COSEWIC
Assessment and Status Report

on the

Suckley's Cuckoo Bumble Bee
Bombus suckleyi

in Canada

THREATENED
2019

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

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

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Production note:
COSEWIC would like to acknowledge Jennifer M. Heron and Cory S. Sheffield for writing the status report on Suckley's Cuckoo Bumble Bee (*Bombus suckleyi*) in Canada, prepared under contract with Environment and Climate Change Canada. This report was overseen and edited by David McCorquodale, Co-chair of the COSEWIC Arthropods Specialist Subcommittee.

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Photograph of Suckley's Cuckoo Bumble Bee from Woodrow, Saskatchewan on June 30, 2019, by Cory S. Sheffield.

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COSEWIC
Assessment Summary

Assessment Summary – November 2019

Common name
Suckley's Cuckoo Bumble Bee

Scientific name
Bombus suckleyi

Status
Threatened

Reason for designation
This bumble bee is a nest parasite of other bumble bees and depends on its hosts to rear its young. It is found in all provinces and territories except Nunavut. It is more frequent in the west than in the east and always much less frequent than its hosts. Despite significantly increased search effort for bumble bees in Canada over the last two decades, fewer individuals of this species have been encountered than in the past. There has been a decline of more than 30% in relative abundance compared to all bumble bees (indicating a population decline) and a decline in area of occupancy. The decline has been particularly severe in areas where the species was historically more frequent, in British Columbia and Alberta. The primary threat is the steep decline of the host bumble bee species, again in British Columbia and Alberta. The major threats to the hosts are the escape of pathogen-infected bumble bees from managed colonies in commercial greenhouses, pesticide use (particularly neonicotinoids), and climate change.

Occurrence
Yukon, Northwest Territories, British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Québec, New Brunswick, Prince Edward island, Nova Scotia, Newfoundland (Island only, no species confirmed in Labrador)

Status history
Designated Threatened in November 2019.

COSEWIC
Executive Summary

Suckley's Cuckoo Bumble Bee
Bombus suckleyi

Wildlife Species Description and Significance

Suckley's Cuckoo Bumble Bee is one of six true cuckoo bumble bee species occurring in North America. Both sexes are medium-sized (15–25 mm length). Females are slightly larger than males and have an abdomen with shiny black terga (dorsal abdominal segments) and yellow hairs near the tip; males have a similar colour pattern, but with more yellow hair on the abdomen. Unlike nest-building bumble bees, female cuckoo bumble bees do not possess a corbicula (pollen basket) on the hind leg as they do not collect pollen for their offspring.

Suckley's Cuckoo Bumble Bee can be distinguished from the similar Gypsy Cuckoo Bumble Bee by the prominent triangular ridges on the underside of the last segment of the abdomen. Males also typically have more yellow hairs on the body than Gypsy Cuckoo Bumble Bee.

Suckley's Cuckoo Bumble Bee is an obligate social parasite of nest-building bumble bees of the subgenus *Bombus*. Of the four species in this subgenus in Canada, Western Bumble Bee is the only confirmed host in western Canada, while Yellow-banded Bumble Bee is the suspected host in eastern Canada due to co-occurrence of the two species in much of its eastern range of Suckley's Cuckoo Bumble Bee. Additional suspected hosts include Rusty-patched Bumble Bee (Ontario and Québec) and Cryptic Bumble Bee (northwestern Canada) because they are also in subgenus *Bombus* (like the confirmed host) and co-occur in the range of Suckley's Cuckoo Bumble Bee. However, there is no direct evidence that either of these are hosts.

Three of the host and probable host species have been assessed at risk in Canada by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC): Western Bumble Bee *occidentalis* subspecies (Threatened) and *mckayi* subspecies (Special Concern), Yellow-banded Bumble Bee (Special Concern) and Rusty-patched Bumble Bee (Endangered). Cryptic Bumble Bee, a Holarctic species and potential host, has not been assessed by COSEWIC and has a conservation status of Secure.

Distribution

Suckley's Cuckoo Bumble Bee has an extensive distribution from the southern United States to the subarctic regions of Canada (Yukon) and east to the island of Newfoundland (not confirmed from Labrador). In Canada, the species has been recorded in all provinces and territories except Nunavut. The species is more abundant in western Canada, and most collection sites are from west of Manitoba.

Canadian records of Suckley's Cuckoo Bumble Bee date from 1897 (British Columbia) and 1901 (Ontario) to 2019 (Saskatchewan and Yukon). Additional records within the last ten years are from Alberta (2018), British Columbia (2013) and the island of Newfoundland (2010). The distribution of Suckley's Cuckoo Bumble Bee is limited by the distribution, and presumably abundance, of its host bumble bee species, although other factors appear to be important because it has not been collected evenly throughout its hosts' range.

Habitat

Suckley's Cuckoo Bumble Bee occurs in diverse habitats including open meadows and prairies, farms and croplands, urban areas, boreal forest, and montane meadows. Records are from sea level to 1200 m although the species could potentially occur at higher elevations where its host(s) occur. In the early spring, hosts typically establish nests in abandoned underground rodent burrows or other dry natural hollows; because Suckley's Cuckoo Bumble Bee is a nest parasite these same host residence sites also serve as its habitat. Adults have been recorded feeding on pollen and nectar from many flowers.

Biology

Suckley's Cuckoo Bumble Bee is an obligatory social parasite of nest-building bumble bees, and therefore does not produce a eusocial colony with distinct castes (i.e. no workers). The species has an annual life cycle. Mated females emerge in the spring, slightly later than host nest-building species (e.g., hosts emerge March – April and cuckoos emerge April – June, sometimes later in higher latitudes and/or elevations) and begin to search for potential host nests. Successful nest parasitism by female cuckoos occurs after hosts have established colonies with some workers, but only if the host nest is not so large that the host workers can defend the colony and drive out the cuckoo. Once a host nest is found, the female cuckoo subdues (or kills) the host queen, and ultimately takes over egg laying in the nest; the workers of the original host queen care for the cuckoo's offspring. Cuckoos emerge throughout the summer and with higher numbers produced in late summer and early autumn. New female and male cuckoos produced in the host nest emerge to feed on nectar, and then mate. Mated females ultimately select an overwintering site, presumably near nest-building host species. Males and the original egg-laying female die at the onset of cold weather.

Population Sizes and Trends

Limited information on the Canadian on global population size and trends for Suckley's Cuckoo Bumble Bee is available. Most bumble bee surveys target all *Bombus* and do not specifically target cuckoo bumble bees. Historically, surveys have included all bumble bees and have mostly been conducted haphazardly or by wandering transects through suitable habitat, and have focused on recording new subpopulations, natural history and habitat information of bumble bees in general. Within the past 20 years, there have been extensive bumble bee surveys and academic research focused on pollinators, including bumble bees, and Suckley's Cuckoo Bumble Bee has been recorded during this work. The species is inherently less abundant than other bumble bees because it does not produce a worker caste and is less common than its hosts.

Historical data show Suckley's Cuckoo Bumble Bee appears to have always been more common in western Canada than in eastern Canada. The species has not been recorded from southern Ontario since the 1970s despite extensive search effort in the past twenty years. However, throughout other parts of its range the species remains present, albeit uncommon, where hosts occur.

Threats and Limiting Factors

The major threat to Suckley's Cuckoo Bumble Bee is the decline of its host species: Western Bumble Bee, in western Canada, and likely Yellow-banded Bumble Bee in eastern Canada. Both Western Bumble Bee and Yellow-banded Bumble Bee were once more common and widespread, and subpopulations have been declining through much of their range, likely due to pesticide use (including neonicotinoids), pathogen spillover (specifically within high intensity agricultural areas), and floral resource and habitat loss from agricultural intensification and natural systems modifications (e.g., fire suppression, natural shrub encroachment into open areas).

Protection, Status and Ranks

Suckley's Cuckoo Bumble Bee has no legal status and is not protected in Canada by any federal or provincial legislation. The species is globally ranked as Critically Imperilled (G1) and nationally in Canada as Vulnerable (N3) (NatureServe 2018). The species is assessed as Critically Endangered (CR) by the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species. Western Bumble Bee *occidentalis* (Threatened) and *mckayi* subspecies (Special Concern) have been assessed by COSEWIC but not listed under SARA. Yellow-banded Bumble Bee (Special Concern) has been assessed by COSEWIC and listed under SARA. Rusty-patched Bumble Bee has been assessed as Endangered by COSEWIC and listed under SARA.

TECHNICAL SUMMARY

Bombus suckleyi

Suckley's Cuckoo Bumble Bee

Bourdon de Suckley

Range of occurrence in Canada: Yukon, Northwest Territories, British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Québec, New Brunswick, Prince Edward island, Nova Scotia, Newfoundland (Island only, no species confirmed in Labrador)

Demographic Information

Generation time	1 year
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Yes, inferred reduction through decline in relative abundance of greater than 30% between decades 1999-2008 and 2009-2018 and decline of host bumble bees.
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	Yes, inferred reduction through decline in relative abundance of greater than 30% between decades 1999-2008 and 2009-2018 and decline of host bumble bees.
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time including both the past and the future.	Yes, inferred reduction through decline in relative abundance of greater than 30% between decades 1999-2008 and 2009-2018 and decline of host bumble bees and anticipated continuation.
Are the causes of the decline a. clearly reversible and b. understood, and c. ceased?	a. no; b. partially; c. no
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence (EOO) • EOO = 9,160,823 km² (based on minimum convex polygon, within Canada's extent of jurisdiction) • EOO = 9,710,188 (based on minimum convex polygon)	9,160,823 km²

Index of area of occupancy (IAO) (2x2 grid value).	5,136 km² based on records from 1901 - 2018, although, likely larger. 112 km² in most recent 10 year period. However, limited surveys in north.
Is the population “severely fragmented” i.e. is >50% of its total area of occupancy in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. No b. Unknown
Number of “locations”	Unknown but >> 50
Is there an [observed, inferred, or projected] decline in extent of occurrence?	Inferred reduction based on decline of host bumble bees.
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	Yes, decline in IAO and inferred reduction based on decline of host bumble bees over the last 10 years
Is there an [observed, inferred, or projected] decline in number of subpopulations?	Yes, inferred reduction based on decline of host bumble bees over the last 10 years
Is there an [observed, inferred, or projected] decline in number of locations?	Unknown
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Yes, inferred reduction based on decline of host bumble bees over the last 10 years
Are there extreme fluctuations in number of subpopulations?	No
Are there extreme fluctuations in number of locations?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each subpopulation)

Subpopulations (give plausible ranges)	**N Mature Individuals**
Total	Unknown

Quantitative Analysis

Is the probability of extinction in the wild at least [20% within 20 years or 5 generations, or 10% within 100 years]?	Insufficient data.

Threats (direct, from highest impact to least, as per IUCN Threats Calculator)

Was a threats calculator completed for this species? Yes, High impact; threats assessment completed December 16, 2018. 7.3 Other ecosystem modifications (mainly decline in abundance and distribution of host bumble bees) – Medium impact 2.1 Annual & perennial non-timber crops – Low impact 9.3 Agricultural & forestry effluents – Low impact 11.1 Habitat shifting and alteration – Low impact 11.2 Droughts – Low impact What additional limiting factors are relevant? 1) Parasitism of bumble bees 2) Predators of adult bumble bees 3) Diploid male extinction vortex 4) Low genetic diversity in cuckoo bumble bees 5) Sustained nectar and pollen availability to both cuckoo and hosts 6) Cuckoo bumble bees are more vulnerable to extinction than their hosts

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	Globally Imperilled (G1) IUCN Critically Endangered Where subnational ranks are available in the United States, it is ranked S1 or S2.
Is immigration known or possible?	Unknown
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Yes
Are conditions deteriorating in Canada?[+]	Yes, in some areas, based on host subpopulation declines.
Are conditions for the source (i.e. outside) population deteriorating?[+]	Yes, in some areas, based on host subpopulation declines.
Is the Canadian population considered to be a sink?[+]	No
Is rescue from outside populations likely?	No

Data Sensitive Species

Is this a data sensitive species?	No

Status History

COSEWIC: Designated Threatened in November 2019.

Status and Reasons for Designation:

Status: Threatened	**Alpha-numeric codes:** A2bce

[+] See Table 3 (Guidelines for modifying status assessment based on rescue effect)

Reasons for designation: This bumble bee is a nest parasite of other bumble bees and depends on its hosts to rear its young. It is found in all provinces and territories except Nunavut. It is more frequent in the west than in the east and always much less frequent than its hosts. Despite significantly increased search effort for bumble bees in Canada over the last two decades, fewer individuals of this species have been encountered than in the past. There has been a decline of more than 30% in relative abundance compared to all bumble bees (indicating a population decline) and a decline in area of occupancy. The decline has been particularly severe in areas where the species was historically more frequent, in British Columbia and Alberta. The primary threat is the steep decline of the host bumble bee species, again in British Columbia and Alberta. The major threats to the hosts are the escape of pathogen-infected bumble bees from managed colonies in commercial greenhouses, pesticide use (particularly neonicotinoids), and climate change.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets criteria for Threatened, A2bce. Inferred reduction of greater than 30% in total number of mature individuals comparing most recent two ten year periods. The decline is based on: (b) an index appropriate to the taxon—when the decades 1999 – 2008 and 2009 – 2018 are compared, the number of mature individuals has declined by greater than 30% (67% using relative abundance of this species over all *Bombus* collected in Canada); (c) a decline in IAO comparing the two most recent ten year periods (approximately 56%) and in the quality of habitat (host species abundance) and (e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. EOO and IAO are larger than thresholds.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. Insufficient data to complete population estimates.
Criterion D (Very Small or Restricted Population): Not applicable.
Criterion E (Quantitative Analysis): Not applicable. Insufficient data to complete analysis.

COSEWIC HISTORY

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

COSEWIC MANDATE

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

COSEWIC MEMBERSHIP

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

DEFINITIONS
(2019)

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

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

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

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

Environment and Climate Change Canada
Canadian Wildlife Service

Environnement et Changement climatique Canada
Service canadien de la faune

Canada

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

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Taxonomic Background

Phylum	Arthropoda - arthropods
Class	Insecta – insects
Order	Hymenoptera – ants, bees, wasps
Infraorder	Aculeata – stinging wasps
Family	Apidae – bumble bees, honey bees, stingless bees, and many others
Subfamily	Apinae
Genus	*Bombus* – bumble bees
Subgenus	*Psithyrus* – cuckoo bumble bees
Species	*Bombus suckleyi* Greene, 1860

French common name: Bourdon de Suckley
English common name: Suckley's Cuckoo Bumble Bee

Scientific name synonyms: *Psithyrus latitarsus* Morrill, 1903

Suckley's Cuckoo Bumble Bee was described as *Bombus suckleyi* in 1860 from a male specimen collected by Dr. George Suckley at Puget Sound, Washington (Greene 1860). The female was described as *Psithyrus latitarsus* in 1903 from Montana (Morrill 1903) and later synonymized by Frison (1926).

Cuckoo bumble bees make up about 11% of all bumble bee species (Lhomme and Hines 2018), and historically were placed in a separate genus from other bumble bees because of their parasitic lifestyle. The earliest generic name used was *Psithyrus* Lepeletier, the name still used for the subgenus. While *Psithyrus* was considered a genus, multiple subgenera were also recognized in North America (e.g., Frison 1927; Thorp *et al.* 1983). More recent phylogenetic analysis of bumble bees (Cameron *et a*l. 2007; Williams *et al*. 2008) recognized *Psithyrus* as a monophyletic unit (subgenus) within the genus *Bombus*, and sister group to the subgenus *Thoracobombus* (Hines 2008; Williams *et al*. 2008). *Thoracobombus* is a taxon particularly prone to nest usurpation (Sakagami and Nishijima 1973; Lhomme and Hines 2018).

Suckley's Cuckoo Bumble Bee belongs to a clade (i.e. formerly subgenus *Ashtonipsithyrus* of Frison, though Lhomme and Hines (2018) called this the "*bohemicus* group" of *Psithyrus*) containing three to five additional species (Hines 2008; Lhomme and Hines 2018): Suckley's Cuckoo Bumble Bee and Gypsy Cuckoo Bumble Bee (formerly *B. ashtoni* (Cresson) now *B. bohemicus*) from North America, Vestal Cuckoo Bumble Bee (*B. vestalis* Geoffroy) in the Palearctic, and Gypsy Cuckoo Bumble Bee (*B. bohemicus s. str.*) from the Palearctic, Arctic, and Orient; Lhomme and Hines (2018) also include *B. coreanus* (Yasumatsu) from the Orient, though little is known about this species, including its host(s) or its relatedness to other members.

Hines (2008) indicated that Suckley's Cuckoo Bumble Bee was likely a sister taxon to the other species, splitting from them about 4 million years ago (mya) in North America, and with Vestal Cuckoo Bumble Bee splitting from Gypsy Cuckoo Bumble Bee in the Old World ca 2.5 mya. As such, Suckley's Cuckoo Bumble Bee is closely related to Gypsy Cuckoo Bumble Bee. The ranges of both species overlap throughout much of Canada. Both species have had their mitochondrial DNA barcoded and have unique Barcode Index Numbers (BINs) with mean interspecies percent sequence divergence of 8.18% (Sheffield pers. data).

Morphological Description

Most bumble bees are primitively eusocial[1] and all have four developmental stages (e.g., egg, larva, pupa, and adult). There are typically three adult forms or castes in bumble bee colonies: the queen (reproductive female), workers (non-reproductive females) and males. However, cuckoo bumble bees are social parasites in other bumble bee colonies and do not have a queen or worker caste (see **Biology**). The morphological description of Suckley's Cuckoo Bumble Bee is summarized below based on information in Morrill (1903), Thorp *et al*. (1983), and Williams *et al*. (2014).

Female (front cover and Figure 1): Body length 15–25 mm; breadth of abdomen 8–9 mm. The outer surface of the hind tibia (i.e. flattened segment of hind leg) is convex, with dense hair covering the surface, and without a corbicula (i.e. the shiny and hairless pollen basket of nest-building species). The hair on the face and top of the head is typically all black, occasionally with some yellow hairs at the posterior top of the head. The sides of the thorax are predominantly with yellow hair (with some exceptions). Hair on the anterior surface of thorax (i.e. in front of wings) is yellow and varies from yellow to black on the remaining dorsal surface. The first two abdominal segments have black hair, the 3rd to 5th abdominal segments are laterally variable yellowish-white, but usually white at least posteriorly in the middle of the 4th segment. Like all cuckoo bumble bees, the tip of abdomen is recurved ventrally, with the ventral surface with two strong triangular carinae (ridges) visible in dorsal view.

[1] produce seasonal colonies

Figure 1. Photographs showing the carinae;, this morphological feature distinguishes female Suckley's Cuckoo Bumble Bee from Gypsy Cuckoo Bumble Bee. Top) Lateral view of female Suckley's Cuckoo Bumble Bee (*Bombus suckleyi*) in the wild, with strong carina of sternum 6 visible (red arrow). Photograph (top) by Cory Sheffield (specimen photographed and collected along with four additional specimens and deposited at the Royal Saskatchewan Museum) from Woodrow, Saskatchewan on June 30, 2019. (Bottom) Magnified view of tip of abdomen showing strong carina (red arrow). Specimen housed at York University, Toronto, Ontario. Photograph by Sheila Dumesh (with permission).

Male (Figure 2): Body length 15–22 mm; breadth of abdomen 5–7 mm. Antenna medium length, with the flagellum (i.e. the long whip-like part consisting of the 2nd to 11th antennal segments) 3 times longer than scape (i.e. first antennal segment, that is attached to the face). Hair of hind basitarsus (i.e., the basal segment of the "foot" on hind leg) posterior fringe predominantly black, the first abdominal segments largely yellow, with some specimens with much black hair intermixed laterally, especially on 2nd segment, the 3rd, 5th, and 6th segments primarily yellow with black hairs present medially, the 4th segment primarily yellow, the 7th segment is entirely black (Figure 2). Proper identification of males may require examination of genitalia structures (Williams *et al.* 2014).

Figure 2. Lateral view of male Suckley's Cuckoo Bumble Bee (*Bombus suckleyi*). Red arrow shows the characteristic yellow pleura. Specimen housed at York University, Toronto, Ontario. Photograph by Sheila Dumesh (with permission).

Suckley's Cuckoo Bumble Bee from eastern Canada were identified correctly in major collections (e.g., Canadian National Collection of Insects, Arachnids and Nematodes [CNC]) but not mentioned in compilations of eastern bumble bees (i.e. Mitchell 1962; Laverty and Harder 1988; Colla and Dumesh 2010; Colla *et al*. 2011). The result was some misidentifications as Gypsy Cuckoo Bumble Bee, now corrected through review of the identifications in museum collections (see **Taxonomic Background**).

Females of both species have pronounced carinae on the 6th sternum that is visible even in dorsal view, that of Suckley's Cuckoo Bumble Bee being even more distinct than that of Gypsy Cuckoo Bumble Bee (Figure 1). Gypsy Cuckoo Bumble Bee females typically have black hair on the pleura (side of thorax; compare to which also is a useful diagnostic feature), though this may also occur on some specimens of Suckley's Cuckoo Bumble Bee.

The eggs, larvae and pupae of Suckley's Cuckoo Bumble Bee have not been described.

Population Spatial Structure and Variability

Genetic variability and population structure have not been studied for Suckley's Cuckoo Bumble Bee. Cytochrome oxidase 1 (COI) gene (i.e. DNA Barcode) sequences are available in the Barcode of Life Data system (BOLD) (www.barcodeoflife.org) from eight specimens from multiple sites in Canada; two sites from Yukon, one site in British Columbia, one site in Saskatchewan, and three specimens from two sites on the island of Newfoundland. All sequences are almost identical, with maximum interspecific distance across samples at 0.3% (average of 0.1%) (Sheffield pers. data) supporting one widespread species, and all sequences have been assigned to Barcode Index Number (BIN) BOLD: ABY1164 (Sheffield *et al*. 2017).

Designatable Units

Sequence analysis of the COI (DNA barcode) gene (Sheffield *et al*. 2017), BIN assignment and other molecular based phylogenies (Hines 2008; Lhomme and Hines 2018) and the absence of other evidence of subspecific genetic structure support Suckley's Cuckoo Bumble Bee being assessed as one designatable unit.

Special Significance

Suckley's Cuckoo Bumble Bee is a social parasite in other bumble bee colonies. The species likely plays a significant ecological role through its effect on host dynamics and distribution (Antonovics and Edwards 2011), as is likely true of most cuckoos (Sheffield *et al*. 2013). In general, bees and their less common cuckoo bees appear to be particularly sensitive to detrimental environmental impacts because of their sex determining mechanism (Zayed and Packer 2005). The smaller population size of cuckoo bumble bees enhances this effect (Williams *et al*. 2010) (see **Limiting Factors**). The rarity and extinction risk of hosts puts cuckoo bumble bees at much higher risk of decline (Suhonen *et al*. 2015). The species is also a floral visitor and pollinator.

DISTRIBUTION

Global Range

Globally, Suckley's Cuckoo Bumble Bee occurs in North America and is primarily a western Nearctic species (Lhomme and Hines 2018) (Figure 3 and Figure 4). It is found from Alaska south to northern California and east to Colorado, Manitoba and South Dakota. East of the 100th meridian the species becomes rarer but has been recorded east to the island of Newfoundland and south to Virginia. In the west it becomes rare north of the 60th parallel. There are scattered records in central and northeastern North America (Williams *et al*. 2014).

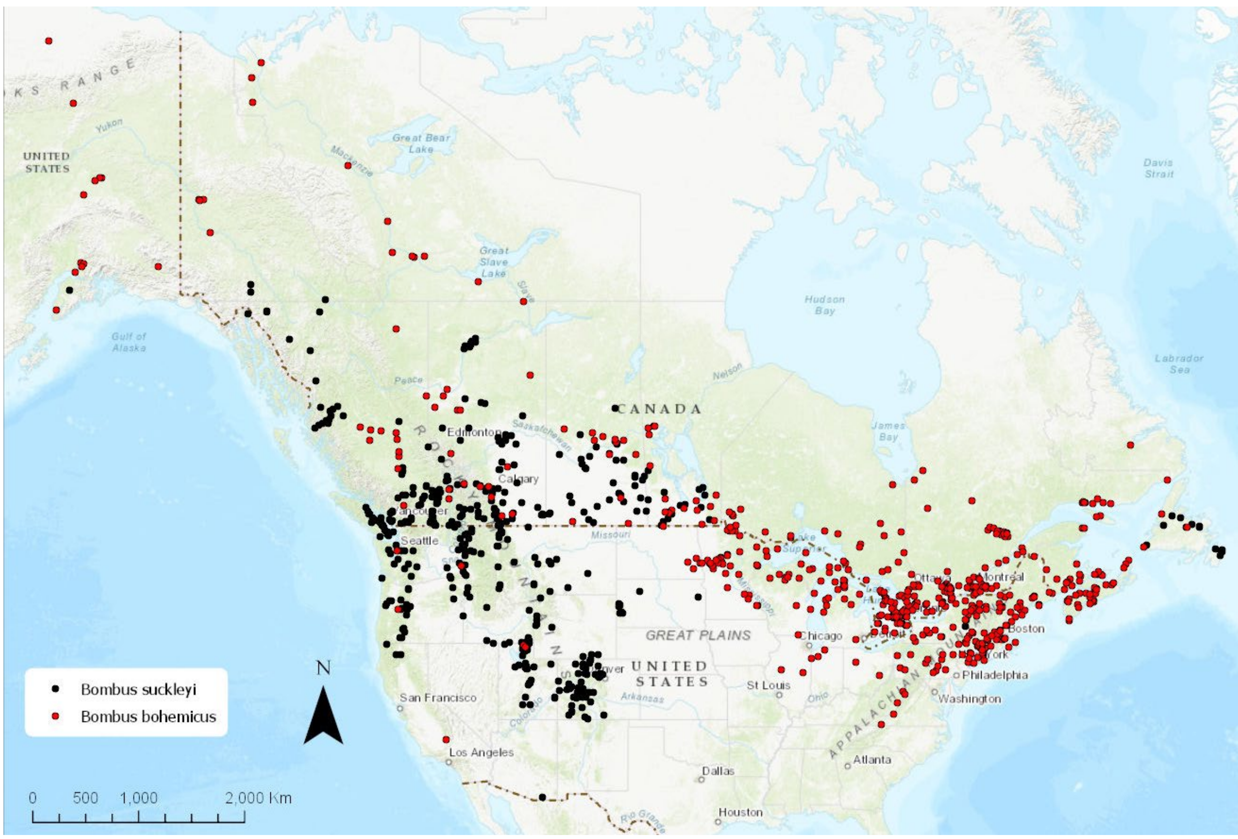

Figure 3. Canadian distribution of Suckley's Cuckoo Bumble Bee (*Bombus suckleyi*) and sister species Gypsy Cuckoo Bumble Bee (*Bombus bohemicus*) (based on museum specimens from Williams *et al*. 2014, and datasets compiled during status report preparation). Map created by the COSEWIC secretariat.

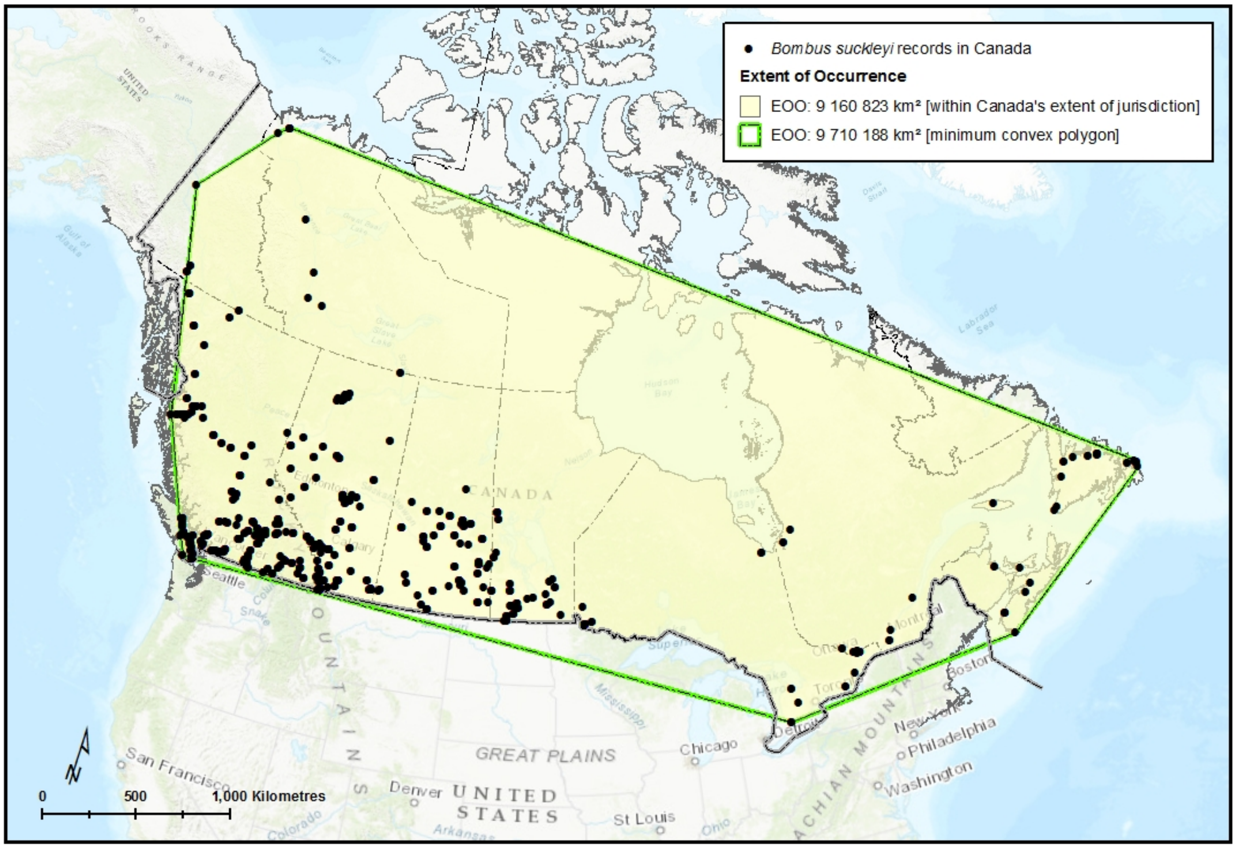

Figure 4. Canadian extent of occurrence (EOO) of Suckley's Cuckoo Bumble Bee (*Bombus suckleyi*) based on databased museum collections and additional data compiled during status report preparation (1901–2018). The EOO (9,710,188 km^2) is based on a minimum convex polygon created around all databased records and 9,160,823 km² within Canada's extent of jurisdiction. Map created by the COSEWIC secretariat.

Canadian Range

In Canada, Suckley's Cuckoo Bumble Bee has been recorded in every province and territory except Nunavut and it is not recorded in Labrador. Suckley's Cuckoo Bumble Bee occurs in most Canadian ecozones (as described in COSEWIC 2011), including: Boreal Cordillera, Mountain Cordillera, Taiga Plains, Boreal Plains, Prairies, Taiga Shield, Boreal Shield, Hudson Plains, Mixed Wood Plains and Atlantic Maritimes. The species has not been recorded from the Arctic ecozone. Most records are from western North America, with fewer records east of Manitoba (Table 1, Figure 3 and Figure 4 and Figure 5) (Williams *et al*. 2014; Sheffield pers. data and see Collections Examined). Its sister species, Gypsy Cuckoo Bumble Bee, is most frequent in eastern and boreal northwestern Canada (Figure 3 and Figure 5).

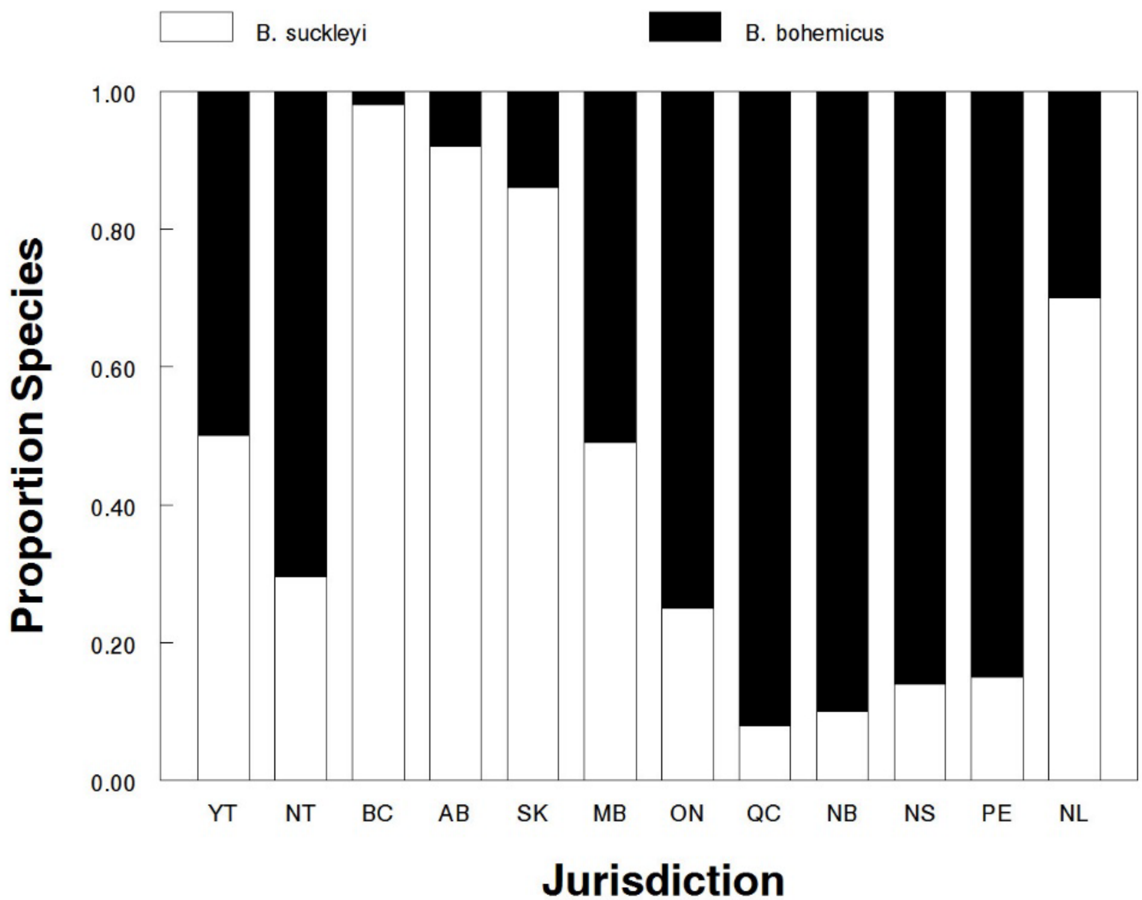

Figure 5. The relative abundance of Suckley's Cuckoo Bumble Bee (*Bombus suckleyi*) [white bars] and Gypsy Cuckoo Bumble Bee (*Bombus bohemicus*) [black bars] in Canada. These two species have a close phylogenetic relationship.

Table 1. The number of databased specimens of Suckley's Cuckoo Bumble Bee (SCBB) (*Bombus suckleyi*) for each province and territory in Canada, the number of unique sites, the earliest and most recent years recorded. Counts for SCBB represent the number of specimens which have collection dates available, and are used in Table 3.

Jurisdiction	No. SCBB specimens	Unique sites/year[1]	Earliest year record[2] of SCBB	Most recent year record of SCBB
Yukon	12	5	1921	2018
Northwest Territories	16	8	1922	1969
Nunavut	0	0	-	-
British Columbia	846	140	1905	2013
Alberta	345	68	1907	2018
Saskatchewan	218	50	1916	2018
Manitoba	99	28	1914	1995
Ontario	120	16	1901	1971
Québec	16	15	1906	1961
New Brunswick	2	2	1977	1978
Nova Scotia	8	4	1910	1961
Prince Edward Island	2	2	1909	1930
Newfoundland	29	7	1925	2010

Jurisdiction	No. SCBB specimens	Unique sites/year[1]	Earliest year record[2] of SCBB	Most recent year record of SCBB
Labrador	0	0	-	-
Total	**1713**	**345**	**1901**	**2018**

[1]As the number of specimens came from multiple databases which "share" data (i.e. Leif Richardson, CNC, GBIF) the number of unique identifiers may not be accurate. Therefore, the column "Unique Sites/Year" represents records of species from a single site for one year, which eliminates any duplications; however, it also eliminates when multiple specimens were collected at a single event.

[2] Earliest record of Suckley's Cuckoo Bumble Bee where the locality information is known (e.g., we did not include specimens labelled with incomplete information).

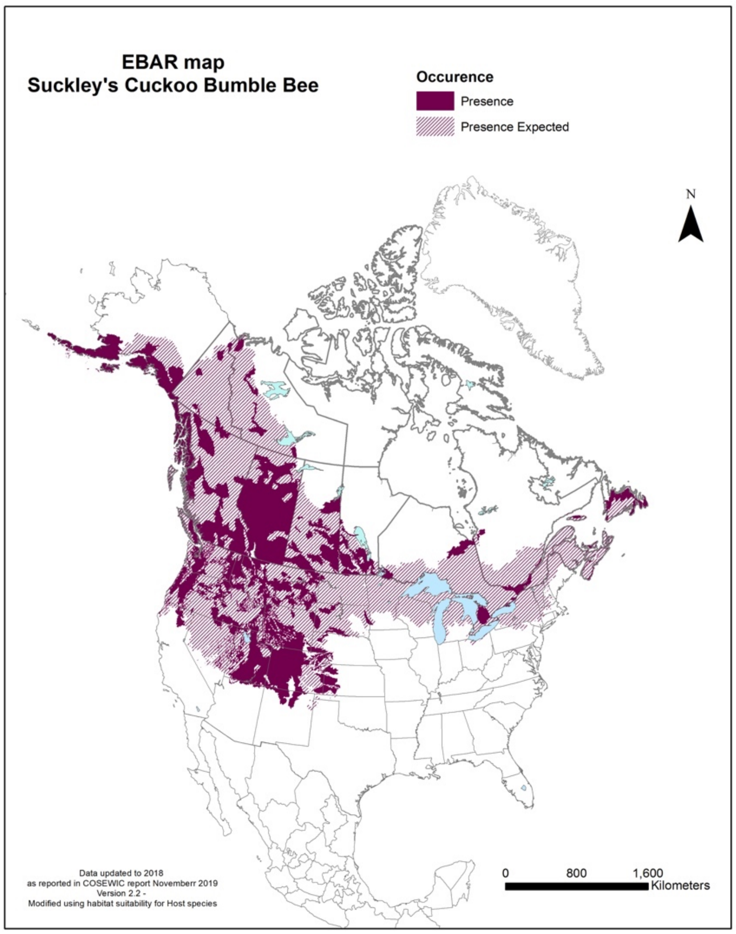

Figure 6. Suckley's Cuckoo Bumble Bee range map depicted using the Ecosystem-based Automated Range (EBAR) mapping method, where a mosaic of ecoshapes (ecological regions or districts) are categorized based on documented site data from Williams *et al*. 2014; Sheffield pers. data and see Collections Examined, modified by documented expert knowledge. Ecoshapes categorized as "presence expected" are based on modelled distribution of all known host species. © NatureServe Canada EBAR Map 2019 under CC Attribution 4.0 International License. Map created by Suzanne Carrière (NT Conservation Data Centre), modified using expert comments from Jenny Heron and Cory Sheffield.

The earliest records of Suckley's Cuckoo Bumble Bee in Canada are 1897 and 1899 from "British Columbia" but the locality information is not precise and hence they are not on the distribution maps. The earliest Suckley's Cuckoo Bumble Bee record in Canada with precise locality data is 1901 from Ontario.

Suckley's Cuckoo Bumble Bee is an obligate social parasite of nest-building host bumble bees and therefore does not produce a eusocial colony with distinct castes (i.e. workers are not produced) (see **Biology**). The ranges of the main host bumble bee species are listed below and shown in Figure 7.

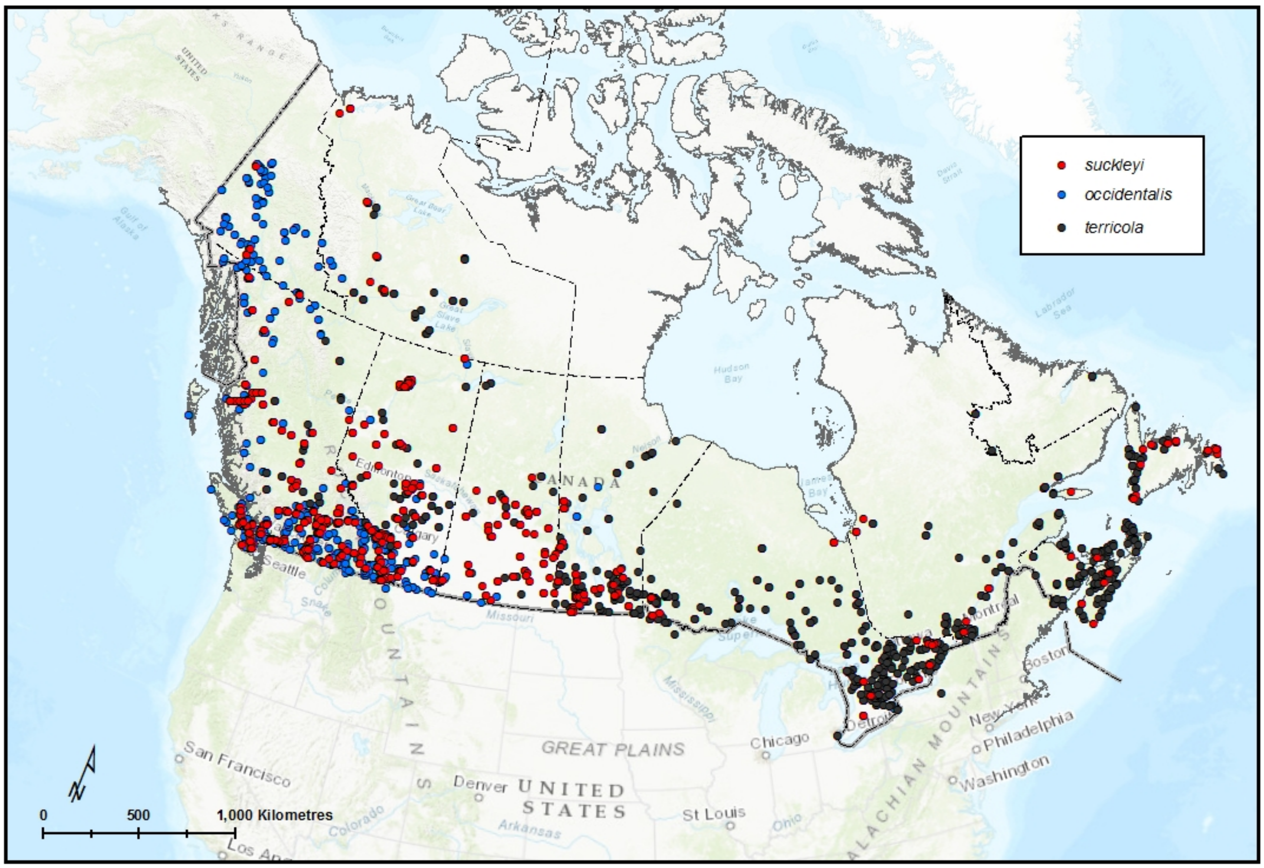

Figure 7. Canadian range of Suckley's Cuckoo Bumble Bee (black dots) and the two host bumble bee species: Western Bumble Bee (southern subspecies *B. occidentalis occidentalis* and northern subspecies *B. o. mckayi*) (red dots) is a confirmed host (Hobbs 1965ab, 1966ab) and Yellow-banded Bumble Bee (*B. terricola*) (blue dots) is a presumed host (see discussion in Canadian Range). The approximate range of Western Bumble Bee southern subspecies is 720,170 km^2, northern subspecies is 623,837 km^2 and Yellow-banded Bumble Bee is 7,913,612 km^2. Map created by the COSEWIC secretariat.

Western Bumble Bee (*B. occidentalis* Greene, northern *mckayi* and southern *occidentalis* subspecies) is a confirmed host for this species (Hobbs 1965ab, 1966; Lhomme and Hines 2018). Hobbs (1965ab, 1966ab) studied the nesting biology of Western Bumble Bee in Alberta and confirmed nest usurpation by Suckley's Cuckoo Bumble Bee. Western Bumble Bee ranges in British Columbia, Alberta, southern Saskatchewan, Yukon and western Northwest Territories (Sheffield *et al*. 2016).

Yellow-banded Bumble Bee (*B. terricola* Kirby) is a presumed host of Suckley's Cuckoo Bumble Bee in Manitoba, Ontario, Québec, the Maritime provinces, and Newfoundland (Lhomme and Hines 2018). Hobbs (1968) observed Suckley's Cuckoo Bumble Bee in the nest of Yellow-banded Bumble Bee in Alberta but did not confirm it as a host. Yellow-banded Bumble Bee is in subgenus *Bombus* and closely phylogenetically related (i.e. sister species) to Western Bumble Bee. This is the main reason we consider Yellow-banded Bumble Bee a likely host, particularly in areas where Western Bumble Bee does not occur. Yellow-banded Bumble Bee ranges from the Rockies in eastern British Columbia through the boreal zone, southern Northwest Territories and southern half of Canada to the island of Newfoundland (Sheffield *et al*. 2016).

Rusty-patched Bumble Bee (*B. affinis* Cresson) is a possible host because it too is in subgenus *Bombus* and phylogenetically closely related to both Western Bumble Bee and Yellow-banded Bumble Bee. Yet there are no confirmed observations of Suckley's Cuckoo Bumble Bee entering the nest or parasitizing this species, nor is it indicated by Lhomme and Hines (2018). However, Rusty-patched Bumble Bee has been observed as a host to the sister species, Gypsy Cuckoo Bumble Bee (Plath 1934). Rusty-patched Bumble Bee has a range in southern Ontario and Québec (Laverty and Harder 1988; Williams *et al*. 2014), and New Brunswick (Klymko and Sabine 2015). This species has not been observed in Canada since 2009 and is designated Endangered by COSEWIC (COSEWIC 2010).

Cryptic Bumble Bee (*Bombus cryptarum*) is a possible host because it is also in subgenus *Bombus*; however, there are no confirmed observations of Suckley's Cuckoo Bumble Bee entering the nest or parasitizing this species (e.g., Williams *et al*. 2014; Lhomme and Hines 2018). The range of Cryptic Bumble Bee overlaps with Suckley's Cuckoo Bumble Bee in most areas in western Canada.

Hobbs (1965ab; 1966ab) observed Suckley's Cuckoo Bumble Bee entering the nests of Red-belted Bumble Bee (*B. rufocinctus* Cresson), Nevada Bumble Bee (*B. nevadensis* Cresson), White-shouldered Bumble Bee (*B. appositus* Cresson), and Yellow Bumble Bee (*B. fervidus* (Fabricius)) (Hobbs 1968). However, there is no further evidence that Suckley's Cuckoo Bumble Bee queens usurped these potential hosts, nor that progeny were reared. In addition, these four bumble bees are not in the phylogenetically related subgenus *Bombus*.

Extent of Occurrence and Area of Occupancy

Extent of occurrence (EOO) for Suckley's Cuckoo Bumble Bee in Canada (Figure 4) is approximate and based on the databased museum collections, online, sight and collection records (see **Collections Examined**). The approximate EOO based on a minimum convex polygon created around all databased records with known localities and dates (1901–2018) is 9,710,188 km^2 (9,160,823 km^2 within Canada's extent of jurisdiction). The index of area of occupancy (IAO) (2 X 2 grid cells) for all known records is 5,136 km^2 and 112 km^2 for the most recent ten year period. Both calculations are undoubtedly underestimates because surveys in northern Canada are limited.

Search Effort

Much time and effort have been invested (recently and historically) in surveys that focus on bumble bees, particularly in southern Canada. There are more data available for wild bumble bees than for most other North American insects. A recently compiled dataset (i.e. used for Williams *et al*. 2014) of approximately 236,260 bumble bee specimens from museums in Canada and the United States shows an increase in bumble bee specimens collected, particularly in the past 15 years (for some studies in Canada see Table 2).

Table 2. Recent (within the past 15 years) bumble bee studies within each jurisdiction in Canada.

Juris-diction	Study year	General area / locality	# SCBB	# WBB	# YBBB	# Sites Searched	Time Searched (days, hours)	*Bombus* caught	Type of search effort	Reference
AB	2010	Forestry Trunk Rd, Innisfail, Barrier Lake (Kannanaskis), Calgary, grasslands and others	0	present 6/8 sites		8	N/A	775	N/A	Colla pers. data 2010 as written in COSEWIC 2014
AB	2013	Edmonton	0		1	1 (min)	2.5 hours	76	HC	Rowe pers. comm. 2013 as cited in COSEWIC 2015
AB	2013	Slave Lake	0		27	1 (min)	2.5 hours	97	HC	Rowe pers. comm. 2013 as cited in COSEWIC 2015
AB	2014	Edmonton area (200km radius)	0			20	30 minutes (min)		HC	Anweiler as part of Sheffield *et al*. 2016
AB	2018	Southern Alberta	1	253	222			approx. 20,000		Galpern pers. comm. 2018
AB	2018	Medicine Hat, Redcliff,				5	Traps operational one month		BVT	Sheffield pers. data
AB	2007 and 2013	Cypress Hills, Dinosaur Provincial Park, Red Cliff (south of Medicine Hat), Edmonton and surrounding areas	0							Sheffield pers. data
AB	2016 - 2018	All records for this jurisdiction	0	6	3	-	-	-	Photographic / visual	iNaturalist 2019

Juris-diction	Study year	General area / locality	# SCBB	# WBB	# YBBB	# Sites Searched	Time Searched (days, hours)	*Bombus* caught	Type of search effort	Reference
AB	2018	Alberta, dataset published with Canadensys	1	5	125			8088	BVT/net	Prescott *et al*. 2019 dataset
BC	2010	Lower Fraser Valley	0	6	N/A	46	18 days			Knopp, Larkin and Heron 2010
BC	2010	Southern interior; Okanagan and Similkameen valleys	0	4	N/A	40	158 hours	>1000		Marks and Heron 2010
BC	2010	Southern Vancouver Island	0	0	N/A	>15	106 hours	0	Visual searches for WBB only	Page, Lilley and Heron 2010
BC	2010	Lower Mainland	0	1	N/A	64	271 hours			Parkinson and Heron 2010
BC	2010	West Kootenays	0	6	N/A	11	40 hours	195	HC	Westcott and Heron 2010
BC	2013	Okanagan, central interior, Peace River, Smithers and surrounding areas	1	115 (36 sites)	295	104	281 hours	6447		Sheffield *et al*. 2016; Sheffield pers. data
BC	2015	Okanagan and Similkameen	0	1	N/A	26	August 18 - October 5	394		Dawson and Heron 2015
BC	2016	Okanagan	0	0	N/A	22	May 6 - October 6	784		Heron and Sheffield 2016
BC	2017	Okanagan, Kelowna, Lake Country	0	2	N/A	32	May 17 - August 16	2094		Heron, Sheffield and Marks. 2017
BC	2018	Okanagan, Rock Creek, Vernon, Armstrong, Grand Forks	0	14	N/A	28	May 28 - August 30	1878		Heron, Sheffield and Marks 2018
BC	2003 & 2004	Fraser Valley	0		N/A			4211		Ratti 2006
BC	2015 - 2018	Northern BC; opportunistic inventory along roadsides, within parks and crown lands	0	present	present	> 50	May - September	> 300		Cannings pers. data; Sheffield pers. data; Heron pers. data
BC	2016 - 2018	All records for this jurisdiction	0	16	0				Photographic / visual	iNaturalist 2019
MB	2010	Gillam and York Factory;			yes					Colla pers. comm. 2014 as cited in COSEWIC 2015
MB	2017	Aweme, Birds Hill and Spruce Woods provincial parks, Winnipeg, Seven Sisters Falls and various other areas	0		4		May to July		HC	Gibbs per data 2019

Juris-diction	Study year	General area / locality	# SCBB	# WBB	# YBBB	# Sites Searched	Time Searched (days, hours)	*Bombus* caught	Type of search effort	Reference
MB	2018	Oak Hammock Marsh, Portage Sandhills, Spruce Woods PP, Skalholt Cemetary, Clematis Wildlife Management Area, Winnipeg, Seven Sisters Falls, Aweme, Delta Marsh	0		13		May to late August		HC	Gibbs pers. data 2019
MB	2005-2006	Prairie sites in southwestern	0				May to September	600	HC	Patenaude 2007
MB	1986-1993	Fourteen sites throughout agricultural areas throughout southern Manitoba	1/14 sites	0	13/14 sites	14	May to August	N/A	Bycatch in baited armyworm traps	Turnock *et al*. 2006
MB	2014-15	Living Prairie Museum, Assiniboine Forest, Frog Plains, Assiniboine Park	0		9	4 (min)			HC	Living Prairie Museum, Winnipeg; Semmlar pers. comm. 2019
MB	2014-2018	Various prairie remnants in the Winnipeg area	0		observed annually	numerous	May to late August		HC	Semmlar pers. comm. 2019
MB	2016 - 2018	All records for this jurisdiction	0	N/A	17	17			Photographic / visual	iNaturalist 2019
NB	2008	Moncton, Fundy National Park, Saint John	0	N/A		3			HC	S. Colla surveyed bumble bees for 4 days in search of Rusty-patched Bumble Bee) (COSEWIC 2010)
NB	2009	Fundy National Park	0	N/A		2				Sheffield pers. comm. 2018
NB	2013	Springfield and Norton	0	N/A	present	3				Colla pers. comm. 2014 as cited in COSEWIC 2015
NB	2010 - 2018	various areas	0	N/A		various areas		304		Klymko pers. comm. 2019
NB	2016 - 2018	All records for this jurisdiction	0	N/A	44	44			Photographic / visual	iNaturalist 2019
NB	2011 - 2015	Various sites around the province	0	N/A	some	306		2404		Sabine pers. comm. 2019
NL	2013	Stephenville; two cranberry farms	0	N/A	14	4		310	PT	Hicks and Sircom 2016
NL	2012 - 2013	around the town of Carbonear	0	N/A	0	6	August 2012; June - July 2013	300	PT; MT	Sellars and Hicks 2015
NL	2016 - 2018	All records for this jurisdiction	0	N/A	6				Photographic / visual	iNaturalist 2019
NL	2011 - 2015	Various sites around the island of Newfoundland	0	N/A	some	27		349		Sabine pers. comm. 2019
NS	2013	Lockeport, Greenfield and New Germany	0	N/A	present					Colla pers. comm. 2014 as cited in COSEWIC 2015
NS	2000s		0	N/A						Sheffield *et al*. 2003, 2009, 2013

Juris-diction	Study year	General area / locality	# SCBB	# WBB	# YBBB	# Sites Searched	Time Searched (days, hours)	*Bombus* caught	Type of search effort	Reference
NS	2010 - 2018	Throughout	0	N/A						Sheffield pers. data
NS	2016 - 2018	All records for this jurisdiction	0	N/A	44				Photographic / visual	iNaturalist 2019
NS	2011 - 2015	Various sites around the province	0	N/A	some	12		63		Sabine pers. comm. 2019
NT	2005	Hay River area	0		present					Stotyn 2012; Sheffield pers. data
NT	2011	Riparian areas of the South Nahanni River from Moose Ponds to the Liard River	0	present		19	July	78		Stotyn 2012
NT	2011	South Nahanni River	0	8			August			Stotyn 2012; Sheffield pers. data
NT	2011	Fort Simpson	0		present					Stotyn 2012; Sheffield pers. data
NT	2017	Tuktoyaktuk, Inuvik, Yellowknife and Norman Wells	0			18			BVT; HC	Heron pers. data
NT	2017	Fort Simpson and surrounding areas	0			15	July 12 - August 31	317+	BVT; HC	Heron pers. data; Larter pers. data
NT	2018	Inuvik (2 days) and Sachs Harbour (8 days)	0		yes		July 2 - 10		BVT; HC	Heron pers. data
NT	2018	Fort Simpson and areas in southern NT	0	1		10	May 16 - August 10	603+	BVT; HC	Heron pers. data; Larter pers. data
NT	2016 - 2018	All records for this jurisdiction	0	0	4				Photographic / visual	iNaturalist 2019
NU	2018	Rankin Inlet	0				August		BVT	Bert pers. data; Heron pers. data
NU	2016 - 2018	All records for this jurisdiction	0	N/A	0				Photographic / visual	iNaturalist 2019
ON	2011	Central and northern Ontario	0	N/A			June 13 - 16			Nardone 2013
ON	2013	Toronto, Barrie and Ottawa	0	N/A	present				HC	Colla pers. comm. 2014 as cited in COSEWIC 2015
ON	2016	Peterborough and Northumberland counties	0	N/A		8	May - Sept		BVT	Jones pers. comm. 2019
ON	2017	Peterborough and Northumberland counties	0	N/A		8	May - Sept		BVT	Jones pers. comm. 2019
ON	2018	Roadsides in northern areas	0							Gibson *et al.* 2018
ON	2018	Roadside surveys in northern ON	0		0			2755	Roadside surveys	Harris *et al.* 2019
ON	2018	Peterborough and Northumberland counties	0	N/A		8	May - Sept		BVT	Jones pers. comm. 2019
ON	2008 - 2011	Pinery Provincial Park	0	N/A						

Juris-diction	Study year	General area / locality	# SCBB	# WBB	# YBBB	# Sites Searched	Time Searched (days, hours)	*Bombus* caught	Type of search effort	Reference
ON	2016 - 2018	All records for this jurisdiction	0	N/A	71				Photographic / visual	iNaturalist 2019
ON	2011	Mississagi Provincial Park	0	N/A						Nardone 2013
ON	2010 and 2011	Algonquin Provincial Park	0	N/A						Miller 2010; Nardone 2013
ON	2011	Niagara region	0	N/A						Onuferko *et al*. 2015
ON	2011	Other areas	0	N/A						Richards *et al*. 2015
PE	2000 - 2011	province-wide	0	N/A	common	57				COSEWIC 2015
PE	2004-2005	Province-wide	0	N/A						MacPhail 2007
PE	2016 - 2018	All records for this jurisdiction	0	N/A	3				Photographic / visual	iNaturalist 2019
PE	2011 - 2015	Various sites around the province	0	N/A	some	2		3		Sabine pers. comm. 2019
QC	2012-2013	Montréal/Québec City	0	0	53			2751	Netting/pan trap	Normandin *et al*. 2017
QC	2013	farms south of Montréal and Québec City	0	N/A	present				HC	M. Chagnon to Sheffield pers. data
QC	2016 - 2018	All records for this jurisdiction	0	N/A	0				Photographic / visual	iNaturalist 2019
SK	1984	Southern portions of the province	0		‘common'					Curry 1984
SK	1984	Southwest corner	0		‘common ’					Curry (1984)
SK	2011	Cypress Hills	0				One week		BVT	Work by A. Crosby as per Colla pers. comm. 2014 as written in COSEWIC 2015
SK	2017	Cypress Hills Provincial Park	0	8 iNaturalist; 10 collected			24 hour bioblitz		BVT; HC	Sheffield pers. data
SK	2018	Prince Albert, Birch Hills areas as far south as Regina	0		most common				BVT; HC	Sheffield pers. data

Juris-diction	Study year	General area / locality	# SCBB	# WBB	# YBBB	# Sites Searched	Time Searched (days, hours)	*Bombus* caught	Type of search effort	Reference
SK	2018	Over Seven Ecoregions, Battleford, Crooked Lake, Douglas Park, Moose Mountain, Humbolt, Yorkton, Bronson Forest, Candle Lk, Makwa Lk, Meadow Lk, Hudson Bay, Melfort, Nipawin, Prince Albert, Waden Bay, Nepattack, Stanley Mission, Old Man On His Back, Cypress Hills, Eastend, Maple Cr, Green Water, Narrow Hills, Green Lk, Wayakwin, Wood Mtn, Sask Landing, Assiniboia, Buffalo Pound, Rowan's Ravine, Regina, Saskatoon Estevan	2	80	41	56	BVT one month	4445	BVT	Sheffield pers. data
SK	2011 - 2013	Grasslands National Park, Saskatchewan Landing Provincial Park, Great Sand Hills, Big Muddy Valley, Eastend, Leader, Swift Current, Prince Albert, Cypress Hills Provincial Park and as far east as Regina; and other areas	0					still being processe d	BVT; HC	Sheffield pers. data
SK	2016 - 2018	All records for this jurisdiction	1	15	17					iNaturalist 2019
SK		Collected and observed routinely throughout the southern third of the province (i.e. Grasslands National Park, Saskatchewan Landing Provincial Park, Great Sand Hills, Big Muddy Valley, and Cypress Hills Provincial Park, Eastend, Swift Current and as far east as Regina)	0						BVT; HC	Sheffield *et al*. 2016
YT	2006	Whitehorse area	6	1	0	1	Pitfall, several weeks	54	Pitfall	Sheffield pers. data
YT	2013	Southern portions	0	4 and 1 CBBB				86	BVT; HC	Cannings pers. comm. 2019; Sheffield pers. data

Juris-diction	Study year	General area / locality	# SCBB	# WBB	# YBBB	# Sites Searched	Time Searched (days, hours)	*Bombus* caught	Type of search effort	Reference
YT	2014	Southern portions	0					93	BVT; HC	Cannings pers. comm. 2019; Sheffield pers. data
YT	2015	Southern portions	0	115	1			1314	BVT; HC	Cannings pers. comm. 2019; Sheffield pers. data
YT	2016	Southern portions	0	12	1			955	BVT; HC	Cannings pers. comm. 2019; Sheffield pers. data
YT	2017	Repeatable roadside surveys	1					705	HC	Cannings pers. comm. 2019
YT	2018	Repeatable roadside surveys	0					1232	HC	Cannings pers. comm. 2019
YT	2018	General collecting throughout the territory	1					1000	BVT; HC	Cannings pers. comm. 2019
YT	2016 - 2018	All records for this jurisdiction	0	3	0					iNaturalist 2019

Suckley's Cuckoo Bumble Bee records in Canada used for the analysis in this report date from 1901–2018 (by decade 1898-2018). The species has been recorded from all provinces and territories except Nunavut (Table 1). The most recent records are from Saskatchewan (N=4) in 2018 (Sheffield pers. data), Alberta (N=1) in 2018 (Galpern pers. data), British Columbia (N=1) in 2013, Newfoundland and Labrador (N=3) in 2010 and Yukon (N=5) in 2018 (Cannings pers. comm. 2019). Suckley's Cuckoo Bumble Bee was recorded from Woodrow (Saskatchewan) in 2019; however, we did not include these specimens in our analysis because we did not have bumble bee data from across the country assembled for 2019.

Suckley's Cuckoo Bumble Bee records in Canada were plotted over all databased *Bombus* in Canada (based on museum collections and additional data compiled during status report preparation; 1899–2018) (Figure 8). In the absence of historical systematic survey efforts, this dataset serves as a proxy of bumble bee search effort throughout the country; we assume that *Bombus* collection events were not biased with respect to species being collected, and that if Suckley's Cuckoo Bumble Bee was present at the time and place of collection it likely also would have been collected.

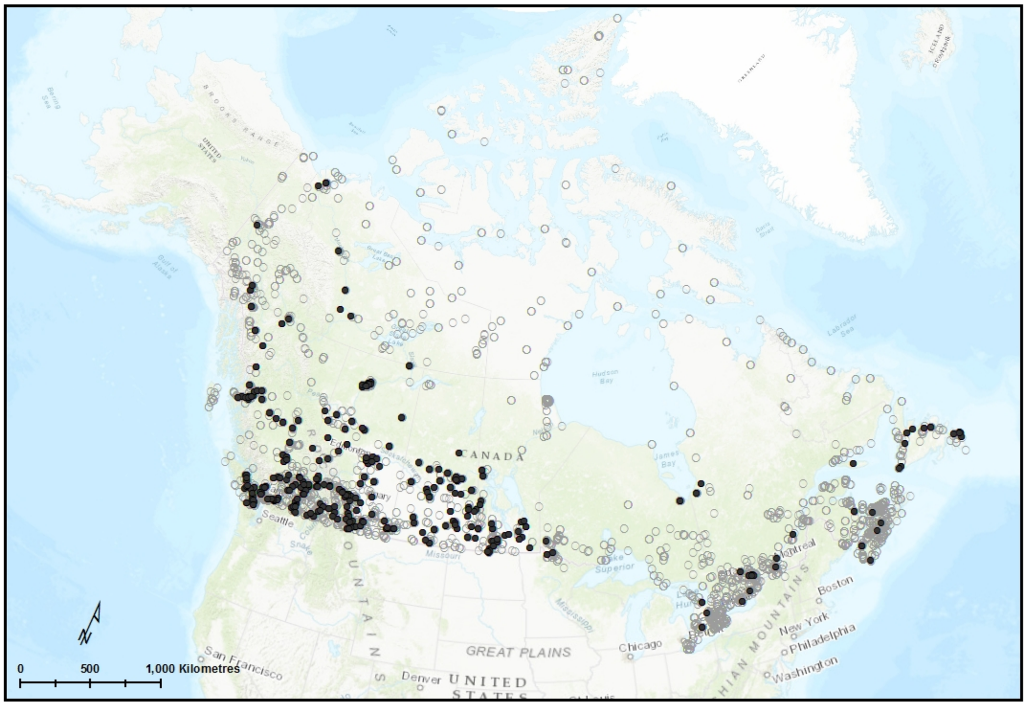

Figure 8. Suckley's Cuckoo Bumble Bee (*Bombus suckleyi*) records in Canada (black dots) plotted over all databased *Bombus* in Canada (open dot) based on databased museum collections and additional data compiled during status report preparation (1901–2018). We assume that *Bombus* collections were not biased and if there was Suckley's Cuckoo Bumble Bee present, it would have been collected. Map created by the COSEWIC secretariat.

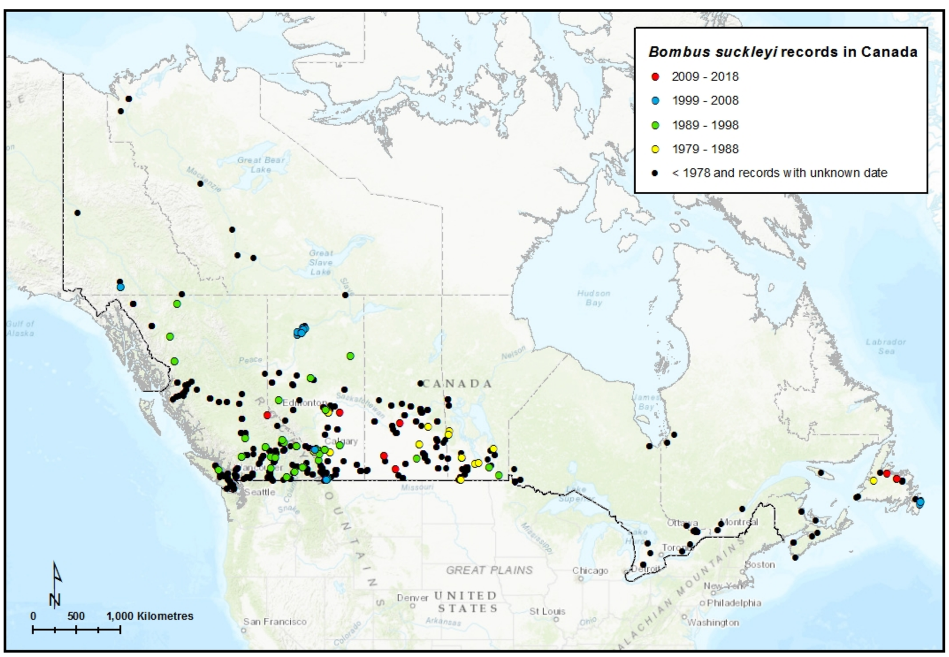

Figure 9. Spatial distribution of Suckley's Cuckoo Bumble Bee (*Bombus suckleyi*) databased records in Canada, emphasizing distribution for the past four decades (1979 – 1988; 1989 – 1998; 1999 – 2008; 2009 – 2018). Map created by the COSEWIC secretariat.

Surveys for bumble bees are typically by sampling methods that include hand netting, blue vane trapping, pan trapping, visual searches, and occasionally Malaise traps. Bumble bee surveys typically do not specifically target one species; the identification of a bumble bee on the wing can be difficult, results and surveyor error are difficult to repeat and quantify and is not always practical when surveying large areas. In the past few years, online citizen science forums such as iNaturalist©, BugGuide© and Bumble Bee Watch© have become valuable sources of additional occurrence information.

There are some shortcomings to the bumble bee search effort and these factors make it difficult to interpret spatial and temporal patterns specifically for Suckley's Cuckoo Bumble Bee. Surveys have not been systematic or comprehensive over time, most surveys have occurred in the southern parts of Canada and were done haphazardly and not quantified by time, distance searched, and number of surveyors. Cuckoo bumble bees are less likely to be collected during the middle of the active season because spring cuckoos are ensconced in host nests and it takes a few weeks before new females/males start to emerge from the host nest. In addition, as cuckoos produce no workers, they are less numerous than social bumble bees which can produce more than a hundred workers. In North America cuckoo bumble bees represent less than 4% of all bumble bees databased (Lhomme and Hines 2018). Regardless, cuckoo bumble bees have been recorded from March through September, suggesting emergence times can vary.

Recent bumble bee search effort (within the past 15 years), including the two main host species, for each province and territory is summarized in Table 2. Search effort is tallied by jurisdiction because there have been different jurisdictional initiatives over time, jurisdictional natural heritage or conservation data centres manage data independently; specimens are housed within jurisdictional museums and academic or local studies are not typically across jurisdictions. In summary, there have been at least 70 separate sites and more than 65,000 bumble bees collected since 2005 (Table 2). More than 50% of the records are from the most recent two decades. Most search effort has been in southern Canada and there remain large areas of subarctic Canada with little recent or historical data.

HABITAT

Habitat Requirements

<u>Nesting Habitat:</u>

Suckley's Cuckoo Bumble Bee is a social parasite, or cuckoo, in nests of hosts in the subgenus *Bombus* (Western Bumble Bee in the west, and probably Yellow-banded Bumble Bee in the east), but may occasionally parasitize other *Bombus* (Williams *et al*. 2014; Lhomme and Hines 2018). Nest-building bumble bees typically select abandoned underground rodent burrows as nests (Plath 1934) in various habitats such as montane meadows, old and fallow fields, farmlands, croplands, urban areas and woodlands.

Foraging Habitat:

Suckley's Cuckoo Bumble Bee does not collect pollen for its own nest provisions. They are generalist nectar foragers and have been recorded on several members of the Asteraceae: *Aster* (*sensu lato*) including *Symphyotrichum,* as well as *Chrysothamnus, Cirsium,* and *Solidago*. Recent observations and collection events in Saskatchewan also indicate that cotoneaster (*Cotoneaster*: Rosaceae) hedges are also attractive to female Suckley's Cuckoo Bumble Bee as a nectar source (Sheffield pers. data).

Overwintering Habitat:

Specific overwintering habitat requirements for Suckley's Cuckoo Bumble Bee are unknown, but like other bumble bees, only mated females overwinter in the ground, in mulch or other decomposing vegetation, and in rotting logs near nesting sites (Macfarlane 1974). The species likely does not disperse far, mainly because it needs to remain near host nests to reproduce the following year.

Habitat Trends

Suckley's Cuckoo Bumble Bee has one of the largest ranges of all bumble bee species in Canada (Figure 3) and it is unlikely that specific habitat trends have caused its decline at such large scales.

The decline of Suckley's Cuckoo Bumble Bee is linked to the declines of its two main host species. Habitat loss due to urbanization or intensive agriculture may threaten this species directly and indirectly (via its hosts) in the southern parts of its range in Canada. It is possible the increase in density of vegetable greenhouses within agricultural areas may be causing the decline of host species (Szabo *et al.* 2012) as well as field crops. The movement of both bumble bees and Western Honey bees is not tracked, and may be spreading diseases (see Threats). In south-central Canada, increased agriculture in ecozones inhabited by the Yellow-banded Bumble Bee (i.e. Prairies, Atlantic Maritime and Mixedwood Plains) show diminished wildlife habitat capacity (Javorek and Grant 2011). Climate change-induced habitat alteration may also negatively impact this species via the effect on its hosts, but more research is required.

BIOLOGY

Information is compiled from general bumble bee references (Alford 1975; Goulson 2003a; Benton 2006) and where applicable references are provided specifically for Suckley's Cuckoo Bumble Bee or other cuckoos (Hobbs 1968; Lhomme and Hines 2018).

Life Cycle and Reproduction

Suckley's Cuckoo Bumble Bee is a social parasite of nest-building bumble bees, but follows the same basic life cycle pattern of other bumble bee species and has a generation time of one year. In the spring, female cuckoos invade the nests of the host nest-building species and displace the resident host queen, either by killing or subduing her. The workers already in the nest (i.e. daughters of the host queen) are controlled by the queen cuckoo using chemical cues to rear both cuckoo and host workers (Michener 2000, 2007; Zimma *et al*. 2003). Eggs hatch approximately four days later, and the small larvae begin to feed on the pollen and nectar provisions collected by host workers. The larval stage of bumble bees has four instars. After almost two weeks of development, cuckoo larvae spin cocoons and pupate. Pupae develop for another two weeks before hatching as adult cuckoos. In total, development takes approximately five weeks but varies with temperature and food supply (Alford 1975). Male and female cuckoos typically emerge in the late summer, and after mating and the onset of frost, the males die, and mated females overwinter.

Information on Suckley's Cuckoo Bumble Bee fecundity and development is limited (Hobbs 1965ab, 1966ab); however, information from the sister species Gypsy Cuckoo Bumble Bee is available and summarized here. Three Gypsy Cuckoo Bumble Bee females and six males were recorded when a Rusty-patched Bumble Bee colony was dug up on August 9th (Plath 1934). This nest also contained the old Rusty-patched Bumble Bee queen and one hundred Rusty-patched Bumble Bee workers (Plath 1934). The colony was observed until the end of September and produced twenty-nine cuckoo males and sixty-one females. Although the injured Rusty-patched Bumble Bee queen was seen with a distended abdomen and laying eggs, no further Rusty-patched Bumble Bee males, workers or queens were produced. Fisher (1983) hypothesized that the presence of a live Rusty-patched Bumble Bee queen is required by Gypsy Cuckoo Bumble Bee females to suppress ovarian development of the worker caste, but that the cuckoo eats the eggs produced by the Rusty-patched Bumble Bee queen to reduce competition with her offspring.

Mating behaviour of Suckley's Cuckoo Bumble Bee is likely similar to Gypsy Cuckoo Bumble Bee. Adult cuckoos visit flowers, both after emergence (sometime in the autumn) and females only, prior to nest invasion in the spring (Antonovics and Edwards 2011). Phenology differs with latitude and altitude but generally females emerge approximately one month after the host species (Plath 1934) and are detected until late summer. Males emerge in early summer and are detected until late autumn.

Though only Western Bumble Bee has been confirmed as a host, the distribution of Suckley's Cuckoo Bumble Bee in Canada (outside the range of Western Bumble Bee) suggests that other nest-building bumble bees must also serve as hosts (Williams 2008; Hines and Cameron 2010; Lhomme and Hines 2018). It is rare that cuckoo bumble bees use a single host, and often they tend to use related species (i.e. members of the same subgenus or even species group). As such, it is likely that other members of the subgenus *Bombus* also serve as hosts (Hobbs 1965ab, 1966ab; Williams *et al*. 2014; Lhomme and Hines 2018).

Physiology and Adaptability

When compared to nest-building bumble bees, female cuckoo bumble bees typically have a thicker, more protective exoskeleton, larger mandibles, a greater number of ovarioles and a longer venom gland (Fisher and Sampson 1992). As they do not collect resources for their own offspring, they do not possess a corbicula (i.e. pollen basket) for pollen carrying on their hind leg, and their abdomens generally have less hair, giving them a shinier appearance in dorsal view than nest-building species.

Dispersal and Migration

The ability and rate of dispersal for Suckley's Cuckoo Bumble Bee depends on its hosts' population dynamics and distribution. In general, there is little information on natural dispersal rates for bumble bees. Regardless, given the patchiness of bumble bee habitat (e.g., Hatfield and LeBuhn 2007) and increased problems associated with small effective population sizes in haplodiploid insects (e.g., Zayed and Packer 2005) (see **Limiting Factors**), dispersal is likely important to survival. An important opportunity for dispersal occurs with the movement of reproductive individuals, primarily females in spring that disperse while searching for suitable nest sites (Goulson 2003a).

There is some evidence that bumble bees can disperse long distances. Males of the well-studied Buff-tailed Bumble Bee (*B. terrestris,* and host to Gypsy Cuckoo Bumble Bee in the Palearctic) are estimated to fly between 2.6 and 9.9 km from the colony of origin (Kraus *et al*. 2009). Additionally, Buff-tailed Bumble Bee was introduced to Tasmania in the early 1990s and has since spread at a rate of approximately 12.5 km per year (Stout and Goulson 2000). It is presumed that these values may also be true of other bumble bee species, including cuckoos, due to their large size.

Interspecific Interactions

Suckley's Cuckoo Bumble Bee, like its sister species the Gypsy Cuckoo Bumble Bee, is a social parasite of bumble bees in the subgenus *Bombus*, the most important being Western Bumble Bee, the only confirmed host for this species (Hobbs 1968; Lhomme and Hines 2018). Cuckoo bumble bees detect their host species using chemical cues (Fisher *et al*. 1993). In the west, the host species is Western Bumble Bee, but likely also includes Yellow-banded Bumble Bee and possibly Cryptic Bumble Bee. Hobbs (1965ab, 1966ab) recorded Suckley's Cuckoo Bumble Bee in the nest of other species in Alberta, though these species have not been confirmed as hosts (Williams *et al*. 2014; Lhomme and Hines 2018).

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

A large dataset of bumble bee records from Canada was assembled for this status report. This Canadian dataset includes records from a larger North American dataset of bumble bees originally used for the Williams *et al*. (2014) publication (see http://www.leifrichardson.org/bbna.html), supplemented with additional data from museums, personal collections, online observation sources (e.g., iNaturalist©, BugGuide©, Bumble Bee Watch©) and other unpublished research datasets. This Canadian dataset is not inclusive of all Canadian bumble bee data; however, we have tried to obtain datasets that represent recent (within the last 15 – 20 years) collection effort from across the Canadian geographic range of Suckley's Cuckoo Bumble Bee (Table 2).

This Canadian dataset was analyzed to assess changes in relative abundance (RA), EOO, and IAO of Suckley's Cuckoo Bumble Bee by 10-year increments dating backwards from 2018. The type of data available to analyze historical bumble bee population trends are limited, and RA can be used as a proxy of abundance when data are not amenable to other analysis. For example, much of the data available is from opportunistic inventory and not geographically repeated; historical collection sites are not precisely georeferenced; or the data is a subset of a specific study.

There are assumptions to using RA when analyzing population trends. Most specimens in this dataset were collected by passive collection methods (e.g., pan traps, Malaise traps, blue vane traps) or hand netting. Passive collection methods are considered non-biased and we assume that a collector, photographer or observer would not bias themselves when capturing a bumble bee.

For analysis we worked backwards in 10-year increments from 2018 (1899 – 2018) for all of Canada (Figure 10). In addition jurisdictions with more than 75 records of Suckley's Cuckoo Bumble Bee had figures prepared (Figures 11-15). Calculations were based on subsets of the data for:

1) RA was calculated for Suckley's Cuckoo Bumble Bee / all databased *Bombus* records available for this analysis (red lines);
2) RA was calculated for Suckley's Cuckoo Bumble Bee / hosts only (Western Bumble Bee northern and southern subspecies and Yellow-banded Bumble Bee) (black lines)
3) RA was calculated for host bumble bees (Western Bumble Bee and Yellow-banded Bumble Bee) / all databased *Bombus* records available for this analysis (blue lines).
4) changes in IAO and EOO for Suckley's Cuckoo Bumble Bee across the Canadian range.

For RA of Suckley's Cuckoo Bumble Bee to hosts we used the known host Western Bumble Bee and sister taxa Yellow-banded Bumble Bee (presumed host and only member of subgenus Bombus in much of the range). We excluded Rusty-patched Bumble Bee and Cryptic Bumble Bee from our analysis because these two species have not been confirmed as hosts.

Suckley's Cuckoo Bumble Bee individuals are predicted to have a bimodal flight period. In the spring mated females emerge and actively look for an established host nest to parasitize; if successful it may take several weeks before the cuckoo progeny become adults. These adults will leave the nest, mate with conspecifics, and the mated queens will overwinter; it is unlikely these new queens would be successful if they attempted to parasitize large host colonies late in the season (e.g., the abundance of workers in the host nest would be great enough to prevent the cuckoo bumble bee from taking over the nest). Suckley's Cuckoo Bumble Bee has been recorded throughout the months of May – September in Canada. Although the cuckoo bumble bee is less abundant in late June and July, emergence times vary according to geography, temperature, phenology and elevation, among other factors. Therefore, we included all bumble bees collected/observed throughout this time in the analysis.

Abundance

Cuckoo bumble bees are, by their nature, less common than non-cuckoo bumble bees (e.g., workers make up most bumble bees collected). Thus, cuckoo bumble bees will naturally make up a low proportion of bumble bee records compared to workers of non-cuckoo species. Lhomme and Hines (2018) showed that less than 6% of all bumble bees databased globally in the Global Biodiversity Information Facility (GBIF) were cuckoo bumble bees. In North America, 3.8% were cuckoo bumble bees, supporting this low proportion compared to non-cuckoos.

Fluctuations and Trends

Little is known about the natural fluctuations and trends of bumble bee subpopulations. Even though surveys have been completed over large geographic areas of Canada (e.g., Cameron *et al*. 2011; Colla and Packer 2008; Colla *et al*. 2012; Sheffield pers. data; and many more), there are few studies that have repeatedly surveyed sites over an entire season, over several years, or gone back to those same places a decade later.

For bumble bees, a site may contain three or four common species and a handful of relatively rare ones (e.g., see Colla and Packer 2008). Common species often have stable subpopulations over time (e.g., large effective population sizes), whereas rare species will fluctuate and suffer from local stochastic extinction (e.g., small effective population sizes), may be uncommon members of the local bee fauna or may have more specific habitat requirements. Cuckoo bumble bees have the added complexity of being dependent on the host bee species' presence, abundance, and subpopulation dynamics. Cuckoo bees in general are susceptible to changes in abundance of their host (Sheffield *et al*. 2013) and have a greater extinction risk than non-cuckoo bumble bees (Suhonen *et al*. 2015).

The results from RA analysis are in Table 3 and Figures 10-15. Only major trends in these data are discussed below.

Table 3. The relative abundance (RA) and number of individuals [] within 10-year periods starting 1899 until 2018 of 1) Suckley's Cuckoo Bumble Bee (*Bombus suckleyi*) / all databased *Bombus* records available for this analysis ("SCBB RA", red text); 2) Suckley's Cuckoo Bumble Bee / hosts only (Western Bumble Bee [both subspecies] [*B. occidentalis occidentalis* and *B. o. mackayi*], Yellow-banded Bumble Bee [*B. terricola*]) ("cuckoo/host", black text); and 3) host bumble bees (two species) / all databased *Bombus* records available for this analysis ("host RA", blue text). For graphical representation of Table 3 figures are shown for jurisdictions with more than 75 records (Figures 10-15). See Collections Examined for complete list of data providers.

			Relative abundance of Suckley's Cuckoo Bumble Bee in ten-year intervals (Figures 10-15)											
			1899-1908	1909-1918	1919-1928	1929-1938	1939-1948	1949-1958	1959-1968	1969-1978	1979-1988	1989-1998	1999-2008	2009-2018
Canada	SCBB/ all *Bombus*	SCBB RA	0.15 [68]	0.08 [138]	0.06 [90]	0.05 [41]	0.16 [253]	0.18 [353]	0.13 [578]	0.01 [35]	0.01 [35]	0.02 [56]	<0.001 [34]	<0.001 [27]
	SCBB/ 2 hosts	cuckoo/ host	0.45 [151]	0.52 [267]	0.19 [481]	0.19 [215]	0.76 [334]	0.41 [865]	0.41 [1424]	0.03 [1221]	0.03 [1252]	0.04 [1295]	0.05 [698]	0.02 [1270]
	2 hosts/ all *Bombus*	Host RA	0.33 [461]	0.16 [1665]	0.34 [1435]	0.24 [897]	0.21 [1586]	0.43 [1996]	0.33 [4324]	0.37 [3265]	0.45 [2784]	0.44 [2921]	0.06 [11,114]	0.05 [27,123]
YT	SCBB/ all *Bombus*	SCBB RA	-	-	0.08 [1]	-	-	0.03 [2]	0.01 [1]	-	-	-	0.09 [6]	<0.001 [2]
	SCBB/ 2 hosts	cuckoo/ host	- [1]	- [2]	0.125 [8]	-	- [12]	0.09 [22]	0.05 [22]	- [273]	- [35]	- [4]	1.2 [5]	0.01 [145]
	2 hosts/ all *Bombus*	Host RA	0.5 [2]	0.17 [12]	0.62 [13]	0.00 [1]	0.12 [98]	0.31 [70]	0.13 [167]	0.62 [439]	0.43 [82]	0.67 [6]	0.07 [67]	0.02 [5838]
NT	SCBB/ all *Bombus*	SCBB RA	-	-	1.50 [3]	-	0.06 [10]	0.04 [2]	-	0.01 [1]	-	-	-	-
	SCBB/ 2 hosts	cuckoo/ host	-	-	3.00 [1]	[8]	10.00 [1]	2.00 [1]	[1]	0.17 [6]	-	-	-	-
	2 hosts/ all *Bombus*	Host RA	[1]	[9]	0.50 [2]	0.10 [77]	0.01 [178]	0.02 [51]	0.01 [137]	0.05 [117]	[31]	-	0.32 [68]	0.26 94]
BC	SCBB/ all *Bombus*	SCBB RA	0.36 [54]	0.11 [64]	0.17 [44]	0.12 [33]	0.41 [194]	0.9 [114]	0.44 [291]	0.07 [18]	-	0.26 [33]	-	<0.001 [1]
	SCBB/ 2 hosts	cuckoo/ host	1.06 [51]	0.52 [119]	0.51 [87]	0.58 [57]	1.30 [149]	0.14 [50]	0.16 [260]	0.07 [156]	0.00 [124]	0.44 [82]	- [51]	<0.01 [770]
	2 hosts/ all *Bombus*	Host RA	0.34 [152]	0.21 [571]	0.33 [262]	0.20 [286]	0.32 [468]	0.40 [126]	0.40 [657]	0.57 [272]	0.49 [252]	0.65 [126]	0.01 [4366]	0.04 [17,303]
AB	SCBB/ all *Bombus*	SCBB RA	0.09 [6]	0.18 [41]	0.09 [33]	0.10 [4]	0.13 [13]	0.43 [81]	0.31 [87]	0.01 [1]	0.17 [11]	0.37 [20]	0.01 [26]	<0.001 [22]
	SCBB/ 2 hosts	cuckoo/ host	0.55 [11]	2.16 [19]	0.20 [168]	0.27 [15]	2.17 [6]	1.11 [73]	2.02 [43]	0.04 [24]	3.67 [3]	5.0 [4]	0.06 [416]	0.02 [995]
	2 hosts/ all *Bombus*	Host RA	0.16 [68]	0.08 [229]	0.45 [374]	0.37 [41]	0.06 [102]	0.38 [190]	0.16 [277]	0.12 [198]	0.05 [63]	0.07 [54]	0.14 [3002]	0.03 [31303]
SK	SCBB/ all *Bombus*	SCBB RA	-	0.06 [2]	1.00 [2]	0.43 [3]	0.31 [35]	11.2 [112]	1.2 [54]	0.14 [4]	0.33 [2]	1.00 [1]	-	<0.001 [3]
	SCBB/ 2 hosts	cuckoo/ host	-	2.00 [1]	2.00 [1]	3.00 [1]	2.69 [13]	22.40 [5]	2.70 [20]	4.00 [1]	-	-	[10]	0.02 [121]
	2 hosts/ all *Bombus*	Host RA	[4]	0.03 [34]	0.50 [2]	0.14 [7]	0.12 [113]	0.50 [10]	0.44 [45]	0.03 [29]	- [6]	- [1]	0.32 [31]	0.03 [4703]
MB	SCBB/ all *Bombus*	SCBB RA	-	0.06 [4]	0.05 [1]	-	-	0.10 [26]	0.15 [43]	0.23 [3]	0.15 [20]	0.09 [2]	-	-

			Relative abundance of Suckley's Cuckoo Bumble Bee in ten-year intervals (Figures 10-15)											
			1899-1908	**1909-1918**	**1919-1928**	**1929-1938**	**1939-1948**	**1949-1958**	**1959-1968**	**1969-1978**	**1979-1988**	**1989-1998**	**1999-2008**	**2009-2018**
	SCBB/ 2 hosts	cuckoo/ host	-	0.15 [27]	0.07 [15]	[53]	[66]	0.13 [205]	2.69 [16]	0.60 [5]	0.23 [88]	0.11 [18]	-	[9]
	2 hosts/ all *Bombus*	Host RA	[2]	0.44 [62]	0.71 [21]	0.70 [76]	0.80 [82]	0.75 [273]	0.06 [282]	0.38 [13]	0.68 [130]	0.82 [22]	[210]	0.04 [253]
ON	SCBB/ all *Bombus*	SCBB RA	0.05 [5]	0.03 [13]	-	-	-	0.01 [4]	0.04 [97]	<0.001 [1]	-	-	-	-
	SCBB/ 2 hosts	cuckoo/ host	0.16 [31]	1.30 [10]	[60]	[32]	[23]	0.07 [59]	0.11 [889]	[540]	[829]	[1044]	[37]	[4]
	2 hosts/ all *Bombus*	Host RA	0.31 [101]	0.03 [382]	0.12 [502]	0.17 [190]	0.15 [153]	0.09 [632]	0.40 [2247]	0.33 [1632]	0.47 [1778]	0.45 [2326]	0.01 [3398]	0.01 [449]
QC	SCBB/ all *Bombus*	SCBB RA	0.23 [3]	0.06 [6]	0.07 [3]	-	<0.001 [1]	0.01 [2]	0.01 [1]	-	-	-	-	-
	SCBB/ 2 hosts	cuckoo/ host	3.00 [1]	3.00 [2]	0.23 [13]	[1]	0.06 [17]	0.03 [60]	0.06 [17]	[6]	[23]	[9]	[34]	[78]
	2 hosts/ all *Bombus*	Host RA	0.08 [13]	0.02 [101]	0.32 [41]	0.01 [67]	0.08 [215]	0.35 [172]	0.20 [86]	0.18 [33]	0.27 [86]	0.47 [19]	0.11 [296]	0.02 [4064]
ATC	SCBB/ all *Bombus*	SCBB RA	-	0.05 [8]	0.08 [3]	0.01 [1]	-	0.27 [10]	0.05 [5]	0.01 [7]	0.01 [2]	-	<0.001 [2]	<0.001 [3]
	SCBB/ 2 hosts	cuckoo/ host	[24]	0.28 [29]	0.19 [16]	0.06 [17]	[3]	0.63 [16]	0.22 [23]	0.04 [196]	0.02 [123]	[97]	0.02 [94]	0.08 [40]
	2 hosts/ all *Bombus*	Host RA	0.27 [89]	0.20 [146]	0.44 [36]	0.20 [85]	0.21 [14]	0.43 [37]	0.21 [110]	0.38 [518]	0.37 [333]	0.29 [338]	0.14 [666]	0.04 [1090]

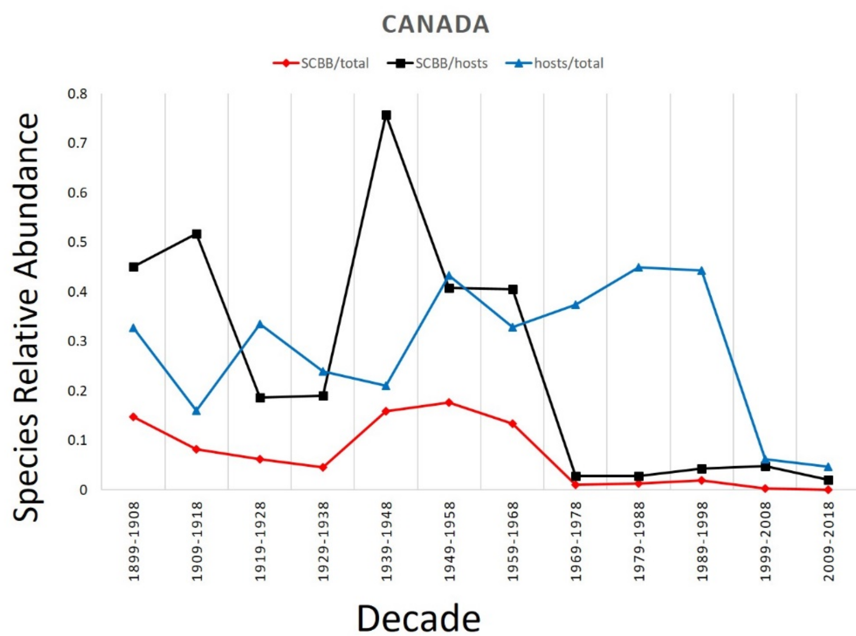

Figure 10. Species relative abundance within Canada by 10-year periods from 1899 until 2018 of 1) Suckley's Cuckoo Bumble Bee (*Bombus suckleyi*) / all databased *Bombus* records available for this analysis (red); 2) Suckley's Cuckoo Bumble Bee / hosts only (Western Bumble Bee [both subspecies] [*B. occidentalis occidentalis* and *B. o. mckayi*], Yellow-banded Bumble Bee [*B. terricola*]) (black); and 3) host bumble bees (two species) / all databased *Bombus* records available for this analysis (blue). Despite the commonness of the two hosts in the 1950s to 1990s, Suckley's Cuckoo Bumble Bee remained uncommon. Also see Table 3.

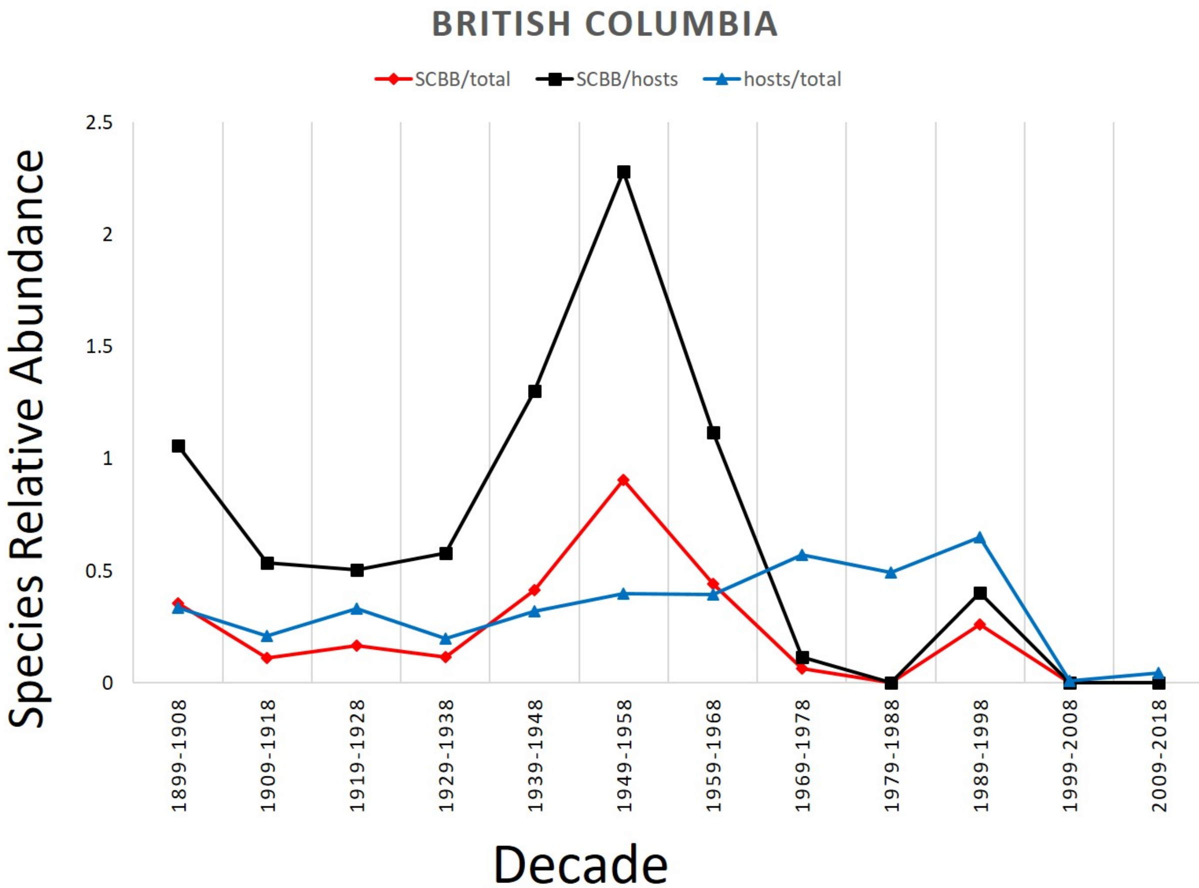

Figure 11. Species relative abundance within British Columbia by 10-year periods from 1899 until 2018 of 1) Suckley's Cuckoo Bumble Bee (*Bombus suckleyi*) / all databased *Bombus* records available for this analysis (red); 2) Suckley's Cuckoo Bumble Bee / hosts only (Western Bumble Bee [both subspecies] [*B. occidentalis occidentalis* and *B. o. mckayi*], Yellow-banded Bumble Bee [*B. terricola*]) (black); and 3) host bumble bees (two species) / all databased *Bombus* records available for this analysis (blue). The relative abundance of Suckley's Cuckoo Bumble Bee was highest pre-1960s, with another large peak in the late 1980s and 1990s, and despite commonness of its main host (Western Bumble Bee) until the late 1990s, the cuckoo has remained uncommon in British Columbia; hosts and cuckoo are now very uncommon in the province. Also see Table 3.

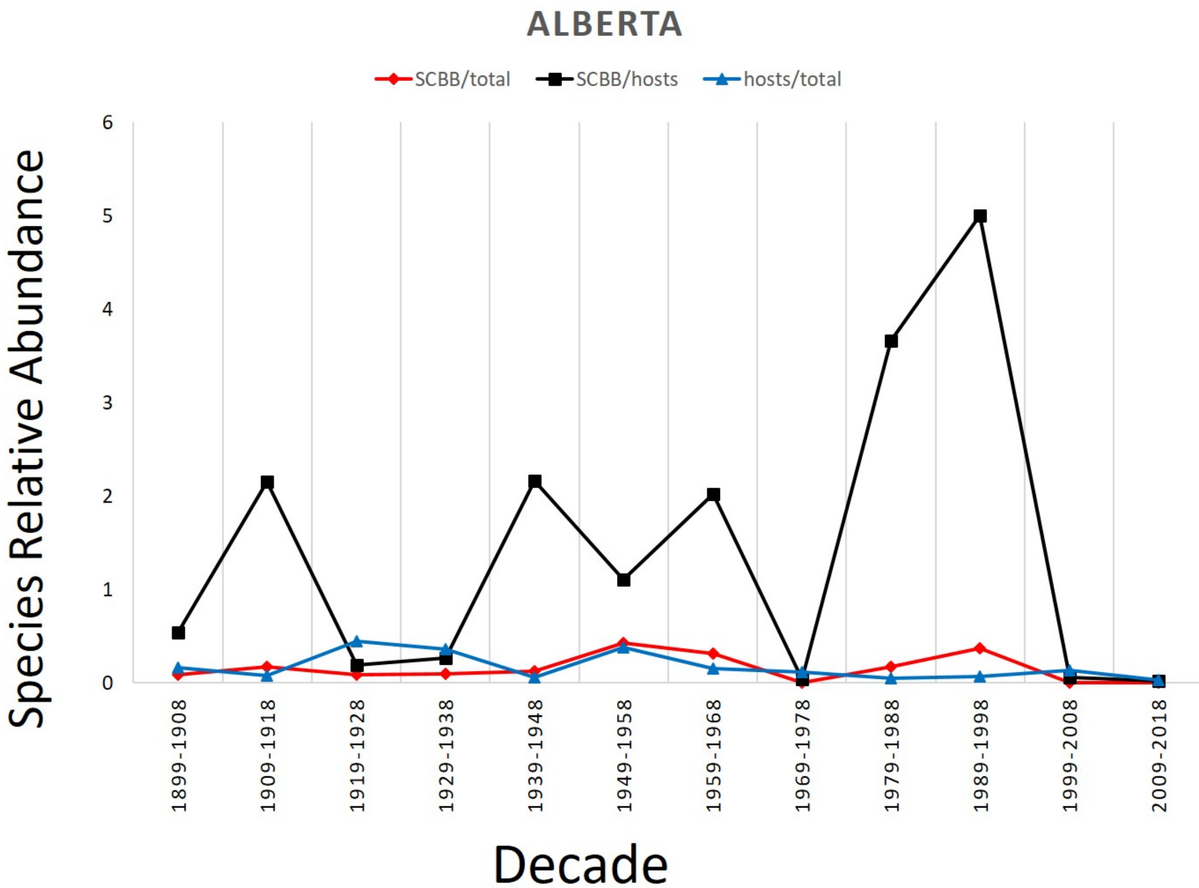

Figure 12. Species relative abundance within Alberta by 10-year periods from 1899 until 2018 of 1) Suckley's Cuckoo Bumble Bee (*Bombus suckleyi*) / all databased *Bombus* records available for this analysis (red); 2) Suckley's Cuckoo Bumble Bee / hosts only (Western Bumble Bee [both subspecies] [*B. occidentalis occidentalis* and *B. o. mckayi*], Yellow-banded Bumble Bee [*B. terricola*]) (black); and 3) host bumble bees (two species) / all databased *Bombus* records available for this analysis (blue). The relative abundance of Suckley's Cuckoo Bumble Bee has fluctuated in Alberta, seemingly following the abundance of its hosts Western Bumble Bee southern subspecies (*B. occidentalis occidentalis*) and Yellow-banded Bumble Bee (*B. terricola*). Although uncommon, it has been detected recently in surveys across the southern half of the province; from the early 1990s it was detected in higher numbers than its hosts (hence the peak), though likely an artifact of sampling and/or data capture. Also see Table 3 which documents the increased search effort since the early 1990s.

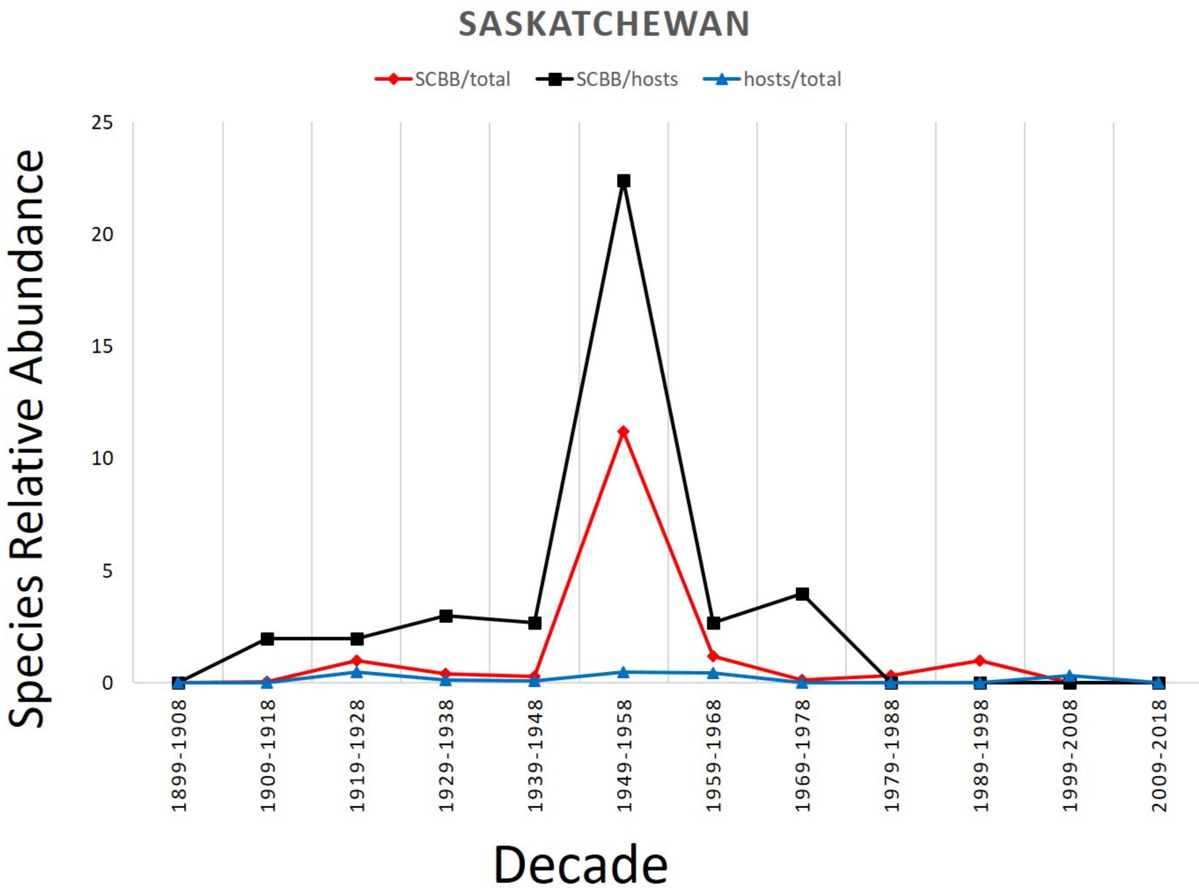

Figure 13. Species relative abundance within Saskatchewan by 10-year periods from 1899 until 2018 of 1) Suckley's Cuckoo Bumble Bee (*Bombus suckleyi*) / all databased *Bombus* records available for this analysis (red); 2) Suckley's Cuckoo Bumble Bee / hosts only (Western Bumble Bee [both subspecies] [*B. occidentalis occidentalis* and *B. o. mckayi*], Yellow-banded Bumble Bee [*B. terricola*]) (black); and 3) host bumble bees (two species) / all databased *Bombus* records available for this analysis (blue). The peaks in relative abundance of Suckley's Cuckoo Bumble Bee have largely been due to infrequent sampling in the province, with bias towards the cuckoo over hosts, and hosts over other bumble bees (1950s), and thus does not reflect the true abundance. Also see Table 3.

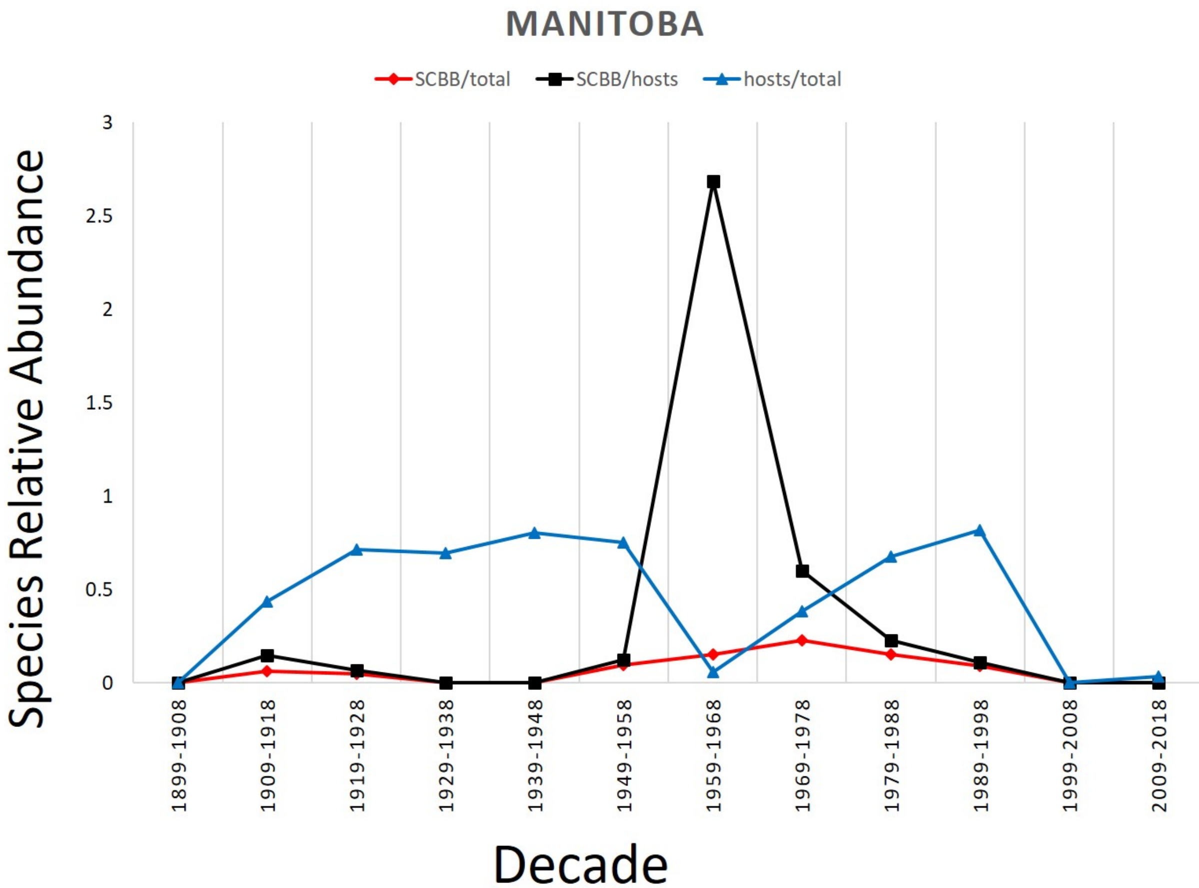

Figure 14. Species relative abundance within Manitoba by 10-year periods from 1899 until 2018 of 1) Suckley's Cuckoo Bumble Bee (*Bombus suckleyi*) / all databased *Bombus* records available for this analysis (red); 2) Suckley's Cuckoo Bumble Bee / hosts only (Western Bumble Bee [both subspecies] [*B. occidentalis occidentalis* and *B. o. mckayi*], Yellow-banded Bumble Bee [*B. terricola*]) (black); and 3) host bumble bees (two species) / all databased *Bombus* records available for this analysis (blue). The peak in relative abundance of Suckley's Cuckoo Bumble Bee in the late 1960s is due to infrequent sampling, with bias towards the cuckoos over hosts, and thus does not reflect the true abundance. Also see Table 3.

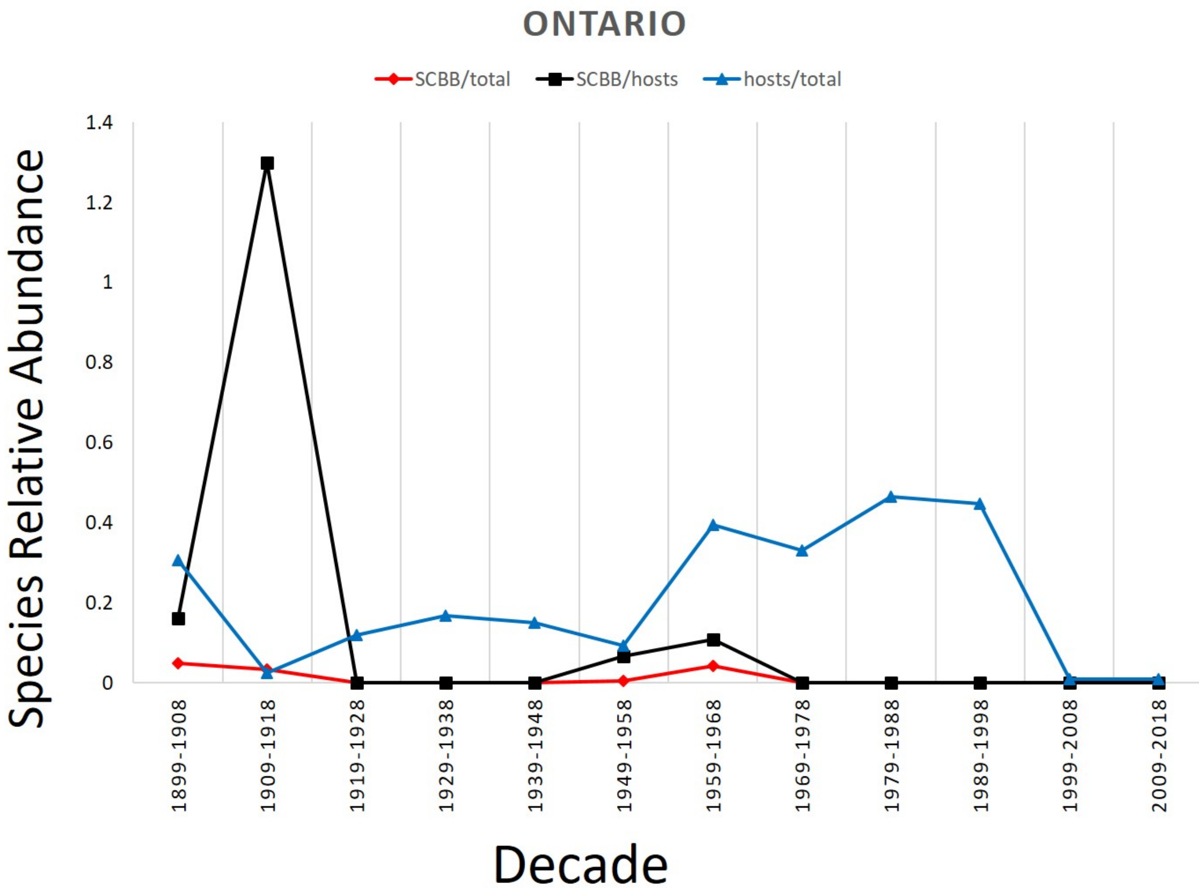

Figure 15. Species relative abundance within Ontario by 10-year periods from 1899 until 2018 of 1) Suckley's Cuckoo Bumble Bee (*Bombus suckleyi*) / all databased *Bombus* records available for this analysis (red); 2) Suckley's Cuckoo Bumble Bee / hosts only (Western Bumble Bee [both subspecies] [*B. occidentalis occidentalis* and *B. o. mckayi*], Yellow-banded Bumble Bee [*B. terricola*]) (black); and 3) host bumble bees (two species) / all databased *Bombus* records available for this analysis (blue). Despite an ample number of hosts (Yellow-banded Bumble Bee) until the 2000s, Suckley's Cuckoo Bumble Bee appears to have always been rare in Ontario; trends are therefore difficult to document. Also see Table 3.

<u>1) Suckley's Cuckoo Bumble Bee / all databased *Bombus* records (SCBB/total) available for this analysis (red lines, Table 3 and Figures 10-15).</u>

- Suckley's Cuckoo Bumble Bee records comprise ca 2% of all *Bombus* in the Canadian dataset. Cuckoo bumble bees typically make up very low proportions of total bumble bee captures as there are no workers produced, and throughout the period from 1901 until 2018, this species has fluctuated with both increases and decreases in RA in Canada (Figure 10).

- Historically (i.e. pre.1969-1978), Suckley's Cuckoo Bumble Bee made up a higher RA of bumble bees in Canada with a peak in RA of 0.18 occurring in the 1950s (Figure 10, red line); Suckley's Cuckoo Bumble Bee has declined in RA in most subsequent decades.
- The RA for Suckley's Cuckoo Bumble Bee for the last three decades for all of Canada (Figure 10) are 0.019 from 1989-1998, 0.003 from 1999-2008 and less than 0.001 for 2009-2018; these represent declines of 84% between decades 1989-1998 and 1999-2008; and 67% between 1999-2008 and 2009-2018. Similar large declines in the last few decades are apparent for Yukon, British Columbia (Figure 11), and Alberta (Figure 12), though too few data are available for other jurisdictions.

2) Suckley's Cuckoo Bumble Bee / hosts (Western Bumble Bee *occidentalis* and *mckayi* subspecies and Yellow-banded Bumble Bee) (black lines, Figures 10-15).

The RA of Suckley's Cuckoo Bumble Bee when calculated in relation to host species across its Canadian range (Figure 10, black line) did not follow the same general trend as its hosts to all bumble bees (Figure 10, blue line). Suckley's Cuckoo Bumble Bee appears to have had a major population crash in the 1960s and 1970s (Figure 10, red and black lines) even though its hosts continued to be relatively common until the 1990s (Figure 10, blue line).

- In British Columbia where most occurrences have been recorded, the RA of Suckley's Cuckoo Bumble Bee to host was highest pre-1960s (with a smaller peak again in the 1990s).
- For other jurisdictions, the data do not reveal declines in the same manner. In Yukon, Suckley's Cuckoo Bumble Bee has historically been very uncommon, though a peak was observed (6 specimens) in 1999–2008, with populations declining with host abundance in the last decade. Similarly, Alberta (Figure 12) and Saskatchewan (Figure 13) have seen peaks in the RA of the cuckoo to its hosts, though these are an artifact of more cuckoos being caught than hosts, which skews the RA calculations. In general, the results are not as clear for Alberta and Saskatchewan, though declines in Suckley's Cuckoo Bumble Bee are apparent between the late 1990s and 2000s for both jurisdictions.

3) Host bumble bees (Western Bumble Bee and Yellow-banded Bumble Bee) / all databased *Bombus* records available for this analysis (blue dots, (Figures 10-15).

Between 1989-1998 and 1999-2008 the RA of hosts to all bumble bees declined by 86%, and again in the next decade by 24% (Table 3, Figure 10).

- On average, RA for Suckley’s Cuckoo Bumble Bee is 1–2% of all bumble bees databased in Canada (Table 3). RA for hosts/total bumble bees (see Table 3 and Figures 10-15) supports recent (i.e. last two decades) downward trends for Western Bumble Bee (*occidentalis* and *mckayi* subspecies, COSEWIC 2014) and Yellow-banded Bumble Bee (Colla and Packer 2008; Cameron *et al*. 2011; COSEWIC 2015).
- When the host bumble bee data are pooled (both species) and RA is calculated for Canada as well as for each jurisdiction, there are declines between decades.
- In British Columbia, most Western Bumble Bee records are from southern regions of the province (*occidentalis* subspecies). There has only been one recent Suckley’s Cuckoo Bumble Bee record (2013, south of McBride) from within this range.
- Throughout their ranges, the RA of hosts declined dramatically between 1989-1999 and 1999-2008 (Yukon, British Columbia, Manitoba, Ontario, Québec) and more recently, between 1999-2008 and 2009-2018 in Alberta and Saskatchewan.

4) Changes in EOO and IAO for Suckley’s Cuckoo Bumble Bee (Table 4).

EOO and IAO were calculated in decade intervals from 1899 to 2018 for all of Canada.

- The total EOO was 9,160,823 km^2; among the decade periods EOO fluctuated between 388,938 km^2 and 8,491,978 km^2. Changes in EOO do not appear to show evidence for strong declines and are likely more indicative of sampling intensity in each period given the broad geographic range.
- The total IAO was 5,138 km^2. IAO fluctuated across the decades and showed a decline between both 1999 - 2008 (45%) and 2009 - 2018 (57%) (Table 4). These two declines occurred as sampling effort increased, but with limited sampling in the northern areas.

Table 4. Percent changes in extent of occurrence (EOO) and index of area of occupancy (IAO) by decade for Suckley's Cuckoo Bumble Bee (*Bombus* suckleyi) in Canada. EOO and IAO calculations done using GeoCAT software (geocat.kew.org). Both EOO and IAO fluctuate between decades, though the IAO declined by 45% and 56% between decades 1989 – 1999 and 1999 – 2008, and 1999 – 2008 and 2009 – 2018, respectively.

Decade	EOO (km^2) within Canada's jurisdiction	IAO (km^2)	% Change EOO	% Change IAO
Total	**9,160,823**	**5,136**		
1899-1908	1,381,523	208		
			+123%	+215%
1909-1918	3,080,735	656		
			+107%	-15%
1919-1928	6,367,019	560		
			-94%	-62%
1929-1938	388,938	208		
			+1,059%	+169%
1939-1948	4,509,373	560		
			+88%	+134%
1949-1958	8,491,978	1,312		
			-4%	-4%
1959-1968	8,131,521	1,264		
			-17%	-75%
1969-1978	6,755,934	320		
			-77%	-20.0%
1979-1988	1,529,929	256		
			-4%	+81%
1989-1998	1,472,040	464		
			+94%	-45%
1999-2008	2,853,892	256		
			+57%	-56%
2009-2018	4,491,017	112		

Rescue Effect

The low abundance of Suckley's Cuckoo Bumble Bee and the possible continued declines of its main host species outside Canada make recolonization by rescue effect throughout its range in southern Canada unlikely.

THREATS AND LIMITING FACTORS

Threats

The International Union for the Conservation of Nature – Conservation Measures Partnership (IUCN-CMP) threats calculator (IUCN-CMP 2006; Salafsky *et al*. 2008; Master *et al*. 2009) was used to classify and list threats to Suckley's Cuckoo Bumble Bee. The calculated overall threat impact is high (Table 5).

Table 5. Threat classification table for Suckley's Cuckoo Bumble Bee (*Bombus suckleyi*) across its geographic range in Canada based on the IUCN-CMP (World Conservation Union–Conservation Measures Partnership) unified threats classification system. For information on how the values are assigned see Master *et al.* (2009). Threats considered not applicable or negligible are included in this table; scored and unknown threats are discussed under subheadings in the report.

Species	Suckley's Cuckoo Bumble Bee (*Bombus suckleyi*)		
Date:	2019-04-04		
Assessors:	Cory Sheffield (report writer), Jennifer Heron (report writer), David McCorquodale (Co-Chair), Kristiina Ovaska (Facilitator), Al Harris (Arthropods SSC), Sarah Semmler (Arthropods SSC), Elisabeth Shapiro (Canadian Wildlife Service), Rob Longair (Arthropods SSC), Purnima Govindarajulu (BC COSEWIC representative), Joanna Wilson (NWT representative), Colin Jones (Ontario representative), John Klymko (Arthropods SSC), Marie-France Chenier (COSEWIC Secretariat)		
Level 1 Threat Impact Counts			
Threat Impact		**high range**	**low range**
A	Very High	0	0
B	High	0	0
C	Medium	1	1
D	Low	3	3
Calculated Overall Threat Impact:		High	High
Assigned Overall Threat Impact:		High	

Threat		**Impact [1] (calculated)**	**Scope [2] (next 10 Yrs)**	**Severity [3] (10 Yrs or 3 Gen.)**	**Timing [4]**	**Comments**
1	Residential & commercial development	Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	
1.1	Housing & urban areas	Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	Considered negligible. There have been a few studies to assess the decline of some bumble bee species within urban areas (e.g., Szabo *et al*. 2012). Host bumble bee species have declined some urban areas. For example, Western Bumble Bee southern subspecies has declined in the greater Vancouver area (e.g., Ratti 2006; Parkinson and Heron 2010; and summarized in COSEWIC 2014) and Yellow-banded Bumble Bee throughout southern Ontario (as summarized in COSEWIC 2015). Range wide impacts are considered small (e.g., <1%) and the overall impact negligible on Suckley's Cuckoo Bumble Bee (the decline in host bumble bees is considered under 7.3 Other ecosystem modifications).
1.2	Commercial & industrial areas	Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	See Threat 1.1

Threat		Impact [1] (calculated)	Scope [2] (next 10 Yrs)	Severity [3] (10 Yrs or 3 Gen.)	Timing [4]	Comments
1.3	Tourism & recreation areas					Considered not applicable and therefore not scored. Larger recreational developments allow for natural habitats and/or areas with floral resources, and bumble bee subpopulations likely remain. Some recreational development may cause bee habitat loss, but overall other cumulative threats may affect bee habitat (e.g., pesticide use on golf courses, water diversion, reduction of floral resources, etc.) and these threats are accounted for elsewhere in this threat calculator.
2	Agriculture & aquaculture	Low	Small (1-10%)	Moderate – Slight (1-30%)	High (Continuing)	
2.1	Annual & perennial non-timber crops	Low	Small (1-10%)	Moderate – Slight (1-30%)	High (Continuing)	Changing land use and crop production leading to fewer floral resources. See text in the Threats section.
2.3	Livestock farming & ranching					Considered not applicable and therefore not scored. In areas where cattle are grazed, it is likely that open habitats are created and maintained, which could be potentially beneficial for both Suckley's Cuckoo Bumble Bee and host bees.
3	Energy production & mining					
3.1	Oil & gas drilling					Considered not applicable and therefore not scored. Any activities that have impacts on host nesting sites and/or local floral resources potentially impact colony success. Conversely, activities that create open grassy areas potentially create habitat for this species.
3.2	Mining & quarrying					Considered not applicable and therefore not scored. Any activities that have impacts on host nesting sites and/or local floral resources potentially impact colony success. Conversely, activities that create open grassy areas potentially create habitat for this species.
4	Transportation & service corridors	Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	
4.1	Roads & railroads	Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	Considered negligible. Roadside clearing of vegetation and/or road expansion may destroy habitat. Conversely, these areas are often kept open thus allowing floral resources to be maintained.
4.2	Utility & service lines	Not a Threat				Considered not applicable and therefore not scored. Utility line maintenance and clearing of vegetation and/or expansion may destroy habitat. Conversely, these areas are often kept open thus allowing floral resources to be maintained.
5	Biological resource use	Not a Threat	Large (31-70%)	Neutral or Potential Benefit	High (Continuing)	

Threat		Impact [1] (calculated)	Scope [2] (next 10 Yrs)	Severity [3] (10 Yrs or 3 Gen.)	Timing [4]	Comments
5.1	Hunting & collecting terrestrial animals					Considered not applicable and therefore not scored. Bumble bee research is ongoing throughout the country, and specimens are collected as part of these studies. The study areas are considered negligible given the potential range of Suckley's Cuckoo Bumble Bee.
5.3	Logging & wood harvesting	Not a Threat	Large (31-70%)	Neutral or Potential Benefit	High (Continuing)	Considered not a threat. Logging takes place throughout much of Canada's forested ecozones, although the impacts to Suckley's Cuckoo Bumble Bee and host bees are largely unknown. Two studies found logging practices negatively impacted the bumble bee and flowering plant communities in general in adjacent pristine sites by disrupting natural density-dependent processes (Cartar 2005; Pengelly and Cartar 2010). Conversely, logged sites may provide more open foraging areas which are preferred by Suckley's Cuckoo Bumble Bee (Williams *et al*. 2014).
6	Human intrusions & disturbance	Negligible	Negligible (<1%)	Unknown	High (Continuing)	
6.1	Recreational activities	Negligible	Negligible (<1%)	Unknown	High (Continuing)	Considered negligible. All-terrain vehicles or other high-impact vehicles may have the potential to destroy or significantly alter existing or potential nest sites for host bumble bees and is considered a potential threat to this species because it could destroy grassy hummocks and collapse abandoned rodent burrows and bird nests. However, these threats are largely unknown and/or unsubstantiated, and negligible when considered across the species' Canadian range.
6.2	War, civil unrest & military exercises					Considered not applicable and therefore not scored. There are numerous military bases with both Suckley's and host bumble bee records. However, there is negligible impact from military exercises on bumble bees. Military training exercises may maintain open habitats needed for bumble bee nests, including nectar and pollen plant resources.
6.3	Work & other activities	Unknown	Unknown	Unknown	High (Continuing)	Unknown. Ongoing captive breeding research of host bumble bee species for greenhouse pollination is a possibility. Captive breeding of Yellow-banded Bumble Bee and Western Bumble Bee are also ideas put forth during recovery planning for these species. There are no decisions around implementation of these techniques; however, this is a potential threat through the spread of disease and/or parasites.
7	Natural system modifications	Medium	Restricted (11-30%)	Extreme (71-100%)	High (Continuing)	

Threat		Impact [1] (calculated)	Scope [2] (next 10 Yrs)	Severity [3] (10 Yrs or 3 Gen.)	Timing [4]	Comments
7.1	Fire & fire suppression	Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)	Considered negligible. Fires and fire suppression may initially have an adverse impact on Suckley's Cuckoo Bumble Bee colonies, including host colony subpopulations. Wildfire directly kills nests and overwintering queens of both hosts and cuckoo bumble bees. Throughout the extensive range of Suckley's Cuckoo Bumble Bee, the incidence of wildfire is low, mainly due to fire suppression programs. However, in cases where wildfires do occur, the impacts are not likely detrimental because over a ten-year time frame, the bees would likely move back in and the open habitat and the rich plant communities are also maintained.
7.3	Other ecosystem modifications	Medium	Restricted (11-30%)	Extreme (71-100%)	High (Continuing)	See text in the Threats section.
8	Invasive & other problematic species & genes	Unknown	Restricted (11-30%)	Unknown	High (Continuing)	
8.1	Invasive non-native/ alien species/ diseases	Unknown	Restricted (11-30%)	Unknown	High (Continuing)	See text in the Threats section.
8.2	Problematic native species/ diseases	Unknown	Small (1-10%)	Unknown	High (Continuing)	See text in the Threats section.
9	Pollution	Low	Small (1-10%)	Moderate (11-30%)	High (Continuing)	
9.2	Industrial & military effluents					Not applicable. Known to occur at Canadian Forces Base Shilo but the use of military effluents is unknown and likely negligible to the overall Canadian population.
9.3	Agricultural & forestry effluents	Low	Small (1-10%)	Moderate (11-30%)	High (Continuing)	See text in the Threats section.
9.5	Air-borne pollutants	Unknown	Restricted - Small (1-30%)	Unknown	High (Continuing)	Unknown. Effects of smoke from forest fires on bumble bees, they may interpret this as 'overcast' and not fly because of sun blockage. But otherwise dust particles and ash particles get incorporated into resources. It may affect their navigation and they may not fly during times of high smoke. Timing of nest finding may not be during peak forest fire season.
11	Climate change & severe weather	Low	Restricted - Small (1-30%)	Moderate - Slight (1-30%)	High (Continuing)	
11.1	Habitat shifting & alteration	Low	Small (1-10%)	Extreme - Moderate (11-100%)	High (Continuing)	See text in the Threats section.
11.2	Droughts	Low	Restricted - Small (1-30%)	Moderate - Slight (1-30%)	High (Continuing)	See text in the Threats section.

Threat		Impact [1] (calculated)	Scope [2] (next 10 Yrs)	Severity [3] (10 Yrs or 3 Gen.)	Timing [4]	Comments
11.3	Temperature extremes	Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	See text in the Threats section.
11.4	Storms & flooding	Negligible	Negligible (<1%)	Unknown	Moderate (Possibly in the short term, < 10 yrs/3 gen)	Negligible. May be affected by flooding (both Suckley's Cuckoo Bumble Bee and host bumble bee colonies) events in low-lying areas. Host nests can be flooded out. In the Prairies, this is certainly a potential threat.

Classification of Threats adopted from IUCN-CMP, Salafsky et al. (2008).

[1]**Impact** – The degree to which a species is observed, inferred, or suspected to be directly or indirectly threatened in interest. The impact of each stress is based on Severity and Scope rating and considers only present and future threats. Threat impact reflects a reduction of a species population or decline/degradation of the area of an ecosystem. The median rate of population reduction or area decline for each combination of scope and severity corresponds to the following classes of threat impact: very high (75% declines), high (40%), medium (15%), and low (3%). Unknown: used when impact cannot be determined (e.g., if values for either scope or severity is unknown).

[2]**Scope** – Proportion of the species that can reasonably be expected to be affected by the threat within 10 years. Usually measured as a proportion of the species' population in the area of interest. (Pervasive = 71–100%; Large = 31–70%; Restricted = 11–30%; Small = 1–10%)

[3]**Severity** – Within the scope, the level of damage to the species from the threat that can reasonably be expected to be affected by the threat within a 10-year or three-generation timeframe. Usually measured as the degree of reduction of the species' population (Extreme = 71–100%; Serious = 31–70%; Moderate = 11–30%; Slight = 1–10%).

[4]**Timing** – High = continuing; Moderate = only in the future (could happen in the short term [< 10 years or 3 generations]) or now suspended (could come back in the short term); Low = only in the future (could happen in the long term) or now suspended (could come back in the long term); Insignificant/Negligible = only in the past and unlikely to return, or no direct effect but limiting

The predominant threat to Suckley's Cuckoo Bumble Bee is the continued decline of host bumble bee subpopulations to abundances low enough to cause local extirpations of this cuckoo bee species (scored under 7.1 Other ecosystem modifications).

Where appropriate, consideration of threats to the host bumble bees are discussed concurrently. Threats are listed from highest to least impact under the associated headings below. The scope of most threats is difficult to quantify, mainly because much of the species' range has not been surveyed for both Suckley's Cuckoo Bumble Bee and host bumble bees.

Threat 7. Natural system modifications (Medium impact)

7.3. Other ecosystem modifications (Medium impact).

The most direct threat to Suckley's Cuckoo Bumble Bee is the continuing decline of its host, Western Bumble Bee (COSEWIC 2015), and its assumed hosts Yellow-banded Bumble Bee (COSEWIC 2014) and Rusty-patched Bumble Bee (COSEWIC 2010). Approximately one-third of the Canadian range of Suckley's Cuckoo Bumble Bee has experienced host bumble bee declines (COSEWIC 2014, 2015). Western Bumble Bee southern subspecies is designated Threatened with an inferred decline of about 50%. The approximate range of Western Bumble Bee southern subspecies is 720,170 km^2 and northern subspecies is 623,837 km^2 and Yellow-banded Bumble Bee is 7,913,612 km^2.

Threat 2. Agriculture and Aquaculture (Low impact)

2.1 Annual and perennial non-timber crops (Low impact).

Habitat loss because of agricultural intensification is ongoing throughout southern portions of Canada, and primarily concentrated in the Prairies, Western Interior Basin and Mixedwood Plains ecozones, which contain some of the most highly urbanized and farmed regions in Canada (Javorek and Grant 2011; ESTR 2016). Much of Canada's landscapes managed for agriculture have low capacities to support wildlife (Javorek and Grant 2011) and it is likely that Suckley's Cuckoo Bumble Bee has been affected by agriculture-related habitat loss. The increased reliance on intensive agriculture over the past few decades has resulted in decreased quality foraging habitat for bumble bees globally (e.g. Williams 1989; Kosior *et al*. 2007), and intensive agriculture expansion has been correlated with declines in species richness and local extirpation of bumble bees in some areas (Grixti *et al*. 2009).

Farmland dedicated to hay production, particularly within areas of high agricultural yield, has declined in recent decades. For example, hay production in Ontario declined from approximately 1 million ha in 2001 to 696,000 ha in 2016 (decline of 31%); hay fields often also have a diversity of wildflowers, as well as abundant rodent populations, and serve as nest sites for hosts and cuckoo bumble bees. Field crops such as soybeans, grain and silage corn, winter and spring wheat, dry field beans, oats and rye increased in the same time span (Statistics Canada 2017). Soybeans are self-pollinated; and grain and silage corn are wind-pollinated, and some of these same crops also use neonicotinoids and other pesticides which are shown to adversely impact pollinators (see Threat 9.3). There is an amplified effect in the hierarchy of parasitism: factors negligible for the host bumble bee may be more serious for the cuckoo bumble bee (Sheffield *et al*. 2013).

Agricultural development and intensification reduce numbers of host species. Western Bumble Bee southern subspecies (COSEWIC 2014), Yellow-banded Bumble Bee (COSEWIC 2015), Rusty-patch Bumble Bee (COSEWIC 2010), as well as other bumble bees have declined within areas with intensive agriculture and the loss of natural areas from within agricultural landscapes (e.g., hedgerows, flowering weeds and natural patches of habitat). However, there are no range-wide studies.

Threat 9. Pollution (Low impact)

9.3 Agricultural and forestry effluents (Low impact).

At local scales pesticides could threaten host nesting subpopulations by decreasing the wildlife habitat suitability (Javorek and Grant 2011). In agricultural and urban areas, subpopulations of Suckley's Cuckoo Bumble Bee and their hosts may be threatened by a variety of pesticides, including neonicotinoids. Neonicotinoids are a class of systemic pesticides that travel and accumulate throughout the plant, including in pollen and nectar, and specifically pose a threat to bees because they are harmful even at concentrations in the parts per billion (ppb) range (Environmental Protection Agency [EPA] 1994; Marletto *et al*. 2003). Neonicotinoids are commonly used on golf courses, ornamental plants and agricultural lands (Sur and Stork 2003). Large treated areas, such as golf courses, may expose bumble bees to large quantities of pesticides in otherwise suitable habitat (Tanner and Gange 2004). In dry conditions, contaminated soil can become airborne with tilling and contaminate adjacent areas where bees might be foraging or nesting (Krupke *et al*. 2012).

Imidacloprid (a neonicotinoid) was registered for use in the United States (in 1994) and Canada (1995) (Cox 2001, Pest Management Regulatory Agency [PMRA] 2001), coinciding with the first declines of Western Bumble Bee in western Canada. The effects of imidacloprid are not lethal to bumble bees when used as directed (e.g., Tasei *et al*. 2001); however, studies of its effects on bumble bees were only tested on Common Eastern Bumble Bee (*B. impatiens*), a commercially available species for which colonies are available and serve as an experimental model for North American bumble bee species (Gels *et al*. 2002; Morandin and Winston 2003).

Colonial insects which produce reproductive individuals at the end of the colony cycle can be negatively impacted by cumulative sub-lethal effects. Further study showed neonicotinoids had negative lethal and sub-lethal impacts on a European bumble bee in the same subgenus, including at levels found in crops treated as directed (Tasei *et al*. 2001; Whitehorn *et al*. 2012; Gill and Raine 2014).

Many species began exhibiting declines prior to the widespread use of neonicotinoids in North America (Colla *et al*. 2012). The data available on neonicotinoid use may not explain landscape levels of decline in some bumble bee species (Colla *et al*. 2013) but may contribute to declines at local scales.

Pesticides can have negative impacts on beneficial insects through direct exposure while foraging or in nesting habitat or indirect exposure while feeding on contaminated pollen and nectar. Effects can be lethal or sub-lethal depending on the chemical and/or concentration (Crall et al. 2017). Effects can also be synergistic with exposure to multiple pesticides (Gill *et al*. 2012), more specifically fungicides.

<u>Threat 8. Invasive and Other Problematic Species and Genes (Unknown impact)</u>

8.1 Invasive non-native/alien species (Unknown impact)

Multiple non-native/alien species potentially threaten subpopulations of Suckley's Cuckoo Bumble Bee and associated host species. These are categorized and discussed below:

Pathogen spillover from managed bees

Pathogen spillover has been implicated in the significant declines of many wide-ranging animals (Morton *et al*. 2004; Power and Mitchell 2004) and is considered a major threat to bumble bees in North America. Pathogen spillover occurs when pathogens spread from a heavily infected 'reservoir' host population to a sympatric 'non-reservoir' host population (Power and Mitchell 2004). Managed bumble bees have been documented to have a higher than natural level of pathogens (Colla *et al*. 2006; Graystock *et al*. 2013a). The use of infected commercial bumble bees, including Common Eastern Bumble Bee, for greenhouse pollination is known to cause pathogen spillover into populations of wild bumble bees foraging nearby (Colla *et al*. 2006; Otterstatter and Thomson 2008).

Two unicellular parasitic species involved in pathogen spillover to wild bumble bees, *Crithidia bombi* (flagellate parasite) and *Nosema bombi* (fungal parasite), have detrimental effects on colony-founding queens, foraging workers and entire nests (Brown *et al*. 2000, 2003; Otterstatter *et al*. 2005). Commercial bumble bees have been found to have high prevalence of these parasites (approx. 34-80%; see Colla *et al*. 2006; Murray *et al*. 2013). These parasites are also found naturally in a variety of bumble bee species at lower levels (Macfarlane 1974; Macfarlane *et al*. 1995; Colla *et al*. 2006), but virulence in Suckley's Cuckoo Bumble Bee and host bumble bees and remains unknown. Szabo *et al*. (2012) found that declines in the Yellow-banded Bumble Bee throughout its range in the United States and in the southern parts of its Canadian range were weakly correlated with the density of vegetable greenhouses, indicating pathogen spillover from managed greenhouse bees may be a factor threatening this species. Additional studies have found declining species to have higher pathogen loads in the wild compared to co-occurring species that are not declining (Cameron *et al*. 2011; Cordes *et al*. 2012); however, pathogen loads have been found to be highly variable in common bumble bees as well (5-44%) (Koch and Strange 2012; Malfi and Roulston 2014). Cordes *et al*. (2012) reported high prevalence of the microsporidium *Nosema bombi* (25%) in Suckley's Cuckoo Bumble Bee, although the sample size consisted of four individuals.

Managed bumble bees

The only known landscape level change weakly correlated with declines in this species is the increasing density of vegetable greenhouses (Szabo *et al*. 2012). The use of managed bumble bees for field and crop pollination is likely increasing across this species' range. Crops which use managed bumble bees include blueberry, cranberry, tomato, eggplant, cucumber, sweet pepper and strawberries. Bumble bees are primarily used for greenhouse crops but are also increasingly used for field crops. The use of bumble bees is increasing throughout Canada as they are more efficient in cooler temperatures, demand for these crops is growing and they are used as an alternative to honey bees, which have suffered major declines in recent years. Currently the movement of managed bumble bees within Canada is not tracked but the potential for these and honey bees to transmit or amplify diseases and other pests (e.g., small hive beetle) to wild bees is high throughout most provinces and territories.

In Canada, greenhouses using managed bees exist across southern BC, ON and QC and to a lesser extent in southern AB, NT and YT. In Canada, greenhouse area (including insect-pollinated vegetables such as tomatoes, cucumbers and peppers) increased 7% from 2015 to 2016 with over 15 million m^2 in 2016. Ontario leads the greenhouse vegetable sector accounting for more than two-thirds of all greenhouse vegetable area in Canada (70%), followed by British Columbia (20%) and Québec (6%) (Statistics Canada 2017). The increase in greenhouses translates into a decline in outdoor habitat for the bee, and a likely increase in the use of Common Eastern Bumble Bee as the greenhouse vegetable pollinator (see Threat 8.2). Pathogen spillover due to the increased use of managed bumble bees in greenhouse operations in recent decades has been implicated in the declines of the Yellow-banded Bumble Bee, the Rusty-patched Bumble Bee and the Western Bumble Bee (Thorp and Shepherd 2005; NRC 2007; Evans *et al*. 2008) and could provide an avenue for rapid and catastrophic disease outbreaks in the future.

Competition from managed honey bees

In agricultural and urban landscapes Suckley's Cuckoo Bumble Bee and associated hosts likely compete for nectar and pollen with the introduced and managed Western Honey Bee (*Apis mellifera*). However, competition is difficult to quantify under natural conditions (Thomson 2006), so the impact in agricultural landscapes is largely unknown. The Western Honey Bee has been in North America for hundreds of years making it difficult to correlate the suspected decline of Suckley's Cuckoo Bumble Bee and associated hosts with direct competition with managed honey bees. However, the number of managed Western Honeybee hives has increased, which thereby has likely increased competition, and there is increasing evidence that the honey bee poses threats to natural mutualisms (reviewed in Aizen *et al*. 2014), and that they do have direct impacts on wild bees. For instance, Cane and Tepedino (2016) calculate that during a single month an individual healthy honey bee colony can collect enough pollen that would otherwise produce 33,000 native bees, thus reducing overall fecundity of nesting native wild bees in the area.

Disease transfer

Recent studies have shown that honey bee diseases may be transmittable to bumble bees (e.g., Li *et al*. 2011; Peng *et al*. 2011). In Canada it is estimated that there are 600,000 honey bee colonies in use for pollination and honey production (Canadian Honey Council 2014) and this number is expected to grow (AAFC 2012). Given that disease is a rampant problem in managed honey bees, honey bees may pose a threat to native bumble bees. In the UK, honey bees have been documented transmitting *Nosema ceranae* to bumble bees (Graystock *et al*. 2013b). Other disease agents, such as viruses, are understudied but may pose a threat.

Other invasive species

The general threat of invasive species in the many parts of Canada is not well-studied; however, it has been identified as an important research priority (Langor *et al*. 2014).

Inappropriately marketed nectar/pollen plants

Other potential threats to bumble bees in urban areas are plants, including those labelled as "bee-friendly", sold in nurseries contaminated with pesticides, and/or the use of pesticides for residential use. Bumble bee diversity and abundance was higher in gardens in France that abstained from pesticides than those that used pesticides (Muratet and Fontaine 2015), especially in gardens in urban areas. Thus, the use of insecticides and herbicides for garden, ornamental, and other residential purposes may pose a risk to all bumble bees, including this species.

8.2 Problematic native species (unknown impact)

The use of the highly competitive Common Eastern Bumble Bee, native to Canada in Ontario and Québec (Laverty and Harder 1988) but now used for pollination of greenhouse crops (e.g., tomato) and field crops (e.g., blueberry) across most of southern Canada may further impact Suckley's Cuckoo Bumble Bee and its hosts. Common Eastern Bumble Bee may out-compete Suckley's Cuckoo Bumble Bee for forage resources and host nesting habitats (Williams *et al*. 2014). The adverse impacts of bumble bees introduced for commercial pollination on native species is unknown in Canada but has been documented elsewhere (Williams and Osborne 2009; Goulson 2003b). Currently the use and movement of the Common Eastern Bumble Bee within and outside its native range within Canada is not being monitored in BC (Heron pers. comm. 2019), SK (Sheffield pers. comm. 2019), Yukon (Cannings pers. comm. 2019) or Northwest Territories (Carrière pers. comm. 2019). It is unlikely monitored in Alberta. Newfoundland and Labrador prohibit and monitor importation of bumble bees not naturally occurring in the province, including *Bombus impatiens*, a species widely used for greenhouse pollination (Humber pers. comm. 2019).

<u>Threat 11. Climate change & severe weather (Low impact)</u>

11.1 – 11.2 (Low impact)

Climate change is another possible threat (Williams and Osborne 2009). Bumble bee species shown to have narrow climatic tolerances are more vulnerable to extrinsic threats (Williams *et al*. 2009). Climatic tolerances for Suckley's Cuckoo Bumble Bee are not currently known, but there is evidence one of the species' hosts (Rusty-patched Bumble Bee) may be negatively impacted by climate change due to the increase in precipitation variability over time (Kerr *et al*. 2015).

Within the genus *Bombus*, some species have narrow climatic tolerances and are more vulnerable to extrinsic threats (Williams *et al*. 2009). A recent study of two bumble bee species that co-occur with Suckley's Cuckoo Bumble Bee in eastern Canada and northeastern United States (Common Eastern Bumble Bee and Two-spotted Bumble Bee [*B. bimaculatus*]) determined that bee species are emerging 10 days earlier than a century ago due to climate change (Bartomeus *et al*. 2011). This could lead to mismatch of early spring forage (e.g., Miller-Rushing and Primack 2008; Bartomeus *et al*. 2011) or increase the likelihood of queens emerging earlier than normal (i.e. before the end of winter storms). Neither of these species are thought to be hosts for Suckley's Cuckoo Bumble Bee; however, there may be similar patterns for the other host species.

Limiting Factors

Numerous factors limit the abundance of cuckoo bumble bees:

1) Parasitism of bumble bees

A wide range of invertebrates parasitize bumble bees at all stages of the colony cycle (Schmid-Hempel 1998), and this includes cuckoo bumble bees. Spring queens which have wintered in the soil (including cuckoos) can be infected by nematodes (*Sphaerularia bombi*) or protozoa (*Apicystis bombi*) rendering them incapable of founding colonies. The internal mite *Locustacarus buchneri* is a common parasite that lives within the respiratory tubes and air sacs of many bumble bee species. Otterstatter and Whidden (2004) found unusually high prevalence of this parasite in Yellow-banded Bumble Bee in Alberta. Although Cryptic Bumble Bee, Western Bumble Bee and Yellow-banded Bumble bee made up only 18% of their total bumble bee sample (n= 4096), these three species accounted for 83% of infected individuals, with 9% of Yellow-banded Bumble Bee individuals infected (Otterstatter and Whidden 2004). Infection rates for nine other species studied ranged from 0-3.9% (Otterstatter and Whidden 2004). This parasite is known to adversely impact the health of bumble bees.

During the summer, bees may acquire parasites (e.g., *Crithidia bombi*, *Nosema bombi*), while foraging on flowers contaminated by infected bees. *Nosema bombi* is a microsporidian gut and tissue parasite of bumble bees which can reduce survival and foraging efficiency (Fisher and Pomeroy 1989). *Nosema bombi* infection is considered infrequent among wild bumble bees (average infection rates = 5–10%; Colla *et al*. 2006). Recent field surveys across the United States (Cameron *et al*. 2011) found the highest levels of *N. bombi* infection (i.e. over 35%) among declining bumble bee species, which supports the hypothesis that this parasite is a serious limiting factor. Thus, these parasites may have direct, and indirect impacts to Suckley's Cuckoo Bumble Bee via their hosts; and a naturally occurring parasite may become a threat to the species.

2) Predators of adult bumble bees

Robber flies (Family Asilidae) and larger spiders (Arachnida) are predators of bumble bees (e.g., crab spiders [Thomisidae], jumping spiders [Salticidae] and orb weavers [Araneidae] (Copley pers. comm. 2019)). Thickheaded (Family Conopidae) and Humpbacked (Family Phoridae) flies are parasitoids of adult bumble bees. Raccoons, skunks, bears and other mammals are known to destroy and consume bumble bee colonies (Breed et al. 2004).

3) Diploid male extinction vortex

Bumble bees are haplodiploid organisms with complementary sex determination, which makes them extremely susceptible to extinction when effective population sizes are small (Zayed and Packer 2005). This is due to the 'diploid male extinction vortex' (Zayed and Packer 2005). The sex of a bee, and most other haplodiploid organisms, is determined by genotype at a single "sex locus": hemizygotes (haploids) are males, heterozygotes are female, and homozygotes are sterile or non-viable males. The number of sex alleles in a subpopulation determines the proportion of diploids that are male and is itself determined primarily by the effective size of the population. Due to the production of sterile males when sex-determining locus heterozygosity is low (i.e. populations are small, and inbreeding occurs), bees are more vulnerable to habitat fragmentation than many other animal species (Packer and Owen 2001). This means that as bumble bee populations decrease in size, the frequency of diploid males will increase. Increases of diploid males in smaller populations increase the rate of population declines, causing a special case of the extinction vortex: "the diploid male extinction vortex".

4) Lower genetic diversity in cuckoo bumble bees

Recent evidence also suggests that bumble bees with small populations have lower genetic diversity and increased susceptibility to parasites (e.g. Whitehorn *et al*. 2014), though this has not been studied in Suckley's Cuckoo Bumble Bee. However, it is true of its hosts which are known to have low genetic diversity and higher than normal parasite loads (Cameron *et al*. 2011), supporting this pattern. These declines are likely to cause similar effects of small population size to the cuckoos that parasitize them.

5) Nectar and pollen availability to both Suckley's Cuckoo Bumble Bee and hosts

Bumble bees are eusocial and require large inputs of floral resources (i.e. pollen and nectar) over the entire growing season to support colony growth and queen production in the fall.

6) Cuckoo bumble bees are more vulnerable to extinction than their hosts (Suhonen *et al*. 2015)

They are social parasites of nest-building bumble bees and depend on the distribution, abundance and colony health of the host species.

Number of Locations

The term location defines a geographically or ecologically distinct area in which a single threatening event can rapidly affect all individuals of the taxon present. It is not possible to calculate the number of locations for Suckley's Cuckoo Bumble Bee in Canada. Since this species is wide ranging and the threats to this species are variable depending on the geographic area, the number of locations is more than 50 and likely in the hundreds.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

Suckley's Cuckoo Bumble Bee is not listed under any provincial or territorial acts in Canada. However, two of the host bumble bee species are listed under Schedule 1 of the federal *Species at Risk Act* (SARA): Rusty-patched Bumble Bee is listed as Endangered (June 2012) and Yellow-banded Bumble Bee is listed as Special Concern (May 2018). Western Bumble Bee *occidentalis* subspecies and *mckayi* subspecies are respectively assessed by COSEWIC as Threatened and Special Concern (2014); however, they are not listed under SARA (as of May 2019).

Non-Legal Status and Ranks

Global Status Rank: G3 (Vulnerable) (NatureServe 2018).

Canada National Rank: N3 (Vulnerable) (last ranked June 2015) (Canadian Endangered Species Conservation Council 2016)

Provincial and territorial subnational ranks (Natureserve 2018):

BC, AB, SK, MB: S3S4 (Vulnerable/Apparently Secure) (June 2015)
YT: S2S3 (Imperiled to Vulnerable) (March 2016)
NF: SU (unknown)
ON, QC, NB, NS, PE – Not Ranked

International Union for the Conservation of Nature (IUCN) Red list Category: CR - Critically endangered

Suckley's Cuckoo Bumble Bee has not been assessed under the United States *Endangered Species Act*. There was a petition to the State of California Fish and Game Commission to list Suckley's Cuckoo Bumble Bee as Endangered under the *California Endangered Species Act* (Xerces Society for Invertebrate Conservation 2018). To date (August 2019) the species is not listed under this act.

Habitat Protection and Ownership

The Canadian range of Suckley's Cuckoo Bumble Bee spans numerous provincial and national parks and protected areas. Records from protected areas include Cypress Hills Provincial Park (Saskatchewan), Banff National Park (Alberta), Birds Hill Provincial Park (Manitoba), Duck Mountain Provincial Park (Saskatchewan), Elk Island National Park (Alberta), Jasper National Park (Alberta), Kouchibouguac National Park (New Brunswick), Mount Revelstoke National Park (British Columbia), Riding Mountain National Park (Manitoba), Sandilands Provincial Forest (Manitoba), Prince Albert National Park (Saskatchewan), Waterton Lakes National Park (Alberta), Wood Mountain Provincial Park

(Saskatchewan). There are localized efforts to ensure nectar and pollen resources are sustained across the landscape; however, most protected areas do not have initiatives to ensure pollinator habitat is sustained and climate change scenarios incorporated into planning measures.

It has been recorded on the Canadian Forces Base Shilo near Brandon, Manitoba.

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The cover photograph of Suckley’s Cuckoo Bumble Bee (photographed and collected along with four additional specimens, and deposited at the Royal Saskatchewan Museum) from Woodrow, Saskatchewan on June 30, 2019, by Cory S. Sheffield. This same photo has been shared in iNaturalist©. Other photos of Suckley’s Cuckoo Bumble Bee by Sheila Dumesh, York University.

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BIOGRAPHICAL SUMMARY OF REPORT WRITERS

Jennifer M. Heron is the provincial invertebrate conservation specialist with the British Columbia Ministry of Environment and Climate Change Strategy. She directs and manages the provincial approach to invertebrate conservation, including the development and implementation of provincial legislation, policy, procedures, and standards for the conservation, and recovery of invertebrate species at risk, their habitats and ecosystems, and to keep these species from becoming at risk. She has written/co-written eleven COSEWIC status reports. Her interests include the native bees of western Canada and thermal spring invertebrates.

Cory S. Sheffield has been studying bees and pollination since 1993, starting with his undergraduate thesis project at Acadia University in Nova Scotia. His Master's research studied insect-plant interactions at Acadia followed by a PhD at the University of Guelph, Ontario. These studies focused on the bee fauna of Nova Scotia, including their diversity and contributions to crop pollination. Cory then worked on post-doctoral studies of bee taxonomy and DNA barcoding, followed by a research associate position in bee taxonomy with the Canadian Pollination Initiative (CANPOLIN) at York University, Ontario. Since 2012, Cory has been a research scientist and curator of invertebrate zoology at the Royal Saskatchewan Museum. His research continues to focus on bees: he has published on the taxonomy of Canadian/North American bees, the utility of DNA barcoding for bees, bee physiology, pollination contributions and diversity of the Canadian bee fauna.

COLLECTIONS EXAMINED

The dataset used for this report comes primarily from a large dataset assembled for "An Identification Guide: Bumble Bees of North America" by Williams *et al*. (2014) and the same list of collections reported for other COSEWIC reports on bumble bees (COSEWIC 2010, 2014, 2015, 2018). Additional collections examined that were not in the original list are marked with an *. Recent data for Suckley's Cuckoo Bumble Bee from Canada was also mined from Bumble Bee Watch©, iNaturalist© and other online sources, and the authors' recent bumble bee collections that are not yet within museum collections.

- Academy of Natural Sciences, Philadelphia, Pennsylvania
- Algonquin Provincial Park, Ontario
- American Museum of Natural History, New York, New York
- André Francoeur Research Collection, Chicoutimi, Québec
- Atlantic Canada Conservation Data Centre, Sackville, New Brunswick
- B. Hicks Personal Collection, College of the North Atlantic, Carbonear, Newfoundland

- Bee Biology and Systematics Laboratory, Logan, Utah
- Bohart Museum, University of California, Davis, California
- Biodiversity Institute of Ontario, Guelph, Ontario
- B. Jacobsen, Greer Labs, Inc, Lenoir, North Carolina
- British Natural History Museum, London, United Kingdom
- C. Buidin/ Y. Rochepault Research Collection, Montréal, Québec
- C. Looney Research Collection, Olympia, Washington
- C. S. Sheffield Research Collection, Regina, Saskatchewan
- Canadian Forestry Service, Québec, Québec
- Canadian Museum of Nature, Ottawa, Ontario
- Canadian National Collection of Insects, Arachnids and Nematodes, Ottawa, Ontario
- College of the North Atlantic, Carbonear, Newfoundland and Labrador
- Connecticut Agricultural Extension Station, New Haven, Connecticut
- D.H. Miller private collection
- E. Nardone Research Collection, Guelph, Ontario
- Essig Museum of Entomology, Berkeley, California
- E. Normandin Research Collection, Laval, Québec
- Illinois Natural History Survey, Champaign, Illinois
- Insectarium Réne-Martineau, Québec, Québec
- Wallis-Roughley Museum of Entomology, University of Manitoba, Winnipeg, Manitoba
- K. Martins Research Collection, Montréal, Québec
- L. Richardson Research Collection, Hanover, New Hampshire
- LA County Museum, Los Angeles, California
- Laval University, Québec, Québec
- Lethbridge Agricultural Research Station, Lethbridge, Alberta
- Lyman Entomological Collection-McGill University, Montréal, Québec
- Madison-University of Wisconsin, Madison, Wisconsin
- M. Savard Research Collection, Saint-Fulgence, Québec
- Ministère des Ressources naturelles et de la Faune Québec, Various, Québec
- National Pollination Insect Collection (Logan), Logan Utah

- New York State Museum, Albany, New York
- North Carolina State University, Raleigh, North Carolina
- Nova Scotia Dept. Natural Resources, various, Nova Scotia
- Nova Scotia Museum, Halifax, Nova Scotia
- Ohio State University, Columbus, Ohio
- Oregon State Arthropod Collection, Corvallis, Oregon
- P.H. Williams Research Collection, London, United Kingdom
- Packer Collection York University, Toronto, Ontario
- Patuxent Wildlife Research Center, Laurel, Maryland
- P. Hallett Personal Collection, Toronto, Ontario
- R. Gegear Research Collection, Toronto, Ontario
- Royal British Columbia Museum, Victoria, British Columbia
- Royal Ontario Museum, Toronto, Ontario
- Royal Saskatchewan Museum, Regina, Saskatchewan
- S. Javorek Research Collection, Kentville, Nova Scotia
- S. Colla Research Collection, Toronto, Ontario
- Spencer Entomological Collection, Beaty Biodiversity Museum at the University of British Columbia, Vancouver, British Columbia
- *University of Calgary, Calgary, Alberta
- University of Colorado, Boulder, Colorado
- University of Massachusetts, Worchester, Massachusetts
- University of Minnesota, Minneapolis, Minnesota
- University of Michigan, Ann Arbor, Michigan
- University of Alaska, Fairbanks, Alaska
- University of Connecticut, Storrs, Connecticut
- University of Guelph, Guelph, Ontario
- University of Idaho, Moscow, Idaho
- University of New Hampshire, Durham, New Hampshire
- University of Prince Edward Island, Charlottetown, Prince Edward Island
- University of Nevada, Reno, Nevada
- V. Fournier Research Collection, Laval, Québec
- Yale Peabody Museum, New Haven, Connecticut