COSEWIC
Assessment and Status Report

on the

Gypsy Cuckoo Bumble Bee
Bombus bohemicus

in Canada

ENDANGERED
2014

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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Gypsy Cuckoo Bumble Bee — Provided by the authors.

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COSEWIC
Assessment Summary

Assessment Summary – May 2014

Common name
Gypsy Cuckoo Bumble Bee

Scientific name
Bombus bohemicus

Status
Endangered

Reason for designation
This large and distinctive bee is a nest parasite of other bumble bees. It had an extensive range in Canada and has been recorded from all provinces and territories except Nunavut. Although not known to be abundant, there has been a large observed decline in relative abundance in the past 20-30 years in areas of Canada where the species was once common, with the most recent records coming from Nova Scotia (2002), Ontario (2008) and Quebec (2008). Significant search effort throughout Canada in recent years has failed to detect this species, even where its hosts are still relatively abundant. Primary threats include decline of hosts (Rusty-patched Bumble Bee, Yellow-banded Bumble Bee, and Western Bumble Bee), pesticide use (particularly neonicotinoids), and the escape of non-native, pathogen-infected bumble bees from commercial greenhouses.

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

Status history
Designated Endangered in May 2014.

COSEWIC
Executive Summary

Gypsy Cuckoo Bumble Bee
Bombus bohemicus

Wildlife Species Description and Significance

Gypsy Cuckoo Bumble Bee (*Bombus bohemicus*) is one of six cuckoo bumble bees (subgenus *Psithyrus*) occurring in North America. Both sexes are medium-sized (12 – 18 mm length), with a white-tipped abdomen and similar colour pattern. Gypsy Cuckoo Bumble Bee is an obligate social parasite of bumble bees of the subgenus *Bombus* in North America, including the Rusty-patched Bumble Bee (*B. affinis*) (assessed Endangered by COSEWIC), Yellow-banded Bumble Bee (*B. terricola*) and Western Bumble Bee (*B. occidentalis)* (both currently being assessed by COSEWIC). Cryptic Bumble Bee (*B. cryptarum*) may also serve as a host. Due to recent analysis of DNA barcode and morphological data, the formerly recognized species *Bombus ashtoni* was found to be conspecific with the widespread Old World species *Bombus bohemicus*.

Distribution

Gypsy Cuckoo Bumble Bee is a holarctic species, occurring throughout most of Europe (except Iceland) and extreme southwestern Europe and parts of north and central Asia. In Canada, Gypsy Cuckoo Bumble Bee has been recorded in every province and territory except Nunavut. Canadian records are from 1883 to 2008, the most recent records being from Pinery Provincial Park in Ontario (2008) and Parc national des Monts-Valin in Quebec (2008). Since 1991, the species has only been recorded from three provinces: Ontario (67 specimens), Quebec (39 specimens) and Nova Scotia (18 specimens). Despite high search effort in recent years (2001 – 2013), only 42 specimens of Gypsy Cuckoo Bumble Bee have been recorded. The species distribution is partially determined by the distribution and abundance of its host bumble bee species.

Habitat

Gypsy Cuckoo Bumble Bee occurs in diverse habitats, including open meadows, mixed farmlands, urban areas, boreal forest and montane meadows. The species feeds on pollen and nectar from a variety of plant genera. Gypsy Cuckoo Bumble Bee emerges slightly later than host queens, and parasitizes host nests in the spring. Host nests occur in abandoned underground rodent burrows and rotten logs.

Biology

Gypsy Cuckoo Bumble Bee is a social parasite, and does not have the typical eusocial colony cycle of other bumble bees, and therefore does not produce workers. Mated females emerge in the spring and look for potential host nests. The female kills or subdues the host queen and lays eggs that the host colony workers tend. In the late summer and autumn, females and males emerge from the host nest and leave to mate with conspecifics. Mated females then select an overwintering site. Like other bumble bees, the males and the egg-laying female of that generation die at the onset of cold weather.

Population Sizes and Trends

Recent surveys at historically occupied sites have recorded no specimens. Historical abundance data on Gypsy Cuckoo Bumble Bee are available for only a fraction of the species Canadian range (mainly southern Ontario and Manitoba). The species has not been recorded at many sites surveyed within the last four decades, even where its hosts remain present.

Threats and Limiting Factors

The most likely threat to Gypsy Cuckoo Bumble Bee is the decline of two of the host species, especially Rusty-patched Bumble Bee in eastern Canada and Western Bumble Bee in western Canada. The third host, Yellow-banded Bumble Bee, is more widespread although may also be declining in parts of its range. At regional scales, pesticide use, pathogen spillover and habitat loss are probable threats.

Protection, Status, and Ranks

Gypsy Cuckoo Bumble Bee is not protected in Canada by any federal or provincial laws. The Canada General Status Rank is undetermined overall in Canada but ‘may be at risk’ in Ontario, Quebec, Nova Scotia, New Brunswick and Newfoundland. The global conservation status rank is possibly extinct (GH).

Given this expansive range of Gypsy Cuckoo Bumble Bee across Canada, many suitable areas of habitat are within protected areas.

TECHNICAL SUMMARY

Bombus bohemicus (previously *Bombus ashtoni*)

Gypsy Cuckoo Bumble Bee Psithyre bohémien

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

Demographic Information

Generation time	1 year
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Yes, observed and inferred decline > 50% based on lack of collected specimens over the past ten years; and despite widespread bumble bee surveys throughout Canada.
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].	Unknown.
[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.	Observed, inferred and suspected decline >50% in 10-year period based on lack of records of Gypsy Cuckoo Bumble Bee and decline in host species.
Are the causes of the decline clearly reversible and understood and ceased?	Not clearly reversible; partially understood; and not ceased.
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence	1.29 million km^2
Index of area of occupancy (IAO)	Unknown. Wide-ranging species >> 2000 km^2. IAO based on records from 1991 – 2008 is 180 km^2.
Is the total population severely fragmented?	Unknown. Perhaps; recent collections are disjunct based on lack of specimens in areas where hosts are still present.
Number of locations[*]	Unknown

[*] See Definitions and Abbreviations on COSEWIC website and IUCN 2010 for more information on this term.

Is there an [observed, inferred, or projected] continuing decline in extent of occurrence?	Unknown
Is there an [observed, inferred, or projected] continuing decline in index of area of occupancy?	Unknown
Is there an [observed, inferred, or projected] continuing decline in number of populations?	Yes. Observed and inferred decline based on decline of some host species.
Is there an [observed, inferred, or projected] continuing decline in number of locations*?	Yes. Observed and inferred decline based on decline of some host species.
Is there an [observed, inferred, or projected] continuing decline in [area, extent and/or quality] of habitat?	Unknown
Are there extreme fluctuations in number of populations?	No
Are there extreme fluctuations in number of locations*?	No
Are there extreme fluctuations in extent of occurrence?	No. Based on lack of collected specimens over the past ten years; and despite widespread bumble bee surveys throughout Canada.
Are there extreme fluctuations in index of area of occupancy?	Unknown

Number of Mature Individuals (in each population)

Population	N Mature Individuals
Total	Unknown

Quantitative Analysis

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

Threats (actual or imminent, to populations or habitats)

Rangewide threats are unclear. At regional scales, primary threats include pesticide use and pathogen spillover. The host bumble bee species have declined in parts of the range of Gypsy Cuckoo Bumble Bee. The Rusty-patched Bumble Bee (*B. affinis*) is gone from its range in southern Ontario and Quebec; Yellow-banded Bumble Bee (*B. terricola*) has declined in southern parts of its Canadian range in central and eastern Canada; and Western Bumble Bee *occidentalis* subspecies (*B. occidentalis occidentalis*) has declined in southern areas of the western provinces.

Rescue Effect (immigration from outside Canada)

Status of outside population(s)? o Unknown in Alaska, in decline in the Northeastern United States o Not in decline in the Old World due to the success of its host, *Bombus terrestris*.	
Is immigration known or possible?	No. Few recent records in the United States.
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Yes to habitat; but unknown if

	sufficient host abundance (inferred from decline of host species) in much of its range.
Is rescue from outside populations likely?	No, except perhaps from Alaska.

Current Status

COSEWIC: none

Status and Reasons for Designation

Recommended Status: Endangered	**Alpha-numeric code**: A2abce
Reasons for designation: This large and distinctive bee is a nest parasite of other bumble bees. It had an extensive range in Canada and has been recorded from all provinces and territories except Nunavut. Although not known to be abundant, there has been a large observed decline in relative abundance in the past 20-30 years in areas of Canada where the species was once common, with the most recent records coming from Nova Scotia (2002), Ontario (2008) and Quebec (2008). Significant search effort throughout Canada in recent years has failed to detect this species, even where its hosts are still relatively abundant. Primary threats include decline of hosts (Rusty-patched Bumble Bee, Yellow-banded Bumble Bee, and Western Bumble Bee), pesticide use (particularly neonicotinoids), and the escape of non-native, pathogen-infected bumble bees from commercial greenhouses.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets Endangered A2abce since there is an inferred reduction in the total number of mature individuals of greater than 50% over the last 10 years. The species has not been recorded in Canada since 2008, despite significant search effort in some historic sites. Once present in all Canadian provinces and territories except Nunavut, its distribution appears to have retreated to Ontario, Nova Scotia, and Quebec, where the last specimens were collected. Pathogen spillover may be an indirect cause of decline through its effect on host(s), though not confirmed as a direct cause.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. EO exceeds threshold (B1). Present distribution unknown. IAO cannot be calculated accurately (B2).
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. Population sizes are unknown.
Criterion D (Very Small or Restricted Total Population): Not applicable. Population sizes are unknown.
Criterion E (Quantitative Analysis): Not applicable. None performed.

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
(2014)

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

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

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

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

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

Canada

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

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Bombus bohemicus

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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 – narrow-waisted hymenopterans, ants, bees, true wasps
Infraorder	Aculeata – stinging wasps
Superfamily	Apoidea – bees, sphecoid wasps, apoid wasps
Family	Apidae – bumble bees, honey bees, stingless bees, and many others
Subfamily	Apinae
Genus	*Bombus* – bumble bees
Subgenus	*Psithyrus* – cuckoo bumble bees
Species	B. bohemicus

French common name (North America): Psithyre bohémien

English common name: Gypsy Cuckoo Bumble Bee (formerly Ashton's Cuckoo Bumble Bee).

Scientific name synonyms: *Bombus ashtoni*

Bombus bohemicus was described by Seidl in 1837, and has been considered a valid species in the Old World since that time. In North America, Cresson (1864) described *Apathus ashtoni* and, until recently, *Bombus ashtoni* (Cresson) (Ashton's Cuckoo Bumble Bee) has been the scientific name used for this taxon. However, Williams (1991) questioned the species status of *B. ashtoni* based on morphological evidence. Later, Cameron *et al.* (2007), using molecular data (i.e., DNA), also suggested that *B. ashtoni* may be conspecific with the Old World *B. bohemicus.* More recently, and using additional genetic data (COI sequences from mitochondrial DNA), the North American *B. ashtoni* has been synonymized under *B. bohemicus*, a name which is now applied to this Holarctic species (Williams 2013; Williams *et al.* 2014).

Morphological Description

The morphological description of Gypsy Cuckoo Bumble Bee below is from information in Plath (1934), Mitchell (1962), Colla *et al.* (2011) (as *B. ashtoni*) and Williams *et al.* (2014).

Female: Body length 17 - 18 mm; breadth of abdomen 8 - 8.5 mm. The outer surface of the hind tibia is convex, with dense hair covering the surface, without a corbicula (i.e., pollen basket). The hair on the face and top of the head is typically all black, occasionally with some yellow hairs at the posterior top of the head. The sides of the thorax are predominantly with black hair; hair on the anterior surface of thorax (i.e., in front of wings) is yellow, and varies from yellow to black on the remaining dorsal surface. The first two abdominal segments have black hair, the 3rd to 5th abdominal segments are laterally variable yellowish-white, but usually white at least posteriorly in the middle of the 4th segment (Figure 2). Like all cuckoo bumble bees, the tip of abdomen is strongly recurved ventrally (Figure 1), with the ventral surface with two strong carina (ridges).

Figure 1. Lateral image of female Gypsy Cuckoo Bumble Bee (*Bombus bohemicus*) housed at the Packer Collection, York University, Toronto, ON. Photograph by Sheila Colla.

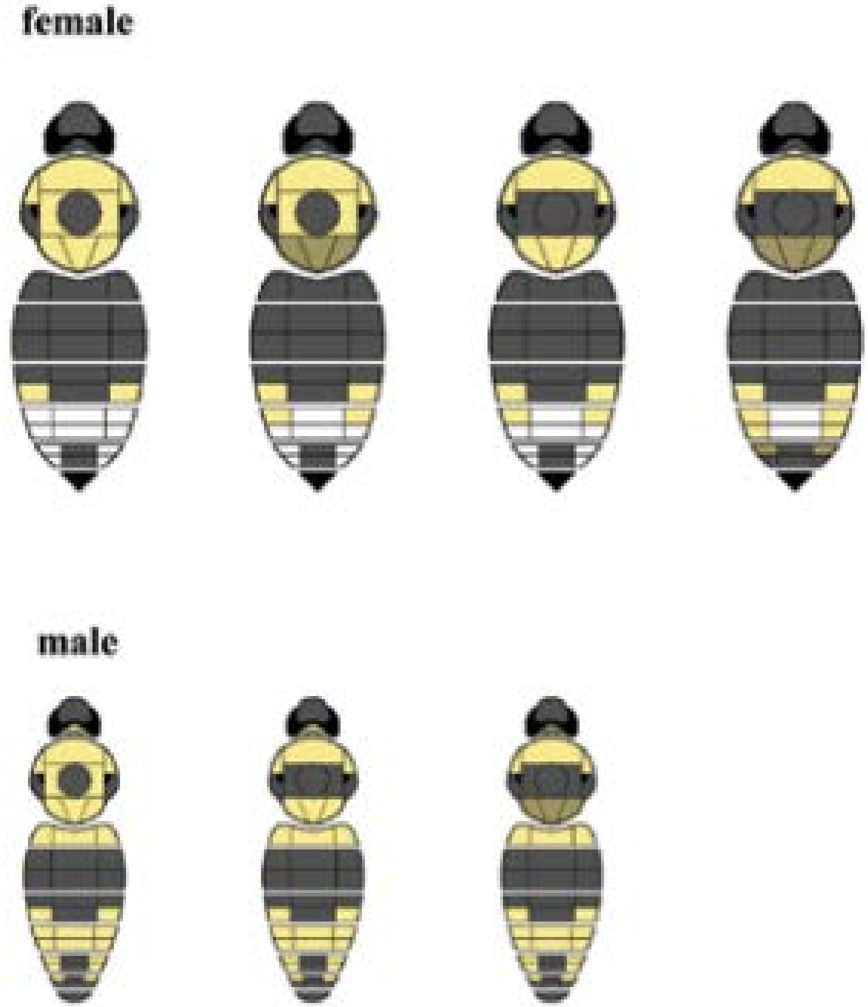

Figure 2. Colour patterns for Gypsy Cuckoo Bumble Bee (reproduced with permission from Colla 2012).

Male: Body length 12-16 mm, breadth of abdomen 5-7 mm. Antenna medium length, flagellum 3 times longer than scape. Hair of hindleg basitarsus posterior fringe predominantly black, The first abdominal segment yellow, with some specimens with much black hair intermixed, the 2nd segment entirely black, the 3rd, 5th, and 6th segments primarily yellow with black hairs present medially, the 4th segment primarily yellow, the 7th segment is entirely black (Figure 2).

Gypsy Cuckoo Bumble Bee is frequently misidentified as one of three co-occurring *Psithyrus* species: *B. insularis*, *B. flavidus*, and *B. suckleyi*. Gypsy Cuckoo Bumble Bee females have predominantly dark hairs on the top of head that differentiate this from other species, which have pale hairs. In addition, the black pleura and carina of the 6th sternum are reliable characters that differentiate females from *B. insularis*, *B. flavidus*, and most specimens of Suckley's Cuckoo Bumble Bee (*B. suckleyi*). Further, the hairs on the 3rd and 4th tergites of Gypsy Cuckoo Bumble Bee females are usually white, at least posteriorly in the middle of T4. Proper identification of males may require examination of genitalia structures (Williams *et al.* 2014).

Population Spatial Structure and Genetic Variability

Genetic variability and population structure have not been studied for Gypsy Cuckoo Bumble Bee. The Barcode of Life database (BOLD) (www.barcodeoflife.org) has eight specimens barcoded from four sites in Canada (from British Columbia and Nova Scotia), and the United States (Alaska) (Packer pers. comm. 2011). All sequences are almost identical, and do not vary significantly from samples of Gypsy Cuckoo Bumble Bee from Germany (Cameron *et al.* 2011; Williams *et al.* 2012). As such, Gypsy Cuckoo Bumble Bee is now considered a Holarctic species, and *B. ashtoni* is now considered a junior synonym.

Designatable Units

Gypsy Cuckoo Bumble Bee is being assessed as one designatable unit, in the absence of information on discreteness or evolutionary significance among populations. The species spans all COSEWIC (2011) Ecological Areas, except the eastern fringe of the Pacific (just west of the Rockies) and the Arctic (where it has not been reported).

Special Significance

Gypsy Cuckoo Bumble Bee is a social parasite in other bumble bee colonies. The species likely plays a significant ecological role through its effect on host dynamics and distribution (Antonovics and Edwards 2011). In this case, host species include the Rusty-patched Bumble Bee (*B. affinis*), Western Bumble Bee (both subspecies of *B. occidentalis*), Yellow-banded Bumble Bee (*B. terricola*) and possibly the Holarctic Cryptic Bumble Bee (*B. cryptarum*) (Owen *et al.* 2012).

The biology of Gypsy Cuckoo Bumble Bee has been studied previously (e.g., Fisher 1983, as *B. ashtoni*). Its main significance lies in its sensitivity to environmental degradation: bees in general, and cuckoo and social bees in particular, are sensitive to impacts of small population size (Williams *et al.* 2010) because of their sex determining mechanism (Zayed and Packer 2005) (see Limiting Factors).

DISTRIBUTION

Global Range

Gypsy Cuckoo Bumble Bee is a Holarctic species. In North America, it ranges throughout most of Canada (except Nunavut) and parts of the northern United States (US) (i.e., Alaska, Connecticut, Indiana, Massachusetts, Minnesota, North Dakota, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Virginia, West Virginia, Wisconsin) (Figure 3). In the Old World the species occurs throughout most of Europe (except Iceland and extreme southwestern Europe) and across Asia.

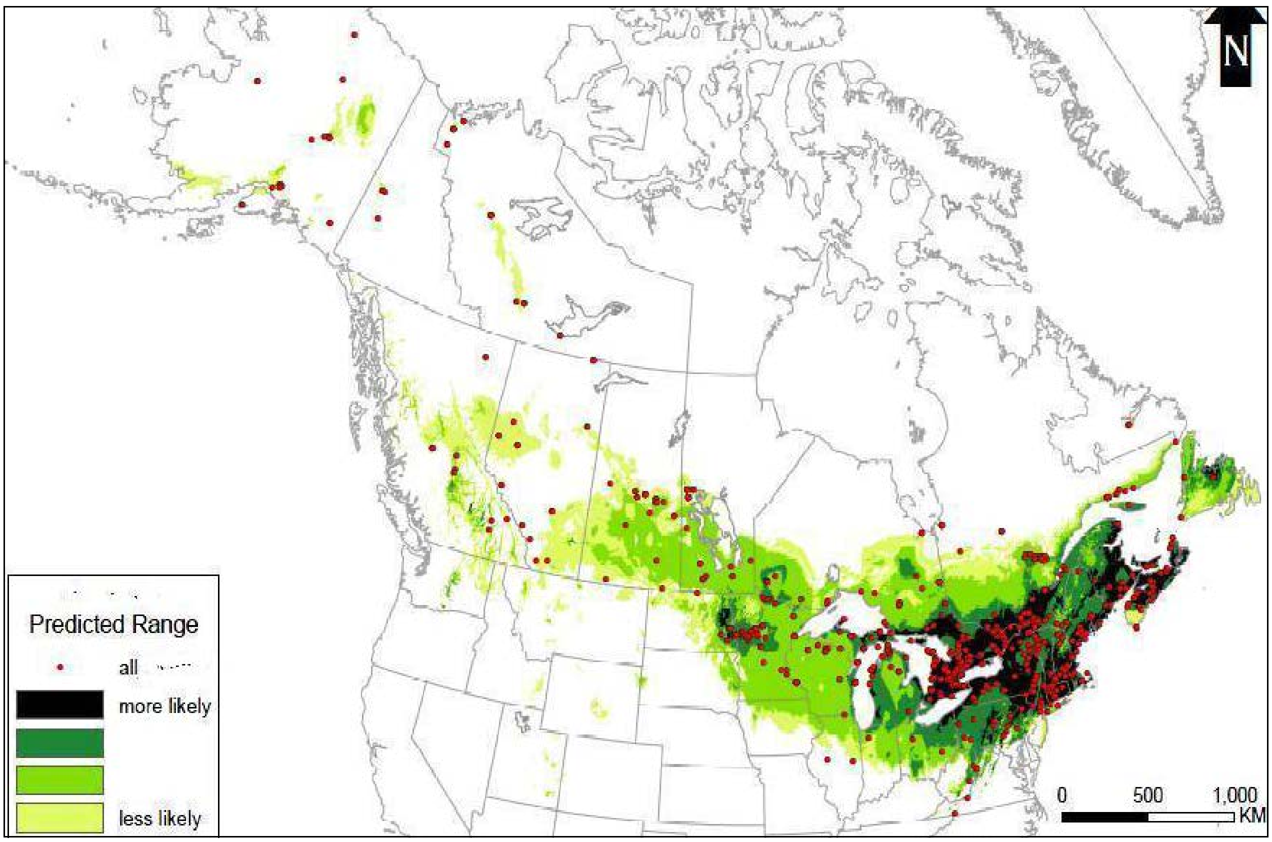

Figure 3. Distribution of Gypsy Cuckoo Bumble Bee in North America with predicted suitability modeled using MaxEnt software (Phillips *et al.* 2006) based on museum specimens (red circles) (reproduced with permission from Williams *et al.* 2014).

Canadian Range

Gypsy Cuckoo Bumble Bee has been recorded from every Canadian province and territory except Nunavut (NU) (Colla and Sheffield 2010) (Figure 4). Canadian records are from 1883 to 2008. Since 1991, the species has been recorded from only three provinces: Ontario (67 specimens), Quebec (39 specimens) and Nova Scotia (18 specimens) (Appendix 1). The most recent are from Pinery Provincial Park in Ontario (2008) and Parc national des Monts-Valin in Quebec (2008). Despite its wide distribution, climate suitability modelling based on collected and museum specimens suggests that southern and central Ontario and Quebec are most suitable for the species (Figure 3), which also corresponds to the most recent records in Canada (2008).

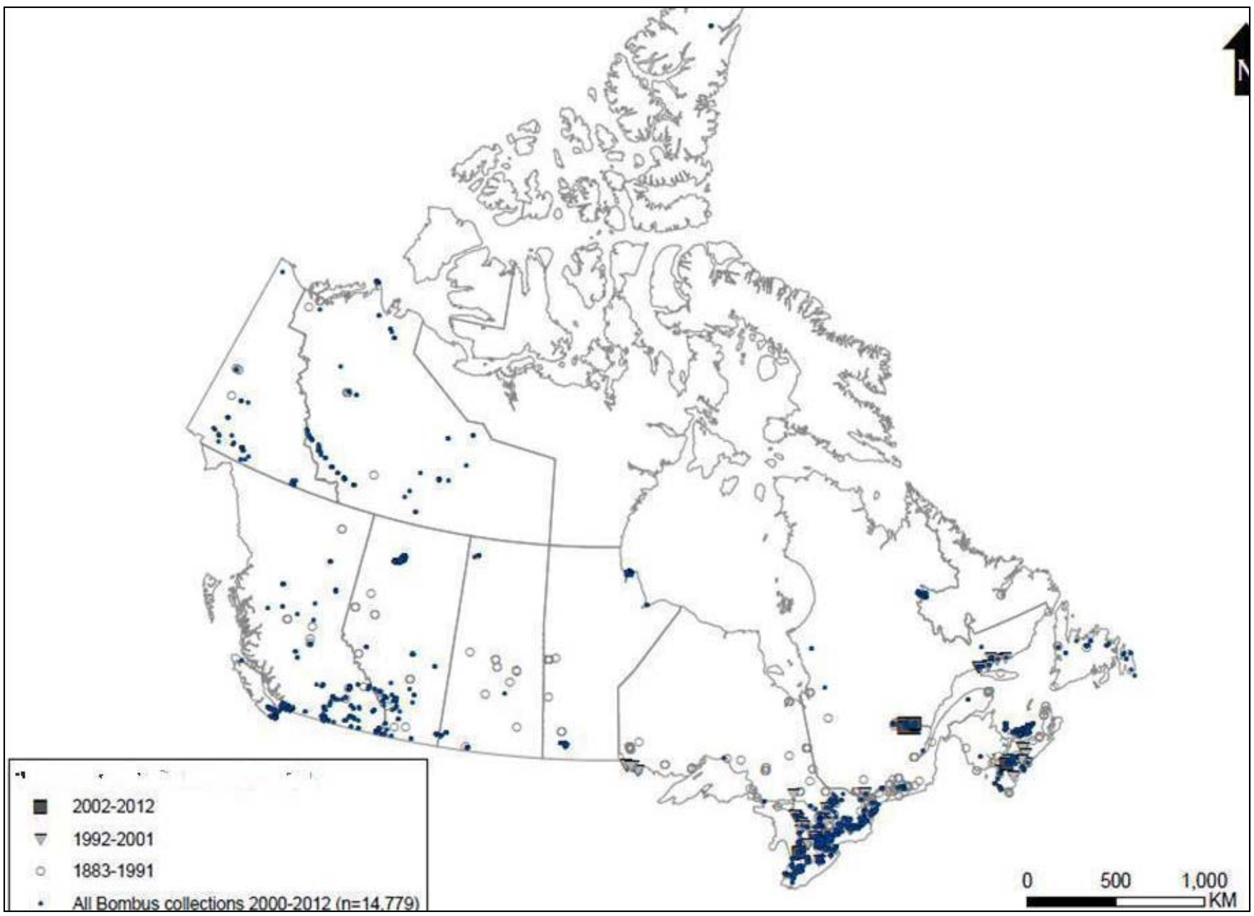

Figure 4. Gypsy Cuckoo Bumble Bee records (n=844) in Canada and recent search effort (2000-2012) that shows collection records for all *Bombus* specimens (reproduced with permission from the dataset of Williams *et al.* 2014).

Each province and territory is listed (Table 2) below (chronologically descending with most recent records first). Information on the range of the host bee within each province is also listed where the data is available. The ranges of host species throughout Canada are:

- Rusty-patched Bumble Bee in southern Ontario (ON) and Quebec (QC);
- Western Bumble Bee (northern and southern subspecies) (Figure 5) in British Columbia (BC), Alberta (AB), southern Saskatchewan (SK), Yukon (YK) and western Northwest Territories (NT);
- Yellow-banded Bumble Bee (Figure 5) from the Rockies in eastern BC through the boreal zone, southern NT and southern half of Canada to Newfoundland (NF);
- Possibly the Holarctic Cryptic Bumble Bee in the YK, NT, BC, AB and SK, with a few unconfirmed records from NU and extreme northern ON (Colla pers. data 2013).

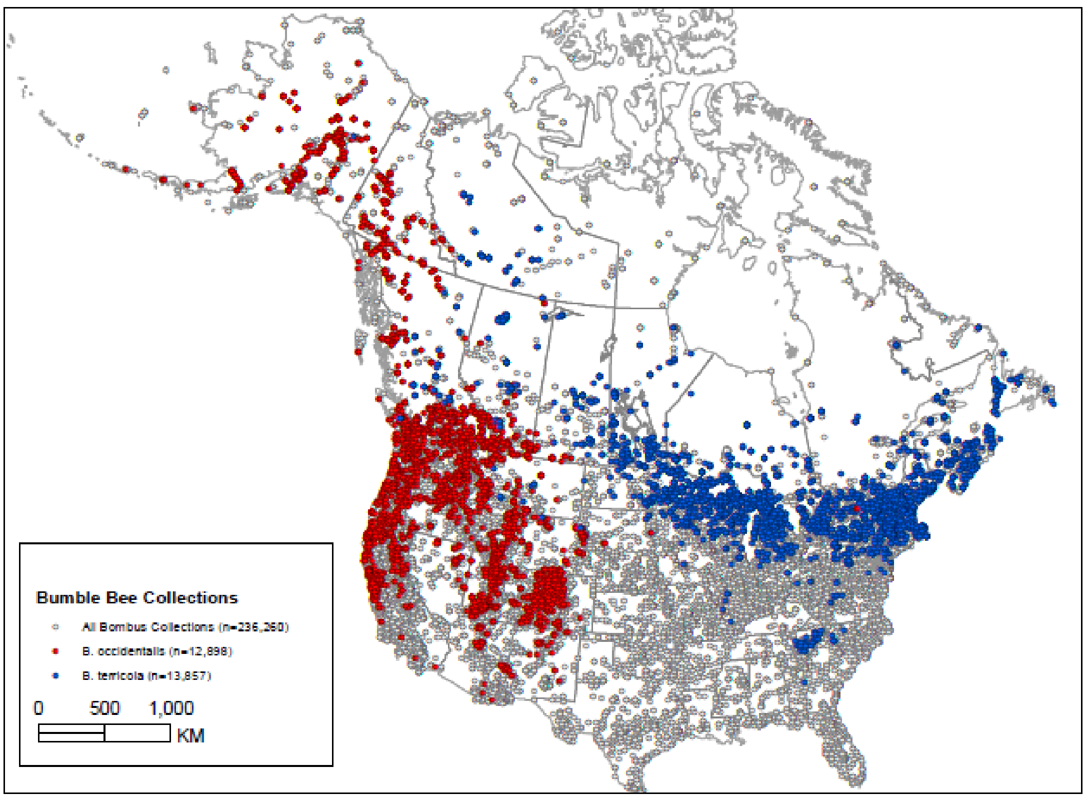

Figure 5. Bumble bee collection points (all dots total 236,260 specimens) for North America from 1892 - 2013. Dots in red represent host bee Western Bumble Bee and dots in blue represent host bee Yellow-banded Bumble Bee (see Wildlife Species Description and Significance). No data exists for areas without points. Note there has been taxonomic debate about Western Bumble Bee and Yellow-banded Bumble Bee, and it is not guaranteed that all specimens used in these maps are correctly identified. These maps should be used as general range maps and outliers further investigated. Map compiled by Leif Richardson November 2013 and used with permission from Sheffield *et al.* (in prep.).

Ontario:

One of the most recent Canadian records for Gypsy Cuckoo Bumble Bee is from Pinery Provincial Park (2008). Host(s) in Ontario: Yellow-banded Bumble Bee ranges across the Mixedwood Plains and Boreal Shield ecozones of southern Ontario, and there are some in the Hudson Bay lowlands around James Bay. This host species was last collected in southern Ontario in 2013 (e.g., Toronto, Barrie and Ottawa) (Colla pers. comm. 2014). Rusty-patched Bumble Bee is much more uncommon and was last recorded in 2009 from Pinery Provincial Park (COSEWIC 2010).

Quebec:

The most recent Canadian records of Gypsy Cuckoo Bumble Bee are from Quebec at Parc national des Monts-Valin – Chalet La Courtepointe (July 4, 2008) (Savard 2012), Parc national des Monts-Valin – Pied-du-Mont (July 29, 2007) (Savard 2012) and Anticosti Island - Jupiter in the Gulf of St. Lawrence (June 16 to 30, 2007) (Brousseau 2011; Savard pers. comm. 2012). Numerous specimens were collected during surveys from 2000-2001 at Magpie, Aguanish, Baie-Johan-Beetz, and Rivière-Saint-Jean (Buidin pers. comm. 2011) (See Appendix 1). Older records are from southern and central Quebec with unconfirmed records from northern Quebec (Laverty and Harder 1988). Host(s) in Quebec: Yellow-banded Bumble Bee remains sparsely distributed throughout southern Quebec. This host species was formerly common across the Mixedwood Plains and Boreal Shield ecozones of southern Quebec, and there are scattered collections from the Taiga Shield as far north as Schefferville at nearly 55° N. Most recently Yellow-banded Bumble Bee was collected in 2013 by M. Chagnon on farms south of Montreal and Quebec City (Sheffield pers. comm. 2014). The Rusty-patched Bumble Bee has not been recorded in Quebec since the 1970s (COSEWIC 2010).

Nova Scotia:

The most recent Gypsy Cuckoo Bumble Bee records are from near Middleton (2002). The species was recorded from many sites throughout the 1990s including specimens housed at Cape Breton University (most recent from 2001) (McCorquodale pers. comm. 2012). Host(s) in Nova Scotia: Yellow-banded Bumble Bee has been collected over most of Nova Scotia, and was most recently collected in 2013 during resurveys of historic collections made in Lockeport, Greenfield and New Germany (Colla pers. comm. 2014).

Prince Edward Island:

The most recent specimen was collected in 1983 (Curley pers. comm. 2011). The University of Prince Edward Island [Entomology] Museum has specimens collected during the 1970s and 1980s from Riverdale, Charlottetown, Cornwall and Vernon River. Host(s) in Prince Edward Island: Yellow-banded Bumble Bee is common at the same survey sites within Riverdale, Charlottetown, Cornwall and Vernon River (Giberson pers. comm. 2011) and most recently recorded in 2013 (Colla pers. comm. 2014).

British Columbia:

The species was last collected 40 km south of Quesnel in 1988. The westernmost range extent for this species is within the central interior of BC. The species has not been detected along the coast, or in the southwestern portion of the province (Figure 3). Host(s) in British Columbia: The hosts include Western Bumble Bee and Yellow-banded Bumble Bee, although both these species appear to be declining within British Columbia. Recent surveys for Western Bumble Bee, with a minimum of 281 hours cumulative search effort over more than 104 sites (additional samples still to be processed), were conducted in BC in 2013 (Sheffield *et al.*; data being used in a manuscript in prep.). These surveys yielded a minimum of 6447 *Bombus* specimens, 115 specimens (or 1.7% of total examined) were Western Bumble Bee (at 36 of the 104 sites) and 295 specimens (or 4% of total) were Yellow-banded Bumble Bee (Sheffield *et al.* in prep.). There were no records of Gypsy Cuckoo Bumble Bee within these surveys, despite finding its hosts.

Manitoba:

Specimens have been recorded only in central and southern Manitoba. The most recent specimen of Gypsy Cuckoo Bumble Bee is from 1986 (see also Turnock *et al.* [2007] in Population Sizes and Trends). Host(s) in Manitoba: Historical collections of Yellow-banded Bumble Bee are predominantly from the Boreal Plains and Prairies ecozones in the southern one third of the province, but a few were made as far north as Hudson Bay. The most recent Yellow-banded Bumble Bee collection is at Gillam and York Factory in 2010 (Colla pers. comm. 2014).

Alberta:

The most recent record of Gypsy Cuckoo Bumble Bee is from Lethbridge in 1983. Host(s) in Alberta: Yellow-banded Bumble Bee is found throughout the province, with collections in all ecozones, including southern Prairies, central Boreal Plains, western mountains and northern Taiga Plains. It was observed at Edmonton and Slave Lake in 2013 during resurveys of historical collection locations (Rowe pers. comm. 2013). Additional specimens were collected in a 200 km radius around Edmonton by G. Anweiler (Sheffield pers. comm. 2014). In 2013, surveys resulted in Western Bumble Bee and Yellow-banded Bumble Bee collections, albeit uncommonly from near Dinosaur Provincial Park (near Red Deer), Red Cliff (south of Medicine Hat) and Cypress Hills areas (Sheffield pers. comm. 2014).

Newfoundland and Labrador:

The most recent record of Gypsy Cuckoo Bumble Bee is 1979 from Gros Morne National Park. Additional specimens have been collected at Goose Bay, Codroy Valley and Grand Falls. Host(s) in Newfoundland and Labrador: Yellow-banded Bumble Bee has been collected mainly in coastal areas, particularly along the Gulf of St. Lawrence. There are a few undated collections (likely <2004) from Labrador in the Canadian National Collection from the towns of Cartwright and St. Anthony. The most recent Yellow-banded Bumble Bee collections from the province are from 2010 where it remains common (Sheffield pers. comm. 2014).

Northwest Territories:

The species has been collected along the western half of this territory, the most recent specimen collected '3 miles southeast' of Fort Simpson in 1972. Host(s) in Northwest Territories: Yellow-banded Bumble Bee occurs in the central Taiga Plains ecozone of NT, but not the mountainous western parts of the territory. The most recent Yellow-banded Bumble Bee collections were made in Hay River area (2005) and Fort Simpson (2011). Very few records exist for Western Bumble Bee (northern subspecies) in the NT, these from the extreme western part of the jurisdiction. There is only one record from pre-2011 (August 4, 1944 – exact site not given). The remaining eight specimens are from various sites on the South Nahanni River, collected on various dates in August 2011 (Stotyn 2012; Sheffield pers. comm. 2014).

Saskatchewan:

The most recent record of Gypsy Cuckoo Bumble Bee is Meadow Lake (1972), and the species has been recorded from southern and central SK, including Val Marie. Host(s) in Saskatchewan: Yellow-banded Bumble Bee is found on the Boreal Plains and Prairies ecozones in the southern third of the province. Curry (1984) describes Yellow-banded Bumble Bee as being common and widespread in the province from prairies to the northern coniferous forests. In 2013 specimens were collected at Killaly and Prince Albert (Colla pers. comm. 2014) and additional collecting events suggest the species is one of the most common in the Prince Albert, Birch Hills areas as far south as Regina (Sheffield pers. comm. 2014). There are few historical surveys or museum collections of Western Bumble Bee from SK. Recently Western Bumble Bee (i.e., 2012-2013) has been recorded throughout the southern third of SK. (i.e., Grasslands National Park, Saskatchewan Landing Provincial Park, Great Sand Hills, Big Muddy Valley, and Cypress Hills Provincial Park, Eastend, Swift Current and as far east as Regina) (samples are still being processed, Sheffield *et al.* (in prep.)). This species appears rather uncommon compared to other bumble bees. Prior to these surveys, there are very few historic records databased from these areas (Sheffield pers. comm. 2014).

Yukon:

The most recent record of Gypsy Cuckoo Bumble Bee is from '15 miles east of Dawson' in 1962. Host(s) in Yukon: Western Bumble Bee has been recorded at numerous sites in YT over the past 3 years without detecting *B. bohemicus* (Cannings pers. comm. 2013; Sheffield pers. comm. 2014). Western Bumble Bee was present at many sites surveyed in 2009, 2010 and 2013 (Cannings pers. comm. 2013; Sheffield pers. comm. 2014). The northern subspecies is still considered common in adjacent Alaska, where it accounted for over 30% of all bumble bees observed (Koch and Strange 2012).

New Brunswick:

The most recent record of Gypsy Cuckoo Bumble Bee is Coldbrook (1961), near Saint John. Host(s) in New Brunswick: Yellow-banded Bumble Bee is found throughout New Brunswick (Laverty and Harder 1988). The species was a common blueberry pollinator in the 1970s and early 1990s (Sheffield pers. comm. 2014). The most recent specimens were collected during 2013 resurveys of historic collection sites in the towns of Springfield and Norton (Colla pers. comm. 2014). There is one confirmed specimen of Rusty-patched Bumble Bee found in New Brunswick from the 1940s (Klymko pers. comm. 2014).

Search Effort

Much time and effort have been invested (recently and historically) in surveys that focus on bumble bees, including Gypsy Cuckoo Bumble Bee. There are more data available for wild bumble bees than for most other North American insects. A recently compiled dataset (Williams *et al.* 2014) of approximately 236,260 bumble bee specimens (Figure 5) from museums in Canada and the United States shows the increase in bumble bee specimens collected, particularly in the past decade. This is due to recent studies in the US (e.g., Cameron *et al.* 2011; Grixti *et al.* 2009) and Canada (e.g. Colla and Packer 2008; Sheffield pers. data 2013; Williams *et al.* 2014) showing substantial search effort, accumulating hundreds of person-hours surveying wild bumble bee populations each decade.

Additionally, many recent bumble bee surveys throughout the range of Gypsy Cuckoo Bumble Bee but targeting Rusty-patched Bumble Bee and Western Bumble Bee have not recorded the species. These surveys used opportunistic hand netting and pan trapping as a sampling method (bees were actively searched out while foraging on flowers, captured with an insect net and either released or captured and pinned). Recent bumble bee surveys in YT, BC, AB and SK are summarized (as part of ongoing preparation for the COSEWIC status report for Western Bumble Bee) and surveys in NB and ON (see COSEWIC 2010).

However, there are shortcomings in search effort. Surveys typically have not been systematic or comprehensive over time and across the range of Gypsy Cuckoo Bumble

Bee. Thus, there are large areas (e.g., northern halves of most Canadian provinces, and the territories, mainly due to inaccessibility) and time periods where no data are available. Most surveys occurred in the southern parts of Gypsy Cuckoo Bumble Bee's range, whereas there are numerous historical sites in the boreal forest biome, which need surveys (Figure 4). Also, surveyors often did not document the time and effort invested, making it difficult to accurately quantify and compare search effort. These factors make it difficult to interpret spatial and temporal patterns in Gypsy Cuckoo Bumble Bee records (see Population Sizes and Trends).

During surveys conducted as part of this report, known historical sites were re-sampled for Gypsy Cuckoo Bumble Bee from June – October 2011, using opportunistic hand netting (Colla pers. data 2011). These historical sites in Ontario include: Toronto (5 days), Pinery Provincial Park (8 days), Beamsville (1 day), Guelph (1 day), and in Quebec, Sainte-Anne-de-Bellevue (2 days). Presqu'ile Provincial Park (Quebec) was surveyed (one day) in June 2012. Gypsy Cuckoo Bumble Bee was not recorded during these surveys.

A summary of search effort for each province and territory is below and *Bombus* collections (general) are shown in Figure 4.

Northwest Territories:

Much of NT has not been sampled for bumble bees. Most recently (July 2011) bumble bees were surveyed at 19 sites along riparian areas of the South Nahanni River from Moose Ponds to the Liard River (Stotyn 2012). Of the 78 individuals collected, none were Gypsy Cuckoo Bumble Bee; however, Western Bumble Bee was recorded (Stotyn 2012).

Manitoba:

Despite frequent surveys within the Churchill and surrounding areas, the species has not been recorded. Patenaude (2007) collected over 600 bumble bees throughout his prairie sites in southwestern Manitoba (May to September 2005 and 2006) without recording the species.

Ontario:

Southern ON has been extensively surveyed for bumble bees (n >4000 *Bombus*) from 2004 – 2012 (Figure 4). One of the most recent Canadian records of Gypsy Cuckoo Bumble Bee is from Pinery Provincial Park (in 2008), the same site where the last known Rusty-patched Bumble Bee (host species) populations are recorded (2009). Pinery Provincial Park has been extensively surveyed from 2008 – 2011 with no new specimens of Gypsy Cuckoo Bumble Bee collected. Some sites in central and northern Ontario (e.g. Mississagi Provincial Park June 13 – 16, 2011) have been surveyed in recent years with no specimens recorded.

Quebec:

Laverty and Harder (1988) report unconfirmed records from Northern QC. Numerous specimens were collected during surveys from 2000 - 2008 at Magpie, Aguanish, Baie-Johan-Beetz, and Rivière-Saint-Jean (Buidin pers. comm. 2011; Savard 2012) (See Appendix 1).

New Brunswick:

The species was not recorded during surveys in the summer of 2008 near Moncton, Fundy National Park, and Saint John (S. Colla surveyed bumble bees for 4 days in search of Rusty-patched Bumble Bee) (COSEWIC 2010). In 2010 and 2011, 219 bumble bees were collected although none were Gypsy Cuckoo Bumble Bee (Klymko pers. comm. 2012).

Nova Scotia:

This province has been thoroughly surveyed for bumble bees over the past ten years by students and others (Sheffield pers. comm. 2012). Gypsy Cuckoo Bumble Bee was recorded from many sites throughout the 1990s. Cape Breton University has a few specimens from 1986 - 1998 with the most recent from 2001 (McCorquodale pers. comm. 2012). No Gypsy Cuckoo Bumble Bee specimens were collected during 2010 and 2011 surveys (Klymko pers. comm. 2012).

Newfoundland and Labrador:

There are no surveys for the species in the past ten years.

Prince Edward Island:

Intensive surveys have been completed over 57 sites since 2000 yielding 266 bumble bee specimens and no new records for Gypsy Cuckoo Bumble Bee, with Yellow-banded Bumble Bee common at these sites (Giberson pers. comm. 2011). Gypsy Cuckoo Bumble Bee was not recorded during fieldwork in 2004 – 2005 (MacPhail 2011).

Yukon:

At least 2000 bumble bees have been recorded from numerous sites over the past three years without detecting Gypsy Cuckoo Bumble Bee, although potential host species Western Bumble Bee and Cryptic Bumble Bee remain common (Cannings pers. comm. 2013).

British Columbia:

Many sites have been surveyed for bumble bees by biologists from universities and government agencies without detection of Gypsy Cuckoo Bumble Bee (Figure 4). The search effort during the past 10 years has been very high, with 1000s of *Bombus* individuals collected over hundreds survey hours. For example, a study in Fraser Valley in 2003 and 2004 yielded 4221 *Bombus* individuals without yielding Gypsy Cuckoo Bumble Bee (Ratti 2006). Recent bumble bee surveys with a minimum of 281 hours cumulative search effort over approximately 104 sites (additional samples still to be processed) were conducted in BC in 2013 (Sheffield *et al.*; data being used in a manuscript in prep.). These surveys were intensive with a minimum of 30 minutes to one hour per site and collecting all species present. No Gypsy Cuckoo Bumble Bees were recorded in the 104 samples processed to date (Sheffield *et al.* in prep.).

Alberta:

Many sites have been surveyed for bumble bees by biologists from universities and government agencies without detection of Gypsy Cuckoo Bumble Bee (e.g. Colla pers. data 2010; Owen *et al.* 2012; Figure 4). The search effort during the past 10 years has been very high, with 1000s of *Bombus* individuals collected over hundreds survey hours. In 2010, 775 *Bombus* individuals were collected from southern Alberta without detecting this species (Colla pers. data 2010). Surveys in Cypress Hills (in 2007 and 2013), Dinosaur Provincial Park, Red Cliff (south of Medicine Hat), Edmonton and surrounding areas did not record the species (Sheffield pers. comm. 2014). At least 20 sites (minimum 30 minutes at each site) within a 200 km radius around Edmonton by G. Anweiler did not record Gypsy Cuckoo Bumble Bee (Sheffield *et al.* in prep).

Saskatchewan:

Recent surveys (i.e., 2011-2013) (i.e., Grasslands National Park, Saskatchewan Landing Provincial Park, Great Sand Hills, Big Muddy Valley, Eastend, Leader, Swift Current, Prince Albert, Cypress Hills Provincial Park and as far east as Regina) and other areas (samples are still being processed, Sheffield *et al.* (in prep.)) have not recorded the species. Additionally bumble bee surveys in 2011 (vane trapping[1] for one week by A. Crosby) at Cypress Hills did not yield any specimens (Colla pers. comm. 2013).

[1] Vane trapping was completed for one week at Cypress Hills. Vane traps are large blue plastic traps with a deep collecting container, which collect bees by visually attracting the bee to the trap, and act as an intercept trap with crossing panels. Bees fall into the collecting container which traps them in a liquid (such as ethanol or ethylene glycol). Vane traps can be used instead of pan traps to collect bees when the traps are left operational for time periods more than two days, and are believed more effective for large bees.

Outside Canada, surveys conducted from 2007 - 2009 at 382 sites (n= 16,788 *Bombus* collected) throughout the continental US failed to detect Gypsy Cuckoo Bumble Bee and found drastic declines in all three occurring host species Yellow-banded Bumble Bee, Western Bumble Bee and Rusty-patched Bumble Bee (Cameron *et al.* 2011).

HABITAT

Habitat Requirements

Nesting Habitat:

Gypsy Cuckoo Bumble Bee is a social parasite or cuckoo in nests of bumble bees in the subgenus *Bombus senso stricto* Host species select abandoned underground rodent burrows as nest sites (Plath 1934), and have been collected in various habitats such as montane meadows, old fields, mixed farmlands, urban areas and open woodlands.

Foraging Habitat:

Gypsy Cuckoo Bumble Bee are generalist foragers, primarily for nectar (see Colla and Dumesh 2010) and are associated with food plants flowering close to wooded areas (Colla and Dumesh 2010) and blueberry fields (*Vaccinium spp.*) (Sheffield pers. comm. 2011)

Overwintering Habitat:

Overwintering habitat requirements are unknown but in general, bumble bees overwinter in the ground, in mulch or other decomposing vegetation, and in rotting logs near nesting sites (Macfarlane 1974).

Habitat Trends

Gypsy Cuckoo Bumble Bee has one of the largest ranges of all bumble bee species in Canada. It is unlikely that specific habitat trends have caused its decline at such large scales, though habitat loss due to urbanization or intensive agriculture may threaten this species (via its hosts) in the southern parts of its range along the international border. Habitat fragmentation, new agricultural development, including the conversion of insect-pollinated crops to wind-pollinated or greenhouse systems), and/or agricultural intensification, possibly in combination with increased pathogen rates have likely contributed to the decline in habitat quality for this species.

Climate change-induced habitat alteration may also negatively impact this species via the effect on its hosts, but more research is required.

BIOLOGY

Life Cycle and Reproduction

Gypsy Cuckoo Bumble Bee is a socially parasitic (or cuckoo) bumble bee, and follows the same life cycle pattern of its host bumble bee species. The generation time is one year. In the spring, females of the subgenus *Psithyrus* (cuckoo bumble bees) invade nests of social *Bombus* (true bumble bees) and displace the resident queen (either by killing or injuring her). The daughters (workers) of the host queen are used by the cuckoo to rear their own offspring (Michener 2000) through the use of chemical cues (Zimma *et al.* 2003). Eggs hatch approximately four days later and the small larvae begin to feed on pollen and nectar. The larval stage of bumble bees has four instars. After almost two weeks of development, larvae spin cocoons and pupate. Pupae develop for another two weeks before hatching as full-sized adults. In total, development takes approximately five weeks but varies with temperature and food supply (Alford 1975). Males and females of *Psithyrus* emerge (Figure 5) and after mating, males die and females overwinter.

One Rusty-patched Bumble Bee colony dug up by Plath (1934) on August 9th contained the old queen, one-hundred Rusty-patched Bumble Bee workers, three Gypsy Cuckoo Bumble Bee females and six Gypsy Cuckoo Bumble Bee males. The colony was observed until the end of September and produced twenty-nine Gypsy Cuckoo Bumble Bee males and sixty-one Gypsy Cuckoo Bumble Bee females. Although the injured Rusty-patched Bumble Bee queen was seen with a distended abdomen and laying eggs, no further Rusty-patched Bumble Bee males, workers or queens were produced. Fisher (1983) hypothesized that the presence of a live Rusty-patched Bumble Bee queen is required by Gypsy Cuckoo Bumble Bee to suppress ovarian development of the worker caste, but that the Gypsy Cuckoo Bumble Bee female eats the eggs produced by the Rusty-patched Bumble Bee queen to reduce competition with her offspring. Similar details are not known for other hosts/potential hosts in Canada, including Western Bumble Bee Yellow-banded Bumble Bee, and Cryptic Bumble Bee.

Very little is known about Gypsy Cuckoo Bumble Bee mating behaviour*.* Adults visit flowers, both after emergence (sometime in the autumn) and, females only, prior to nest invasion in the spring (Antonovics and Edwards 2011). Phenology differs with latitude and altitude but generally females emerge approximately one month after the host species (Plath 1934) and are detected until late summer. Males emerge early summer and are detected until late autumn. Figure 6 shows the phenology of the species in southern Ontario, one of the best-sampled regions of Canada. Phenology for Gypsy Cuckoo Bumble Bee likely differs slightly by latitude, elevation and host emergence but similar information is not known for other parts of its range.

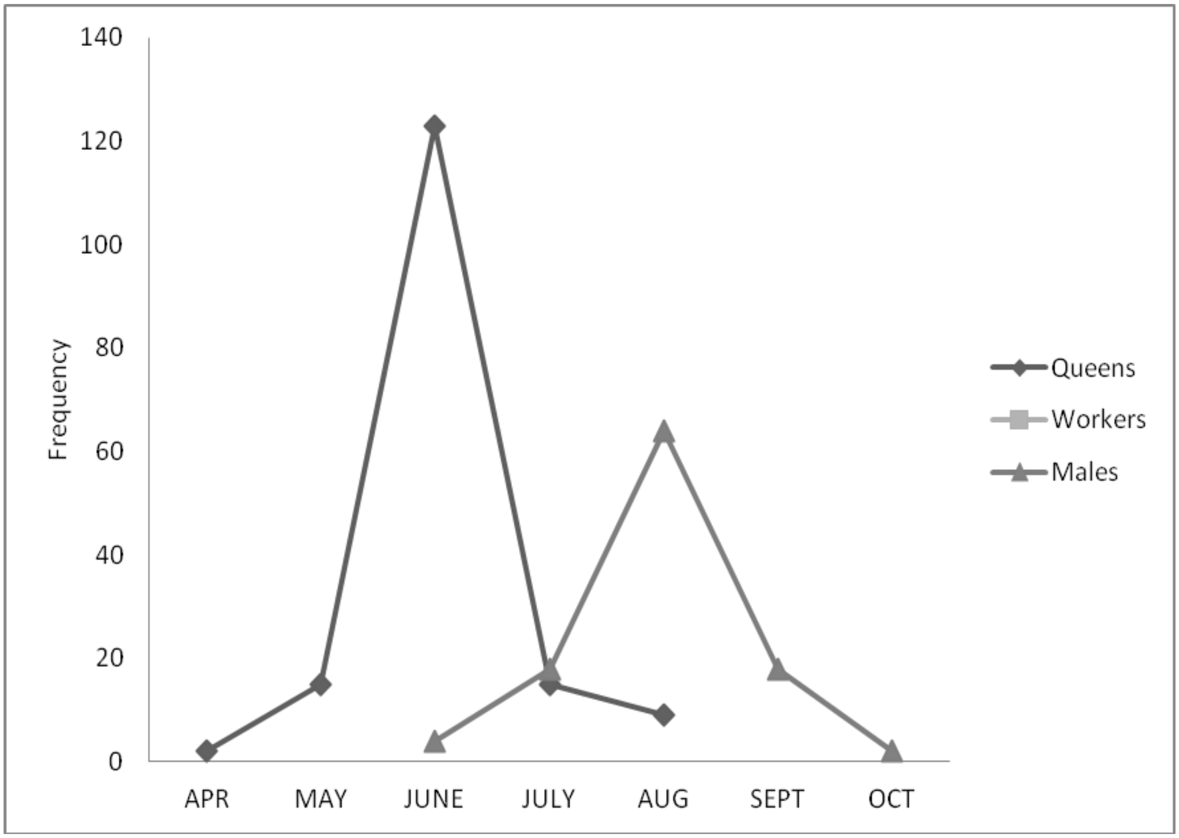

Figure 6. Phenology for Gypsy Cuckoo Bumble Bee in southern Ontario (specimens from 1883-2008), earliest spring record April 21 (n= 275 [note additional historic records have been added to Ontario records since this graph was produced, see Table 2]) (reproduced with permission from Colla 2012).

Table 1. Number of North American records of selected *Bombus* species by time period and results of logistic regression on relative abundance [* indicates the species is a social parasite (cuckoo); bold/underlined indicates significant change in relative abundance over time] (from Colla *et al.* 2012).

Species	Total records in North America	<1931	1931-1960	1961-1990	1991-2009	Slope (sign indicates direction of change)	X^2	P-value
Rusty-patched Bumble Bee (*B. affinis*)	1563	355	303	812	93	-0.2779	0.5281	0.4674
Gypsy Cuckoo Bumble Bee (*B. bohemicus*)*	941	311	280	267	83	**-0.5166**	**13.7488**	**0.0002**
Lemon Cuckoo Bumble Bee (*B. citrinus**)	1202	222	217	178	585	0.1750	0.4106	0.5217
Fernald's Cuckoo Bumble Bee (*B. fernaldae**)	474	77	277	97	23	-0.5064	1.0955	0.2952
Common Eastern Bumble Bee (*B. impatiens*)	9111	1141	851	2709	4410	**0.3984**	**6.7176**	**0.0095**

Species	Total records in North America	<1931	1931-1960	1961-1990	1991-2009	Slope (sign indicates direction of change)	X^2	P-value
Indiscriminate Cuckoo Bumble Bee (*B. insularis**)	1025	159	361	470	35	-0.3099	0.5251	0.4687
Yellow-banded Bumble Bee (*B. terricola*)	3724	963	456	1632	673	-0.1723	0.4516	0.5016
Variable Cuckoo Bumble Bee (*B. variabilis)**	94	76	11	7	0	**-1.7406**	**39.2118**	**0.0000**
Total (all species)	69600	12375	16093	21386	19746	-0.0682	1.2002	0.2733

Table 2. Number of Gypsy Cuckoo Bumble Bee records by province. Records compiled for this status report are part of a database that is continuously being updated with new information. More than 70 individuals and institutions contributed to the dataset, and are listed at: www.leifrichardson.org/bbna.html.

Province	Earliest record	Most recent record	Number of records*	Sites collected
Alberta	1953	1983	15	McMurray, Calais, Beaverlodge, Delburne, Fairview, Lethbridge, Jasper
British Columbia	1915	1988	11	Revelstoke, Golden, Fort Nelson, Peters Lake, Kenney Dam, 40km South of Quesnel
Manitoba	1924	1986	84	Teulon, Aweme, Cormorant Lake, Winnipeg, Carberry, Victoria B[each], The Pas, Wanless, Erickson, Bowsman and specimens in Turnock *et al.* 1986.
New Brunswick	1914	1961	8	Painsec, Fredericton, St. Andrews, Coldbrook
Newfoundland and Labrador	1925	1979	5	Grand Falls, Goose Bay, Codroy Valley
Nova Scotia	1910	2002	45	Barrington Passage, Digby, Antigonish, Jimtown, Ottawa, Thession, Halifax, South Maitland, Shubernacadie Lake, Truro, Merigomish Harbour, Pleasant River, McNabs Island, Meat Cove, Pleasant Bay, Debert, Belaps Cove, West Dover, Greenfield, Mount Uniacke, Armdale, Whycocomagh, West Black Rock, Middleton, Cheticamp (Cape Breton Island)
Northwest Territories	1948	1972	38	Reindeer Depot, Norman Wells, Fort Smith, Fort Simpson, Hay River, Aklavik, Fort McPherson, No Name Creek
Yukon	1916	1962	4	Dawson, and non-gazetted sites
Saskatchewan	1938	1972	34	Saskatoon, Waskesiu Lake, Love, White Fox, Hudson Bay, Torch River, Estevan, Candle Lake, Greenwater Lake, Emma Lake, Meadow Lake, Val Marie, Melfort, Indian Head
Ontario	1883	2008	352	Throughout southern Ontario, including Toronto, Guelph, London, Mica Bay, Merivale, Ottawa, Pinery Provincial Park, Port Franks, Presqu'ile Provincial Park, Speedside, Sudbury and other sites.
Quebec	1913	2008	121	Throughout southern Quebec including Lakeside, St.-Hilaire, Shawbridge, Montréal, Lac Jean-Venne, Luskville Falls, Gaspé, Hull, Lanoraie. and other sites.
Prince Edward Island	1970	1983	5	Riverdale, Vernon River, Charlottetown, Cornwall
Total			722	

* Historical records are continually being added to the database, as bee taxonomists accurately identify more museum specimens.

Physiology and Adaptability

Female *Psithyrus* are adapted for their parasitic lifestyle and have a thicker, more protective exoskeleton, larger mandibles, greater number of ovarioles and a longer venom gland compared to host females (Fisher and Sampson 1992). They do not have hindleg corbicula (so do not carry pollen) and their abdomens generally have less pile.

In one study, females emerged approximately one month after its host species Rusty-patch Bumble Bee (Plath 1934). Although this host species is only in a small portion of Gypsy Cuckoo Bumble Bee range in Canada, the emergence pattern is probably similar for other host species in other parts of its range.

Dispersal and Migration

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

There is some evidence bumble bees are able to disperse long distances. Males of the well-studied Buff-tailed Bumble Bee (*B. terrestris,* and host to Gypsy Cuckoo Bumble Bee in the Old World) are estimated to fly between 2.6 and 9.9 km from the colony of origin (Kraus *et al.* 2008). Additionally, Buff-tailed Bumble Bee was introduced to Tasmania in the early 1990s and has since spread at a rate of approximately 10 km per year (Stout and Goulson 2000).

Interspecific Interactions

Gypsy Cuckoo Bumble Bee is an obligate social parasite of bumble bees in the subgenus *Bombus senso stricto*. The species detects its host using chemical cues (Fisher *et al.* 1993). In the eastern range of Gypsy Cuckoo Bumble Bee, Rusty-patched Bumble Bee was a more common host than Yellow-banded Bumble Bee (at least in New England where both species co-occur) (Plath 1934). In the west, host species are unknown but likely include Cryptic Bumble Bee, Yellow-banded Bumble Bee and Western Bumble Bee. In the Old World, Gypsy Cuckoo Bumble Bee specializes on Old World members of the same subgenus (e.g. *B. lucorum* and *B. terrestris*), and potentially the Holarctic Cryptic Bumble Bee.

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Four different analysis are used to show declines in relative abundance of Gypsy Cuckoo Bumble Bee. Relative abundance (RA) is the number of individuals of one species (e.g., Gypsy Cuckoo Bumble Bee) divided by the total number of individuals (e.g., *Bombus*) collected, and is often used as a proxy of abundance when data are not amenable to other analysis. The RA is also used as an index of search effort for Gypsy Cuckoo Bumble Bee, and it is assumed that if the species was within an area during a collection event, that it would likely have been collected. It is noted that measuring the RA of a species may not reflect actual population abundance. Historically, relative abundance data for Gypsy Cuckoo Bumble Bee is estimated at 1-2% of all bumble bees collected (Colla *et al.* 2012). Although bumble bee surveys have increased in the recent decade in some areas, few Gypsy Cuckoo Bumble Bee individuals have been recorded. For ease of reference between the next sections, these studies are numbered.

1) The first study uses a dataset of bumble bees for Canada, with 44,706 museum and observation records from 1882 – 2011 (this dataset does not include data from 2012 and 2013 [e.g., Sheffield *et al.* in prep.]). The RA of Gypsy Cuckoo Bumble Bee, western host Western Bumble Bee, and one of its eastern hosts Yellow-banded Bumble Bee were analyzed in ten-year increments and for each jurisdiction where found (Table 3; Figure 8 [YT, NT, BC, AB and SK], Figure 9 [MB, ON, QC, NB and NS] and Figure 10 [PE and NL]) and Figure 11 [all collections]).

2) Historical relative abundances of Gypsy Cuckoo Bumble Bee in North America were compared in 30 year time periods, from 1864 - 1930, 1931-1960, 1961-1990 and 1991- 2009 (Table 1).

3) Indirect results of a study in Manitoba (see Turnock *et al.* 2007) can be interpreted as data applicable to population trends for Gypsy Cuckoo Bumble Bee. In this study, traps were placed in a Canola (*Brassica rapa* L.) field to trap Bertha Armyworm (*Mamestra configurata* Wlk.). Fourteen sites in four regions located in southern MB (Swan River Valley, Western Upland, Manitoba Lowlands and Red River Valley) were sampled every two weeks from mid-June to early August, and yearly from 1986 - 1993 (Turnock *et al.* 2007).

4) A study in Guelph and surrounding areas of southern Ontario, replicated surveys completed from 1971 - 1973 (Macfarlane 1974) again in 2004 - 2006 (Colla and Packer 2008; COSEWIC 2010). Bees were collected opportunistically using insect nets and regularly sampled from April-October for both studies.

5) The conservation status (using IUCN [2001] methodology and only considering records within the past 20 years) of 21 native bumble bee species throughout their North American ranges was assessed based on more than 69,000 georeferenced records dating back to 1864 (Colla *et al.* 2012). Grid cells measuring 50 km x 50 km were resampled for bumble bees.

Table 3. Relative abundance of Gypsy Cuckoo Bumble Bee (GCBB) and two of its hosts, Western Bumble Bee (WBB) and Yellow-banded Bumble Bee (YBBB) compared with databased *Bombus* collection data (1882 - 2011) in Canada. Note the decline in relative abundance of GCBB from 1991 - 2001 and 2002 - 2011 (red). See Figures 8 - 12 for graphical representation of this data. More than 70 individuals and institutions contributed to the dataset, and are listed at: www.leifrichardson.org/bbna.html. Specimens compiled in a dataset for Williams *et al.* 2014.

		Relative abundance of Gypsy Cuckoo Bumble Bee in ten-year intervals (Figures 8 – 11)												
		1882-1891	**1892-1901**	**1902-1911**	**1912-1921**	**1922-1931**	**1932-1941**	**1942-1951**	**1952-1961**	**1962-1971**	**1972-1981**	**1982-1991**	**1992-2001**	**2002-2011**
YT	GCBB	-	-	-	0.048	-	-	0.013	-	0.003	-	-	-	-
	WBB	-	-	0.50	0.38	0.67	-	0.18	0.12	0.69	0.36	0.35	0.50	0.63
	YBBB	-	-	-	-	-	-	-	-	-	-	-	-	-
NT	GCBB	-	-	-	-	-	-	0.06	0.25	0.005	0.03; 1 specimen	-	-	-
	WBB	-	-	-	-	-	-	-	-	-	-	-	-	0.09
	YBBB	-	-	-	-	0.900	-	0.004	0.250	0.000	0.182	-	0.167	0.221
NU	GCBB	-	-	-	-	-	-	-	-	-	-	-	-	-
	WBB	-	-	-	-	-	-	-	-	-	-	-	-	-
	YBBB	-	-	-	-	-	-	-	-	-	-	-	-	-
BC	GCBB	-	-	-	0.003	-	-	0.006	-	0.01	-	0.0044; 1 specimen	-	-
	WBB	0.40	0.17	0.30	0.22	0.24	0.31	0.30	0.36	0.50	0.44	0.45	0.43	0.03
	YBBB	-	-	0.006	-	0.003	-	0.029	0.008	0.015	0.138	0.020	0.086	0.002
AB	GCBB	-	-	0.017	0.012	-	-	0.007	0.024	0.02	0.008; 1 specimen	0.034; 2 specimens	-	-
	WBB	0.18	0.09	0.09	0.14	0.20	0.15	0.30	0.18	0.16	0.13	0.02	0.83	0.07
	YBBB	0.077	-	0.017	0.012	0.247	0.051	0.000	0.043	0.060	0.008	-	-	0.135
SK	GCBB	-	-	-	-	-	0.057	-	-	0.03	0.56; 5 specimens	-	-	-
	WBB	-	-	-	-	-	0.06	0.02	-	0.01	-	-	0.09	0.03
	YBBB	0.500	-	-	0.065	-	0.071	0.107	0.500	0.284	-	-	0.364	-
MB	GCBB	-	-	-	0.018	0.045	-	-	0.09	-	0.32; 6 specimens	0.035; 5 specimens	0.14; 1 specimen	-
	WBB	-	-	-	-	-	0.46	-	-	-	-	0.01	-	-
	YBBB	-	-	0.200	0.464	0.727	0.224	0.795	0.351	0.256	0.316	0.716	0.429	0.019
ON	GCBB	0.1; 3 specimens	0.075; 4 specimens	0.036	0.04	0.13	0.09	0.06	0.09	0.02	0.02; 46 specimens	0.012; 23 specimens	0.045; 65 specimens	0.00027; 1 specimen
	WBB	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	YBBB	0.100	0.170	0.325	0.028	0.292	0.148	0.113	0.078	0.393	0.416	0.542	0.310	0.009

		Relative abundance of Gypsy Cuckoo Bumble Bee in ten-year intervals (Figures 8 – 11)												
		1882-1891	**1892-1901**	**1902-1911**	**1912-1921**	**1922-1931**	**1932-1941**	**1942-1951**	**1952-1961**	**1962-1971**	**1972-1981**	**1982-1991**	**1992-2001**	**2002-2011**
QC	GCBB	-	-	-	0.29	0.09	0.08	0.04	-	0.12	0.34; 12 specimens	0.47; 45 specimens	0.28; 29 specimens	0.0066; 10 specimens
	WBB	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	YBBB	-	-	0.077	0.018	0.233	0.032	0.115	0.725	0.207	0.171	0.292	0.288	0.021
NB	GCBB	-	-	-	0.038	-	-	-	0.33	-	0.02; 7 specimens	-	-	-
	WBB	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	YBBB	-	-	-	0.038	-	0.400	-	0.667	0.391	0.356	0.818	0.399	0.200
NS	GCBB	-	-	-	0.052	0.04	-	-	0.15	0.29	0.006; 1 specimen	0.035; 4 specimens	0.07; 16 specimens	0.02; 2 specimens
	WBB	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	YBBB	-	-	0.169	0.247	0.654	0.184	-	0.135	0.419	0.479	0.281	0.158	0.173
PE	GCBB	-	-	-	-	-	-	-	-	0.15	0.02; 2 specimens	2 0.04; specimens	-	-
	WBB	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	YBBB	-	-	-	-	-	0.600	-	1.000	0.208	0.384	0.064	1.000	0.037
NL	GCBB	-	-	-	-	0.042	-	0.07	-	-	0.09; 3 specimens	-	-	-
	WBB	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	YBBB	-	-	0.750	0.222	0.083	0.333	0.250	-	-	0.594	0.000	0.416	0.050
All	GCBB	0.034	0.026	0.01	0.044	0.035	0.035	0.029	0.06	0.02	0.024	0.03	0.05	0.00089
	WBB	0.15	0.08	0.13	0.09	0.14	0.12	0.10	0.09	0.13	0.05	0.05	0.02	0.02
	YBBB	0.080	0.058	0.113	0.041	0.201	0.097	0.105	0.143	0.249	0.355	0.448	0.297	0.033

Table 4. The threat classification below is 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 web site (CMP 2010). For information on how the values are assigned, see Master *et al.* (2009) and table footnotes for details. Threats for Gypsy Cuckoo Bumble Bee were assessed across the species' geographic range in Canada. Threats calculator completed by Sheila Colla, Jennifer Heron, Cory Sheffield and Dave Fraser (November 2013). For additional threat information see Threats section.

		Level 1 Threat Impact Counts	
Threat Impact		**high range**	**low range**
A	Very High	0	0
B	High	0	0
C	Medium	0	0
D	Low	2	2
	Calculated Overall Threat Impact:	Low	Low

Threat		Impact (calculated)	Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1	Residential & commercial development	Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	Negligible scope because there are large areas of natural habitat where development is not ongoing. Slight severity because cumulative impacts of housing and industrial development surrounding the urban centres of western Canada, specifically in southern regions approximately 200km from the US border, often results in complete loss of habitat High timing because the practice is continuing.
1.1	Housing & urban areas	Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	Another suspected threat to host colony populations is habitat loss as a result of agricultural intensification and increased urbanization. Both Gypsy Cuckoo Bumble Bee and host bumble bees require large amounts of pollen over a long period of time, as reproductives for the next generation are only produced towards the end of the colony cycle.
1.2	Commercial & industrial areas	Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	Another suspected threat to host colony populations is habitat loss as a result of agricultural intensification and increased urbanization.
1.3	Tourism & recreation areas					N/A; some recreational development may cause bee habitat to be lost, but overall other tangential impacts may affect bee habitat (e.g., pesticide use on golf courses, water diversion, etc.) and captured in other threats.
2	Agriculture & aquaculture	Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	Negligible scope because there are large areas of natural habitat where agricultural practices do not apply; slight severity because there are agricultural areas where bees are abundant and widespread; high timing because the practice is continuing.

Threat		Impact (calculated)	Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
2.1	Annual & perennial non-timber crops	Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	Another suspected threat to host colony populations is habitat loss as a result of agricultural intensification. Both Gypsy Cuckoo Bumble Bee and host bumble bees require large amounts of pollen over a long period of time, as reproductives for the next generation are only produced towards the end of the colony cycle. 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). Small parts of the Canadian range of Gypsy Cuckoo Bumble Bee (although potentially the most suitable) contain some of the most highly urbanized/ farmed regions of Canada (e.g., southern ON and southern regions of SK and MB). Suitable habitat is possibly in short supply and difficult to find in these regions for this species and its hosts.
2.2	Wood & pulp plantations					N/A
2.3	Livestock farming & ranching					N/A
2.4	Marine & freshwater aquaculture					N/A
3	Energy production & mining					
3.1	Oil & gas drilling					N/A
3.2	Mining & quarrying					N/A
3.3	Renewable energy					N/A
4	Transportation & service corridors	Negligible	Negligible (<1%)	Unknown	High (Continuing)	Negligible scope because there are large areas of natural habitat where road building and utility/service lines are not planned. Negligible severity because in many cases transportation corridors may leave habitat more open for bees (provided the transportation corridor is not paved). High timing because the practice is continuing.
4.1	Roads & railroads	Negligible	Negligible (<1%)	Unknown	High (Continuing)	N/A; may temporarily increase habitat adjacent to roadsides
4.2	Utility & service lines	Negligible	Negligible (<1%)	Unknown	High (Continuing)	N/A; may temporarily increase habitat adjacent to roadsides
4.3	Shipping lanes					N/A
4.4	Flight paths					N/A
5	Biological resource use	Not a Threat	Negligible (<1%)	Negligible (<1%)	High (Continuing)	N/A
5.1	Hunting & collecting terrestrial animals					N/A

Threat		Impact (calculated)	Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
5.2	Gathering terrestrial plants					N/A
5.3	Logging & wood harvesting	Not a Threat	Negligible (<1%)	Negligible (<1%)	High (Continuing)	The threat is considered negligible. Logging may temporarily increase available habitat if there are habitat connections.
5.4	Fishing & harvesting aquatic resources					N/A
6	Human intrusions & disturbance	Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	Negligible scope because there are large areas of natural habitat where recreational activities are not ongoing; negligible severity because recreational activities may trample or decrease host nest sites, although every host nest will not likely have Gypsy Cuckoo Bumble Bee; high timing because the practice is continuing.
6.1	Recreational activities	Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	N/A; some recreational activities may cause local extirpations of nests; overall likely minor.
6.2	War, civil unrest & military exercises					N/A
6.3	Work & other activities					N/A
7	Natural system modifications					
7.1	Fire & fire suppression					N/A
7.2	Dams & water management/use					N/A
7.3	Other ecosystem modifications					N/A
8	Invasive & other problematic species & genes	Medium	Small (1-10%)	Extreme (71-100%)	High (Continuing)	Small scope because the spread of invasive species is primarily within the urban and agricultural areas of Canada. The natural habitats do not appear to have non-native bees present. Pathogen spillover and impacts remain unstudied in much of the ssp. range. Extreme severity because these practices impact bees. High timing because these practices are continuing.

Threat		Impact (calculated)	Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
8.1	Invasive non-native/alien species	Medium	Small (1-10%)	Extreme (71-100%)	High (Continuing)	The introduction and use of Common Eastern Bumble Bee (*B. impatiens*) for pollination services in western Canada may further impact declining host populations of Western Bumble Bee and Yellow-banded Bumble Bee. Common Eastern Bumble Bee may out-compete native bee species for nesting habitat or forage resources, and may serve as a pathogen or disease source. Pathogen spillover is a poorly understood threat for bumble bees. The use of infected commercial bumble bees (e.g., Common Eastern Bumble Bee in Canada) 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). Lab studies have shown the parasite species *Crithidia bombi* and *Nosema bombi* (suspected) have devastating effect on Bombus colony-founding queens, foraging workers and entire nests (Brown *et al.* 2000, 2003; Otterstatter *et al.* 2005). The increased use of bumble bees in greenhouse operations in recent decades has been implicated in the decline of members of the subgenus *Bombus*.
8.2	Problematic native species					N/A
8.3	Introduced genetic material					N/A
9	Pollution	Medium	Small (1-10%)	Serious (31-70%)	High (Continuing)	Small scope because there are large areas of natural habitat where the pesticide is not applied; serious severity because of the known impacts of pesticides, and high timing because the practice is continuing.
9.1	Household sewage & urban waste water					N/A
9.2	Industrial & military effluents					N/A
9.3	Agricultural & forestry effluents	Medium	Small (1-10%)	Serious (31-70%)	High (Continuing)	Imidacloprid (a neonicotinoid), pose a particular threat to bees (compared to other pesticides) because they are harmful even at concentrations in the parts per billion (ppb) range (Environmental Protection Agency [EPA] 1994; Marletto *et al.* 2003). These pesticides are systemic and travel throughout the plant.
9.4	Garbage & solid waste					N/A

Threat		Impact (calculated)	Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
9.5	Air-borne pollutants					N/A
9.6	Excess energy					N/A
10	Geological events					N/A
10.1	Volcanoes					N/A
10.2	Earthquakes/tsunamis					N/A
10.3	Avalanches/landslides					N/A
11	Climate change & severe weather	Not calculated	Pervasive (71-100%)	Unknown	High (Continuing)	Pervasive scope because climate change is ongoing across the entire species range. Unknown severity because impacts are unstudied at a large scale. High timing because the threat is continuing.
11.1	Habitat shifting & alteration					N/A
11.2	Droughts		Pervasive (71-100%)	Unknown	High (Continuing)	Climate change is another possible threat (Williams and Osborne 2009). Bumble bee species been shown to have narrow climatic tolerances are more vulnerable to extrinsic threats (Williams *et al.* 2009). Climatic tolerances for Gypsy Cuckoo Bumble Bee are not currently known, but there is evidence one of the species' hosts (Rusty-patched Bumble Bee) may be negatively impacted by climate change due to the increase in precipitation variability over time (Kerr *et al.* in revision).
11.3	Temperature extremes					N/A
11.4	Storms & flooding					N/A

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

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

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

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

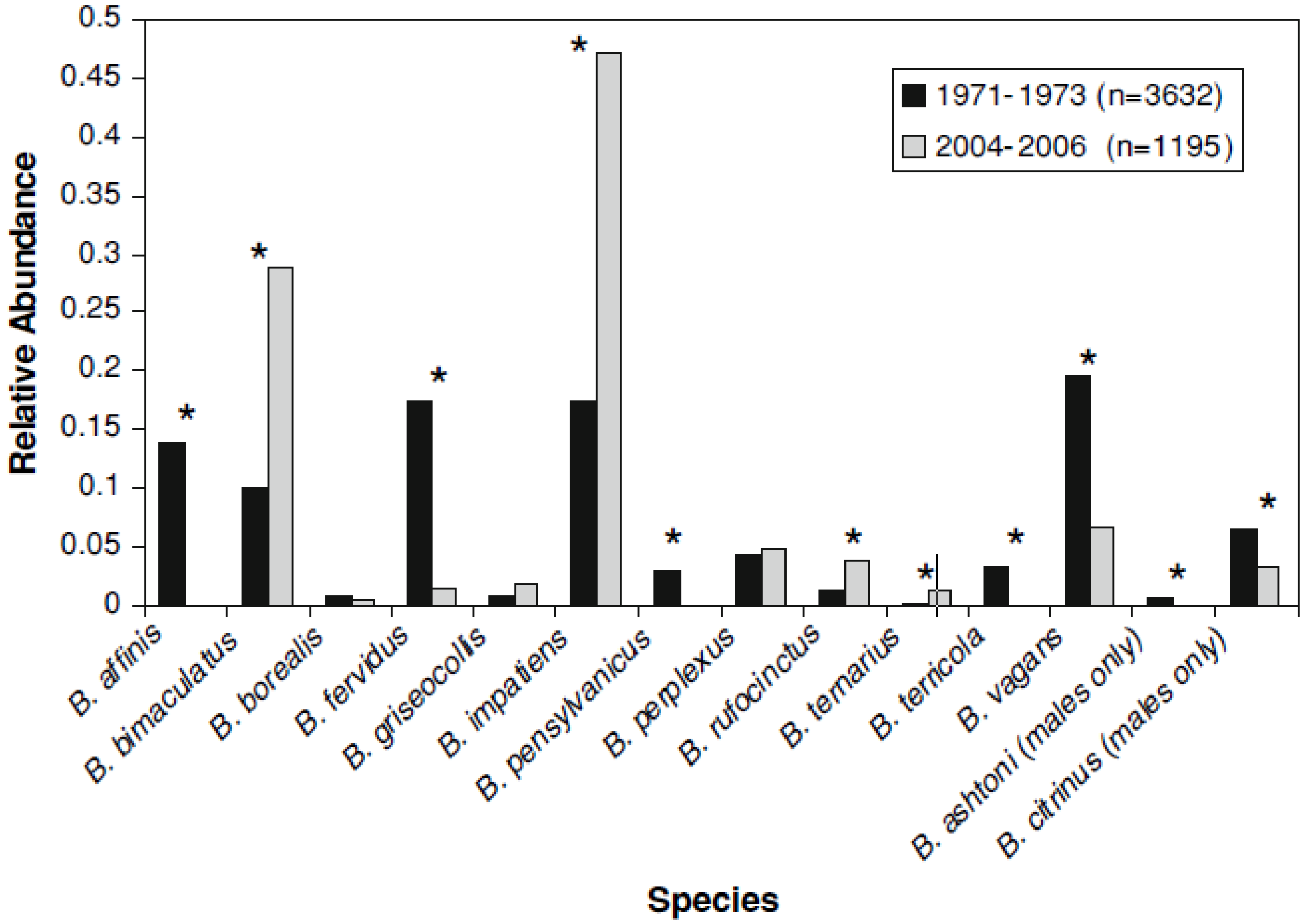

Figure 7. Comparison of the relative abundance of each bumble bee species collected from 1971-1973 (black) and 2004-2006 (grey) in Guelph and Belwood, Ontario (* indicate P <0.0001) (reproduced with permission from Colla 2012).

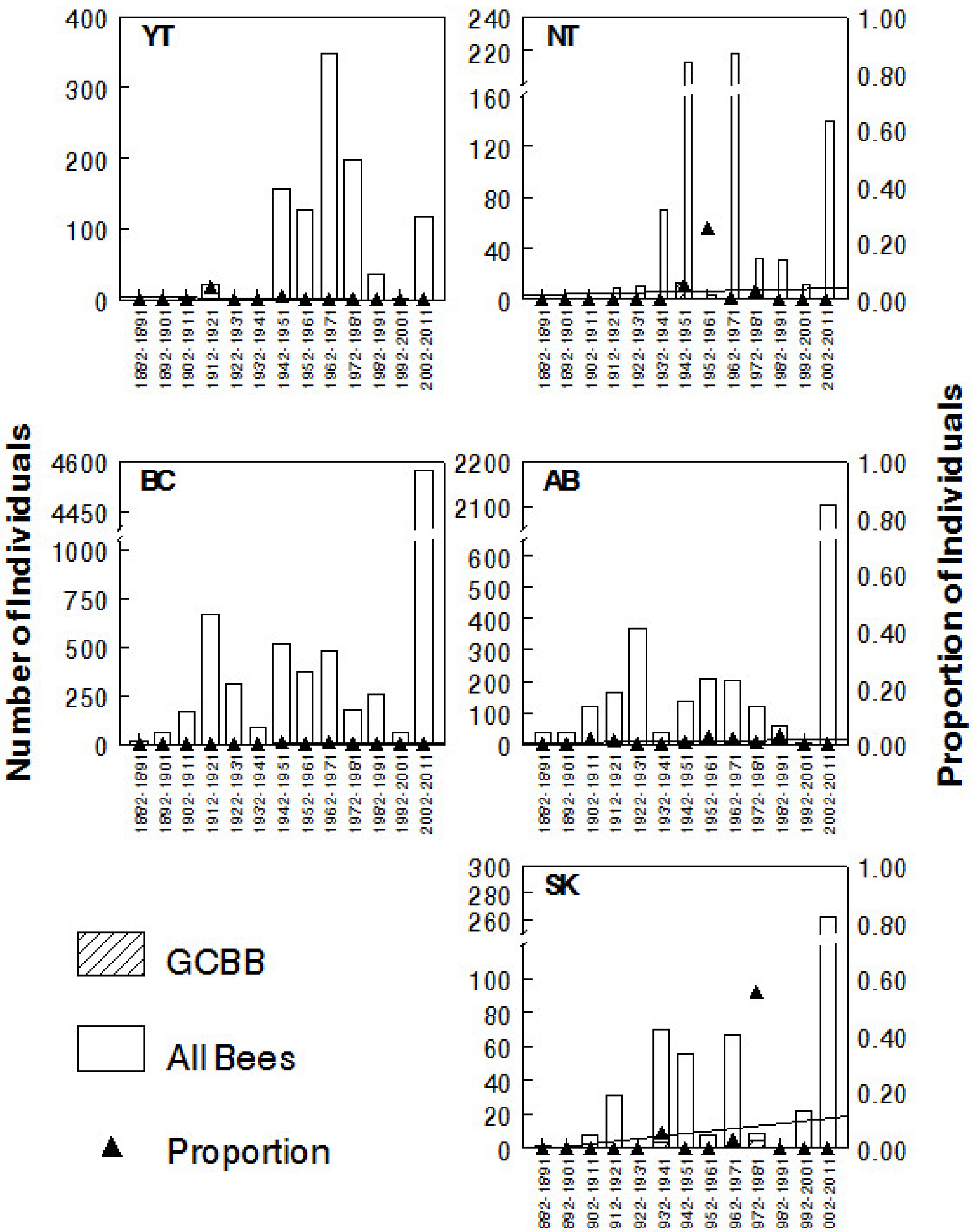

Figure 8. Relative abundance of Gypsy Cuckoo Bumble Bee (GCBB) in YT, NT, BC, AB and SK based on all databased *Bombus* records in Canada (1882 - 2011). The left Y-axis (shaded portions of bars) indicates GCBB specimens and the right Y-axis (triangles) represents the proportion of GCBB specimens by ten-year intervals. Linear regression was used to examine trends in relative abundance in GCBB over time; the line represents a best fit of the data. See also Table 3. Graphs generated using Minitab ® software.

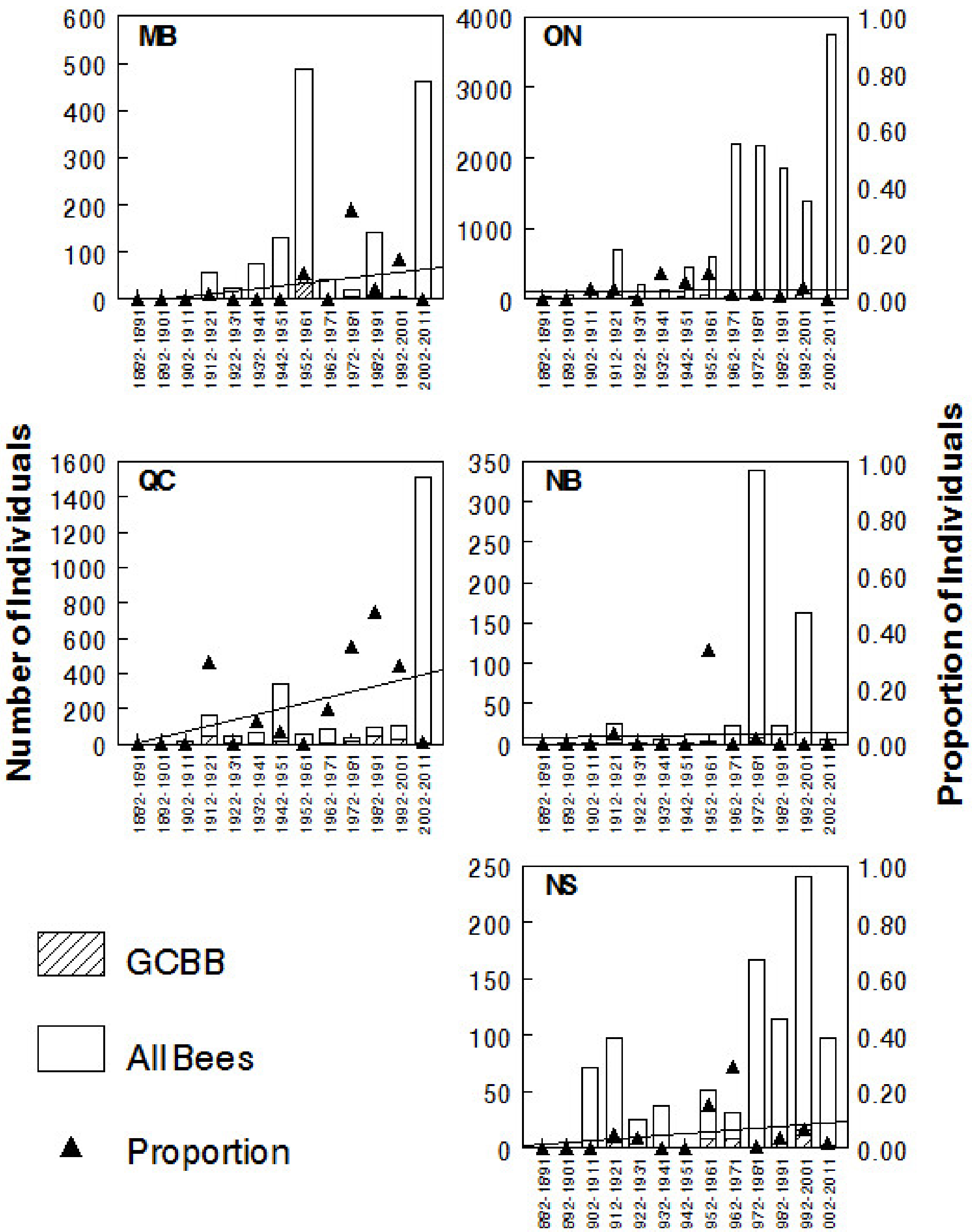

Figure 9. Relative abundance of Gypsy Cuckoo Bumble Bee (GCBB) in MB, ON, QC, NB and NS based on all databased *Bombus* records in Canada (1882 - 2011). The left Y-axis (shaded portions of bars) indicates GCBB specimens and the right Y-axis (triangles) represent the proportion of GCBB specimens by ten-year intervals. Linear regression was used to examine trends in relative abundance in GCBB over time; the line represents a best fit of the data. See also Table 3. Graphs generated using Minitab ® software.

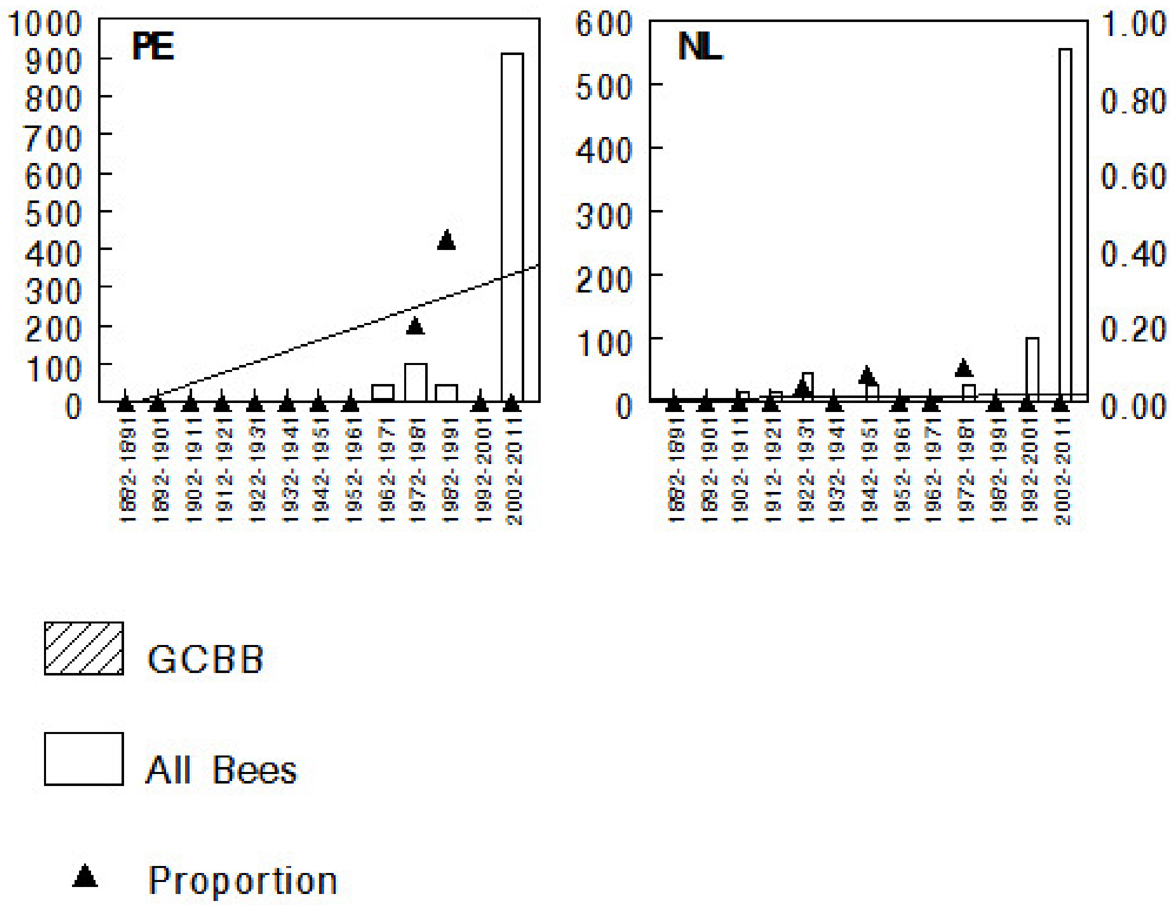

Figure 10. Relative abundance of Gypsy Cuckoo Bumble Bee (GCBB) in PE and NL based on all databased *Bombus* records in Canada (1882 - 2011). The left Y-axis (shaded portions of bars) indicates GCBB specimens and the right Y-axis (triangles) represent the proportion of GCBB specimens by ten-year intervals. Linear regression was used to examine trends in Relative abundance in GCBB over time; the line represents a best fit of the data. See also Table 3. Graphs generated using Minitab ® software.

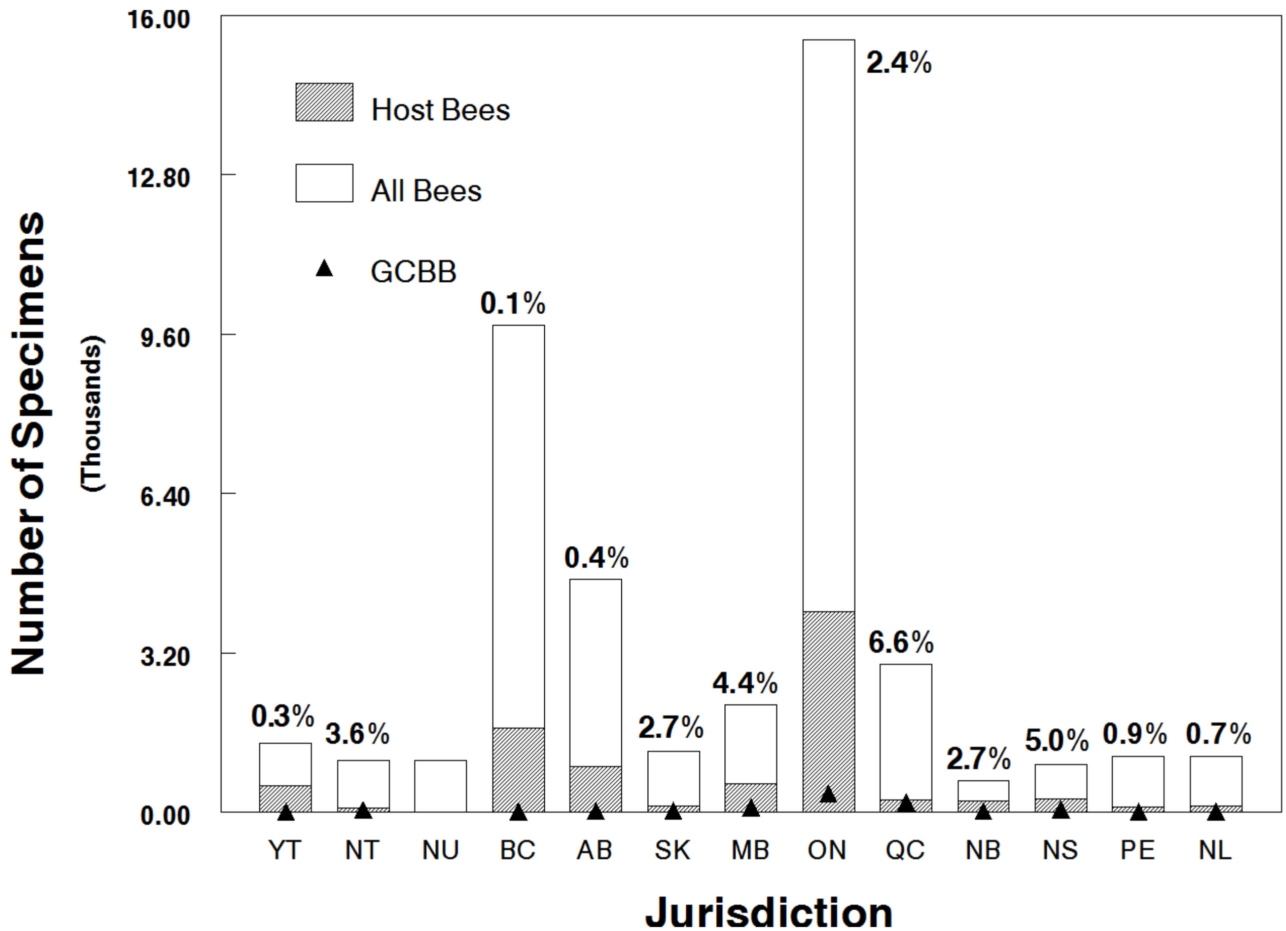

Figure 11. Total number of databased bumble bee specimens in Canada (1882 - 2011) from each province and territory; triangles represent the number of Gypsy Cuckoo Bumble Bee (GCBB) specimens. Values above each bar represent the percentage of specimens, which are GCBB. See also Table 3. Graphs generated using Minitab ® software.

Abundance

11) The RA of Gypsy Cuckoo Bumble Bee declines > 90% when the time interval 1992 - 2001 (0.5) is compared with 2002 - 2011 (0.00089) (Table 3; Figures 8 - 10).

The RA of the host species also declined within the past ten years. In BC, RA of Western Bumble Bee declines from approximately 40% (1992 - 2001) to approximately 3% within the last ten-year increment (2002 - 2011). In AB, RA of Western Bumble Bee declines from more than 80% (1992 - 2001) to less than 10% (2002 - 2011). The eastern host, Yellow-banded Bumble Bee, does not exhibit the same declines as the western host.

2) Historical relative abundances of Gypsy Cuckoo Bumble Bee in North America show a decline (Colla *et al.* 2010). From 1864 - 1930 RA is 2.5%, 1931-1960 is 7%, 1961-1990 is 1.2 % and 1991- 2009 is 0.4% (n= 69600 *Bombus*) (Table 1). This decline in relative abundance over these time periods is statistically significant (X^2= 13.7488, p-value =0.0002) (Colla *et al.* 2012).

3) The MB study recorded 47 Gypsy Cuckoo Bumble Bee from 1986-1993 in all regions except the Red River Valley site in 1986 (Turnock *et al.* 2007). In 1986, a total of 398 bumble bees were collected with RA of Gypsy Cuckoo Bumble Bee 1.1% of bees collected (Turnock *et al.* 2007). Surveys in remaining years (1987-1993) did not record Gypsy Cuckoo Bumble Bee (total of 1891 *Bombus* collected) (Turnock *et al.* 2007).

4) The Ontario (Guelph and Belwood) study shows that from 1971-1973, the RA of Gypsy Cuckoo Bumble Bee was 1% (n = 3632 specimens), while its hosts Rusty-patched Bumble Bee and Yellow-banded Bumble Bee made up 14% and 4%, respectively (Figure 7; Colla and Packer 2008). Neither Gypsy Cuckoo Bumble Bee nor Rusty-patched Bumble Bee was recorded during surveys from 2004 - 2006 within these areas (n = 1195), and only two specimens of Yellow-banded Bumble Bee were recorded (Colla and Packer 2008).

5) The proportion of re-sampled historical (1864-1990) 50 km x 50 km grid cells occupied by Gypsy Cuckoo Bumble Bee in the most recent time period (1991 - 2010) was 0.347 (Colla *et al.* 2012). In summary, Gypsy Cuckoo Bumble Bee was found in only 35% of those portions of its historical range (209 grid cells) that had been resampled at least once from 1991 - 2010. The species significantly declined throughout its entire range, unlike other cuckoo bee species (e.g., Lemon Cuckoo Bumble Bee [*B. citrinus*], although this species has different host taxa) (Table 1) (Colla *et al.* 2012).

Other studies that show declines include a recent study considering over 30,000 museum specimens from 438 bee species (including bumble bees) occurring in the Northeastern US (38 to 45° N latitude & -85 to - 70° W longitude); it found Gypsy Cuckoo Bumble Bee to be within the top three species in “rapid and recent decline” within the study region (Bartomeus *et al.* 2013). The other two species in decline were also bumble bees, including a host species, Rusty-patched Bumble Bee (Bartomeus *et al.* 2013).

Fluctuations and Trends

Little is known about the natural fluctuations and trends of bumble bee populations. Despite that surveys have been done over large geographic areas of Canada (e.g., Colla *et al.* 2012; Cameron *et al.* 2011; Colla and Packer 2008), there are few studies that have repeatedly surveyed sites over an entire season or several years. For bumble bees (e.g. Colla and Packer 2008) some areas may contain three or four common species and a handful of relatively rare ones. Common species will have fairly stable populations over time (e.g., large effective population sizes), whereas rare species will fluctuate and suffer from local stochastic extinction (e.g., small effective population sizes, may be uncommon members of the local bee fauna or may have more specific habitat requirements. Cuckoo bumble bees have the added complexity of being dependent on the host bee species' presence, abundance, and subsequent population dynamics.

Rescue Effect

The low abundance of Gypsy Cuckoo Bumble Bee and the possible declines of its host species make recolonization by rescue effect throughout its historical range in southern Canada unlikely. In the past decade, there have been few confirmed records from the US, all from Alaska (Williams *et al.* 2014). Immigration from Alaska may be possible if adequate host populations are present in YK. Recent surveys in YK have recorded potential host species (see Search Effort) (Cannings pers. comm. 2013).

THREATS AND LIMITING FACTORS

The International Union for Conservation of Nature-Conservation Measures Partnership (2006) (IUCN-CMP) threats calculator (Salafsky *et al.* 2008; Master *et al.* 2009) was used to classify and list threats to Gypsy Cuckoo Bumble Bee. The calculated overall threat impact is low (Table 3). The scope of most threats is difficult to quantify, mainly because much of the species range has not been surveyed and there appears not to be one unifying threat across the species range. Regardless, the species has not been collected since 2008 within parts of its range where host species are also declining (southern Canada) or are still present and not declining (YK, NT).

The most significant threat to Gypsy Cuckoo Bumble Bee is the decline of host bumble bee populations (primarily Rusty-patched Bumble Bee, Western Bumble Bee and Yellow-banded Bumble Bee) in southern Canada to abundances low enough to cause local extirpations of this cuckoo bee species.

The rapid decline of members of the subgenus *Bombus senso stricto* appears to have started in the mid-1990s (National Research Council [NRC] 2007). These declines have not yet been attributed to any one cause, but based on the timing of the observed collapse; possible threats have been hypothesized and are discussed below (NRC 2007; Evans *et al.* 2008). One species in the subgenus, Cryptic Bumble Bee, seems to be increasing its range and in abundance (Owen *et al.* 2012). Whether or not this species is a suitable host for Gypsy Cuckoo Bumble Bee is unknown.

Invasive and Other Problematic Species and Genes (Threat 8)

<u>Invasive non-native/alien species (8.1)</u>

The introduction and use of the highly successful Common Eastern Bumble Bee (*B. impatiens*) for pollination services in Canada may further impact declining host populations of Western Bumble Bee and Yellow-banded Bumble Bee in the southern parts of their range. Common Eastern Bumble Bee may out-compete some native bee species for nesting habitat or forage resources, and may serve as a source for pathogen or disease. The status of establishment of wild populations of Common Eastern Bumble Bee in western Canada is unknown, but likely to have a negative impact on native species, as has been documented in other parts of the world (Williams and Osborne 2009).

Pathogen spillover is implicated in the significant declines of many animals (e.g., Morton *et al.* 2004; Power and Mitchell 2004) but is a poorly understood threat for bumble bees. Pathogen spillover occurs when pathogens spread from a heavily infected 'reservoir' host population to a sympatric 'non-reservoir' host population (Power and Mitchell 2004). The use of infected commercial bumble bees (e.g., Common Eastern Bumble Bee) in Canada 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).

Lab studies have shown the parasite species *Crithidia bombi* and *Nosema bombi* (suspected) have devastating effect on *Bombus* colony-founding queens, foraging workers and entire nests (Brown *et al.* 2000, 2003; Otterstatter *et al.* 2005). These parasites are found in a variety of bumble bee species (Macfarlane 1974; Macfarlane *et al.* 1995; Colla *et al.* 2006), but their virulence in wild bumble bees remains unknown. Nonetheless, the increased use of commercially available bumble bee colonies in greenhouse operations in recent decades has been implicated as a possible contributing factor in the decline of members of the subgenus *Bombus*, including Rusty-patched Bumble Bee, Yellow-banded Bumble Bee and Western Bumble Bee in southern parts of the country (Thorp and Shepherd 2005; NRC 2007; Evans *et al.* 2008; COSEWIC 2010; Szabo *et al.* 2012), though seemingly not members of other subgenera. Hosts in these areas may be the most important for Gypsy Cuckoo Bumble Bee (see Figure 3), though remain relatively common in other areas.

Pollution (Threat 9)

Agricultural and forestry effluents (9.3)

It has long been known that chemicals used in agricultural applications (i.e., pesticides) can have negative impacts on bees (e.g., see Johansen and Mayer 1990; NRC 2007). Around the time when the declines of subgenus *Bombus* were observed in North America, a new pesticide, Imidacloprid (a neonicotinoid), was registered for use in the United States and Canada (1994 and 1995 respectively: Cox 2001; Pest Management Regulatory Agency [PMRA] 2001). Neonicotinoids can pose a particularly severe threat to bees because they can be harmful even at concentrations in the parts per billion (ppb) range (Environmental Protection Agency [EPA] 1994; Marletto *et al.* 2003). These pesticides are systemic, travelling throughout plant tissues and integrating with pollen and nectar; they are routinely used on golf courses and agricultural lands (Sur and Stork 2003). The effects of Imidacloprid are not lethal to bumble bees when used as directed (e.g., Tasei *et al.* 2001), though in North America studies of its effects on bumble bees have been largely tested on one species, the commercially available Common Eastern Bumble Bee, as a representative for all North American species (e.g., Gels *et al.* 2002; Morandin and Winston 2003). It is unknown if that species serves as an accurate model for all bumble bee species. Additionally, colonial insects (e.g., insects which produce reproductive individuals at the end of the colony cycle) may be negatively impacted by cumulative sub-lethal effects of this and other pesticides. Studies on the lethal and sub-lethal effects of this group of pesticides on other wild bumble bees are lacking at this time.

Residential & Commercial Development and Agriculture and Aquaculture (Threat 1 and Threat 2)

Housing and urban areas and Commercial and industrial areas (1.1 and 1.2) and Annual and perennial non-timber crops (2.1)

Another suspected threat to host colony populations is habitat loss as a result of agricultural intensification and increased urbanization. Both Gypsy Cuckoo Bumble Bee and its host bumble bees require large amounts of pollen over a long period of time, as reproductives for the next generation are only produced towards the end of the colony cycle. The increased and continuing 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 probably has had similar impact in Canada as much of the area traditionally occupied by Gypsy Cuckoo Bumble Bee and its hosts in Canada has changed significantly (Grant and Javorek 2011). The part of the Canadian range of Gypsy Cuckoo Bumble Bee adjacent to the international border though the most suitable habitat for wildlife, contains some of the most highly urbanized/ farmed regions of Canada (e.g., southern ON and southern regions of SK and MB).

Climate Change and Severe Weather (Threat 11)

Climate change is another possible threat to bumble bees worldwide (Williams and Osborne 2009). Bumble bee species with narrow climatic tolerances are shown to be more vulnerable to extrinsic threats (Williams *et al.* 2009). Climatic tolerances of Gypsy Cuckoo Bumble Bee are currently unknown, but there is some evidence that one of the species' hosts (Rusty-patched Bumble Bee) may be negatively impacted by climate change due to the increase in precipitation variability over time (Kerr *et al.* in revision). However, the other known hosts (subgenus *Bombus senso stricto*) are more widespread in Canada, and their climatic tolerances are also unknown. In general, female *Psithryrs* emerge approximately one month after its host species (Plath 1934), but it is unknown if emergence synchrony of host/parasite could be affected by climate change.

Limiting Factors

Bumble bees require a constant suite of floral resources to support colony growth: pollen and nectar needs to be constant throughout the growing season. Without these resources, emerging queens, workers and colony growth is limited. Only mated queens overwinter, so lack of abundant early season floral resources will cause colonies to die, or newly emerged queens to disperse. Abundant food resources throughout the colony growth period ensure that local populations will persist.

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 diploid males. Diploid males are usually sterile or inviable. 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. This means that as bumble bee populations decrease in size, the frequency of diploid males increases. As diploid males are attempts at female production, their increasing production in smaller populations increases the rate of population decline causing a special case of the extinction vortex: "the diploid male extinction vortex." This special form of genetic load is the largest known (Hedrick *et al.*, 2006). In practical terms, if a bee population decreases to a few reproducing individuals, it is certain to become locally extirpated even under stable environmental conditions unless its number increases within a few generations.

PROTECTION, STATUS, AND RANKS

Legal Protection and Status

There are no federal or provincial laws that protect Gypsy Cuckoo Bumble Bee, mitigate threats or protect the species nest sites or habitat.

Non-Legal Status and Ranks

- Wild Species 2010 General Status Rankings (Canadian Endangered Species Conservation Council 2011)
    - Not ranked in YT, BC, AB, SK, NT, MB
    - May be at risk in ON, QC, NS, NB, PE, NL, LB
    - Undetermined overall in Canada.

- Global Status Rank: GH (Possibly Extinct) (NatureServe 2012).

- International Union for the Conservation of Nature (IUCN) Red list: None

- Provincial/Territorial Sub-national Conservation Status Ranks:
    - YT (Status not ranked [SNR]),
    - AB (Undetermined),
    - ON (S4, apparently secure),
    - Atlantic Canada Conservation Data Centre (SNR).
    - This species is not listed in Quebec, and is not on the Liste des espèces susceptibles d'être designées menaces ou vulnérables: http://www.mddep.gouv.qc.ca/faune/especes/menacees/liste.asp#insectes .
    - Not ranked in other territories or provinces.

Habitat Protection and Ownership

Most Gypsy Cuckoo Bumble Bee records are from provincially owned and managed lands. At present, there are approximately 44 Gypsy Cuckoo Bumble Bee records from protected areas in Canada. The provinces and territories of BC, AB, SK, NB, PE, NT, YT and NU have no records within protected areas. In Ontario, the species has been recorded from Algonquin Provincial Park, Presqu'ile Provincial Park, Awenda Provincial Park, McGregor Point Provincial Park and Pinery Provincial Park. In Quebec the species has been recorded from Forillon National Park, Parc nationale des Monts-Valin, Parc nationale du Canada Forillon, Queens Park, Aylmer. In Nova Scotia, the species has been recorded from Cape Breton Highlands National Park, and in Newfoundland the species has been recorded from Gros Morne National Park.

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Authorities Contacted

Anderson, Robert. 2011. Research Scientist, Canadian Museum of Nature, Ottawa, ON.

Amirault, Diane. 2011. Biologist, Environment Canada, Bélanger; Ste-Foy, QC

Belanger, Luc. 2011. Biologist, Environment Canada, Bélanger; Ste-Foy, QC

Blaney, Sean. 2011. Botanist, Atlantic Canada Conservation Data Centre, Sackville, NB

Boates, Sherman. 2011. Manager, Biodiversity Wildlife Division Department of Natural Resources, Government of Nova Scotia, Kentville, NS

Bromwell, Vivian. 2011. Senior Species at Risk Biologist, Ontario Ministry of Natural Resources, Peterborough, ON

Bucknell, Shelagh. 2011. Pacific Wildlife Research Centre, Environment Canada, Delta, BC

Carrière, Suzanne. 2011. Biologist, Department of Environment and Natural Resources (ENR), Government of the Northwest Territories, Yellowknife, NT

Charlwood, Vanessa. 2011. Environment Canada, Yellowknife, NT

Court, Gord. 2011. Provincial Wildlife Status Biologist, Dept. of Sustainable Resource Development, Edmonton, AB.

Curley, Rosemary. 2011. Conservation Biologist, Department of Agriculture and Forestry, Charlottetown, PE

Desmet, Ken. 2011. Species at Risk Biologist, Manitoba Conservation Data Centre, Winnipeg, MB

Duncan, Dave. 2011. Biologist, Environment Canada, Edmonton, AB

Elder, K.M.F. 2011. Species at Risk Biologist, Department of Natural Resources, Kentville, NS

Fournier, Francois. 2011. Direction de la conservation de l'environnement, Environment Canada, Sainte-Foy, QC.

Fraser, Dave. 2011. Unit Head Scientific Authority Assessment, B.C. Ministry of Environment, Ecosystems Branch, Victoria, BC.

Gauthier, Isabelle. 2014. Biologiste, Coordonnatrice provinciale, espèces fauniques menacées et vulnérables, Ministère des Forêts, de la Faune et des Parcs, Québec (Québec)

Giasson, Pascal. 2011. Manager, Species at Risk Program, Fish and Wildlife Branch, Department of Natural Resources, Fredericton, NB.

Gravel, Mike. 2011. Provincial Species at Risk Biologist, Department of Natural Resources, Kentville, NS.

Howes, Briar. 2011. Ecological Integrity Branch, Parks Canada Agency, Gatineau, QC

Ingstrup, David. 2011. Biologist, Environment Canada, Edmonton. AB.

Jung, Thomas. 2011. Senior Wildlife Biologist, Environment Yukon, Whitehorse, YT.

Levesque, Annie. 2011. Biologiste, Coordonnatrice provinciale, espèces fauniques menacées et vulnérables, Ministère des Forêts, de la Faune et des Parcs, Québec (Québec)

MacDonald, Bruce. 2011. Biologist, Environment Canada, Yellowknife, NT

McConnell, Angela. 2011. Biologist, Environment Canada, Toronto, ON

Millikin, Rhonda. 2011. A/Head Population Assessment, Pacific Wildlife Research Centre, Environment Canada, Delta, BC.

Nantel, Patrick. 2011. Conservation Biologist, Parks Canada Agency, Vancouver, B.C.

Oldman, Michael. 2011. Botanist, Ontario Natural Heritage Information Centre, Perterborough, ON

Paquet, Annie. 2011. Biologiste, Coordonnatrice provinciale, espèces fauniques menacées et vulnérables, Ministère des Forêts, de la Faune et des Parcs, Québec (Québec)

Pardy, Shelley. 2011. Senior Manager, Department of Environment and Conservation, NL

Pepper, Jeanette. 2011. Science Panning Section, Saskatoon, SK

Pittoello, Gigi. 2011. Habitat Ecologist, Saskatchewan Ministry of Environment, Regina, SK

Quinlan, Richard. 2011. Biologist, Alberta Fish and Wildlife, Lethbridge, AB

Raillard, Martin. 2011. Manager, Environment Canada, Sackville, NB.

Sabine, Mary. 2011. Biologist, Department of Natural Resources, Department of Environment and Conservation, Fredericton, NB.

Squires, Susan. 2011. Ecosystem Management Ecologist, Corner Brook, NL

Stipec, Katrina. 2011. Data Management Specialist. B.C. Conservation Data Centre, Victoria, B.C.

Tuininga, Ken. 2011. Biologist, Environment Canada, Toronto, ON

Watkins, William. 2011. Wildlife and Ecosystem Protection Branch, Manitoba Department of Conservation, Winnipeg, MB.

INFORMATION SOURCES

Alford DV. 1975. Bumble Bees. London: Davis-Poynter. xii+352 pp.

Antonovics, J. and M. Edwards. 2011. Spatio-temporal dynamics of Bumble Bee nest parasites (*Bombus* subgenus *Psithyrus* ssp.) and their hosts (*Bombus* spp.). Journal of Animal Ecology 80: 999-1011.

Bartomeus, I., Ascher, J.S., Gibbs, J., Danforth, B.N., Wagner, D.L., Hedtke, S. and Winfree, R. 2013. Historical changes in northeastern US bee pollinators related to shared ecological traits. Proceedings of the National Academy of Sciences. Available at http://www.pnas.org/content/110/12/4656.full. Accessed February 21, 2014

Brousseau, P.-M. 2011. Impact de la densité de cerfs de Virginie sur les communautés d'insectes de l'île d'Anticosti. Mémoire de maîtrise, Université Laval, Québec. 92 pp.

Brown M.J.F., R. Loosli and P. Schmid-Hempel. 2000. Condition-dependent expression of virulence in a trypanosome infecting Bumble Bees. Oikos 91: 421–427.

Brown M.J.F., R. Schmid-Hempel and P. Schmid-Hempel. 2003. Strong context-dependent virulence in a host-parasite system: reconciling genetic evidence with theory. Journal of Animal Ecology 72: 994–1002.

Buidin, C., pers. comm. 2011. *Email correspondence to S. Colla. 2011*. Association Le Balbuzard de la Minganie, Rivière-Saint-Jean, Québec.

Cameron, S. A., H. M. Hines, and P. H. Williams. 2007. A comprehensive phylogeny of the Bumble Bees (*Bombus*), Biological Journal of the Linnean Society 91, 161-188.

Cameron, S.A., J.D. Lozier, J.P. Strange, J.B. Koch, N. Cordes, L.F. Solter and T. Griswold. 2011. Patterns of widespread decline in North American Bumble Bees. Proceedings of the National Academy of Science 108: 662-667.

Canadian Endangered Species Conservation Council (CESCC). 2011. Wild Species 2010: The General Status of Species in Canada. National General Status Working Group: 302 pp.

Cannings, S. pers. comm. 2011-13. Email correspondence to S. Colla and J.Heron. Biologist, Environment Canada, Whitehorse, Yukon.

Colla, S.R. (2012) The Ecology and Conservation of Eastern North American Bumblebees (*Bombus* spp*.),* Ph.D. Dissertation, York University, Toronto, ON. 214 pp.

Colla, S.R. and S. Dumesh. 2010. Natural history notes for the Bumble Bees of southern Ontario. Journal of the Entomological Society of Ontario 141: 38-67.

Colla, S.R., F. Gadallah, L. Richardson, D. Wagner and L. Gall (2012) Assessing declines of North American Bumble Bees (*Bombus* spp.) using museum specimens. Biodiversity and Conservation 21: 3585-3595.

Colla, S. R., M. C. Otterstatter, R. J. Gegear and J. D. Thomson. 2006. Plight of the Bumble Bee: Pathogen spillover from commercial to wild populations. Biological Conservation 129:461-467.

Colla, S.R. and L. Packer. 2008. Evidence for decline in eastern North American Bumble Bees (Hymenoptera: Apidae), with special focus on *Bombus affinis* Cresson. Biodiversity and Conservation 17:1379-1391.

Colla, S.R, L. Richardson and P. Williams. 2011. Bumble Bees of the Eastern United States, USDA Forest Service Publication [Online] http://www.fs.fed.us/wildflowers/pollinators/documents/Bumble BeeGuide2011.pdf [accessed September 24, 2011]

Conservation Measures Partnership (CMP). 2010. http://www.conservationmeasures.org/ [accessed February 27, 2013].

COSEWIC 2010. COSEWIC assessment and status report on the Rusty-patched Bumble Bee *Bombus affinis* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 34 pp. [Online] www.sararegistry.gc.ca/status/status_e.cfm.

COSEWIC. 2011. Guidelines for recognizing designatable units. Web site: http://www.cosewic.gc.ca/eng/sct2/sct2_5_e.cfm [accessed February 27, 2013].

Cox, C. 2001. Insecticide factsheet: Imidacloprid. Journal of Pesticide Reform 21:15-22.

Cresson, E.T. 1864. Descriptions of several new species of North American Apidae. *Proceedings of the Entomological Society of Philadelphia* **3**: 38-43.

Curley, R., pers. comm. 2011 *Email correspondence to S. Colla.* 2011. Conservation Biologist, Forests Fish and Wildlife Division, PEI Dept Environment, Energy and Forestry, Charlottetown, Prince Edward Island

Environmental Protection Agency (EPA), U.S.A. 1994. Pesticide fact sheet: Imidacloprid, Washington, D.C. Mar. 18

Evans, E., R. Thorp, S. Jepsen and S.H. Black. 2008. Status Review of Three Formerly Common Species of Bumble Bee in the Subgenus *Bombus.* The Xerces Society for Invertebrate Conservation, Portland, OR.

Fisher, R.M. 1983. Inability of the social parasite *Psithyrus ashtoni* to suppress ovarian development in workers of *Bombus affinis* (Hymenoptera:Apidae). Journal of the Kansas Entomological Society 56:69-73.

Fisher, R.M., D.R. Greenwood and G.J. Shaw. 1993. Host recognition and the study of a chemical basis for attraction by cuckoo Bumble Bees (Hymenoptera: Apidae). Journal of Chemical Ecology 19: 771-786.

Fisher, R.M. and B.J. Sampson 1992. Morphological specializations of the Bumble Bee social parasite *Psithyrus- Ashtoni* (Cresson) (Hymenoptera, Apidae) Canadian Entomologist 124:69-77.

Gels, J. A., D. W. Held, and D. A. Potter. 2002. Hazards of insecticides to the Bumble Bees *Bombus impatiens* (Hymenoptera: Apidae) foraging on flowering white clover in turf. Journal of Economic Entomology 95:722-728.

Giberson, D., 2011. pers. comm. 2011 Email correspondence via L. Packer. 2011. Professor at the University of Prince Edward Island, Charlottetown, Prince Edward Island.

Goulson, D. 2003. Bumble Bees, Their Behaviour and Ecology. Oxford University Press, Oxford, 235 pp.

Grixti, J. C., L.T. Wong, S.A. Cameron, and C. Favret. 2009. Decline of Bumble Bees (*Bombus*) in the North American Midwest. Biological Conservation 142: 75-84.

Hatfield, R.G. and G. LeBuhn. 2007. Patch and landscape factors shape community assemblages of Bumble Bees, *Bombus* spp. (Hymenoptera:Apidae), in montane meadows. *Biological Conservation* 139: 150-158.

IUCN (International Union of Conservation Networks). 2001. IUCN red list categories and criteria: Version 3.1. IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, UK. ii + 30pp.

Javorek, S.K. and M.C. Grant. 2011. Trends in wildlife habitat capacity on agricultural land in Canada, 1986 – 2006. Canadian Biodiversity: Ecosystem Status and Trends 2010, Technical Thematic Report No. 14. Canadian Councils of Resource Ministers. Ottawa, ON. vi + 46 p. http://www.biodivcanada.ca/default.asp?lang=En&n=137E1147-1

Johansen, C.A., and D.F. Mayer. 1990. Pollinator Protection. A Bee and Pesticide Handbook. Cheshire, CT. Wicwas Press.

Kerr, J., N.Szabo, S.R. Colla, L. Richardson and L. Packer (in Revision). Strongly increasing climatic variation and concurrent near extinction of a historically abundant pollinator.

Klymko, J. 2012. Personal Communication to S. Colla. Atlantic Canada Conservation Data Centre, Cornerbrook, NL.

Klymko, J. 2014. Personal Communication to C. Sheffield. Atlantic Canada Conservation Data Centre, Cornerbrook, NL.

Kosoir, A., W. Celary, P. Olejniczak, J. Fijal, W. Krol, W. Solarz, and P.Plonka. 2007. The decline of the Bumble Bees and cuckoo bees (Hymenoptera:Apidae : Bombini) of Western and Central Europe. Oryx 41:79-88

Laverty , T.M. and L. Harder. 1988. The Bumble Bees of Eastern Canada. Canadian Entomologist 120: 965-987.

Macfarlane, R. 1974. Ecology of Bombinae (Hymenoptera: Apidae) of Southern Ontario, with emphasis on their natural enemies and relationships with flowers. PhD, University of Guelph, Guelph, Ontario.

Macfarlane, R. P., J. J. Lipa, and H. J. Liu. 1995. Bumble Bee pathogens and internal enemies. Bee World 76: 130-148.

Macfarlane, R. P. and Patten, K. D. 1997. Food sources in the management of Bumble Bee populations around cranberry marshes. *In* Proceedings of the 7th International Symposium on Pollination. K. W. Richards (ed.) Acta Horticulturae: 239-244.

MacPhail, V.J. 2007. Pollination Biology of Wild Roses (Rosa spp.) in Eastern Canada. MSC thesis. University of Guelph, Ontario. 174pp.

Marletto, F., A. Patetta, and A. Manino. 2003. Laboratory assessment of pesticide toxicity to Bumble Bees. Bulletin of Insectology 56:155-158.

Master, L., D. Faber-Langendoen, R. Bittman, G.A. Hammerson, B. Heidel, J. Nichols, L. Ramsay, and A. Tomaino. 2009. NatureServe conservation status assessments: factors for assessing extinction risk. NatureServe, Arlington, Virginia, USA. Web site: http://www.NatureServe.org/publications/ConsStatusAssess_StatusFactors.pdf [accessed June 15, 2012].

McCorquodale, D., pers. comm. 2012 Email correspondence to S. Colla. 2012. Cape Breton University, Sydney, Nova Scotia

Michener, C.S. 2000. The Bees of the World. The Johns Hopkins University Press, Baltimore, 952 pp.

Mitchell, T.B. 1962 Bees of the Eastern United States. North Carolina Agricultural Experiment Station Technical Bulletin No. 152.

Morandin, L. A., and M. L. Winston. 2003. Effects of novel pesticides on bumble bee (Hymenoptera: Apidae) colony health and foraging ability. Community and Ecosystem Ecology 32:555-563.

Morton, A., Routledge, R. C. Peet, and A. Ladwig. 2004. Sea lice infection rates on juvenile pink and chum salmon in the nearshore environment of British Columbia, Canada. Canadian Journal of Fish and Aquatic Sciences 61:147-158.

National Research Council (NRC). 2007. Status of Pollinators in North America. The National Academies Press, Washington, DC.

NatureServe. 2012. [Online] http://www.NatureServe.org/explorer/ranking.htm [accessed January 22, 2013].

National Research Council (NRC) 2007. Status of pollinators in North America. Committee on the Status of Pollinators in North America, The National Academies Press, Washington, D.C. 312 pp.

Otterstatter, M.C., R.J. Gegear, S.R. Colla and J.D. Thomson. 2005. Effects of parasitic mites and protozoa on the flower constancy and foraging rate of Bumble Bees. Behavioral Ecology and Sociobiology, 58: 383-389.

Otterstatter, M.C., and J.D. Thomson. 2008 Does Pathogen Spillover from Commercially Reared Bumble Bees Threaten Wild Pollinators? PLoS One 3: e2771.

Owen, R., M.C. Otterstatter, R.V. Cartar, A. Farmer, S.R. Colla and N. O'Toole (2012) Significant expansion of the distribution of the Bumble Bee *Bombus moderatus* (Hymenoptera:Apidae) over twenty years. Canadian Journal of Zoology 90:133-138.

Packer, L., pers. comm. 2011 Email correspondence to S. Colla. 2011. Professor at York University, Toronto, Ontario

Patanaude, A. 2007. Diversity, composition and seasonality of wild bees (Hymenoptera: Apoidea) in a northern mixed-grass prairie preserve. M.Sc. Thesis, University of Manitoba, 235 pp.

Pest Management Regulatory Agency (PMRA). 2001. Imidacloprid. Regulatory Note. REG2001-11. Ottawa: Health Canada, Pest Management Regulatory Agency. Available at http://www.pmra-arla.gc.ca/english/pdf/reg/reg2001-11-e.pdf [accessed January 22, 2013].

Phillips, S.J., M. Dudik, and R.E. Shapire. 2006. Maximum entropy modeling of species geographic distributions. Ecological Modelling 190:231-259.

Plath, O.E. 1934. Bumble Bees and their ways, Macmillan, New York, US, 201 pp.

Power, A. G., and C. E. Mitchell. 2004. Pathogen Spillover in Disease Epidemics. American Naturalist 164:S79-S89.

Ratti, C.M. 2006. Bee abundance and diversity in berry agriculture. M.Sc. thesis, Simon Fraser University

Salafsky, N., D. Salzer, A.J. Stattersfield, C. Hilton-Taylor, R. Neugarten, S.H.M. Butchart, B. Collen, N. Cox, L.L. Master, S. O'Connor, and D. Wilkie. 2008. A standard lexicon for biodiversity conservation: unified classifications of threats and actions. Conservation Biology 22:897–911.

Savard, M. 2012. Données inédites sur la présence historique du *Bombus* (*Psithyrus*) *ashtoni* au sud du Québec, au Saguenay-Lac-Saint-Jean et en Minganie. Déposé au ministère des Ressources naturelles et de la Faune du Québec, 17 mai 2012. 8pp.

Sheffield, C.S., pers. comm. 2011 Email correspondence to S. Colla. 2011. Research Associate, at York University, Toronto, Ontario

Stotyn, S. 2012. Wild Bumble Bees of the Nahanni River Region, NT. Final Report, Environment Canada, 10 pp.

Stout, J.C and D. Goulson. 2000. Bumble Bees in Tasmania: their distribution and potential impact on Australian flora and fauna. Bee World 81: 80-86.

Sur, R. and A. Stork. 2003. Uptake, translocation and metabolism of imidacloprid in plants. Bulletin of Insectology 1:35-40.

Szabo, N., S.R. Colla, D.Wagner, L.F. Gall, and J.T. Kerr (2012) Is pathogen spillover from commercial bumble bees responsible for North American wild Bumble Bee declines? Conservation Letters 5: 232-239.

Tasei, J. N., G. Ripault, and E. Rivault. 2001. Hazards of Imidacloprid seed coating to *Bombus terrestris* (Hymenoptera: Apidae) when applied to Sunflower. Journal of Economic Entomology 94:623-627.

Thorp R.W., Shepherd M.D. 2005/ Profile: subgenus *Bombus*. In: Shepherd M.D., Vaughan D.M., Black S.H.(eds) Red list of pollinator insects of North America. The Xerces Society for Invertebrate Conservation, Portland, OR.

Turnock, W.J. P.G. Kevan, T.M. Laverty, & L. Dumouchel. 2007. Abundance and species of Bumble Bees in fields of canola, *Brassica rapa,* in Manitoba: an 8 year study. Journal of the Entomological Society of Ontario 137:31-41

Williams, P. H. 1991. The bumble bees of the Kashmir Himalaya (Hymenoptera: Apidae, Bombinae). Bulletin of the British Museum of Natural History (Entomology) 60:1-204 (page 46).

Williams, P.H. 2011. *Bombus* of the World [Online] http://www.nhm.ac.uk/research-curation/research/projects/bombus/ [accessed January 22, 2013].

Williams, P.H., Brown, M.J.F., Carolan, J.C., Goulson, D., An, Jiandong, Aytekin, A.M., Best, L.R., Byvaltsev, A.M., Cederberg, B., Dawson, R., Huang, J., Ito, M., Monfared, A., Raina, R.H., Schmid-Hempel, P., Sheffield, C.S., Šima, P., Xie, Z. 2012. Assessing cryptic species of the bumblebee subgenus Bombus s. str. world-wide with COI barcodes (Hymenoptera: Apidae). Systematics and Biodiversity 10: 21-56.

Williams, P.H. 2013. *Bombus*: Species world-wide listed by old and new subgenera [Online]. Natural History Museum, London, UK. Available at: http://www.nhm.ac.uk/research-curation/research/projects/bombus/ps.html#bohemicus. [accessed January 22, 2013].

Williams, P.H., R.W. Thorp, L.L. Richardson, and S.R. Colla. 2014. The Bumble Bees of North America: an identification guide. Princeton University Press. NY, USA. 208 pp.

Williams, P.H., and J.L. Osborne. 2009. Bumble Bee vulnerability and conservation worldwide. Apidologie 40:367-387.

Williams, P.H., S.R. Colla and Z. Xie. 2009. Bumble Bee vulnerability: common correlates of winners and losers across three continents. *Conservation Biology* 23: 931-940

Williams, P.H. 1989. Bumble Bees - and their decline in Britain. Ilford: Central Association of Bee-Keepers. 15 pp. [Online] http://www.nhm.ac.uk/research-curation/research/projects/bombus/decline.html [accessed January 22, 2013].

Zayed, A. and L. Packer. 2005. Complementary sex determination substantially increases extinction proneness of haplodiploid populations. Proceedings of the National Academy of Sciences 102:10742-10746.

Zimma, B. O., M. Ayasse, J. Tengo, F. Ibarra, C. Schulz and W. Francke. 2003. Do social parasitic Bumble Bees use chemical weapons? (Hymenoptera, Apidae). Journal of Comparative Physiology 189:769-775.

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Sheila R. Colla has been studying native North American Bumble Bees since 2003 during her undergraduate degree at the University of Toronto. She received her Ph.D. and was the recipient of the National Science and Engineering Research Council Alexander Graham Bell Canadian Graduate Scholarship at York University, Toronto, ON under the supervision of Dr. Laurence Packer. Her dissertation examined changes in Bumble Bee communities over the past century and looked into the causes for observed declines. She is the North American Co-Coordinator of the IUCN Species Survival Commission Bumble Bee Specialist Group and her research has been featured in *The Washington Post*, *Canadian Gardening*, *The Toronto Star, BioScience,* CBC's *Quirks and Quarks*, and *The Daily Planet* for Discovery Channel Canada.

Leif L. Richardson is a PhD candidate at Dartmouth College, Hanover, NH, where he examines the effects of floral nectar chemistry on bees and their parasites. Additionally, he combines bee surveys with museum collections data to study changes in the distribution of North American bumble bees. With Sheila R. Colla and other co-authors he produced a Guide to the Bumble Bees of North America, to be published by Princeton University Press in 2014.

Cory S. Sheffield has been studying bees and pollination since 1993, as part of undergraduate honours studies at Acadia University, Wolfville, NS. He continued graduate studies (MSc) of insect-plant interactions at Acadia, and at Agriculture and Agri-Food Canada (AAFC), Kentville, NS from 1994 - 2006. Cory did graduate studies (PhD) at the University of Guelph, ON 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

University of Guelph Insect Collection, Guelph, Ontario

Canadian National Collection, Ottawa, Ontario

Lyman Museum, McGill University, Ste. Anne-de-Bellevue, Québec

The Royal Ontario Museum, Toronto, Ontario

Packer Collection, York University, Toronto, Ontario

Royal British Columbia Museum, Victoria, British Columbia

Royal Saskatchewan Museum, Regina, Saskatchewan

Illinois Natural History Survey, Champaign, Illinois

Kansas State University Insect Collection, Manhattan, Kansas

Nova Scotia Museum, Halifax, Nova Scotia

Ohio State University Columbus Collection, Columbus, Ohio

American Museum of Natural History, New York, New York

University of Massachusetts, Amherst, Massachusetts

University of New Hampshire, Durham, New Hampshire

New York State Museum, Albany, New York

Connecticut Agricultural Experiment Station, New Haven, Connecticut

University of Prince Edward Island, Charlottetown, Prince Edward Island

Collection André Francoeur (Université du Québec), Chicoutimi, Québec

Collection Michel Savard, Saguenay, Québec

Collection Christophe Buidin-Yann Rochepault (Association Le Balbuzard de la Minganie), Rivière-Saint-Jean, Québec

Canadian Museum of Nature, Ottawa, Ontario

Cape Breton University, Sydney, Nova Scotia

Appendix 1. Most recent Canadian Gypsy Cuckoo Bumble Bee records 1991-2008. Each row represents a single specimen.

Province	Survey Area/Site	Day	Month	Year
Nova Scotia	Colchester County, DEBERT, NS	27	6	1995
Nova Scotia	Colchester County, DEBERT, NS	5	6	1995
Nova Scotia	Colchester County, DEBERT, NS	6	6	1995
Nova Scotia	Digby County, DELAPS COVE, N.S.	19	6	1995
Nova Scotia	Colchester County, DEBERT, NS	19	7	1996
Nova Scotia	Colchester County, DEBERT, NS	6	6	1996
Nova Scotia	Halifax County, WEST DOVER, NS	6	8	1998
Nova Scotia	Colchester County, SHUBENACADIE, N.S.	20	5	1998
Nova Scotia	Halifax County, ARMDALE, N.S.	11	8	1999
Nova Scotia	Colchester County, GREENFIELD, N.S.	5	8	1999
Nova Scotia	Hants County, MOUNT UNIACKE, N.S.	11	8	1999
Nova Scotia	Hants County, MOUNT UNIACKE, N.S.	11	8	1999
Nova Scotia	West Black Rock, Kings County	16	8	2001
Nova Scotia	Whycocomagh, Inverness County	3	8	2001
Nova Scotia		3	8	2001
Nova Scotia		16	8	2001
Nova Scotia	Middleton, Annapolis County	12	6	2002
Nova Scotia		12	6	2002
Ontario	Flesherton	12	5	1991
Ontario	Blue twp.	29	5	1992
Ontario	Worthington Twp	11	6	1992
Ontario	Worthington Twp	9	6	1992
Ontario	Chapple twp.	17	8	1992
Ontario	Chapple twp.	4	8	1992
Ontario	Atwood twp	15	6	1992
Ontario	Atwood twp	22	6	1992
Ontario	Atwood twp	26	7	1992
Ontario	Atwood twp	26	7	1992
Ontario	Atwood twp	27	7	1992
Ontario	Atwood twp	18	8	1992
Ontario	Blue twp	14	8	1992
Ontario	Chapple twp	22	7	1992
Ontario	Chapple twp	17	8	1992
Ontario	Morley township	15	6	1992
Ontario	Pinery Provincial Park, Lambton County	8	6	1992
Ontario	Worthington twp	8	6	1992

Province	Survey Area/Site	Day	Month	Year
Ontario	Macgregor Point Provincial Park	21	5	1993
Ontario	Shallow Lake	15	7	1993
Ontario	Spencer Gorge, Niagara escarpment	18	8	1993
Ontario	Hepworth, Grey County	16	7	1994
Ontario	Luther Marsh, Wellington County	20	8	1994
Ontario	Pinery Prov pk, Lambton County	1	6	1994
Ontario	Pinery Prov pk, Lambton County	15	6	1994
Ontario	Pinery Prov pk, Lambton County	24	6	1994
Ontario	Spencer Gorge, Niagara escarpment	31	7	1994
Ontario	St.Williams tract, Norfolk County	5	6	1994
Ontario	St.Williams tract, Norfolk County	5	6	1994
Ontario	Lac Jean-Venne	5	6	1995
Ontario	Pinery Prov pk, Lambton County	27	6	1995
Ontario	Pinery Prov pk, Lambton County	17	6	1995
Ontario	Pinery Prov pk, Lambton County	17	6	1995
Ontario	Lake Matchedash, Simcoe County	12	8	1996
Ontario	Port Franks, Lambton County	15	6	1996
Ontario	Port Franks, Lambton County	20	6	1996
Ontario	Port Franks, Lambton County	27	6	1996
Ontario	Port Franks, Lambton County	9	6	1996
Ontario	Port Franks, Lambton County	9	6	1996
Ontario	Port Franks, Lambton County	9	6	1996
Ontario	Port Franks, Lambton County	12	6	1996
Ontario	Port Franks, Lambton County	14	6	1996
Ontario	Port Franks, Lambton County	14	6	1996
Ontario	Port Franks, Lambton County	14	6	1996
Ontario	Port Franks, Lambton County	16	6	1996
Ontario	Port Franks, Lambton County	16	6	1996

Province	Survey Area/Site	Day	Month	Year
Ontario	Port Franks, Lambton County	16	6	1996
Ontario	Port Franks, Lambton County	15	6	1996
Ontario	Port Franks, Lambton County	15	6	1996
Ontario	Port Franks, Lambton County	23	6	1996
Ontario	Port Franks, Lambton County	23	6	1996
Ontario	Port Franks, Lambton County	14	8	1996
Ontario	Port Franks, Lambton County	29	8	1996
Ontario	Elmira, Salem Creek	18	5	1997
Ontario	Crane River, Bruce County	27	9	1997
Ontario	Hope Bay, Bruce County	1	6	1997
Ontario	Huntsville	18	8	1997
Ontario	Orillia, Simcoe County	13	8	1998
Ontario	Cameron Lake, Bruce County	16	6	1999
Ontario	Dorcas Bay, Bruce County	19	6	1999
Ontario	Dorcas bay, Bruce County	19	6	1999
Ontario	Toronto, Humber River near Old Mill,	9	5	1999
Ontario	Dunks Bay, Bruce County	5	7	2000
Ontario	Oliphant Fen, Bruce County	5	7	2000
Ontario	Presqu'ile Provincial Park,	28	4	2000
Ontario	Presqu'ile Provincial Park,	17	6	2000
Ontario	Pinery,	6	8	2008
Quebec	Lac Jean-Venne	24	8	1995
Quebec	Lac Jean-Venne	4	6	1995
Quebec	Magpie	17	6	2000
Quebec	Aguanish	16	6	2001
Quebec	Baie-Johan-Beetz	16	6	2001
Quebec	Rivière-Saint-Jean	12	8	2001
Quebec	Rivière-Saint-Jean	15	7	2001
Quebec	Rivière-Saint-Jean	13	7	2001
Quebec	Rivière-Saint-Jean	16	7	2001
Quebec	Rivière-Saint-Jean	9	6	2001
Quebec	Rivière-Saint-Jean	17	6	2001
Quebec	Rivière-Saint-Jean	16	6	2001
Quebec	Rivière-Saint-Jean	28	5	2001

Province	Survey Area/Site	Day	Month	Year
Quebec	Havre-Saint-Pierre	22	6	2001
Quebec	Chemin du Grand-Ruisseau ou ch. du Grand-Ruisseau	22	5	2001
Quebec	Chemin du Grand-Ruisseau ou ch. du Grand-Ruisseau	28	5	2001
Quebec	Chemin du Grand-Ruisseau ou ch. du Grand-Ruisseau	9	6	2001
Quebec	Sentier Val-Menaud, Saint-Charles-de-Bourget	9	6	2001
Quebec	Baie-à-Forest, Saint-Gédéon	10	6	2001
Quebec	Chemin du Grand-Ruisseau ou ch. du Grand-Ruisseau	16	6	2001
Quebec	Chemin du Grand-Ruisseau ou ch. du Grand-Ruisseau	17	6	2001
Quebec	Havre-Saint-Pierre	19	6	2001
Quebec	Baie-à-Forest, Saint-Gédéon	24	6	2001
Quebec	Camp Patmos, L'Ascension	25	6	2001
Quebec	Havre-Saint-Pierre	26	6	2001
Quebec	Bout-du-Banc, space Rivière-Saint-Jean	13	7	2001
Quebec	Berge de la riviere Saint-Jean, Longue-Pointe-de-Mingan	15	7	2001
Quebec	Chemin du Grand-Ruisseau ou ch. du Grand-Ruisseau	16	7	2001
Quebec	Bout-du-Banc, Rivière-Saint-Jean	18	7	2001
Quebec	Parc Rivière-du-Moulin, Chicoutimi	6	6	2002
Quebec	Parc Rivière-du-Moulin, Chicoutimi	8	6	2002
Quebec	Chicoutimi (réservoir d'eau au quartier des Oiseaux), Chicoutimi	13	6	2002
Quebec	Baie-à-Forest, Saint-Gédéon	1	7	2002
Quebec	Route Fillion, Saint-Honoré	7	6	2003
Quebec	Camp Patmos, L'Ascension-de-Notre-Seigneur	28	6	2003
Quebec	Baie-à-Forest, Saint-Gédéon	1	7	2003
Quebec	Pied-du-Mont, Parc national du Mont-Orford	29	7	2007
Quebec	Anticosti Island			2007
Quebec	Chalet La Courtepointe, Parc national du Mont-Orford	4	7	2008