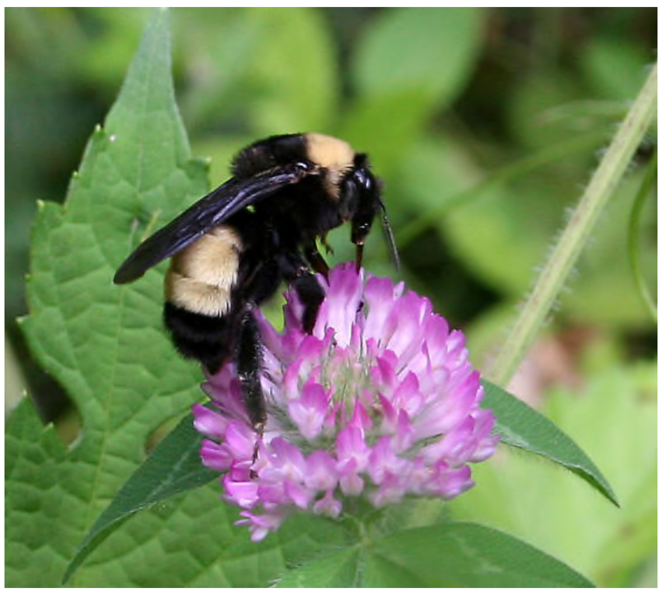
COSEWIC
Assessment and Status Report

on the

American Bumble Bee
Bombus pensylvanicus

in Canada



SPECIAL CONCERN
2018

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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COSEWIC would like to acknowledge Cory Sheffield for writing the status report on American Bumble Bee, *Bombus pensylvanicus*, prepared under contract with Environment and Climate Change Canada. This report was overseen and edited by Dr. Paul Grant, COSEWIC Arthropods Specialist Subcommittee Co-chair.

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American Bumble Bee provided by Thom Wilson of Baltimore City, MD, USA.

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COSEWIC
Assessment Summary

Assessment Summary – November 2018

Common name
American Bumble Bee

Scientific name
Bombus pensylvanicus

Status
Special Concern

Reason for designation
This insect occurs throughout much of North America, and Ontario and Québec represent the northern edge of its distribution. The species experienced significant declines prior to 1980, and overall trends suggest it is still becoming rarer, though it persists within a portion of its historical range in Canada. Causes for declines remain unclear, but pesticide use, habitat conversion, and pathogen spillover from managed colonies are probably contributing factors. Limiting factors such as increasing parasite loads and low genetic diversity negatively influence the persistence of this wildlife species.

Occurrence
Ontario, Québec

Status history
Designated Special Concern in November 2018.

COSEWIC
Executive Summary

American Bumble Bee
Bombus pensylvanicus

Wildlife Species Description and Significance

The American Bumble Bee (*Bombus pensylvanicus*) is a medium-sized bumble bee with a relatively long head and tongue length compared to many other bumble bee species in Canada. The distinctive dark wings and characteristic yellow and black abdominal banding pattern of females are diagnostic, and consistent throughout its Canadian range. Males have longer antennae than females, with a predominantly yellow abdomen with an orange tip. The American Bumble Bee is an important pollinator of a variety of plant species.

Distribution

The American Bumble Bee occurs throughout much of southern North America from southern Canada, throughout the United States to Mexico. Ontario and Québec represent the northern edge of its distribution, and approximately 7.1% of its global range for the subspecies *pensylvanicus;* 2.3% for the species).

Habitat

The American Bumble Bee occurs in a range of open habitats including farmlands, meadows and grasslands. It has been recorded foraging on flowers for pollen and nectar from a variety of plant genera. It predominantly nests above ground in dense mats of long grass, but is also known to opportunistically nest in abandoned rodent burrows and abandoned bird nests well above the ground surface. Like all bumble bees, American Bumble Bee queens overwinter underground and in decomposing organic material such as rotting logs and compost.

Biology

Like all bumble bees, the American Bumble Bee has an annual life cycle. Mated queens (the colony founders) emerge from wintering sites in the spring, feed, and search for potential nest sites. Once a nest site is chosen, the queen forages for pollen and nectar, returns to the nest site and lays eggs to produce a brood of workers. Workers emerge and take over nest care, defence, and foraging. In late summer, males and new queens are produced. These reproductive individuals leave the colony to mate. Mated queens subsequently enter hibernation while all other castes, including the old queen, perish by autumn.

Population Sizes and Trends

Historically, the American Bumble Bee is not considered a common species in Canada and represents 3-10% of bumble bee specimens collected in southern Ontario, likely because this represents the northern edge of its range. However, it appears to be declining in abundance in recent decades throughout its range, including Ontario where it represented <1% of all bumble bees collected in the last three decades. In some areas where it was once seemingly more common than it is at present it has not been detected, although this may be a reflection of sampling intensity. Overall trends suggest this species is becoming rarer throughout North America, though it continues to persist throughout its historical range in Canada.

Threats and Limiting Factors

The specific causes of decline for American Bumble Bee are unknown, although it is likely due to a combination of factors. The American Bumble Bees are susceptible to pesticide use, land use activities that reduce floral resources and/or nesting site availability, and pathogens. American Bumble Bee also appears to have low genetic diversity, which likely contributes to its decline and increases the production of sterile males.

Protection, Status and Ranks

There are no laws in Canada that specifically protect the American Bumble Bee, its nest sites, or habitat. The NatureServe global conservation status rank is G3G4 (Vulnerable to Apparently Secure). The IUCN Red List Category & Criteria rank for American Bumble Bee is Vulnerable.

TECHNICAL SUMMARY

Bombus pensylvanicus

American Bumble Bee

Bourdon américain

Range : Ontario, Québec

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines(2011) is being used)	1 Year
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Inferred declines based on failure to detect this species during surveys at some revisited sites, and ongoing threats.
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].	Inferred declines based on failure to detect this species during surveys at some revisited sites, and ongoing threats.
[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 period including both the past and the future.	Unknown.
Are the causes of the decline a. clearly reversible and b. understood and c. ceased?	a. No b. No c. No
Are there extreme fluctuations in number of mature individuals?	No.

Extent and Occupancy Information

Estimated extent of occurrence (EOO)	45,000 km² (last decade)
Index of area of occupancy (IAO) (Always report 2x2 grid value).	40 km² (last decade)
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?	No

Number of “locations”[*] (use plausible range to reflect uncertainty if appropriate)	Not applicable
Is there an [observed, inferred, or projected] decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	Inferred continued decline in area, extent quality of habitat due to agricultural intensification
Is there an [observed, inferred, or projected] decline in number of subpopulations?	Inferred based on low detection, higher than normal pathogen load.
Is there an [observed, inferred, or projected] decline in number of “locations”*?	Not applicable.
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Inferred continued decline in area, extent quality of habitat due to conversion of open meadows and farmland to more intense agriculture.
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)	**Unknown**
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]?	Unknown.

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

Overall threat calculated as High–Medium impact

- 9: Pollution (Medium impact)
- 8: Invasive & other problematic species & genes (Medium impact)
- 2: Agriculture and aquaculture (Medium–Low impact)
- 1: Residential & commercial development (Negligible impact)
- 6: Human intrusions & disturbance (Negligible impact)
- 7: Natural system modifications (Negligible impact)

Limiting Factors: Recent evidence also suggests that bumble bees with small populations suffer from lowered genetic diversity and increased susceptibility to parasites. American Bumble Bee is known to have low genetic diversity and higher than normal parasite loads, supporting this pattern. Another limiting factor is food plant availability.

[*] See Definitions and Abbreviations on COSEWIC website and IUCN (Feb 2014) for more information on this term

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	Evidence for decline throughout most of its range in the United States Global Status rank: G3G4 Canada National status rank: N3N5 United States National Status Rank: NU
Is immigration known or possible?	Yes. But unlikely, as species has declined in the United States.
Would immigrants be adapted to survive in Canada?	Yes, but only in southern areas as this species is warm-climate adapted.
Is there sufficient habitat for immigrants in Canada?	Yes.
Are conditions deteriorating in Canada?[+]	Likely.
Are conditions for the source population deteriorating?[+]	Yes.
Is the Canadian population considered to be a sink?[+]	Unlikely.
Is rescue from outside populations likely?	Unlikely. This species has also declined in the United States.

Data Sensitive Species

Is this a data sensitive species? No.

Status History

COSEWIC: Designated Special Concern in November 2018.

Status and Reasons for Designation:

Status: Special Concern	**Alpha-numeric codes:** Not applicable
Reasons for designation: This insect occurs throughout much of North America, and Ontario and Québec represent the northern edge of its distribution. The species experienced significant declines prior to 1980, and overall trends suggest it is still becoming rarer, though it persists within a portion of its historical range in Canada. Causes for declines remain unclear, but pesticide use, habitat conversion, and pathogen spillover from managed colonies are probably contributing factors. Limiting factors such as increasing parasite loads and low genetic diversity negatively influence the persistence of this wildlife species.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. Insufficient data on number of mature individuals.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. Meets IAO threshold for Endangered and a continuing decline in habitat extent and quality, but does not meet other criteria.

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

Criterion C (Small and Declining Number of Mature Individuals): Not Applicable. Insufficient data on number of mature individuals.
Criterion D (Very Small or Restricted Population): Not applicable. Insufficient data on number of mature individuals and does not meet criteria for locations or IAO, and is not prone to effects of human activities or stochastic events within a very short time period across its range.
Criterion E (Quantitative Analysis): Not applicable. Insufficient data for quantitative 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
(2018)

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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American Bumble Bee
Bombus pensylvanicus

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Phylum	Arthropoda – arthropods
Class	Insecta – insects
Subclass	Pterygota – winged insects
Order	Hymenoptera – ants, bees, wasps
Suborder	Apocrita
Infraorder	Aculeata – stinging wasps
Superfamily	Apoidea – bees, apoid wasps
Family	Apidae – honey bees, bumble bees, carpenter bees and allies [the non-megachilid long-tongued bees]
Subfamily	Apinae – honey bees, bumble bees, digger bees, orchid bees, stingless bees, and others
Tribe	Bombini – bumble bees and cuckoo bumble bees
Genus	*Bombus* Latreille - bumble bees and cuckoo bumble bees
Subgenus	*Thoracobombus* Dalla Torre
Species	*Bombus pensylvanicus* (DeGeer, 1773)
Subspecies	*Bombus pensylvanicus pensylvanicus* (DeGeer, 1773)

English Common Name: American Bumble Bee

French Common Name: Bourdon Américain

Synonyms of *Bombus pensylvanicus*:

Apis pensylvanica DeGeer, 1773: 575 (as *Apis penfylvanica*)

Apis americanorum Fabricius, 1775: 380

Apis antiguensis Fabricius, 1775: 380 (as *Apis antiguenfis*) [questionably synonymy; see discussion below]

Apis nidulans Fabricius, 1798: 274 [questionably synonymy; see discussion below]

Bombus sonorus Say, 1837: 413

Bombus pallidus Cresson, 1863: 92

Bombus sonorus flavodorsalis Franklin, 1913: 409

Psithyrus cevalliae Cockerell, 1899: 157

Bombus titusi Ashmead, 1902: 50

Bombus pennsilvanicus var. *umbratus* Friese, 1931 [questionably synonymy; see discussion below]

The taxonomic history of *Bombus pensylvanicus* is somewhat convoluted, and there are taxonomic disputes and/or differing species interpretations in the literature. In general, bumble bee taxonomy is challenging as specimens are primarily identified using colour patterns, but conspecific males, female workers and queens can be variable in colour, and non-related species can share colour patterns (Williams *et al.* 2014). This variation has contributed to historical and recent taxonomic difficulties with this and many other bumble bee species, and citizen based-monitoring programs may be particularly prone to misidentifications (Austen *et al.* 2016).

<u>Genus and subgenus information:</u>

Globally, there are approximately 250 species in the genus *Bombus* Latreille (*i.e.,* the bumble bees and cuckoo bumble bees) (Cameron *et al.* 2007; Williams *et al.* 2008). Within the genus *Bombus*, there are 15 globally recognized subgenera; *Bombus pensylvanicus* belongs to the subgenus *Thoracobombus* Dalla Torre (Williams *et al.* 2008). In North America north of Mexico, the subgenus *Thoracobombus* contains at least one additional species (potentially two more, based on taxonomic interpretations), *Bombus fervidus* (Fabricius, 1798) (Yellow [or Golden Northern] Bumble Bee). *Bombus californicus* Smith (California Bumble Bee) has been previously (*e.g.,* Franklin 1913; Stephen 1957; Thorp *et al.* 1983) and more recently (*i.e.,* Dolan *et al.* 2017) considered a distinct species from Yellow Bumble Bee, but based on DNA barcoding and the existence of intermediate colour patterns across its range, it is here considered a western, darker colour variant of Yellow Bumble Bee (Williams *et al.* 2014).

<u>Species taxonomic history:</u>

Similarly, *Bombus pensylvanicus* has also been recognized as one or two species in the past. *Bombus pensylvanicus* was first described as a distinct species by DeGeer (1773), two years before Fabricius (1775) described *Apis americanorum*, the earlier taking priority as the scientific name, while the latter responsible for the common name "American Bumble Bee". It should be noted that "*pensylvanicus*" and not "*pennsylvanicus*" is the correct spelling, though the latter has been incorrectly used many times (*e.g.,* Mitchell 1962; Hurd 1979); the type locality is in Pennsylvania. Frison (1922) recognized and addressed some of the taxonomic difficulties with these two species names, indicating that the original description by DeGeer (1773) suggested association with Yellow Bumble Bee (*B. fervidus*). Milliron (1960), who designated the lectotype of *Apis pensylvanica*, also indicated that the colouration was "not entirely typical for the species", likely leading to the original confusion of earlier workers.

At least three of the synonyms listed above may be questionable. Lutz and Cockerell (1920) suggest that *Apis antiguensis* Fabricius (type material from "Antigua") was probably not a *Bombus*, as no native bumble bee has been recorded in the Antilles. However, they do suggest that there is an Antigua in Guatemala which does correspond to the range of American Bumble Bee in Central America (Labougle 1990), though that work did not treat Fabricius's specimen as a synonym. Hurd (1979) did include Fabricius's species as a synonym of American Bumble Bee. Milliron (1960) supported Lutz and Cockerell (1920), indicating that the original type material was likely a *Xylocopa* and was probably lost, and the specimens assumed to be the type material should not be accepted as they do not match the original description of Fabricius (1775). He (Milliron 1960) indicated that the name *Apis antiguensis* should be suppressed.

Apis nidulans Fabricius was listed as a synonym of *B. americanorum* by Lutz and Cockerell (1920), though considered as a possible synonym by Mitchell (1962) and Hurd (1979) for *B. pensylvanicus* (as *B. americanorum* was treated as a junior synonym). However, this was not reflected in other taxonomic works (Stephen 1957; Milliron 1973; Thorp *et al.* 1983; Labougle 1990). Milliron (1960) indicated that the type material was in poor condition, though typical of the species it represents, though he did not indicate it was a synonym of *B. pensylvanicus* in later works (*i.e.,* Milliron 1973).

Lastly, Friese's (Friese 1931) variety of *B. pensylvanicus* (*B. pennsilvanicus* var. *umbratus*) is also listed as questionable, as the type locality (Labrador) is out of the range of this species (though presumably this could represent Québec). It too was listed as a questionable synonym in the treatments of Michener (1951) and Mitchell (1962; as *B. americanorum* var. *umbratus*), though Milliron (1973) placed this into synonymy with B. *pensylvanicus*, later supported by Hurd (1979), but not included by Labougle (1990).

<u>Subspecies taxonomic history:</u>

There is some disagreement and/or differing interpretation of "American Bumble Bee" in terms of species/subspecies recognition. Some consider Sonoran Bumble Bee (*Bombus sonorus* Say) conspecific and/or as a subspecies of *B. pensylvanicus* (Handlirsch 1888; Milliron 1973; Labougle *et al.* 1985; Labougle 1990; Cameron and Williams 2003; Di Trani de la Hoz 2006; Cameron *et al.* 2007; Hines 2008; Williams *et al.* 2014), while others have considered it a separate species (*e.g.,* Franklin 1913; Stephen 1957; Hazeltine and Chandler 1964; Thorp *et al.* 1983). However, DNA barcoding of both support two subspecies: *B. p. pensylvanicus* and *B. p. sonorus*. The only subspecies which occurs in Canada is: *B. p. pensylvanicus*.

The American Bumble Bee is a valid and accepted taxonomic species, that naturally occurs in Canada. There are no other subspecies or varieties other than *B. p. pensylvanicus* in Canada. Therefore, the entire species (*B. pensylvanicus*) is the single designatable unit considered in this status report.

Morphological Description

Morphological characters are summarized from Mitchell (1962) and Williams *et al.* (2014). American Bumble Bee has a medium to large-sized body (queen 21–26 mm, worker 13–19 mm, male 16–22 mm) with a relatively long head (*i.e.,* the malar space, distance between the edge of the eye and edge of the jaws, is slightly longer than broad). The body hair is short and even.

American Bumble Bee females differ from males (as in all bumble bees) by the outer surface of the hind tibia, which is flat with a smooth surface without long hair internally, and with long lateral fringes forming the corbicula (pollen basket). The corner of the midleg basitarsus is narrowed to an acute projection or spine. The hair on the head is overall dark. The anterior area of the thorax is yellow, with the remaining dorsal area and sides black (Figure 1). The first abdominal segment ranges from black to completely yellow (especially at midline), with the second and third segments yellow, segments 4 to 7 are black. The wings are dark brown, with black veins. Queens are larger than workers, but share the same colour pattern.

Figure 1. American Bumble Bee (*B. p. pensyvanicus*), female. Specimen collected near Ottawa, ON in 2012. Photo by Cory Sheffield, Royal Saskatchewan Museum.

American Bumble Bee males have longer antennae than females (including an extra segment), and yellow hairs are usually present on the face. The hair colour pattern of the thorax is generally similar to that of queens and workers. The abdomen usually has extensive yellow hair on segments 1 through 4, and occasionally segment 5, the tip (segments 6 and 7) usually with varying amounts of reddish to black hairs (Figure 2).

Figure 2. American Bumble Bee (*B. p. pensyvanicus*), male. Specimen collected near Ottawa, ON in 2012. Photo by Cory Sheffield, Royal Saskatchewan Museum.

American Bumble Bee females are variable in colour and may be confused with some of the colour variants of Yellow-banded Bumble Bee (*B. terricola*), Black-and-Gold Bumble Bee (*B. auricomus*), Western Bumble Bee (*B. occidentalis*), and Nevada Bumble Bee (*B. nevadensis*), though the latter two species are western in distribution. Like females, males of American Bumble Bee can be similar to Yellow Bumble Bee (when they have extensive yellow on the posterior regions of the thorax).

Population Spatial Structure and Variability

Little is known regarding the population structure of American Bumble Bee. Work was conducted analyzing cytochrome oxidase 1 (COI) gene for multiple *Bombus pensylvanicus* specimens collected throughout the species' range, and showed no genetic differentiation between American Bumble Bee specimens. Lozier and Cameron (2009) also conducted genetic studies on the American Bumble Bee, and indicated that genetic variation was particularly low in this species, and suggested that this is a possible contributing factor in its decline in the United States.

Designatable Units

American Bumble Bee occurs primarily in the Mixedwood Plains and the extreme south of the Boreal national ecological areas (COSEWIC 2015). There is no evidence of subspecific genetic structure or population isolation in Canada, therefore American Bumble Bee is being assessed as one designatable unit.

Special Significance

Like most bees, American Bumble Bee is an ecologically significant pollinator in natural ecosystems and provides pollination services to various native plants throughout its range (Williams *et al.* 2014). As pollinators, bees facilitate plant reproduction, which supports structure and productivity in terrestrial ecosystems, and ultimately provides food for other animals. Bumble bees typically fly during inclement weather conditions when other bees (*e.g.,* Frier *et al.* 2016) and many other winged insects cannot. American Bumble Bee is also unique in that it is one of the few bumble bee species that builds its nest at or above ground level (as opposed to underground, like numerous other bumble bees), and will on occasion use abandoned bird nests (Rau 1922, 1924).

DISTRIBUTION

Global Range

American Bumble Bee is a wide-ranging species. The northernmost portion of its global range is southeastern Canada (southern Ontario and Québec), and its range broadens farther south, spanning the continent from the east coast to Washington. Southwards, the species ranges into Mexico, with a few specimens recorded from Central America as far south as Costa Rica (Figure 3). The ranges of the two subspecies likely overlap: American Bumble Bee (*B. p. pensylvanicus*) occurring in southern Canada and the eastern United States), and Sonoran Bumble Bee (*B. p. sonorus*) occurring in the western United States, Mexico and into Central America.

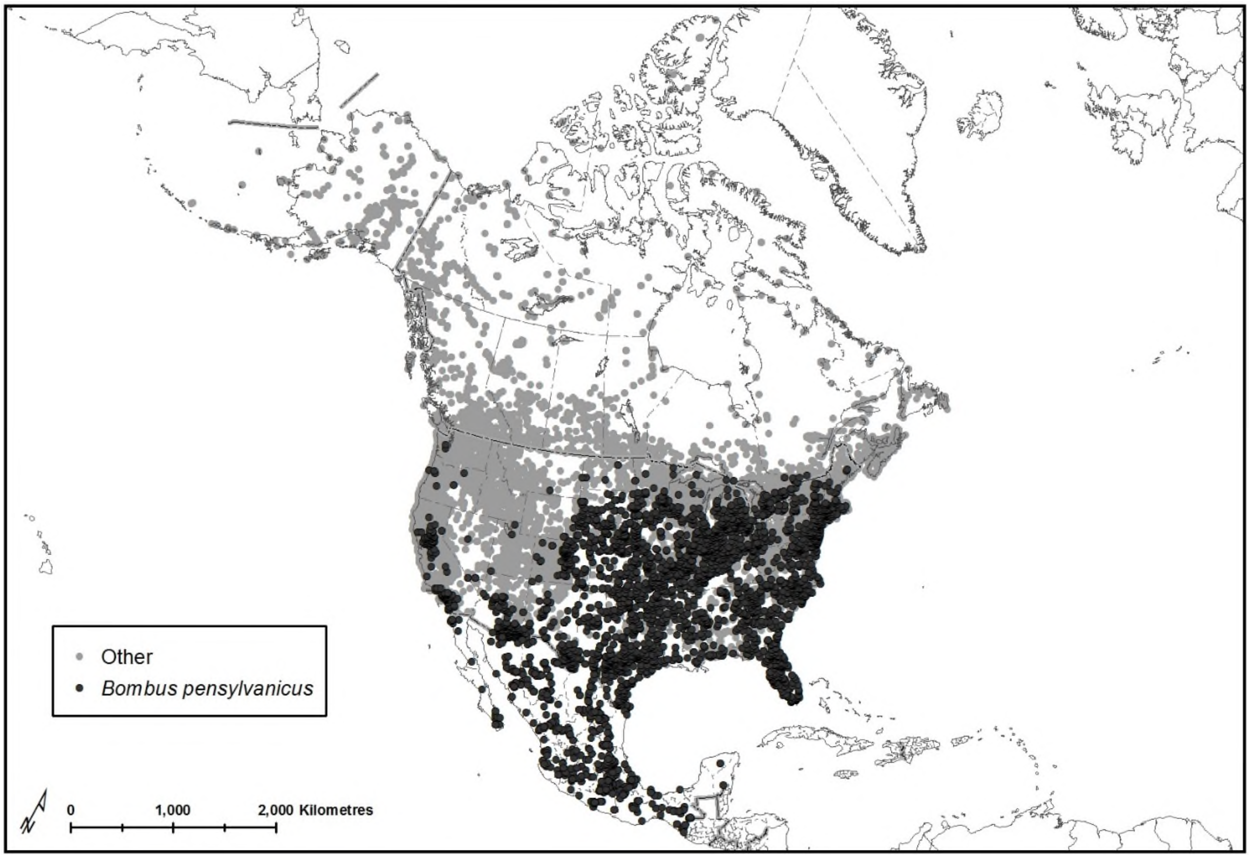

Figure 3. Global range of American Bumble Bee and Collection localities for 200,000 North American bumble bee specimens (black circles show points for American Bumble Bee (*B. pensylvanicus*; grey circles show other bumble bee species).

This species and its close relatives are considered warm-adapted species (Hines 2008), and this is supported by the fact that it reaches its northern limit in southern Canada.

The global range of American Bumble Bee (*i.e.,* both subspecies) is approximately 9,120,000 km^2, with approximately 2.3% of its range in Canada. The American Bumble Bee is restricted to eastern North America, with a global range of approximately 2,950,000 km^2, with 7.1% of its range in Canada.

Canadian Range

Databased American Bumble Bee records, dating from 1882–2016, were used to delineate the species' Canadian range, with additional information from experts and published literature (Figure 4).

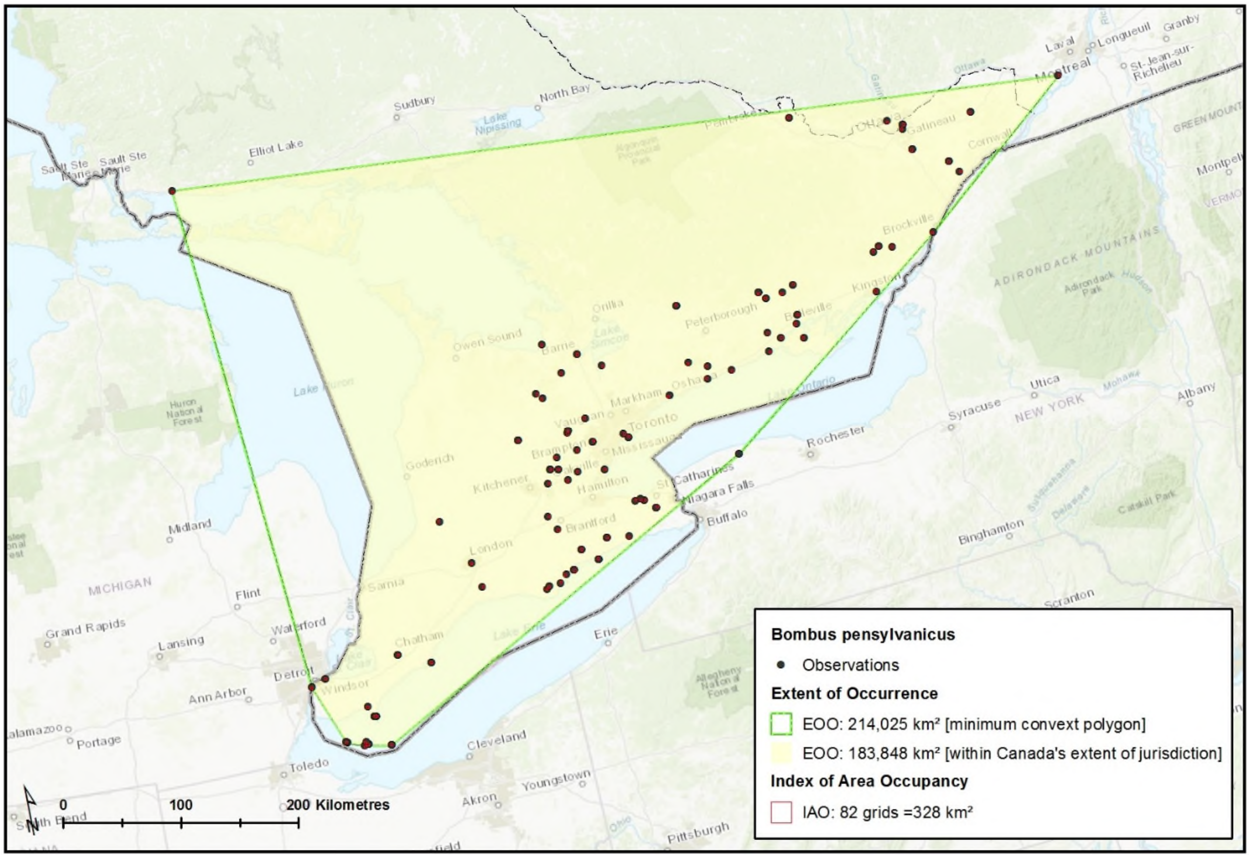

Figure 4. Canadian range and extent of occurrence (EOO) of American Bumble Bee based on databased museum collections (1882–2016). The EOO is 183,848 km^2 based on a minimum convex polygon within Canada's extent of jurisdiction. IAO is 328 km^2.

The Canadian range of American Bumble Bee is within the southern portion of Ontario and a small portion of Québec. Most of this Canadian range corresponds to the Mixedwood Plains Ecozone (ESTR 2016) and possibly the southern fringes of the much larger Boreal Shield Ecozone (ESTR 2014). Ecozones are one way of classifying the ecological framework of Canada (see Ecological Stratification Working Group 1996), with the country being divided into 16 terrestrial ecozones. The Mixedwood Plains Ecozone is approximately 119,000 km^2 and 1.2% of Canada's land mass (ESTR 2016).

There are numerous misidentified records for American Bumble Bee, particularly those in online sources, as well as some museum specimens reported in various databases. During data compilation for this status report, many records that appeared questionable were verified and these misidentifications are summarized below.

Yukon (YT):

The data from a single specimen on Discover Life (2017; the original dataset is from the Global Biodiversity Information Facility (2017) was originally incorrectly recorded as being from the Yukon. The locality on the label is “Rio Hondo, Roswell.” This was misinterpreted as “Boswell” and placed in the Yukon at the mouth of the Boswell River (Cardinal pers. com. 2016). The specimen is actually from New Mexico. As such, Yukon is not considered within the range of this warm-climate species.

British Columbia (BC):

The data from a single specimen in British Columbia (Kaslo) from 1912 (also Discover Life 2017) is based on a misidentification. Specimen OSUC 123249 and three other specimens in the Ohio State University Collection are actually *Bombus appositus* Cresson (as identified by Dr. Doug Yanega in 2014) (Johnson and Wallace pers. com. 2015). Recent bumble bee surveys (Sheffield pers. data; Heron pers. data) from 2010–2016 failed to confirm its presence in this region. British Columbia is no longer considered within the range of American Bumble Bee.

Alberta (AB):

One specimen (KSEM475033) identified as *B. pensylvanicus* was collected by Charles Michener on July 29, 1971 from Prairie Bluff Mountain, in southwestern Alberta (southwest of Pincher Creek, near Waterton Lakes NP). This specimen was a misidentified specimen of *Bombus rufocinctus*.

Saskatchewan (SK):

Curry (1984) did not record this species from Saskatchewan in his key to the bumble bees of that province. Recent bumble bee surveys (Sheffield pers. data) from 2012–2016 failed to confirm its presence in this region.

Ontario (ON):

American Bumble Bee ranges across most of southern Ontario, from the southwestern areas (*i.e.,* Windsor) east to Ottawa, and largely within the Mixedwood Plains Ecozone, with only one confirmed record north of this in the southern portion of the Boreal ecological area (COSEWIC 2015). Several erroneous records exist for Ontario, mainly due to georeferencing errors; “Jordan” [50, -92.0666] was corrected to 43.14, -79.37 (for Jordan, Ontario), and “C. Borden” [47.9, -83.1833, the coordinates for Lake Borden] was corrected to 44.27, -79.90, the coordinates of Canadian Forces Base Borden west of Barrie. Colla and Dumesh (2010) provide a detailed map of this species in southern Ontario.

Québec (QC):

The Mixedwood Plains Ecozone extends into southern Québec, so American Bumble Bee likely occurs in southwestern parts of the province. The species was recently (*i.e.,* 2012) collected near Ottawa, Ontario suggesting that it could be present in adjacent Gatineau, Québec. There is one specimen recorded from near Montréal. Variable Cuckoo Bumble Bee (*B. variabilis*), the cuckoo of American Bumble Bee (Pengelly 1953), and now exceptionally rare in North America, is known from one Canadian specimen collected in 1991 near the city of Québec (Williams *et al.* 2014). As such, its presence this far into the northeast would suggest that American Bumble Bee was once more widespread in this province.

Extent of Occurrence and Area of Occupancy

The extent of occurrence (EOO) is based on the databased museum collections used for Williams *et al.* (2014), the writer's personal bumble bee database, and the presence of Variable Cuckoo Bumble Bee from the city of Québec. The total approximate EOO, based on a minimum convex polygon created around all databased records (1882–2016), is 214,025 km^2. However, within Canada's extent of jurisdiction the EOO (1882–2016) is 183,848 km^2. For the last decade (2007-2016) EOO is only 45,000 km^2.

An index of area of occupancy (IAO) based on these museum records for the same time period is 328 km^2 (based on 2 x 2 km grids). For the last decade (2007-2016) IAO is only 40 km^2.

Search Effort

American Bumble Bee records available for this status report are from 1882–2016 (Williams *et al.* 2014; Sheffield pers. data). In general, search effort for bumble bees for most of southern North America has been extensive (Williams *et al.* 2014; Koch *et al.* 2015). Unlike most insects in North America (including other bee species), bumble bees have been relatively well surveyed, and extensive distributional, phenological, and host plant data have been captured from museum specimens collected in the past century, though primarily for the United States (*e.g.,* Koch *et al.* 2015).

In Canada, most search and the vast majority of bumble bee collection events have been opportunistic, rather than having been made as part of an intensive, repeatable, spatially and temporally explicit sampling regime. There are large geographic gaps in survey coverage, predominantly in the northern half of the country (Figure 3). However, Ontario and specifically southern Ontario and the historical range of American Bumble Bee, has good survey coverage. Recent concerns over the decline of pollinators including bumble bees has led to the coordination of methods for bee sampling, and many high quality data sets are currently being collected. As such, the increase in numbers of collectors and collecting events is resulting in increased numbers of bumble bee specimens overall. When comparing collecting over time, actual count data are not likely to reflect actual population sizes, but rather increased sampling effort. For this reason, it is more relevant to compare relative capture rates of species of interest to total numbers of bumble bees captured versus time.

Search effort for American Bumble Bee is indirectly measured using the bumble bee datasets of museum and sight records in Canada. It is assumed that entomologists collecting bumble bees would not discriminate between species during inventory, and collect a representative sample of bumble bees from a site. Thus American Bumble Bee would be collected if present and these electronic datasets indirectly represent search effort for this species.

The datasets used as a proxy for search effort include one dataset with ~50,000 bumble bee specimens dating from 1882 to 2013 (Williams *et al.* 2014); a recent dataset of ~14,000 bumble bees from southern Alberta (University of Calgary) from 2014 to 2016 (Galpern pers. data); and personal databases (Sheffield pers. data). Large datasets exist from eastern Canada, including several recent (*i.e.,* since 2009) studies in Ontario and Québec (Sheffield pers. data).

In addition to these sources, recent data for American Bumble Bee from Bumble Bee Watch, an online citizen science website where members of the public can upload photographs of bumble bees and specialists will confirm identification, was used. As of 2016, there were 53 tentative records of American Bumble Bee on this website, but only nine of these were confirmed as American Bumble Bee. These nine records were used for recent search effort and EOO/IAO calculations (see **Extent of Occurrence and Area of Occupancy**) and data presented in **Populations and Trends**.

In addition, other collections with specimen data not used in previous COSEWIC assessments for bumble bees were examined for American Bumble Bee (see **Collections Examined**).

Additional fieldwork and search effort in preparation of this status report was largely focused on confirming the presence of this species in western Canada. The status report writer completed fieldwork in southern Saskatchewan (southern portion), Alberta (southern portion) and British Columbia (Kaslo area; southern Okanagan areas and through the Kootenays) (Sheffield pers. data).

HABITAT

Habitat Requirements

The American Bumble Bee requires various habitats depending on its life stage, and the different habitats needed are described below in association with the specific life stage. The general life cycle starts with mated female queens that overwinter solitarily. In the spring, each mated queen emerges and finds a site to build her nest and grow the colony of workers. Initially after laying eggs, the queen forages and brings pollen back to the nest to feed developing larvae. Eventually, these initial batches of brood develop into female workers that start to forage for the colony. In the fall males develop (from unfertilized eggs), leave the nest to mate with new fertile queens (likely from other colonies), and the life cycle starts again. See **Life Cycle** for more detailed information.

The American Bumble Bee is a habitat generalist, and foraging workers, queens, and nests are most often found in or adjacent to open fields and meadows (Williams *et al.* 2014), grasslands, and other undisturbed open habitats. The species is a generalist pollen forager (for list of plants see Colla and Dumesh 2010; Williams *et al.* 2014) and requires a constant supply of flowering plants throughout the growing season to support colony growth and development.

American Bumble Bee nests are typically built within dense mats of long grass at or just above ground level, sometimes within abandoned rodent dens, but occasionally underground (Rau 1924; Williams *et al.* 2014). There are records of this species nesting in artificial items such as an empty and dry paint can with a nest previously occupied by a House Wren (*Troglodytes aedon*), and within straw in an old sack in a barn (Rau 1922, 1924). Other examples include them nesting in an abandoned House Wren nest under the roof of a building at a height of 3.65 m (Osborn 1883) and within an old rodent's den in a hollow of a fallen log (Rau 1941). Pengelly (1953) reported similar nesting habits in Ontario, including in a hollow root of a stump, and in a second story farm building.

The preference of American Bumble Bee for nesting at or above the ground surface may put the species at greater risk of predation and/or nest destruction than bumble bees that nest underground. American Bumble Bee is also considered one of the most aggressive nest-defending bumble bee species, likely because it nests at or above ground and needs to more readily defend its nest and progeny from predation or parasitism (Williams *et al.* 2014).

Bumble bees have annual colony cycles, and only mated queens overwinter. Wintering sites are usually in soil, mulch, leaf litter and similar senescent vegetation, and away from the original colony, and thus constitute a different residence and habitat. Wintering sites for these queens typically include those created by burrowing into loose soil or rotting trees (Alford 1975; Benton 2006). Specific wintering sites for American Bumble Bee have not been reported, although are likely similar to those of other bumble bees.

Habitat Trends

The Canadian range of American Bumble Bee overlaps with the Mixedwood Plains and the southern edge of the Boreal Shield ecozones. For bumble bees, colony size is known to influence nesting success in fragmented landscapes, with species with medium-sized colonies being most affected due to having medium-sized foraging ranges (Rundlöf *et al.* 2008). There are few data on colony size for Canada. Habitat trends that decrease habitat quality include further reductions in floral resources, which then impact the colony size, number of mated queens and subsequent maintenance of subpopulations.

Mixedwood Plains habitat trends:

The Mixedwood Plains Ecozone is one of the most highly modified and most heavily populated in the country (ESTR 2016). This area was the centre of European settlement starting in the early 1700s, with much of the open grassland and meadow habitats in this region favoured for clearing and farming. There have been extensive land use changes, second only to the Prairies, including urban development, road networks and agricultural intensification, particularly in the lacustrine clay plains of southern Ontario and marine clay plains of St. Lawrence Lowlands of Québec (ESTR 2016). American Bumble Bee predominantly occupies the open native grasslands, prairies and savanna habitats originally found within this ecozone; however, less than 3% of this habitat remains (ESTR 2016).

As of 2011, the Mixedwood Plains held 53% of Canada's human population and approximately 68% of this ecozone is agricultural land. Between 1951 and 2006 the urban population densities tripled and the open rural landscape within the Ontario portion of this ecozone declined 58%. The main areas of habitat conversion during this time period were the expansion of urban areas into farmland, and hayfields/pasturelands being converted to more intensive agricultural cropland (ESTR 2016). Such changes typically involve removal of adjacent natural or semi-natural habitat with rich flower resources that can be used by bumble bees, other pollinating insects, and wildlife in general (Boutin *et al*. 2002; McGauley 2004).

There have been moderate decreases in wildlife habitat capacity in recent decades (Javorek *et al.* 2007) with at least 60% of the Mixedwood Plains Ecozone being used for agriculture (Javorek and Grant 2011). Although American Bumble Bee typically uses open farmland and grassland habitats, it is likely that land use practices associated with agriculture (*i.e.,* pesticide use, fragmentation) rather than conversion of other open lands back to woodlands has caused the species to decline.

Boreal Shield habitat trends:

Most of the Boreal Shield Ecozone is forested and development has been in the form of logging roads, small cities and hydroelectric projects (ESTR 2014). The historical and ongoing changes in this ecozone have predominantly been along the border with the northern portions of the Mixedwood Plains. American Bumble Bee record(s) from within this ecozone are few, but seem atypical based on the known habitat preferences for the species; the lack of recent records suggests the species may not range in this region.

BIOLOGY

Information is compiled from general bumble bee references (Alford 1975; Goulson 2003a; Benton 2006) and where applicable references are provided specifically for American Bumble Bee, or its close relative, Yellow Bumble Bee.

Life Cycle and Reproduction

Bumble bees are holometabolous insects with four developmental stages: egg, larva, pupa, and adult. Bumble bees are eusocial and have three adult forms or castes: the queen (the reproductive female), workers (unmated daughters of the queen that usually do not reproduce) and males. Bumble bee colonies are annual, with one generation per year.

Production of reproductive castes (autumn-produced queens and males) occurs late in the colony cycle, and mating occurs shortly afterwards when these castes leave the nest. At the onset of frost, the old queen, workers and males die, and only the new mated queens overwinter. Winter is spent in the hibernaculum within the soil. Wintered queens of American Bumble Bees are considered late-emerging, with flight commencing in late May–June (Frison 1930; Plath 1934; Pengelly 1953; Colla and Dumesh 2010). These queens forage for pollen and nectar, and commence searching for suitable nest sites to begin their colonies.

American Bumble Bees are quite variable in their nesting preferences (Frison 1930; Hobbs 1966). They typically nest at the ground surface level in grassy hummocks, though nests have also been recorded well above the ground in House Wren nests (Rau 1922, 1924), in hollows in logs (Rau 1941) and in buildings (Pengelly 1953).

The nest founding queen builds the nest, lays eggs and defends the nest during the earliest stages of colony development. Eggs hatch after approximately four days and larvae are fed pollen and nectar. The larval stage of bumble bees has four instars. After approximately two weeks, larvae spin cocoons and pupate. Pupae develop for two weeks before hatching as adults. Immature development may take up to five weeks, but varies with temperature and food supply (Alford 1975). For American Bumble Bee, 21–30 days after the queen's initial egg laying, 8–10 female workers (Frison 1930) emerge and begin foraging for the colony, tending the nest, protecting the colony and feeding the brood. From this point on, the queen remains in the nest and continues to produce eggs.

As summer progresses, at least two more worker broods are produced (Hobbs 1966), with multiple eggs deposited in individual egg cells. Frison (1930) found that 9–14 eggs per cell were deposited in later season colony development in American Bumble Bee. The workers become progressively larger (*i.e.,* some almost as large as the queen) as the colony reaches maximum brood production and switches to producing reproductive castes (Frison 1930).

American Bumble Bee produces males (and presumably new queens) earlier than most bumble bee species in southern Ontario (Pengelly 1953; Colla and Dumesh 2010). The total number of workers and reproductive castes produced in bumble bees varies according to species, colony dynamics, and resource availability during colony development. For example, the number of potential queens produced by Yellow-banded Bumble Bee colonies ranged from 0–58 (Owen *et al.* 1980). Rau (1941) studied a single nest of American Bumble Bee within a hollow portion of a stump, and reported a total of 132 adults and 238 immatures (370 individuals) in the nest at the onset of reproductive caste production in late August. This may be unusually large for this species, as this nesting substrate may offer more protection than surface nests constructed in grassy hummocks, though few nests of this species have been studied; Robertson (1890) reported colony sizes ranging from about 60 to over 120 individuals. Hobbs (1966) reported colony sizes of between 247 and 287 in the closely related Yellow Bumble Bee (*B. fervidus*) in Alberta. Different from other bumble bees, the males of American Bumble Bee have been reported to participate in brood care (Cameron 1985).

Little is known about mating behaviour in the American Bumble Bee. In the Common Eastern Bumble Bee (*B. impatiens*), females mate with a single male during a single mating event and (as with all bees) the sperm is stored in a spermatheca until used in fertilization (Greeff and Schmid-Hempel 2008). Ultimately, reproductive individuals leave the nest and mate with conspecifics from other nests, though males of American Bumble Bee may try to copulate with females in the nest (Frison 1930). After mating, young queens enter their hibernacula and overwinter, completing the annual colony cycle.

The average lifespan of an individual bumble bee varies; a study in Doaktown, New Brunswick (NB) found that the average lifetime for a wild foraging worker was 13 days, substantially lower than lab-reared workers, likely due to exposure to environmental hazards (Rodd *et al.* 1980). Queens live for just over a year (including the wintering period) and males just a few weeks at the end of the colony cycle.

Physiology and Adaptability

Bumble bee queens emerge in the spring (the timing varying with species and/or geography) and require early-flowering plants to nectar upon in order to gain energy for nest initiation. American Bumble Bee is a floral generalist, and adaptable to a diverse range of available flowering plants for pollen and nectar, but requires floral sources throughout the season. Therefore, only habitats supporting rich flowering plant communities provide enough nutrition to support bumble bee colonies.

Bumble bees are found throughout most of Canada and are relatively cold-tolerant in the active season due to their physiological capability for thermoregulation. They are able to “shiver” to generate heat in their thoracic muscles to warm up to the required minimum body temperature (approx. 30°C) during low ambient temperatures (Heinrich 2004). However, American Bumble Bee is likely not as tolerant of colder climates as most bumble bees in Canada as the American members of *Thoracobombus* are seemingly adapted to warm climates (Hines 2008).

Dispersal and Migration

There is little information on natural dispersal rates for bumble bees, including American Bumble Bee. Dispersal occurs primarily in the spring by queens while searching for suitable nest sites (Goulson 2003a), and there is some evidence that bumble bees are able to disperse relatively long distances in search for nesting sites. Males also can contribute to gene dispersal from the initial colony, and males of some species have been estimated to fly between 2 and 10 km from the colony of origin (Kraus *et al.* 2009). Additionally, a species introduced to Tasmania in the early 1990s has been reported to have spread its range at a rate of approximately 10 km per year (Stout and Goulson 2000). Dispersal is likely important for survival based on studies that have examined the patchiness of bumble bee habitat (*e.g.,* Hatfield and LeBuhn 2007) and increased problems associated with small effective population sizes in haplodiploid insects (Zayed and Packer 2005) (see **Limiting Factors**).

Interspecific Interactions

American Bumble Bee is a generalist forager; it naturally co-forages and competes with many other bee species for food pollen and nectar, and likely has important mutualistic relationships with native flowering plant species (*e.g.,* Milliron 1973; Colla and Dumesh 2010), which may rely on it for pollination. These plants could be adversely impacted by declines in American Bumble Bee subpopulations. The extent of interdependence of individual plant species is unknown. Some of the competition with other bees, especially the managed European Honey Bee (*Apis mellifera*), may have adverse impacts on American Bumble Bee. 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 bee progeny, thus reducing overall fecundity of native nesting bees in the area.

Cuckoo bumble bees (subgenus *Psithyrus*) specialize in usurping queens of non-parasitic bumble bees. Adult female cuckoo bumble bees enter the colony, occasionally killing the queen or otherwise injuring her, and lay their own eggs, which are cared for by the remaining host workers. Any eggs laid by the host queen are destroyed by the cuckoo bumble bee queen. American Bumble Bee is host to Variable Cuckoo Bumble Bee, *B. variabilis* (Cresson) (Pengelly 1953; Williams *et al.* 2014), a species that is now exceptionally rare in North America, likely as a result of the declining numbers of its host (Williams *et al.* 2014). As such, this could be an interspecific relationship that has been impacted by declines of American Bumble Bee. Only one specimen of the Variable Cuckoo Bumble Bee has been reported in Canada from Québec (Williams *et al.* 2014).

A wide range of invertebrates parasitize bumble bees at all stages of the colony cycle (Schmid-Hempel 1998). Spring queens can be infected by nematodes (*Sphaerularia bombi* Dufour) (Fye 1966). Although the infection rate varies by time, place, and species, McCorquodale *et al.* (1998) reported rates of infection in Cape Breton that ranged from 0% to almost 40%. The nematode effectively castrates the queens, and infected individual females may have one to over 40 worms in their body (Alford 1969). These queens will not initiate new colonies, but will continue to forage (Kadoya and Ishii 2015). The nematodes are passed out of the body of infected females, and reach adulthood in the soil, where they likely re-infect the next cohort of wintering queens (Poinar and Van der Laan 1972). Kadoya and Ishii (2015) indicate that *S. bombi* may also increase interspecific and intraspecific interactions among bumble bees in flower patches, as infected queens continue to forage and consume floral resources, significantly reducing standing nectar volumes available for non-parasitized workers.

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 several bumble bee species in Alberta. This parasite is known to adversely impact the health of bumble 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 low among wild bumble bees (average infection rates = 5–10%; Colla *et al.* 2006), though levels in several declining species are unusually high. Recent field surveys across the United States (Cameron *et al.* 2011; Koch and Strange 2012) found the highest levels of *N. bombi* infection (*i.e.,* over 35%) among declining bumble bee species, including American Bumble Bee (Cameron *et al.* 2011), which supports the hypothesis that this parasite is a serious threat (see **Threats and Limiting Factors**). During the summer, workers may acquire a range of parasites such as *Nosema bombi*, and *Crithidia bombi* (a trypanosomatid), while foraging on flowers contaminated by infected bees.

The Small Hive Beetle (*Aethina tumida*) can also be a destructive pest of bee colonies in North America, including bumble bees, causing damage to nests, comb, stored honey, and pollen (Ambrose *et al.* 2000; Hoffmann *et al.* 2008). They can also potentially serve as a vector of virus from honey bees (Eyer *et al.* 2009) and other bumble bee colonies (see **Threats and Limiting Factors**). Commercially managed bumble bee colonies may also serve as a source for the spread of these beetles into wild colonies (Spiewok and Neumann 2006) (see **Threats and Limiting Factors**).

Invertebrate predators of adult bumble bees include robber flies (Family Asilidae) and crab spiders (Family Thomisidae) (Dukas *et al.* 2005). Thickheaded (Family Conopidae) and Humpbacked (Family Phoridae) flies are parasitoids of adult bumble bees.

Several vertebrate predators, including Raccoons (*Procyon lotor*), skunks, bears and other mammals are known to destroy and consume bumble bee colonies (Breed *et al.* 2004). American Bumble Bee may be particularly susceptible, as their colonies are normally established at the ground surface.

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Data from a large dataset of North American bumble bee specimen records (N = 281,000) produced for a recent guide to these insects (Williams *et al.* 2014) was examined to infer changes in abundance and distribution of the American Bumble Bee in Canada. These data were reduced to correspond to the records within the approximate total Canadian EOO of the American Bumble Bee, reducing the number of bumble bee specimens to 18,384. Additional datasets not used in Williams *et al.* (2014) were also included in this assessment (*i.e.,* Horn 2010; Richards *et al.* 2011; Nardone 2013; Andrachuk 2014; Onuferko *et al.* 2015).

From these data, the percentage of American Bumble Bee to other *Bombus* specimens for each decade, commencing in the period 1887–1896, through to 2007–2016 was calculated (Figure 5; Table 1). These were also plotted to show potential change in EOO over time (Figure 6; Table 2). Using changes in percent of total bumble bees (i.e., relative abundance) over time is considered more reflecting of population trends as sampling intensity was not consistent across sites nor decade to use actual counts. These results are discussed in **Fluctuations and Trends**.

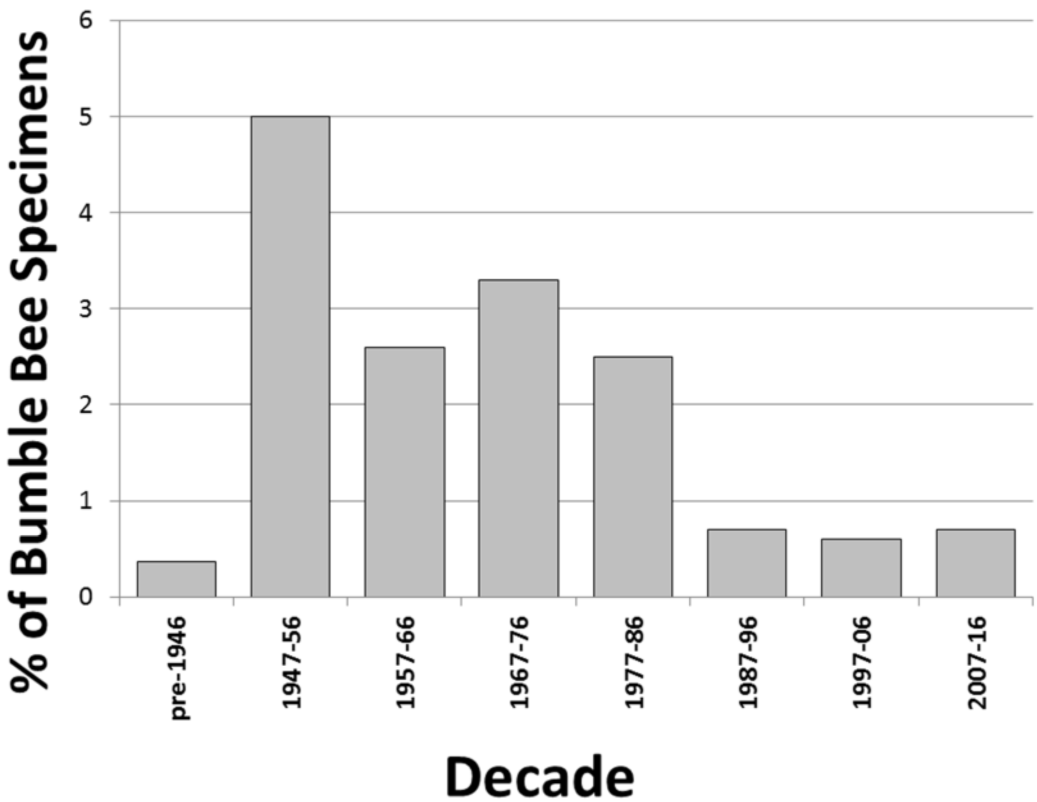

Figure 5. The relative abundance (i.e., % of specimens) of American Bumble Bee collected compared to other *Bombus* species collected within Canada by 10-year periods starting in pre-1946 until 2016.

Table 1. Relative abundance over time for American Bumble Bee (ABB) in Canada versus other bumble bees. Only includes data from within the approximate known Canadian range of American Bumble Bee. Also see Figure 5. Thus, the percent value for ABB is likely lower than 0.7%. Also included is number of collectors of ABB for each time period, and the average number of ABB specimens captured per collector.

Time Period	ABB	No. Collectors	Avg/Collector	All Bumble Bees	Percent
1896-1946	39*	9	4.3	10,514	0.37
1947-1956	27	5	5.4	538	5
1957-1966	19	9	2.1	728	2.6
1967-1976	26	9	2.9	787	3.3
1977-1986	23	11	2.1	927	2.5
1987-1996	7	4	1.8	946	0.7
1997-2006	12	5	2.4	2019	0.6
2007-2016	5 [9***]	3 [8***]	1.7	*1925	0.7

*This value is likely higher, as bumble bee data post-2013 (excluding ABB) was not available.

**Twelve of the specimens were collected by one person at the same site over a three-month period, so may represent workers/new queens from a single colony.

***Numbers in [] are provided for Bumble Bee Watch data; those not in [] represent typical pinned specimens.

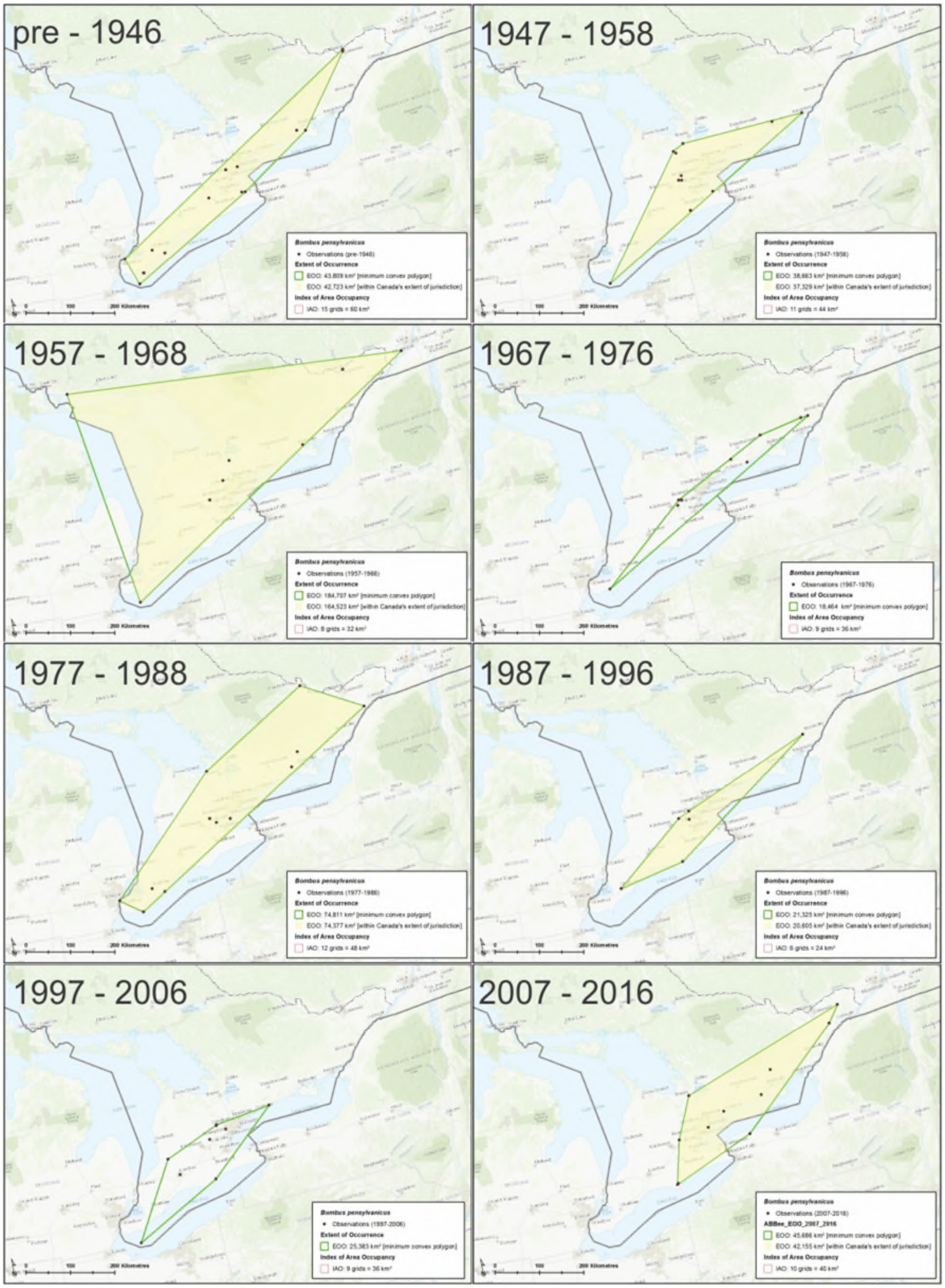

Figure 6. EOO over time. See Table 2 for EOO and IAO values.

Table 2. Changes in extent of occurrence (EOO) and index of area of occupancy (IAO) over time for American Bumble Bee in Canada. Also see Figure 6.

Time Period	EOO (km^2)	IAO (km^2)	% Change EOO	% Change IAO
1896-1946	42723	60		
1947-1956	37329	44	-12.6	-26.7
1957-1966	164523	32	340.7	-27.3
1967-1976	18464	36	-88.8	12.5
1977-1986	74377	48	302.8	33.3
1987-1996	20605	24	-72.3	-50.0
1997-2006	25383	36	23.2	50.0
2007-2016	45686	40	80.0	11.1

Abundance

Estimating abundance for eusocial insects such as bumble bees is not possible with current available data. In a given area, captured individual workers and males of the same species can represent one, or several local colonies. For eusocial insects, it is the colonies (or individual founding queens), not the workers, that should be representative of abundance. However, as described above, relative abundance of species, based on all individual captures can show overall declines, as all individuals are treated equally.

Fluctuations and Trends

Using datasets above (see **Sampling Effort and Methods**) it is evident American Bumble Bee has not been commonly collected within its Canadian range either historically (*i.e.,* representing a maximum of 5% of all species in all periods considered) or during the recent decade (*i.e.,* 0.7% of all species) (Figure 5, Table 1). Numerous studies are cited below that together frame a case for an overall decline in relative abundance and/or number of subpopulations throughout its range in Canada. Overall, the American Bumble Bee appears to be persisting throughout most of its Canadian range (*i.e.,* no range collapse) with no consistent declines in EOO (Table 2, Figure 6); fluctuations in IAO over time may be reflective of sampling intensity within these sampling periods, and may or may not represent an actual decline of IAO. This is one of the challenges to assessing wide-ranging arthropod species.

<u>Relative abundance of American Bumble Bee compared with other bumble bees:</u>

The strongest evidence for the decline of American Bumble Bee across its Canadian range is shown by a decline in relative abundance for the species over ten-year time periods (Table 1, Figure 5). Using the dataset compiled above (see **Sampling Effort and Methods**), American Bumble Bee represents on average 2% (range 0.4 to 5%) of the total bumble bees collected per time period pre-1987 (Table 1, Figure 5) within its Canadian range. After 1986, the relative abundance of American Bumble Bee dropped considerably, remaining at or below 0.7% of all bumble bees collected per decade between 1987 and 2016. The relative abundance in the past decade (*i.e.*, 2007–2016) does not differ from the preceding two decades (Table 1, Figure 5), suggesting that the species may have become rarer in Canada pre-1980s, but remains stable at these lower abundances in the time frame considered here. Data from the last ten years (2007–2016; EOO 45,686 km^2) also does not support an overall change in EOO for this species in Canada based on past fluctuations that are due largely to sampling effort (Figure 6, Table 1).

Academic studies and anecdotal evidence that suggest subpopulation declines:

American Bumble Bee specimens are rarely caught or observed throughout their range in southern Ontario and appear to be uncommon (Horn 2010; Richards *et al.* 2011; Nardone 2013; Andrachuk 2014; Onuferko *et al.* 2015; Bumble Bee Watch 2017; Sheffield pers. data).

Pengelly (1953) indicated that this was one of the more common bumble bees in some sites in southern Ontario in the early 1950s. Yet in his revision, Milliron (1973) only examined six female specimens from Canada, which may suggest a decline in the following twenty years (supported in Table 1 and Figure 6), or that the species may periodically be locally abundant (i.e., Pengelly 1953).

Recent research specifically on American Bumble Bee shows a decline in Canada (Colla and Packer 2008). This study used failure to detect this species in two sites in southern Ontario versus its presence in these sites in the 1970s (as per Macfarlane 1974) as evidence of decline (Colla and Packer 2008). More recent data from 2014–2018 in Ontario failed to collect any specimens in 2017 and 2018, despite a few specimens collected each year from 2014–2016 (Cowan T. pers. data 2018). However, some bumble bee populations can exhibit strong variation across years, so such changes are not necessarily evidence of decline (*e.g.,* Roubik and Ackerman 1987). The results from this study may be a reflection of a localized subpopulation decline based on a decline in local habitat quality during the 30+ year time period. The species has recently been observed near those same areas; however, these records may be more indicative of the higher levels of search effort as part of bumble bee research in the past ten years.

Colla and Dumesh (2010) binned collection data of American Bumble Bee to 30-year periods and looked for population trends. Their analysis did not support changes in overall distribution (EOO) (which was evident in a past study by Laverty and Harder (1988)) or count (*i.e.,* number of specimens) in southern Ontario. The division of data into 30-year periods makes it difficult to show declines for American Bumble Bee. However, if this same dataset was reanalyzed to show the relative abundance of American Bumble Bee, perhaps the results would have shown a decline versus other species.

James (2011) collected one specimen of American Bumble Bees among 280 specimens collected in eastern Ontario. Numerous additional studies in southern Ontario have failed to detect American Bumble Bee among other bumble bees collected (Horn 2010; Miller 2010; Richards *et al.* 2011; Andrachuk 2014; Onuferko *et al.* 2015) (Figure 4). Failure to detect the species in these studies is some evidence to support the decline of American Bumble Bee within its Canadian range.

Studies that assess the global decline of American Bumble Bee:

Several papers on bumble bee decline have indicated some support for loss of American Bumble Bee (Colla and Packer 2008), or suggest putative declines (Cameron *et al.* 2011). Conversely, a study over a period of seven years in Arkansas failed to report a decline in American Bumble Bee abundance and documented that it was one of three most frequently recorded species (Warriner 2011). Assessing the species over its global range, Hatfield *et al.* (2015) estimated a total global range loss of 23%, in addition to a 50% drop in persistence and even larger (*i.e.,* 88.56%) drop in relative abundance for this species, 51.38% occurring over the past decade (based on relative abundance, persistence, and range decline).

Rescue Effect

The global range of American Bumble Bee is primarily within United States, with approximately 7.1% of its range in Canada. The species appears to be declining throughout its global range (Hatfield *et al.* 2015). Rescue is possible from remnant populations within the United States; however, dispersal is only during the fall when mated queens disperse and find suitable overwintering sites, as well as the spring when these same queens found colonies. These dispersal events are likely less than 10 km, thus rescue from United States populations would be slow.

THREATS AND LIMITING FACTORS

The International Union for the Conservation of Nature-Conservation Measures Partnership (IUCN-CMP) threats calculator (Salafsky *et al.* 2008; Master *et al.* 2009) was used to classify and list threats to the species. The overall threat impact was calculated at High–Medium, indicating a possible population decline between 15–40% over the next ten years (Table 3). Threats listed below are in order from the highest to lowest impact.

Table 3. Threat classification table for American Bumble Bee (*Bombus pensylvanicus*) across its geographic range in Canada and based on the IUCN-CMP (World Conservation Union–Conservation Measures Partnership) unified threats classification system. For a detailed description of the threat classification system, see the Conservation Measures Partnership website (CMP 2006). For information on how the values are assigned, see Master *et al.* (2009).

Species Scientific Name	American Bumble Bee, *Bombus pensylvanicus*		
Date of threats assessment:	December 13, 2016.		
Assessor(s):	Paul Grant, Jenny Heron (co-chairs), Cory Sheffield (writer and SSC member), John Klymko, Sara Semler (SSC members), Ruben Boles (COSEWIC member for CWS) Robin Gutsell (COSEWIC member for Alberta) and Angèle Cyr (COSEWIC Secretariat and recorder).		
Overall Threat Impact Calculation		**Level 1 Threat Impact Counts**	
Threat Impact		**high range**	**low range**
A	Very High	0	0
B	High	0	0
C	Medium	3	2
D	Low	0	1
	Calculated Overall Threat Impact:	High	Medium

Threat		**Impact (calculated)**		**Scope (next 10 Yrs)**	**Severity (10 Yrs or 3 Gen.)**	**Timing**	**Comments**
1	Residential & commercial development	D	Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	
1.1	Housing & urban areas	D	Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	Specifically within southern Ontario and Québec, within the Mixedwood Plains ecozone. See Threats
1.2	Commercial & industrial areas		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	Considered negligible.
1.3	Tourism & recreation areas		Not a Threat	Negligible (<1%)	Neutral or Potential Benefit	High (Continuing)	Not applicable.
2	Agriculture & aquaculture	CD	Medium - Low	Restricted (11-30%)	Moderate - Slight (1-30%)	High (Continuing)	
2.1	Annual & perennial non-timber crops	CD	Medium - Low	Restricted (11-30%)	Moderate - Slight (1-30%)	High (Continuing)	Applicable throughout the Mixedwood Plains portion of its range, see Threats.
2.2	Wood & pulp plantations						Not applicable.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
2.3	Livestock farming & ranching		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	In areas where cattle are grazed, it is likely that open habitats are created and maintained, which could be potentially beneficial for American Bumble Bee. In general, extensive livestock grazing keeps grass height short, which would not be good for American Bumble Bee. Conversely, as this bumble bee nests at surface level, it is possible that nests could be disturbed and/or destroyed by cattle and/or other activities. Within southern Ontario, dairy farming is more widespread than ranching.
2.4	Marine & freshwater aquaculture						Not applicable.
3	Energy production & mining		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	
3.1	Oil & gas drilling		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	Any activities that have impacts on nesting sites and/or local floral resources potentially could impact colony success. Conversely, activities that create open grassy areas potentially create habitat for this species.
3.2	Mining & quarrying		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	Same as 3.1
3.3	Renewable energy		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	Same as 3.1
4	Transportation & service corridors		Not a Threat	Negligible (<1%)	Neutral or Potential Benefit	High (Continuing)	
4.1	Roads & railroads		Not a Threat	Negligible (<1%)	Neutral or Potential Benefit	High (Continuing)	Maintenance likely maintains habitat for bees.
4.2	Utility & service lines		Not a Threat	Negligible (<1%)	Neutral or Potential Benefit	High (Continuing)	Same as 4.1
4.3	Shipping lanes						Not applicable.
4.4	Flight paths						Not applicable.
5	Biological resource use		Not a Threat	Small (1-10%)	Neutral or Potential Benefit	High (Continuing)	
5.1	Hunting & collecting terrestrial animals						Not applicable.
5.2	Gathering terrestrial plants						Not applicable.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
5.3	Logging & wood harvesting		Not a Threat	Small (1-10%)	Neutral or Potential Benefit	High (Continuing)	Logging and wood harvesting (Not a threat). Although logging takes place throughout much of Boreal ecozone, those areas are likely not important for this species, and the threat of logging to the American Bumble Bee is 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 American Bumble Bee (Williams *et al.* 2014), which may ultimately prove beneficial if this species moves northward in response to climate warming.
5.4	Fishing & harvesting aquatic resources						Not applicable.
6	Human intrusions & disturbance	D	Negligible	Negligible (<1%)	Moderate - Slight (1-30%)	High (Continuing)	
6.1	Recreational activities	D	Negligible	Negligible (<1%)	Moderate - Slight (1-30%)	High (Continuing)	See Threats.
6.2	War, civil unrest & military exercises		Unknown	Unknown	Unknown	Unknown	Any activities that have impacts on nesting sites and/or local floral resources potential could impact colony success.
6.3	Work & other activities		Negligible	Negligible (<1%)	Unknown	High (Continuing)	Any work related activities that have impacts on nesting sites and/or local floral resources potential could impact colony success.
7	Natural system modifications	D	Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	
7.1	Fire & fire suppression		Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)	See Threats
7.2	Dams & water management/ use						Not applicable.
7.3	Other ecosystem modifications						Not applicable.
8	Invasive & other problematic species & genes	AB	Medium	Pervasive - Large (31-100%)	Moderate (11-30%)	High (Continuing)	
8.1	Invasive non-native/alien species/diseases	AB	Medium	Pervasive - Large (31-100%)	Moderate (11-30%)	High (Continuing)	See Threats.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
8.2	Problematic native species/diseases	AB	Medium	Pervasive - Large (31-100%)	Moderate (11-30%)	High (Continuing)	See Threats.
8.3	Introduced genetic material		Unknown	Unknown	Unknown	Unknown	Unknown
8.4	Problem atic species/diseases of unknown origin		Unknown	Unknown	Unknown	Unknown	Unknown
8.5	Viral/prion-induced diseases		Unknown	Unknown	Unknown	Unknown	Unknown
8.6	Diseases of unknown cause		Unknown	Unknown	Unknown	Unknown	Unknown
9	Pollution	C	Medium	Large (31-70%)	Moderate (11-30%)	High (Continuing)	
9.1	Domestic & urban waste water						Not applicable.
9.2	Industrial & military effluents						Unknown.
9.3	Agricultural & forestry effluents	C	Medium	Large (31-70%)	Moderate (11-30%)	High (Continuing)	See Threats.
9.4	Garbage & solid waste						Not applicable.
9.5	Air-borne pollutants						Not applicable.
9.6	Excess energy						Not applicable.
10	Geological events						
10.1	Volcanoes						Not applicable.
10.2	Earthquakes/tsunamis						Not applicable.
10.3	Avalanches/landslides						Not applicable.
11	Climate change & severe weather		Unknown	Unknown	Unknown	Unknown	
11.1	Habitat shifting & alteration		Unknown	Unknown	Unknown	Unknown	See Threats.
11.2	Droughts		Unknown	Unknown	Unknown	Unknown	See Threats.
11.3	Temperature extremes		Unknown	Unknown	Unknown	Unknown	See Threats.
11.4	Storms & flooding		Unknown	Unknown	Unknown	Unknown	See Threats.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
11.5	Other impacts		Unknown	Unknown	Unknown	Unknown	See Threats.

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

Threat 9 Pollution (Medium impact)

9.3 Agricultural and forestry effluents (Medium impact)

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. Various life history traits of American Bumble Bee (such as large body size, long colony cycle, surface nesting) may make it more vulnerable to accumulation of pesticides in the colony compared to other species at local scales. Effects can also be synergistic with exposure to multiple pesticides (Gill *et al.* 2012).

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.

At local scales pesticides could threaten nesting populations, especially in the intensively agricultural Mixedwood Plains Ecozone (Javorek and Grant 2011). In urban and agricultural landscapes, populations 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. These pesticides are more detrimental to bees (than other pesticide classes) at concentrations in the parts per billion (ppb) (EPA 1994; Marletto *et al.* 2003).

Imidacloprid is non-lethal to bumble bees when used as directed (*e.g.,* Tasei *et al.* 2001). However, studies of its effects on bumble bees only tested managed bees as representative of all North American species (Gels *et al.* 2002; Morandin and Winston 2003). 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).

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).

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.

Threat 8. Invasive and Other Problematic Species and Genes (Medium impact)

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

Pathogen spillover has been implicated in 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 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 (*Bombus affinis* – Endangered) and the Western Bumble Bee (*Bombus occidentalis occidentalis* – Threatened) (Thorp and Shepherd 2005; NRC 2007; Evans *et al.* 2008) and could provide an avenue for rapid and catastrophic disease outbreaks in the future. Cameron *et al.* (2011) found higher prevalence (*i.e.,* 15.2%) of pathogens in American Bumble Bee than species considered stable (*i.e.,* not declining), suggesting that declines observed in the United States, and likely Canada, are likely linked to pathogens.

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 much higher than natural levels of pathogens (Colla *et al.* 2006; Graystock *et al.* 2013a). The use of infected commercial bumble bees 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). In Canada, greenhouses using managed bees are present mostly across southern BC, ON and QC and to a lesser extent in southern AB, NT and YT. The area used by vegetable greenhouses grew 37% from 2001 to 2006; in Canada and specifically in Ontario, greenhouse area construction for vegetables rose 22.5% from 2011 to 2016 (1537 ha). Ontario leads all other provinces, accounting for more than two-thirds of all greenhouse vegetable area in Canada (Statistics Canada 2017).

Two of the parasite species involved in spillover to wild bumble bee, *Crithidia bombi* and *Nosema bombi*, 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 their virulence in wild American Bumble Bees remains unknown. Additional studies have found declining species, including the American Bumble Bee, 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). Szabo *et al.* (2012) found that declines in the Yellow-banded Bumble Bee throughout its US range 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.

In agricultural and urban landscapes American Bumble Bee likely competes for nectar and pollen with the introduced and managed European Honey Bee. However, competition is difficult to quantify under natural conditions (Thomson 2006), so the impact in agricultural landscapes is largely unknown. The European Honey Bee has been in North America for hundreds of years making it difficult to correlate the suspected decline of American Bumble Bee to direct competition with managed honey bees. However, 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 a during a single month an individual healthy honey bee colony can collect enough pollen that would otherwise produce 33,000 native bee progeny, thus reducing overall fecundity of nesting bees in the area.

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.

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.

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 in many places in Canada, including Ontario (Langor *et al.* 2014).

<u>8.2 Problematic native species (Medium impact)</u>

The use of the highly successful (*i.e.,* 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 American Bumble Bee populations in southern Ontario. Common Eastern Bumble Bee may out-compete the American Bumble Bee for forage resources, though nesting habitats are different (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 at any jurisdictional level.

Threat 2: Agriculture and Aquaculture (Medium–Low impact)

<u>2.1 Annual and perennial non-timber crops (Medium–Low impact)</u>

Habitat loss as a result of agricultural intensification is ongoing throughout southern portions of Canada, including in the Mixedwood Plains, which contains some of the most highly urbanized and farmed regions in Canada (Javorek and Grant 2011; ESTR 2016). 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 bee in some areas (Grixti *et al.* 2009). As Javorek and Grant (2011) indicated that most of Canada's agricultural regions, including those in the Mixedwood Plains ecozone, have low capacities to support wildlife, it is likely that American Bumble Bee has been affected by agriculture-related habitat loss.

In Ontario, greenhouse area (for vegetables) increased 22.5% from 2011 to 2016 (1537 ha) and the province leads all others, accounting for more than two-thirds of all greenhouse vegetable area in Canada (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). Farmland dedicated to hay production in Ontario declined from approximately 1 million ha in 2001 to 696,000 ha in 2016 (decline of 31%); while 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). Some of these same crops also use neonicotinoids and other pesticides which are shown to impact pollinators (see Threat 9.3).

Threat 1: Residential and Commercial Development (Negligible)

<u>1.1 Housing and urban areas (Negligible impact)</u>

In Canada, the bee's range is primarily in a region with one of the highest rates of urbanization and agriculture (Javorek and Grant 2011; ESTR 2016). This species prefers open fields and other open areas (Williams *et al.* 2014), building its nest at or above ground level in mounds of long grass. While it uses plants within residential and commercial areas for foraging and nesting, development activities that alter foraging habitat and/or nesting sites may cause cumulative declines. While declines and/or absences have been noted near some urban areas (*e.g.,* Colla and Packer 2008; Horn 2010; Richards *et al.* 2011), there have also been recent observations of American Bumble Bee in several of these urban areas in southern Ontario (*i.e.,* Bumble Bee Watch).

Threat 6. Human intrusions and disturbance (Negligible impact)

<u>6.1 Recreational activities (Negligible impact)</u>

All-terrain vehicles or other high-impact vehicles may have the potential to destroy or significantly alter American Bumble Bee nesting habitat and/or existing nest sites. As such, intensive recreation, including the use of all-terrain vehicle riding or off-road vehicle use, is considered a potential threat to this species because it could destroy grassy hummocks and collapse abandoned rodent burrows and bird nests.

Threat 7. Natural system modifications (Negligible impact)

<u>7.3. Other ecosystem modifications (Negligible impact)</u>

This species usually nests at or above the ground, normally in grassy hummocks; surface level grass fires can likely have direct impacts on this species. Indirect effects of fires would include immediate loss of floral resources, though this may be potentially beneficial for colonies in subsequent years, as this species prefers open habitats. Fire suppression programs lead to the natural succession of forests, and the decline in the open and grassy habitats the American Bumble Bee prefers.

Threat 11. Climate Change and Severe Weather (Unknown impact)

Climate change is a possible threat to bumble bees and climatic variability likely impacts this group, as could corresponding drought and/or flooding. However, the scope and severity of these threats are unknown. Given the predicted patterns of greater climate extremes with climate change (Seneviratne *et al.* 2012), Vasseur *et al.* (2014) modelled invertebrate responses under climate models, and found climate variability to likely have a greater detrimental effect on invertebrates than warmer temperatures. Temperate invertebrates were found to be most at risk to such fluctuations (Vasseur *et al.* 2014).

American Bumble Bee is considered a warm-adapted species (Hines 2008), and it may respond favourably to increased temperatures (though not necessarily climate variability). However, within the genus *Bombus*, it has been found that species with narrow climatic tolerances are more vulnerable to extrinsic threats (Williams *et al.* 2009). A recent study of two bumble bee species that co-occur with American Bumble Bee in eastern Canada and northeastern US (*B. impatiens* and *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).

Limiting Factors

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). Sex in bees, and most other haplodiploids, 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 population 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 increases. Increases of diploid males in smaller populations increases the rate of population declines causing a special case of the extinction vortex: "the diploid male extinction vortex". In practical terms, if a bee population decreases to a few reproducing individuals, it is certain to become extinct even under stable environmental conditions unless its number increases within a few generations (Hedrick *et al.* 2006).

Recent evidence also suggests that bumble bees with small populations suffer from lowered genetic diversity and increased susceptibility to parasites (*e.g.,* Whitehorn *et al.* 2014). American Bumble Bee is known to have low genetic diversity and higher than normal parasite loads (Cameron *et al.* 2011), supporting this pattern.

Another limiting factor is food plant availability. As bumble bees are eusocial, they require large inputs of floral resources (*i.e.,* pollen and nectar) over the entire growing season to support colony growth and queen production. Losses of flowering plants due to land use may have impacts on colony number in subsequent years.

Number of Locations

It is not possible to calculate the number of locations for this species. 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. This species is wide-ranging and the threats to this species remain unclear. Therefore, the term 'location' cannot be used and the subcriteria that refer to the number of locations will not be met.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

There are no federal or provincial laws that specifically protect American Bumble Bee or its habitat in Canada.

Non-Legal Status and Ranks

Status ranks (Natureserve 2015):

Global Status rank: G3G4 (Vulnerable to Apparently Secure).

Canada National status rank: N3N5 (2015)

Provincial Subnational Status Ranks (2015):
Ontario: S3S4 (Vulnerable to Apparently Secure)
Québec: SNR (Unranked)

Although ranks for other jurisdictions in Canada exist (*i.e.*, British Columbia and Alberta: SU; Manitoba: S3S5) (Canadian Endangered Species Conservation Council 2016), these are excluded here as these ranks were based on older data which have subsequently been verified. Thus only ranks for Ontario and Québec are considered.

United States National Status Rank: NU (2010)

United States subnational status ranks (ranked in 26 states): Arizona (SNR), Arkansas (SNR), California (SNR), Colorado (SNR), Delaware (SNR), Florida (SNR), Illinois (SNR), Indiana (S4), Iowa (SNR), Louisiana (SNR), Maine (SH), Maryland (SNR), Massachusetts (SNR), Michigan (SNR), Mississippi (SNR), Montana (SNR), Nebraska (SNR), New Hampshire (SNR), New York (S1), North Carolina (SNR), Pennsylvania (SNR), Rhode Island (SNR), Texas (SNR), Vermont (S1), Wisconsin (S1S2), and Wyoming (SNR).

International Union for the Conservation of Nature Red list (2015): Vulnerable A2be (ver 3.1).

Habitat Protection and Ownership

American Bumble Bee is primarily found in the Mixedwood Plains ecozone of southern Ontario and there are several suitable areas of potentially suitable habitat within protected areas. In Ontario, these include, but are not limited to: Awenda Provincial Park, Blue Lake Provincial Park, Bruce Peninsula National Park, Cabot Head Provincial Nature Reserve, Esker Lakes Provincial Park, Fathom Five National Park, Georgian Bay Islands National Park, Killarney Provincial Park, Lake of the Woods Waters Conservation Reserve, Lake Superior Provincial Park, Missinaibi Provincial Park, Rouge Park, Sleeping Giant Provincial Park.

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BIOGRAPHICAL SUMMARY OF REPORT WRITER(S)

Cory S. Sheffield has been studying bees and pollination since 1993, as part of undergraduate honours studies at Acadia University, Wolfville, Nova Scotia. He continued graduate studies (MSc) of insect-plant interactions at Acadia, and at Agriculture and Agri-Food Canada (AAFC), Kentville, Nova Scotia from 1994–2006. Cory did graduate studies (PhD) at the University of Guelph, Ontario, while continuing to work at the AAFC. These studies focused on the bee fauna of Nova Scotia, including their diversity and contributions to crop pollination. During this time, Cory and several co-authors published on the re-discovery of *Epeoloides pilosulus* in Nova Scotia, which was thought extinct. Cory then worked on post-doctoral studies at York University, ON in bee taxonomy and DNA barcoding, followed by a research associate position in bee taxonomy with the Canadian Pollination Initiative (CANPOLIN). He is now research scientist and curator of invertebrate zoology at the Royal Saskatchewan Museum in Regina, SK. 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

As the data set used for this report comes primarily from that used for "An Identification Guide: Bumble Bees of North America" by Williams *et al.* (2014), I provide the same list of collections reported for other COSEWIC reports on bumble bees. Additional collections examined that were not in the original list are marked with an *. Recent data for American Bumble Bee from Canada was also mined from Bumble Bee Watch.

Academy of Natural Sciences, Philadelphia, PA

Algonquin Provincial Park, Hunstville, ON

American Museum of Natural History, New York, New York

André Francoeur Research Collection, Chicoutimi, QC

Atlantic Canada Conservation Data Centre, Sackville, NB

B. Hicks Personal Collection, College of the N. Atlantic, Stephenville, NL

BBSL-Utah Logan, Utah

Spencer Entomological Collection, Beaty Biodiversity Museum at the University of British Columbia, Vancouver, BC

Biodiversity Institute of Ontario, Guelph, ON

B. Jacobsen, Greer Labs, Inc, Lenoir, NC

British Natural History Museum, London, England

C. Looney Research Collection

C. Sheffield Research Collection, Regina, SK

Canadian Museum of Nature, Ottawa, ON
C. Buidin/ Y. Rochepault Research Collection; Montréal, QC
Canadian National Collection of Insects, Arachnids and Nematodes, Ottawa, ON
College of the North Atlantic, Sackville, NB
Connecticut Agricultural Extension Station, New Haven, CT
D.H. Miller private collection
Davis (Bohart), University of California; Davis, California
E. Nardone Research Collection, Guelph, ON
Essig Museum of Entomology; Berkeley, California
E. Normandin Research Collection; Laval, QC
Illinois Natural History Survey; Champaign, IL
Insectarium Réne-Martineau, Québec, QC
Canadian Forestry Service, Québec; QC
J.B. Wallis Museum of Entomology, University of Manitoba, Winnipeg, MB
K. Martins Research Collection; Montréal, QC
L. Richardson Research Collection; Hanover, NH
LA County Museum; Laval University; Laval, QC
Lethbridge Agricultural Research Station; Lethbridge, AB
Lyman Entomological Collection-McGill University; Montréal, QC
Madison-University of Wisconsin; Madison, WI
M. Savard Research Collection; Saint-Fulgence, QC
Ministère des Ressources naturelles et de la Faune Québec, Various, QC
National Pollination Insect Collection (Logan); Logan UT
New York State Museum, Albany, NY
North Carolina State University, Raleigh, NS
Nova Scotia Dept Natural Resources, various, NS
Nova Scotia Museum, Halifax, NS.
Ohio State University; Columbus, OH
Oregon State Arthropod Collection, Corvallis, Oregon
P.H. Williams Research Collection, London, UK
Packer Collection York University, Toronto, ON
Patuxent Wildlife Research Center; Laurel, MD
P. Hallett Personal Collection, Toronto, ON

R. Gegear Research Collection, Toronto, ON
Royal British Columbia Museum, Victoria, BC
Royal Ontario Museum, Toronto, ON.
Royal Saskatchewan Museum, Regina, SK
S. Javorek Research Collection, Kentville, NS
S. Colla Research Collection, Toronto, ON
*University of Calgary, Calgary, AB
University of Colorado, Boulder, Colorado
*University of Manitoba, Winnipeg, MB
University of Massachusetts, Worchester, MA
University of Minnesota; Minneapolis, MN
University of Michigan; Ann Arbor, MI
University of Alaska, Fairbanks; Alaska
University of Connecticut; Storrs, CT
University of Guelph, Guelph, ON
University of Idaho; Moscow, ID
University of New Hampshire, Durham; New Hampshire
University of Prince Edward Island; Charlottetown, PE
University of Nevada, Reno; NV
V. Fournier Research Collection; Laval, QC
Yale Peabody Museum, New Haven CT