

COSEWIC
Assessment and Status Report

on the

Canada Warbler
Cardellina canadensis

in Canada



SPECIAL CONCERN
2020

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada



COSEPAC
Comité sur la situation
des espèces en péril
au Canada

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

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For additional copies contact:

COSEWIC Secretariat
c/o Canadian Wildlife Service
Environment and Climate Change Canada
Ottawa, ON
K1A 0H3

Tel.: 819-938-4125

Fax: 819-938-3984

E-mail: ec.cosepac-cosewic.ec@canada.ca
www.cosewic.ca

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COSEWIC Assessment Summary

Assessment Summary – November 2020

Common name

Canada Warbler

Scientific name

Cardellina canadensis

Status

Special Concern

Reason for designation

This small songbird has 80% of its breeding range in Canada and winters in the northern Andes Mountains. Breeding Bird Survey results show that the long-term decline of the Canadian population began to slow down in 2003 and that numbers have increased steadily since 2012, with an overall growth of 46% over the past decade. However, significant threats persist, most notably clearing of forests in South America for livestock farming and other agriculture. The revised status reflects the substantial improvement in population trend since the previous assessment of Threatened, but concern remains that the species is at risk of becoming Threatened again if threats are not managed effectively.

Occurrence

British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, Yukon, Northwest Territories

Status history

Designated Threatened in April 2008. Status re-examined and designated Special Concern in November 2020.



COSEWIC Executive Summary

Canada Warbler *Cardellina canadensis*

Wildlife Species Description and Significance

Canada Warbler is a small, colourful songbird. Males are more brightly marked than females and immatures, with blue-grey upperparts and tail contrasting with a yellow throat and breast. Black stripes form a necklace on the breast, which is bolder on males than on females. Nearly 80% of the global population breeds in Canada, giving the country a large jurisdictional responsibility for conservation of this species.

Distribution

Canada Warbler breeds in all provinces and territories except Nunavut and Newfoundland and Labrador. In the United States, it breeds in several northern states and southward along the Appalachian Mountains. It migrates to overwinter in northwestern South America.

Habitat

Wet, mixed deciduous-coniferous forests with a well-developed shrub layer tend to be preferred for breeding, but Canada Warbler also uses riparian shrub forest on slopes and in ravines, and in stands regenerating after natural and anthropogenic disturbances. In its wintering range, Canada Warbler favours mature forest at altitudes of 1000 to 2000 m, but also occurs in second-growth forests, forest edges, shade coffee plantations, and other semi-open areas. During migration, the species most frequently occurs in woodlands with dense understory, including floodplain forests.

Biology

Canada Warbler breeds once annually, typically laying four to five eggs. Incubation lasts about 12 days. Chicks remain in the nest for 10 days, and are dependent on parents for 2 to 3 weeks after they leave the nest. Generation time is estimated to be 2 years.

Population Sizes and Trends

The Canadian population of Canada Warbler is estimated to be between 2 million and 10.4 million individuals. Breeding Bird Survey results for Canada indicate a cumulative

decline of 51% between 1970 and 2019, but an improving trend since around 2003, including a cumulative increase of 46% between 2009 and 2019, which has restored the population to mid-1990s levels. Trends vary regionally in Canada, with the strongest short-term increases in the core of the range in the central and eastern boreal forest, contrasting with ongoing declines in Alberta and the Maritimes. Other data sources agree with a long-term decrease in Canada Warbler population size; the majority also indicate ongoing declines in the short-term, but in many cases the most recent data are at least 5-10 years old, largely preceding the recent increase documented by the Breeding Bird Survey.

Threats and Limiting Factors

Habitat loss and degradation on the South American wintering range in the Andes are thought to be the most likely factors responsible for the long-term decline of Canada Warbler. Within Canada Warbler's wintering range, over 90% of the primary mountain forests have been cleared since the 1970s. In recent years there has been some regrowth at higher elevations in parts of the wintering range, but ongoing losses elsewhere and at lower elevations. Habitat loss has also occurred within parts of its Canadian breeding range, and along migration corridors, especially where wet forests have been drained for urban development or conversion to agricultural land (particularly in the east), or industrial expansion and road development (particularly in the west). During migration, evidence suggests the species is disproportionately vulnerable to collisions with tall buildings and other structures.

The need for forested wintering habitat in the northern Andes is a key limiting factor for Canada Warbler. The species shows some flexibility with regard to its ability to occupy shade-grown coffee plantations, but these are increasingly being converted to sun coffee cultivation, which is unsuitable for Canada Warbler.

Protection, Status and Ranks

Canada Warbler adults, nests and eggs are protected in Canada under the *Migratory Birds Convention Act, 1994*. It is also currently protected under Canada's *Species at Risk Act* as a Threatened species. It is listed as Endangered under the Nova Scotia *Endangered Species Act*, Threatened under Manitoba's *Endangered Species and Ecosystems Act* and the New Brunswick *Endangered Species Act*, and Special Concern under Ontario's *Endangered Species Act*. It is also considered Vulnerable in British Columbia and is on the list of species likely to be designated threatened or vulnerable in Quebec. Canada Warbler is considered a species of high conservation concern by Partners in Flight in Canada and the United States. NatureServe ranks it as globally secure and the IUCN ranks it as Least Concern.

TECHNICAL SUMMARY

Cardellina canadensis

Canada Warbler

Paruline du Canada

Range of occurrence in Canada: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, Yukon, Northwest Territories

Demographic Information:

Generation time (usually average age of parents in the population)	Approximately 2 years Based on IUCN estimate (Bird <i>et al.</i> 2020)
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	No Population size has been increasing since 2012
Estimated percent of continuing decline in total number of mature individuals within 5 years [or 2 generations; whichever is longer up to a maximum of 100 years]	Not applicable Population size has been increasing since 2012
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last 10 years [or 3 generations; whichever is longer up to a maximum of 100 years]	46% increase over 10 years (2009-2019) Inferred based on Breeding Bird Survey data for Canada
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations]	Unknown Projected to decline based on threats assessment, but concerns may be overestimated considering recent population size increase
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any period of 10 years [or 3 generations; whichever is longer, up to a maximum of 100 years], including both the past and future	Unknown Recent trends and future projections are contradictory
Are the causes of the decline a. clearly reversible and b. understood and c. ceased?	a. Yes, habitat loss can theoretically be reversed b. Yes, habitat loss is the primary concern c. No, some habitat loss ongoing
Are there extreme fluctuations in number of mature individuals	No

Extent and Occupancy Information:

Estimated extent of occurrence (EOO)	2.2 million km ² Calculated based on minimum convex polygon around known occurrences in the breeding range (wintering range is smaller, but has not been accurately estimated).
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Index of area of occupancy (IAO), reported as 2x2 km grid value	>20,000 km ² Based on known territory size and population estimate
Is the population “severely fragmented”, i.e., is >50% of its total area of occupancy in habitat patches that are both (a) smaller than required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. No b. No
Number of “locations” (use plausible range to reflect uncertainty if appropriate)	>10 Exact number is unknown, but numerous given the large EOO and distribution of threats
Is there an [observed, inferred, or projected] continuing decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] continuing decline in area of occupancy?	Unknown. Second-generation breeding bird atlases in Ontario, Quebec, and the Maritimes each reported a slight reduction in number of occupied atlas squares, but largely preceded the recent population rebound and occupancy may have since increased in some areas.
Is there an [observed, inferred, or projected] continuing decline in number of subpopulations?	No
Is there an [observed, inferred, or projected] continuing decline in number of “locations”?	No
Is there an [observed, inferred, or projected] continuing decline in [area, extent and/or quality] of habitat?	Yes Observed and projected declines in area, extent, and quality of wintering habitat, and to a lesser extent also breeding habitat
Are there extreme fluctuations in number of subpopulations?	No
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 (by subpopulation):

Subpopulations (give plausible ranges)	N Mature Individuals
Total Based on PIF (2019) and BAM (2020)	2 to 10.4 million

Quantitative Analysis:

Is the probability of extinction in the wild at least 20% within 20 years [or 5 generations], or 10% within 100 years]	Unknown Analysis not conducted
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Threats:

Was a threats calculator completed for this species? Yes; overall threat impact high (see Appendix 1)
Key threats were identified as: <ul style="list-style-type: none"> i. Livestock farming and ranching (IUCN 2.3), primarily on the wintering grounds – medium threat impact ii. Logging and wood harvesting (IUCN 5.3), primarily on the wintering grounds, but also to a lesser extent on the breeding grounds – medium threat impact iii. Climate change and severe weather (IUCN 11), especially drought on the wintering grounds – low to medium threat impact iv. Residential and commercial development (IUCN 1), notably collisions with tall – low threat impact v. Annual and perennial non-timber crops (IUCN 2.1), primarily on the wintering grounds – low threat impact vi. Energy production and mining (IUCN 3) – low threat impact vii. Utility and service lines (IUCN 4.2), especially collisions with communication towers – low threat impact viii. Other ecosystem modifications (IUCN 7.3) – low threat impact
What other limiting factors are relevant? Requirement for forest on its montane wintering grounds in the Andes

Rescue Effect (from outside Canada):

Status of outside population(s) most likely to provide immigrants to Canada.	Increasing United States population has increased 19% overall during the past 10 years, driven primarily by rapid growth in Minnesota and New York, but partly offset by declines in many other states.
Is immigration known or possible?	Yes
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Yes
Are conditions deteriorating in Canada?	Yes, in part (some ongoing habitat loss)
Are conditions for the source (i.e., outside) population deteriorating?	Unknown
Is the Canadian population considered to be a sink?	No
Is rescue from outside populations likely?	Unknown Population is currently growing both inside and outside Canada.

Data Sensitivity:

Is this a data sensitive species?	No
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Status History:

COSEWIC Status History: Designated Threatened in April 2008. Status re-examined and designated Special Concern in November 2020.

Status and Reasons for Designation

Status: Special Concern	Alpha-numeric codes: Not applicable
Reasons for designation This small songbird has 80% of its breeding range in Canada and winters in the northern Andes Mountains. Breeding Bird Survey results show that the long-term decline of the Canadian population began to slow down in 2003 and that numbers have increased steadily since 2012, with an overall growth of 46% over the past decade. However, significant threats persist, most notably clearing of forests in South America for livestock farming and other agriculture. The revised status reflects the substantial improvement in population trend since the previous assessment of Threatened, but concern remains that the species is at risk of becoming Threatened again if threats are not managed effectively.	

Applicability of Criteria:

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. Population has increased 46% over the past ten years.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. EOO of 2,200,000 km ² and IAO of >20,000 km ² both exceed thresholds.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. Number of mature individuals is 2 to 10.4 million, exceeding thresholds.
Criterion D (Very Small or Restricted Population): Not applicable. Estimate of 2 to 10.4 million mature individuals exceeds thresholds for D1, and population is not vulnerable to rapid and substantial decline.
Criterion E (Quantitative Analysis): Not applicable. Analysis not conducted.

PREFACE

At the time of the first status report on Canada Warbler (COSEWIC 2008), the species was considered to be in the genus *Wilsonia*; it has since been reclassified as *Cardellina*.

Many studies have been undertaken on Canada Warbler since the previous status report. These have included research aimed at understanding migration routes, identifying important wintering areas, and establishing linkages to breeding areas (e.g., Cárdenas-Ortiz *et al.* 2017; González-Prieto 2018a,b; Roberto-Charron 2018a). Other studies have focused on better understanding habitat needs on both the breeding grounds (e.g., Haché *et al.* 2014; Ball *et al.* 2016; Grinde and Niemi 2016; Hunt *et al.* 2017; Westwood *et al.* 2019) and the wintering grounds (e.g., González-Prieto *et al.* 2017; Céspedes and Bayly 2018; González-Prieto 2018a,b), as well as the role of landscape-scale disturbance during the breeding and non-breeding periods on demographic and population trends (Wilson *et al.* 2018). Collectively, the research undertaken over the past decade provides a better understanding of Canada Warbler ecology, and the relative importance of potential threats. Population trend estimates have also been refined and updated, including reanalysis indicating that the rate of decline at the time of the previous assessment was likely not as steep as reported then. Additional trend estimates have become available, including results from the Canadian Migration Monitoring Network and some second-generation breeding bird atlases.

Development of hemisphere-wide conservation efforts was launched in 2013 through creation of the Canada Warbler International Conservation Initiative (CWICI; Rosenberg *et al.* 2016). A national recovery strategy has been prepared (Environment Canada 2016).



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 (2020)

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 and
Climate Change Canada
Canadian Wildlife Service

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Canada

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

COSEWIC Status Report

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SPECIES INFORMATION

Name and Classification

Scientific name: *Cardellina canadensis*

English name: Canada Warbler

French name: Paruline du Canada

Spanish name: Reinita Canadiense

Classification: Class: Aves, Order: Passeriformes, Family: Parulidae

This species was previously placed in the genus *Wilsonia*, but phylogenetic analyses showed that it is most closely related to other species in the genus *Cardellina* (Chesser *et al.* 2011).

Morphological Description

Canada Warbler is a small, colourful songbird. Males are more brightly coloured than females and immatures, with bluish-grey upperparts and tail contrasting with a yellow neck and throat. Males have a black forehead and cheeks, which join with a necklace of well-defined black stripes that run across the breast. Both sexes have prominent yellowish-white “spectacles” around the eyes. In females, the upperparts and tail are dull bluish-grey and the throat and breast are yellow with a somewhat lighter and less distinct necklace (Reitsma *et al.* 2009).

Population Spatial Structure and Variability

No subspecies of Canada Warbler have been recognized (Reitsma *et al.* 2009), but preliminary results indicate some genetic differences between southern U.S.A. and eastern/western populations in Canada (Haché pers. comm. 2019; see below).

Designatable Units

There is no geographic variation in morphology (Reitsma *et al.* 2009). Ferrari *et al.* (2018) found evidence that there might be subpopulations based on subtle genetic structuring, and preliminary unpublished results from another analysis suggested genetic differences between individuals from the United States, eastern Canada, and western Canada (Bossu and Ruegg 2019), perhaps reflecting genetic diversity that covaries with climatic variables. Isolation by distance seems to be the predominant mechanism of differentiation across the Canada Warbler’s breeding range. Four unique ecotypes of Canada Warbler may occur, defined as North Carolina, northeast (Maritimes), Quebec (central Canada), and western boreal. However, as yet there are no known distinctions that would warrant consideration of designatable units according to COSEWIC’s definition; therefore this report is based on the species as a whole (see also **Dispersal and Migration**).

Special Significance

Canada supports nearly 80% of the global breeding population of Canada Warbler, giving it a large jurisdictional responsibility for conservation of this species. Aboriginal Traditional Knowledge was not available. However, Canada Warbler is part of an ecosystem that is important to Indigenous people who recognize the interconnectedness of all species.

DISTRIBUTION

Global Range

Canada Warbler breeds across the western and southern parts of the boreal ecoregion and much of southeastern Canada, extending south into the United States around the Great Lakes, northeastern states, and along the Appalachian Mountains as far south as Tennessee and Georgia (Reitsma *et al.* 2009; Figure 1).

Its winter range includes most of Venezuela, and the east slope of the Andes as far south as Peru (Robinson *et al.* 1995; American Ornithologists' Union 1998; Figure 1). There are also some winter records from the foothills of Panama and Costa Rica. The greatest winter abundance is in the Andes of eastern Colombia, western Venezuela, northern Peru, and southern Ecuador (Reitsma *et al.* 2009; Roberto-Charron 2018a).

During spring and fall migration, records from the Caribbean islands are rather sparse, as the species seems to mostly follow an overland route through eastern Mexico and Central America (Cárdenas-Ortiz *et al.* 2017; Roberto-Charron 2018a; see Figure 1). Recent results from unpublished geolocator data suggest that a short-distance, partial trans-gulf migration (i.e., from coastal Texas to coastal Mexico) also occurs fairly commonly (Roberto-Charron pers. comm. 2019).



Figure 1. Global range of Canada Warbler across the seasons (from Environment Canada 2016, based on multiple sources).

Canadian Range

The Canadian breeding range of Canada Warbler extends from British Columbia to the Maritimes (Figure 1). Its range includes extreme southeastern Yukon (Sinclair *et al.* 2003; Bennett pers. comm. 2019), northeastern British Columbia (Phinney 2015), the extreme southwestern corner of the Northwest Territories (Machtans and Latour 2003), northern and central Alberta (Federation of Alberta Naturalists 2007), north-central Saskatchewan (Smith 1996), south-central Manitoba (Roberto-Charron 2018b), most of Ontario except the far south and far north (Cadman *et al.* 2007), south-central and southern Quebec (Robert *et al.* 2019), New Brunswick, Prince Edward Island, and Nova Scotia (Stewart *et al.* 2015). It does not regularly occur in Nunavut or Newfoundland and Labrador.

Extent of Occurrence and Area of Occupancy

Current extent of occurrence (EOO) is approximately 2.2 million km², calculated as a minimum convex polygon around the known breeding distribution per Figure 1. This is unchanged from the previous status report (COSEWIC 2008).

The index of area of occupancy (IAO) based on 2x2 km squares has not been calculated, as the specific distribution of the species is not known. The previous status report estimated a biological area of occupancy of 27,000 km² based on a population estimate of 1.35 million pairs and a mean home range of 2 ha (Chace 2005). By the same approach, the current equivalent would be 20,000 km² to 104,000 km².

Search Effort

Recent data on the Canadian breeding distribution of Canada Warbler come primarily from breeding bird atlas projects carried out in British Columbia (Phinney 2015), Alberta (Federation of Alberta Naturalists 2007), Saskatchewan (Smith 1996), Manitoba (Roberto-Charron 2018b), Ontario (Cadman *et al.*, 2007), Quebec (Robert *et al.* 2019), and the Maritimes (Stewart *et al.* 2015). Bird checklists submitted to eBird (Fink *et al.* 2018) also provide valuable data on relative abundance and distribution, including during the non-breeding period.

HABITAT

Habitat Requirements

Breeding habitat

Canada Warbler is found in a wide variety of forest types, with preferences varying considerably by region (Crosby *et al.* 2019). In general, it is most common in wet, mixed deciduous-coniferous forest types having a well-developed shrub layer, often as a result of canopy gaps and suitable drainage and soil moisture conditions (Reitsma *et al.* 2009; Grinde and Niemi 2016; Churchill *et al.* 2017; Hunt *et al.* 2017). Across its range, Canada Warbler occurs variably in wet Red Maple (*Acer rubrum*) stands, cedar and spruce swamps, aspen stands, mixed aspen / birch / fir forests, beaver ponds, brushy slopes, riparian woodlands, and densely forested ravines (Peck and James 1987; Larue *et al.* 1995; Cooper *et al.* 1997; Drapeau *et al.* 2000; Chace 2005; Semenchuk 2007; Hallworth *et al.* 2008a; Reitsma *et al.* 2008; Chace *et al.* 2009; Stewart *et al.* 2015; Boone 2016; Westwood 2016; Roberto-Charron 2018b; Toussaint 2019; Westwood *et al.* 2019; Dufour-Pelletier *et al.* in prep.). Beaked Hazelnut (*Corylus cornuta*) and Mountain Maple (*Acer spicatum*) are particularly prominent in the shrub layer at sites favoured by Canada Warbler in central and eastern Canada (Dufour-Pelletier *et al.* in prep.). Hunt *et al.* (2017) reported that Canada Warbler occupancy is also heavily influenced by conspecific attraction.

Especially in western Canada, the species has an affinity for mature to old (>80 year) forest (Haché *et al.* 2014; Hunt *et al.* 2015; Phinney 2015; Ball *et al.* 2016; Grinde and Niemi 2016; Roberto-Charron 2018b); in Alberta, the relative abundance of Canada Warbler peaks in old (>140 year) deciduous forests (ABMI and BAM 2019). This can include upland forests, provided that there are canopy gaps that promote or allow for growth of a dense, well-developed shrub layer (Schieck *et al.* 1995; Enns and Siddle 1996; Cooper *et al.* 1997; Hobson and Bayne 2000a; Hobson *et al.* 2000; Schieck and Hobson 2000; Schieck *et al.* 2000; Cumming and Machtans 2001; Machtans and Latour 2003; Hannon *et al.* 2004, Krikun *et al.* 2018).

In western Canada, Canada Warbler is typically most abundant in unharvested forest, but it can also be common in regenerating forests (i.e., 6–30 years post-disturbance) following fire, insect, or harvesting disturbances (Titterington *et al.* 1979; Welsh and Fillman 1980; Christian *et al.* 1996; Hobson and Schieck 1999; Drapeau *et al.* 2000; Hobson and Bayne 2000b; Schieck and Hobson 2000; Hunt *et al.* 2015, 2017). In studies in northern Alberta, there was no evidence of reduced reproductive success in managed forest compared to protected areas, but population density was lower in harvested areas, and proximity to unharvested stands and conspecifics were important factors in determining the likelihood of use of harvested areas (Hunt *et al.* 2015, 2017).

Migration habitat

During migration, Canada Warbler favours areas with a well-developed shrub layer, such as forest edges, riparian habitats, and second-growth forests (Reitsma *et al.* 2009), seemingly with an affinity for floodplain forest (Power 1971), and typically foraging close to the ground in herbaceous and low woody vegetation (Keast 1980). In Mexico and northern Central America, it uses the shrub layer and upper layers of humid to semi-humid forests and forest edges from sea level to 2500 m (Binford 1989; Howell and Webb 1995). In Honduras and Panama, it occurs in open forests, second-growth forests, shrubland habitat, and mangrove forests (Monroe 1968).

Winter habitat

In Colombia, Canada Warbler occurs in mountainous areas and foothills at 750–2300 m, being most abundant at elevations between 1000-2000 m and occurring at higher densities in mature forest than in secondary forest, shade coffee plantations, forest edges, or other semi-open areas (Céspedes and Bayly 2018). In forest habitat, birds foraged at mid-levels in the canopy (5-15 m above ground). In one Colombian study, Canada Warbler was not found in landscapes having less than 20% forest cover (Colorado 2011).

In Peru and Ecuador, Canada Warbler uses rainforests on the east slope of the Andes and the adjacent lowlands (Paynter 1995). In the Venezuelan Andes, it is found in humid to wet montane forests and older second-growth forests (Hilty 2003). Throughout, it is fairly common in shade coffee plantations (Bakermans *et al.* 2009; González-Prieto 2018a), though these appear to be of lesser quality than natural forests (see **Physiology and Adaptability**).

Habitat Trends

Breeding range

Over the past century or more, some of the forested wetland habitat in the species' breeding range from southern Ontario east to the Maritimes has been drained (Tiner 1984; Reitsma *et al.* 2009) or converted to agriculture or urban areas (Gauthier and Aubry 1996). However, more recent regeneration of forest in this region following clearing in the early to mid-1900s has reclaimed patches of habitat for Canada Warbler (Reitsma *et al.* 2009). Habitat loss within the species' range in the boreal ecoregion has been more localized and related primarily to agricultural expansion, road construction and, especially in the western part of its range, also oil and gas drilling, oil sands development, and other industrial infrastructure (SSBF 1999; Hobson *et al.* 2002; Schneider *et al.* 2003; AESRD and ACA 2014; Westwood *et al.* 2019). In some areas, over-browsing by ungulates is also reducing the shrub layer, potentially reducing the suitability of some forests for Canada Warbler (Cardinal *et al.* 2012).

Net loss of forest in Canada has been ongoing, but the rate has dropped from about 64,000 ha/year in 1990 to about 37,000 ha/year in 2016, with less than 0.5% of Canada's total forest area converted to other land uses over this period (Natural Resources Canada 2018). The conversion of old growth forest and old even-growth forest to younger stands may be of greater concern, especially in the western part of the breeding range (Hobson and Bayne 2000a). Near the end of the 20th century, 60-70% of harvesting in northwestern Canada was occurring in old-growth stands (SSBF 1999).

While long-term (permanent) loss of forest cover from logging activities is largely offset by natural regeneration, tree planting, and other forest management activities (CCFM 2019), pre- and post-harvest management practices that reduce the shrub layer could adversely affect the quality of Canada Warbler habitat in managed areas (Gauthier and Aubry 1996). Further studies are needed to assess the impact of silvicultural practices on the suitability of managed forests for Canada Warbler.

Winter range

The forests of the northern Andes (primarily in Colombia), between 500 and 2000 m in altitude, were considered by Davis *et al.* (1997) to be among the most threatened forests in the world. By the early 1990s, about 90% of all primary forest in the northern Andes, including 95% of the cloud forest, had been cleared for agriculture, fuel wood, cultivation of illegal drugs, and herbicide spraying to eliminate these drug crops (Henderson *et al.* 1991; Davis *et al.* 1997). In Colombia alone, the rate of deforestation in the early 2000s was about 2000 km² per year (Butler 2006), with only 9.6% of the 2,763,523 ha of original forest in the Colombian Andes within the 1500–2000 m elevation range remaining intact (Rodriguez *et al.* 2004). Expansion of cattle pastures since the mid-1800s has been a major driver of habitat change in the Andes (Dillon 1994; Etter *et al.* 2008).

Recent habitat trends have been more mixed. There was some expansion of forest cover in Colombia over the period 2001 to 2010 (Sánchez-Cuervo *et al.* 2012). Aide *et al.* (2019) noted that from 2001 to 2014, forest loss in the Andes was most prevalent between 1000 and 1499 m elevation, whereas forest gains were observed above 1500 m. Given that Canada Warbler winters at elevations of 750 to 2300 m, and is most abundant between 1000 and 2000 m (Céspedes and Bayly 2018), the overall implications of these changes are somewhat unclear. Recent satellite monitoring observations by the World Resources Institute show that over 421,000 ha of tree cover were lost in Colombia in 2017, a 46% increase over 2016 (Clynes 2018). The recent declines are believed to be related in part to a rise in land clearing following the 2016 signing of the peace accord between the Colombian government and the Revolutionary Armed Forces of Colombia (FARC) (Salazar *et al.* 2018; Prem *et al.* 2020). Prior to signing of the accord, security risks limited economic activity in many regions of Colombia, including Andean regions that provide wintering habitat to Canada Warbler. Increased security since implementation of the accord has stimulated economic activity, particularly from larger industrial operations (Prem *et al.* 2020), resulting in loss of forest cover; these trends are projected to increase (Salazar *et al.* 2018). The Andean regions of Colombia are also one of the primary regions in Latin America where habitat for Neotropical migrant songbirds (e.g., mature and secondary forest, mosaic forest-cropland) is expected to be lost to open agriculture between now and 2050 (Wilson *et al.* 2019). One such cause is that traditional shade coffee plantations, which Canada Warbler uses frequently, are increasingly being replaced by coffee grown in full sun, which does not provide habitat for this species (Perfecto *et al.* 1996; Escobar 2013; González-Prieto 2018a,b; Wilson *et al.* 2019).

Migration habitat

In the southern U.S. and Mexico, forest loss along the Gulf coast has been occurring due to urban and commercial development, agriculture, livestock grazing, logging, and the spread of exotic species (see Barrow *et al.* 2005).

BIOLOGY

Life Cycle and Reproduction

Generation time for Canada Warbler is estimated at 2 years by BirdLife International (Bird *et al.* 2020), taking into account its age at first breeding (1 year; Reitsma *et al.* 2009), maximum life span (~8 years; Klimkiewicz *et al.* 1983), and average annual adult survival rate of 0.51, considered low for a small landbird (Albert *et al.* 2016). This estimate of adult survival is consistent with the estimate of 0.47 (std = 0.027; CV = 5.7%; range = 0.44 to 0.54) derived from the Monitoring Avian Productivity and Survivorship program (MAPS; DeSante *et al.* 2015). Wilson *et al.* (2018) found apparent survival probability to be higher in the central part of the breeding range, compared to western or eastern.

Nests are on or near the ground and used only once. They are well-concealed by dense, low vegetation (e.g., moss hummocks, upturned tree roots, small hillocks with deep

leaf litter and dense saplings) and are difficult to find (Reitsma *et al.* 2008, 2009; Goodnow and Reitsma 2011).

In high-quality breeding habitat, Canada Warbler breeding territories are often clumped near one another in “neighbourhoods” (Reitsma *et al.* 2009; Hunt *et al.* 2017). In various studies, average territory sizes range from 0.2 ha to about 1 ha (Chace 2005; Machtans 2006; Hallworth *et al.* 2008a; Reitsma *et al.* 2009; Flockhart *et al.* 2016). Average home range size ranges from 1 to 2 ha (Chace 2005; Hunt *et al.* 2015).

The egg and nestling stages in Canada can last from the end of May to end of July (Rousseu and Drolet 2017). The typical clutch size is four to five eggs, with one brood produced annually (Peck and James 1987; Reitsma *et al.* 2009). Incubation lasts about 12 days; chicks remain in the nest for about 7-9 days, and are dependent on parents for 2 to 3 weeks after they leave the nest (Reitsma *et al.* 2009). Fledging brood size averages about 3.8 young (Reitsma *et al.* 2009).

Physiology and Adaptability

Canada Warbler requires a well-developed shrub layer in its breeding habitat. Given this, it exhibits a certain degree of adaptability to human disturbances such as forest harvesting, as well as natural disturbances (e.g., fire, wind, insect defoliation).

Harvest intensity (e.g., single-tree selection versus clearcuts) is important. Canada Warbler readily occupies forests that are regenerating following harvesting, particularly stands between 6-20 years post-harvest in the east (Lambert and Faccio 2005) and 20-30 years post-harvest in the west (Hobson and Schieck 1999; Schieck and Hobson 2000; Hunt *et al.* 2015). This is because the shrub layer peaks during early regeneration stages (Sodhi and Paszkowski 1995; Norton and Hannon 1997; Tittler *et al.* 2001). Similarly, it occupies stands recovering from fire (Hobson and Schieck 1999; Schieck and Hobson 2000), although it tends to be less abundant there than in stands regenerating from harvest (Hobson and Schieck 1999).

Canada Warbler appears to be relatively tolerant of habitat fragmentation that results from forest harvesting (Schmiegelow *et al.* 1997; Ball *et al.* 2016). This may be because a well-developed shrub layer often regenerates adjacent to the fragments following harvesting (Schmiegelow *et al.* 1997), but occupancy is influenced by the availability of surrounding suitable habitat (Sólymos *et al.* 2015). Canada Warbler is less tolerant of forest fragmentation associated with agriculture, which has a more permanent impact (Robbins *et al.* 1989; Hobson and Bayne 2000c).

On its wintering grounds, Canada Warbler makes heavy use of shade coffee plantations (Finch and Stangel 1993; Bakermans *et al.* 2009; González-Prieto 2018a,b). Compared to natural forest, coffee plantations appear to offer less food over the course of the winter (González-Prieto 2018a); however, no differences in apparent annual survival were observed between individuals that overwintered in shade coffee versus native forests (González-Prieto *et al.* 2020).

Canada Warbler feeds primarily on flying insects (e.g., Diptera and Lepidoptera) and spiders in the shrub layer, which explains a previous common name – “Canadian Flycatcher” (Reitsma *et al.* 2009). It uses a variety of foraging techniques, including fly-catching, sallying, hover gleaning, foliage gleaning, and ground gleaning (Reitsma *et al.* 2009). Although not considered a Spruce Budworm (*Choristoneura fumiferana*) specialist, Canada Warbler has been reported to respond to budworm outbreaks (Crawford and Jennings 1989; Sleep *et al.* 2009). These studies were correlative and later refuted by Venier and Holmes (2010) and Venier *et al.* (2012). A more recent study concluded that there may be local or regional effects on Canada Warbler populations resulting from budworm outbreaks, but that they are perhaps driven by short-term changes in forest structure, such as proliferation of shrub growth following tree defoliation (Drever *et al.* 2018). Walker and Taylor (2020) also found a positive correlation between Spruce Budworm indices and both spring and fall trends.

Dispersal and Migration

Territory fidelity was considered high by Reitsma *et al.* (2009). Average site fidelity of adult males returning in one study in New Hampshire was estimated to be 52% across four years (Hallworth *et al.* 2008a). Because this was a single study area, these results for fidelity do not necessarily contradict the lower survival results (47%) reported earlier from a much larger geographic scale and time period (see **Life Cycle and Reproduction** above).

Canada Warbler is a long-distance (neotropical), nocturnal migrant (Reitsma *et al.* 2009). It arrives on its breeding grounds later in spring than many other species of wood warbler, and departs on its southbound migration early in fall (Flockhart 2007; McLaren 2007). Spring arrival is typically between mid-May and early June in most of Canada, while fall migration can begin as early as mid-July, and overall peaks in Canada from late August to early September (NatureCounts 2020; Bégin-Marchand *in review*).

The species may exhibit some migratory connectivity between its breeding and wintering grounds, but the pattern is not clear. Based on results from feather isotope analyses, Canada Warblers originating from the eastern part of the species’ breeding range tend to overwinter in the eastern Andes, whereas birds wintering in the western Andes tend to breed in western North America (González-Prieto *et al.* 2017; González-Prieto 2018a). This geographic segregation, coupled with differential rates of loss/degradation of wintering habitat in the eastern and western Andes, could explain the stronger population declines observed in eastern North America than in the west (Wilson *et al.* 2018; see **Fluctuations and Trends**). However, results from a tracking study using light-sensitive geolocators found that individuals from western, central, and eastern parts of the breeding range all funnelled through a small area along the western Gulf of Mexico, with 72% (N = 25) of them overwintering in Colombia, and no evidence of population-specific migration routes (Roberto-Charron 2018a, 2020). Both technologies have limitations and imprecision, so more research is needed to better determine the strength of migratory connectivity of the species.

Interspecific Interactions

No specific information is available on interactions with predators (Reitsma *et al.* 2009), though Red Squirrel (*Tamiasciurus hudsonicus*) is thought to be an important nest predator in Alberta (AESRD and ACA 2014; Flockhart *et al.* 2016).

Peck and James (1987) reported a 20% rate (N = 25) of parasitism of Canada Warbler nests by Brown-headed Cowbird (*Molothrus ater*). However, cowbird parasitism is not thought to be a major factor affecting nest success of boreal songbirds (AESRD and ACA 2014), and the overlap in peak abundance between the two species is relatively minor (Cadman *et al.* 2007). Although Canada Warbler is regularly parasitized in more southerly regions (see Reitsma *et al.* 2009), the extent to which this is a factor in Canada is likely more limited.

Like other forest songbirds, Canada Warbler is territorial during both the breeding and wintering seasons. Antagonistic interactions occur with other warblers during the breeding season, and within mixed-species flocks during dispersal, migration, and on the wintering grounds (Ridgely and Gwynne 1989; Hobson and Van Wilgenburg 2006; Reitsma *et al.* 2009), but have not been reported to have any population level impacts.

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Several bird monitoring programs capture information on abundance and/or distribution of Canada Warbler and can be used to estimate population trends. In addition to the sources listed below, eBird is anticipated to soon become a valuable tool for such analyses (e.g., Walker and Taylor 2017; Horns *et al.* 2018), but results are not yet available for Canada Warbler.

The Breeding Bird Survey (BBS)

The Breeding Bird Survey (BBS) is a large-scale program that monitors breeding bird populations across North America (Hudson *et al.* 2017). Breeding bird abundance data are collected by volunteers at 50, 400-m radius stops spaced 0.8 km apart along permanent 39.2-km routes. In Canada, the surveys usually take place in June during the breeding season of most forest birds and are conducted from 0.5 hour before to about 4.5 hours after sunrise. The BBS provides medium reliability in terms of geographic coverage for Canada Warbler in Canada (Smith pers. comm. 2018), and there are issues with bias associated with roadside detection for this species (Haché *et al.* 2014). Still, it is the best available source of population trend information.

Breeding Bird Atlas Projects

Provincial and state breeding bird atlas projects are normally carried out within a period of about five years and are designed to be repeated at 20-year intervals. They provide 20-year snapshots of species' breeding distribution and abundance. When repeated, they also give information on change in both the extent and area of occupancy. In Canada, atlas projects have been completed (or have begun) in all provinces except Newfoundland and Labrador. To estimate change in status, atlas projects must be repeated; such repeat surveys have occurred only in Alberta, the Maritimes, Quebec, and Ontario, in addition to several states in the U.S.

The second Ontario breeding bird atlas compared the province's distribution of breeding birds between 1981-1985 and 2001-2005 (Cadman *et al.* 2007). Data were gathered by volunteers who visited 10 x 10-km squares during the breeding season. The percent change in rate of occurrence in Ontario over the period of 20 years was then calculated by comparing the percentage of the 10 x 10-km squares with breeding evidence in the first atlas period to the percentage of squares with breeding evidence in the second atlas, adjusting for observation effort (Cadman *et al.* 2007). This program covered the entire breeding range of the species in Ontario.

Second breeding bird atlas projects that have been carried out in the Maritimes (2006-2010; Stewart *et al.* 2015) and Quebec (2010-2014; Robert *et al.* 2019) are based on similar methodologies to those developed in Ontario. Because atlas projects provide snapshots across long time periods (usually at 20-year intervals), they are not sensitive measures of short-term change.

Ontario Forest Bird Monitoring Program (FBMP)

The Ontario Forest Bird Monitoring Program began in 1987 and is coordinated by the Canadian Wildlife Service. Its objective is to document forest bird population trends and the relationships between the birds and their habitat during the breeding period in relatively unfragmented forest landscapes (Canadian Wildlife Service 2008). Volunteers use point counts to survey birds in both large forest areas and forest fragments. One of the limitations of this program for monitoring Canada Warbler is that the species occurs at relatively few sites. In addition, the survey is biased towards relatively intact, unmanaged mature forests. The most recent trend estimates currently available are from 2011 (Cadman pers. comm. 2019).

Canadian Migration Monitoring Network

This program is designed to monitor populations of migratory passerines at a series of over 20 monitoring stations across Canada. Fall migration, in particular, reflects the annual productivity and abundance of birds breeding in the boreal forest, as they move from their northern breeding grounds to their southern wintering areas (Crewe *et al.* 2008). The primary activities carried out at these stations are daily bird banding and visual counts of birds during spring and/or fall migration. The program assumes that the number of birds

detected at each station is proportional to the actual number of birds migrating on the days monitored. A major limitation is that the geographic origin of birds is not well understood, especially for northern species like Canada Warbler. Only stations and seasons with adequate data to monitor Canada Warbler migration were considered, i.e., those covering at least 75% of the migration window, and with a clear migratory surge during the station's coverage period (3-4 times the level of local birds pre- and/or post-migration).

Boreal Avian Modelling (BAM) Project

The Boreal Avian Modelling (BAM) Project was developed to improve understanding of the ecology of boreal birds and their habitats, and to project the impacts of climate change and industrial development on bird populations and distribution (Boreal Avian Modelling Project 2019). It is built on a vast data set derived from tens of thousands of bird point-counts that have been collated from a large number of partners from governments, environmental organizations, industries, consultants, and academia, including the BBS and breeding bird atlases. BAM is most useful for studying patterns of relative abundance across the boreal forest and for investigating habitat relationships, but may not be as suitable for population trend analysis because data are less uniformly standardized than the BBS and are primarily from a shorter time period. As with the BBS, a potential source of bias is that most point counts in the database are conducted on or near roadsides, although BAM analyses allow for this factor to be accounted for in models.

Abundance

According to the most recent abundance estimates derived largely from BBS data, Canada Warbler populations in North America total 2.6 million individuals, with about 2 million occurring in Canada, or about 77% of the global population (PIF 2019). The most recent analysis by BAM estimates a range of approximately 9.2 to 10.4 million individuals in Canada (BAM 2020). This difference may be a function of the greater roadside bias of the BBS, coupled with differences in how detection distances were estimated (Haché *et al.* 2014). Which estimate is most accurate is uncertain, but all results greatly exceed COSEWIC quantitative thresholds for status assessment based on population size. It is important to note that the sources of bias underlying these differences have a greater influence on estimates of absolute abundance than they do on trends; therefore the discrepancies in population size do not undermine the reliability of population trends derived from the BBS.

The latest Partners in Flight abundance estimates show that breeding populations are largest in Ontario, Quebec, and Manitoba, which together comprise 79% of the Canadian total (see Table 1; PIF 2019).

Table 1. Regional population size estimates for Canada Warbler in Canada; note that the national estimate is different from the sum of regional estimates (from PIF 2019).

Region	Population Estimate	Lower 95% bound	Upper 95% bound
Northwest Territories	20,000	0	67,000
British Columbia	26,000	0	83,000
Alberta	170,000	29,000	370,000
Saskatchewan	110,000	34,000	200,000
Manitoba	330,000	100,000	640,000
Ontario	820,000	510,000	1,200,000
Quebec	460,000	260,000	740,000
New Brunswick	90,000	39,000	160,000
Nova Scotia	20,000	9,300	35,000
Prince Edward Island	280	0	1,200
Canada	2,000,000	1,500,000	2,700,000

Fluctuations and Trends

Breeding Bird Survey

Although there is a roadside bias to the BBS, it is nonetheless considered the best available estimator of Canada Warbler population trends as it provides the greatest spatial and temporal coverage of all surveys, and any biases are expected to have remained relatively consistent over time. Long-term BBS data for Canada show an average annual trend estimate of -1.46%/year (95% Credible Interval [CI] = -2.29%, -0.61%) between 1970 and 2019, amounting to a cumulative long-term change estimate of -51.4% (95% CI = -67.8, -26.1; Table 2). At a provincial scale, long-term declines are steepest in the Maritimes and Quebec (Table 2).

Table 2. Short-term (2009-2019) and long-term (1970-2019) population trends for Canada Warbler in Canada, based on Breeding Bird Survey data; bolded trends have 95% credible intervals that do not cross zero and are highly likely to represent a substantial rate of change (A. Smith, unpubl. data). The low reliability of most short-term trends is a function of precision being limited by sample size over a small number of years.

Region	Annual % Rate of Change (95% Lower/Upper Credible Intervals)	Cumulative % Change (95% Lower/Upper Credible Intervals)	Probability of decline >30%	# routes	Reliability
Short-term					
Canada	3.85 (1.14, 7.17)	45.9 (12.0, 99.8)	0	333	Medium
Alberta	-1.62 (-7.47, 4.57)	-15.1 (-54.0, 56.3)	0.27	14	Low
Saskatchewan	3.27 (-7.36, 15.19)	38.0 (-53.4, 311.1)	0.11	6	Low
Manitoba	2.45 (-2.72, 8.10)	27.3 (-24.1, 117.9)	0.01	21	Low
Ontario	1.85 (-1.85, 5.95)	20.1 (-17.0, 78.2)	0	115	Low
Quebec	7.39 (2.81, 12.91)	104.0 (32.0, 237.0)	0	113	Low

Region	Annual % Rate of Change (95% Lower/Upper Credible Intervals)	Cumulative % Change (95% Lower/Upper Credible Intervals)	Probability of decline >30%	# routes	Reliability
New Brunswick	-8.02 (-12.34, -3.32)	-56.6 (-73.2, -28.7)	0.97	31	Low
Nova Scotia & Prince Edward Island	-2.74 (-8.26, 2.70)	-24.3 (-57.8, 30.5)	0.39	32	Low
Long-term					
Canada	-1.46 (-2.29, -0.61)	-51.4 (-67.8, -26.1)	0.96	415	High
Alberta	-2.95 (-6.00, 0.07)	-76.9 (-95.2, 3.5)	0.92	19	Medium
Saskatchewan	0.44 (-3.30, 4.35)	24.0 (-80.7, 707.4)	0.27	11	Low
Manitoba	-0.70 (-2.84, 1.56)	-29.1 (-75.6, 113.1)	0.49	22	Medium
Ontario	-1.20 (-2.26, -0.15)	-44.5 (-67.3, -7.2)	0.80	141	High
Quebec	-1.40 (-2.80, -0.01)	-49.9 (-75.1, -0.4)	0.83	143	High
New Brunswick	-5.66 (-6.71, -4.59)	-94.2 (-96.7, -90.0)	1.00	40	High
Nova Scotia & Prince Edward Island	-3.09 (-4.48, -1.81)	-78.5 (-89.4, -59.1)	1.00	36	High

Over the last decade (2009-2019), BBS data indicate that declines have reversed in some parts of Canada including Quebec, northern and southern Ontario, northern and eastern Manitoba, and Saskatchewan, but that declines continue in Alberta, central Ontario, and the Maritimes (Figure 2). BBS data for the most recent 10-year period (2009-2019) estimate an average annual increase of 3.85%/year (95% CI = 1.14% to 7.17%; Table 2), which amounts to an increase of 45.9% (95% CI = 12.0, 99.8) over the 10-year period, with zero probability of a reduction of >30%. The annual rate of increase was highest in Quebec, at 7.39% (95% CI = 2.81, 12.91), corresponding to a cumulative increase of 104% (95% CI = 32, 237). Only New Brunswick has continued to experience a substantial decline (-8.02%/year, 95% CI = -12.34, -3.32) during this time span, corresponding to a 0.97 probability of a reduction of >30%. At a national scale, the plot of annual indices of abundance indicates that population size as of 2019 is comparable to levels from the mid-1990s (Figure 3).

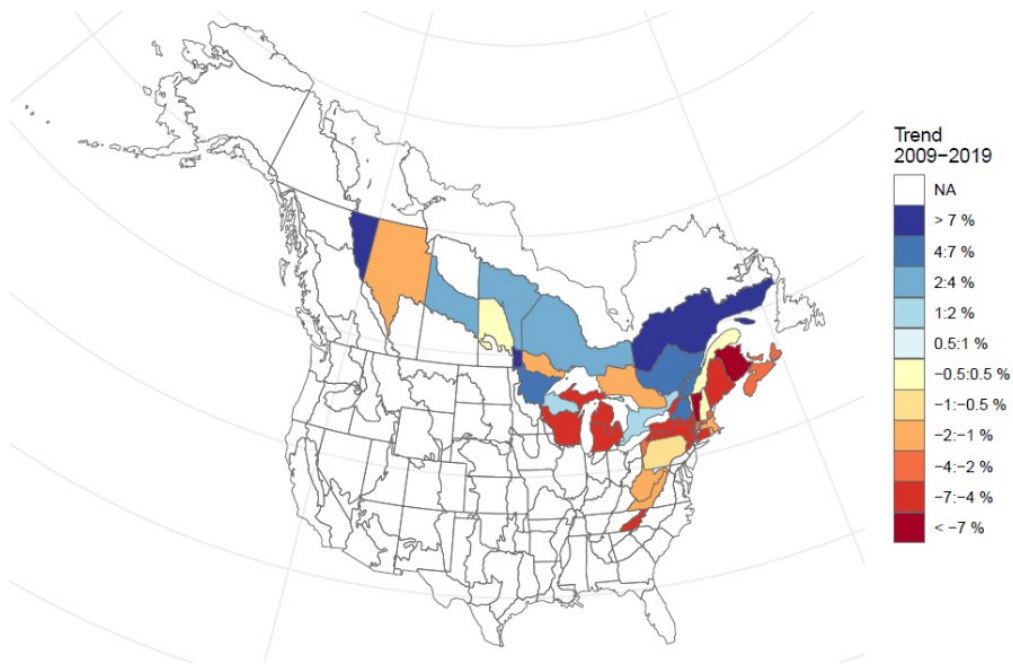


Figure 2. Short-term (2009-2019) annual rates of population change estimated from Breeding Bird Survey data for Bird Conservation Regions within provinces and states with sufficient data to estimate trends for Canada Warbler (A. Smith, unpubl. data).

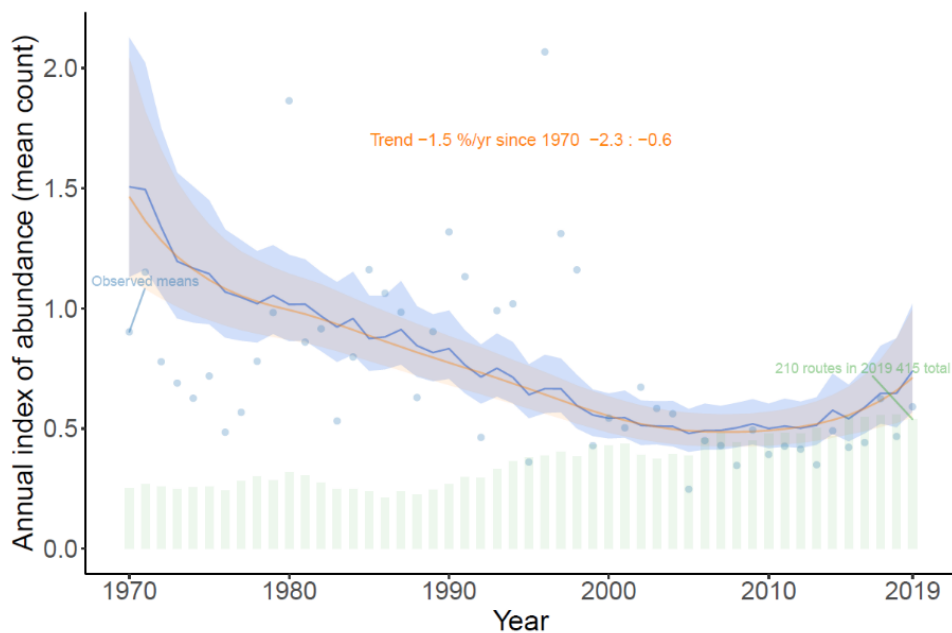


Figure 3. Annual index of population abundance for Canada Warbler in Canada, based on Breeding Bird Survey data from 1970-2019 (N=415 routes). The GAM (generalized additive model) trend in orange represents the best curvilinear fit of data, whereas the slope trend in blue represents a straight-line comparison between start and end points. Orange (appearing grey in areas of overlap) and blue shading, respectively, show 95% credible intervals for the GAM and slope trends; green bars indicate the number of survey routes in Canada with Canada Warbler detections.

Rolling 10-year population trends for Canada Warbler in Canada based on BBS data from 1995 to 2019 show they have been improving annually over the past 15 years, and have been consistently positive since 2012 (Figure 4). At the time of the previous status report, the short-term trend was reported as -43% over 10 years (1997-2007; COSEWIC 2008). However, revised analysis of BBS data using a newer generalized additive model approach, which provides more accurate estimates of short-term trends than the previous method, indicates that the value at that time was actually -23% (Figure 4).

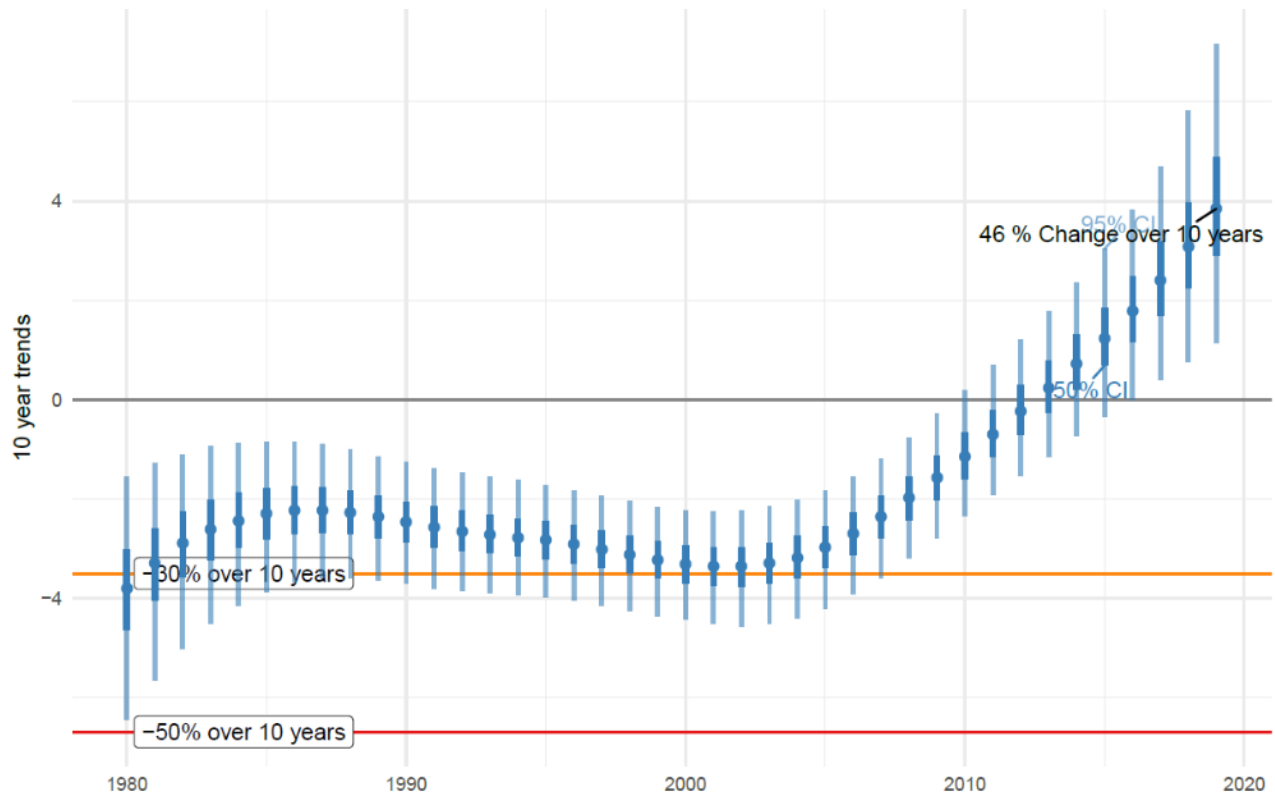


Figure 4. Rolling 10-year trends of Canada Warbler population change in Canada based on Breeding Bird Survey data from 1995 to 2019 (A. Smith pers. comm. 2020). The orange and red horizontal lines show the 10-year trends for COSEWIC threshold declines of 30% and 50%, respectively. Each point estimate represents the 10-year trend ending in a particular year. Vertical bars represent the 50% (dark blue) and 95% (light blue) credible intervals.

Breeding Bird Atlas Projects

Repeat breeding bird atlas projects conducted in eastern North America generally show a decline in Canada Warbler occupancy rates over approximately 20-year time periods (see Table 3). Converted to 10-year time frames, the Canadian values in Table 3 give losses of 5% to 11%. This is indicative of regional reductions in measures of both area of occupancy and in abundance. However, the Maritimes and Ontario results largely to entirely precede the 2009-2019 short-term assessment window, and correspond to a period when BBS data were also indicating declines. The second Quebec atlas is somewhat more recent, and the decline in probability of observation relative to the first Quebec atlas

contrasts with the increase observed through the BBS. Direct comparison is complicated though, as the BBS trend appears to be driven by particularly high counts in the five years after the second atlas survey period ended.

Table 3. Changes in Canada Warbler occurrence across two periods for breeding bird atlas projects in eastern North America.

Region	Period	% Change in Occurrence	Reference
Ontario	1981-85 vs 2001-05	-15%	Cadman <i>et al.</i> (2007)
Quebec	1984-89 vs 2010-14	-25%	Toussaint (2019); M. Robert pers. comm. 2019)
Maritimes	1986-90 vs 2006-10	-9%*	Stewart <i>et al.</i> (2015)
Alberta	1987-92 vs 2000-05	“unchanged distribution”	Semenchuk <i>et al.</i> (2007)
Ohio	1982-87 vs 2006-11	“stable”	Boone (2016)
New York	1980-85 vs 2000-05	-23%	McGowan and Corwin (2008)
Vermont	1977-81 vs 2003-07	-31%	Lambert and Reitsma (2013)

*Maritimes atlas results are raw changes in number of squares occupied, not a change in probability of occurrence.

Ontario Forest Bird Monitoring Program

Population trends calculated from this program showed a statistically significant decline of 6.3%/year (LCI = -9.4; UCI = -3.0; $n = 545$) for the 25-year period between 1987 and 2011 for Ontario (Cadman pers. comm. 2019). This is equivalent to a decline of about 79% for the entire time series. However, population trends for this monitoring program have not been calculated since 2011, so it is not possible to determine whether it would reflect the change to increasing trends observed in BBS data after 2011 (see above).

Canadian Migration Monitoring Network

Trend results from migration monitoring stations are variable. Long-term data are available only for Long Point Bird Observatory, where statistically non-significant trends of -0.7%/year in fall and 0.1%/year in spring were recorded over the period 1968 to 2016. For the 10-year period from 2006-2016, eight migration monitoring stations have trend information available. Trends are negative at sites in Saskatchewan and Ontario, which primarily sample individuals from the central to western parts of the Canadian breeding range; the lone positive trend is from McGill Bird Observatory in Montréal, which largely encounters those breeding in Quebec (Crysler pers. comm. 2019; Table 4).

Table 4. Canada Warbler 10-year population trends and associated 95% credible intervals (CIs) based on data from Canadian Migration Monitoring Network stations during spring and/or fall migration for the period 2006-2016 (Z. Crysler pers. comm. 2019). Trends considered statistically significant (posterior probability >0.95) appear in bold.

Station Name	Province	Period	Average Annual Trend	95% Lower CI	95% Upper CI	Posterior probability
Last Mountain Lake Bird Observatory	SK	Fall	-5.29	-20.77	12.19	0.77
Thunder Cape Bird Observatory	ON	Spring	-3.24	-8.61	2.54	0.89
Bruce Peninsula Bird Observatory	ON	Spring	-11.22	-22.24	0.80	0.97
Haldimand Bird Observatory	ON	Spring	-1.42	-24.19	29.10	0.56
Long Point Bird Observatory	ON	Fall Spring	-0.33 -2.86	-9.74 -10.75	11.33 6.71	0.55 0.79
Peelee Island Bird Observatory	ON	Fall Spring	-6.86 -9.38	-11.17 -14.72	-2.39 -3.82	1.00 1.00
Prince Edward Point Bird Observatory	ON	Fall	-5.88	-11.12	-0.43	0.98
McGill Bird Observatory	QC	Fall	3.47	-1.29	8.26	0.92

Summary of Trends

In summary, results from the Breeding Bird Survey, which provide the best trend information on Canada Warbler populations across Canada, show widespread and substantial long-term declines. At the time of the previous status report, the short-term decline based on BBS data was -43% over ten years, but revised analysis suggests the rate was actually -23% (Figure 4). The most recent short-term trend (2009-2019) indicates a considerable increase of 46%, although there is regional variability, with increases from Saskatchewan through Quebec, spanning the core of the Canadian range with approximately 85% of the population, but ongoing modest decreases in Alberta, Nova Scotia, and Prince Edward Island, and an accelerating decline in New Brunswick. Canadian Migration Monitoring Network data differ in showing slight to serious declines in the central and western part of the breeding range, with an increase only in Quebec. The particularly strong population growth in Quebec correlates with a large Spruce Budworm outbreak over the past decade (National Forestry Database 2018; see Figure 5), although it remains unclear to what extent Canada Warbler benefits from such episodes. The observed national population increase may also be related to some recent regrowth of high-elevation forest cover in Canada Warbler's wintering range in South America (Aide *et al.* 2019).

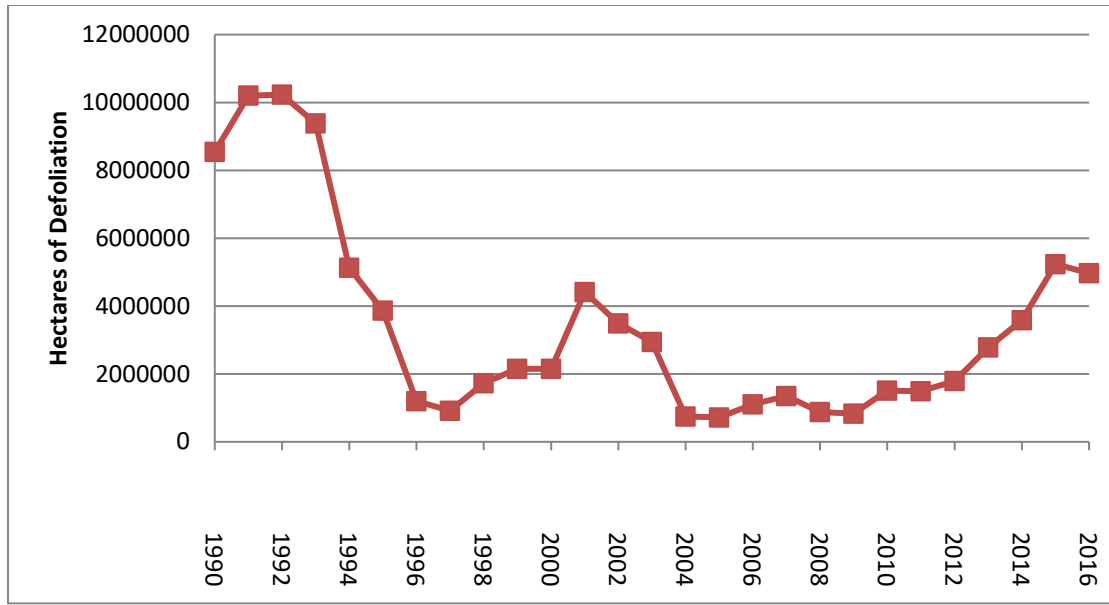


Figure 5. Area of forest defoliation by Spruce Budworm in Canada from 1990 to 2016, showing the increasing trend in recent years (based on National Forestry Database 2018).

Rescue Effect

In the event of the extirpation of the Canadian population, immigration of individuals from a number of U.S. border states is possible. In the United States, Canada Warbler has increased at 1.73%/year (95% CI = -0.20% to 3.87%; N = 351 routes) over the most recent 10-year period from 2009 to 2019, although growth has been strong only in Minnesota and New York state, with stable to declining numbers elsewhere (Environment and Climate Change Canada, unpubl. data). Immigration would be possible and immigrants would be adapted to survive in Canada. Given that the population is currently increasing both in Canada and the U.S. it is difficult to predict the likelihood of rescue under a scenario of severe decline in the Canadian population, as such a change could also affect the outside population.

THREATS AND LIMITING FACTORS

Canada Warbler is vulnerable to the cumulative effects of various threats throughout its annual cycle. These factors are categorized below and in Appendix 1, following the IUCN-CMP (International Union for the Conservation of Nature – Conservation Measures Partnership) unified threats classification system (based on Salafsky *et al.* 2008). The evaluation assesses impacts for each of 11 main categories of threats and their subcategories, based on the scope (proportion of population exposed to the threat over the next 10-year period), severity (predicted population decline among those exposed to the threat, during the next 10 years), and timing of each threat. The overall threat impact is calculated by taking into account the separate impacts of all threat categories and can be adjusted by the species experts participating in the evaluation.

For Canada Warbler, the overall threat impact is considered to be high, corresponding to an anticipated decline of between 10 and 70% over the next 10 years (see **Appendix 1** for details). However, the actual rate of change is expected to be closer to the low end of this range, given that the population has been steadily increasing despite the recognized threats largely being ongoing. Threats are discussed below, in order of decreasing severity of impact.

Threats

IUCN 2, Agriculture and aquaculture (medium threat impact) and IUCN 5, Biological resource use (medium threat impact):

IUCN 2.1, Annual and perennial non-timber crop (low threat impact), IUCN 2.3, Livestock farming and ranching (medium threat impact), and IUCN 5.3, Logging and wood harvesting (medium threat impact):

Description of threat:

These threats are discussed jointly, as Canada Warbler winters in areas where deforestation is intensive, but it can be difficult to differentiate whether the underlying motivation is to expand agricultural crops, increase livestock ranching, or simply undertake forestry operations (Reitsma *et al.* 2009; Clynes 2018). The forests of the northern Andes (primarily in Colombia), which are the main wintering grounds of Canada Warbler, are among the most threatened in the world (Davis *et al.* 1997; Rodriguez *et al.* 2004), and habitat loss there has been identified as the greatest threat to the species (Lambert and Faccio 2005; Wilson *et al.* 2018). For example, over the period 1993-2009, Wilson *et al.* (2018) calculated that an index of the “human footprint” on the breeding grounds increased by only 0.1%, compared to 14% on the wintering grounds, although their analysis excluded effects of forestry. Over 90% of forest cover in the northern Andes has been lost (see **Habitat Trends**), and the Food and Agriculture Organization (2010) reported ongoing forest cover loss in the Andes of 50,000 to 500,000 ha per year. Natural forest provides the best wintering habitat for Canada Warbler. A secondary wintering habitat is shade-coffee plantations, but their extent is being reduced through conversion to ranching, or coffee grown in full sun (Perfecto *et al.* 1996; Escobar 2013; González-Prieto 2018a,b), which is not nearly as suitable for Canada Warbler.

In the breeding range, Canada Warbler exhibits a degree of adaptability to human disturbance. Cumulative effects of forest harvesting, fire, and energy sector development are negative, but can be counter-balanced by a positive response to shrub succession following selective forest management and natural disturbances (e.g., Hallworth *et al.* 2008a,b; Reitsma *et al.* 2009; Leston *et al.* 2020). Silvicultural practices that adversely affect the development of the shrub layer in managed forests may decrease habitat for the species, but again mostly in the short term (Askins and Philbrick 1987; Cooper *et al.* 1997; Norton and Hannon 1997; Schieck *et al.* 2000; Tittler *et al.* 2001; Hunt *et al.* 2015, 2017). Although effects from forest management are not consistent across studies (Reitsma *et al.*

2009; Haché *et al.* 2014), the species generally appears to respond positively to selective logging (Hallworth *et al.* 2008b; Becker *et al.* 2012). Abundance may subsequently decline again after the regenerating shrubby understory grows above a certain height (e.g., Hagan and Meehan 2002; Grinde and Niemi 2016).

Draining of swamp forests for agriculture (and to some extent also for urbanization), especially between 1950 and 1980, is thought to have contributed to the historical decline of Canada Warbler populations in eastern North America, especially south of the boreal region (Tiner 1984; Miller 1999; Reitsma *et al.* 2009). Although still ongoing, the extent and rate of forest swamp drainage has decreased. Ongoing loss of mature forest (especially associated with riparian areas) remains a concern especially in the western boreal region (Ball *et al.* 2016). Boreal mixedwood forest has been cleared for agriculture in western Canada (SSBF 1999; Hobson *et al.* 2002), as well as industrial development (e.g., road and pipeline construction, drilling sites, oil sands development) in the oil and gas sector (Cooper *et al.* 1997; SSBF 1999; Hobson *et al.* 2002; AESRD and ACA 2014; Ball *et al.* 2016; see **Habitat Trends**).

Information on the effects of forest habitat fragmentation on Canada Warbler is mixed. Some studies suggest that the species is sensitive to fragmentation (Askins and Philbrick 1987; Robbins *et al.* 1989; Litwin and Smith 1992; Hobson and Bayne 2000c; Westwood 2016); others indicate that the species is tolerant of habitat fragmentation that results from forest harvesting (Schmiegelow *et al.* 1997; Schmiegelow and Monkkonen 2002), possibly because of the high rate of temporary forest/shrub regeneration that occurs within the regenerating stands.

Scope:

Within the next decade, the proportion of the wintering range likely to be affected by some form of forest loss is anticipated to be in the range of 11-30%. In the breeding range, only 24% of the species' breeding distribution in the boreal forest is in areas exposed to anthropogenic disturbance (Wells 2011), suggesting that the scope of exposure during the breeding season is likely also restricted at most.

Severity:

Loss of forest cover in the wintering range for any reason is likely to have a serious effect, as there is limited alternate habitat available. Evidence from the breeding range suggests that forest loss there may have both positive and negative short-term effects, and severity there is overall unlikely to be more than slight.

IUCN 11, Climate change and severe weather (low to medium threat impact)

Description of threat:

Price *et al.* (2013) predicted that boreal forests will be highly altered by climate change. Over the long term, changes in forest composition due to climate change could

drive Canada Warbler's breeding range northward (e.g., Matthews *et al.* 2004; Stralberg *et al.* 2015). The potential for increasingly severe winter storms resulting in wind throw or ice damage may create canopy gaps that facilitate shrub growth in forests (Faccio 2003). Whether any of these changes will result in a net loss of population size is unknown, because there is potential for a compensatory growth of population at the northern extreme of the species' breeding range.

The impact of climate change may vary depending on the extent of forestry activities. Under the worst case scenario for climate change and high harvesting, Canada Warbler abundance in northeastern Alberta is predicted to decline by 17%, compared to an estimated 39% increase under the same conditions with no harvest (Cadieux *et al.* 2020). Simulations for eastern Canada also suggest that choice of harvesting strategies is likely to have a greater influence on population trends than climate change (Bognounou *et al. in prep*).

Spring migration arrival dates advanced slightly but not significantly for Canada Warbler in an investigation of climate change effects in the Great Lakes Basin (Marra *et al.* 2005). A more recent study reported that Canada Warbler populations in the same general region of the Great Lakes were moderately vulnerable to climate change risks (Marra *et al.* 2014).

On the winter grounds, González-Prieto (2018a) and Gonzalez-Prieto *et al.* (2020) suggested that more frequent drought conditions induced by climate change could compound the consequences of drought arising from deforestation (Bagley *et al.* 2014), including loss in quality of winter habitat, body condition, and potentially annual survival of Canada Warbler.

Scope:

Nearly all of the Canada Warbler population will be exposed to habitat shifting and alteration and to increased risk of drought.

Severity:

More research is required to understand the implications of habitat shifting and alteration, temperature extremes, and storms and flooding on Canada Warbler. Effects of drought also remain only partially understood, but are likely to range from slight to moderate.

IUCN 1, Residential and commercial development (low threat impact)

Description of threat:

Canada Warbler has historically lost breeding and migratory stopover habitat to urban development, and to a minor extent this continues. However, for this species a greater risk associated with buildings is the risk of collisions during nocturnal migration, especially with

tall illuminated structures such as office towers. Although not a particularly abundant species overall, it was among the top ten for collision mortalities in a large study across the U.S. (Loss *et al.* 2014), and communication towers were estimated to kill 1.5% of the North American population annually (Longcore *et al.* 2013). Based on daily lighthouse kill data collected at the Long Point Bird Observatory (Ontario) in spring and fall from 1960 to 2001, it was also in the top 15 species killed there (J.D. McCracken, unpubl. data). With the proliferation of tall buildings and communications towers, this threat continues to increase in scope (see Calvert *et al.* 2013 for an overview of anthropogenic threats). Collisions with windows of residential buildings during migration also represents a threat.

Scope:

The proportion of Canada Warblers encountering this threat is believed to be small, although it is difficult to quantify.

Severity:

Of those that encounter collision risks with buildings, most are likely unaffected, but given the relative frequency of mortality reports, the overall severity is probably sufficient to be considered slight rather than negligible.

IUCN 3, Energy production and mining (low threat impact)

Description of threat:

Oil and gas drilling and mining can affect Canada Warbler through removal of habitat, as well as displacement arising from sensory disturbance. Mortality through collision with wind turbines is possible, but not documented as a particular concern.

Scope:

Oil and gas drilling (IUCN 3.1) occurs across parts of Canada Warbler's western breeding range, but population density is lower there than in eastern Canada, and likely far fewer than 10% of individuals are exposed to this threat. Exposure to mining and quarrying (IUCN 3.2) is even more limited, and considered negligible. A small portion of the population likely migrates through renewable energy projects (IUCN 3.3).

Severity:

Displacement by oil and gas drilling, mining, or quarrying would likely have a moderate effect at a local level, although modelling of effects on recruitment suggested a low impact (Van Wilgenburg *et al.* 2013). The likelihood of collision with wind turbines is lower, and is considered slight, but may even be negligible.

IUCN 4, Transportation and service corridors (low threat impact)

Description of threat:

Several studies have shown that breeding density of Canada Warbler is lower near roads (Miller 1999; Schneider *et al.* 2003; Haché *et al.* 2014; Westwood 2016; Westwood *et al.* 2019). Conversely, Becker *et al.* (2012) found a positive relationship with roads in Virginia, but their study might have been influenced by detection bias and/or a correlation between roads and canopy disturbance favouring the species (Roberto-Charron pers. comm. 2019). Regrowth of abandoned logging roads can provide suitable habitat for Canada Warbler, especially in southern boreal forests. Overall, the severity of roads appears to be negligible.

Collisions with communication towers and associated guy wires is likely a somewhat greater concern (see IUCN 1). This is particularly problematic where lights attract birds toward these hazards. The increasing demand for communication network upgrades means that the number of towers will continue to grow, and the threat will increase unless mitigation measures are improved.

Scope:

A restricted portion of the population is likely exposed to utility and service lines; considering a tendency to avoid linear disturbances, only a small portion of the population may be affected by roads and railroads.

Severity:

Mortalities from communication towers are sufficiently frequent to suggest a severity score of moderate. Roads and railroads likely have negligible effects.

IUCN 7, Natural system modifications (low threat impact)

Description of threat:

Effects on Canada Warbler under this category are likely limited to other ecosystem modifications (IUCN 7.3), as the severity of fire and fire suppression (IUCN 7.1) is unknown, and the scope of dams and water management/use (IUCN 7.2) is negligible. Herbicide application and changes in drainage resulting from forestry, logging roads, and other landscape modifications may result in changes to vegetation structure that reduce suitability for Canada Warbler. In the southern part of its range, Canada Warbler may be affected by White-tailed Deer overbrowsing the shrub layer (DeGraaf *et al.* 1991). The death of Eastern Hemlock (*Tsuga canadensis*) due to Hemlock Woolly Adelgid (*Adelges tsugae*) has been identified as a threat to Canada Warbler in Ohio through loss of habitat (Boone 2016). Hemlock Woolly Adelgid has reached parts of southern Ontario and Nova Scotia since 2013, and may become an increasing concern in Canada (Government of Canada 2019a).

Scope:

Collectively, other ecosystem modifications likely affect only 11-30% of the Canadian population.

Severity:

Other ecosystem modifications are expected to have a moderate effect, primarily through reduced productivity.

Limiting Factors

The biggest limiting factor appears to be the concentration of Canada Warbler's winter range in the northern Andes, and the restricted amount of remaining forest habitat there.

Number of Locations

Number of locations for Canada Warbler is unknown, but considering that the greatest threats are related to forest loss on privately owned land, there are likely far more than 10.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

In Canada, Canada Warbler individuals and their nests and eggs are protected under the *Migratory Birds Convention Act, 1994* (Government of Canada 2017). Canada Warbler is also protected under Canada's *Species at Risk Act* as a Threatened species (Government of Canada 2019b). The species is listed as Endangered under the Nova Scotia *Endangered Species Act*, Threatened under Manitoba's *Endangered Species and Ecosystems Act* and the New Brunswick *Endangered Species Act*, and Special Concern under Ontario's *Endangered Species Act*. In Quebec, Canada Warbler is included on the list of wildlife species likely to be designated as threatened or vulnerable (Gouvernement du Quebec 2018).

Non-legal Status and Ranks

Canada Warbler is regarded as a Sensitive species in Alberta (AESRD and ACA 2014). In British Columbia, it is considered Vulnerable (blue-listed; BC Conservation Data Centre 2019), because of uncertainty about the effects of forest harvesting on the quality of its habitat (Cooper *et al.* 1997).

NatureServe (2020) ranks Canada Warbler as globally secure (G5, Table 5) and the IUCN ranks it as Least Concern (BirdLife International 2019). In Canada, NatureServe (2020) considers the species as Apparently Secure (N4B) overall; at the provincial/territorial

level, it is Imperilled or Critically Imperilled only in Yukon, Northwest Territories, and Prince Edward Island, all of which are at the edge of the species' distribution and have very small populations, but is considered Vulnerable or Vulnerable to Apparently Secure in an additional six provinces (Table 5). It is one of 10 species of high conservation concern for forest managers in commercial forest in Alberta (Hannon *et al.* 2004).

Table 5. Ranks assigned to Canada Warbler, based on NatureServe (2018).

Region	Rank ¹	Definition
Global	G5	Secure
United States	N5B	Secure
Canada	N4B	Apparently Secure
British Columbia	S3S4B	Vulnerable to Apparently Secure
Alberta	S3S4B	Vulnerable to Apparently Secure
Saskatchewan	S5B	Secure
Manitoba	S3B	Vulnerable
Ontario	S4B	Apparently Secure
Quebec	S3S4B	Vulnerable to Apparently Secure
New Brunswick	S3B	Vulnerable
New Scotia	S3B	Vulnerable
Prince Edward Island	S2B	Imperilled
Yukon	S1B	Critically Imperilled
Northwest Territories	S2S3B	Imperilled to Vulnerable

¹ – G = Global; N = National; S = Subnational; B = Breeding; 1 = Critically Imperilled; 2 = Imperilled; 3 = Vulnerable; 4 = Apparently Secure; 5 = Secure; U = Unrankable (due to lack of information or conflicting information).

In the United States, Canada Warbler is considered to be a Species of Management Concern (U.S. Fish and Wildlife Service 2011). NatureServe (2020) considers its overall status to be Secure (Table 5), though Critically Imperilled or Imperilled in four U.S. states (Illinois, Indiana, Ohio, and Oklahoma).

Partners in Flight lists Canada Warbler as a species of continental importance in Canada and the United States, and a species of high conservation concern in the Northern Forest region (Rosenberg *et al.* 2016). Launched in 2013, the Canada Warbler International Conservation Initiative (CWICI) is a public-private partnership to improve the population status of Canada Warbler throughout its breeding and wintering ranges (Rosenberg *et al.* 2016). CWICI brings together representatives from the forest industry, First Nations, academia, and government and non-government agencies ranging from North America to South America, to undertake applied research priorities, and to design national and international recovery plans.

On the wintering grounds in the Andes, Finch and Stangel (1993) considered Canada Warbler as a vulnerable species due to extensive deforestation.

Habitat Protection and Ownership

Canada Warbler is known to occur in at least 25 of Canada's national parks (Pruss pers. comm. 2019) and in many other protected sites under provincial and territorial jurisdiction. The total area of these protected sites is a small proportion of the species' breeding range. Notable regional examples of large protected sites supporting Canada Warbler include: Nahanni National Park Reserve in Northwest Territories; Wood Buffalo National Park in Alberta; Prince Albert National Park and Lac La Ronge Provincial Park in Saskatchewan; Riding Mountain National Park in Manitoba; Wabakimi Provincial Park, Woodland Caribou Provincial Park, Algonquin Provincial Park, Pukaskwa National Park, and Georgian Bay Islands National Park in Ontario; La Mauricie National Park in Quebec; Fundy National Park in New Brunswick; Kejimikujik National Park in Nova Scotia; and Prince Edward Island National Park in Prince Edward Island.

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- Blaney, S. Executive Director and Senior Scientist, Atlantic Canada Conservation Data Centre, Sackville, New Brunswick.
- Bennett, B. Coordinator, Yukon Conservation Data Centre. Whitehorse, Yukon.
- Cadman, M. Songbird Biologist, Canadian Wildlife Service, Environment and Climate Change Canada, Burlington, Ontario.
- Camfield, A. Bird Conservation Biologist, Canadian Wildlife Service, Environment and Climate Change Canada. Ottawa, Ontario.
- Carriere, S. Wildlife Biologist, Northwest Territories Conservation Data Centre, Yellowknife, Northwest Territories.
- Churchill, J. Data Manager and Avian Surveys Biologist, Atlantic Canada Conservation Data Centre, Sackville, New Brunswick.
- Crysler, Z. Bird Population Biologist, Bird Studies Canada, Port Rowan, Ontario.
- DeSmet, K. Wildlife Biologist, Conservation Manitoba, Government of Manitoba, Winnipeg, Manitoba.
- Furrer, M. Biodiversity Information Biologist, Ontario Natural Heritage Information Centre, Ontario Ministry of Natural Resources and Forestry, Peterborough, Ontario.
- Gauthier, I. Biologiste, Coordonnatrice provinciale des espèces fauniques menacées et vulnérables, Direction générale de la gestion de la faune et des habitats, Ministère des Forêts, de la Faune et des Parcs, Québec, Québec.
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- Gutsell, R. Wildlife Status Biologist, Fish and Wildlife Policy Branch, Policy and Planning Division, Alberta Environment and Parks, Edmonton, Alberta.
- Gonzalez, A.M. PhD. student. University of Saskatchewan, Saskatoon, Saskatchewan.
- Laurendeau, C. Assistant Zoologist. Centre de données sur le patrimoine naturel du Québec, Direction du développement de la faune, Quebec, Quebec.
- Pruss, S. Species Conservation Specialist, Elk Island National Park, Parks Canada, Fort Saskatchewan, Alberta.
- Rand, G. Assistant Collections Manager, Canadian Museum of Nature, Ottawa, Ontario.
- Robert, M. Biologist, Migratory Birds, Environment and Climate Change Canada, Quebec, Quebec.
- Sabine, M. Biologist, Species at Risk Program, Fish and Wildlife Branch, Department of Natural Resources, Fredericton, New Brunswick.

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BIOGRAPHICAL SUMMARY OF REPORT WRITER

For over 30 years, Jon McCracken worked as a senior manager at Bird Studies Canada (BSC) – a non-profit institution dedicated to the research, monitoring, and conservation of Canada’s birds. He graduated from the University of Western Ontario with an Honour’s Bachelor of Science in zoology in 1977. Afterwards, as a contract biologist and environmental consultant for government and non-government agencies, he subsequently worked on a large variety of projects, with a particular focus on site and regional assessments of breeding birds. After joining BSC in 1989, he was heavily involved in developing, implementing and overseeing a variety of volunteer-based, bird monitoring

programs, including the Canadian Migration Monitoring Network, the Marsh Monitoring Program, and the Ontario Breeding Bird Atlas. He was also extensively involved in a large variety of species at risk assessments and species recovery programs, including authoring several COSEWIC status reports, and served as co-chair of COSEWIC's Bird Specialist Sub-committee for eight years.

COLLECTIONS EXAMINED

No museum specimens were examined in the preparation of this status report.

Appendix 1. IUCN threats calculator for the Canada Warbler.

Species or Ecosystem Scientific Name	Canada Warbler		
Date :	05/06/2019		
Assessor(s):	Jon McCracken (report writer), Marcel Gahbauer (co-chair), Dwayne Lepitzki (facilitator), Sydney Allen, Mike Burrell, Alaine Camfield, Ana Maria Gonzalez, Robin Gutsell, Thomas Jung, Piia Kukka, Marie-France Noel, Leah Ramsay, Rich Russell, Mary Sabine, Donald Sam, Cindy Staicer, David Toews, Greg Wilson, Marc-Andre Villard		
References:			
Overall Threat Impact Calculation Help:		Level 1 Threat Impact Counts	
	Threat Impact	high range	low range
	A Very High	0	0
	B High	0	0
	C Medium	3	2
	D Low	4	5
Calculated Overall Threat Impact:		High	High
Assigned Overall Threat Impact:		B = High	
Overall Threat Comments		Overall, threats on the wintering grounds have potential to affect a large proportion of the population, and tend to have greater severity than those on the breeding grounds, because of the limited availability of alternate habitat. There is some overlap between scope of agriculture and logging on wintering grounds, but even if only one of these threats was scored, the overall score would remain high because of the number of other threats scored as low or medium. However, considering this overlap and the recent increase in population size despite these ongoing threats, the impact over the next ten years is anticipated to be toward the low end of the 10-70% range predicted by an overall high impact.	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1	Residential & commercial development	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	
1.1	Housing & urban areas	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	Primarily a concern with respect to collisions with windows; houses likely of lesser concern than tall buildings.
1.2	Commercial & industrial areas	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	Of concern during migration, given disproportionately high representation among communication tower mortalities (see 4.2), which likely also applies to other structures.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1.3	Tourism & recreation areas						No projects known in Canada Warbler habitat.
2	Agriculture & aquaculture	C	Medium	Restricted (11-30%)	Serious (31-70%)	High (Continuing)	
2.1	Annual & perennial non-timber crops	D	Low	Small (1-10%)	Serious (31-70%)	High (Continuing)	Loss of the shrub layer reduces suitability for Canada Warbler. Only 10% of montane forest remains in wintering grounds. Shade grown coffee is essentially the only way to supplement that habitat, but there are growing concerns that it is not sufficiently profitable. Ongoing conversion of forest to agriculture is negligible in the breeding range. Severity probably similar regardless of whether crop or grazing is the outcome.
2.2	Wood & pulp plantations						Likely limited to scattered Christmas tree farm plantations, too small in scope to be scored.
2.3	Livestock farming & ranching	C	Medium	Restricted (11-30%)	Serious (31-70%)	High (Continuing)	Primarily a concern on the wintering grounds, through conversion of shade grown coffee (or other forested habitat) to ranching.
2.4	Marine & freshwater aquaculture						Not applicable
3	Energy production & mining	D	Low	Small (1-10%)	Moderate (11-30%)	High (Continuing)	
3.1	Oil & gas drilling	D	Low	Small (1-10%)	Moderate (11-30%)	High (Continuing)	May affect Canada Warbler in Yukon, British Columbia, and Alberta primarily, which together account for <10% of the range in Canada. Where drilling occurs, some displacement or effects on productivity can be expected.
3.2	Mining & quarrying		Negligible	Negligible (<1%)	Moderate (11-30%)	High (Continuing)	Mining is likely limited to a negligible part of the range.
3.3	Renewable energy	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	Potentially susceptible to collisions with wind turbines. May be attracted by illumination (although most now have red lights, which are less problematic).
4	Transportation & service corridors	D	Low	Restricted (11-30%)	Moderate (11-30%)	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
4.1	Roads & railroads		Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)	Roads are generally avoided, therefore low risk of collision mortality, but avoidance due to fragmentation may be a concern. Road expansion (mostly logging) occurring in some regions, but regrowth of abandoned logging roads can provide suitable shrubby habitat, though productivity there is unknown.
4.2	Utility & service lines	D	Low	Restricted (11-30%)	Moderate (11-30%)	High (Continuing)	Likely applicable mostly during migration; mortality counts indicate Canada Warbler is particularly vulnerable to collisions with communication towers (and associated guy wires). Threat expanding geographically (not limited to urban areas) as demand for communication network upgrades increases.
4.3	Shipping lanes						Not applicable
4.4	Flight paths						Not applicable
5	Biological resource use	C	Medium	Restricted (11-30%)	Serious (31-70%)	High (Continuing)	
5.1	Hunting & collecting terrestrial animals						Not applicable
5.2	Gathering terrestrial plants						Not applicable
5.3	Logging & wood harvesting	C	Medium	Restricted (11-30%)	Serious (31-70%)	High (Continuing)	Ongoing forest loss in wintering grounds is the primary concern, with some evidence it is accelerating again. Some logging occurs within the breeding range, but affects a smaller proportion of the population, and severity there is probably minor overall, given a mix of positive and negative responses to forest harvesting; response may vary somewhat by region.
5.4	Fishing & harvesting aquatic resources						Not applicable
6	Human intrusions & disturbance		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
6.1	Recreational activities		Unknown	Negligible (<1%)	Unknown	High (Continuing)	Recreational activities (e.g., ATV trails, hiking, dog walking) could affect breeding Canada Warbler, but likely limited to southernmost portions of the breeding range. Severity is unknown, but probably minimal.
6.2	War, civil unrest & military exercises						Not applicable
6.3	Work & other activities		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	Scientific research (including use of geolocators and radio tags, as well as biological sampling) likely has a negligible impact but should continue to be monitored.
7	Natural system modifications	D	Low	Restricted (11-30%)	Moderate (11-30%)	High (Continuing)	
7.1	Fire & fire suppression		Unknown	Restricted (11-30%)	Unknown	High (Continuing)	Fire can reduce short-term availability of nesting habitat, but can create suitable conditions where succession is currently too far advanced. A restricted part of the range is vulnerable to large and intense forest fires; models suggest increasing frequency (less so in northeast Ontario and Quebec, but more to the west). Severity is difficult to predict as it depends on the net availability of suitable conditions at a landscape scale.
7.2	Dams & water management/use		Unknown	Negligible (<1%)	Unknown	High (Continuing)	May be affected by construction of Site C in British Columbia, and possibly projects in Quebec, but scope almost certainly negligible, and severity at a population scale is unclear.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
7.3	Other ecosystem modifications	D	Low	Restricted (11-30%)	Moderate (11-30%)	High (Continuing)	Herbicide use can alter vegetation structure, as can overbrowsing by White-tailed Deer (<i>Odocoileus virginianus</i>), primarily in south-central Ontario and Quebec. Mortality of Eastern Hemlock (<i>Tsuga canadensis</i>) due to Hemlock Woolly Adelgid (<i>Adelges tsugae</i>) has been identified as a concern in Ohio. Collectively, these concerns are likely applicable to only a restricted portion of the population along the southern edge; impacts are not well documented, but may include effects on productivity, rather than outright displacement.
8	Invasive & other problematic species & genes		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	
8.1	Invasive non-native/alien species		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	Some exposure to cats on migration, but likely a negligible proportion on the ground and vulnerable.
8.2	Problematic native species		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	Parasitism by Brown-headed Cowbird could increase if its range overlap with Canada Warbler grows, although cowbird numbers currently declining. Increasing abundance in edge-specialist predators could increase Canada Warbler mortality, but likely applicable to a negligible part of the range.
8.3	Introduced genetic material						Not applicable
9	Pollution		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	
9.1	Household sewage & urban waste water						Not applicable
9.2	Industrial & military effluents		Negligible	Negligible (<1%)	Serious - Slight (1-70%)	High (Continuing)	Could be an issue in areas such as the oil sands, but generally localized. Mortality possible, but more study needed.
9.3	Agricultural & forestry effluents						Not applicable
9.4	Garbage & solid waste						Not applicable

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
9.5	Air-borne pollutants		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Almost all birds exposed to one or more forms of airborne pollution (e.g., mercury, acid precipitation). No evidence of direct mortality or impact on productivity, but direct effects or indirect effects (e.g., loss of prey base) possible. More study needed.
9.6	Excess energy						Light can be an issue, but primarily as an attractant to collisions, addressed earlier.
10	Geological events						
10.1	Volcanoes						Not applicable
10.2	Earthquakes/tsunamis						Not applicable
10.3	Avalanches/landslides						Not applicable
11	Climate change & severe weather	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	
11.1	Habitat shifting & alteration		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	May lead to mismatches between breeding season and insect emergence, and could also prompt elevational shifts in the wintering range. Research required.
11.2	Droughts	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	Expected to degrade breeding habitat given a preference for wet environments. Birds from eastern part of range also show effects from drought in winter (explains over 50% of variation in survival).
11.3	Temperature extremes		Unknown	Unknown	Unknown	High (Continuing)	Could impact nesting activities. Limited understanding of near-term scope and severity.
11.4	Storms & flooding		Unknown	Unknown	Unknown	High (Continuing)	Could impact nesting activities. Limited understanding of near-term scope and severity.