PROPOSED

Species at Risk Act
Recovery Strategy Series

Recovery Strategy for Canada Warbler (*Cardellina canadensis*) in Canada

Canada Warbler

2015

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Canada

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For copies of the recovery strategy, or for additional information on species at risk, including COSEWIC Status Reports, residence descriptions, action plans, and other related recovery documents, please visit the SAR Public Registry[1]

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[1] http://registrelep-sararegistry.gc.ca/default.asp?lang=En&n=24F7211B-1

PREFACE

The federal, provincial, and territorial government signatories under the Accord for the Protection of Species at Risk (1996)[2] agreed to establish complementary legislation and programs that provide for effective protection of species at risk throughout Canada. Under the *Species at Risk Act* (S.C. 2002, c.29) (SARA), the federal competent ministers are responsible for the preparation of recovery strategies for listed Extirpated, Endangered, and Threatened species and are required to report on progress within five years.

The Minister of the Environment and the Minister responsible for the Parks Canada Agency are the competent ministers for the recovery of Canada Warbler and have prepared this strategy, as per section 37 of SARA. It has been prepared in cooperation, to the extent possible, with the Provinces of British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec (Ministère des Forêts, de la Faune et des Parcs), New Brunswick, Prince Edward Island, and Nova Scotia, as well as the territories of Yukon, and Northwest Territories, and others as per section 39(1) of SARA.

Success in the recovery of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this strategy and will not be achieved by Environment Canada, or any other jurisdiction alone. All Canadians are invited to join in supporting and implementing this strategy for the benefit of Canada Warbler and Canadian society as a whole.

This recovery strategy will be followed by one or more action plans that will provide information on recovery measures to be taken by Environment Canada, the Parks Canada Agency, and other jurisdictions and/or organizations involved in the conservation of the species. Implementation of this strategy is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations.

[2] http://registrelep-sararegistry.gc.ca/default.asp?lang=en&n=6B319869-1#2

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EXECUTIVE SUMMARY

Canada Warbler (*Cardellina canadensis*) is a small forest songbird. It generally breeds in deciduous-coniferous mixedwood or deciduous forests with a dense, complex understory, with geographic variation in the composition of tree species and the importance of topography and wet areas across its Canadian range.

The species was designated as Threatened by the Committee for the Status of Endangered Wildlife in Canada (COSEWIC) in 2008 and since 2010, has been listed according to the same status under Schedule 1 of the *Species at Risk Act* (SARA). Approximately 3 million individuals, or 82 % of the global range and 75 % of the population are found in Canada. The species breeds in most provinces and territories, with the exception of Nunavut and Newfoundland and Labrador.

The primary threats to Canada Warbler include land conversion of breeding and nonbreeding habitat, forest harvesting and silviculture, removal of shrubs, energy and mining exploration and extraction, overbrowsing, reduced availability of insect prey, and collisions with windows. The significance of each threat varies across Canada Warbler's geographical range.

Canada Warbler recovery is considered feasible; however, there are several unknown factors associated with their potential for recovery. Despite these unknowns, and in keeping with the precautionary principle, a recovery strategy has been prepared as per section 41(1) of SARA.

This recovery strategy identifies both short-term and long-term objectives for Canada Warbler. The short-term population objective for Canada Warbler is to halt the national decline by 2025 (i.e., 10 years after this recovery strategy is posted on the Species at Risk Public Registry), while ensuring the population does not decrease more than 10 % over this time. The long-term (after 2025) population objective is to ensure a positive 10-year population trend for Canada Warbler in Canada. The distribution objective is to maintain the current extent of occurrence (the area that encompasses the geographic distribution of all known populations) in Canada. Broad strategies and approaches to achieve these objectives are outlined in this recovery strategy.

At present, the available information is not adequate to identify the habitat necessary for the survival or recovery of Canada Warbler in Canada. A Schedule of Studies is provided to obtain the information needed for the identification of critical habitat.

One or more action plans for this species will be posted on the Species at Risk Public Registry within 5 years of the posting of this recovery strategy.

RECOVERY FEASIBILITY SUMMARY

Based on the following four criteria that Environment Canada uses to establish recovery feasibility, there are unknowns regarding the feasibility of recovery of Canada Warbler. Nevertheless, in keeping with the precautionary principle, this recovery strategy has been prepared as per section 41(1) of SARA as would be done when recovery is determined to be feasible. This recovery strategy addresses the unknowns surrounding the feasibility of recovery.

1. *Individuals of the wildlife species that are capable of reproduction are available now or in the foreseeable future to sustain the population or improve its abundance.*

   Yes. The species is still found throughout its range and breeding individuals are currently distributed throughout Canada, as well as in the United States. The Canadian population is estimated to be 3,000,000 individuals. It is believed there are currently adequate numbers of individuals available to sustain the species in Canada or increase its abundance with the implementation of proper conservation actions.

2. *Sufficient suitable habitat is available to support the species or could be made available through habitat management or restoration.*

   Unknown. Sufficient suitable breeding habitat is likely available to support the species, and more could be made available through management (e.g., forestry practices that preserve the shrub layer, retain perching trees, and maintain moist forest floors, and/or leave large tracts of old-growth deciduous-dominated forest with dense shrub layers next to riparian corridors) or restoration. Characteristics of suitable habitat at a landscape scale are currently insufficiently documented to fully identify habitat requirements for recovery.

   Canada Warbler can tolerate a degree of habitat disturbance (e.g., shade-grown cardamom habitat) in nonbreeding areas, but in general, wintering habitat in South America is declining. It is therefore unknown whether sufficient suitable habitat remains for this species on its wintering grounds.

3. *The primary threats to the species or its habitat (including threats outside Canada) can be avoided or mitigated.*

   Unknown. It is expected that the most significant threats to habitat on the breeding grounds in Canada (e.g., forest harvesting and silviculture, land conversion, shrub removal, and overbrowsing) can be mitigated or avoided through targeted conservation actions driven by focused research and stewardship efforts.

A significant threat to the species may be the degradation and loss of wintering habitat. However, it is uncertain whether there is a direct cause-and-effect link between population declines and wintering habitat availability. If a cause-effect relationship were established, it remains unclear what mechanisms could be employed to protect or restore wintering ground habitat. Nevertheless, there are numerous programs / organizations (e.g., Southern Wings and Important Bird Areas) currently in operation and aimed at the conservation of wintering habitat for Neotropical migrants.

Possible primary threats, other than those related to habitat availability, have been identified, but most have not been studied or verified and include the decline in insect availability and collisions during migration. These threats can likely be mitigated with targeted conservation actions.

4. *Recovery techniques exist to achieve the population and distribution objectives or can be expected to be developed within a reasonable timeframe.*

   Unknown. It is expected that one of the main recovery techniques will be to maintain existing breeding and nonbreeding habitats. Habitat management and habitat stewardship could be effective for this species. Availability of suitable habitat on the breeding grounds may not be limiting. Research is required to identify critical habitat elements and inform land-use practices and habitat management that will benefit the species in breeding and nonbreeding areas. Targeted conservation actions could mitigate the threat of collisions with windows during migration within a reasonable timeframe.

   A significant challenge will be to conduct the necessary research on the importance of wintering habitat loss and work toward protecting existing suitable habitats. Existing programs and organizations can be used (whenever possible) to help ensure these measures are conducted within a reasonable timeframe.

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1. COSEWIC* SPECIES ASSESSMENT INFORMATION

Date of Assessment: April 2008

Common Name (population): Canada Warbler

Scientific Name: *Cardellina Canadensis***

COSEWIC Status: Threatened

Reason for Designation: Most (80%) of the breeding range of this species occurs in Canada. While regional trends may vary, overall the species has experienced a significant long-term decline. This decline is particularly evident in the case of the species' Canadian range and there is no indication that this trend will be reversed. The reasons for the decline are unclear, but loss of primary forest on the wintering grounds in South America is a potential cause.

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

COSEWIC Status History: Designated Threatened in April 2008.

* COSEWIC (Committee on the Status of Endangered Wildlife in Canada)
** When Canada Warbler was assessed by COSEWIC in 2008, the scientific name was *Wilsonia canadensis*. Since that time the American Ornithologists Union (AOU) – the body that oversees naming of bird species in North America – updated the scientific name to *Cardellina canadensis* (see Chesser et al. 2011), and this is the name used for the purposes of this Recovery Strategy.

2. SPECIES STATUS INFORMATION

Canada hosts approximately 82 % of the global breeding range of Canada Warbler (*Cardellina canadensis*)[2] (Partners in Flight Science Committee 2012) and an estimated 75 % of the breeding population (Partners in Flight Science Committee 2013). The species was listed as Threatened under Schedule 1 of the *Species at Risk Act* (S.C. 2002, c. 29) in 2010. Its national status rankings in the United States and Canada are listed in Table 1 in addition to the Canadian sub-national conservation ranks. Under provincial endangered species legislation, Canada Warbler is listed as Special Concern in Ontario (S.O. 2007, CHAPTER 6), Threatened in New Brunswick (S.N.B. 2012, c. 6), and Endangered in Manitoba (C.C.S.M. c E111) and Nova Scotia (S.N.S 1998, c.11). In Quebec, the species is listed on the Liste des espèces susceptibles d'être désignées menacées ou vulnérables (list of wildlife species likely to be designated threatened or vulnerable). This list is produced according to the *Loi sur les espèces menacées ou vulnérables* (RLRQ, c. E-12.01) (Act respecting threatened or vulnerable species) (CQLR, c E-12.01). Canada Warbler is assessed as Blue (or Special Concern) in

British Columbia, but not legislatively protected as such. The species is not currently listed in Yukon, the Northwest Territories, Alberta, Saskatchewan, and Prince Edward Island. The species is also on the US-Canada Watch List, the Species of High Tri-National Concern List, and the US-Canada Stewardship List of Partners in Flight (Partners in Flight Science Committee 2012) because of declining trends and significant threats. The Watch List represents species of greatest concern at the continental level. The global NatureServe rank is G5 – Secure (NatureServe 2013). Other NatureServe rankings include those in Table 1.

Table 1. NatureServe conservation status ranks for Canada Warbler in Canada (NatureServe 2013).

Global (G) Rank [a]	National (N) Ranks [b]	Sub-national (S) Rank [c]
G5	Canada N5B (12 Feb 2012) United States N5B (19 Mar 1997)	Alberta (S3S4) British Columbia (S3S4B) Manitoba (S4B) New Brunswick (S3S4B) Newfoundland Island (S1) Northwest Territories (SUB) Nova Scotia (S3B) Ontario (S4B) Prince Edward Island (S3B) Quebec (S3S4) Saskatchewan (S5B) Yukon Territory (S1B)

[a] G-Rank – Global Conservation Status Rank, G5 = Secure
[b] N-Rank – National Conservation Status Rank, N5 = Secure
[c] S-Rank – Sub-national (provincial or territorial) ranks, S1 = Critically Imperiled; S2 = Imperiled; S3 = Vulnerable; S4 = Apparently Secure; and S5 = Secure (for subnational ranks in the United States, refer to NatureServe (2013)).
B = breeding; and U = Unrankable.

3. SPECIES INFORMATION

3.1 Species Description

Canada Warbler is a small songbird with a slate-coloured back, yellow underparts, and, in the male, distinctive yellow spectacles, and a necklace of black stripes. Females have similar features as males, but are duller than males, and young birds are duller than females. Canada Warblers are 12-14 cm long and are 10-12 grams on average, depending, in part, upon seasonal mass gain (Reitsma et al. 2010). The male's song is short and loud, with sharp chip notes followed by a jumble of rich warbled notes.

3.2 Population and Distribution

Canada Warbler breeds across the southern boreal forest and mixedwood regions, as well as the Great Lakes-St. Lawrence forest, and northern portion of the mixedwood plains to the southern Hudson Plains. It is found in extreme southeastern Yukon, northeastern British Columbia, southwestern Northwest Territories, northern Alberta, central Saskatchewan and Manitoba, central and southern Ontario and Quebec, and the Maritimes (Figure 1). In the U.S., the breeding range extends south to northeast Minnesota, northern Wisconsin, Michigan, Ohio, and, patchily, down the Appalachians as far as northernmost Georgia (Figure 1). In the western portion of its range, it may occasionally breed as far south as North Dakota and Iowa (Reitsma et al. 2010). The species range may have contracted in southwestern Ontario, the lower peninsula of Michigan, and eastern Pennsylvania, but may have expanded into British Columbia, south-central Ontario, and southward in New York as a result of changes in available habitat throughout the past century (Reitsma et al. 2010).

Compared to other warblers, Canada Warbler tends to arrive late on breeding grounds, begin fall migration early, and exhibit a rapid and compressed migration (Reitsma et al. 2010). Sanders and Mennill (2014a) recorded Canada Warbler (using night-flight call detections) crossing Lake Erie. Canada Warbler is a Neotropical migrant and winters in northernmost Brazil, Venezuela, Panama, northern Colombia, and the eastern slope of the Andes in Ecuador and northern Peru (Figure 1).

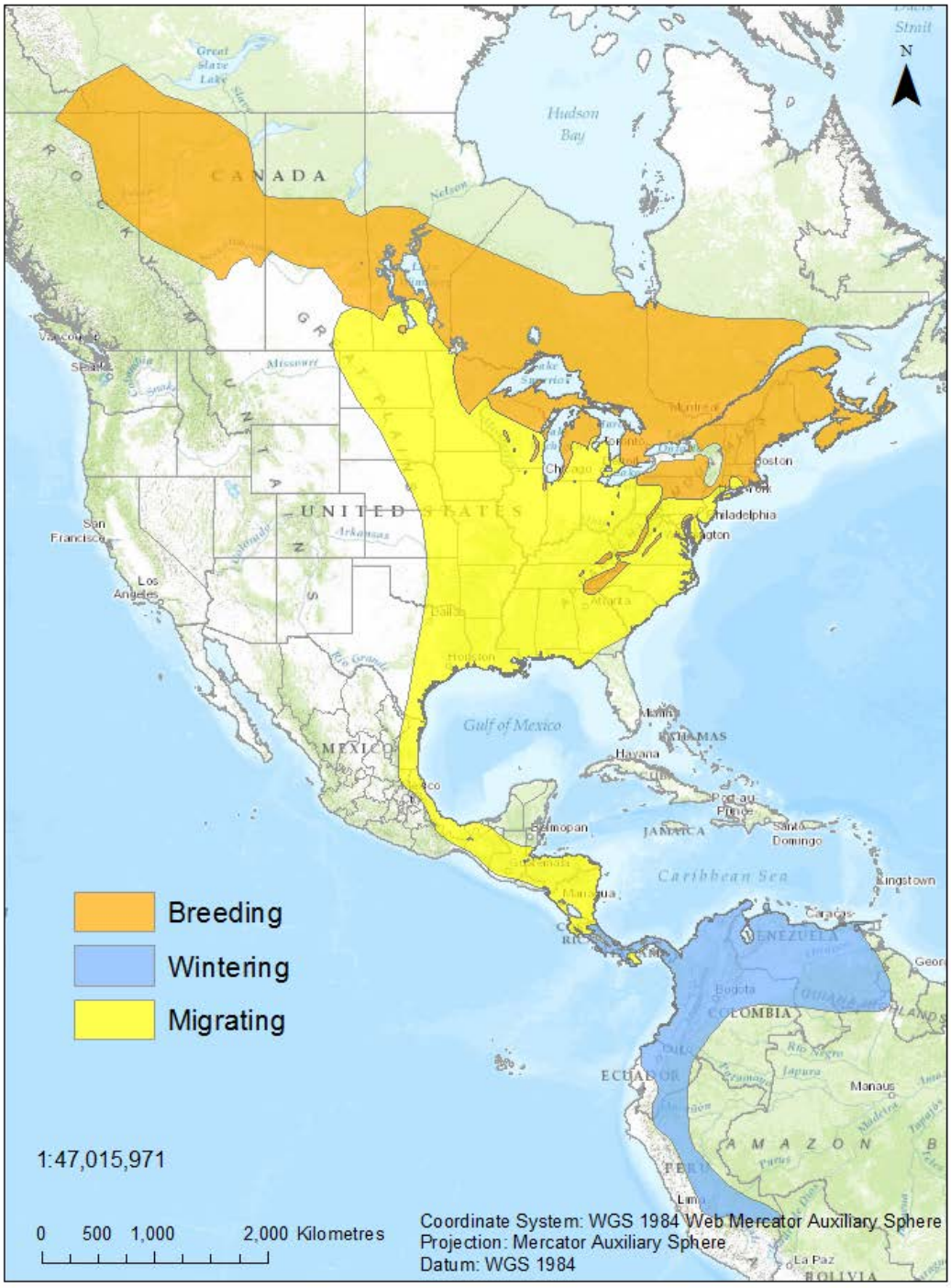

Figure 1. Breeding, migrating, and wintering distribution of Canada Warbler (adapted from BirdLife International and NatureServe (2013), using data from Haché et al. (2014), and eBird (2014)).

The COSEWIC status report used the Partners in Flight document from 2004 to generate its estimate of 1.4 million individuals (Rich et al. 2004). More recently, the Partners in Flight Population Estimates database was updated and now provides the most comprehensive information on North American landbirds. The new population estimate presented in the Partners in Flight database is 4,000,000 individuals with 3,000,000 of these in Canada (Partners in Flight Science Committee 2013). The data quality rating for the Partners in Flight estimate is considered “Beige”, which is second only to a rating of “Green”. In this case, “Beige” is in reference to the level of variance in the average count; the 95 % confidence interval is within 50 % of the regional average count (Blancher et al. 2007). This change in population estimate does not represent an actual increase in the population, but rather is the result of newer analytical techniques. It is largely a result of a refined detection distance used to estimate density. Because of uncertainty in precisely estimating absolute population numbers, the trend of the population is the key metric used to judge population health in this recovery strategy.

The Breeding Bird Survey (BBS) indicates that abundance of this species has decreased significantly, at least in more southern areas of their range where data are available for assessment. Updated BBS analyses completed by Environment Canada, indicate an annual population trend change of -2.9 % between 1970 and 2012 in Canada with a lower and upper 95 % credible limit on the annual index of -4.07 and -1.78, respectively (Environment Canada 2014d). This annual rate of decline corresponds to approximately 71 % decline in population size from 1970 to 2012 (Adam Smith pers. comm.). However, there are fundamental problems with interpreting BBS data that relate to coverage and bias (Machtans et al. 2014). Breeding Bird Survey data do not sample the species entire range at random; the majority of BBS routes tend to be located in southern and disturbed areas of Canada which may bias population estimates of species with northern distributions, such as Canada Warbler (Machtans et al. 2014). Breeding Bird Survey data also tend to underestimate Canada Warbler densities because of road-side bias (Haché et al. 2014). For these reasons, there is uncertainty in estimating population size and range-wide trends for this species.

Regional BBS results in southwestern Northwest Territories show that Canada Warbler has declined by 0.85 % annually between 1998 and 2014 (S. Wilson pers. comm.). In Ontario, the Forest Bird Monitoring Program estimates an annual population trend in Bird Conservation Areas 12 and 13 of -6.3 % (A. Smith pers. comm.). Approximately 50 % of the Canadian population of Canada Warblers may reside in Ontario and the Ontario Breeding Bird Atlases showed an annual trend change of -0.8 % per year (confidence intervals: -2 to 0.3) between the first (1981-1985) and second (2001-2005) atlas periods for the entire province (Environment Canada 2011b). The Maritimes Breeding Bird Atlas found significant declines in the probability of Canada Warbler observations throughout most of the region between the first (1986-1990) and second (2006-2010) atlas periods (Phil Taylor pers. comm.). The Alberta Breeding Bird Atlas showed an unchanged distribution and increasing population between 1987-1992 and 2000-2005 (Semenchuk 2007).

3.3 Needs of Canada Warbler

Current understanding of the ecological needs of Canada Warbler is biased by the selection of study sites (and associated findings), which are influenced by site accessibility. Furthermore, the species' apparent habitat needs might be distorted by limitations in current habitat availability compared to historical conditions.

Breeding and Foraging

Forest type
Canada Warbler breeds in a variety of habitats that differ across its range, but is almost always associated with moist forests with a dense, deciduous shrub layer, complex understory, and available perch trees. Nevertheless, regional and local habitat preferences can be relatively specific.

Examples of documented habitat preferences and descriptions include (but are not limited to) the following:

- Alberta: Most common in old-growth aspen (and to a lesser extent mixedwood) forests (>120 years old) (Schieck et al. 1995, Hobson and Schieck 1999, Schieck and Song 2006, Ball et al. 2013). Canada Warblers have also been reported in lower densities in early seral habitats (e.g., 22-28 year post-harvest mixedwood stands), when an average of 6 % of the pre-harvest canopy trees (Hobson and Schieck 1999) or large residual patches of trees were retained (Ball et al. 2013), but were notably absent from young (23-26 years) stands in east-central Alberta (Schieck et al. 1995).
- Saskatchewan: Pure young, mature, and old aspen stands (Hobson and Bayne 2000a, Hobson and Bayne 2000b), but most common in mature stands (Hobson and Bayne 2000a). Individuals were significantly more common in contiguous forest compared to fragmented forests surrounded by agriculture (Hobson and Bayne 2000c).
- Ontario: Boreal mixedwood forest. Particularly high densities have been recorded in ~ 6 year old upland cutover, with 72 % canopy cover, and substantial tall shrub cover and herbaceous cover (Welsh and Fillman 1980).
- Quebec: Most abundant in boreal mixedwood forests characterized by natural disturbances, but also found (at fewer stations) in boreal mixedwood forests modified by pre-industrial landscapes and industrial timber management (Drapeau et al. 2000).
- Maritimes: Mature cedar swamps and other wet habitats, complex, mature or regenerating mixed forest, partial cuts, and shrublands (Maritimes Breeding Bird Atlas, unpublished data).

- New Hampshire: Red-maple swamp, dominated by Red Maple, Balsam Fir, and Red Spruce, with complex ground cover, dense understory, and both standing and moving water. As well as, regenerating mixed deciduous/coniferous forest 6-20 years post-harvest, with residual trees and understory growth < 6 m in height (Hallworth et al. 2008a).

A breeding range-wide study found Canada Warbler densities to be generally higher in mixedwood and deciduous stands with tall trees (Haché et al. 2014). Densities were negatively affected by the proportion of agriculture and human development within 16 km^2 (Haché et al. 2014).

Canada Warbler habitats have also been described generally as including forested swamps, shrub thicket swamps, riparian woodlands, moist forests, brushy ravines, northern hardwood forests, mature forests with gaps in the canopy, open and treed muskeg, etc. (Hallworth et al. 2008b, Chace et al. 2009, Reitsma et al. 2010).

Local scale

During breeding, Canada Warbler is territorial, with territory size generally averaging 1 ha, but ranging up to 3.3 ha (Hallworth et al. 2008b). Home-range size of territorial males in Alberta ranged from 0.18 to 9.87 ha (mean = 1.43 ha) (Lesser Slave Lake Bird Observatory and University of Alberta, unpublished data). Local habitats tend to have abundant shrubs and groundcover, perch trees for singing males, and low canopy height (Hobson and Bayne 2000a, Hobson and Bayne 2000b, Hallworth et al. 2008b, Chace et al. 2009). Complex forest floors (e.g., downed trees, hummocks) with ferns and shrubs likely provide protective cover for nests and young (Chace et al. 2009).

Canada Warbler can often be found near standing water or streams (Reitsma et al. 2010, Ball et al. 2013). A study in North Minnesota found Canada Warbler to be most common within 100 m of riparian corridors (Zlonis and Niemi 2014), and Ball et al. (2013) identified local suitable habitat as old-growth deciduous forest, near small, incised streams in Alberta.

Nest site:

Nests are built on or near the ground (Reitsma et al. 2010). They are placed on moss and raised hummocks, within holes of root masses, rotting tree stumps, clumps of grass, rock cavities, etc. (Reitsma et al. 2010). Nests are generally placed (and significantly more successful) in areas with coarse woody debris, high nest concealment, and dense stems from woody plants and ferns (Hallworth et al. 2008b, Chace et al. 2009, Goodnow and Reitsma 2011).

Foraging:

Adults primarily forage in the shrub layer, mostly by flycatching and gleaning, but do forage elsewhere on a range of insects and spiders (Sodhi and Paszkowski 1995). Specific prey items can include mosquitoes, flies, moths, beetles, worms, bees, Lepidoptera, and snails (Reitsma et al. 2010).

Nestlings and young are fed a variety of food items which include lepidopeteran larvae, moths, mosquitos, and craneflies (Bent 1953, Reitsma et al. 2010). After leaving the nest, young remain near the nest site for several days within the understory cover (Reitsma et al. 2010).

Migratory and Wintering Habitat

Canada Warbler migrates at night. During the day, it stops in a variety of habitats that are typically shrubby and wet, such as forest, stream edges, and forested swamps. Reitsma et al. (2010) also note that migrating Canada Warbler are found in bushes and shrubs near edges of parks and populated areas.

Canada Warbler generally winters in rainforest and cloud forests that are 500-2500 m in elevation (COSEWIC 2008, Bakermans et al. 2009, Bakermans et al. 2012, BirdLife International 2014). In Colombia, the species has been reported in dry tropical forests, montane forests, humid submontane and subtropical forests, and cloud forests, as well as disturbed sites, such as mixed-forest plantations, agroforestry systems, and shade plantations (BirdLife International 2014). In Ecuador, Canada Warbler has most often been recorded in mature and secondary-growth humid forest (BirdLife International 2014).

During winter, the species is not thought to be territorial, but instead often forages through the habitat with loose flocks that include several other songbird species (COSEWIC 2008, Reitsma et al. 2010).

Limiting Factors

Limiting factors influence a species' survival and reproduction, and therefore population size. For instance, Canada Warbler's residency on the breeding grounds is brief compared to other warblers, placing particularly strong constraints on the duration and timing of breeding and timing of migration (Flockhart 2010, Reitsma et al. 2010). This factor reduces the possibility of producing more than one clutch per season and adapting to climatic changes, thereby limiting the species' ability to respond to threats and possibly recover from such threats once they are alleviated.

4. THREATS

4.1 Threat Assessment

Table 2. Threat Assessment for Canada Warbler

Threat	Level of Concern[a]	Extent	Occurrence	Frequency	Severity[b]	Causal Certainty[c]
Habitat Loss or Degradation						
Nonbreeding habitat - deforestation and land conversion	High	Widespread	Current	Continuous	High	Medium
Breeding habitat: removal of shrub layer	High	Widespread	Current	Continuous	Moderate	Medium
Breeding habitat: land conversion	High	Widespread	Current	Continuous	Moderate	Medium
Breeding habitat: forest harvesting	Medium	Widespread	Current	Continuous	Moderate	Medium
Energy and mining (exploration and extraction)	Medium	Widespread	Current	Continuous	Moderate	Low
Overbrowsing	Medium	Localized	Current	Continuous	Moderate	Medium
Changes in Ecological Dynamics or Natural Processes						
Reduced availability of insect prey (ultimate causes: loss of insect-producing habitats, prey-breeding temporal mismatch due to climate change, habitat acidification, and pesticides)	Medium	Widespread	Current	Continuous	Moderate	Medium

Accidental Mortality						
Collisions with anthropogenic structures and vehicles	High	Widespread	Current	Seasonal	Moderate	Medium
Exotic, Invasive or Introduced Species/Genome						
Problematic native and non-native species	Low	Localized	Current	Continuous	Low	Low
Climate and Natural Disasters						
Habitat shifting and alteration	Unknown	Widespread	Current	Continuous	Unknown	Low
Temperature extremes and storms	Unknown	Widespread	Current	Seasonal	Unknown	Low
Pollution						
Pesticides (direct effects)	Unknown	Localized	Current	Seasonal	Unknown	Low
Mercury	Unknown	Widespread (E. Canada)	Current	Continuous	Unknown	Low
Acid precipitation	Unknown	Widespread (E. Canada)	Current	Continuous	Unknown	Low

[a] *Level of Concern: signifies that managing the threat is of (high, medium or low) concern for the recovery of the species, consistent with the population and distribution objectives. This criterion considers the assessment of all information in the table).*
[b] *Severity: reflects the population-level effect (High: very large population-level effect, Moderate, Low, Unknown).*
[c] *Causal certainty: reflects the degree of evidence that is known for the threat (High: available evidence strongly links the threat to stresses on population viability; Medium: there is a correlation between the threat and population viability e.g., expert opinion; and Low: the threat is assumed or plausible).*

4.2 Description of Threats

Threats are listed here in the order in which they are presented in Table 2. The Boreal Songbird Initiative estimated that 24% of Canada Warbler's breeding habitat in the boreal forest of Canada has been disturbed by anthropogenic activities (Boreal Songbird Initiative 2012), but the extent to which those disturbances directly affect the species' abundance, survival, and productivity has not been quantified.

Most information pertaining to threats is a result of studies on the breeding grounds. Nonetheless, threats in nonbreeding areas may be particularly important for this species (Reitsma et al. 2010).

Non-breeding Habitat: Deforestation and Land Conversion

Intensive deforestation in Canada Warbler's wintering areas has been suggested as an important threat facing Canada Warbler (COSEWIC 2008, BirdLife International 2014). This conclusion is generally based on the intense levels of deforestation in these areas, rather than a direct-causal relationship between the Canada Warbler population and this threat (BirdLife International 2014).

In 1991, it was determined that the forested area in the northern Andes (Peru, Ecuador, and Colombia) had declined by approximately 90% from its historical levels (Henderson et al. 1991), and by 1998, an estimated 180,600 km^2 (69%) of the Andean forests in Colombia were cleared for agriculture (Etter et al. 2006). Although there may have been some local gains over the past decade (Sánchez-Cuervo et al. 2012), large tracts of forested area within Canada Warbler's wintering range (particularly in Colombia) are continuing to exhibit overall trends of forest loss (Portillo-Quintero et al. 2012, Hansen et al. 2013).

The ultimate causes of deforestation vary locally, but have been identified as human encroachment, increased pasture area, conversion of shade coffee to sun-tolerant coffee, timber harvest, plantations of native fruits (naranjilla), other agricultural activities, and monocultures (Davis et al. 1997, Portillo-Quintero et al. 2012, BirdLife International 2014).

A study in Colombia showed that the probability of Canada Warbler being present decreased with the loss of structural diversity in the habitat (Suarez and Colorado 2013, as cited in BirdLife International 2014). McDermott and Rodewald (2014) found the abundance of Canada Warbler was highest in forest and shade-grown cardamom, lower in shade-grown coffee, and lowest in silvopastures, which corresponded to a gradient of high to low percent canopy cover, vertical complexity, midstory canopy complexity, and high canopy complexity.

There has also been substantial forest loss between 2000 and 2012 throughout large portions of Canada Warbler's migratory range, particularly in Central America (Hansen et al. 2013). However, dense foliage in the lower canopy layers predicted

Canada Warbler habitat-use during migration in Costa Rica (Wolfe et al. 2014). This type of complex understory is often associated with young secondary forests, which led Wolfe et al. (2014) to suggest that migrants may not be limited by available stopover habitat in Central America, where there is a widespread conversion of primary to secondary forests.

Breeding Habitat: Removal of Shrub Layer

High shrub density is considered a critical feature of Canada Warbler's breeding habitat (see section 3.3. Needs of Canada Warbler). Therefore, activities that remove or potentially destroy the shrub cover may render the habitat unsuitable for the species. For example, shrubs can be destroyed (purposefully or as a side effect) during silvicultural practices (e.g., herbicides, weeding, thinning) or harvesting (e.g., selective harvesting, clearcut) (Cooper et al. 1997, Schieck et al. 2000). While harm can be reduced from practices that preserve the complex understory, and dense ground cover required by this species, clear-cut harvesting and regeneration of short rotation even-aged stands do not reflect the natural gap creation processes (e.g., fire, insect outbreaks, wind throw) that would normally regenerate the habitat features found in natural Canadian boreal forests (Bergeron and Fenton 2012). Efforts to reduce adverse effects on the shrub understory would be beneficial for this species (if other habitat features are also retained), but dense, abundant shrubs may also slow forest succession in some forests (e.g., Black Spruce forests) (Thiffault et al. 2013).

Breeding Habitat: Land Conversion

Land conversion has been intensive in portions of Canada Warbler's breeding range, especially in the northern hardwood and boreal hardwood transition areas. For example, 73% of the boreal hardwood transition zone in Saskatchewan has converted to agriculture, with 25% lost between 1966 and 1994 (Hobson et al. 2002). Young et al. (2006) calculated an annual rate of change in forest cover along the southern boreal edge of Alberta to be -0.82% per year; an area were Canada Warbler are predicted to be locally abundant (Ball et al. 2013).

Canada Warbler declines in the northeastern United States from 1950 to 1980 are thought to have resulted from the drainage of swamp forests for agriculture and urban development (Miller 1999), although the evidence for this is indirect. Hobson and Bayne (2000c) found that Canada Warblers were more common in contiguous forest than in forest fragments surrounded by agriculture and were found in interior forests, not edge. In Alberta, cultivation and urban-industrial habitats negatively affected Canada Warbler densities at a local scale, but not a landscape scale (Ball et al. 2013). The direct impacts of land conversion on Canada Warbler's population numbers are unknown.

Breeding Habitat: Forest Harvesting

Logging and wood harvesting is the third largest cause of forest conversion in Canada, after agriculture and residential and commercial development (Masek et al. 2011). Harvest rates in Canada are highest in Quebec, British Columbia, and Ontario and have been relatively stable in Canada since the 1980s (Masek et al. 2011). Between 2000 and 2012, approximately 11,041,217 ha of forest were harvested throughout Canada (NFD 2014). Much of Canada Warbler's breeding range is under forest management, but forestry practices vary across this range.

Forest harvesting, in general, can have short term negative impacts on nesting birds by disrupting breeding activities (Hobson et al. 2013). The nests and/or eggs can be inadvertently harmed or disturbed as a result of clearing trees and other vegetation (e.g., pre-commercial thinning) (Environment Canada 2014a). Nesting failure could also result from disruptive activities experienced by a nesting bird (Environment Canada 2014a). Hobson et al. (2013) estimated that between 616,000 and 2.09 million nests (of many species) are lost annually as a result of industrial forest harvesting.

Studies in portions of Canada Warbler's range (particularly in the east) have noted that Canada Warbler may be tolerant to some degree of forest harvesting (Hagen et al. 1997, King and DeGraaf 2000, Chace et al. 2009). Forest harvest regimes that approximate processes such as storms, fire, and insect damage that naturally modify habitat may be appropriate habitat for breeding Canada Warbler. Canada Warblers were relatively abundant at sites 5-20 years post-harvest (partial cuts, shelterwood cuts, and clearcuts), when some trees were left unharvested in the overstory and sites had relatively dense understory (Titterington et al. 1979, Hagen et al. 1997, King and DeGraaf 2000, DeGraaf and Yamasaki 2003, Chace et al. 2009). Hallsworth et al. (2008b) found no significant difference between the reproductive success of males in second-growth plots, compared to Red Maple swamps in New Hampshire. They suggested that Canada Warbler habitat could potentially be maintained at a landscape level by rotating harvests that leave residual trees and create dense understories (Hallworth et al. 2008b). However, this technique may only be appropriate in certain portions of Canada Warbler's breeding range. In Quebec's southern boreal forest, a large proportion of Canada Warbler sightings are associated with dense deciduous bushes found along right-of-ways created by the timber industry (B. Drolet, pers comm.).

In parts of Canada Warbler's range, old-growth (> 120 years old) forests (often naturally disturbed) are preferred habitat (Drapeau et al. 2000, Schieck and Song 2006, Zlonis and Niemi 2014). For example, a study in Northern Minnesota found Canada Warbler to be more common in a wilderness forest, compared to a managed forest (Zlonis and Niemi 2014). Haché et al. (2014) found Canada Warbler densities to generally be higher in areas with tall trees (a proxy for forest age) and DeGraaf et al. (1991) found Canada Warbler to be more abundant in unthinned stands compared to thinned stands. Higher densities of Canada Warblers were consistently found in survey blocks with lower percentages of harvested area in Alberta, but the results were not always

significant (Lesser Slave Lake Bird Observatory and University of Alberta, unpublished data). Short forest rotations between harvesting that do not produce older, structurally complex forests could negatively affect Canada Warbler in areas where old-growth forests are the preferred habitat. Angers et al. (2005) found that it was highly unlikely that selection cuts would develop old-growth characteristics before the next logging interval and could have detrimental impacts on the availability and characteristics of woody debris (which is important for Canada Warbler nesting success).

Ball et al. (2013) found Canada Warbler in early seral habitats in Alberta, but individuals were found within patches of residual forest (not areas with just residual trees – as reported elsewhere (e.g., Hallworth et al. 2008b)). This finding led Ball et al. (2013) to suggest that large stands of old-growth deciduous forest (particularly forests adjacent to streams) should be retained and width of retention buffers adjacent to streams should be increased.

Energy and Mining (Exploration and Extraction)

Exploration to find energy (e.g., oil, gas, and hydroelectricity) and mineral sources, exploitation of these resources (e.g., flooding of large areas to create reservoirs and mine residues), and the creation of corridors for transportation (e.g., pipelines, transmission lines and roads) have caused substantial habitat loss, degradation, and fragmentation in some portions of the Canada Warbler's range (Drummond and Loveland 2010, Masek et al. 2011, Birch and Kaye 2012). Activities associated with these industries can also lead to the unintentional destruction of nest, eggs, nestling, and/or adults (Van Wilgenburg et al. 2013).

Van Wilgenburg et al. (2013) estimated that approximately 48,400 ha of areas are disturbed annually from the construction of wells, pipelines, and seismic lines in the Boreal Ecozone of the Western Canadian Sedimentary Basin. This coincides with approximately 7301 nests (of many species) being lost annually in this area (Van Wilgenburg et al. 2013). Van Wilgenburg et al. (2013) found that Canada Warbler had relatively low estimates of recruits lost (52-107) as a result of this construction because of Canada Warbler's relatively low densities. The construction of wells, pipelines, and seismic lines is especially prevalent in northern Alberta and northeastern British Columbia (Schneider et al. 2003, Calvert et al. 2013, Van Wilgenburg et al. 2013). Oil extraction, mining projects, and associated pipelines and road construction are also proceeding locally in the species' wintering range in the northern Andes (Davis et al. 1997, BirdLife International 2014).

Mining activities occur across the Canadian range of Canada Warbler and include a large variety of targets (e.g., gold, diamonds, zinc, lead, and copper) (Stothart 2011). The total area under mineral lease in Canada is 2.1 million ha (Cheng and Lee 2014); provinces/territories that have the most boreal forest zone dedicated to mineral leases and are within Canada Warbler's range include Alberta (3206 km^2), Ontario (1,686 km^2), and Manitoba (1,463 km^2) (Cheng and Lee 2014). The level of impact resulting from these industries on Canada Warbler's population is unknown.

Energy extraction and mining can alter local hydrological regimes and soil moisture by direct water removal (e.g., for fracturing) and hydroelectricity facilities (e.g., dams). Because Canada Warblers are more abundant near riparian corridors throughout their range (Reitsma et al. 2010, Zlonis and Niemi 2014) and are known to breed in forested swamps, bogs, and near open water in their eastern range (Reitsma et al. 2010), they would likely be affected by changes in hydrological regimes.

Overbrowsing

Deer browsing can radically alter the shrub strata used by Canada Warbler for nesting and foraging (Reitsma et al. 2010) by decreasing shrub cover and diversity, and modifying vegetation dynamics (Côté et al. 2004, Rooney 2009). One study in the northeastern United States showed that Canada Warbler abundance was lower in areas with high numbers of White-tailed Deer (*Odocoileus virginianus*) (DeGraaf et al. 1991). Like Canada Warbler, Kentucky Warbler (*Geothlypis formosus*) is also known to utilize understory as primary breeding habitat (McDonald 2013). McShea et al. (1995) showed that Kentucky Warblers were found most often in areas with low White-tailed Deer numbers. Deer browsing has also impacted European species with similar habitat requirements as the Canada Warbler. For example, Holt et al. (2013) demonstrated that Blackcaps (*Sylvia atricapilla*) exhibited earlier territory establishment and superior body condition in the absence of deer. This results from deer browsing the shrub layer that the birds require (Reitsma et al. 2010). White-tailed deer populations are increasing across the southern range of Canada Warbler (Russell et al. 2001). At present, the level and extent to which this threat is affecting the Canada Warbler population is uncertain, but it would be most prominent in northeastern United States and south-eastern Canada where White-tailed Deer are particularly abundant (Russell et al. 2001).

Uncontrolled grazing by cattle has also contributed to the degradation of forest habitat in the migration, wintering, and breeding range. Cattle grazing occurs along the boreal fringe of western Canada (primarily in aspen forests) in areas that might otherwise be suitable for Canada Warbler. The effects of cattle grazing on the habitat depend on the timing, duration, and soil properties (Krzic et al. 2004).

Reduced Availability of Insect Prey

Populations of aerial insectivores are showing dramatic declines, particularly in northeast North America (Nebel et al. 2010). The trait common to all species in this diverse group is insectivory, which has led multiple researchers to implicate a reduction in available insect prey in breeding, migratory, and/or wintering areas as a probable contributing factor in the declining population trends (Nebel et al. 2010, Paquette et al. 2014). Although Canada Warbler is not considered an aerial insectivore, it primarily forages on insects (often on the wing) and therefore the effects of changes in insect availability on Canada Warbler may be similar to those suspected for aerial insectivores.

Insect populations are exhibiting significant declines worldwide. A recent review of global faunal population trends, noted that 33 % of all insects with available IUCN-documented population trends were declining and many also exhibited range retractions (Dirzo et al. 2014). These declines are considered a global pattern, but are more severe in heavily disturbed locations, such as the tropics (Dirzo et al. 2014). The possible causes for reduced availability of insect prey are identified and described below.

Loss of Insect-Producing Habitats

Many insects are limited to specific habitat for some part of their life cycle and any activities that diminish these habitats may harm them. Over 90 % of insect groups considered threatened are impacted by habitat loss or degradation (Price et al. 2011). A number of human activities alter or destroy natural habitats necessary for particular insect life stages, including wetland drainage and peat extraction, intensive agriculture, wetland destruction, industrial activities, and urban development (U.S. Bureau of Land Management 1978, Benton et al. 2002, Price et al. 2011, Brooks et al. 2012). For example, the drilling, construction, and development associated with oil and gas extraction can lead to the loss of insect habitat and result in reductions in insect populations and changes in species compositions (U.S. Bureau of Land Management 1978). Foster (1991) noted the drainage of wetlands and peat extraction as a significant threat facing insect populations.

The effects of habitat loss for insects are not restricted to Canada Warbler's breeding range; they could also be affecting their nonbreeding range. Forest fragmentation in rainforests can cause declines in insect species richness and some species' populations (Price et al. 2011). In general, insect responses to changes in land use in the tropical Andes are context dependent, but some research has shown that species richness, diversity, and abundance declined in response to land-use disturbances (Larsen et al. 2011).

Prey-Breeding Temporal Mismatch

Birds often exhibit a strong synchronization between their reproductive timing (i.e. hatching) and peak food abundance, but climate change has caused the timing of peaks in some insects to advance (Both et al. 2009). Because warming is less severe in Canada Warbler's wintering areas than in their breeding grounds, they may experience migration cues at dates that are too late for them to arrive at breeding grounds at the optimal time (Jones and Cresswell 2010). As a result, climate change is creating a temporal mismatch between reproduction and maximal prey abundance (i.e. insects) for species that are not adapting to the changing climate at the same rate as their prey (Strode 2003). Both et al. (2006) found that an aerial insectivore in the Netherlands, Pied Flycatcher (*Ficedula hypoleuca*), had declined by 90% between 1987 and 2003 in areas where the prey peaked too early in the breeding season to provide adequate food for nestlings. Strode (2003) found that many American wood warblers (Parulidae) that feed on caterpillars may not be responding to climate change by migrating earlier. As a

result, it is possible that they could have inadequate food for refueling from migration, breeding, and feeding their nestlings. Great Tits (*Parus major*) have also exhibited a mismatch between optimal timing of nestlings and peak caterpillar biomass as a result of recent warming (Visser et al. 2006). Both the weight and the number of chicks that fledged were affected by their timing in relation to this peak (Visser et al. 2006). A prey-breeding temporal mismatch has also been linked to the population declines of migrant birds across Europe (Møller et al. 2008, Saino et al. 2011), and is believed to be contributing to the declines of other avian species heavily reliant on invertebrates, such as the Rusty Blackbird (*Euphagus carolinus*) (McClure et al. 2012).

Populations of migratory birds that exhibit long-distance migrations and breed in seasonal habitats are more vulnerable to climate change because the temporal mismatch is more likely and more severe (Both et al. 2006, Both et al. 2009). Although no species-specific data are currently available, Canada Warbler is an insectivore, migrates long distances, and breeds / forages in seasonal habitats, so a climate-induced mismatch between breeding and prey availability is certainly plausible.

Habitat Acidification

Since the 1980s, there has been a substantial decline in the rate of acid deposition, but acidifying compounds (e.g., sulphur dioxide and nitrogen oxide) are still being released into the environment (Shannon 1999, Environment Canada 2014c). Acidification of surface water can reduce the abundance and diversity of flying insects that are aquatic for part of their life cycle (Graveland 1998) and acidification of forests can cause thinning of the canopy resulting in changes to the insect communities and abundances (Mahony et al. 1997, Brotons et al. 1998, Zang 1998). Canada Warbler's prey items such as mosquitoes (Culicidae), crane flies (Tipulidae), caterpillars (Lepidoptera), and spiders (Arachnida) may be affected by habitat acidification. Reduced reproductive success of Tree Swallows (*Tachycineta bicolor*) nesting near acidified wetlands in Ontario was linked to changes in available calcium-rich prey for nestlings (Blancher and McNicol 1991) and acidification of forests was implicated in the decline of the Wood Thrush (*Hylocichla mustelina*) (Hames et al. 2002). Nevertheless, a study in central Ontario showed no difference in forest songbird productivity between acidified and non-acidified sites (Mahony et al. 1997). Although, at present, there is no evidence to support a range-wide effect of reduced insect prey abundance and/or nutritional quality as a result of habitat acidification, it may have implications for Canada Warbler in areas of local, severe acid deposition and eastern North America where soil buffering is relatively poor.

Pesticides (Indirect Effects)

Most organochlorine pesticides (chemicals in the same family as dichlorodiphenyltrichloroethane – DDT) have been banned in North America for decades, but there is indication that Neotropical migrant insectivores are still being exposed to organochlorine pesticides throughout their ranges (Sager 1997, Klemens et al. 2000). These chemicals can have long-lasting effects on insect

communities and thus the birds that rely on them. Dietary records of Chimney Swift's (*Chaetura pelagica*) confirmed a marked decrease in beetles (Coleoptera) and an increase in true bugs (Hemiptera) that was temporally correlated with a steep rise in DDT and its metabolites. Nocera et al. (2012) argued that DDT caused declines in Coleoptera and dramatic (possibly permanent) shifts in the insect communities, resulting in a nutrient-poor diet and ultimately a declining Chimney Swift population.

The harmful effects of chemical insecticides have led to the increased use of biological insecticides. Currently, insecticides used for forestry operations in Canada are mainly biological (*Bacillus thuringiensis* var. *kurstaki* (*Btk*)) and target larval Lepidoptera such as Jack Pine Budworm (*Choristoneura pinus*) and Spruce Budworm (*Choristoneura fumiferana*). The average area sprayed per year with *Btk* across Canada's forests between 1988 and 2000 was 273,440 ha (range: 73,209-855,535 ha) (NFD 2014). In 2012, *Btk* was sprayed in the forests of four Canadian provinces: Quebec (98,044 ha), Manitoba (828 ha), Saskatchewan (15,639 ha), and British Columbia (116,012 ha) (NFD 2014). On average, Quebec sprays the most forest area with *Btk* per year (1988-2012) (NFD 2014). Although many microbial insecticides are considered non-toxic to birds, their indirect effects caused by changes in available prey items remain inconclusive. A 12,803 ha area of Vancouver Island, British Columbia, exhibited no difference in species richness or relative abundance of songbirds 1 year after being sprayed with *Btk* to control for Gypsy Moth (*Lymantria dispar*) (Sopuck et al. 2002). Holmes (1998) found that the nestling survival and growth of Tennessee Warblers (*Vermivora peregrina*) were unaffected by sites treated with *Btk* in Ontario, and although nests in sprayed sites had smaller clutches, smaller broods, and lower hatch rates, the differences were not significant. Other studies have found significant indirect impacts of microbial pesticides to birds. Spruce Grouse (*Dendragapus canadensis*) chicks in an area treated with *Btk* in Ontario had significantly slower growth rates compared with chicks raised in study sites not treated with *Btk* (Norton et al. 2001). Norton et al. (2001) attributed this to the reduction in available Lepidoptera larvae as a result of spraying.

Neonicotinoid insecticides were introduced in the 1990s and although their rates of use are poorly known across Canada Warbler's range, nearly 11 million ha of cropland across the Canadian Prairies were estimated to be treated with neonicotinoids (Main et al. 2014). Neonicotinoids are generally used on agricultural lands, but have been detected in wetlands (Main et al. 2014) and waterways in Canada (Environment Canada 2011a, Xing et al. 2013). The indirect impacts of neonicotinoids on Canada Warblers are unknown but, given that Canada Warbler's habitat does not include cropland, they are likely very small, even given the insecticides mobility and persistence in the environment (Hladik et al. 2014). Nevertheless, Mineau and Palmer (2013) suggested that the effects of neonicotinoids to birds may not be limited to the farm scale, but likely expand to the watershed or regional scale; therefore neonicotinoids could be impacting insect and bird species found outside of the arable lands and have been included here as a contributing factor to the threat. Neonicotinoids are adversely affecting insect populations and in 2013 the European Food Safety Authority declared that they posed "unacceptable" risk to insects (Goulson 2014). In the Netherlands, neonicotinoid concentrations in surface waters were correlated with the declines in

farmland insectivorous birds (Hallmann et al. 2014). Hallmann et al. (2014) suggested these declines were likely caused by a reduction of insect prey as a result of insecticide use. The indirect effects of these insecticides have also been noted in Skylark (*Alauda arvensis*), Yellowhammer (*Emberiza citronella*), Whinchat (*Saxicola rubetra*), Reed Bunting (*Emberiza schoeniclus*), and Corn Bunting (*Miliaria calandra*) (Boatman et al. 2004, Gibbons et al. 2014).

Coffee plantations in Canada Warbler's wintering range are known to use high levels of pesticides (Rappole et al. 2003). It is unknown how these may affect Canada Warbler prey availability.

Collisions with Anthropogenic Structures and Vehicles

During their nocturnal migration, Canada Warblers can collide with man-made structures such as buildings, communications towers, power lines, and wind turbines. Even if such kills are episodic, they may be significant at the population level.

Approximately 25 million birds (of many species) are killed annually in Canada from collisions with windows (Machtans et al. 2013) and between 365 and 988 million birds are killed each year in the United States (Loss et al. 2014a). Canada Warblers are considered to be highly vulnerable to collisions with buildings, including with low-rises, high-rises (Loss et al. 2014a). They are at 17.9 times greater risk of collisions than the average species across all building types, 46.7 times greater risk of collisions with low-rise buildings, and 25.8 times greater risk of collisions with high-rise buildings (Loss et al. 2014a).

An estimated 6.8 million birds (of many species) are killed by collisions with communication towers each year in the United States and Canada (Longcore et al. 2012). Mortality is most frequent for Neotropical migrants and nocturnal migrants attracted to tower lights (Longcore et al. 2013). One study of collisions with communication towers in central and eastern North America estimated that 20,622 Canada Warblers are killed in this way each year (Longcore et al. 2013).

It is estimated that 2.5-25.6 million birds (of many species) are killed each year by transmission lines in Canada (Rioux et al. 2013) and between 12 and 64 million birds are killed each year by power lines in the United States (8-57 million of these by collisions and 0.9-11.6 million by electrocution) (Loss et al. 2014c). The impact of these collisions has not been quantified for Canada Warbler.

Approximately 23,300 birds (of many species) are killed in Canada each year from collisions with wind turbines (Zimmerling et al. 2013). Almost 50% of the deaths from collisions with wind turbines are predicted to occur in Ontario (Zimmerling et al. 2013). Approximately, 70 Canada Warblers are predicted to die annually as a result of collisions with wind turbines in Canada (Zimmerling et al. 2013).

Bishop and Brogan (2013) estimated that approximately 3,462 birds (of many species) were killed per 100 km of 1- and 2-lane paved roads outside of major urban centers in Canada during each breeding season, and Loss et al. (2014b) estimated that between 89 and 340 million birds die each year in the United States from vehicle collisions. Although there are exceptions, in general, mortality rates due to vehicle collisions often increase with increasing traffic speed, road corridor width, and road elevation (above surrounding land) (Case 1978, Baudvin 1997, Loss et al. 2014b). Passeriformes make up 40% of all avian vehicle-collision casualities in North America, but Canada Warbler was not recorded in any of the 28 studies that surveyed roads in North America reviewed by Bishop and Brogan (2013).

Problematic Native and Non-native Species

Brood parasitism is a behavior practiced by certain bird species where eggs are laid in another species' nest, at the detriment of that particular individual. Brood parasitism by Brown-headed Cowbirds is a potential threat to Canada Warblers, at least in localized areas where the two species overlap (Cooper et al. 1997). Although cowbirds parasitize Canada Warbler nests, there is no evidence that this threat is causing negative effects on population size (Reitsma et al. 2010).

Domestic and feral cats are the largest source of human-related mortality of birds in Canada (Calvert et al. 2013). An estimated 2-7% of all birds in southern Canada are killed by cats annually (Blancher 2013). Although cats are less of a concern in northern areas and within interior forests, Canada Warbler would be vulnerable to cat predation (particularly because it nests near ground level) in southern and rural parts of its breeding range. Canada Warbler is likely most susceptible to cat predation along its migration route, where the species has been noted near parks and populated areas.

Parasitism and predation may be of particular concern to Canada Warbler during breeding because it lays a single brood.

Habitat Shifting and Alteration

Migratory bird species that travel long distances are dependent on multiple, spatially disparate, habitats during their annual cycle (breeding, migration, and wintering). This makes them particularly sensitive to the impacts of climate change because any change along the route could negatively impact the population (Newson et al. 2009, Robinson et al. 2009). There is little information to directly link climate change to the population decline of Canada Warbler, but Cumming et al. (2014) suggested a large potential for avian distributional shifts in response to climate change.

Temperature Extremes and Storms

The increased frequency of tropical storms and other adverse weather conditions (e.g., heavy rain, extreme temperatures, intense wind storms) caused by climate change could result in higher nest failure and direct mortality throughout Canada

Warbler's annual cycle (Rodenhouse et al. 2008). Severe weather could also reduce foraging opportunities, create thermoregulation problems for adults and young, disrupt migration, and damage wintering habitats.

Fire activity is strongly influenced by weather (Flannigan et al. 2009) and the extent, intensity, and frequency of forest fires are projected to further increase because of warmer and drier springs and summers (Flannigan et al. 2009, North American Bird Conservation Initiative US Committee 2010, de Groot et al. 2013, Girardin et al. 2013).

The significance of these weather extremes on Canada Warbler's population is currently unknown.

Pesticides (Direct Effects)

Mineau and Whiteside (2013) suggested that pesticides be strongly considered in efforts to identify the causes of bird population declines in North America, especially for those species that breed, winter, or migrate through agricultural areas. They were unable to separate between the direct (i.e., toxicity through ingestion of products such as coated seeds, inhalation, absorption through the skin, or by eating contaminated prey) and indirect (e.g., habitat or disruption to the food chain) effects of pesticides and they concluded that both are likely occurring (Mineau and Whiteside 2013). Although largely undocumented for this species, pesticide use on both breeding and wintering grounds has been implicated in direct mortality and habitat loss of many avian species (e.g., Chamberlain et al. 2000, Boatman et al. 2004, Mineau 2005).

Most organochlorine pesticides (chemicals in the same family as DDT) have been banned for decades in North America. Little is known about the extent to which Canada Warbler and other Neotropical migrant passerines were exposed to organochlorine pesticides throughout their lifetime (Gard et al. 1993, Klemens et al. 2000), but there is some indication that Neotropical migrant insectivores are still being exposed to organochlorine pesticides in North America (Sager 1997, Klemens et al. 2000). This may be legally through loopholes in the restriction laws, or illegally. These pesticides may still be in use in Central and South America (Klemens et al. 2000, Lebbin et al. 2010, Nebel et al. 2010) for nuisance mosquito control and agricultural or other applications. Endosulfan, which is primarily used on a wide variety of food crops is an exception to the ban of organochlorine pesticides but will be phased out of use in the US by 2016 because it was deemed to pose an unacceptable risk to farmworkers and wildlife (birds, in general, are fairly sensitive to endosulfan poisoning) (U.S. Environmental Protection Agency 2010). Several other countries have followed suit acting to ban the chemical through the Stockholm Convention on Persistent Organic Pollutants: an international environmental treaty signed in 2001 (Secretariat of the Stockholm Convention 2011).

Organophosphorus/organophosphate and carbamate compounds have been used increasingly since the majority of organochlorine pesticides were restricted in North America in the 1970s and banned in the 1980s (Commission for Environmental

Cooperation of North America 2003). Birds and other vertebrate species are susceptible if they ingest or otherwise absorb enough organophosphate or carbamate pesticides and birds appear to be more sensitive than other vertebrates (Freedman 1995, Friend and Franson 1999).

The direct impacts of a relatively new class of pesticides, neonicotinoids, are unknown for insectivorous species such as Canada Warbler. Hallmann et al. (2014) correlated neonicotinoid concentrations in surface waters to declines in insectivorous birds in the Netherlands. They suggested the declines were in relation to a reduction of insect prey, but they could not rule out direct pathways in which the neonicotinoids may have had an effect on the birds (Hallmann et al. 2014). The exposure of Canada Warbler to neonicotinoid pesticides is unknown but, given its habitat preferences, is probably low on its breeding grounds even given the pesticide's mobility and persistence in the environment (Hladik et al. 2014).

In Canada Warbler's wintering habitat, coffee plantations are known to use high levels of pesticides and have associated run-offs (Rappole et al. 2003). It is unknown how these may affect Canada Warbler.

Mercury

Mercury is a naturally occurring element that is enriched in the environment by human activities. Long-range atmospheric transport and deposition is the dominant source of mercury to many aquatic habitats over much of the landscape (Fitzgerald et al. 1998, U.S. Geological Survey 2000). Bio-available mercury is also mobilized within watersheds by forestry activities, hydroelectric reservoir creation, and various industrial-related activities (Porvari et al. 2003, Vuori et al. 2003, Wiener et al. 2003). Mercury concentrations in aquatic food webs are usually correlated with low pH levels, and as a result mercury concentrations increase from west to east across Canada in freshwater food webs (Depew et al. 2013).

Mercury exposure can decrease reproductive success, alter immune responsiveness, and cause behavioural and physiological effects in birds (Scheuhammer et al. 2007, Hawley et al. 2009). Research by Keller et al. (2014) and Rimmer et al. (2010) suggested that mercury is biomagnifying in terrestrial songbirds that eat invertebrates. Canada Warbler may be exposed in some parts of its range to elevated methylmercury (MeHg; toxic form of mercury), due to its consumption of predatory insects from acidic wetlands where mercury is easily converted to methylmercury (Greenberg and Matsuoka 2010, Evers et al. 2011, Edmonds et al. 2012). A recent large-scale study of mercury in an insectivorous bird, the Rusty Blackbird, emphasized the potential threat of mercury, especially to the population in northeastern North America (Edmonds et al. 2010). The feathers of Rusty Blackbirds breeding in the Acadian forest ecoregion of New England and the Maritimes (Maine, New Hampshire, Vermont, New Brunswick, and Nova Scotia,) had mercury concentrations that were orders of magnitude higher than concentrations observed in the wintering sites in the southern United States and breeding sites in Alaska (Edmonds et al. 2010).

Acid Precipitation

Acid precipitation has been identified as a contributing factor in the decline of spruce-fir forests throughout eastern United States (U.S. Environmental Protection Agency 2014) and this is presumably occurring in Canada as well. Acidification may modify habitat leading to altered soil invertebrate assemblages (see section: Reduced Availability of Insect Prey), loss of favoured nesting and/or foraging sites (Hames et al. 2002), increased vigilance and incubation, and increased predation risk (Brotons et al. 1998). Acidification of forests also contributes to the leaching of calcium from soils, a phenomenon that is particularly marked in the northeastern part of the continent (Driscoll et al. 2001), where soil buffering is relatively poor due to low pH and nitrogen saturation (i.e., nitrates can remove additional calcium from the soil) (U.S. Environmental Protection Agency 2014). Passerines must obtain calcium from their food during the egg-laying period (Hames et al. 2002), and calcium deficiency during this time may lead to birds laying eggs with shells that are thin, weak, and more porous which can lead to breeding failure. Although there is no direct evidence for Canada Warbler, acidification of its breeding habitat could negatively affect the species. Acidification has been implicated in the decline of Wood Thrush (Hames et al. 2002), as well as other passerine birds from northern Europe that nest in acidified parts of their range (Graveland and Drent 1997, Mänd et al. 2000).

5. POPULATION AND DISTRIBUTION OBJECTIVES

The short-term population objective for Canada Warbler in Canada is to halt the national decline by 2025 (i.e., 10 years after this recovery strategy is posted on the Species at Risk Public Registry), while ensuring the population does not decrease more than 10% over this time. The long-term (after 2025) population objective is to ensure a positive 10-year population trend for Canada Warbler in Canada.

The distribution objective for Canada Warbler is to maintain the current extent of occurrence (the area that encompasses the geographic distribution of all known populations) in Canada.

The population objectives address the species' long-term decline, which was the reason for its designation as Threatened (COSEWIC 2008). Short comings with the BBS dataset (see section 3.2 Population and Distribution) for this species are acknowledged and this strategy includes approaches to improve monitoring for the Canada Warbler. As new information becomes available, population and distribution objectives might be revised, as appropriate to species recovery.

The 10-year time frame was deemed appropriate to assess population change in the Canada Warbler. This time frame was selected because halting the decline of a species is challenging, and cannot be done in just a few years, and because COSEWIC species

assessments occur every 10 years. Their criteria for assessment include reviewing population change within 10-year windows.

These objectives will be reviewed during the development of the report required 5 years after this strategy is posted to assess the implementation of the strategy and the progress towards meeting its objectives (s. 46 SARA).

6. BROAD STRATEGIES AND GENERAL APPROACHES TO MEET OBJECTIVES

6.1 Actions Already Completed or Currently Underway

Numerous activities have been initiated since the latest COSEWIC assessment (COSEWIC 2008). The following list is not exhaustive, but is meant to illustrate the main areas where work is already underway and to give context to the broad strategies to recovery outlined in section 6.2. Actions completed or underway include the following:

- The creation of the Canada Warbler Conservation Initiative led by Environment Canada (Bird Studies Canada 2013).
- Habitat Stewardship Program (HSP) projects to determine significant habitat in Alberta (Ball et al. 2013).
- Observational studies of habitat use to identify the characteristics that distinguish suitable habitat in British Columbia (Manning Cooper and Associates Ltd. 2007), Alberta (Krikun 2012), Nova Scotia (Ryan 2012, A. Westwood pers. comm.), and Canada-wide (Cumming et al. 2010).
- Modelling research to determine significant habitat attributes for Canada Warbler at varying spatial scales across Canada (Haché et al. 2014).
- Observational studies of singing behavior to improve song survey methods (Cummings 2011, Demko et al. 2013) .
- Completion and publication of Bird Conservation Region plans for Canada that identify conservation objectives and actions for priority bird species (including Canada Warbler) (Environment Canada 2014b).
- Research regarding the broad-scale predictors of aerial insectivore declines across North America (e.g., http://homepage.usask.ca/~cam202/page11.html).
- Alberta status report for Canada Warbler (Ball and Bayne *In review*).
- Research to determine breeding, migratory, and wintering linkages of Canada Warbler breeding across the species range (K. Fraser, pers. comm.; S. Haché, pers. comm.).
- Acoustic monitoring of nocturnal migrants (including Canada Warbler) near Lake Erie (Sanders and Mennill 2014b, a).
- Report identifying the current knowledge of Canada Warbler wintering distribution and ecology in South America (BirdLife International 2014).
- Fatal Light Awareness Program (FLAP): a program focused on tracking and preventing migratory bird collisions with windows (FLAP Canada 2014).

- Forestry and silviculture practices and initiatives in areas across the country that attempt to preserve habitat features thought to be important for Canada Warbler and/or identify occupied habitat.
- Articles and websites to motivate interest and participation in recovery actions (by federal, provincial, and non-governmental agencies and organizations - e.g., CWS, Bird Studies Canada, Georgian Bay Biosphere Reserve, Ontario Nature, Fatal Light Awareness Program). Examples:
    - http://www.bsc-eoc.org/download/BWCwi09.pdf
    - http://onnaturemagazine.com/canada-warbler.html
    - http://www.borealbirds.org/bird/canada-warbler
- Several conservation-oriented projects have been implemented in Canada and the United States that include Canada Warbler in the framework of activities. These include the following groups and/or projects:
    - The Boreal Avian Modeling Project (http://www.borealbirds.ca/)
    - The Boreal Songbird Initiative (http://www.borealbirds.org/)
    - The Canadian Boreal Initiative (http://www.borealcanada.ca/)
    - The Breeding Bird Survey (https://www.pwrc.usgs.gov/BBS/ and https://ec.gc.ca/reom-mbs/default.asp?lang=En&n=416B57CA-1)
    - Breeding Bird Atlases throughout Canada, and associated rare-species forms (http://www.bsc-eoc.org/volunteer/atlas)

6.2 Strategic Direction for Recovery

Table 3. Recovery Planning for Canada Warbler

Threat or Limitation	Broad Strategy to Recovery	Priority	General Description of Research and Management Approaches
Habitat loss and degradation, Natural system modification, Invasive and problematic species, Pollution	Habitat and species conservation and management	High	• Conserve habitat deemed important for this species and its prey in breeding and nonbreeding areas
		Low	• Control problematic species, where feasible and deemed necessary • Encourage adherence to the principles of Integrated Pest Management and encourage use of environmentally benign pesticides at small scales
Knowledge gaps to recovery	Monitoring and research	High	• Determine relative importance of known and suspected threats to the species, its prey, and their habitat (see Appendix B for more details) • Develop and implement standardized protocols and survey designs (data collection and analysis) for the population (particularly for areas outside of Breeding Bird Survey (BBS) coverage), its insect prey populations, and their habitat characteristics • Determine migratory routes, migratory connectivity, and important stopover locations • Determine habitat use, local population trends, and habitat trends on wintering grounds and during migration • Determine key demographic parameter estimates throughout the annual cycle • Investigate factors affecting reproductive output, survival, and fidelity to breeding sites • Develop and validate habitat models at both national and regional scales
		Low	• Refine Canadian population estimate
All threats	Law and policy	High	• Develop and implement beneficial management practices and policies for the species,

Threat or Limitation	Broad Strategy to Recovery	Priority	General Description of Research and Management Approaches
			its prey, and their habitat (e.g., related to forest harvesting and silviculture, shrub removal, energy and mining, browsing and grazing, and bird-window strikes)
		Medium	• Review policies regarding window design for federal and non-federal buildings along migration routes to reduce likelihood of window collisions and develop regulations and incentives to make windows less prone to bird strikes along Canada Warbler migration routes • Implement ecosystem conservation through private sector standards and codes • Implement existing policies and reduction programs to reduce and/or mitigate the threat of pollution and develop new policies and programs where gaps exist
All threats	Education and Awareness, Stewardship, and Partnerships	High	• Promote compliance of international, federal (e.g., SARA, *Migratory Birds Convention Act, 1994*), provincial, and municipal acts and policies, as well as BMPs that protect the species, its prey, and their habitat • Promote national cooperation and collaboration to fill knowledge gaps and to mitigate threats in Canada • Promote international cooperation and collaboration to fill knowledge gaps and to mitigate threats outside the breeding season • Foster cooperative relationships with government, landowners, foresters, farmers, industry, pet owners, and others to mitigate threats to the species, its prey, and habitat
		Medium	• Create opportunities for public involvement in habitat conservation initiatives • Promote volunteer participation in surveys and monitoring • Promote ecosystem conservation through private sector certification, if deemed effective for recovery of the species

6.3 Narrative to Support the Recovery Planning Table

Canada Warbler recovery will require the commitment, collaboration and cooperation among international, federal, provincial and territorial jurisdictions, wildlife management boards, aboriginal people, local communities, landowners, industry, and other interested parties. Owing to Canada Warbler's widespread range, it will be important to monitor habitat conditions, population trend, and the distribution of the species so that the effectiveness of the recovery efforts can be evaluated and adjusted as necessary.

Habitat and Species Conservation and Management

It is currently unknown whether breeding habitat is limiting in Canada. Nevertheless, adequate breeding habitat must be managed and protected to ensure species survival, particularly in areas where large portions of habitat could be transformed or degraded. As well, trends in prey population dynamics must be better understood to know whether maintaining, enhancing, and/or restoring insect-producing habitats will significantly benefit Canada Warbler populations.

Resolving how to determine the relative importance of nonbreeding versus breeding habitat supply is an important activity for the recovery of this species. Knowing where to most effectively place economic support, and research and monitoring is important for habitat and species conservation.

The best management of breeding habitat will fail to recover the species unless migration and wintering habitat is also maintained. Thus, collaboration with international jurisdictions and non-governmental organizations to preserve, restore, and enhance winter and migration habitat is an equally important component of this strategy. Such collaboration should have an additive effect on other species at risk, whose winter and migration ranges overlap with Canada Warbler (see Appendix A).

Monitoring and Research

It is unclear to what extent threats in Canada are affecting population decline of Canada Warbler or whether the significant drivers of population decline are occurring elsewhere during another part of the species' annual cycle. A comprehensive approach to research and monitoring (which includes all stages of the annual life cycle and the entire range of occupancy) will be required to more completely understand the status of the species, as well as its threats and limiting factors in Canada and beyond (see Appendix B for examples of threat-based research needs). Currently, monitoring of the species is limited primarily to the southern extent of their breeding range (especially in the east), and as a result, additional effort and focus is required in more northern extents of their range.

Since the population objective for this species includes halting the decline and ultimately increasing the population over time, identifying potentially suitable habitat that is currently unoccupied is necessary. Furthermore, identifying migratory routes, stopover

sites, and migratory connectivity is also important. Determining key demographic parameters through Canada Warbler's annual cycle (e.g., survival and reproductive success in different habitat types) will provide insight into the most suitable habitat characteristics, as well as effective activities/locations of concern for the species, population size, etc. Associated with these efforts, there is a need to build and validate corresponding habitat models at national and regional scales to better understand where on the landscape the species would be expected to breed, and assist with efforts to protect habitat. There are fewer monitoring programs established on the wintering grounds, but these are essential and need to be developed and implemented to provide better information on habitat use and local habitat and population trends.

While some research has clarified the habitat needs and limiting factors of Canada Warbler since the status report was written in 2008, most of this research was conducted at a few study sites in eastern United States (Vermont and New Hampshire) (Reitsma et al. 2010). Research should be extended to the Canadian portion of the bird's breeding range, with particular emphasis on the issues that relate to the following: 1) determining the relative importance of the suggested threats, 2) determine habitat features that maximize abundance and reproductive success, and 3) determine whether data on abundance are a valid measure of habitat quality.

While necessary monitoring and research occurs, the current state of available science can provide a base of knowledge to protect known habitats and mitigate threats for the species.

Law and Policy

There are multiple legal means available to protect Canada Warblers and their habitat in Canada. It is important that these tools are fully realized and utilized for the protection of the species. Four Canadian provinces (Manitoba, Ontario, Quebec, and New Brunswick) presently have this species listed on their respective species-at-risk legislation, and fully realizing the potential of the protection offered by these designations is important.

General prohibitions under the *Migratory Birds Convention Act* (1994) and its regulations protect Canada Warbler nests and eggs anywhere they are found in Canada, regardless of land ownership. Nevertheless, nests and eggs can be inadvertently harmed or disturbed as a result of many activities, including but not limited to clearing trees. During the breeding period, potential destructive or disruptive activities should be avoided at locations where Canada Warbler is likely to be encountered or known to occur (Environment Canada 2014a). This mitigation can also be accomplished through various avenues, including planning policies and regulations, and environmental assessments.

Beneficial management practices (BMPs) and associated policies for Canada Warbler, its prey, and their habitat must be developed and implemented based on the best available science. These can include BMPs and policies related to a variety of known

and suspected threats, including forest harvesting and silviculture, energy and mining exploration and extraction, bird-window strikes, browsing and grazing animals, and problematic species. Beneficial management practices for this species must be integrated with those for other species to maintain heterogeneous landscapes that are a dynamic mosaic of habitat conditions that will benefit several species. Whenever possible a multi-species approach to recovery should be considered. Beneficial management practices for governments, industry, and even individuals can play an important role for the ongoing efforts across the range of the species and will be needed to promote recovery of the Canada Warbler and conservation on a large scale across the continent and into South America.

Beyond Canada's borders, international collaboration on research and stewardship programs will be important for Canada Warbler recovery and conservation considering the potential threats in nonbreeding areas. An example of such an approach has already been established – the Canada Warbler Conservation Initiative will be tackling these types of initiatives on an international scale in the years to come.

Education and Awareness, Stewardship, and Partnerships

Cooperative relations should be fostered with various levels of governments, landowners, foresters, industry, and pet owners (to name a few). Stewardship initiatives need to be pursued in strategic locations throughout Canada Warbler's range, especially in areas of increased likelihood of development in the near future. Within these areas of potential development, the need for BMPs and appropriate policies will be increasingly important. Regulations, policies, and BMPs that provide protection for the species should be promoted to encourage compliance. Some parts of the boreal region of Canada are experiencing increased exploration, and the threats in these areas will only increase with time.

Preserving and enhancing Canada Warbler breeding habitat will require promotion of conservation and stewardship on a broad scale. The key actions that can be promoted include the forest harvesting and silviculture practices that provide breeding habitat and reduce the risk of nest and egg disruption and/or destruction and practices which reduce the risk of window-strikes. In addition, because broad-scale monitoring and surveying is complicated by the large range of the species and the relative inaccessibility of portions of its range (e.g., northern range), developing targeted surveys, innovative survey approaches (e.g., acoustic monitoring), and promoting volunteer participation and collaborations are critical. Volunteers whose efforts should be promoted include local bird clubs who have local knowledge of areas with high breeding densities and citizen scientists participating in bird atlases and BBS programs. As well, citizen-based data collection (e.g., eBird) should continue to be encouraged to aid in ongoing research and monitoring.

Voluntary private sector standards and codes such as third-party sustainable forest management certification, international rating systems that recognize excellence for green building and programs, such as the Integrated Pest Management Accreditation

Program may also help reduce some of the potential threats faced by the species and its prey.

7. CRITICAL HABITAT

Section 41(1)(c) of SARA requires that a recovery strategy includes an identification of the species' critical habitat to the extent possible.

7.1 Identification of the Species' Critical Habitat

An examination of the geographic range of the species, its habitat specificity, its population size, and threats indicates that critical habitat should be identified at a landscape scale[3]. Although habitat suitability is generally understood (see section 3.3) and some habitat suitability modeling has been done (Haché et al. 2014), currently, it is unknown whether habitat is limiting in Canada. The available information is not adequate to identify critical habitat at a landscape scale for the following reasons:

- There is a lack of understanding and data to indicate the appropriate configuration of important landscape biophysical attributes.
- Habitat requirements may vary across the range of the species. Management units (i.e., geographic units within which critical habitat would be managed) need to be identified in such a way to best reflect variation in habitat use and management patterns.
- There is a lack of data related to Canada Warbler presence and abundance in large portions of its range. Without this information any model used to predict critical habitat with current data may have a limited ability to do so in these areas.
- For Canada Warbler, it is unclear whether certain habitats with specific biophysical attributes may be functionally more important than others. For example, specific habitats may have greater densities of individuals or pairs and/or result in higher reproductive success.
- The relationships between anthropogenic disturbance and habitat quality are poorly known. A better understanding of these relationships is needed to ensure sufficient suitable habitat is available for Canada Warbler and to identify at what scale and intensity activities would be likely to destroy the critical habitat.

[3] Environment Canada recognizes three broad approaches in identifying critical habitat: site-level (small/localized geographic range, narrow habitat specificity), area-level (intermediate geographic range, wide or narrow habitat specificity), and landscape-level (large geographic range, wide habitat specificity) (Environment Canada 2013). These three conceptual scales are used to help provide context for the critical habitat identification, its presentation, and description of activities likely to destroy critical habitat.

A Schedule of Studies has been developed to provide the information necessary to identify the critical habitat that will be sufficient to meet the population and distribution objectives. The identification of critical habitat will be included in a revised recovery strategy or an action plan.

7.2 Schedule of Studies to Identify Critical Habitat

To inform the Schedule of Studies a recent project was undertaken by the Boreal Avian Modelling group to help identify patterns of habitat use for Canada Warbler (Haché et al. 2014). Haché et al. (2014) assessed habitat attributes of Canada Warblers across Canada based on avian point counts, available land classification metrics (i.e., land cover, disturbance and topography), and environmental data (i.e., climate). While the results have added to our knowledge of habitat use by Canada Warbler, the work cannot be used to identify habitat that is critical for the survival or recovery of the species because of the lack of adequate information (outlined in section 7.1).

The following Schedule of Studies is required to identify critical habitat.

Table 4. Schedule of Studies

Description of Activity	Rationale	Timeline
Determine the appropriate management units based on habitat requirements across the species range.	Habitat requirements may vary across the range of the species. Management units need to be identified to best reflect this variation in habitat use.	2016
Increase monitoring at strategic locations.	Information on abundance, productivity and other measures of habitat quality is poor in many regions of the country. Increased monitoring in pre-determined locations is necessary to validate and improve recent habitat models (i.e., Haché et al. 2014).	2016-2020
Determine the appropriate configuration of landscape biophysical attributes.	To identify critical habitat at a landscape scale it is necessary to understand the biophysical attributes required by the species at this scale and to determine how these should be configured to meet the species' needs.	2016-2019

Description of Activity	Rationale	Timeline
Determine habitat quality across and within management units.	Information on abundance, productivity and other measures of habitat quality may lead to the identification of areas that contribute disproportionately to the survival or recovery of Canada Warbler.	2016-2020
Determine the scale and intensity at which suitable habitat would likely be destroyed by anthropogenic activities.	A better understanding of the relationship between anthropogenic disturbance and habitat quality is needed to ensure sufficient suitable habitat is available for Canada Warbler and to identify at what scale and intensity activities would be likely to destroy critical habitat.	2016-2020
Determine how much suitable habitat is required to meet the population and distribution objectives.	It is uncertain whether habitat is limiting in Canada for Canada Warbler. An assessment of whether there is sufficient habitat in Canada to meet the population and distribution objectives is required.	2020
Develop and validate habitat models to determine where biophysical attributes are present in required quantity, quality and configuration within each management unit to meet population and distribution objectives.	Results from studies listed above, will allow models to be built to identify the location, quantity, and quality of habitat that should be identified as critical habitat for Canada Warbler.	2021

8. MEASURING PROGRESS

The performance indicators presented below provide a way to define and measure progress toward achieving the population and distribution objectives.

- In the short term (10 years; before 2025), declining population trends have been halted or reversed to a point where Canadian populations of Canada Warbler have declined no more than 10% during this time.
- In the long term (after 2025), a positive 10-year trend is achieved (i.e., the population is increasing).
- The breeding extent of occurrence for Canada Warbler is maintained throughout Canada.

9. STATEMENT ON ACTION PLANS

One or more action plans for Canada Warbler will be posted on the Species at Risk Public Registry within 5 years of the posting of the recovery strategy.

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PERSONAL COMMUNICATIONS

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S. Wilson. 2014. Science and Technology Branch, Environment Canada, Ottawa, ON.

APPENDIX A: EFFECTS ON THE ENVIRONMENT AND OTHER SPECIES

A strategic environmental assessment (SEA) is conducted on all SARA recovery planning documents, in accordance with the Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals[4]. The purpose of a SEA is to incorporate environmental considerations into the development of public policies, plans, and program proposals to support environmentally sound decision-making and to evaluate whether the outcomes of a recovery planning document could affect any component of the environment or any of the Federal Sustainable Development Strategy's[5] (FSDS) goals and targets.

Recovery planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that strategies may also inadvertently lead to environmental effects beyond the intended benefits. The planning process based on national guidelines directly incorporates consideration of all environmental effects, with a particular focus on possible impacts upon non-target species or habitats. The results of the SEA are incorporated directly into the strategy itself, but are also summarized below in this statement.

Canada Warblers often breed in moist, richly vegetated habitats within a forested landscape, so protection of its breeding habitat may be consistent with protecting wetlands (depending on local habitat preferences) and old-growth forests, which will benefit other forest species. For example, Canada Warbler are recorded in similar locations as Cape May Warbler (*Setophaga tigrina*), Barred Owl (*Strix varia*), and Least Flycatcher (*Empidonax minimus*). Similarly, actions that enhance wintering habitat may have additive effects favouring several other landbird species at risk which share Canada Warbler wintering habitat or have overlapping ranges: Olive-sided Flycatcher (*Contopus cooperi),* Eastern Wood-pewee (*Contopus virens* - COSEWIC assessed but not yet SARA listed*)*, Cerulean Warbler (*Setophaga caerulea)*, Common Nighthawk, (*Chordeiles minor),* Chimney Swift (*Chaetura pelagica*), Acadian Flycatcher (*Empidonax virescens*), Golden-winged Warbler (*Vermivora chrysoptera),* Prothonotary Warbler (*Protonotaria citrea*) (Robinson et al. 1995, Roca et al. 1996). Canada Warbler migratory route also overlaps with the migratory routes of other species at risk: Bobolink (*Dolichonyx oryzivorus*), Cerulean Warbler (Sanders and Mennill 2014a), Bank Swallow (*Riparia riparia*), and Barn Swallow (*Hirundo rustica*) (Stiles 1994).

Nonetheless, some species, including other species at risk, may prefer different forest conditions. For example, two landbirds require different forest breeding habitat than Canada Warbler: Eastern Wood-pewee, assessed as special concern by COSEWIC, breeds in intermediate and mature forest stands with little underbrush (COSEWIC 2012) and the Threatened Eastern Whip-poor-will breeds in semi-open forests with little

[4] http://www.ceaa.gc.ca/default.asp?lang=En&n=B3186435-1
[5] http://www.ec.gc.ca/dd-sd/default.asp?lang=En&n=CD30F295-1

understory vegetation (COSEWIC 2009). Recovery actions for the species must be integrated with best practices for other songbird and wildlife species.

The possibility that the present recovery strategy inadvertently generates negative effects on the environment and on other species was considered. The majority of recommended actions are non-intrusive in nature, including surveys and outreach. It is unlikely that the present recovery strategy will produce significant negative effects.

APPENDIX B: ADDITIONAL RESEARCH FOR KNOWN AND SUSPECTED THREATS TO CANADA WARBLER, ITS PREY, AND THEIR HABITATS

The following list is not exhaustive, but illustrates some of the research required to understand the threats to the species, its prey, and their habitats.

Habitat Loss or Degradation

- Investigate the rate and impact of various types of habitat loss throughout nonbreeding areas.
- Determine the relative importance of nonbreeding versus breeding habitat supply in population declines.
- Determine the amount (and characteristics) of forest harvesting and silviculture that can be completed while maintaining enough suitable habitat at a landscape scale for Canada Warbler populations.
- Determine the effects of alterations in hydrological regimes on Canada Warbler.
- Determine the impact of cattle grazing on Canada Warbler habitat along the boreal fringe of western Canada.

Natural System Modifications

- Determine potential links between insect availability and breeding productivity.
- Determine whether there is a temporal mismatch between reproduction and maximal prey abundance is occurring.
- Determine the effects of habitat loss (particularly in wintering areas) on Canada Warbler's prey availability.
- Determine the exposure of pesticides, mercury, and acidification throughout Canada Warbler's range, and their potential effects on prey availability.

Accidental Mortality

- Monitor frequency of collisions and determine site characteristics contributing to high collision rates.

Invasive and Other Problematic Species

- Investigate the impact of brood parasitism on Canada Warbler productivity.
- Determine human-related predation risk in urban and rural areas (e.g., by cats and other species with increased populations due to human habitation).

Climate Change and Severe Weather

- Determine the impacts of climate change on the species and its habitat.

Pollution

- Determine Canada Warblers' exposure to pollution (pesticides and mercury) and identify impacts.

- Determine whether acidification of the species' environment is negatively affecting the Canada Warbler and its habitat (e.g., through loss of favoured nesting and/or foraging sites, increased predation risk, and calcium deficiency during egg-laying and chick-rearing phases).