# COSEWIC
# Assessment and Status Report

on the

# Cerulean Warbler
*Dendroica cerulea*

**in Canada**

**ENDANGERED**
**2010**

**COSEWIC**
Committee on the Status
of Endangered Wildlife
in Canada

**COSEPAC**
Comité sur la situation
des espèces en péril
au Canada

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Cerulean Warbler — Photo courtesy: Carl Savignac.


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# COSEWIC
# Assessment Summary

**Assessment Summary – November 2010**

**Common name**
Cerulean Warbler

**Scientific name**
*Dendroica cerulea*

**Status**
Endangered

**Reason for designation**
This sky-blue forest songbird is at the northern edge of its breeding range in Canada. Relying on relatively large tracts of undisturbed hardwood forest, it has rather specialized habitat requirements on both its breeding and wintering grounds. Its population has been experiencing significant declines across most of its range since the 1960s and the present Canadian population is estimated at about only 1000 individuals. These declines are believed to be driven mostly by loss and degradation of this species' wintering habitat, which is restricted to montane forests in the northern Andes of South America. It is also threatened by habitat loss and degradation on its breeding grounds. There is evidence for continuing declines. Also, new information on demographics suggests that chances for population rescue in Canada are lower than previously thought.

**Occurrence**
Ontario, Quebec

**Status history**
Designated Special Concern in April 1993. Status re-examined and confirmed in May 2003. Status re-examined and designated Endangered in November 2010.

# COSEWIC
# Executive Summary

## Cerulean Warbler
*Dendroica cerulea*

### Description and significance

The Cerulean Warbler (*Dendroica cerulea*) is a small wood-warbler. The adult male is sky blue above and white below, while the female is blue-green above and whitish below. Both sexes have two prominent white wing-bars and white tail spots. The species has generated considerable public, scientific and conservation interest recently due to its beauty, habitat specificity, and international conservation concerns. It is considered an umbrella species that reflects the maintenance of populations of other bird species that require mature deciduous forest habitats.

### Distribution

This species breeds in the deciduous forests of eastern North America but has a patchy distribution. The Canadian breeding range consists of two main geographic clusters in southwestern and southeastern Ontario, plus a small number of breeding individuals in southwestern Quebec. It winters in a relatively narrow elevational zone in the eastern Andes of South America, from Venezuela to northwestern Bolivia.

### Habitat

On the breeding grounds, Cerulean Warblers are associated with large tracts of mature deciduous forest with tall trees and an open understory. They are found in both wet bottomland forests and upland areas. At a finer spatial scale, canopy configuration (e.g., foliage stratification, gap distribution, tree species distribution) are predictors of habitat suitability. On the wintering grounds in the Andes, they occupy a rather narrow elevational range (roughly 500-2000 m above sea level). Here, they are found principally in mature and relatively undisturbed humid forests, but will also use rustic shade-coffee, cardamom and cacao plantations that retain native trees.

## Biology

Female Cerulean Warblers lay 2-5 eggs per clutch. Only a single brood is produced per year. Generally 2-3 fledglings are produced per breeding pair and about 75% of pairs have successful nests. The species appears to have low between-year survivorship, likely due to a combination of mortality experienced during long-distance migration and low survivorship on the wintering grounds. While demographic studies across the species' breeding range have shown that nest success and fecundity in eastern Ontario are among the highest in North America, it appears that immigration from the U.S. is required to maintain the Canadian population.

## Population size and trends

The Canadian population is estimated to be 433-543 pairs (866-1086 mature individuals), most of which are found in the Frontenac Axis region of southeastern Ontario. The most recent global population estimate is 625,000 mature individuals. Hence, Canada supports roughly 0.2% of the global population.

The Cerulean Warbler's North American population experienced an average decline of about 2.9% per year from 1966 to 2006. In Ontario, recent breeding bird atlas work suggests a non-significant decline of 30% province-wide over a 20-year period (1981-85 and 2001-2005), which is equivalent to a decline of at least 16% over 10 years. More severe declines have occurred in the province's Carolinian region (at least 24% over 10 years). In Quebec, Cerulean Warblers have disappeared from five of six known sites occupied since the 1960s. Overall, the Canadian population has declined by at least 16% over the past 10 years. The potential for rescue is believed to be low, owing to ongoing population declines in the U.S.

## Threats and limiting factors

Habitat loss and degradation on the wintering grounds are believed to be the primary threats. Massive deforestation of primary montane forests of the northern Andes has occurred in recent decades, and this threat continues. The major threats on the breeding grounds are also related to habitat loss and degradation caused by some forms of intensive logging and the conversion of mature forest to agricultural lands. Habitat fragmentation, which increases nest parasitism by cowbirds and the risk of nest depredation, also seems to be an important threat. Other threats include predicted increases in catastrophic weather events (e.g., severe ice-storms and hurricanes) on the breeding grounds and during migration, decreasing habitat quality due to exotic forest pathogens and forest insect outbreaks, and increasing risks of collision with tall structures during migration.

## Protection, status and ranks

In Canada, the Cerulean Warbler was assessed by COSEWIC in May 2003 as Special Concern and is currently listed under Schedule 1 of the Canadian *Species at Risk Act*. Its nests and eggs are also protected under the *Migratory Birds Convention Act*, 1994. In Ontario, it is classified as Special Concern and receives consideration under the *Endangered Species Act, 2007*. In Quebec, effective October 2009, the species is listed as Threatened under the *Act Respecting Threatened or Vulnerable Species*. In the United States, it is of Conservation Concern and is under consideration for listing as Threatened under the U.S. *Endangered Species Act*. Globally, the species is considered vulnerable by the International Union for the Conservation of Nature. NatureServe ranks it as Vulnerable in Canada and Ontario. In Quebec, it is ranked as Severely Imperiled.

# TECHNICAL SUMMARY

*Dendroica cerulea*
Cerulean Warbler Paruline azurée
Range of Occurrence in Canada: Ontario, Quebec

**Demographic Information**

| | |
|---|---|
| Generation time (average age of parents in the population) | 2 yrs |
| Is there an [observed, inferred, or projected] continuing decline in number of mature individuals? | Yes |
| Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations] | Unknown |
| Estimated percent reduction in total number of mature individuals over the last 10 years.<br>- based upon statistically non-significant decline of 16% in probability of occurrence in 10 x 10 km atlas squares in Ontario over 10 years. This is judged to be a minimum estimate (see **Population Sizes and Trends)**. | ~16% |
| [Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations]. | Unknown, but declines are likely to continue |
| [Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future. | Unknown |
| Are the causes of the decline clearly reversible and understood and ceased? | No |
| Are there extreme fluctuations in number of mature individuals? | No |

**Extent and Occupancy Information**

| | |
|---|---|
| Estimated extent of occurrence<br>- based on a minimum convex polygon of the species' range map shown in Figure 2 | 134,308 km² |
| Index of area of occupancy (IAO)<br>- estimate based on a 2 x 2 km grid | 500-2000 $km^2$ |
| Is the total population severely fragmented? | No |
| Number of "locations"<br>- insufficient information is available to estimate number of locations in relation to threats | Unknown |
| Is there an observed, inferred, or projected continuing decline in extent of occurrence? | No; apparently stable |
| Is there an observed continuing decline in index of area of occupancy?<br>- based on a statistically non-significant 30% reduction in probability of occupancy in atlas squares in Ontario over 20 years, and reduced occupancy rates in Quebec | Yes |
| Is there an [observed, inferred, or projected] continuing decline in number of populations? | Not applicable |
| Is there an [observed, inferred, or projected] continuing decline in number of locations? | Unknown |
| Is there an observed, inferred, or projected continuing decline in area, extent and quality of habitat?<br>- yes in southwestern Ontario, Quebec and on wintering grounds; probably more stable breeding habitat currently in southeastern Ontario. | Yes |
| Are there extreme fluctuations in number of populations? | Not applicable |
| Are there extreme fluctuations in number of locations? | No |
| Are there extreme fluctuations in extent of occurrence? | No |
| Are there extreme fluctuations in index of area of occupancy? | No |

**Number of Mature Individuals (in each population)**

| Population | N Mature Individuals |
|---|---|
| Total (based on estimate of 433-543 territories) | 866-1086 |
| Number of populations (based on the genetic study by Veit *et al*. 2005) | 1 |

**Quantitative Analysis**

| | |
|---|---|
| Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years]. | Not done |

Rescue Effect (immigration from outside Canada)

| | |
|---|---|
| Status of outside population(s)?<br>U.S.: Conservation Concern (candidate for Threatened status)<br>- significant average annual decline of 2.89% per year (1966-2007) | |
| Is immigration known or possible? | Yes |
| Would immigrants be adapted to survive in Canada? | Yes |
| Is there sufficient habitat for immigrants in Canada? | Likely, but mostly in southeastern Ontario |
| Is rescue from outside populations likely? | Yes, but increasingly tempered by declines in the U.S. |

**Current Status**

COSEWIC: Endangered (November 2010)

**Status and Reasons for Designation**

| **Status:** | **Alpha-numeric code:** |
|---|---|
| Endangered | C2a(ii) |

**Reasons for designation:**

This sky-blue forest songbird is at the northern edge of its breeding range in Canada. Relying on relatively large tracts of undisturbed hardwood forest, it has rather specialized habitat requirements on both its breeding and wintering grounds. Its population has been experiencing significant declines across most of its range since the 1960s and the present Canadian population is estimated at about only 1000 individuals. These declines are believed to be driven mostly by loss and degradation of this species' wintering habitat, which is restricted to montane forests in the northern Andes of South America. It is also threatened by habitat loss and degradation on its breeding grounds. There is evidence for continuing declines. Also, new information on demographics suggests that chances for population rescue in Canada are lower than previously thought.

**Applicability of Criteria**

| |
|---|
| **Criterion A** (Decline in Total Number of Mature Individuals): Does not meet criterion; declines do not exceed thresholds. |
| **Criterion B** (Small Distribution Range and Decline or Fluctuation): Does not meet criterion. The index of area of occupancy falls within the 2000 $km^2$ threshold for Threatened, but other necessary elements are not met for this criterion. |
| **Criterion C** (Small and Declining Number of Mature Individuals): Meets Threatened C1 because the population is less than 10,000 mature individuals and there has been an estimated continuing decline of more than 10% (but probably less than 20%) over the past 10 years or 3 generations. Meets Endangered C2a(ii) because there are fewer than 2500 individuals with more than 95% in a single population. |
| **Criterion D** (Very Small or Restricted Total Population): Likely meets Threatened D1, but there is some question about the precision of current population estimates. |
| **Criterion E** (Quantitative Analysis): Not applicable |

## PREFACE

This is an update of a previous status report (COSEWIC 2003). An early reassessment of this species was warranted because considerable recent advances have been made in the knowledge of Cerulean Warbler biology. New information has been gathered from studies on demographics, dispersal and adult survival (e.g., Jones *et al*. 2004a; Barg *et al*. 2006a,b; Buehler *et al*. 2008), regional patterns of population genetic structure (e.g., Veit *et al.* 2005), information on distribution, population size and trends in Canada (e.g., Francis 2007), and aspects of the species' wintering ecology (e.g., Calderón-Franco 2006, 2007; Moreno *et al*. 2006; Bakermans *et al.* 2009). In addition, an international Cerulean Warbler working group was established in 2001 to study and conserve this species across its breeding and wintering ranges (Hamel 2004).

## COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

## COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

## COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

## DEFINITIONS (2010)

| | |
|---|---|
| Wildlife Species | A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years. |
| Extinct (X) | A wildlife species that no longer exists. |
| Extirpated (XT) | A wildlife species no longer existing in the wild in Canada, but occurring elsewhere. |
| Endangered (E) | A wildlife species facing imminent extirpation or extinction. |
| Threatened (T) | A wildlife species likely to become endangered if limiting factors are not reversed. |
| Special Concern (SC)* | A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats. |
| Not at Risk (NAR)** | A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances. |
| Data Deficient (DD)*** | A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction. |

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

Environment Canada / Environnement Canada
Canadian Wildlife Service / Service canadien de la faune
Canada

The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

# COSEWIC Status Report

on the

# Cerulean Warbler

*Dendroica cerulea*

**in Canada**

2010

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## WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

### Name and classification

The common name of *Dendroica cerulea* Wilson (1810) is Cerulean Warbler in English and Paruline azurée in French. The taxonomy of the species is as follows:

| | |
|---|---|
| Class: | Aves |
| Order: | Passeriformes |
| Family: | Parulidae |
| Genus: | *Dendroica* |
| Species: | *Dendroica cerulea* |

### Morphological description

The Cerulean Warbler is a small (8-10 g) wood-warbler. The adult male is sky blue above, white below, and has a blue-black band across its throat (Hamel 2000a). The adult female is blue-green above, whitish below (often with a yellowish wash) and has a yellow-white eyebrow or supercilium. Both sexes have two prominent white wing-bars and white tail spots. Young individuals (second-year birds) are similar to adults, but duller overall. There is little consensus, however, on what plumage colour characteristics best distinguish female age classes (Dunn and Garrett 1997; Hamel 2000a).

Confusion with other species is unlikely for adults of either sex. Immatures in their first fall can look superficially similar to young female Blackburnian Warblers (*Dendroica fusca*), but young Cerulean Warblers tend to be yellow-white below, while Blackburnian Warblers tend to be buffy. In addition, Blackburnian Warblers have pale streaking on the sides of the back, which is not seen in Cerulean Warblers (COSEWIC 2003).

### Population spatial structure and variability

Veit *et al.* (2005) assayed variation in five microsatellite loci and a 366 base-pair fragment of the mitochondrial control region among 154 Cerulean Warblers sampled from five populations throughout the breeding range (southeastern Ontario, southwestern Ontario, Illinois, Arkansas and Tennessee). No evidence of population genetic structure was found, supporting the existence of a single genetic management unit (Veit *et al*. 2005). Because inter-regional breeding dispersal of adults appears to be fairly commonplace (Veit *et al.* 2005; Girvan *et al.* 2007), all individuals in Canada are considered to belong to one population.

## Designatable units

No subspecies have been recognized for the Cerulean Warbler (Hamel 2000a). Genetic interchange occurs across the species' range (Veit *et al*. 2005). Similarly, in a study of stable isotopes, Girvan *et al*. (2007) found that long-distance dispersal of Cerulean Warblers was a fairly common occurrence. Hence, this report deals with a single designatable unit.

## Special significance

The Cerulean Warbler has generated considerable public, scientific and conservation interest lately due to its appeal, habitat specificity and population declines. It can be considered an effective umbrella species for the maintenance of populations of other species that require mature deciduous forest habitats (Jones *et al*. 2004b). In Ontario, management of forested habitats for Cerulean Warblers will likely have a positive effect on other species of interest (McCracken 1993). These include Acadian Flycatcher (*Empidonax virescens*), Louisiana Waterthrush (*Seiurus motacilla*), and Hooded Warbler (*Wilsonia citrina*; COSEWIC 2003).

No recent information is apparently available from Aboriginal Traditional Knowledge sources for this species in Canada.

# DISTRIBUTION

## Global range

Breeding

The majority of the Cerulean Warbler's population occurs in the Central Hardwoods Forest Region (Hamel and Rosenberg 2007). The species breeds mainly from north-central Minnesota, northern Wisconsin, the central Lower Peninsula of Michigan, southern Ontario, southern Quebec, New York, and western Vermont, south through Massachusetts, Connecticut, New Jersey, Pennsylvania, northern Delaware, West Virginia, North Carolina, and northern Georgia, and west to central Arkansas, Missouri and Iowa. Local breeding has also been recorded in northern Mississippi, and eastern Oklahoma, Kansas and Nebraska (Dunn and Garret 1997; Hamel 2000a; Rosenberg *et al*. 2000; Figure 1). The Cerulean Warbler is not uniformly distributed throughout its range, with notable concentrations in the Cumberland Mountains of Tennessee, the Erie-Ontario Plain of the Great Lakes Plain Ecozone including the Montezuma Wetlands complex in New York, southern Illinois, southeastern Ontario, and West Virginia (COSEWIC 2003; Rosenberg 2008).

Wintering

The Cerulean Warbler spends the winter primarily in a relatively narrow elevational zone (500-2000 m) on the eastern slopes of the Andes – from Colombia and Venezuela south through Ecuador to Peru and northern Bolivia (Ridgley and Tudor 1989; Robbins *et al*. 1992; American Ornithologists' Union 1998; Colorado and Cuadros 2006; Herzog *et al*. 2009; NatureServe 2009; Figure 1). According to Colorado and Cuadros (2006), it is more abundant on the eastern side of the Andes than on the western and central parts. About 95% of wintering records are from Colombia, Venezuela and Ecuador (U.S. Fish and Wilidlife Service 2006).

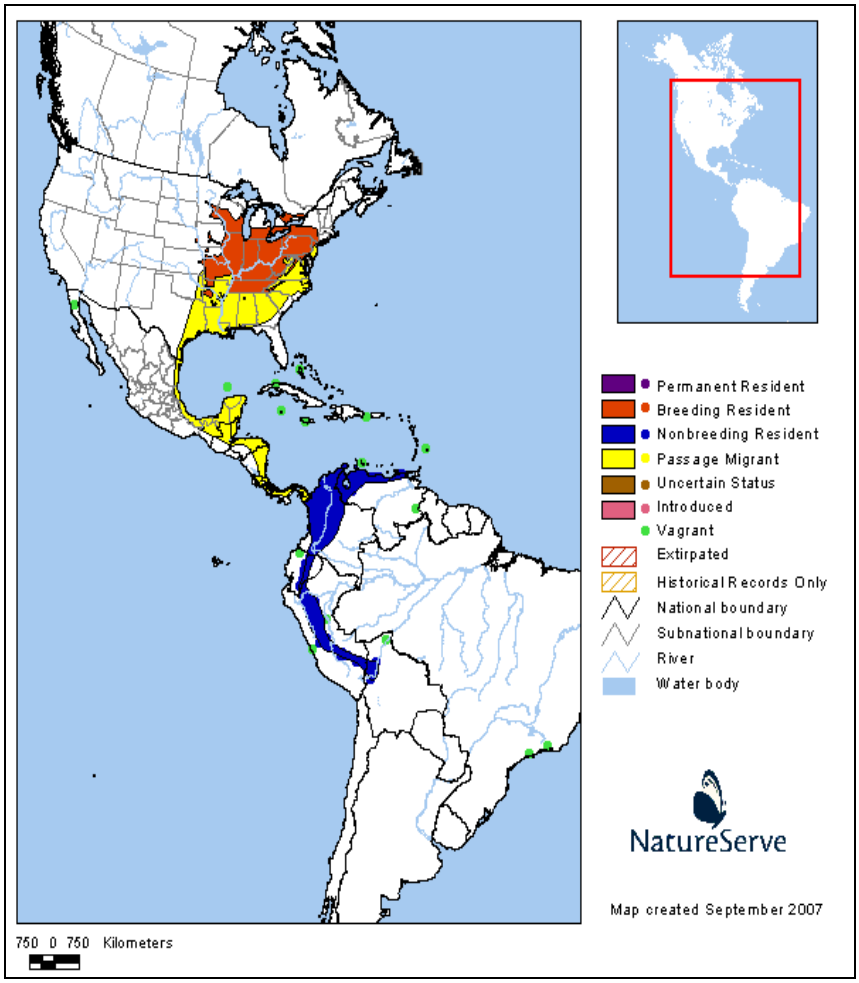


Figure 1. Global range of the Cerulean Warbler (from Ridgely *et al.* 2003). Data provided by NatureServe in collaboration with: Robert Ridgely, James Zook, The Nature Conservancy - Migratory Bird Program, Conservation International - CABS, World Wildlife Fund – U.S., and Environment Canada - WILDSPACE.

## Canadian range

The Canadian population is restricted to the Carolinian Forest zone and the southern part of the Great Lakes-St. Lawrence Forest zone (Francis 2007). No noticeable changes have been detected in the overall extent of its Canadian range since the last status report (COSEWIC 2003). Despite some local extirpations that have occurred since the first breeding bird atlas was undertaken from 1981 to 1985, Ontario still holds the two main geographic clusters (representing ≥ 95% of the Canadian population) – one in the Carolinian region, and the other extending from southeastern Georgian Bay along the Precambrian-Paleozoic interface east to the Frontenac Axis (Francis 2007). There are also a small number of breeding pairs in southwestern Quebec (C. Savignac, unpubl. data), especially south of Montérégie and in the Outaouais region, where the most northerly breeding record exists for the species in North America according to the *Centre de données sur le patrimoine naturel du Québec* (CDPNQ 2009).

In southeastern Ontario, the species was known as a breeder in the early 1900s (Broley 1929). Beginning sometime around the mid-1900s, it is thought that Cerulean Warbler populations began to expand into parts of the northeastern U.S., southern Ontario and southwestern Quebec (Ouellet 1974; Weir 1989; Bannon and Robert 1995; Sauer *et al*. 2003), likely in response to the maturation of second-growth forests. Evidence since the early 1980s, however, shows that any earlier range expansion has largely ceased (Bannon and Robert 1995; Gouvernement du Québec 2005; Francis 2007).

The Canadian range of the Cerulean Warbler roughly corresponds to 4% of the global breeding range (NatureServe 2009). The extent of occurrence in Canada is 134,308 $km^2$, as measured by a minimum convex polygon based on the range map shown in Figure 2.

A value for index of area of occupancy (IAO) cannot be calculated with precision based on the data available, but it most likely falls in the range of 500 $km^2$ to 2000 $km^2$ using the 2 x 2 km grid cell method (A. Filion pers. comm. 2010). The biological area of occupancy is estimated at 3.0-3.8 $km^2$, based on an average territory size of 0.7 ha for 433-543 territories in Canada (see **Abundance**; Barg *et al*. 2005).

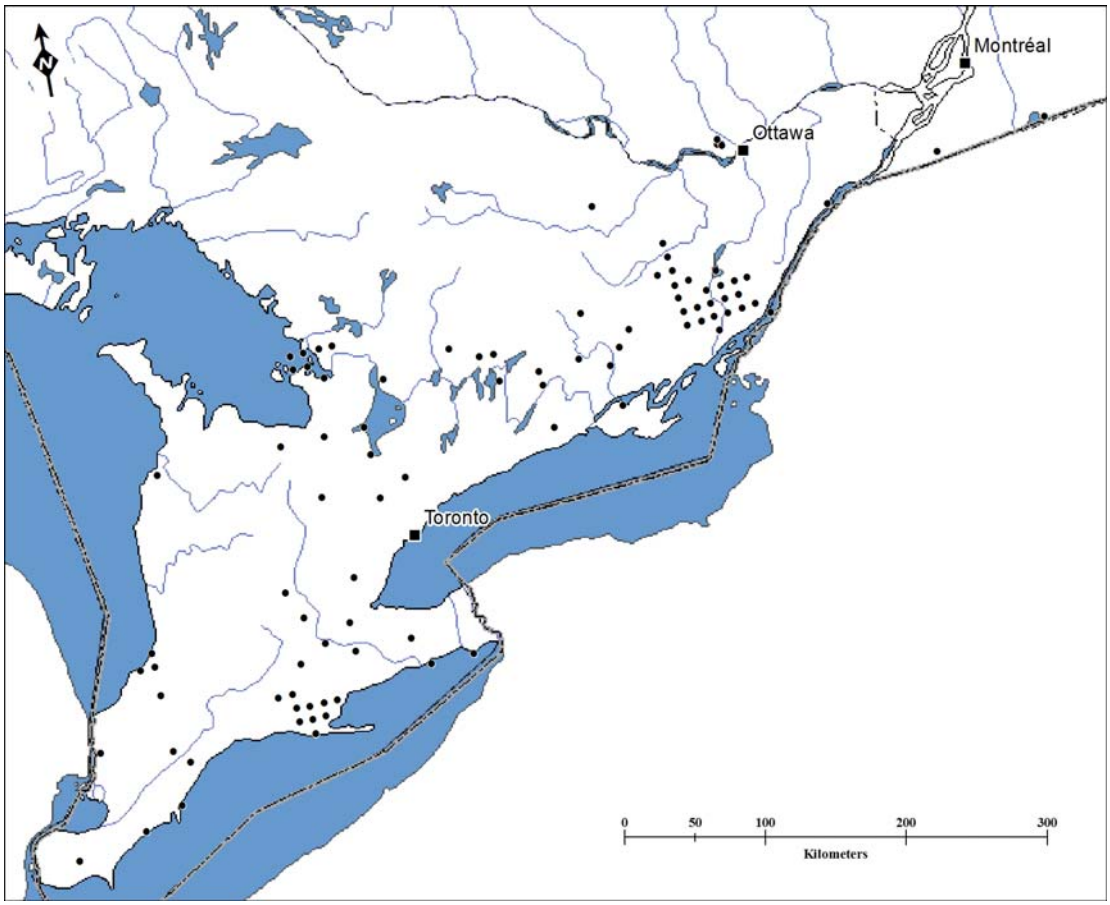


Figure 2. Current breeding range of the Cerulean Warbler in Canada (based on Cadman *et al.* 2007 and CDPNQ 2009). Black dots represent 10 x 10 km atlas squares with breeding evidence for the period 2001-2005 in Ontario and for the period 2001-2008 in Quebec.

## HABITAT

### Habitat requirements

Breeding range

Primary breeding habitat for this species is most often described as large, mature deciduous forest, typified by structurally mature hardwood species in mesic or floodplain conditions containing a closed or semi-open canopy (Peck and James 1987; Robbins *et al*. 1992; Hamel 2000b; Rosenberg *et al*. 2000; Jones and Robertson 2001; Weakland and Wood 2005; Buehler *et al*. 2006). In some regions, the distribution of Cerulean Warblers is often bimodal, with birds occurring in riparian bottomland and dry upland forests (ridgetops), but not between (Weakland and Wood 2005; Buehler *et al*. 2006; Wood *et al*. 2006; Hamel and Rosenberg 2007). In the Upper Great Lakes Plain, Cerulean Warblers are predominately associated with large, dry, upland forests embedded within a larger matrix of forested wetlands (Thogmartin *et al*. 2004).

In Canada, habitat requirements are similar to the rest of the species' range, with birds mostly occupying older deciduous forests (Peck and James 1987; Jones and Robertson 2001; Frontenac Bird Studies, unpubl. data). In Ontario, Cerulean Warblers favour mature deciduous stands dominated by oak-maple, often in association with swampy bottomlands (Frontenac Bird Studies, unpubl. data; J. McCracken pers. comm. 2010). In Quebec, Cerulean Warblers are similarly found in large, mature deciduous stands, often in bottomland forests such as those found in the Huntington and Philipsburg areas (Bannon and Robert 1995; CDPNQ 2009; SOS-POP 2009), often in the presence of permanent forest creeks, and on southwestern exposed ridges in Gatineau Park (Savignac 2005).

Cerulean Warblers exhibit strong preferences for certain microhabitats within territories (Robbins *et al*. 1992; Oliarnyk and Robertson 1996; Jones and Robertson 2001; Weakland and Wood 2005; Wood *et al*. 2006; Hamel and Rosenberg 2007; Roth and Islam 2007). Territories are usually characterized by well-spaced, large-diameter trees, with tall well-developed canopies; birds tend to avoid areas of dense understory (Hamel 2000a; Jones and Robertson 2001; Robbins *et al*. 1992; Hamel 2003; Weakland and Wood 2005; Roth and Islam 2007). It appears that canopy configuration showing a heterogeneous forest structure (e.g., foliage stratification, gap distribution, tree species distribution) may be an important predictor of breeding habitat suitability (Barg 2002). Cerulean Warblers seem to concentrate their territorial activities in core areas associated with forest canopy gaps that provide a slightly broken spatial distribution of singing post trees (Peck and James 1987; Barg *et al*. 2005, 2006a; Wood *et al*. 2005).

Males are often selective in terms of singing posts, and show a preference for large trees (Robbins *et al*. 1992; COSEWIC 2003). Because the Cerulean Warbler's song does not appear to be particularly well suited to transmission in densely forested habitats (Woodward 1995), it is hypothesized that males select core areas that help maximize song propagation through the canopy (Barg 2002). In the Lower Mississippi Alluvial Valley, males predominantly use trees that are dominant or co-dominant in the canopy. These may be any of a wide variety of species, but are most often a shade-intolerant species (Hamel 2003). Individuals spend the majority of their time foraging and singing above the middle of trees, but not right at the top (Robbins *et al*. 1992). There appears to be no consistent tree species preferred for nesting across the species range (Oliarnyk and Robertson 1996; Hamel 2000a; Jones and Robertson 2001).

Migration

During migration along the coast of Central America, Cerulean Warblers mostly use primary forests (also secondary forests and plantations) at a broad elevational range from 200 to 800 m (Ridgely and Gwynne 1989; Stiles and Skutch 1989; Parker 1994; Welton *et al*. 2007; Caycedo 2009). Little other information is available on stopover habitat (Hamel 2000b).

Wintering grounds

Most Cerulean Warblers winter on the eastern slope of the Andes Mountains of South America primarily at an elevational range corresponding to about 500-2000 m above sea level (Fundación Proaves Colombia 2006; USFWS 2006; Caycedo 2009). They are found in mature and relatively undisturbed humid evergreen forests (Robbins *et al*. 1992; Jones *et al*. 2000; Fundación Proaves Colombia 2006; Calderón-Franco 2007; Colorado *et al*. 2008; Herzog *et al*. 2009), but will also use secondary forest, as well as rustic shade-coffee, cardamom and cacao plantations that retain native trees such as guamo (*Inga* sp.) and carbonero (*Albizia* sp.; Andrade *et al*. 2006; Jahn and Valenzuela 2006; Herzog *et al*. 2009).

In Venezuela, density estimates of migrants are 3-14% higher in shade coffee plantations than primary forest sites, even after accounting for differences in detectability (Bakermans *et al*. 2009). When foraging in plantations, Cerulean Warblers rarely use the coffee trees or cardamom shrubs themselves, and prefer canopy trees – especially guamo (Calderón-Franco 2006). In Colombian shade plantations, other species frequently used for foraging include members of the *Melastomataceae*, Mango (*Mangifera indica*), a species of *Urticaceae* (cf. *Boehmeria*; Calderón-Franco 2006), Naked Albizia (*Albizia carbonaria)*, and Laurel (*Cordia alliodora*; Colorado and Cuadros 2006). In secondary forests, Cerulean Warblers have been observed feeding on insects on lianas and vines, as well as in trees such as Monkeypod (*Pithecellobium dulce)* and guamo (Colorado and Cuadros 2006).

**Habitat trends**

Breeding grounds

No information is available on the Cerulean Warbler's Canadian distribution and abundance at the time of European settlement. It is possible that the species has always been rather rare here, in part owing to climatic constraints. Still, it is assumed that Cerulean Warblers historically suffered from large-scale habitat loss from deforestation in the Great Lakes region (Eagles 1987) and probably along the St. Lawrence Valley in Quebec (Bannon and Robert 1995). In eastern Ontario, 70-80% of the original deciduous forest had been removed by the 1880s, largely through the establishment of European settlers and the logging industry (Keddy 1994; Ontario Ministry of Natural Resources 1997). Similarly, intensive agriculture and urban development have reduced forest cover in southwestern Ontario's Carolinian zone from over 80% historically to only 11% since European settlement (Ontario Ministry of Natural Resources 2000).

Over the last century, Cerulean Warblers have benefited from the abandonment of farmland in parts of their Canadian range (Oliarnyk and Robertson 1996). In southeastern Ontario, the resulting increase in average overall forest cover is expected to level out at about 40% of the land area in the foreseeable future (Oliarnyk and Robertson 1996; OMNR 1997), which could ultimately benefit Cerulean Warblers, depending on how forest lands are managed. This forest regrowth parallels what has been observed in parts of the northeastern United States over the last several decades (Askins 1993). However, such increases in forest cover have not been noted across most of southwestern Ontario.

Wintering grounds

Forests of the northern Andes located between 500 and 2000 m in altitude are among the most threatened forests in the world (Robbins *et al*. 1992; Henderson *et al*. 1991; Davis *et al*. 1997) for agriculture, fuel wood, and the cultivation of illegal drugs (Davis *et al*. 1997). In Colombia alone, primary montane forest once covered an estimated total area of 930,343 $km^2$ (World Press Review 1993; USFWS 2006), of which only 36% is thought to now remain (USFWS 2006). Similar losses have occurred for cloud forests in Ecuador and northern Peru, although habitat there has been lost at a slower rate (Dillon 1994).

The preferred wintering habitats of Cerulean Warblers occur in landscapes that are increasingly exposed to human settlement and agriculture, most notably for the production of coffee, cacao, tea, hill rice, and coca (Robbins *et al*. 1992). While the Cerulean Warbler does occur in modified forest habitats survival rates in disturbed habitats are largely unknown (Jones *et al.* 2004a). The only such information presently available comes from a study conducted in shade coffee plantations in Venezuela, which found that monthly survival rates of wintering territorial Cerulean Warblers was high, averaging 0.97 (0.90-0.99; 95% CI; Bakermans *et al.* 2009).

## BIOLOGY

### Reproduction

Cerulean Warblers are capable of breeding when one year old (Hamel 2000a). They are generally monogamous, but polygyny has been documented in about 10% of breeding males in Ontario (Barg *et al*. 2006b).

In Ontario, males arrive on nesting territories beginning in the first week of May; females start to follow a week or two later (Oliarnyk and Robertson 1996). Nest building is performed by females over a period of 5-6 days (Oliarnyk and Robertson 1996). One brood is raised per year, although second or third nesting attempts have been recorded after failure of the first nest (Hamel 2000a; Barg *et al*. 2006b; Rogers 2006). There are no published records of multiple broods (Hamel 2000a).

In Ontario, female Cerulean Warblers typically lay 2-5 eggs per clutch (modal clutch size = 5 eggs, n = 6 nests; Oliarnyk and Robertson 1996). Eggs have been found in Ontario nests from 24 May to 27 June (n = 36 nests; Peck and James 1987). Incubation is performed by the female for 11-12 days. Nestlings typically fledge after 10-11 days, usually by the first week of July (Oliarnyk and Robertson 1996).

Over an 8-year period in eastern Ontario, fecundity varied greatly, averaging 1.9 fledglings per breeding pair (Jones *et al*. 2004a). Lower fecundity rates are reported for Michigan (1.1 ± 0.2 fledglings per nest; n = 46 nests; Rogers 2006). Elsewhere in the United States, reports of fecundity range from 1.9 fledglings/nest in the Mississippi Valley to 2.5 in the Cumberland Mountains, Tennessee (Buehler *et al*. 2008).

**Survival**

The longevity record is an 8-year-old male (Jones and Barg, unpubl. data in COSEWIC 2003). Generation time is assumed to be 2 years (Veit *et al.* 2005).

Using mark-recapture models, Jones *et al*. (2004a) estimated adult male annual survival probability in eastern Ontario at 0.49 ± 0.05 (SE). No estimates are currently available for females or juveniles.

Jones *et al*. (2004a) found that average monthly survival rate of adult males during the relatively short 3-month breeding period (0.98 ± 0.01) was significantly greater than that during the longer 9-month period that encompasses migration and winter (0.93 ± 0.01). This indicates that mortality in adult males is nearly 3.5 X higher during migration and winter than during the breeding season. Jones *et al.* (2004a) suggested that relatively low survival of Cerulean Warblers during migration and winter may reflect the higher physiological stress that the birds face during lengthy migrations and/or a higher degree of habitat degradation/loss on the wintering grounds.

**Population dynamics**

A recent study among five sites across the species' breeding range, including birds in Ontario (1995-2002, n = 179 nests), estimated daily nest survival at 0.965 ± 0.004 (SE), nesting success at 40.4 ± 3.4%, number of fledglings/successful nest at 2.8 ± 0.1 and the fecundity rate (average number of female offspring/year/adult female) at 1.11 (Buehler *et al*. 2008). Generally, the populations located in more forested landscapes (Ontario and Tennessee) had the highest daily nest survival, nest success and number of fledged young/successful nest compared to populations located farther south in agricultural landscapes in the Mississippi Alluvial Valley, Indiana and Michigan (Buehler *et al*. 2008).

These demographic models also showed that populations at all five sites studied are declining more ($\lambda$ : 0.665-0.838) than predicted by the survey-wide BBS data for 1995-2005 ($\lambda$ = 0.94), suggesting that BBS had a positive bias (Buehler *et al*. 2008). According to these models, the eastern Ontario population had the highest population growth rate ($\lambda$ =0.84 ± 0.027) among the five sites studied (Buehler *et al*. 2008). Despite an apparent stability of this population (as evidenced by low annual variation in number of breeding pairs), it may not be currently reproducing at a high enough rate to accommodate adult mortality (Jones *et al*. 2004a; Buehler *et al*. 2008). To achieve population stability, the assumed female survival rates for the Ontario population would need to increase by 11% and >0.5 more female offspring would need to be produced per successful nest (Buehler *et al*. 2008). According to these authors, the Ontario population appears to be demographically capable of producing stable populations in some years when fecundity is good and when female survival rates reach a minimum of 0.65 (Jones *et al*. 2004a; Buehler *et al*. 2008), but this is difficult for a long-distance migrant songbird that apparently experiences high levels of mortality outside the breeding season (Jones *et al*. 2004a).

**Movements/dispersal**

Cerulean Warblers are long-distance, nocturnal migrants (Hamel 2000a). The bulk of their migration (both spring and fall) appears to occur along the Mississippi and Ohio River valleys and along the coastal Atlantic states (Hamel 2000a). A possible fall migration route is thought to be southward along the U.S. Atlantic Coast and Mississippi Valley, overseas across the Gulf of Mexico toward the western tip of Cuba, and offshore along the coast of Central America to the eastern side of Costa Rica and the northeastern coast of South America (Venezuela south to Ecuador; USFWS 2006). Banding, collected specimens, and observation records across South America indicate that the species begins to arrive on its wintering areas in the first week of August and that some individuals may stay as long as the second week of May (USFWS 2006).

In spring, it is suggested that in mid-March, most individuals move northward along the eastern slopes of the Andes to northern Columbia, then fly >1500 km across the western Gulf of Mexico, moving northwest until reaching land somewhere over the coast between Nicaragua and Belize. They continue inland to suitable low montane forest on the Caribbean coast (Parker 1994; Welton *et al*. 2007). During spring migration, the largest numbers of Cerulean Warblers appear to occur in southern Mexico and central Guatemala (decreasing toward eastern Honduras) at an altitude ranging from 100-1200 m (Caycedo 2009). From the Yucatan Peninsula, it is believed that spring migrants then cross the Gulf of Mexico directly north toward the coast of Arkansas and Louisiana and then move up the Mississippi River valley to their respective breeding sites (USFWS 2006).

Using stable-hydrogen isotopes in feathers, Jones *et al*. (2008) found that Cerulean Warblers across their breeding range exhibit a strong degree of migratory connectivity with a specific wintering region in South America. They exhibit a parallel migration system, whereby western breeding populations are generally connected to southwestern wintering sites and eastern breeding populations are generally connected to northeastern wintering sites (Jones *et al*. 2008).

Using stable isotopes, Girvan *et al*. (2007) found that long-distance breeding dispersal by adult male Cerulean Warblers was a fairly common occurrence, with 20 of 71 (28.2%) individuals originating from a region other than the one in which they were sampled in. This pattern of dispersal was also suggested by a genetic study that appeared to show that some individual males captured at the Queen's University Biological Station (QUBS) in eastern Ontario were hatched as far away as Illinois and Arkansas (Veit *et al*. 2005). On the other hand, long-distance natal dispersal of young birds was surprisingly uncommon at the QUBS; only 3 of 32 (9.4%) second-year birds were estimated to have hatched outside their capture region (Girvan *et al*. 2007).

**Diet and foraging behaviour**

The Cerulean Warbler is an insectivorous canopy-dweller during the breeding season, mainly consuming Homopterans, Lepidopterans (larvae), Dipterans and Coleopterans (Hamel 2000a). Nestlings and fledglings are fed larval Lepidopterans almost exclusively. No evidence exists to support the conjecture that food availability is limiting in Cerulean Warbler populations (COSEWIC 2003).

In the core of its range in the U.S., the species shows strong preference for foraging in Kingnut Hickory (*Carya laciniosa*) and Bitternut Hickory (*C. cordiformis*) and avoids foraging in Red Maple (*Acer rubrum*; Gabbe *et al*. 2002).

During migration along the coast of Mexico, Cerulean Warblers forage mainly among mixed groups of passerines (Welton *et al*. 2007; Herzog *et al*. 2009). Transient Cerulean Warblers in Central America forage in the mid-canopy layer (Welton *et al*. 2007).

In winter, they are insectivorous (lepidopteran larvae, spiders, and large flies), but will also feed on nectar (Jones *et al*. 2000; Calderón-Franco 2006; Colorado and Cuadros 2006; USFWS 2006). Gleaning insects from tree foliage seems to be the principal technique used by wintering birds in shade-coffee plantations in Colombia (Jones *et al*. 2000; Calderón-Franco 2006; Herzog *et al*. 2009). In rustic shade-coffee plantations, Cerulean Warblers glean insects from flowers and leaves of native canopy trees, but rarely forage on coffee shrubs (Jones *et al*. 2000).

## Interspecific interactions

During the breeding season, aggressive interactions between Cerulean Warblers and Least Flycatchers (*Empidonax minimus*), Red-eyed Vireos (*Vireo olivaceus*), and American Redstarts (*Setophaga ruticilla*) are common in Ontario and Quebec, but the consequences are unknown (COSEWIC 2003; Savignac 2005). Hands *et al*. (1989) suggested that Red-eyed Vireos, Northern Parulas (*Parula americana*), and Yellow-throated Warblers (*D. dominica*) are possible competitors in the United States. On the non-breeding areas, Cerulean Warblers regularly occur in mixed-species assemblages predominantly composed of resident species, but often including North American migrants such as Bay-breasted Warbler (*D. castanea*), Black-and-white Warbler (*Mniotilta varia)*, Blackburnian Warbler, Chestnut-sided Warbler (*D. pensylvanica*), and American Redstart (Jones *et al*. 2000; Andrade *et al*. 2006; Fundación Proaves Colombia 2006; Calderón-Franco 2007).

Hybridization is rare. A hybrid Cerulean Warbler × Black-and-white Warbler was collected in 1954 (Parkes 1978).

## Home range and territory

Throughout its breeding range, the Cerulean Warbler exhibits high site fidelity (Jones *et al*. 2004a; Roth and Islam 2007). It nests generally in loose colonies, likely due to conspecific attraction (Peck and James 1987; Oliarnyk and Robertson 1996; Roth and Islam 2007). Standard territory mapping techniques previously indicated that territory size averaged 1.04 ha ± 0.16 at the QUBS (Oliarnyk and Robertson 1996). More recent estimates of average territory size for this population are 0.70 ha ± 0.16 (range 0.12-2.35 ha, n = 14 males), using the Kernel Density Estimation technique, which may be a more precise approach than previous calculations (Barg *et al*. 2005).

On the wintering grounds, individuals tend to stay in one locale for the whole season (Colorado and Cuadros 2006; Bakermans *et al*. 2009). As on the breeding grounds, Cerulean Warblers exhibit high levels of between-year fidelity to particular wintering sites (Bakermans *et al*. 2009).

## Behaviour and adaptability

On the breeding grounds, the Cerulean Warbler appears to be relatively tolerant to modest levels of habitat disturbance, both anthropogenic and natural (Jones *et al*. 2000; 2001). In eastern Ontario, it breeds successfully in forests managed for the production of maple syrup and for shelterwood silviculture (Oliarnyk 1996; Jones 2000). It occupies forests exposed to group- and single-tree selection cutting in Indiana (Register and Islam 2008), uneven-age regenerated clearcut stands in West Virginia (Wood *et al*. 2005), and shelterwood cuts with prescribed burning treatments (Stoleson 2004). In Arkansas, Cerulean Warblers responded negatively to standard harvesting prescriptions involving partial cutting (thinning, and regeneration cutting and removal of mature elm trees), but tolerated this type of logging when several shade-tolerant mid-story trees are kept (Hamel *et al*. 2006).

In a study in eastern Ontario, where the amount of canopy foliage was reduced in the year following a major ice-storm, reproductive output of Cerulean Warblers declined significantly; there was also a significant increase in territory size and a significant shift in nest-site location patterns (Jones *et al*. 2001). In southern Quebec, ice storms in 1980 and 1998 may have been responsible for the local extirpation of Cerulean Warblers at one of the most important regional populations at Mont-Saint-Hilaire (Bannon and Robert 1995; Morneau 2002). While the species may tolerate habitat disruptions caused by periodic extreme weather events, this likely depends on their frequency, geographic breadth and intensity.

On the wintering grounds, the Cerulean Warbler is mostly associated with primary montane forests in a very narrow elevational zone in the Andes, which makes it particularly vulnerable to conversion to agro-forested landscapes (Robbins *et al*. 1992). Despite the already high degree of deforestation in this zone, Cerulean Warblers have shown some degree of tolerance for plantations that retain native tree species in the canopy, including rustic shade-coffee, cardamom and cacao plantations (Jones *et al*. 2000; Herzog *et al*. 2009). More studies are needed to assess how these surrogate habitats affect winter survival.

A behaviour that renders Cerulean Warblers vulnerable is their long-distance migration, which subjects individuals to high physiological stresses and can expose them to violent weather in the Gulf of Mexico (USFWS 2006). Migration has been implicated as a major cause of mortality for Cerulean Warblers (Jones *et al*. 2004a) and other wood-warblers (Sillett and Holmes 2002).

Cerulean Warblers may be vulnerable to the impact of climate change, which is expected to cause shifts in plant and insect emergence in temperate latitudes (Miller-Rushing *et al*. 2008).

## POPULATION SIZES AND TRENDS

### Sampling effort and methods

Outwardly, the lack of comprehensive survey data from large areas of unprotected private lands might suggest that the species is present in greater numbers than presently known. However, the Cerulean Warbler is quite habitat-specific. Its preferred habitat (relatively large tracts of undisturbed, mature deciduous forest) is known to be rare across its Canadian breeding range, especially on private lands that are typically subject to forest harvest regimes that target removal of all or most mature trees.

North American Breeding Bird Survey (BBS)

The BBS is a program that surveys North American breeding bird populations (Sauer *et al*. 2008). Breeding bird abundance data are collected by volunteers along roadsides at 50, 400-m radius stops spaced at 0.8 km intervals along permanent 39.2 km routes across the U.S. and southern Canada (Downes and Collins 2008). In Canada, the surveys are generally conducted in June, coinciding with the peak breeding period of most bird species, including Cerulean Warbler. Surveys start a half-hour before sunrise and last 4.5 hours (3-minute point counts at each station).

The BBS is not particularly well suited for monitoring rare species such as Cerulean Warblers because: 1) roadside sampling does not reflect the entire landscape and only covers a limited portion of the kinds of forested habitats favoured by this species (Link and Sauer 2002; Weakland and Wood 2005); and 2) 3-minute point counts likely underestimate occurrence because the species' song does not carry long distances (USFWS 2006; Robbins *et al*. 2009).

Due to the small number of routes where this species is detected in Ontario and Quebec, no BBS trend data are available for Canada (Downes and Collins 2008). BBS trends presented later in this report were obtained from survey-wide efforts (Sauer *et al*. 2008).

Ontario Breeding Bird Atlas

The second Ontario Breeding Bird Atlas is the principal source of data assessing Cerulean Warbler population trends in the core of its breeding range in Canada. This program compares the distribution of breeding birds in the 20-year period between 1981-85 and 2001-05, using data collected by volunteers who visited representative habitats within 10 x 10-km squares for at least 20 hours during the entire breeding season (Cadman *et al*. 2007). The percent change in the probability of observation of the Cerulean Warbler in Ontario over a period of 20 years was calculated by comparing the percentage of the squares with breeding evidence in the first atlas period to that in the second atlas period, adjusting for known differences in observer effort (Blancher *et al*. 2007).

Because it is based on presence/absence information, the main limitation of this method is that it underestimates change in actual population numbers for common species (Francis *et al*. 2009). However, the Cerulean Warbler is not common in most atlas squares, and overall changes in square occupancy are likely reflective of changes in abundance. Moreover, because this species is restricted to southern Ontario, where the level of search effort was high during both atlas periods, changes in effort-corrected occurrence should not be biased by sampling coverage. On the other hand, there is likely some unmeasured positive bias in the second atlas, because participants were asked to look for Cerulean Warblers at known historical sites (Francis 2007).

A major limitation of atlas projects is that they are repeated only at 20-year intervals, which means they cannot detect changes in status at shorter intervals (Francis *et al*. 2009).

Database on Quebec species at risk (SOS-POP 2009)

SOS-POP is a database including all known breeding sites for species designated as vulnerable and threatened and those likely to be designated as such by the *ministère des Ressources naturelles et de la Faune du Québec*. This database includes all records since 1966 from the *Étude des population d'oiseaux du Québec* (ÉPOQ) database, a database that assimilates checklists from birdwatchers across the province. The SOS-POP database combines all possible, probable and confirmed breeding records for all species at risk into a single database. Under the direction of regional coordinators, participants are asked to visit known species at risk breeding sites and to report their observations annually. The database is managed by the provincial coordinator of Regroupement QuébecOiseaux. There are currently 13 known sites for Cerulean Warbler in the SOS-POP database, the majority of which have been monitored since 1966.

The methods described here suggest a bias toward finding population losses, because participants are asked to visit previous breeding sites (any change in presence/absence will be a loss), rather than a random selection of sites, where change in presence/absence could be either a loss or a gain.

Queen's University Biological Station (QUBS) research studies

Located within the Great Lakes-St. Lawrence mixed-forest region in Leeds and Grenville counties in southeastern Ontario, the QUBS is a 2600-ha managed research tract characterized as mature, second-growth (between 80 and 90 years old), upland mixed deciduous forest with a canopy layer dominated by Sugar Maple (*A. saccharum*), and to a lesser extent oak (*Quercus* sp.) and elm (*Ulmus* sp.; Jones *et al*. 2004a). The study area is largely forested but is liberally interspersed with beaver meadows, abandoned farm fields, and dry, rocky ridges. The QUBS site has been the focus of several Cerulean Warbler research studies (habitat use, behavioural studies, and population dynamics) since 1994, and represents one of the best studied and largest remaining populations across the species' breeding range (COSEWIC 2003). Although these studies do not include population monitoring per se, there is considerable demographic information available for the area (e.g., Jones *et al.* 2004a; Buehler *et al*. 2008).

Ontario Birds At Risk program (OBAR)

Administered through Bird Studies Canada, OBAR maintains a database of breeding season occurrences of rare bird species in Ontario, particularly southern Ontario. In addition to atlas records, this database also includes information on Cerulean Warblers obtained through periodic, special surveys targeting forest birds at risk in the Carolinian zone.

Frontenac Bird Studies - Migration Research Foundation

The Frontenac Bird Studies program was established in 2009 (Migration Research Foundation 2009). The aim is to gather a baseline assessment of all breeding bird species within an area of 15,000 ha in Frontenac County (both private and public lands) including most of Frontenac Provincial Park, using a combination of roadside (secondary and tertiary roads) and off-road point counts. The study area is dominated (80%) by deciduous forests with relatively little agricultural or developed land. A total of 164 point count stations was surveyed (63 off-road, 101 roadside) in 2009.

Ontario Forest Bird Monitoring Program (FBMP)

The Ontario Forest Bird Monitoring Program (FBMP) is coordinated by Environment Canada. It began in 1987 and is designed to provide information on population trends and habitat associations of birds that breed in the forest interior. Sites consist of three to five stations in woodlands. Volunteers perform 10-minute point counts at each station twice between late May and early July. Its main limitation is that it is unknown how representative the study sites are of the landscape. In addition, it does not provide many detections of rare species like Cerulean Warbler.

## Abundance

The North American Landbird Conservation Plan estimated the North American population of Cerulean Warblers at 560,000 adults (280,000 pairs) based on BBS data for 1990-1999 and based on the assumption of a detection distance of 125 m from BBS survey routes (Rich *et al*. 2004). A test of this assumption in bottomland forest in Tennessee by Hamel *et al*. (2009) suggests that the detection distance is smaller (94 m; 95% CI: 88-101 m; n = 204) than the earlier estimate. A corrected estimated should be about 875,000 adults or 437,500 pairs (Hamel *et al*. 2009). More recently, Partners In Flight has updated its estimate to about 625,000 adults (P. Blancher, PIF unpublished data), shortening the detection distance from 125 m to 100 m based on Hamel *et al*. (2009), and updating the BBS data to 1998-2007. The revised lower estimate is largely a result of fewer Cerulean Warblers detected on BBS routes in 1998-2007 compared to 1990-1999 (P. Blancher pers. comm. 2010).

In Canada, the previous estimate of population size prior to the second Ontario breeding bird atlas was 500-1000 breeding pairs (COSEWIC 2003). Based on results from Ontario's second breeding bird atlas completed in 2005, this estimate still seemed reasonable to Francis (2007). At least 200 territorial birds were reported during the atlas, and the species was recorded in 86 10x10 km squares (Francis 2007).

Since the completion of the atlas in 2005, additional targeted surveys have been conducted in Ontario by Frontenac Bird Studies, Bird Studies Canada and the Ontario Ministry of Natural Resources Natural Heritage Information Centre; and in Quebec by Carl Savignac. These surveys provide a somewhat more refined population estimate for Canada, which is now estimated to support between 433 and 543 pairs (866-1086 mature individuals; see Table 1). Canada supports roughly 0.2% of the global population.

The largest concentration in Canada is found in the Frontenac Axis region of southeastern Ontario, which supports upwards of 300 pairs (Table 1). In this region, the QUBS provides habitat for about 90 pairs (D.A. Sutherland pers. comm. 2010), while up to 120 pairs are estimated to breed in Frontenac Provincial Park (D. Derbyshire pers. comm. 2009; D.A. Sutherland pers. comm. 2010), and 18 pairs in Charleston Lake Provincial Park (D.A. Sutherland pers. comm. 2010). An additional 50-60 pairs are believed to nest elsewhere in Frontenac County (D. Derbyshire pers. comm. 2009). The rest of the Ontario population is scattered in the Carolinian zone and along the southern limit of the Southern Shield region. About 80 pairs occur in pockets of concentration in Middlesex County, Norfolk County, Georgian Bay Islands National Park, Awenda and Pinery provincial parks, and Minsesing Swamp (Francis 2007; J. McCracken pers. comm. 2010; D.A. Sutherland pers. comm. 2010). Outside these areas of concentration, there are few large tracts of mature deciduous forest remaining; and it is believed that the rest of southern Ontario holds no more than 50-150 pairs in scattered sites (D. Sutherland pers. comm. 2010; J. McCracken pers. comm. 2010).

In Quebec, 6 of 13 sites having historic breeding season occurrences were occupied between 2001 and 2009 (SOS-POP 2009; Savignac 2005). Breeding pairs are distributed mainly south of the Outaouais region (four sites in Gatineau Park involving 5-10 pairs; Savignac 2005, 2006, 2007), and in the southern Montérégie region (two sites; 5-10 pairs). Considering the lack of extensive surveys on public and private lands, a rough estimate of the maximum number in Quebec is about 25 pairs.

**Table 1. Recent population estimates of Cerulean Warblers in Canada.**

| **Site/Region** | **N Territorial Males** (inferred pairs) | **N Mature Individuals** |
|---|---|---|
| Frontenac Axis Region of Ontario: | | |
| a) Queen's University Biological Station | 90 | 180 |
| b) Frontenac Provincial Park | 120 | 240 |
| c) Charleston Lake Provincial Park | 18 | 36 |
| d) Other sites in Frontenac County | 50-60 | 100-120 |
| Norfolk County | 32 | 64 |
| Skunk's Misery (Middlesex County) | 14 | 28 |
| Awenda Provincial Park | 12 | 24 |
| Georgian Bay Islands National Park/Beausoleil Island | 9 | 18 |
| Port Franks/Pinery Provincial Park | 7 | 14 |
| Minesing Swamp | 6 | 12 |
| Rest of Ontario | 50-150 | 100-300 |
| Quebec (maximum) | 25 | 50 |
| **Total** | **433-543** | **866-1086** |

## Fluctuations and trends

Ontario Breeding Bird Atlas

A comparison of the species' distribution in Ontario in the 20-year period from the first (1981-85) to the second (2001-05) atlas period shows an overall non-significant decline of 30% (P = 0.18) in the probability of occurrence (Francis 2007). The most pronounced, statistically significant decline was in the Carolinian region (-47%; P = 0.08; Francis 2007), where roughly 20% of the Canadian population of Cerulean Warblers currently resides. Over a 10-year period (roughly three generations), the above values represent a non-significant decline in occurrence of about 16% overall, and a significant decline of about 27% (equivalent to -1.6% per year; 90% CI = -3.1% to -0.1%) within the Carolinian region.

North American Breeding Bird Survey

As noted above, BBS trend data are not available for Canada because of small sample sizes. Across the species' range, several analyses were performed using new statistical approaches (Link and Sauer 2002; Sauer and Link, unpubl. data in USFWS 2006; Buehler *et al*. 2008). Hierarchical analysis probably represents the most reliable way to analyze BBS data, in which population parameters at different geographic scales are viewed as random variables, and regional variation in survey quality and a variety of

distributional assumptions about observer effects and other nuisance parameters are taken into consideration. The most recent hierarchical analysis that was conducted for the 1966-2005 period shows an average range-wide decline of 3.2%/year (95% CI = -4.2 to -2.0; P = 0.001; n = 243 routes; Sauer and Link, unpubl. data in USFWS 2006; Figure 3). This represents an overall continental decline of 73% for the 40-year period. Over the most recent 10-year period, the BBS trend is -1.9%/yr (P = 0.177, n = 125 routes), which translates to a 17% loss (P. Blancher pers. comm. 2010).

Database on Quebec Species at Risk (SOS-POP 2009)

In the Montérégie region of Québec, species at risk monitoring programs indicate that sites with breeding evidence have declined by 83% since 1966, with the species apparently disappearing from 5 of 6 sites that were followed for ≥15 years (SOS-POP 2009; CDPNQ 2009).

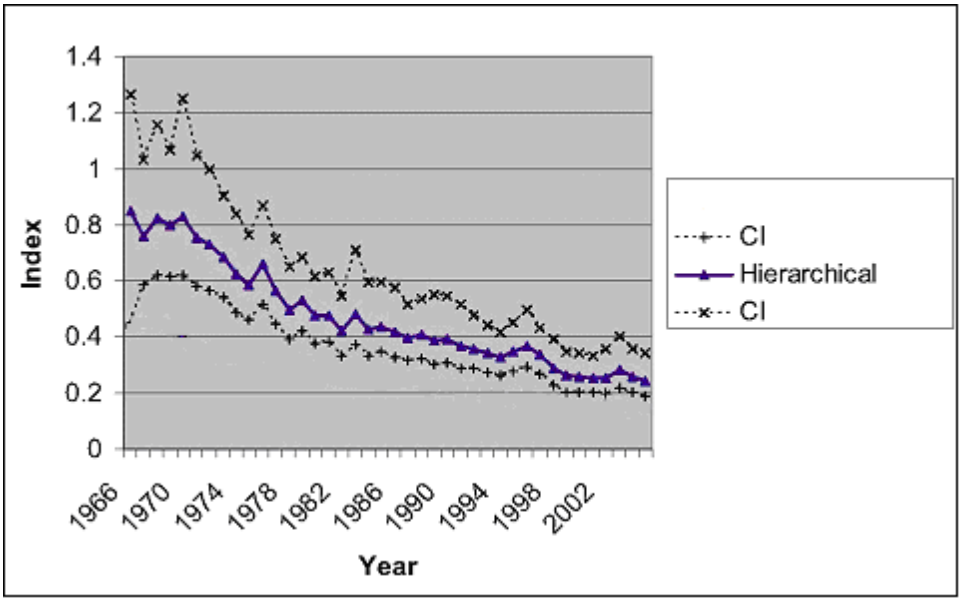


Figure 3. Survey-wide BBS hierarchical trend analysis for the Cerulean Warbler, 1966-2005, showing 95% Confidence Intervals (from Sauer and Link's unpubl. data in USFWS 2006).

Queen's University Biological Station (QUBS)

The demographic data set (1995-2004) on Cerulean Warblers in eastern Ontario indicates that the population at the QUBS has remained relatively constant over an 8-year period (Jones *et al*. 2004a). However, this persistence may be largely due to birds immigrating from other areas, because the QUBS population is not producing enough fledglings to sustain itself (Jones *et al*. 2004a), for reasons that are not clear at this time.

Ontario Forest Bird Monitoring Program (FBMP)

An analysis of FBMP data from 16 sites that supported Cerulean Warblers during the period 1987 to 2009 yielded a statistically non-significant trend averaging 2.6% per year (-11.9 to 19.5; 95% CI; R. Russell pers. comm. 2010).

**Population trend summary**

To conclude, data provided by the second breeding bird atlas in Ontario probably gives the best overall picture of Cerulean Warbler trends in the Canadian range. These results suggest that Cerulean Warblers are declining in certain parts of the province (Carolinian region) and may be somewhat more stable in others (Frontenac Axis). Monitoring of breeding sites over more than 40 years in southwestern Quebec also suggests a decline in number of occupied sites there. Outside Canada, BBS results for the U.S. suggest that the Cerulean Warbler has been declining significantly, with a decadal trend of -17% (Sauer *et al*. 2008).

Overall for Canada, the best estimate for population change is the decadal 16% decline in probability of occurrence reported in the second Ontario breeding bird atlas. Although this value was statistically not significant (P = 0.18), it is a minimum estimate, recognizing that there was an unmeasured positive bias in the second atlas. This bias occurs because a) participants were asked to look for Cerulean Warblers at known historical sites (see **Sampling Effort and Methods**), and b) disappearances from an unknown number of 10 x 10 km squares would have involved more than a single territorial pair.

**Rescue effect**

Genetic studies indicate that there is a high probability of continued gene flow between Cerulean Warbler populations in Canada and the U.S. However, the future likelihood of birds immigrating from adjacent U.S. states to augment the Canadian population is weakening, given the strength of population declines across the U.S. (Buehler *et al*. 2008). It is reasonable to assume that these population declines can be expected to continue into the foreseeable future, largely owing to continuing threats on the wintering grounds (see below). Moreover, if rescue was occurring effectively, the Canadian population should be relatively stable, which has not been the case over at least the past 20 years. As such, the available evidence suggests that the current volume of immigration from the U.S. does not appear to be sufficient to mitigate further declines in Canada.

## THREATS AND LIMITING FACTORS

### Habitat loss

Loss of humid montane forest on the wintering grounds is one of the major threats facing the Cerulean Warbler (Caycedo 2009). Areas where Cerulean Warblers winter (mainly between 500-2000 m in the Andes Mountains) are under intense pressure from human development and agriculture; it is estimated that about 60% of the natural forest habitat used by Cerulean Warblers in the Northern Andes ecoregion has already been lost (Moreno *et al*. 2006).

Threats occurring on the wintering grounds include: deforestation of forest remnants to enhance production of agro-forestry systems (mainly sun coffee and pastures); application of pesticides that reduce insect food supplies; and lack of connectivity between suitable habitats at the landscape level due to extensive areas of monocultures. Although Cerulean Warblers will use modified landscapes for overwintering and even appear to do well in rustic shade-coffee plantations (Bakermans *et al*. 2009), there is evidence of a high mortality rate sometime during the non-breeding period (Jones *et al*. 2004a). Furthermore, increasing rates of conversion of rustic shade-coffee plantation to commercial plantations of sun coffee and banana may result in future reduction of suitable habitat (USFWS 2006; Caycedo 2009).

Loss of migratory stopover habitat is also a threat to this species (Welton *et al*. 2008; Caycedo 2009). Cerulean Warblers may be particularly vulnerable to habitat loss in Central America, because spring stopovers take place in a narrow arc that includes southern Belize, eastern Guatemala, northern Honduras, and possibly northwestern Nicaragua (Welton *et al*. 2008; Caycedo 2009). In addition, substantial loss of suitable stop-over habitat for many Neotropical migrants has occurred along the Gulf coast of the U.S. (Barrow *et al*. 2005).

Habitat loss is also assumed to be a primary factor driving the decline of Cerulean Warbler populations on the breeding grounds (Robbins *et al*. 1992). Habitat loss and degradation are likely responsible for the observed decline in the Carolinian region of southwestern Ontario (Eagles 1987), but more studies are needed. In the southern United States, Cerulean Warbler populations are affected by the conversion of floodplain forests to agricultural lands, stream channelization, reservoir construction, housing, and commercial development (Robbins *et al*. 1992). Other industrial development activities happening in the core range in the northeast (e.g., ridge-top mining activities) also have significant impacts on abundance and territory density of Cerulean Warblers (Weakland and Wood 2002; Wood *et al*. 2006).

## Habitat fragmentation

The Cerulean Warbler is considered an area-sensitive species and is negatively affected by habitat fragmentation (Robbins *et al*. 1992; Hamel 2000a; Parker *et al*. 2005; Weakland and Wood, 2005; Wood *et al*. 2006). Cerulean Warblers are reported to require minimum forest tract sizes ranging from at least 10 ha in Ontario (Oliarnyk and Robertson 1996), to 138 ha in the mid-Atlantic States (Robbins *et al*. 1989) and to ≥1600 ha in the Coastal Plain (Robbins *et al*. 1992). In the mid-Atlantic States, maximum density of Cerulean Warblers occur in woodlands ≥3000 ha (Robbins *et al*. 1989). In the north and northeast portions of the range, Cerulean Warblers occupy a wide array of tract sizes, but most records are from very large tracts of forest (>2500 ha), and only 10% are found in patches ≤ 250 ha (Rosenberg *et al*. 2000). The spatial distribution of forest patches (especially distance between suitable patches) undoubtedly also plays an important role in settlement patterns and area sensitivity (COSEWIC 2003).

In a landscape dominated by coal mining development in West Virginia, Cerulean Warblers do not appear to avoid internal (soft) edges, such as roads and trails, but do appear to avoid the external (hard) edges created by mining (Weakland and Wood 2005). Territory density in intact forest is 6.5 times greater than in fragmented forests (4.6 territories per 10 ha in intact forest vs 0.7 territories per 10 ha in fragmented forest; Weakland and Wood 2005). Moreover, abundance and territory density increased with distance from the edge, and edge effects extended 340 m into the forest, which suggests that habitat near the edge is less suitable for breeding Cerulean Warblers (Weakland and Wood 2005; Wood *et al*. 2006).

Additionally, demographic models of five populations distributed across the species' breeding range suggest that populations located principally in agriculture-dominated landscapes with ≤50 % of forest cover appeared to be incapable of producing sufficient young to offset mortality, compared to populations in large, intact forested landscapes (Buehler *et al*. 2008). Cerulean Warbler populations in highly fragmented landscapes can become sink populations and extirpation can occur rapidly without immigration to offset poor reproduction and annual mortality (Buehler *et al*. 2008). In contrast, populations located in large forested landscapes (e.g., Frontenac Axis in southeastern Ontario) may be demographically capable of producing stable populations, at least in years when fecundity and survival rates are high (Buehler *et al*. 2008).

### Forest harvesting

Several studies have reported negative impacts of forest harvesting on Cerulean Warbler populations (Wood *et al*. 2005; Hamel *et al*. 2006; Register and Islam 2008). Generally, current forest harvesting practices in many regions favour short-rotations, which does not allow the forest to reach older-growth conditions and reduces forest structural diversity (Hamel *et al*. 2006). In West Virginia, Cerulean Warblers responded negatively to even-age, 15-18 year clearcuts (Wood *et al*. 2005). In Arkansas, Cerulean Warblers were reduced in abundance when harvest prescriptions included removing tall, shade-tolerant mid-story trees that are favoured by Cerulean Warblers for nesting (Hamel *et al*. 2006).

### Effects of outbreaks of forest insects and exotic forest pathogens on habitat quality

The loss of key tree species (especially oaks from Oak Wilt and Gypsy Moth outbreaks) may be negatively affecting habitat quality across the species' breeding range. The recent discovery of the European Oak Borer (*Agrilus sulcicollis*) in southern Ontario poses a serious potential threat to oak stands and Cerulean Warbler breeding habitat in Canada (D.A. Sutherland pers. comm. 2010) considering that ca. 50% of nesting trees in some areas in Ontario are in oaks (Peck and James 1987; Robbins *et al*. 1992). More studies are needed to assess the severity of this threat in Canada. Potential affects on Cerulean Warbler habitat stemming from the recent invasion of Emerald Ash Borer (*Agrilus planipennis)* into southern Ontario are presently unknown.

### Collisions with tall structures

Cerulean Warblers are known to collide with tall structures during nocturnal migration (e.g., Stoddard and Norris 1967; Shire *et al.* 2000). The intensity of this threat may be expected to continue to increase with burgeoning numbers of telecommunications towers and other tall structures across the landscape (e.g., see Avatar Environmental *et al.* 2004), but more studies are needed to assess this.

### Predation

Across the species' breeding range, principal nest predators are thought to include American Crow (*Corvus brachyrhynchos*), Blue Jay (*Cyanocitta cristata*), Eastern Gray Squirrel (*Sciurus carolinensis*), Red Squirrel (*Tamiasciurus hudsonicus*), and occasionally snakes (Buehler *et al*. 2008; Roth and Islam 2008). Potential predators in southeastern Ontario include Gray Squirrel, Blue Jay, Gray Ratsnake (*Elaphe obsoleta*) and Red-shouldered Hawk (*Buteo lineatus*; Oliarnyk and Robertson 1996).

Negative effects from nest predation pressure have been reported in several studies of Cerulean Warblers (Oliarnyk and Robertson 1996; Barg *et al*. 2006b; Rogers 2006; Buehler *et al*. 2008; Roth and Islam 2008). However, such losses seem relatively minor. For example, nest loss due to predation was only 19% in Michigan (Rogers 2006) and 14% in a study conducted in Ontario (Oliarnyk and Robertson 1996). Nevertheless, nest predation rates are significantly higher in landscapes with ≤50% forest cover within a 10-km radius, even when forest patch size is relatively large (i.e., ≥250 ha; Buehler *et al*. 2008).

**Brood-parasitism by Brown-headed Cowbirds**

A low to moderate level of brood parasitism by Brown-headed Cowbirds (*Molothrus ater*) has been documented across the Cerulean Warbler's range (Peck and James 1987; Oliarnyk and Robertson 1996; Hamel 2000a; Rogers 2006). At QUBS, parasitism by cowbirds is generally low (Oliarnyk 1996; Oliarnyk and Robertson 1996). Reported rates of parasitism include 17.9% (n = 39 nests) for Ontario (Peck and James 1987), 16% (n = 26) in Indiana (Buehler *et al*. 2008), and 25% (n = 12) in Michigan (Rogers 2006).

**Weather-related events**

Intense ice storms in the breeding range of the Cerulean Warbler are known to negatively affect breeding success and abundance of this species (Bannon and Robert 1995; Jones *et al*. 2001; Morneau 2002; Hamel *et al*. 2004). In the year following the 1998 ice storm in eastern Ontario, nest success dropped from about 70% in the first years of the study (1995-1997) to only 10% after the ice storm disturbance (Jones *et al*. 2001). Reduction in foliage cover may have rendered Cerulean Warbler nests more susceptible to predation (Jones *et al*. 2001). Similarly, small populations of Cerulean Warblers in southern Quebec appear to have disappeared in four localities and decreased in abundance in another following frequent ice-storm events (Bannon and Robert 1995; Morneau 2002). Similar effects of ice storms were also noted in Arkansas (Hamel *et al*. 2004).

Other severe climate-related events occurring during the early parts of the breeding season can negatively affect Cerulean Warblers. In 2003, two cold spells caused 29% (n = 14 nests) and 57% (n = 7 nests) nest failure in Indiana (Roth and Islam 2008).

## PROTECTION, STATUS AND RANKS

### Legal protection and status

In Canada, the Cerulean Warbler and its nests and eggs are protected under the *Migratory Birds Convention Act*, *1994* (Environment Canada 2004). COSEWIC previously assessed this species in May 2003 as Special Concern. It is presently listed under Canada's *Species at Risk Act* Schedule 1 as a species of Special Concern (Government of Canada 2009). In Ontario, it is recognized as a species of Special Concern under the *Endangered Species Act, 2007* (OMNR 2009). In Quebec, Cerulean Warblers are protected under the *Act respecting the conservation and development of wildlife* (L.R.Q., c. C-61.1; Gouvernement du Québec 2009), and it is prohibited to hunt, capture, keep in captivity, sell this species, or destroy or damage its nest and eggs. Its Threatened status in Quebec offers additional protection through the *Act Respecting Threatened or Vulnerable Species*

### Non-legal protection and ranks

Globally, the species is considered vulnerable by the International Union for the Conservation of Nature (IUCN Red List 2004; see Table 2). NatureServe ranks it as apparently secure globally (G4; NatureServe 2009). In the United States, the Cerulean Warbler is ranked as apparently secure, but is ranked as vulnerable in 11 states, imperiled in 7 and critically imperiled in 10 (NatureServe 2009). It is listed as being of Conservation Concern by the U.S. Fish and Wildlife Service and is under consideration for listing as Threatened under the U.S. *Endangered Species Act* (Ruley 2000; Salveter 2002). It is on the Partners In Flight 'Watch List' and has been identified as a top priority for conservation efforts throughout its range (Rich *et al*. 2004).

In Canada, the Cerulean Warbler is ranked as Vulnerable (N3B) by NatureServe (Table 2). In Ontario, it is is ranked Vulnerable (S3B; Table 2). In Quebec, it is ranked as Severely Imperiled (S1B; Table 2).

**Table 2. Ranks assigned to the Cerulean Warbler, based on NatureServe (2009) and General Status Ranks (Canadian Endangered Species Conservation Council (CESCC) 2006).**

| Region | Rank* | General Status |
|---|---|---|
| Global | G4 | – |
| United States | N4B | – |
| Canada | N3B | May be at risk |
| Ontario | S3B | May be at risk |
| Québec | S1B | May be at risk |
| Manitoba | – | Accidental |
| New Brunswick | – | Accidental |
| Nova Scotia | – | Accidental |
| Newfoundland | – | Accidental |

* G = global rank; N = national rank; S = subnational rank assigned to a province or state. S1 indicates that a species is critically imperiled because of extreme rarity (often 5 or fewer occurrences) or because of some factor(s) such as very steep declines, making it especially vulnerable to extirpation; S2 indicates that a species is imperiled because of rarity or other factors making it very vulnerable to extirpation, usually with 6 to 20 occurrences or few individuals remaining (i.e., 1000 to 3000); S3 indicates that a species is vulnerable at the subnational level because it is rare or uncommon, or found only in a restricted range, or because of other factors making it vulnerable to extirpation; S4 indicates a species is apparently secure; S5 indicates that a species is secure because it is common, widespread, and abundant in the state/province. A B suffix indicates that the status refers to the breeding population.

## Habitat protection and ownership

Although relatively large numbers of Cerulean Warblers are found on public lands, the bulk of potentially suitable breeding habitat in Canada is privately owned (COSEWIC 2003). For example, in eastern Ontario, about 2600 ha of prime Cerulean Warbler habitat is privately owned by Queen's University (Jones and Robertson 2001).

It has been estimated that 10-20% of the Canadian population is found on public lands, but further surveys are needed to increase the accuracy of this estimate (COSEWIC 2003). Frontenac Provincial Park, located less than 50 km west of the Queen's University Biological Station (QUBS), probably represents one of the most important nesting areas in Ontario on public land (D. Derbyshire pers. comm. 2009). Other provincial protected areas in Ontario that hold breeding pairs include Charleston Lake Provincial Park, Murphy Point Provincial Park, Awenda Provincial Park, Pinery Provincial Park, Rondeau Provincial Park, forests owned and managed by Middlesex County, and forests in Norfolk County largely owned and managed by the Long Point Region Conservation Authority (COSEWIC 2003; D.A. Sutherland, J. McCracken, and S. Lunn pers. comms. 2010). Cerulean Warblers also occur in some protected areas managed by Parks Canada, including Georgian Bay National Park (*fide* P. Nantel unpubl. data 2009) and Rideau Canal National Historic Site (*fide* V. Blazeski unpubl. data 2010). In Quebec, federal protected sites include Gatineau Park (Savignac 2005). Other protected lands in Quebec include Mont-Saint-Hilaire Natural Reserve, Mont Saint-Bruno National Park and Philipsburg Migratory Bird Refuge (Bannon and Robert 1995).

Depending on forest management regimes of land owners (e.g., tree harvest rotational periods and intensity of harvests), occurrence on “protected” lands does not necessarily confer protection for Cerulean Warblers, owing to this species’ reliance on the retention of older-growth forest attributes.

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## AUTHORITIES CONSULTED

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