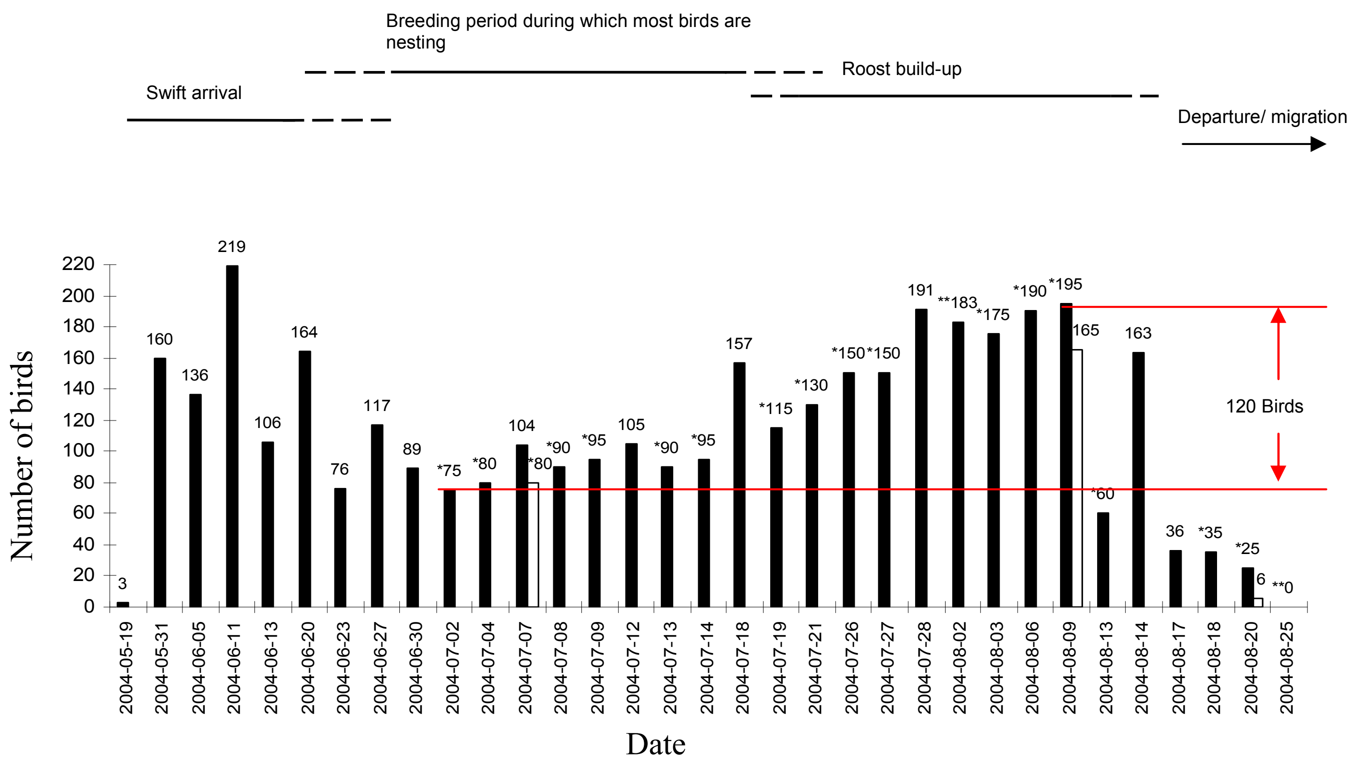
The best models are described in the above table, in order of likelihood based on the AIC criteria. On the basis of these results, there is no difference in survival rates and recapture probability between the two age groups (HY and AHY). Also, these parameters seem to be constant over time. However, survival rates for HY and AHY were calculated with the third model, containing a different survival rate for both age groups. Parameter values were also calculated with a weighted average based on the likelihood (AIC weight value) of the models. The first 19 models, or those possessing an AIC weight value, were used to generate the weighted average. This procedure ensures that the values obtained from the third model are valid (Cooch and White 2001).

Appendix 2. Existing Chimney Swift demographic parameters.

Parameter	Value ± SD	n	Place	Year (s)	Author (s)
Adult annual survival rate	0.727 ± 0.0717 (Calculated with *Program Mark 4.1*)		Texas	1989-2002	Kyle and Kyle, unpublished data
	0.630 ± 0.013	544	Total in U.S. and CAN	1920-35	Henny 1972
	0.627 ± 0.009	1156	Total in U.S. and CAN	1936-45	Henny 1972
	0.630 ± 0.011	762	Total in U.S. and CAN	1946-56	Henny 1972
	0.625 ± ?	61	New York	1952	Fisher 1958
Juvenile annual survival rate	0.788 ± 0.219 (Calculated with *Program Mark 4.1*)	146	Texas	1989-2002	Kyle and Kyle, unpublished data
	0.108 ± ?	92	New York	1952	Fisher 1958
Mean number of juveniles fledged per year	3.24 ± 0.685	86 eggs in 24 nests	New York	1939-53	Fisher 1958
	2.76 ± 1.75	347 eggs in 56 nests	Texas	1989-2002	Kyle and Kyle, unpublished data
	3.6 ± ?	?	?	?	Chantler 2000
	2.67 ± ?	?	?	1944-62	Dexter *in:* Henny 1972
	2.27 ± 1.60 (calculated with raw data)	150 juveniles fledged from 66 nests	Ohio	1944-70	Dexter 1950, 1951, 1956, 1961, 1968, 1979, 1986
	2.83 ± 1.47 (juveniles out of nest)	2 nests during 8 years	Québec	1998-2005	C. Garneau, unpublished data

Appendix 3A. Roost monitoring methodology along with an example of how to estimate the annual number of breeding, non-breeding and hatch-year birds.

Since 1998, volonteers and Québec CWS employees involved in the Québec Chimney Swift Survey Program have discovered and monitored many roosts. Every year, major roosts are visited regularly from May 22 until the birds leave to migrate in late August. Swift counts are generally done twice a week by volunteers. Chimney monitoring starts at dusk, 30 minutes before sunset, and lasts until no more birds are seen entering the roost. These counts are done during rainless evenings. Weather conditions (temperature, wind speed and cloud cover) during counts are also noted.



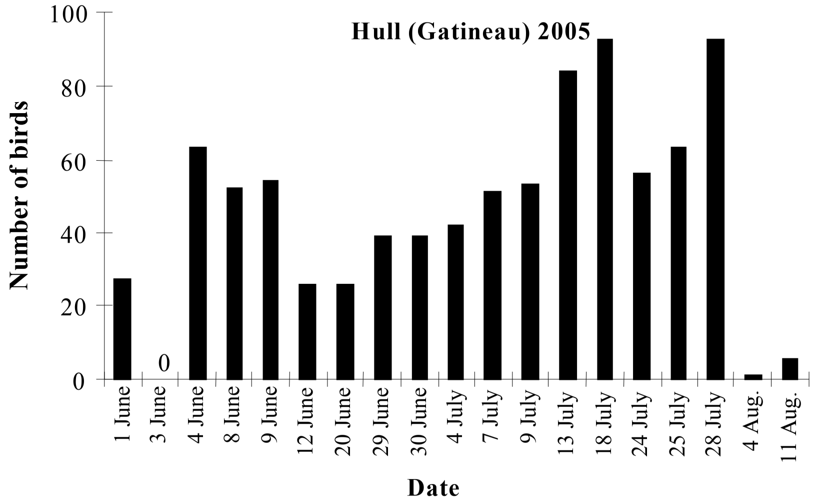
Number of Chimney Swifts in a summer roost, by date of observation

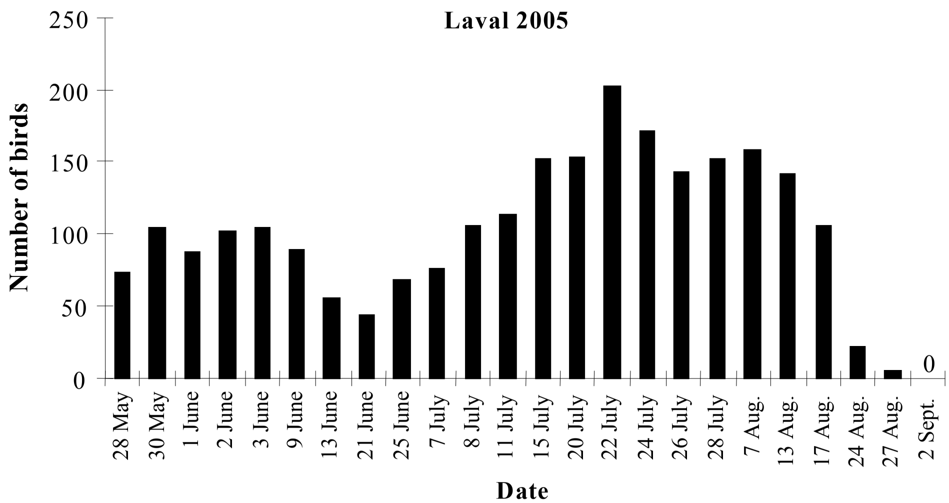
Appendix 3A. Roost monitoring methodology along with an example of how to estimate the annual number of breeders, non-breeders and hatch-year birds (continued).

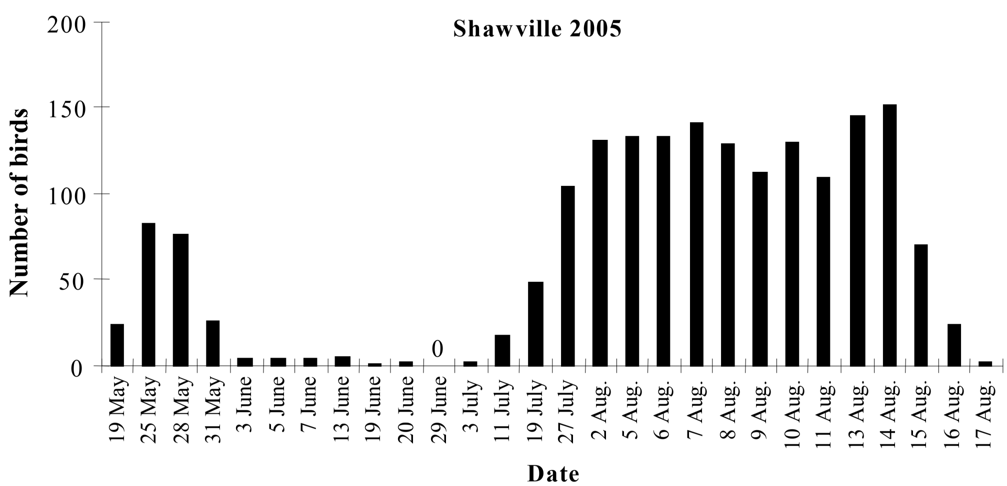
With the roost monitoring data, it is possible to estimate the number of adult birds (AHY) that reproduce and those that do not, along with the number of juveniles (HY). Most non-breeders use the summer roost during the entire breeding season.

The number of AHY that do not reproduce is estimated on the basis of the minimum number of birds seen during the nesting period (75 in this case). In order to estimate the number of HY along with the number of breeding AHY, subtract the non-breeding individuals (75) from the maximum number of birds after the breeding period (195 in this case), which yields 120 birds. Because a breeding pair usually fledges 3 young, multiply 120 by 3/5, for a total of 72 HY birds along with 48 breeding AHY birds. Adding together the number of AHY (48+75), a total of 123 AHY birds is obtained, which is approximately the number of birds observed on average during the arrival period in the spring. The maximum number of birds during this period is much higher than 123, but is not used in the calculations, because of greater daily variability. During this period, birds are still migrating and therefore, birds seen at a particular roost might just using the site as a stopover and will continue on later to their breeding grounds which are further away. This behaviour explains the turnover observed during this period. Therefore, the proportion of birds that do not reproduce equals the number of non-breeders divided by the total number of adults then multiply by 100 as the example shows it represents 61% (75/123*100).

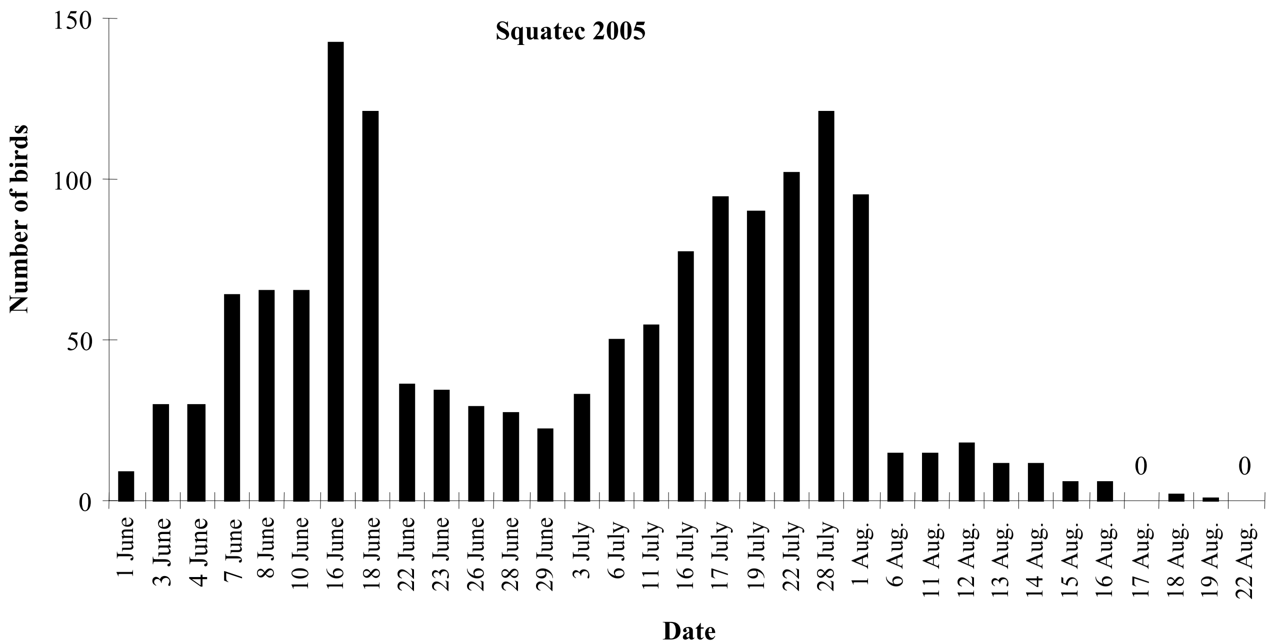
Appendix 3B. Results from roosts monitored during the Québec Chimney Swift Survey Program. The roosts had over 20 birds, were observed a minimum of 10 times and exhibited a natural roost pattern. Roosts are identified by site and year.

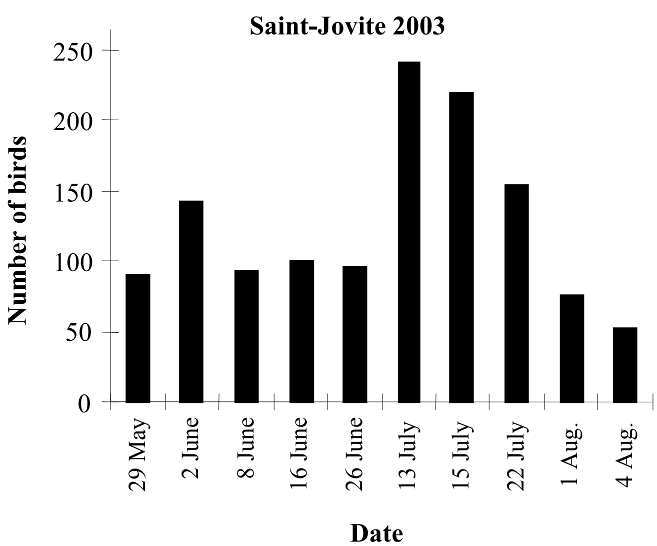


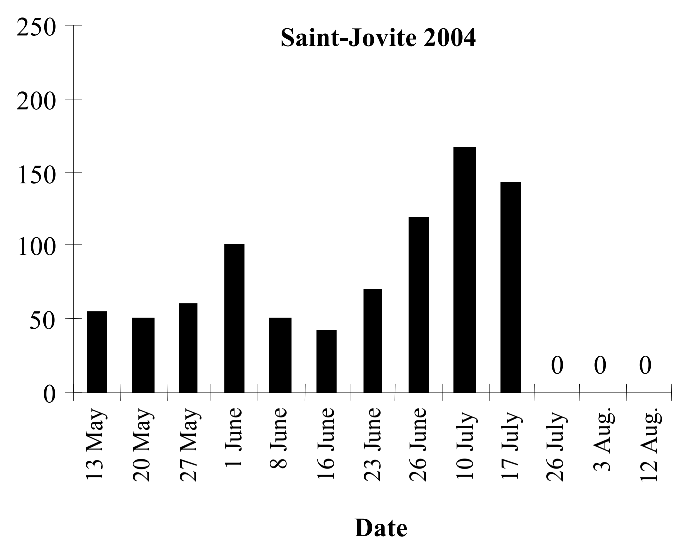




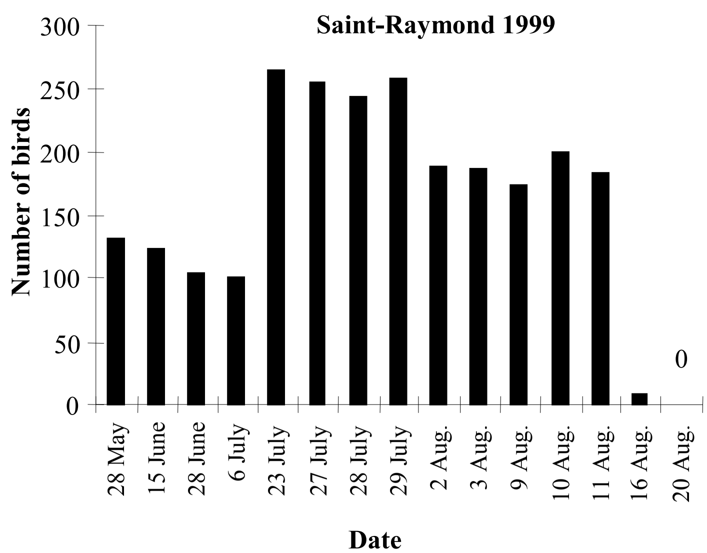
Appendix 3B. Results from roosts monitored during the Québec Chimney Swift Survey Program (continued).

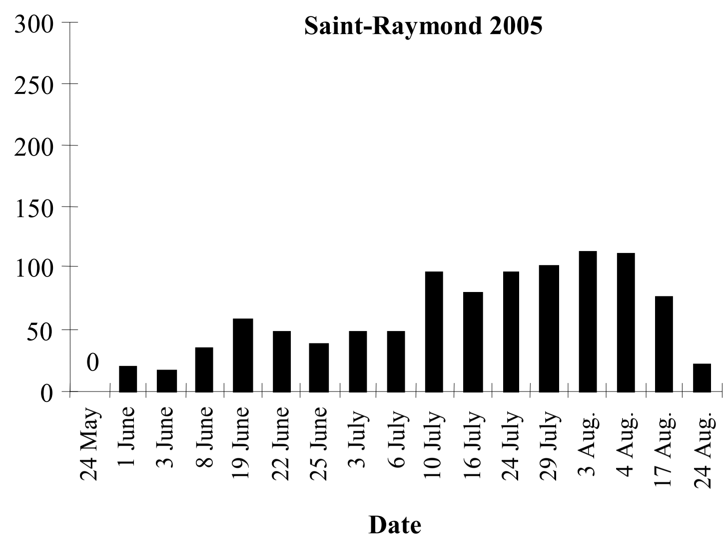


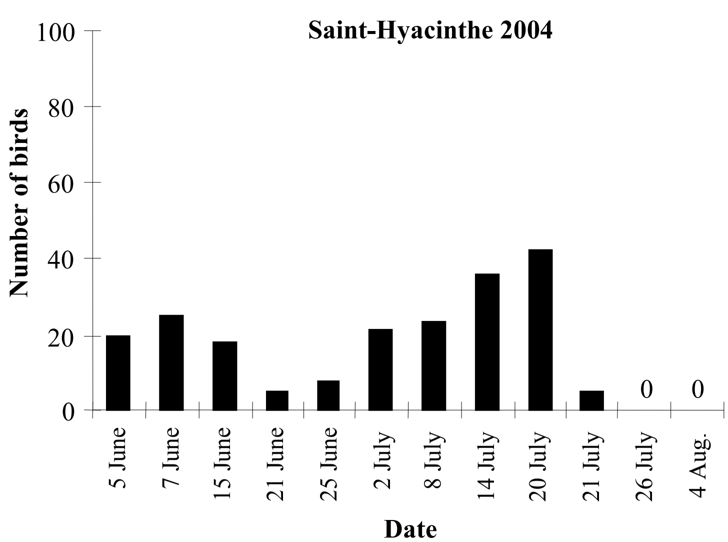


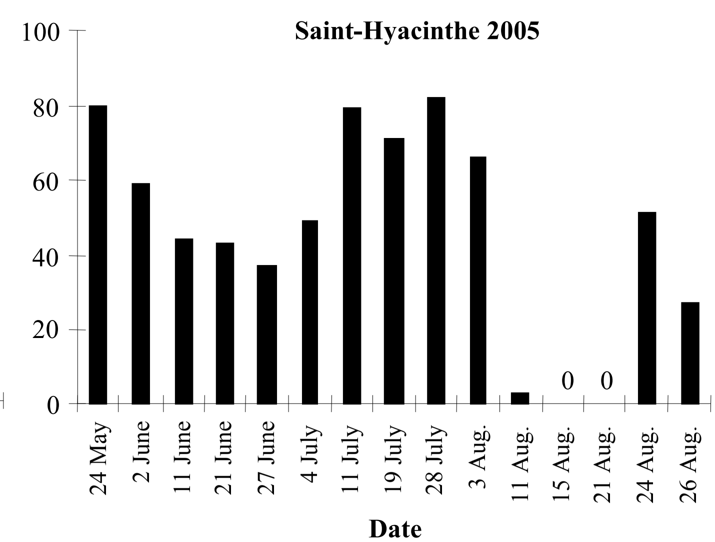


Appendix 3B. Results from roosts monitored during the Québec Chimney Swift Survey Program (1998-2005) (continued).

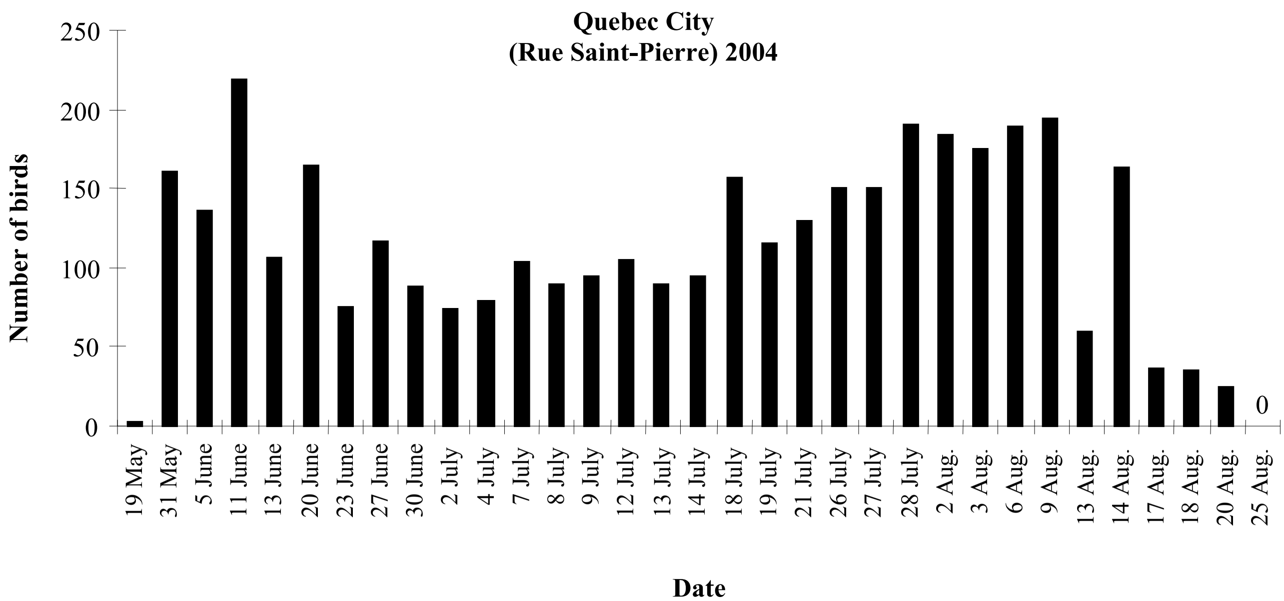


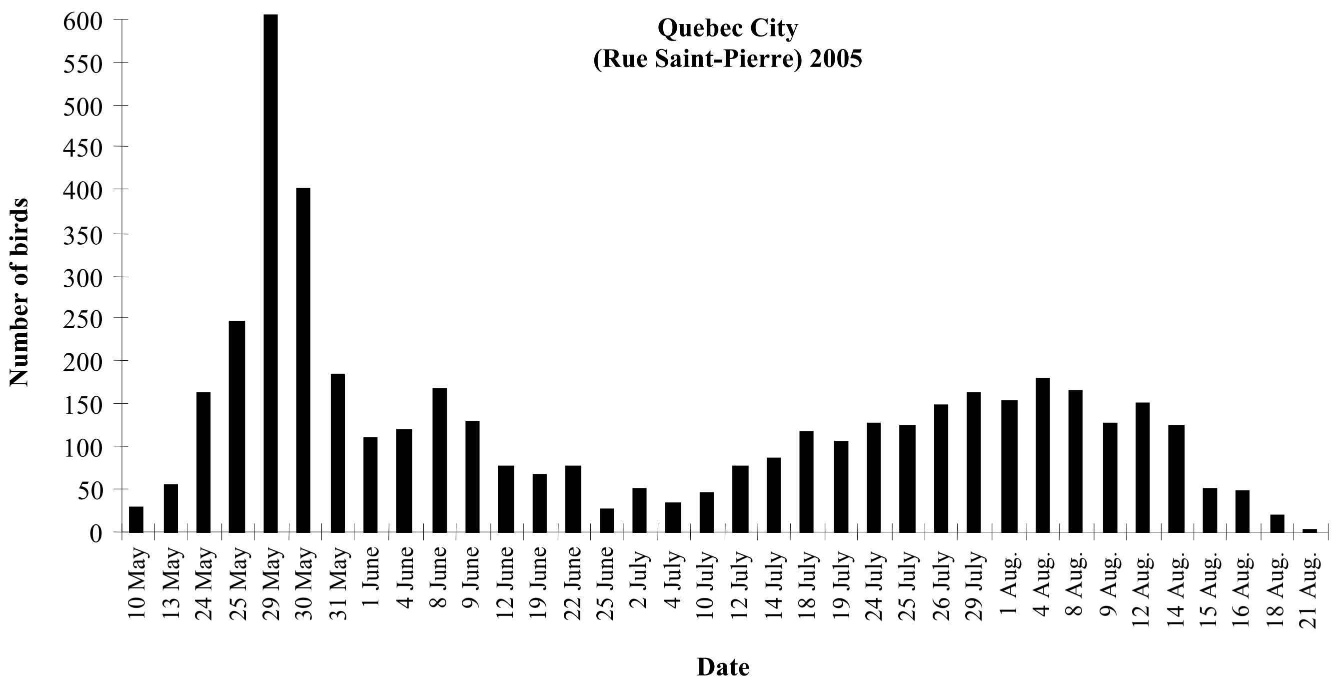




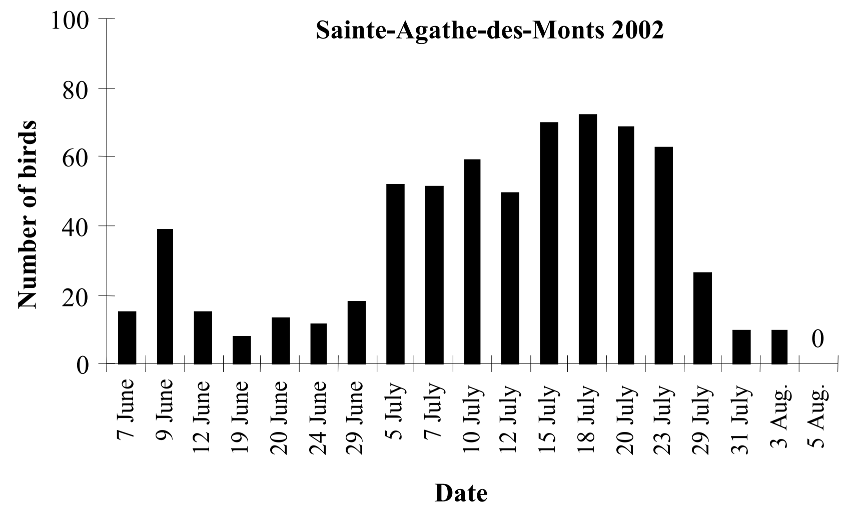


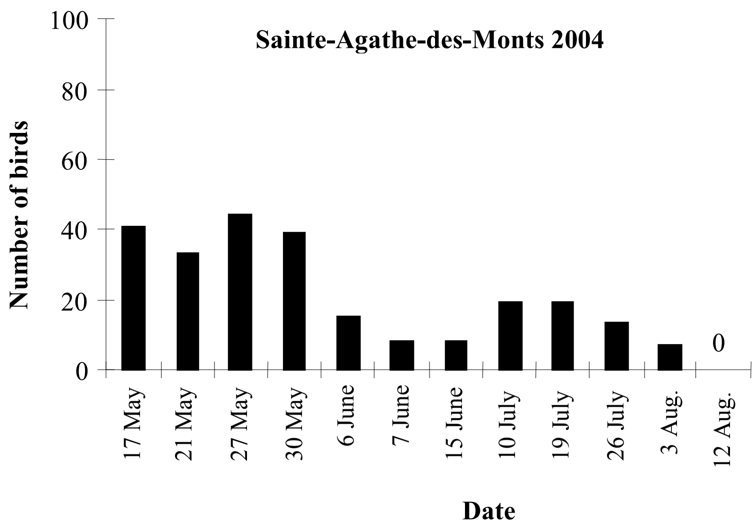
Appendix 3B. Results from roosts monitored during the Québec Chimney Swift Survey Program (1998-2005) (continued).

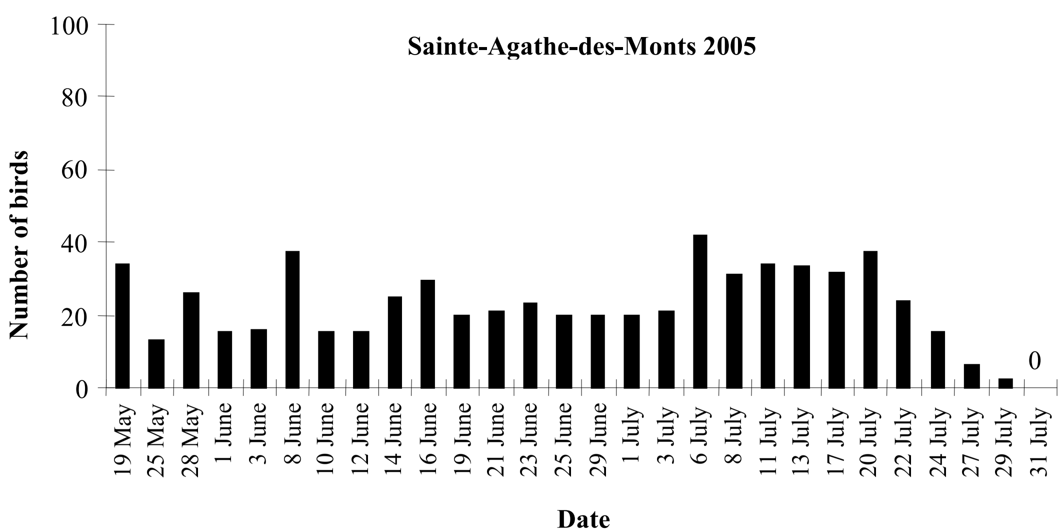




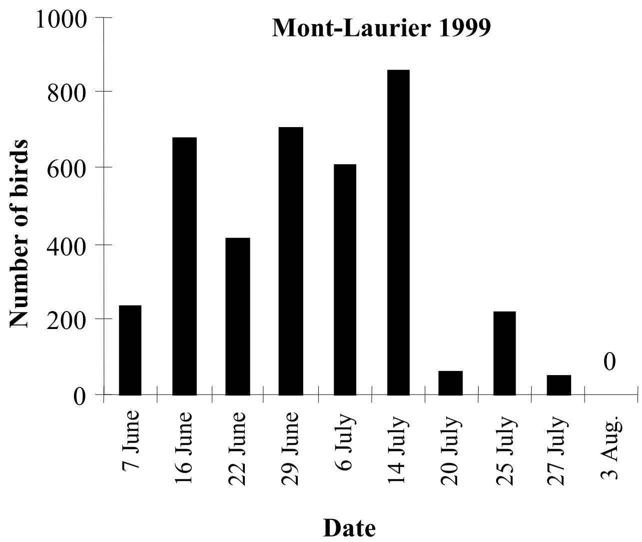
Appendix 3B. Results from roosts monitored during the Québec Chimney Swift Survey Program (1998-2005) (continued).

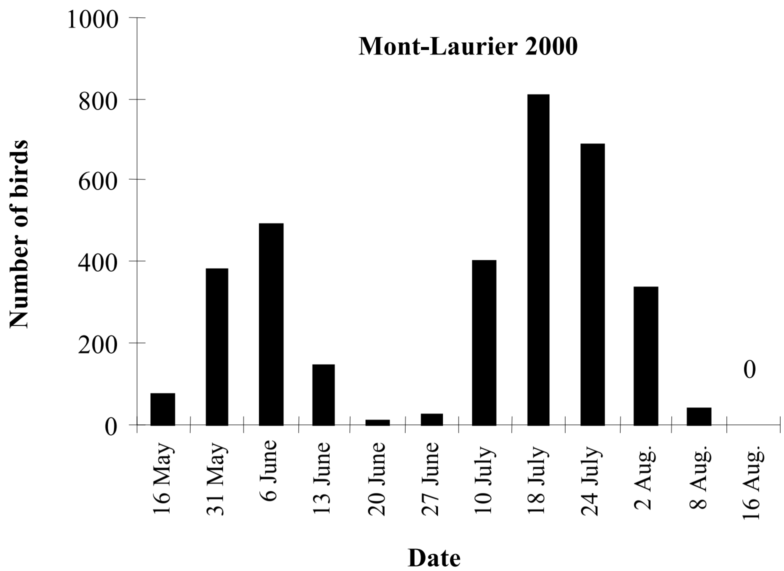


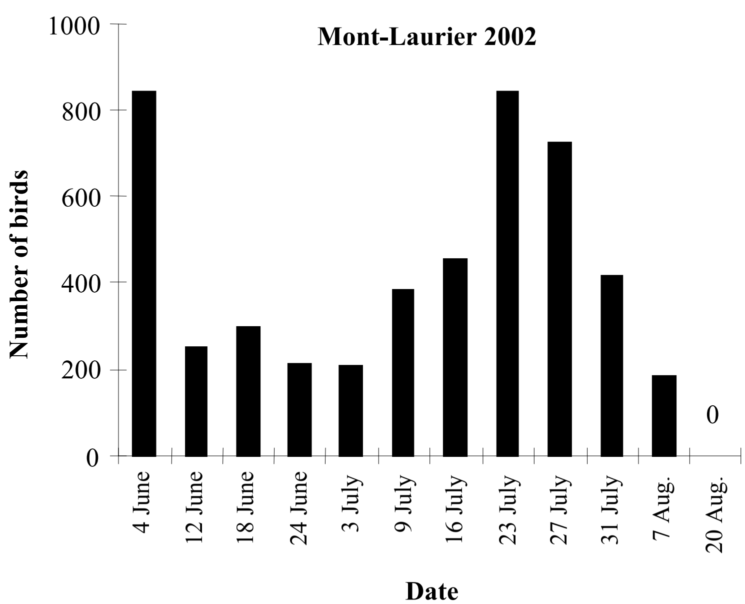




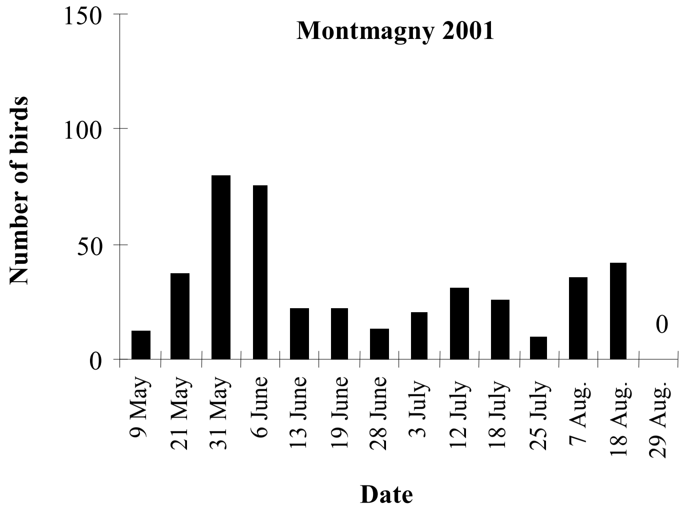
Appendix 3B. Results from roosts monitored during the Québec Chimney Swift Survey Program (1998-2005) (continued).

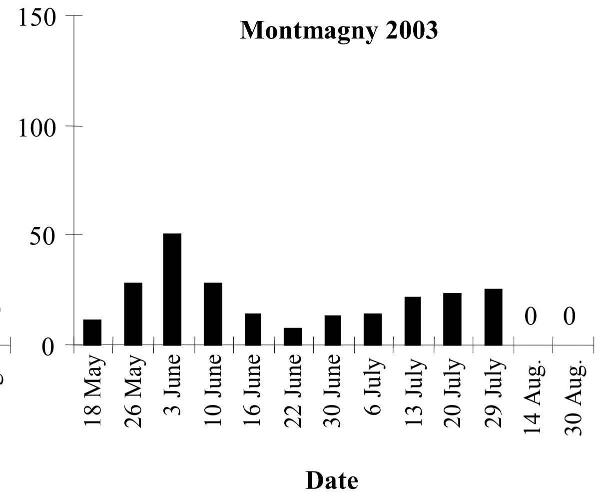


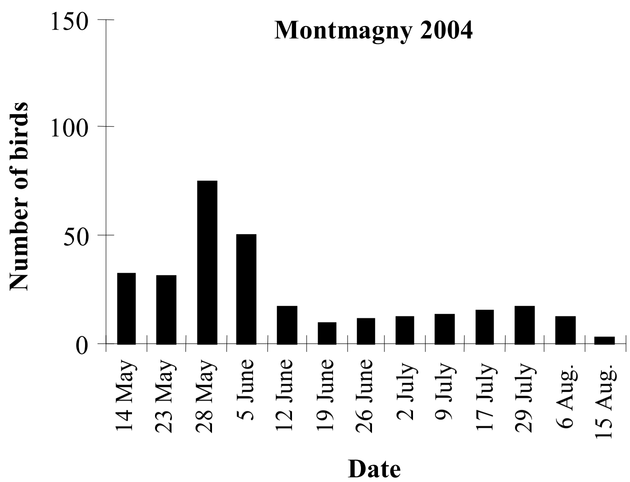


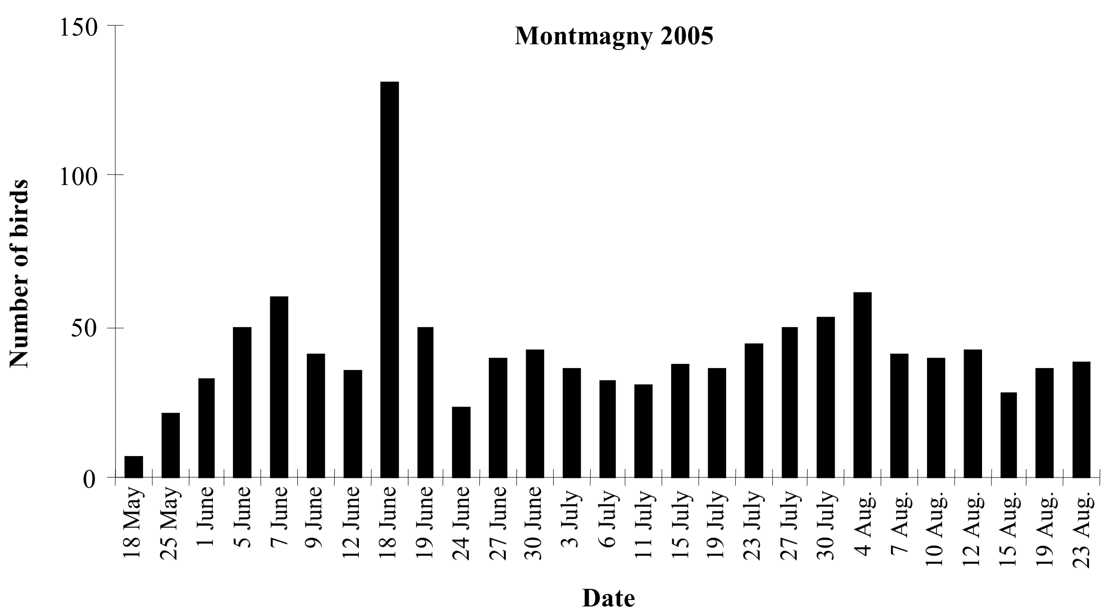


Appendix 3B. Results from roosts monitored during the Québec Chimney Swift Survey Program (1998-2005) (continued).

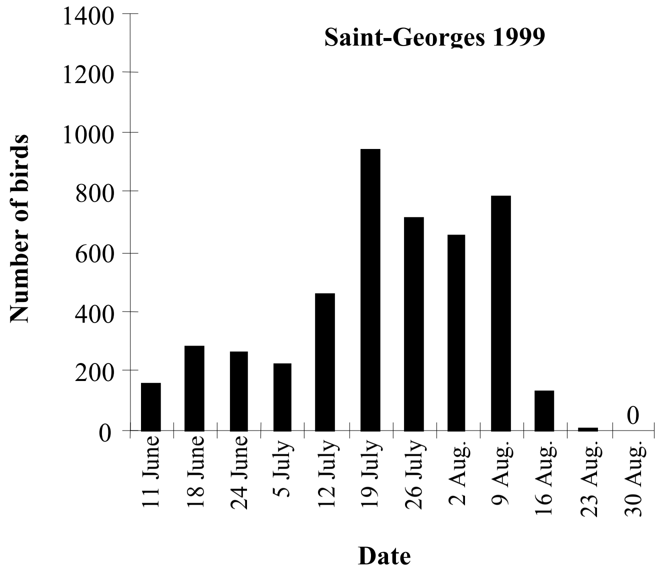


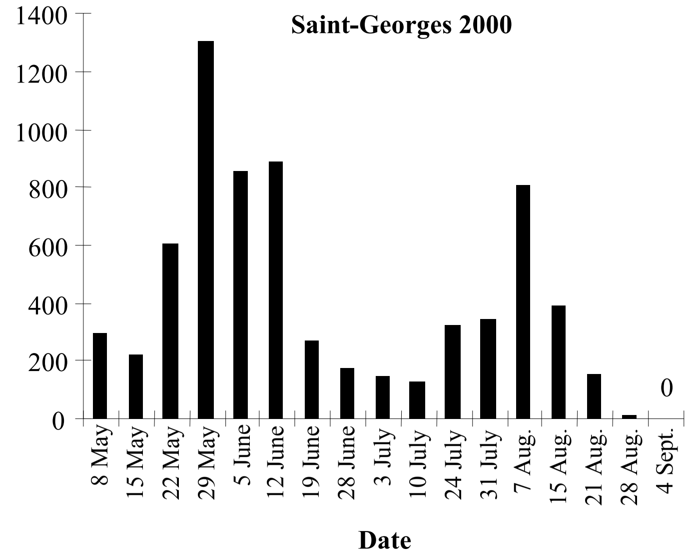


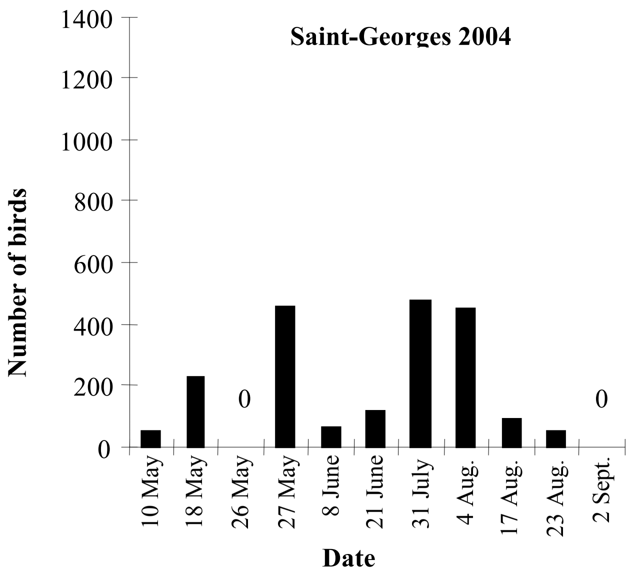


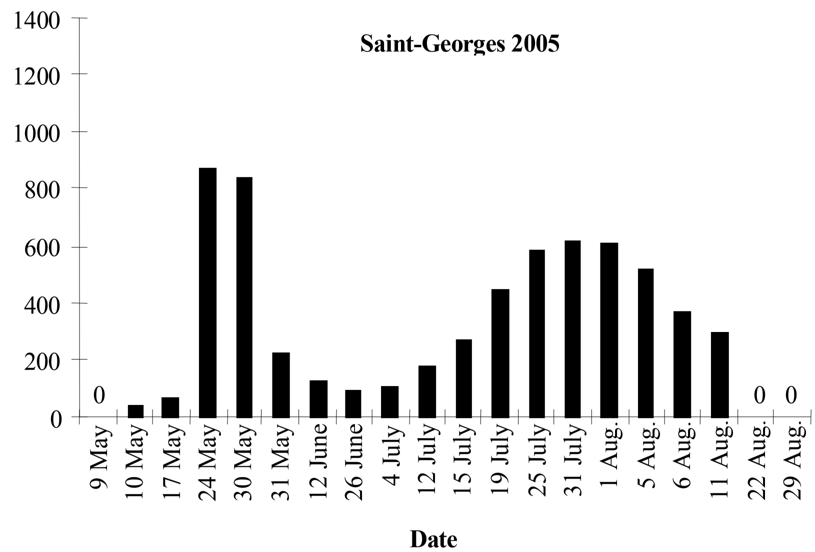


Appendix 3B. Results from roosts monitored during the Québec Chimney Swift Survey Program (1998-2005) (continued).









Appendix 4. Methodology used to calculate distances from Chimney Swift sites (roosts and nests) to bodies of water for **A-** data from known Québec Chimney Swift Survey Program sites (1998-2002) and, **B-** sites reported in Zammuto's master's thesis (1978).

A- Data from known Québec Chimney Swift Survey Program sites (1998-2002).

Known Chimney Swift sites were visited in order to acquire geographic coordinates for the sites themselves along with those of the closest body of water. Coordinates were taken with a *GEO Explorer 3* GPS from Trimble and were then transferred onto topographic computer maps (1:50,000) from the Québec Department of Natural Resources and Wildlife in order to measure distances between sites and water with *Map Info Version 7.5*. When no bodies of water were located in the field around a site, the closest body of water appearing on the electronic map was used instead.

B- Sites reported in: Zammuto, R. M. 1978. Seasonal activity of the Chimney Swift (*Chaetura pelagica*) population in Macomb, Illinois. Master's thesis, Western Illinois University, Macomb, Illinois, 106 p.

A city map of Malcomb, Illinois was generated using *MapQuest* software available at www.mapquest.com (2005 MapQuest Inc. All rights reserved). Nesting sites referred to in the study (n=19) were positioned on the map, which was then printed out. Distances between sites and bodies of water appearing on the map were measured with a ruler, and conversions were made with the appropriate scale. Results are presented in the following table:

Nesting site	Measured distance on map (cm)	Distance (m)
First Christian Church (rear)	6.83	962.0
322 E Pierce	3	422.5
First Christian Church (front)	6.83	962.0
214 W Adams	4.8	676.1
Baptist Church	7.03	990.1
414 E Pierce	3.05	429.6
406 N MacArthur (front)	5.5	774.6
Assembly of God Church	0.5	70.4
Lamoine Hotel	6.1	859.2
Hageman Furniture (rear)	5.96	839.4
Hageman Furniture (front)	5.96	839.4
505 N Johnson	3.95	556.3
605 N Randolph	1.96	276.1
406 N MacArthur (rear)	5.5	774.6
405 S Madison	1.85	260.6
Italian Villa	6	845.1
400 E Pierce	3.1	436.6
811 W Adams	7.46	1050.7
333 Woodbury	4.6	647.9

Appendix 5. Methodology used to calculate the proportion of Atlas survey squares in Ontario and Québec having Chimney Swift sightings, with and without agglomerations.

The proportion of Atlas survey squares in Ontario and Québec having Chimney Swift sightings, when an agglomeration is present or absent was determined using original data from both atlases: Gauthier and Aubry 1995 and Cadman *et al*. (in prep.). Only completed survey squares (Québec: n=1033, Ontario: n=2090) were considered (see original documents for a description of what constitutes a completed survey square). In Québec, survey squares were divided in two bird abundance zones according to bioclimatic region: Low (region 9 to 14) and High (region 1 to 8). Other regions were ignored because they are located outside the bird's range of distribution. Survey squares in Ontario were divided into two categories (north and south), according to the original classification. For both atlases, Chimney Swifts were considered present in a survey square when breeding was considered confirmed, probable or possible.

An agglomeration is considered to be present when it is inside the square or when a 12-km radius buffer zone around an agglomeration comes into contact with the survey square. Agglomerations and their buffer zones were positioned on computer topographic maps (1:250,000) from the Department of Natural Resources (NRCan). Survey squares with or without an agglomeration were determined using *MapInfo Version 7.8*. For Québec, the agglomeration data file comes from the Québec Department of Municipal Affairs. Agglomeration data for Ontario comes from the *Agglome_a* and *Agglome_p* files of NRCan topographical maps.

Appendix 6. Description of the methodology used to survey Chimney Swifts in old-growth forests in Québec.

In 2002, potential Chimney Swift forest sites were evaluated on the basis of data from the Québec Department of Natural Resources (Q-DNR) with the help of a forest engineer, Normand Villeneuve. Sites in old-growth forests included in the Chimney Swift range of distribution were selected from the Exceptional Forest Ecosystems data base, with data covering the 1997-2001 period. Site requirements included an abundant and diversified source of large diameter hollow trees (≥ 50 cm at diameter breast height) and had to be located near a lake with road access. Surveys were then carried out on the lake using a canoe equipped with an electrical motor in order to maximize coverage of swifts flying over the forest.

Sites having these criteria but located in northern Québec were eliminated because of the distribution range limit for this species and the late season period when the survey had to be conducted. In all, five sites were selected, three in the Outaouais region and two in the Laurentides region.
Two sites were located in the Papineau Labelle Wildlife Reserve. Proposed sites were designated by the name of the associated lake: Preston Lake and Poisson Blanc-Baie Amélia Lake in the Laurentides and La Blanche Lake, Britannique Lake and Écluse Lake in the Ouatouais. Sites were surveyed between July 18 and July 30, 2002, from at least an hour prior to sunset until light became too dim. This protocol increased the chances of detecting roosting sites, based on the gathering behaviour exhibited by the species towards the end of the day.

In 2004, an old-growth forest was visited during surveys of Atlas squares in the Kipawa Controlled Harvesting Zone (ZEC) in the Abitibi-Témiscamingue region (see Appendix 8 for details on the methodology).

In 2005, another old-growth forest was surveyed using the 2002 method. The site is part of the Tantaré Ecological Reserve forest in Québec Region.

Appendix 7A. Methodology used to determine the ambient temperature in different nesting sites in comparison to the corresponding outdoor temperature.

During the summer of 1999, the internal temperature of different chimneys (traditional and artificial) was measured and compared with the corresponding outside temperatures. *Emco* thermographs (Type: TR; Temperature interval: -30 to 40°C; Resolution: 0.3°C; Precision: ±0,5°C) were placed inside three traditional masonry chimneys and seven wooded artificial ones (insulated and uninsulated), at 1.5 m from the top. Temperature was recorded every hour. The artificial chimneys were made out of wooden boards with an inside measurement of 50 by 50 cm. The insulated artificial chimneys were identical to the uninsulated ones in that the joints between boards were sealed and expanded cellular polystyrene (~ 8 cm thick) and covered the outside of the insulated chimneys. The location and height of the chimneys along with the temperature recording periods are described in Table 5. Outdoor temperature data were obtained from Environment Canada. Mean temperatures were generated for day, night and 24-hour periods.

Appendix 7B. Methodology used to determine the critical inside temperature of an artificial chimney (nesting site) for Chimney Swifts to leave the premises.

In 2000, during the third week of May, experiments were carried out to determine the threshold temperature at which Chimney Swifts would leave an artificial nesting site in Québec City area (Lévis). The artificial chimney was insulated and had an adjustable gas heating device. The chimney was designed and insulated like those described in Appendix 7A.

During consecutive days of bad weather (rain, wind and an outdoor temperature of about 9°C), the temperature inside the artificial chimney was gradually reduced until the birds left. The experiment was repeated three times with the same results: the birds left the chimney once the inside temperature reached approximately 13°C. After each trial, the temperature was reset to its original level and the birds would come back to the site shortly after. During the last trial, the temperature was maintained at just below 13°C. The birds came back and then left again, not returning until the following day. Between 1999 and 2003, a video camera was installed in the same chimney. Thanks to this set-up, Gauthier *et al*. (CWS, unpublished data) were able to observe that Chimney Swifts stayed inside their nesting site during consecutive days of bad weather, without eating or coming out.

Appendix 8. The 2004 Chimney Swift survey in Québec, based on a modified version of the Breeding Bird Atlas survey method.

Data from the second Ontario Breeding Bird Atlas revealed a dramatic decrease in the Chimney Swift's range of distribution in that province, compared with the first Atlas (M. D. Cadman, CWS, pers. comm.). After receiving these results, biologists from the Canadian Wildlife Service wanted to know if a similar phenomenon had occurred in Québec or, in other words, if the proportion of survey squares with the presence of Chimney Swifts from the first Breeding Bird Atlas (Gauthier and Aubry 1995) had decreased in the same way.

In order to establish the Chimney Swift's distribution during the first Breeding Bird Atlas in Québec (1984-1989), the territory was divided into 10 by 10-km survey squares from a 1:50,000 map, using the Universal Transverse Mercator (UTM) coordinate system. The province had a total of 5,261 survey squares, but most were not accessible or had too little coverage to be analyzed. A total of 1,077 survey squares were deemed to have sufficient coverage. Chimney Swifts were present in 566 squares, or 52.6%. If only high abundance areas (bioclimatic region 1 to 10 with 790 survey squares) are considered, swifts were present in 65.7% of survey squares

To find out whether the Chimney Swift range of distribution in Québec (presence or absence in a survey square) had changed since the first Breeding Bird Atlas, a modified version of the original survey method was implemented during the summer of 2004. A subsample of survey squares (n=200) was chosen from the squares in high abundance areas (n=790) in the first Atlas. Selection was made in a stratified manner among the bioclimatic regions to reflect the original proportion of surveyed squares in the different regions. However, for logistical reasons, squares were chosen randomly only among the high abundance areas (bioclimatic regions 1 to 10) to check for presence or absence.

To confirm the presence of the species in a survey square, 10 five-minute stops (heard or seen) were made along accessible roads inside each square in order to survey all potential habitats. The surveys were made from June 28 to July 24, 2004 between 6:00 a.m. and 9:00 p.m., at periods of the day without rain or strong winds, and with temperatures above 15°C. A GPS (*Garmin 76*) was used to determine the limits of a survey square (Datum: NAD27; unit: UTM/UPS). When a survey square contained a known site (roost or nesting site from the Québec Chimney Swift Survey Program), the survey began there. If at least one Chimney Swift was present, then the survey stopped there. If there were no swifts at the first stop, the observer continued to the next predetermined stop and so on, until a swift was detected (Presence) or until the last stop was reached (Absence). When different potential habitat types were present in a survey square, the most probable ones were surveyed first following a pre-established order:

1. Agglomerations: Starting with old neighbourhoods (churches, church rectories, schools), followed by old buildings (barns, silos, abandoned buildings) and then bodies of water (rivers, lakes, marshes, bogs).

2. Forests: Starting with old growth (hollow trees) followed by areas containing bodies of water (rivers, lakes, marshes, bogs).

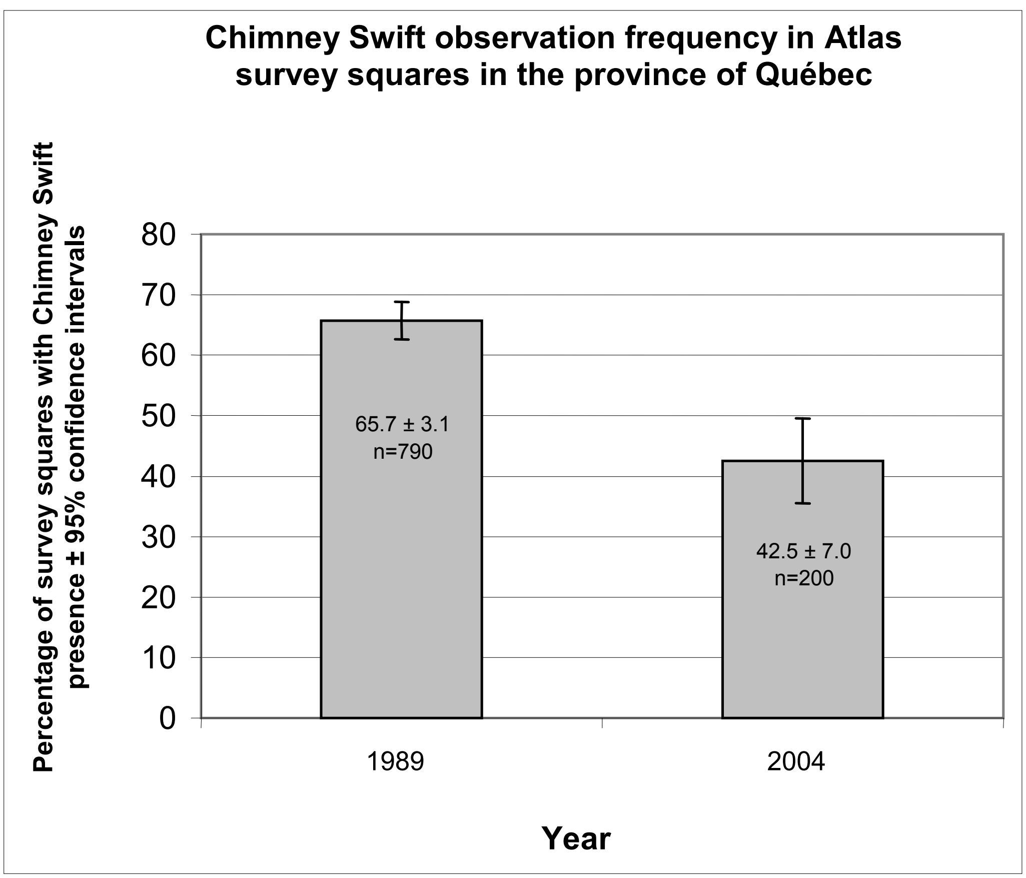
Appendix 8. The 2004 Chimney Swift survey in Québec, based on a modified version of the Breeding Bird Atlas survey method (continued).

For each survey square, the following information was noted: map location of the survey stops and presence or absence of the species. When the species was present, the following information was also noted: bird seen or heard, nest or roost, number of individuals, time of day, date, weather conditions and a brief description of the habitat.

The proportion of survey squares where Chimney Swifts were detected in 2004 (n=200) was compared with data from the first Atlas (n=1,077) with confidence intervals (95%) based on Cochrane's method (1977):

$$P \pm \left[t \times \sqrt{1 - f} \times \sqrt{p \times q/(n-1)} + 1/2n \right]$$

The statistical population corresponds to the total number of survey squares (n=5,261) as described in Gauthier and Aubry (1995).



Appendix 9. The Québec Chimney Swift Survey Program

In 1998, the Canadian Wildlife Service (Québec Region) started a survey program to identify and characterize Chimney Swift roosts and nesting sites across the province and to monitor population trends. This project was conducted in collaboration with the Québec Association of Ornithologist Groups (AQGO) and the Québec government's Société de la Faune et des Parcs (FAPAQ).

Between 1998 and 2005, a total of 331 different parishes were visited by volunteers (about 100 people per year), following the proposed method:

For a given parish, all potential Chimney Swift habitats were systematically visited by one or a few volunteers starting in late May, when swifts begin arriving. Old neighbourhoods were the first to be visited because of the many traditional masonry chimneys of religious buildings (churches, church rectories, convents and schools), commercial and residential buildings and the presence of abandoned chimneys. Potential habitats located in rural areas were the next ones to be surveyed (barns, silos, tobacco dryers, sheds, etc.). Some old-growth forests and habitats located near bodies of water were also visited. Sites were normally surveyed at the end of the day, at least 30 minutes before sunset in order to observe the typical Chimney Swift gathering when a roost is present, until birds were no longer visible. Surveys were carried out during days of appropriate weather (winds not exceeding 20 km/h and temperatures over 15°C). When a site was discovered that hosted swifts, surveys continued to determine the number of birds using the site (also see Appendix 3). Volunteers also filled out a field data sheet containing the following information:

- Location of site
- Type of structure sheltering the birds (hollow tree, brick chimney, stone chimney etc.)
- Type of building holding the chimney (church, church rectory, convent, school, etc.)
- Habitat (dominant habitat type surrounding the Chimney Swift site, e.g., forest, farmland, urban)
- Survey date
- Weather conditions: cloud cover, wind speed, temperature and entry time of first and last bird
- Number of swifts entering the observed structure

Appendix 10. Comparison of the different population estimates of Chimney Swifts (breeding pairs) in Canada

On the basis of the figures from Québec, 55% of the tallied population is composed of juveniles (hatch-year birds). The original estimates from Ontario and the Maritimes do not distinguish adults or juvenile, therefore, adult estimates were adjusted based on juvenile percentage results from Québec.

Québec: (also see section 9.1)

1- 1,058 pairs: based on the sites visited during the 2005 inventory. Juveniles (55%) were removed from the total.

2- 1,260 pairs: based on the cumulated sites from the 2005 inventory. Cumulated sites include the maximum number of swifts for each visited site and numbers for sites not visited during that particular year, to which we added the count from the closest previous year survey. Juveniles (55%) were removed from the total.

Ontario: (also see section 9.2)

1- 4,331 pairs: based on the estimate from the first Ontario Breeding Bird Atlas (17,500 pairs; Helleiner 1987) to which we applied the 45% reduction in occurrence observed during the second Atlas (Cadman *et al*., in prep.). Juveniles (55%) were then removed from the total.

2- 1,420 pairs: based on the estimate from the first Ontario Breeding Bird Atlas (17,500 pairs; Helleiner 1987) to which we applied the -9.0% BBS annual (1968-2004) from 1985 (last year of the Atlas field work) up to 2004. Juveniles (55%) were then removed from the total.

3- 1,494 pairs: based on a proportional calculation from the pair to building ratio in Québec (see below).

Maritimes: (also see section 9.3)

1- 3,398 pairs: based on the estimate of the first Maritimes Breeding Bird Atlas (NB: 12,000, NE: 8500; Erskine 1992) to which we applied the BBS downward trends (1968-2002) from 1990 (last year of the Atlas field work) to 2004. The BBS trends for NB and NS are -6.3% and -7.8% per year respectively. Juveniles (55%) were then removed from the total.

2- 345 couples: based on a proportional calculation from the pair to building ratio in Québec (see below).

Appendix 10. Comparison of the different population estimates of Chimney Swifts (breeding pairs) in Canada (continued)

The last traditional masonry chimneys were built before 1960. This is when the number of suitable chimneys available to swifts was probably at its highest. After that period changes started to occur (electricity, new construction standards and technologies) leading to a decrease in number of chimneys for swifts. Therefore, the human population level at that time should give us a good indication of the maximum number of potential nesting sites still available for swifts today, as they are now nesting almost exclusively in the chimneys of buildings.

Table comparing numbers of estimated Chimney Swift breeding pairs in relation to the potential number of buildings.

Province	Estimate	Population in 1961 (Statistics Canada)	Potential number of buildings (Pop.1961 / 4)	Swift population (Breeding pairs)	Pair/ Building Ratio
Québec	1	5,259,211	1,314,803	1,058	1 / 1,243
	2			1,260	1 / 1,043
Ontario	1	6,236,092	1,559,023	4,331	1 / 360
	2			1,420	1 / 1,098
	3			1,494	1 / 1,043
Maritimes	1	1,439,572	359,893	3,398	1 / 106
	2			345	1 / 1,043

It would be very surprising if the proportion of buildings occupied by Chimney Swifts (Pair/ Building Ratio) in the Maritimes (1) was 9.8 times greater than in Québec (2), when the situation of traditional chimneys (closure, modification and destruction) is basically the same. Similarly, the proportion of occupied buildings in Ontario (1) is probably not 2.9 greater than in Québec (2). However, the second estimate in Ontario (2) is in the same range as the one in Québec (2), which is considered reliable. Estimates for Ontario (3) and the Maritimes (2) are also calculated based on pair per building ratio in Québec (2) in order to make a comparison with the Québec reference level in terms of Québec's Chimney Swift population abundance.

Example of a calculation using a pair per building ratio of 1/1043:

1,260 pairs ------------> 1,314,803 potential buildings in Québec

X pairs <------------ 1,559,023 potential buildings in Ontario X = 1,494 pairs

Y pairs <------------ 359,893 potential buildings in the Maritimes Y = 345 pairs

Appendix 11. Model structures and assumptions related to population viability analyses (PVA) (Akçakaya 2000)

Structure of the different models

- Fecundity estimates based on a pre-breeding census ($f_x = m_x * s_0$)
  f_x: Fecundity
  m_x: Mean number of young fledged per year
  s_0: Juvenile (HY) annual survival rate

- Unstructured models with a 2 by 2 matrix (1Y & 2+Y)
  1Y: One year-old birds
  2+Y: Birds at least two years of age

f_x 1Y	f_x 2+Y
s_1	s_1

- Replicates: 1,000
- Duration: 100 years
- Constraints active
- Demographic stochasticity active
- Females only (Fecundity *0.5)
- Initial population: 14,000 (1Y: 1,400; 2+Y: 12,600)
- Annual survival rate of adults 1Y & 2+Y, s_1: 0.63 ± 0.013 (Henny 1972)
- Annual survival rate of juveniles HY, s_0: 0.788 ± 0.219 (Kyle and Kyle 1989-2002)
- No density effect
- Fecundity estimate example: $f_x = m_x * 0.5 * x_i * 0.788 \pm 0.219$
  x_i: Proportion of individuals nesting in a specific age class (1Y or 2+Y)

Assumptions of the models

- Adults (1Y & 2+Y) annual survival rate is constant in time
- Adults (1Y & 2+Y) fecundity estimates are constant in time
- Male:Female ratio is 50:50, for adults and juveniles
- No dispersal or recruitment (emigration and immigration)
- No inbreeding
- Single population
- No mutation or selection