COSEWIC
Assessment and Status Report

on the

Yellow-banded Bumble Bee
Bombus terricola

in Canada

SPECIAL CONCERN
2015

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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Yellow-banded Bumble Bee — Provided by author.

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COSEWIC
Assessment Summary

Assessment Summary – May 2015

Common name
Yellow-banded Bumble Bee

Scientific name
Bombus terricola

Status
Special Concern

Reason for designation
This bee has an extensive distribution in Canada, ranging from the Island of Newfoundland and the Maritime provinces, west to eastern British Columbia, and north into the Northwest Territories and extreme southwestern Yukon. Perhaps 50-60% of the global range of this species occurs in Canada. This species was historically one of the most common bumble bee species in Canada within its range. However, while this species remains relatively abundant in the northern part of its range, it has recently declined by at least 34% in areas of southern Canada. Causes for declines remain unclear, yet pesticide use, habitat conversion, and pathogen spill over from managed bumble bee colonies are suspected contributing factors.

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

Status history
Designated Special Concern in May 2015.

COSEWIC
Executive Summary

Yellow-banded Bumble Bee
Bombus terricola

Wildlife Species Description and Significance

Yellow-banded Bumble Bee is a medium-sized bumble bee with a short head and tongue length relative to other species. The distinctive yellow and black abdominal band pattern is consistent throughout its range. This species is an important pollinator of a variety of agricultural crops and native plant species.

Distribution

Yellow-banded Bumble Bee occurs in eastern North America from New Jersey to Newfoundland and Labrador, and west through the northern United States and most of Canada to southern Northwest Territories, southeastern Yukon, and eastern British Columbia. In the southern part of its range, there are scattered records from upper elevations of the Appalachian Mountains as far south as Georgia.

Habitat

Yellow-banded Bumble Bee occurs in a diverse range of habitats, including mixed woodlands, farmlands, urban areas, montane meadows, prairie grasslands and boreal habitats. It has been recorded foraging on flowers for pollen and nectar from a variety of plant genera. Like many bumble bees, it usually nests underground in pre-existing cavities such as abandoned rodent burrows and rotten logs. Yellow-banded Bumble Bee queens overwinter underground and in decomposing organic material such as rotting logs.

Biology

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

Population Sizes and Trends

Yellow-banded Bumble Bee was once one of the most common species in collections of bumble bees made in Canada. However, in the early 1990s populations began to decline in the southeastern part of their range in Ontario. At many sites, Yellow-banded Bumble Bees once accounted for > 20% of all bumble bees collected, yet in recent studies (in the past ten years), they typically make up < 4%. The Yellow-banded Bumble Bee has declined significantly at nine of 10 sites analyzed across southern and central Canada, with an average of 66.5% reduction in proportional abundance between pre- and post-10-year sampling periods. The species is now thought absent from many historical collection sites in these areas. However, there are few historical and modern collection data across the northern part of the species' range in the boreal forest.

Threats and Limiting Factors

The specific causes of decline for Yellow-banded Bumble Bee are unknown, although it is likely due to a combination of factors. Possible threats include introduced pathogens from managed bumble bees used in greenhouses and the transfer of these pathogens to native bumble bees when introduced bees escape, pesticide use associated with agriculture (including neonicotinoids), climate change and habitat loss within urban areas and areas of intensive agriculture.

Protection, Status, and Ranks

There are no laws in Canada that specifically protect the Yellow-Banded Bumble Bee, its nest sites or habitat. In Québec, Yellow-banded Bumble Bee is integrated on the Liste des espèces susceptibles d'être désignées menacées ou vulnérables (list of wildlife species likely to be designated threatened or vulnerable). The NatureServe global conservation status rank is G2G4 (Imperiled to Apparently Secure).

TECHNICAL SUMMARY

Bombus terricola

Yellow-banded Bumble Bee Bourdon terricole

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

Demographic Information

Generation time	1 year
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Yes. Observed based on lower abundance during surveys at revisited sites. Inferred decline based on overall decreases in proportional abundance throughout its range, using museum collections.
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].	Rate of decline unknown range-wide; average of 66.5% reduction at ten sites across southeastern and south-central Canada
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Unknown.
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	Unknown.
Are the causes of the decline clearly reversible and understood and ceased?	No. Causes of decline speculative and/or unknown.
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence • based on minimum convex polygon within Canada's extent of jurisdiction.	2004 – 2013: 6 934 370 km² 1882 – 2013: 7 913 612 km²
Index of area of occupancy (IAO) • 192 grid cells based on grids over recent observations from 2004 - 2013	2004 – 2013: 768 km² 1882 – 2013 : 3 464 km²
Is the population severely fragmented?	No
Number of locations	>>10

Is there an [observed, inferred, or projected] continuing decline in extent of occurrence?	Yes. Observed and inferred continuing decline. Yellow-banded Bumble Bee persists in approximately 52% of its re-sampled historical range.
Is there an [observed, inferred, or projected] continuing decline in index of area of occupancy?	Yes. In 11 ecozones, IAO declined, with 24.4% modern relative to historical grid cell occupancy (range: 8.2 - 76.9%; Table 3).
Is there an [observed, inferred, or projected] continuing decline in number of populations?	Yes. Loss of some local populations has resulted in a decline in IAO.
Is there an [observed, inferred, or projected] continuing decline in number of locations*?	Unknown.
Is there an [observed, inferred, or projected] continuing decline in [area, extent and/or quality] of habitat?	Yes. Inferred continuing decline in area, extent and quality of habitat in the southern parts of its range due to agriculture and urbanization.
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.
Are there extreme fluctuations in index of area of occupancy?	No.

Number of Mature Individuals (in each population)

Population	**N Mature Individuals**
Total	Still abundant in parts of its range; likely many thousands

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	Unknown

Threats (actual or imminent, to populations or habitats)

Threats include possible detrimental impacts from pathogen spillover from managed honey bees and bumble bees, habitat loss (nesting, foraging or overwintering), pesticide exposure, interspecific competition, and climate change.

Rescue Effect (immigration from outside Canada)

Status of outside population(s)?	Evidence for decline throughout most of its range in the United States.
Is immigration known or possible?	Unlikely, as species has declined in the United States.
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Likely

Is rescue from outside populations likely?	Unlikely, as species has declined in the United States; and unknown as the northern region in the United States is under-surveyed.

Data Sensitive Species

Is this a data sensitive species?	No

Status History

COSEWIC: Designated Special Concern in May 2015.

Status and Reasons for Designation:

Status: Special Concern	**Alpha-numeric code:** Not applicable
Reasons for designation: This bee has an extensive distribution in Canada, ranging from the Island of Newfoundland and the Maritime provinces, west to eastern British Columbia, and north into the Northwest Territories and extreme southwestern Yukon. Perhaps 50-60% of the global range of this species occurs in Canada. This species was historically one of the most common bumble bee species in Canada within its range. However, while this species remains relatively abundant in the northern part of its range, it has recently declined by at least 34% in areas of southern Canada. Causes for declines remain unclear, yet pesticide use, habitat conversion, and pathogen spillover from managed bumble bee colonies are suspected contributing factors.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Almost meets Threatened A2abce with a suspected reduction of greater than 30% in the total number of mature individuals over the last 10 years in the southern parts of its range. There are confirmed declines of at least 34% in southern parts of range where threats such as widespread pesticide use, pathogen spillover, climate and habitat change are most prevalent. However, the species continues to be common throughout north and west and range-wide decline is probably less, so Threatened A2abce is not met. A1 not applicable. The causes of decline are not clearly reversible, only partially understood and have not ceased. A3 not applicable. Difficult to show reduction because major declines have already occurred in the past two decades in many parts of range. This once common species (i.e., 20% of specimens), though still widespread, now makes up less than 5% of all bumble bees collected in many southern historic sites. A4 not applicable. Difficult to substantiate or model future reduction. Continued conversion/degradation of habitat in southern Canada, combined with the potential increasing pathogen load may lead to even further decreases.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. EOO is unknown and IAO exceeds the threshold.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable since population size is unknown. High numbers of individuals collected during a single event may actually represent a single colony; thus, counts may overestimate the abundance.
Criterion D (Very Small or Restricted Population): Not applicable. The population size is unknown.
Criterion E (Quantitative Analysis): Not applicable. No data to complete analysis.

COSEWIC HISTORY

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

COSEWIC MANDATE

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

COSEWIC MEMBERSHIP

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

DEFINITIONS
(2015)

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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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Phylum	Arthropoda – arthropods
Class	Insecta – insects
Subclass	Pterygota – winged insects
Order	Hymenoptera – ants, bees, wasps
Suborder	Apocrita
Infraorder	Aculeata
Superfamily	Apoidea – bees, apoid wasps
Family	Apidae – honey bees, bumble bees and allies; cuckoo bees, carpenter bees
Subfamily	Apinae - honey bees, bumble bees, digger bees, orchid bees, stingless bees and others
Genus	*Bombus* Latreille - bumble bees
Subgenus	*Bombus* Latreille *sensu stricto*
Species	*B. terricola* Kirby

English Common Name: Yellow-banded Bumble bee

French Common Name: Bourdon terricole

The genus *Bombus* includes approximately 250 species primarily found in temperate regions of North America, Central America, South America, Europe and Asia. The Yellow-banded Bumble Bee (*Bombus terricola*) belongs to the subgenus *Bombus sensu stricto*, one of 15 globally recognized subgenera (Williams *et al.* 2008). In North America, the subgenus contains four additional species: the Rusty-patched Bumble Bee (*Bombus affinis* Cresson), the Cryptic Bumble Bee (*B. cryptarum* Fabricius), Franklin's Bumble Bee (*B. franklini* Frison), and the Western Bumble Bee (*B. occidentalis* Greene).

Bumble bees are primarily identified using colour pattern and all castes (i.e., adult forms) can be variable in colour. This variation has contributed to historical and recent taxonomic difficulties with this and many other bumble bee species.

Yellow-banded Bumble Bee was first described as a distinct species by Kirby (1837) and at one time considered conspecific with the Western Bumble Bee (*e.g.*, Milliron 1971; Cameron *et al.* 2007 [though Milliron considered it a distinct subspecies]), and by other authors as a distinct species (*e.g.*, Stephen 1957; Thorp *et al.* 1983). Cameron *et al.* (2007) compared DNA sequences from the 16S mitochondrial gene and suggest the two taxa (*e.g.*, the Western and Yellow-banded Bumble Bees) are likely conspecific. However, Williams *et al.* (2012) reported that mitochondrial cytochrome c oxidase (CO1) gene sequences (i.e., DNA barcodes) were sufficiently different to consider the Yellow-banded Bumble Bee a distinct species. These results support those of Bertsch *et al.* (2010), with an overall CO1 sequence divergence of approximately 5% between the two species. Furthermore, Owen and Whidden (2013) found consistent morphological and molecular characters supporting two distinct taxa. Thus, strong evidence suggests that the Yellow-banded Bumble Bee is a monophyletic taxon separable at the species level from the Western Bumble Bee.

Morphological Description

Morphological characters are summarized from Williams *et al.* 2014.

Yellow-banded Bumble Bee has a medium-sized body (queen 19-21 mm, worker 10-15 mm, male 13-15 mm) with a short head (malar space just shorter than broad) (Figure 1). The body hair is short and even.

Figure 1. Female Yellow-banded Bumble Bee (*Bombus terricola*) (face) from Caledon, Ontario. Note the short malar space (white arrow) between the bottom of the eye and the mandibles. Photo by Sheila Colla (October 30, 2009). Specimen housed in the Packer Collection, York University.

In females, the corner of the midleg basitarsus is rounded and the outer surface of the hindleg tibia is flat without long hair but with long lateral fringes and forming a pollen basket (corbicula). The head hair is completely black or with a minority of intermixed short pale hairs. The front of the second metasomal tergite (T2) (the dorsal surface of the second abdominal segment) is usually yellow without black or with only a narrow fringe along the front margin, but if T2 is more extensively black then T4-5 are also predominantly black (Figure 2). T1 is black, T3 is usually yellow and T5 black or yellow-brown. Wings are slightly brown. Queens are larger than workers but share the same colour pattern.

Figure 2. Female Yellow-banded Bumble Bee (*Bombus terricola*). Specimen collected in Caledon, ON, July 2003. Photo by Sheila Colla (October 30, 2009). Specimen housed in the Packer Collection, York University.

In males, the antenna has a flagellum just over two times longer than the scape. Hair colour pattern is similar to that of queens and workers, usually with more yellow hairs on the face (Figure 3).

Figure 3. Male Yellow-banded Bumble Bee (*Bombus terricola*). Specimen collected in Caledon, ON, July 2003. Photo by Marguerita Miklasevskaja (July 10, 2013). Specimen housed in the Packer Collection, York University.

Because of similarities in colour patterns, Yellow-banded Bumble Bee is often confused with the Western Bumble Bee, the Cryptic Bumble Bee, the American Bumble Bee (*B. pensylvanicus*), the Black-and-Gold Bumble Bee (*B. auricomus*), and the Nevada Bumble Bee (*B. nevadensis*).

Population Spatial Structure and Variability

The cytochrome oxidase 1 (COI) gene has been sequenced and analyzed for Yellow-banded Bumble Bee specimens collected throughout the species' range and using Barcode of Life Data Systems (BOLD) protocols (Williams *et al.* 2012). Yellow-banded Bumble Bee specimens cluster together in a phylogeny that includes other members of the subgenus *Bombus sensu stricto*, and there is currently no evidence of subspecific genetic structure.

Designatable Units

The species occurs in most Canadian ecozones, including: Boreal Cordillera, Mountain Cordillera, Taiga Plains, Boreal Plains, Prairies, Taiga Shield, Boreal Shield, Hudson Plains, Mixed Wood Plains and Atlantic Maritimes. In the absence of evidence of subspecific genetic structure or population isolation, the Yellow-banded Bumble Bee is being assessed as one designatable unit.

Special Significance

Like most bees, the Yellow-banded Bumble Bee is ecologically significant in natural ecosystems as it provides pollination services to various native plant species throughout its range (Ascher and Pickering 2013). Bumble bees are active throughout the growing season, flying during inclement weather conditions that ground other winged insects. As pollinators, bees facilitate plant reproduction, which ultimately provides shelter and food for other animals.

The Yellow-banded Bumble Bee may be a particularly important pollinator for cultivated cranberry (Mackenzie and Averill 1995), potato (*Solanum tuberosum*) flowers for production of seed (Batra 1993), Alfalfa (*Medicago sativa*) (Stephen 1955; Holm 1966), Lowbush Blueberry (*Vaccinium angustifolium*) (Javorek *et al.* 2002) and other berries (*Rubus* spp.) (Mitchell 1962), and many other pollinated crops.

One of the most easily reared North American bumble bees in captivity, the Yellow-banded Bumble Bee has proved to be an excellent organism for scientific study in the past (*e.g.* Sutcliffe and Plowright 1988) and is potentially a good alternative to the Common Eastern Bumble Bee (*Bombus impatiens)* for commercial greenhouse and field crop pollination.

DISTRIBUTION

Global Range

The Yellow-banded Bumble Bee occurs only in North America. It ranges from Georgia north through the eastern United States to Labrador, and west through the northern United States and Canada to Montana, British Columbia (BC), and the Northwest Territories (NT) (Figure 4). The northernmost extent of its range is 65.4° latitude (Alaska); easternmost extent of its range is -53.2° longitude (Newfoundland); southernmost extent is in 32.8° (Georgia) and westernmost extent is -146.3° (Alaska). It is found in the following states: ME, NH, VT, NY, MA, CT, RI, NJ, MD, PA, WV, VA, NC, TN, GA, OH, MI, IL, MN, SD, ND, MT, WY, UT and AK (Figure 4). Approximately 50-60% of the global range of this species occurs in Canada.

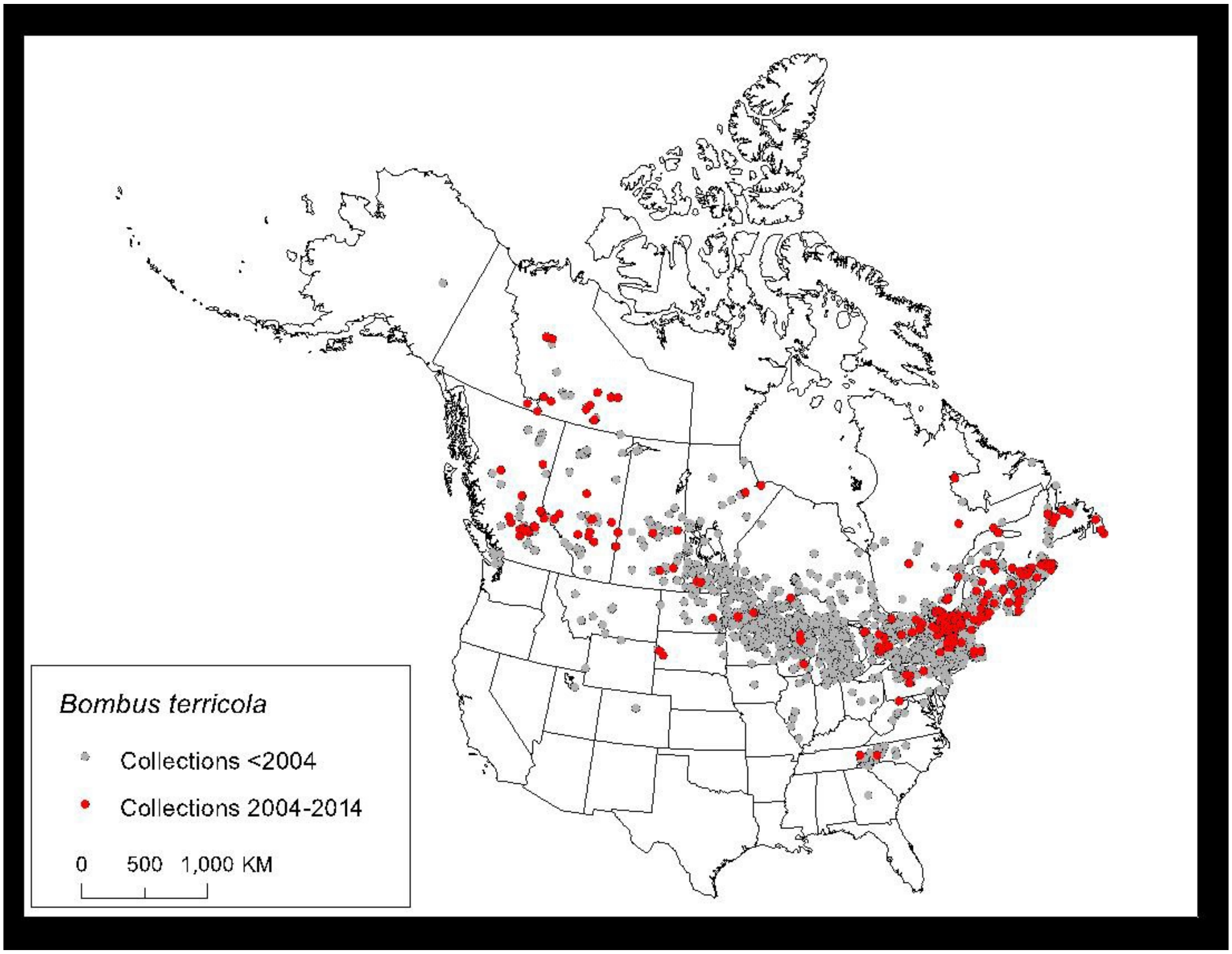

Figure 4. Global range of Yellow-banded Bumble Bee. Red dots show collections made 2004 – 2014 and grey dots are older collections.

Canadian Range

The Yellow-banded Bumble Bee is known to occur in every Canadian province and territory except Nunavut (NU) (Figure 4). Surveys in 2014 located this species in at least two sites in extreme southeastern Yukon. Additional suitable habitat may be found in southwestern NU, but very few surveys have been made in this territory. Each province and territory where the species has been recorded is discussed below. Distribution descriptions are based on the dataset of museum specimen records used in this report, with additional information from experts and the published literature. Yellow-banded Bumble Bee records date from 1894 – 2014.

British Columbia (BC):

The Yellow-banded Bumble Bee occurs mainly in the Montane Cordillera Ecozone of central BC, where its range overlaps with the contact zone between the two subspecies of the Western Bumble Bee to the south and north. It has also been reported from some coastal sites around Vancouver, but these specimens have not been verified. In 2013, the Yellow-banded Bumble Bee was collected at 25 sites in south and central BC, but was absent from many other sites surveyed for bumble bees (Heron pers. comm. 2014; Sheffield pers. comm. 2014;). Buckell (1951) states it was the most common bumble bee species in the central interior of BC but was uncommon in the southern interior of the province.

Alberta (AB):

The species is found throughout the province, with collections in all ecoregions, 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 localities for this report (Rowe pers. comm. 2013).

Saskatchewan (SK):

The species is found on the Boreal Plains and Prairies Ecozones in the southern part of the province but there are recent collections. Two collections were made in 2013 at Killaly and Prince Albert (Sheffield pers. comm. 2013). Curry (1984) describes the species as being common and widespread in the province from prairies to the northern coniferous forests.

Manitoba (MB):

Historical collections are predominantly from the Boreal Plains and Prairies Ecozones in the southern part of the province, but a few were made as far north as Hudson Bay. The most recent collections are at Gillam and York Factory in 2010. Bumble bee specimen data are not available for any more recent collections made in MB.

Ontario (ON):

The Yellow-banded Bumble Bee ranges across the Mixedwood Plains and Boreal Shield Ecozones of southern ON, with scattered collections having been made in the Hudson Bay lowlands around James Bay. It was collected in 2013 in southern ON, including at Toronto, Oro Station and Ottawa (Colla pers. data).

Québec (QC):

The Yellow-banded Bumble Bee was formerly common across the Mixedwood Plains and Boreal Shield Ecozones of southern QC, and there are a few collections from the Taiga Shield as far north as Schefferville at nearly 55° N. The bee was collected in 2013 on farms south of Montréal and Québec (Colla pers. data).

New Brunswick (NB):

The Yellow-banded Bumble Bee is found throughout NB. The most recent specimens were collected during 2013 resurveys of historical collection sites in the towns of Springfield and Norton. The species was present at several sites in Fredericton in 2014 (Sabine pers. comm. 2015).

Nova Scotia (NS):

The Yellow-banded Bumble Bee has been collected over most of NS, and was most recently taken in 2013 during resurveys of historical collections made in Lockeport, Greenfield and New Germany.

Newfoundland and Labrador (NL):

In Newfoundland, the species has been collected mainly in coastal areas, particularly along the Gulf of St. Lawrence. There are a few undated collections (likely before 2004) from the towns of Cartwright and St. Anthony in the Canadian National Collection of Insects, Spiders and Nematodes (CNC). The most recent collections from the province are from 2010.

Prince Edward Island (PE):

Historically the species was collected at sites across PE, and a 2013 collection was made at Charlottetown.

Northwest Territories (NT):

The Yellow-banded Bumble Bee occurs in the central Taiga Plains ecozone of NT, but apparently not the Montane Cordillera. The most recent collections were made along the lower Nahanni River and Fort Simpson in 2011.

Yukon (YT):

Specimens were collected of this species for the first time in the extreme southeastern part of this territory in July 2014 (Cannings pers. comm. 2014).

Extent of Occurrence and Area of Occupancy

Extent of occurrence (EO) for the Yellow-banded Bumble Bee is approximate and based on the databased museum collections and observational surveys. The approximate EO based on a minimum convex polygon created around all databased records (1882 – 2013) is 7 913 612 km^2. The EO calculated from 2004 – 2013 records is 6 934 370 km^2.

An index of area of occupancy (IAO) based on all museum, sight and collection records is 3 464 km^2. The IAO calculated from 2004 – 2013 records only (the past ten years) is 768 km^2.

Search Effort

Search effort for bumble bees in North America has been extensive in the past decade, with approximately ~30,000 databased *Bombus* specimens dating from 1884 to 2013 (Table 1; Figure 5).

Table 1. There are ~30,000 *Bombus* specimens known from the collecting period 2004-2013 in Canada. These specimens reside in numerous academic, research and private collections in Canada and elsewhere (See Collections Examined).

Province	*Bombus* Specimens
Alberta	372
British Columbia	15,123
Manitoba	461
New Brunswick	1,030
Newfoundland and Labrador	2,708
Northwest Territories	134
Nova Scotia	1,111
Nunavut	59
Ontario	4,244
Prince Edward Island	1,307
Quebec	2,965
Saskatchewan	270
Yukon Territory	1456
Total:	29,972

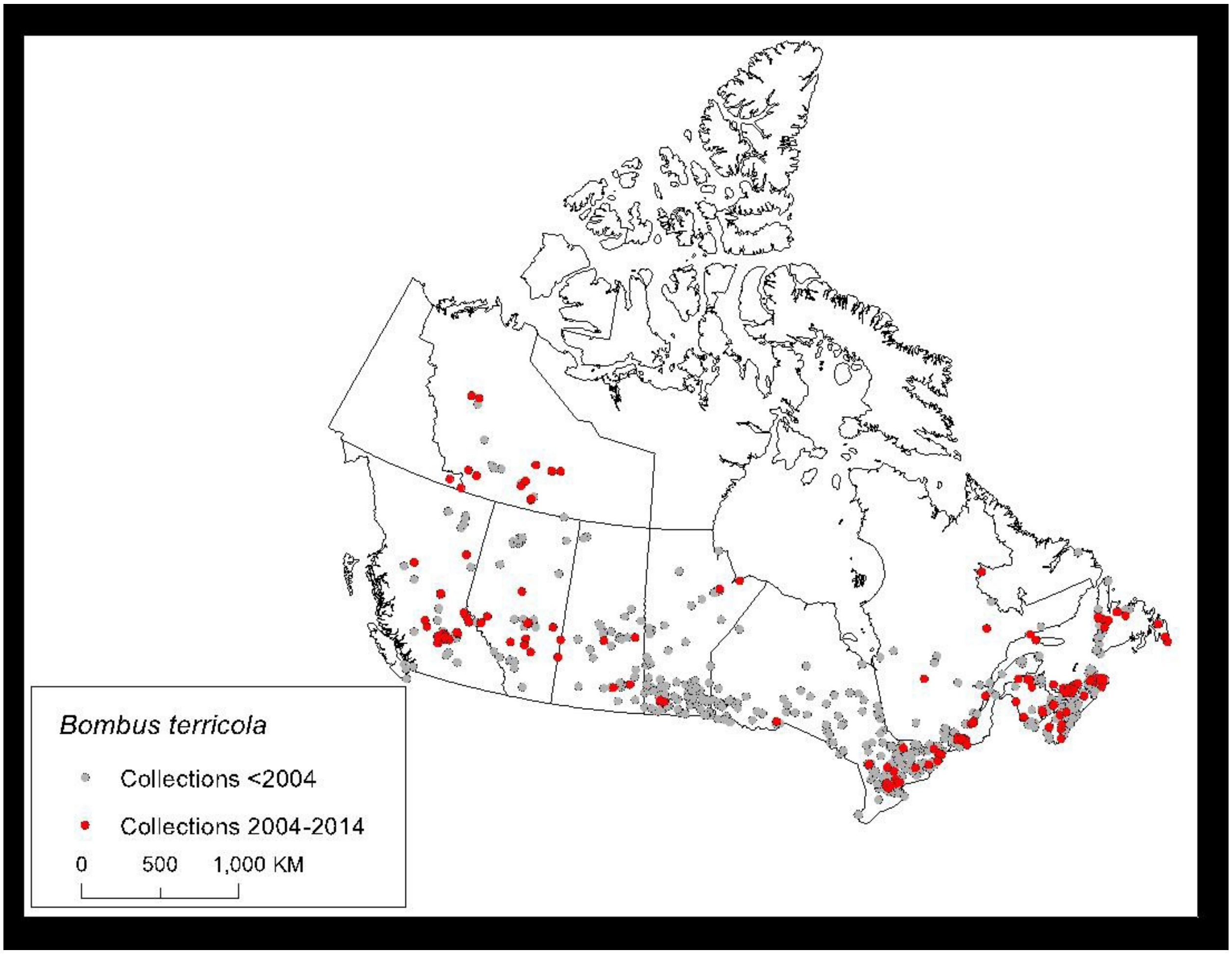

Figure 5. Museum specimen records of Yellow-banded Bumble Bee in Canada within the last 10 years (red) and those made prior to 2004 (grey). Data are from most major academic and museum collections in Canada and many U.S. collections, but some additional *Yellow-banded Bumble bee* collections data exist in collections that have not been digitized.

Recent targeted searches for the Yellow-banded Bumble Bee at selected historical sites and general bumble bee surveys were carried out during preparation of this status report and for other research (Appendix 1). The data collected from these surveys were used in calculations of proportional abundance and measures of decline.

Despite the relatively large effort made by scientists to collect *Bombus* specimens, there are some notable gaps in our knowledge of bumble bee distribution in Canada. In particular, comparatively few specimen records exist from the boreal and arctic zones (e.g. Figure 4), yet bumble bees are known to occur at high latitude in Canada and elsewhere. We consequently know little about historical or recent abundance of the Yellow-banded Bumble Bee at the northern portion of its range. As an illustration of this, a 2011 collection at Schefferville (54.8° N) expanded the known northern range margin in QC by hundreds of kilometres and in 2014 the species was found in the YT for the first time. In addition to this knowledge gap in northern Canada, there are relatively few known Yellow-banded Bumble Bee collections from the last decade from eastern MB and western ON (Figure 6).

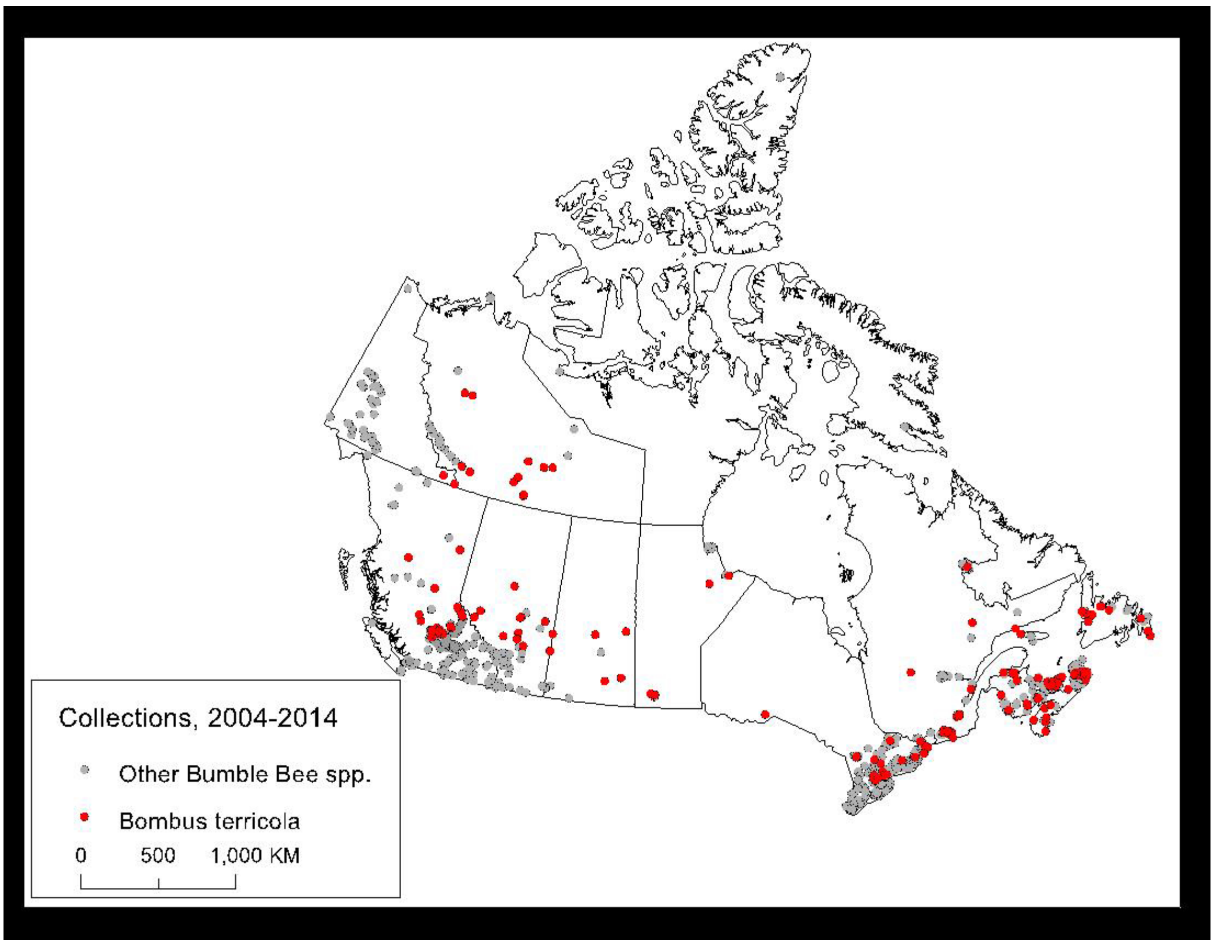

Figure 6. Collections of Yellow-banded Bumble Bees made in Canada in the last decade (red) and those made of other *Bombus* species during the same time period (grey). Many areas of this species' range have been resurveyed in the last decade.

In the US, a study by Grixti *et al.* (2009) analyzed changes in bumble bees throughout Illinois. Although the Yellow-banded Bumble Bee made up 1.2% proportional abundance of the bumble bees from collections from 1900-1949, it was not present in state collections from 1950-2007 or from extensive surveys performed in 2007 (Grixti *et al.* 2009).

In 2007 – 2009, a field study conducted throughout the continental US focusing on the status and distribution of eight species found evidence for decline in the Yellow-banded Bumble Bee's American range. The quantified range reduction compared to historical records was estimated at 31%; however, search effort in the northern parts of its US range was likely not adequate (Cameron *et al.* 2011).

HABITAT

Habitat Requirements

Yellow-banded Bumble Bee is a habitat generalist within open coniferous, deciduous and mixed-wood forests, wet and dry meadows and prairie grasslands, meadows bordering riparian zones, and along roadsides, in taiga adjacent to wooded areas, urban parks, gardens and agricultural areas, subalpine habitats and more isolated natural areas. Like other bumble bees, the Yellow-banded Bumble Bee is a generalist pollen forager and has been collected from a wide variety of plant species.

Queens overwinter, typically by burrowing in loose soil or rotting trees (Benton 2006). Yellow-banded Bumble Bees nest underground (Laverty and Harder 1988), often in abandoned rodent burrows located at depths of 15 to 45 cm with downward sloping entrances (Hobbs 1968; Plath 1927). Nest sites have been located in old fields (Harder 1986).

Habitat Trends

The Yellow-banded Bumble Bee has a large range in Canada spanning numerous ecozones and habitat types. It is unlikely that habitat loss has caused its decline at such large scales. Threats which may work to decrease habitat quality at this large scale include pathogen spillover and climate change (see Threats).

Agriculture makes up less than 1% of the boreal shield (Javorek and Grant 2012). However, habitat loss due to urbanization or intensive agriculture may threaten this species in parts of its range. According to Javorek and Grant (2012), increased agriculture in ecozones inhabited by the Yellow-banded Bumble Bee (*i.e.* Mixedwood Plains, Atlantic Maritime, Prairies) show diminished wildlife habitat capacity. However, some recent sightings have been in agricultural and urban areas, indicating the species may be able to persist in certain conditions.

BIOLOGY

Information is compiled from general bumble bee references (Alford 1975; Goulson 2003a; Benton 2006) and where applicable references are provided specifically for the Yellow-banded Bumble Bee.

Life Cycle and Reproduction

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

Mating occurs in the fall, males die and only the queen overwinters; typically they emerge in April or May and begin to forage for pollen and nectar, and to search for suitable nest sites to begin their colonies (Williams *et al.* 2014; Figure 7). Nests are established in abandoned rodent burrows, grassy hummocks, rotted logs or openings in dead wood. The queen builds and defends this nest early on. A few weeks after the queen's initial egg laying, female workers emerge and begin foraging for the colony, tending the nest, protecting the colony and feeding the brood. The queen remains in the nest and continues to produce eggs. The maximum number of workers recorded by a captive Yellow-banded Bumble Bee colony was 94 (Plowright 1966), which is slightly similar to two wild colonies that contained 104 and 87 workers. The estimated total number of workers produced was likely close to twice that amount (Plowright 1966).

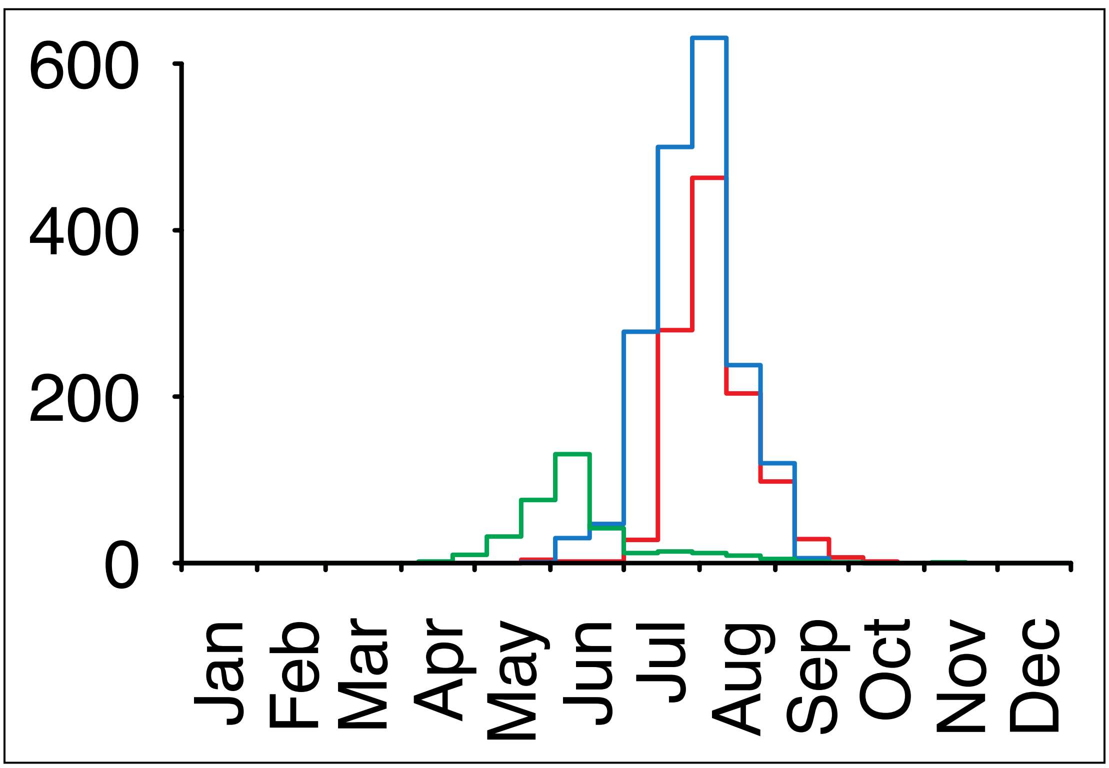

Figure 7. Histogram of timing of activity of the Yellow-banded Bumble Bee, as inferred from 3,322 Canadian specimens for which date of collection and caste were recorded. Queens (green) emerge first, followed by workers (blue) and males (red). The vertical axis represents number of bee specimens in each time period.

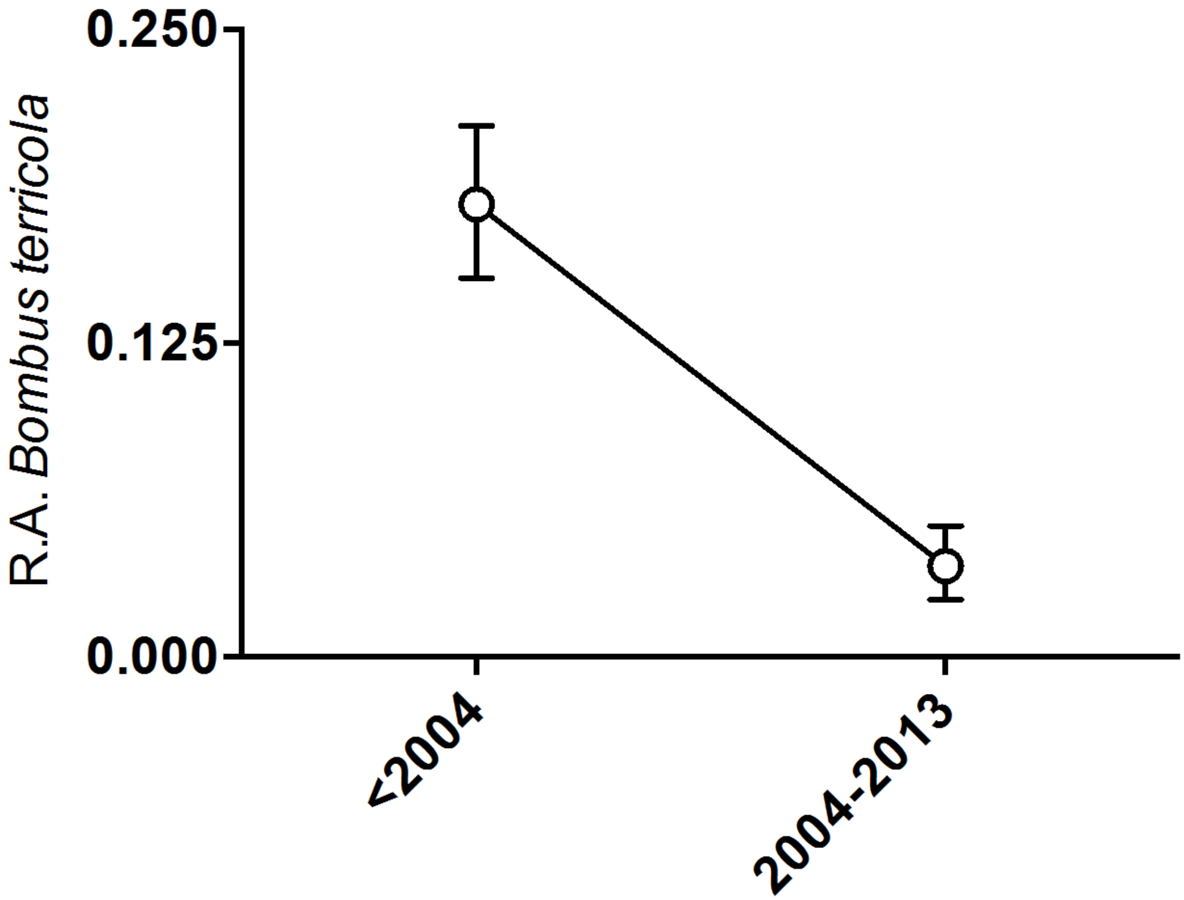

Figure 8. Proportional abundance of *Yellow-banded Bumble Bee* in bumble bee collections in 10 areas of Canada (see Table 2) has strongly declined (repeat measures ANOVA: $F_{1,18} = 19.60$, $P = 0.0003$). Least square means ± SE are depicted. See text for details of analysis.

As summer progresses the colony reaches maximum worker production and begins producing males and potential queens. Owen *et al.* (1980) found that the number of potential queens produced by Yellow-banded Bumble Bee colonies ranged from 0 - 58. These reproductive individuals leave the nest and mate. After mating, young queens enter diapause and overwinter. The males and workers decline as fall approaches, and ultimately die.

Little is known about mating behavior and colony dynamics in the Yellow-banded Bumble Bee. In the closely related Common Eastern Bumble Bee, females mate with a single male during a single mating event and (as with all bees) the sperm is stored in a spermatheca until used in fertilization (Greeff and Schmid-Hempel 2008).

Eggs hatch after approximately four days and larvae feed on pollen and nectar. The larval stage of bumble bees has four instars. After almost two weeks larvae spin cocoons and pupate. Pupae develop for two weeks before hatching as adults. In total, development takes approximately five weeks but varies with temperature and food supply (Alford 1975).

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

Eusocial organisms are at increased risk of extinction compared with many other animal species due to their haplodiploid genetic system. Under normal conditions, unfertilized eggs become males and fertilized eggs become females. Thus, males (haploid) contain half the genes a female (diploid) does. In cases where there is a small population due to inbreeding and decline, sex-determining locus heterozygosity is low and diploid males are produced leading to an extinction vortex (Zayad and Packer 2005; Darvill *et al.* 2012). Thus, bees are more vulnerable than most other animal species to habitat fragmentation (Packer and Owen 2001). See Limiting Factors.

Physiology and Adaptability

Bumble bee queens emerge early in the spring, and thus require early-flowering plants to succeed. Most bumble bees are able to feed on a wide range of flowers. As these bees are obligatorily social, they are dependent on diverse plant communities, and need pollen and nectar resource availability to remain high throughout the active period of the colony. Therefore, only habitats supporting rich plant communities provide the nutrition to support bumble bee colonies.

Bumble bees are found throughout most of Canada and are relatively cold-tolerant due to their physiological capability for thermoregulation. They are able to “shiver” to generate heat in their thoracic muscles to warm up to the required minimum body temperature (approx. 30°C) during low ambient temperatures (Heinrich 2004). Thermoregulation is likely an important adaptation because Yellow-banded Bumble Bee is an early-emerging species and occurs at high latitudes.

Dispersal and Migration

There is little information on natural dispersal rates for bumble bees. Dispersal occurs primarily in spring by queens while searching for suitable nest sites (Goulson 2003a). There is some evidence that bumble bees are able to disperse relatively long distances. Males of a closely related old world species, Buff-tailed Bumble Bee (*Bombus terrestris*), 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). Dispersal is likely important to survival based on studies that have examined the patchiness of bumble bee habitat (*e.g.*, Hatfield and LeBuhn 2007) and increased problems associated with small effective population sizes in haplodiploid insects (Zayed and Packer 2005) (see Limiting Factors).

Interspecific Interactions

Yellow-banded Bumble Bee is a generalist forager; it naturally co-forages and competes with many other bee species for food pollen and nectar. This species also can “nectar-rob” (i.e., the bees bite holes in the base of flowers to reach the nectar without contacting anthers and/or stigma, and thus do not pollinate the flower) allowing workers to forage for nectar from long-tubed flowers (Laverty and Harder 1988).

Yellow-banded Bumble Bee likely has important mutualistic relationships with native flowering plant species, which may rely on it for pollination. These plants could be negatively impacted by declines in Yellow-banded Bumble Bee populations. The extent of interdependence of individual plant species is unknown. Where its range overlaps with the Western Bumble Bee, the Western Bumble Bee is usually more common in montane habitats and the Yellow-banded more common at lower elevations (Hobbs 1968), though both species are sympatric in parts of the prairies.

Predation and Parasitism

A wide range of invertebrates parasitize bumble bees at all stages of the colony cycle (Schmid-Hempel 1998). Spring queens can be infected by nematodes (*Sphaerularia bombi*) or protozoa (*Apicystis bombi*) rendering them incapable of founding colonies. During the summer, workers may acquire parasites (*e.g.*, *Crithidia bombi, Nosema bombi*), while foraging on flowers contaminated by infected bees.

Some cuckoo bumble bees (subgenus *Psithyrus*) specialize in usurping queens of the subgenus *Bombus s.str*. (e.g. the Yellow-banded Bumble Bee). Adult female cuckoo bumble bees enter the colony, occasionally killing the queen or otherwise injuring her, and lay their own eggs, which are cared for by the remaining host workers. Any eggs laid by the Yellow-banded Bumble Bee queen are destroyed by the cuckoo bumble bee queen. Yellow-banded Bumble Bee is host to the Gypsy Cuckoo Bumble Bee (*B. bohemicus*) and may also be host to Suckley’s Bumble Bee (*B. suckleyi*) and Indiscriminate Cuckoo Bumble Bee (*B. insularis*) (Fisher 1992; Williams *et al.* 2014).

The internal mite *Locustacarus buchneri* is a common parasite that lives within the respiratory tubes and air sacs of many bumble bee species. Otterstatter and Whidden (2004) found unusually high prevalence of this parasite in Yellow-banded Bumble Bee in Alberta. Although the Cryptic Bumble Bee, the Western Bumble Bee and the Yellow-banded Bumble bee made up only 18% of their total bumble bee sample (n = 4096), the three species accounted for 83% of infected individuals, with 9% of Yellow-banded Bumble Bee individuals infected (Otterstatter and Whidden 2004). Infection rates for nine other species studied ranged from 0-3.9% (Otterstatter and Whidden 2004). This parasite is known to adversely impact the health of bumble bees.

Nosema bombi is a microsporidian gut and tissue parasite of bumble bees which can reduce survival and foraging efficiency (Fisher and Pomeroy 1989). *Nosema bombi* infection is considered low among wild bumble bees (average infection rates = 5-10%; Colla *et al.* 2006). Recent field surveys across the United States (Cameron *et al.* 2011) found the highest levels of *N. bombi* infection (i.e., over 35%) among declining bumble bee species, which supports the hypothesis that this parasite is a serious threat. Although the Yellow-banded was excluded from the analyses due to too few specimens, the proportion of infected individuals was nonetheless greater than that of any stable species (Cameron *et al.* 2011).

Predators of adult bumble bees include robber flies (Family Asilidae) and crab spiders (Family Thomisidae) (Dukas *et al.* 2005). Thickheaded (Family Conopidae) and Humpbacked (Family Phoridae) flies are parasitoids of adult bumble bees. Raccoons, skunks, bears and other mammals are known to destroy and consume bumble bee colonies (Breed *et al.* 2004).

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Relative to other insects, bumble bees have been well surveyed, and data on distribution, phenology and host plants is available from the labels of museum specimens from the past century. However, the vast majority of bumble bee collections have been opportunistic, rather than having been made as part of a repeatable, spatially and temporally explicit sampling regime. Recent concerns over the decline of pollinators including bumble bees has led to the coordination of methods for bee sampling, and many high quality data sets have been produced in the last decade.

We examined a large dataset of North American bumble bee specimen records (N = 281,000) produced for a recent guide to these insects (Williams *et al.* 2014) to infer changes in abundance and distribution of the Yellow-banded Bumble Bee. Additionally, in 2013 we conducted field surveys at ten historical collection sites identified by this dataset. We also obtained recent collection data from scientists studying pollinators around Canada.

We used three approaches to characterize changes in distribution of Yellow-banded Bumble Bee over time:

<u>Approach 1. Comparisons of proportional abundance of Yellow-banded Bumble Bee collections at ten sites resampled again for this status report</u>

Proportional abundance (PA) is the number of individuals of one species divided by the total number of individuals collected (in this case species of *Bombus*) and can be used as a proxy of abundance when data are not amenable to other analyses (e.g. Colla and Packer 2008). To study changes in Yellow-banded Bumble Bee abundance with this method, we identified 10 sites across the range of the species for which we had the most data, then compared its PA in recent (i.e. 2004-2013) and historical (i.e., <2004) collections (Table 2). This time period was chosen based on the 10-year component of COSEWIC assessment criteria. We excluded from consideration any collections that we assessed to have been made in a non-random manner, as well as those that focused on individual bee species (whether Yellow-banded Bumble Bee or other bumble bees). Our analysis is necessarily biased toward human population centres, where the best collection records exist. It is possible that in these places the species encounters threats of a different magnitude or scope than elsewhere; however, we drew specimens from a large buffer that included non-urban land, and overall our samples comprised 73% of the ~30,000 Canadian bumble bee records in our dataset.

Table 2. Proportional abundance (PA) of Yellow-banded Bumble Bee across 10 sites. At nine of the 10 sites, PA is markedly lower in the last 10 years than in historical (before 2004) collections from the same areas. Sampling took place in multiple sites and years. Records were drawn from the entire province, except locations that were centroids for 10,000 km^2 squares (*) and 40,000 km^2 squares (**).

Location	Historical Collections (<2004)			Recent Collections (2004-2013)			% change
	No. *B. terricola*	No. All *Bombus*	PA	No. *B. terricola*	No. All *Bombus*	PA	
Southwestern Quebec (Montréal*)	17	93	0.183	18	1,604	0.011	-93.9
New Brunswick	218	588	0.371	31	1,030	0.030	-91.9
Newfoundland	88	218	0.404	58	1,218	0.048	-88.2
Southwestern Ontario (Toronto*)	132	2,112	0.063	10	1,237	0.008	-87.1
Prince Edward Island	71	327	0.217	41	1,306	0.031	-85.5
Nova Scotia	421	1,921	0.219	41	1,111	0.037	-83.2
Central Alberta (Edmonton*)	48	245	0.196	6	90	0.067	-66.0
Southeastern Ontario (Ottawa*)	41	539	0.076	4	129	0.031	-59.2
Southern Quebec (Québec*)	10	50	0.200	41	468	0.088	-56.2
Central Interior British Columbia (100 Mile House**)	23	774	0.030	295	6,801	0.043	46.0
Totals:	1,069	6,867		545	14,994		

Most comparisons were made between datasets drawn from non-overlapping 10,000 km^2 squares centred on population centres. Due to smaller sample sizes, one comparison for an area of BC centred on 100 Mile House necessitated that records be used from the surrounding 40,000 km^2. For NB, NS and PE, we drew records from the entire province, and for NL we used all records from Newfoundland but did not use records from Labrador (see below and Table 2).

In addition to presenting these changes in PA, we used repeated measures ANOVA to determine whether there is a statistically significant difference in Yellow-banded Bumble Bee proportional abundance (i.e. relative to other *Bombus* spp.) between the two time periods. In this analysis, PA was the dependent variable, and site (n = 10) and time period (historical vs. modern) were independent variables.

Approach 2. Changes in the COSEWIC Index of Area of Occupancy (IAO) when the last ten years IAO (2004 – 2013) were compared with the IAO prior to 2003

In this approach the index of area of occupancy (IAO) of Yellow-banded Bumble Bee was calculated in each of Canada's 15 terrestrial ecozones (see COSEWIC 2009), comparing collections from 2004-2013 to all previous collections in our dataset. We used ArcGIS software to divide the land area of Canada into 2 km^2 grid cells. We obtained GIS data for the ecozones (Government of Canada 2013), then calculated for each ecozone the number of grid cells total, the number with one or more occurrences collected before 2004, and the number with one or more collections from 2004-2013. We then divided the proportion of historically occupied cells that were occupied in the modern period, or IAO. We calculated this metric for each ecozone and for all of Canada.

Approach 3. The proportional abundance in ten-year increments of Yellow-banded Bumble Bee within museum collections

This analysis used a dataset of bumble bees for Canada, with > 45,000 museum and observation records, ranging from the years 1882 – 2011. The PA of Yellow-banded Bumble Bee was plotted in ten-year increments at the national level, and for each jurisdiction where found in Canada (Figures 9-13).

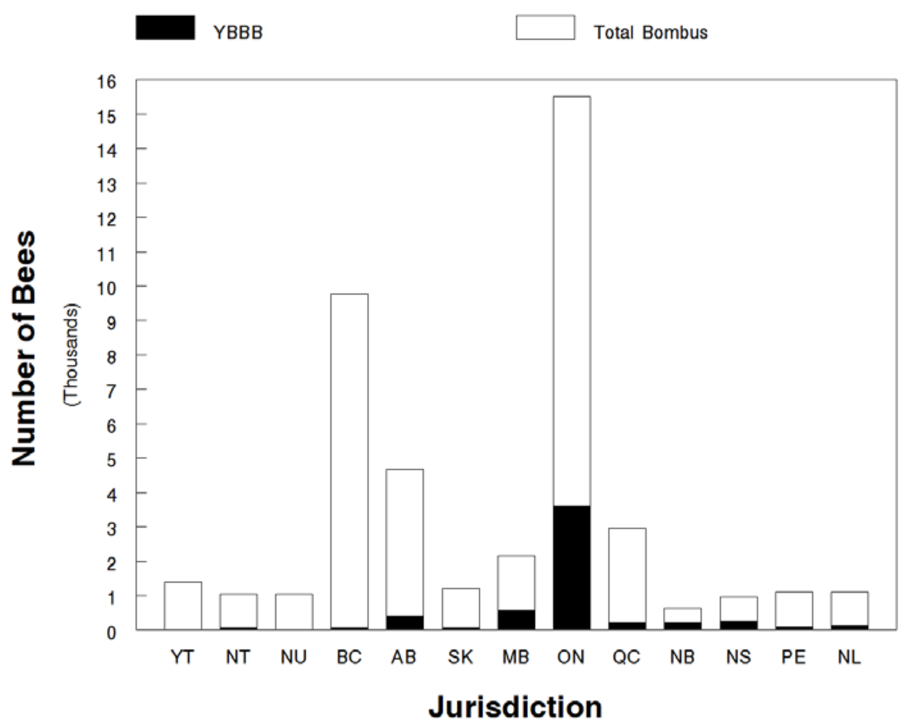

Figure 9. Total number of bumble bees (in thousands) by jurisdiction. Black shading represents the proportional abundance of Yellow-banded Bumble Bee. Note the low PA of the species in the west, as well as NS, NB, PE and NL.

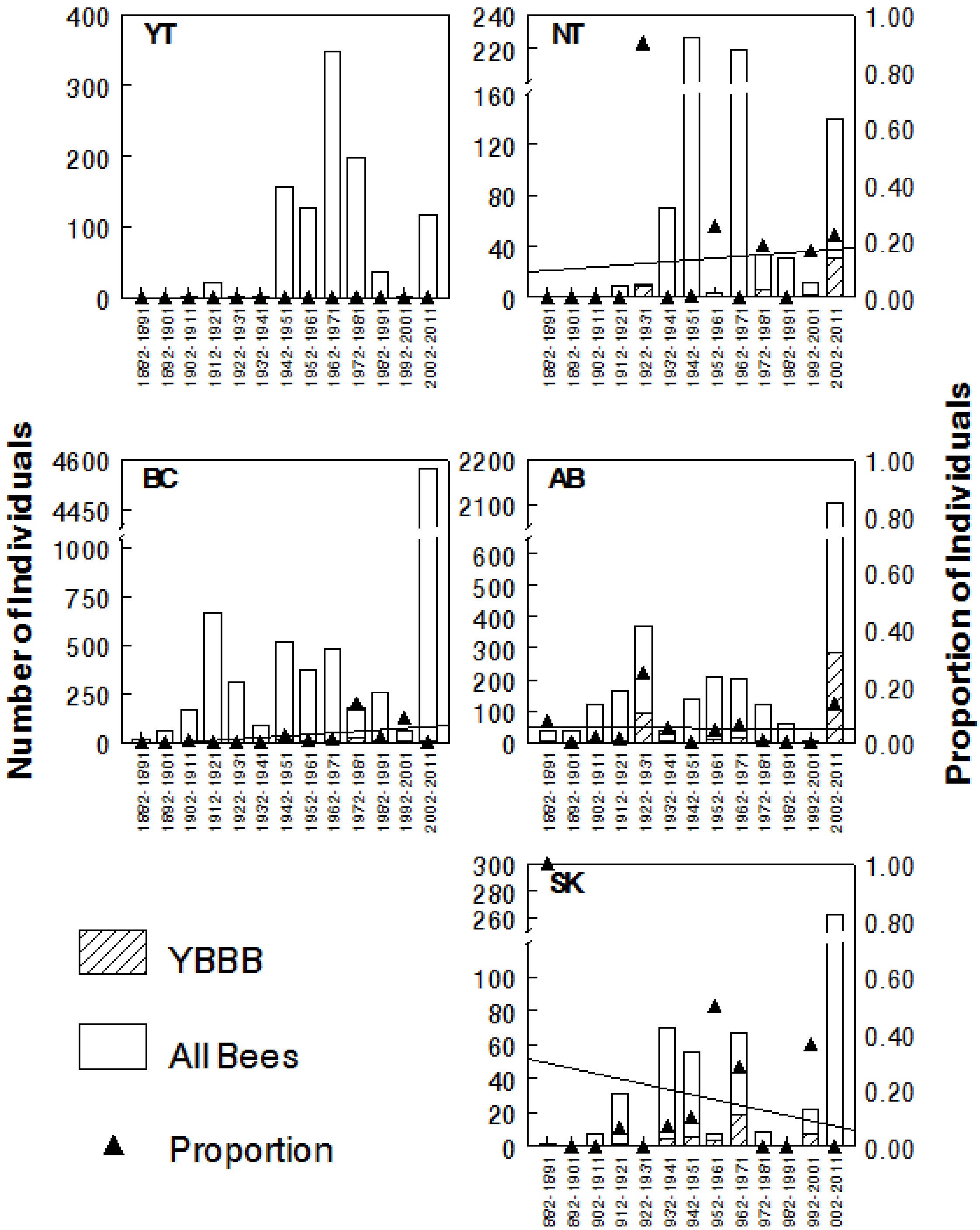

Figure 10. Proportional abundance of the Yellow-banded Bumble Bee (YBBB) based on a dataset of *Bombus* records in YT, NT, BC, AB and SK (1882 – 2011). The left Y-axis (shaded portions of bars) indicates YBBB specimens and the right Y-axis (triangles) represents the proportion of YBBB specimens by ten-year intervals. Linear regression was used to examine trends in proportional abundance over time; the line represents a best fit of the data. Graphs generated using Minitab ® software.

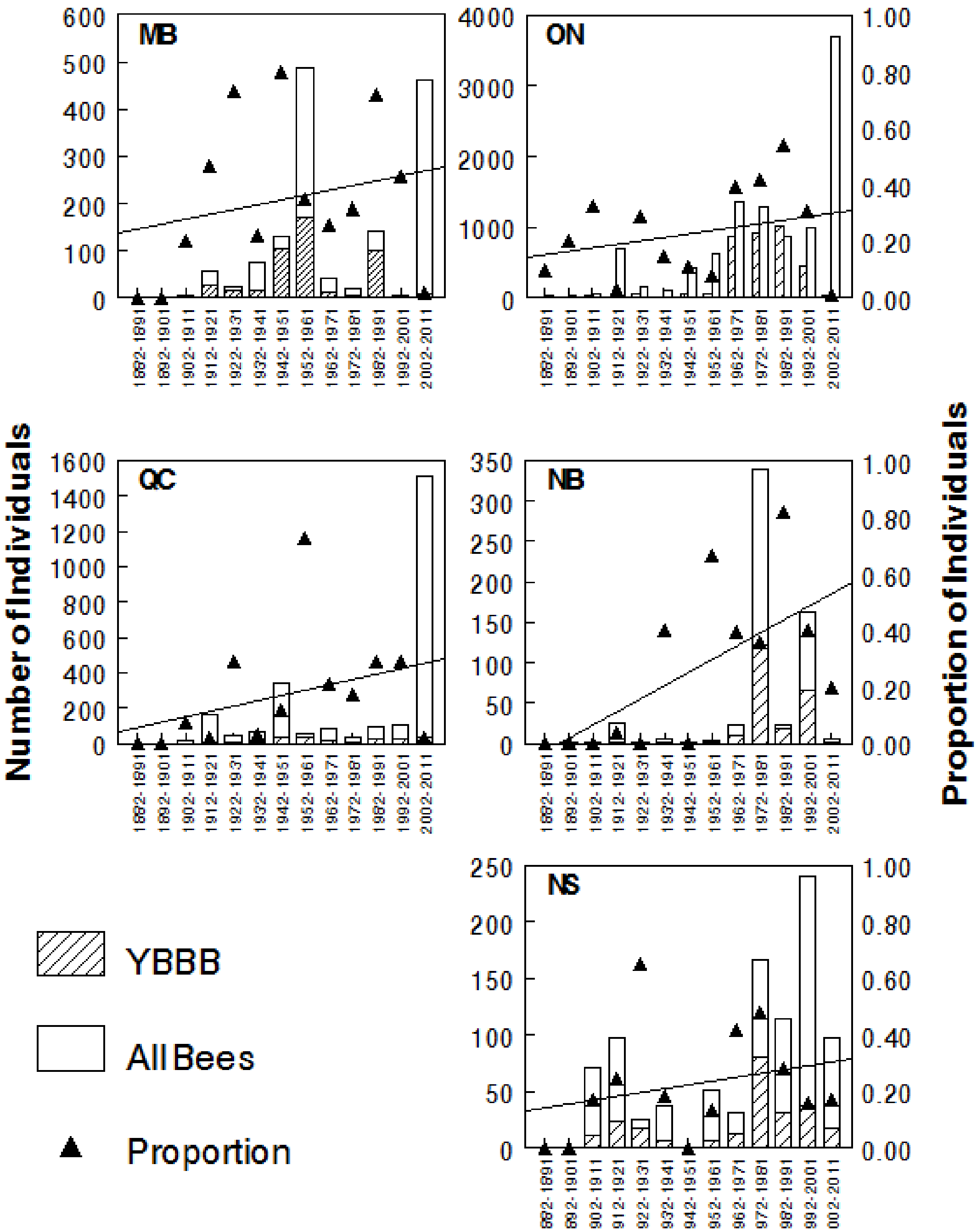

Figure 11. Proportional abundance of the Yellow-banded Bumble Bee (YBBB) based on a dataset of *Bombus* records in MB, ON, QC, NB and NS (1882 – 2011). The left Y-axis (shaded portions of bars) indicates YBBB specimens and the right Y-axis (solid triangles) represents the proportion of YBBB specimens by ten-year intervals. Linear regression was used to examine trends in proportional abundance over time; the line represents a best fit of the data. Graphs generated using Minitab ® software.

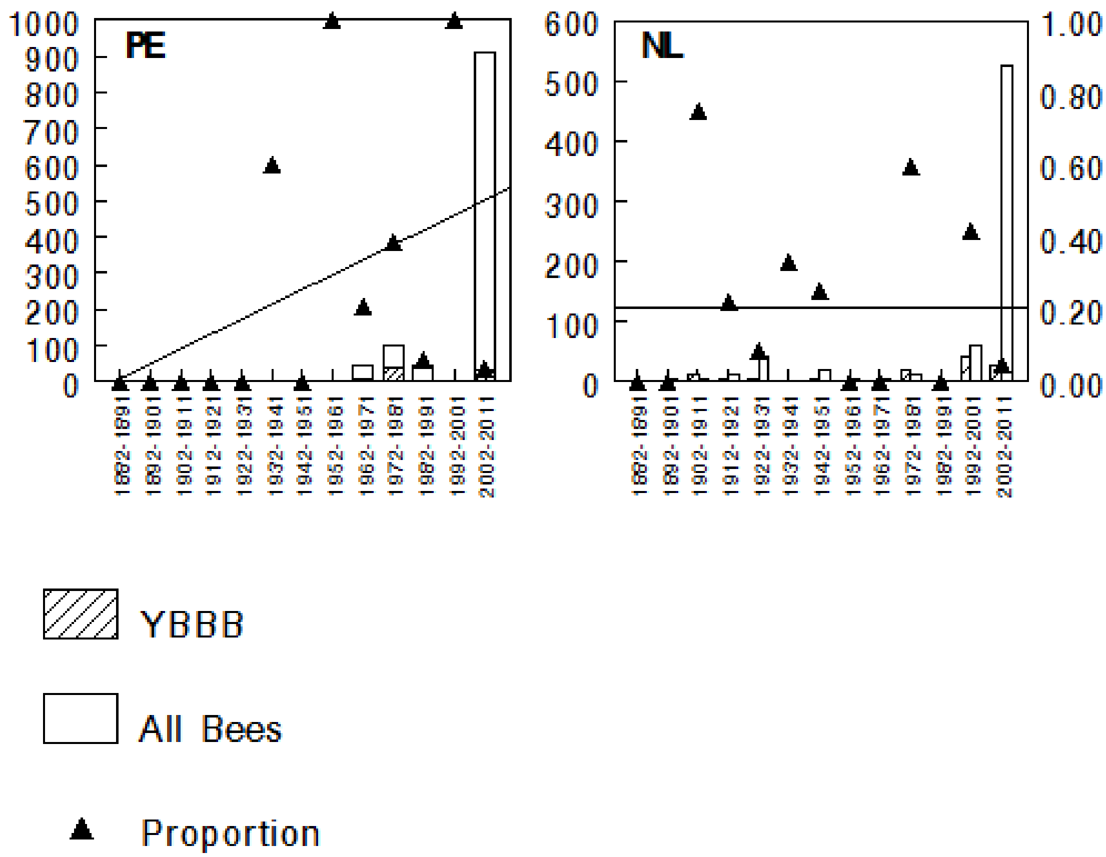

Figure 12. Proportional abundance of Yellow-banded Bumble Bee (YBBB) in PE and NL (1882 – 2011) by decade. The left Y-axis (shaded portions of bars) shows number of YBBB and the right Y-axis (solid triangles) represents the proportion of YBBB specimens by decade. Linear regression was used to examine trends in proportional abundance over time; the line represents a best fit of the data. Dataset from Williams *et al.* 2014. Graphs generated using Minitab ® software.

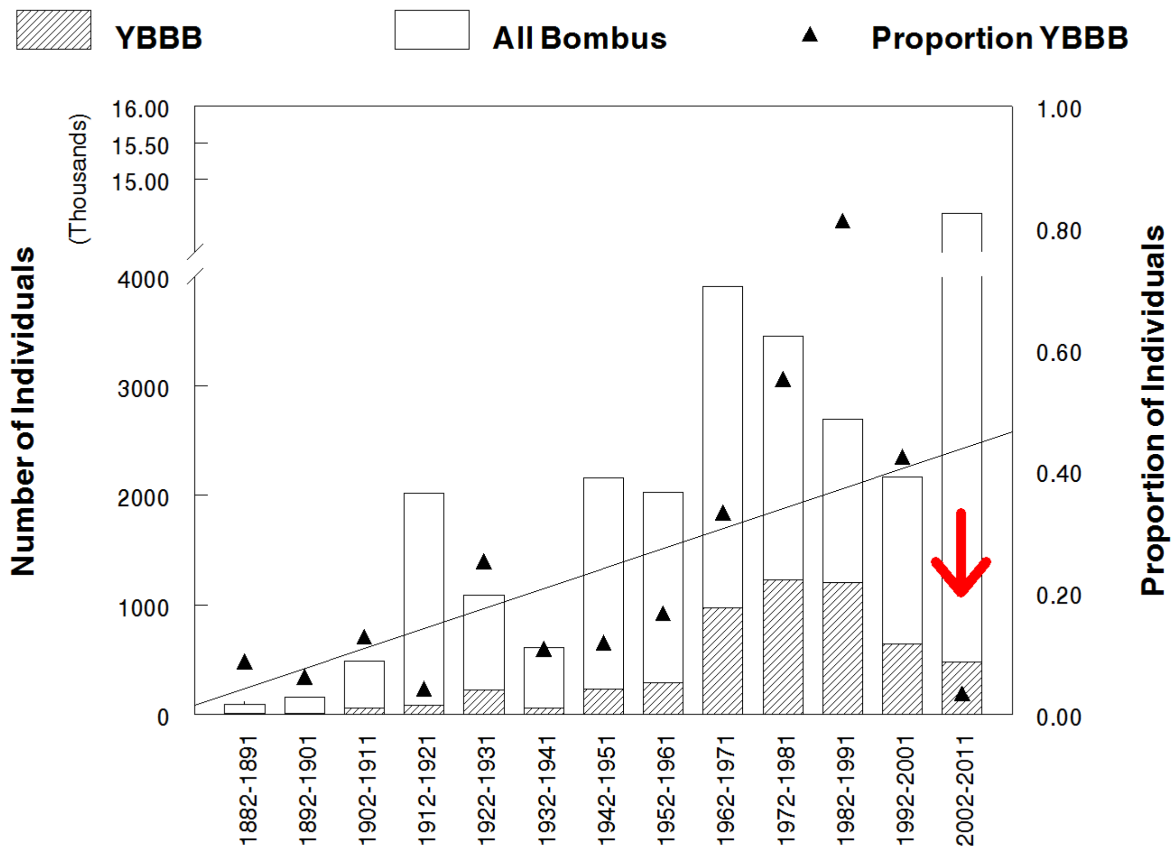

Figure 13. Proportional abundance of Yellow-banded Bumble bee (YBBB) (1882 – 2011) in Canada across each decade. The left Y-axis (shaded portions of bars) shows number of YBBB and the right Y-axis (solid triangles) represents the proportion of YBBB specimens by decade. Linear regression was used to examine trends in proportional abundance over time; the line represents a best fit of the data. Dataset from Williams *et al.* 2014. Graphs generated using Minitab ® software.

Based on the PA of Yellow-banded Bumble Bee in proportion to other bumble bee species over time, there appears to be recent (i.e. past 10-20 years; decade 1992 – 2001 compared with the most recent decade 2002 – 2011) declines within the jurisdictions of BC, SK, MB, ON, QC, NB and NS (Table 3; Figure 10, 11 and 12). Across Canada, PA of Yellow-banded Bumble Bee has declined: 1982 – 1991 (26.05% of collections), 1992 – 2001 (to -33.63) and 2002 – 2011 (-88.91) (Figure 13; Table 3). Much of the boreal and arctic regions of Canada have not been surveyed for bumble bees, and it is not possible to make inferences on declines in these regions (YT, NT and northern portions of AB, SK, MB, ON, QC and NF).

Table 3. Number of specimens and proportional abundance (PA) of Yellow-banded Bumble Bee compared with *Bombus* collection data (1882 – 2011) in Canada. More than 70 individuals and institutions contributed to the dataset. Specimens compiled in a dataset for Williams *et al.* 2014. PA of Yellow-banded Bumble Bee is given in ten-year intervals (graphical representation in Figures 10-12).

	Decade	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL	All YBBB Across Canada	Percent Change in PA from previous decade
All	1882-1891	0	0	1	15	39	2	0	30	1	0	0	0	0	88	-
YBBB		0	0	0	0	3	1	0	3	0	0	0	0	0	7	
PA		0	0	0	0	0.076923	0.5	0	0.1	0	0	0	0	0	0.079545	
All	1892-1901	0	0	0	59	34	0	1	53	0	1	0	0	7	155	-27.00
YBBB		0	0	0	0	0	0	0	9	0	0	0	0	0	9	
PA		0	0	0	0	0	0	0	0.169811	0	0	0	0	0	0.058065	
All	1902-1911	2	1	3	166	119	8	5	80	13	1	71	2	16	487	94.50
YBBB		0	0	0	1	2	0	1	26	1	0	12	0	12	55	
PA		0	0	0	0.006024	0.016807	0	0.2	0.325	0.076923	0	0.169014	0	0.75	0.112936	
All	1912-1921	21	9	44	668	166	31	56	716	165	26	97	1	18	2018	-64.02
YBBB		0	0	0	0	2	2	26	20	3	1	24	0	4	82	
PA		0	0	0	0	0.012048	0.064516	0.464286	0.027933	0.018182	0.038462	0.247423	0	0.222222	0.040634	
All	1922-1931	3	10	13	313	372	0	22	240	43	1	26	0	48	1091	394.00
YBBB		0	9	0	1	92	0	16	70	10	0	17	0	4	219	
PA		0	0.9	0	0.003195	0.247312	#DIV/0!	0.727273	0.291667	0.232558	0	0.653846	0	0.083333	0.200733	
All	1932-1941	1	70	15	88	39	70	76	135	63	5	38	5	3	608	-51.66
YBBB		0	0	0	0	2	5	17	20	2	2	7	3	1	59	
PA		0	0	0	0	0.051282	0.071429	0.223684	0.148148	0.031746	0.4	0.184211	0.6	0.333333	0.097039	
All	1942-1951	157	226	92	513	135	56	132	477	340	2	0	0	28	2158	08.39
YBBB		0	1	0	15	0	6	105	54	39	0	0	0	7	227	
PA		0	0.004425	0	0.02924	0	0.107143	0.795455	0.113208	0.114706	0	0	0	0.25	0.10519	
All	1952-1961	126	4	33	377	211	8	487	666	51	3	52	3	5	2026	35.61
YBBB		0	1	0	3	9	4	171	52	37	2	7	3	0	289	
PA		0	0.25	0	0.007958	0.042654	0.5	0.351129	0.078078	0.72549	0.666667	0.134615	1	0	0.142646	
All	1962-1971	348	219	135	478	201	67	43	2233	82	23	31	48	4	3912	74.72
YBBB		0	0	0	7	12	19	11	877	17	9	13	10	0	975	
PA		0	0	0	0.014644	0.059701	0.283582	0.255814	0.392745	0.207317	0.391304	0.419355	0.208333	0	0.249233	
All	1972-1981	198	33	1	174	120	9	19	2225	35	340	167	99	32	3452	42.62
YBBB		0	6	0	24	1	0	6	926	6	121	80	38	19	1227	
PA		0	0.181818	0	0.137931	0.008333	0	0.315789	0.41618	0.171429	0.355882	0.479042	0.383838	0.59375	0.355446	
All	1982-	37	31	10	253	59	1	141	1882	96	22	114	47	1	2694	26.05

	Decade	YT	NT	NU	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL	All YBBB Across Canada	Percent Change in PA from previous decade
YBBB	1991	0	0	0	5	0	0	101	1020	28	18	32	3	0	1207	
PA		0	0	0	0.019763	0	0	0.716312	0.541977	0.291667	0.818182	0.280702	0.06383	0	0.448033	
All	1992-2001	2	12	0	58	6	22	7	1452	104	163	240	2	101	2169	-33.63
YBBB		0	2	0	5	0	8	3	450	30	65	38	2	42	645	
PA		0	0.166667	0	0.086207	0	0.363636	0.428571	0.309917	0.288462	0.398773	0.158333	1	0.415842	0.297372	
All	2002-2011	116	140	59	4573	2103	263	462	3739	1508	5	98	908	555	14529	-88.91
YBBB		0	31	0	10	284	0	9	34	31	1	17	34	28	479	
PA		0	0.221429	0	0.002187	0.135045	0	0.019481	0.009093	0.020557	0.2	0.173469	0.037445	0.05045	0.032969	

Table 4. Number of 2 km² X 2 km² grid cells occupied within each Canadian ecozone where Yellow-banded Bumble Bee is recorded. Comparisons with grid cells prior to 2003 (historical) and 2004 – 2013 (past ten years). More than 70 individuals and institutions contributed to the dataset. Specimens compiled in a dataset for Williams *et al.* 2014.

Ecozone	Total cells (each 2 km² X 2 km²)	Ecozone area (km²)	2003 and prior cells occupied	2004 to 2013 cells occupied	total cells occupied	2003 and prior AO (km²)	2004 to 2013 AO (km²)	overall historical occupancy (km²)	change in IAO, modern/ historical
Arctic Cordillera	83,025	332,100	0	0	0	0	0	0	n/a
Atlantic Maritime	42,556	170,224	175	55	216	700	220	864	0.314
Boreal Cordillera	117,083	468,332	2	0	2	8	0	8	n/a
Boreal Plain	162,751	651,004	73	6	78	292	24	312	0.082
Boreal Shield	418,291	1,673,164	194	21	213	776	84	852	0.108
Hudson Plain	85,407	341,628	7	2	9	28	8	36	0.286
Mixed Wood Plain	23,527	94,108	109	45	150	436	180	600	0.413
Montane Cordillera	111,659	446,636	22	5	26	88	20	104	0.227
Northern Arctic	470,169	1,880,676	0	0	0	0	0	0	n/a
Pacific Maritime	43,725	174,900	4	0	4	16	0	16	n/a
Prairie	104,056	416,224	70	15	85	280	60	340	0.214
Southern Arctic	224,843	899,372	0	0	0	0	0	0	n/a
Taiga Cordillera	71,563	286,252	0	0	0	0	0	0	n/a
Taiga Plain	172,136	688,544	13	10	23	52	40	92	0.769
Taiga Shield	334,315	1,337,260	4	5	8	16	20	32	1.250
Canada	**2,465,106**	**9,860,424**	**673**	**164**	**814**	**2,692**	**656**	**3,256**	**0.244**

Several other methods have been used to infer changes in bumble bee species distributions at the local scale (using museum datasets).

1. Proportional abundance of bumble bees collected at sites in and around Guelph, ON were compared from 1971-1973 (N = 3,632) and again in 2004-2006 (N = 1,195), and the Yellow-banded Bumble Bee significantly declined in proportional abundance from 3% to 0% between the two time periods (Colla and Packer 2008). Surveys used hand nets and occurred approximately every few days for the historical study. In 2004-2005, surveys were done every month from May-September. In 2006, surveys were approximately weekly from April-October along two 1 km belt transects at each of the three sites studied during the historical study.

2. Using an earlier version of the present dataset (N = 69,600 bumble bee records), grid cell occupancy was compared between two time periods for 20 species of bumble bees in Canada and the US, and it was concluded that the Yellow-banded Bumble Bee persists in approximately 52% of its re-sampled historical range (Colla *et al.* 2012a). The region was divided into 50 x 50 km grid cells and records from 1991-2009 were considered positive for 'persistence' if that species had occurred in that cell in previous time periods. Cameron *et al.* (2011) (who developed part of the dataset used in the preparation of this status report) inferred declines of the Yellow-banded Bumble Bee across most of its US range using proportional abundance measures and found a decline from 12% to 1% in proportional abundance in the Northern/Coastal Eastern US. They compared proportional abundance levels from surveys across the US done in 2007-2009 (382 sites, n=16,788 netted bumble bees) and compared to specimens from 1900-1999 (n=73,759 specimens).

3. Hatfield *et al.* (in prep.) used the same dataset to assign IUCN threat ranks to 43 bumble bee species in Canada and the US, but compared several spatial statistics (*e.g.* extent of occurrence (EOO)) between modern and historical datasets rarified to the same number of records. Average decline for this species was calculated by averaging the change in abundance, persistence, and EOO. They report an average decline of 49.94% in the Yellow-banded Bumble Bee between the historical and modern periods. The proportional abundance change from the mean proportional abundance has declined by more than 66% in the past decade.

4. Adjacent to Quebec in Vermont, US, the Yellow-banded Bumble Bee formerly accounted for 20-30% of all *Bombus* specimens collected, yet a 2012-2013 citizen scientist bumble bee inventory by the Vermont Center for Ecostudies netted ~10,000 specimens, less than 1% of them the Yellow-banded Bumble Bee (McFarland and Richardson 2013).

Abundance

Estimating abundance for wide-ranging, eusocial insects such as the Yellow-banded Bumble Bee is not possible with current available data. As described above, previous studies have used proportional abundance to show declines. The total number of bumble bee and Yellow-banded Bumble Bee collections by province and territory can be found in Figure 9, although this does not include the recent YT specimens. In general, the species appears to have been more historically abundant eastward of AB (Figure 9).

Fluctuations and Trends

It is important to note that bee populations can exhibit strong inter-annual variation, and that such changes are not necessarily evidence of decline (*e.g.* Roubik and Ackerman 1987). However, as noted above the declines we detect for Yellow-banded Bumble Bee are sustained and observable in many disparate areas of its range. Also, for certain areas with large numbers of bumble bee specimens collected (*e.g.* Nova Scotia), a decade-to-decade PA comparison is possible from the 1960s. In such cases, we detect general stability of Yellow-banded Bumble Bee numbers for much of the 20^{th} century, followed by declines starting in the 1980s (Figures 10-13).

In approach 1, the PA of Yellow-banded Bumble Bees declined at nine of 10 sites for which this comparison was made. Historical PA across these 10 sites was 0.20 ± 0.12 SD, while recent (in the past ten years) PA was 0.04 ± 0.02 SD, an average decline of 66.5% (range: -46.0 - 93.9%; Table 2). Overall, these declines were highly statistically significant, even when considering BC, where PA increased rather than decreased (repeat measures ANOVA: $F_{1,18} = 19.60$, $P = 0.0003$; Figure 8). Although the species did not decline in central BC (where it likely was not historically abundant), historical PA was much lower than at other sites (Table 2).

In approach 2 (COSEWIC IAO, we found that in each of 11 ecozones where Yellow-banded Bumble Bee occurs, IAO declined, with 24.4% modern relative to historical grid cell occupancy (range: 8.2 - 76.9%; Table 3).

In approach 3 (comparisons of PA of this species in bumble bee collections) we report evidence that the Yellow-banded Bumble Bee has declined between the historical (<2003) and recent (2004-2011) time periods.

Using the percent composition data to estimate trends in the numbers of individuals over time is biased: the percent composition is the ratio of the abundance of the species of interest (Yellow-banded Bumble Bee) to the abundance of all Bombus species (e.g., if the trend in percent composition of Yellow-banded Bumble Bee is a function of changes in its abundance and that of all other *Bombus* species). If YBBB abundance remains constant while that of all other *Bombus* increases, the percent composition of Yellow-banded Bumble Bee will decline. If Yellow-banded Bumble Bee abundance remains constant while that of all other *Bombus* decreases, the percent composition of Yellow-banded Bumble Bee will increase. If the abundance of all *Bombus* species, including Yellow-banded Bumble Bee declines at the same rate, the percent composition of Yellow-banded Bumble Bee would be constant. What is significant and unknown is that the total abundance of all *Bombus* may be declining in some localized areas, and this would mean the slope estimate of Yellow-banded Bumble Bee based on percent composition would be an underestimate of the true rate of decline.

Rescue Effect

The range of the Yellow-banded Bumble Bee extends into the United States and stretches along the international border from coast to coast. Rescue effect may occur from natural areas along this international border. However, the species has also declined in PA and range within the US (Cameron *et al.* 2011).

THREATS AND LIMITING FACTORS

The International Union for the Conservation of Nature-Conservation Measures Partnership (IUCN- CMP) threats calculator (Salafsky *et al.* 2008; Master *et al.* 2009) was used to classify and list threats to the species with an overall low threat impact (Appendix 2). Most threats to Yellow-banded Bumble Bee have a high impact at a local scale. However, when threats are considered across the species' Canadian range and throughout the natural areas where the species occurs, many of the threats are unknown or considered negligible.

Pollution (Low) (Threat 9)

<u>Agricultural and forestry effluents (Threat 9.3)</u>

Pesticides can have negative impacts on beneficial insects through direct exposure while foraging or in nesting habitat or indirect exposure while feeding on contaminated pollen and nectar. Effects can be lethal or sub-lethal depending on the chemical and/or concentration. Various life history traits of the Yellow-banded Bumble Bee (such as large body size, early emergence and long colony cycle) may make it more vulnerable to accumulation of pesticides in the colony compared to other species at local scales. Effects can also be synergistic with exposure to multiple pesticides (Gill *et al.* 2012). However, an analysis of pesticide use did not explain large-scale patterns of decline in the Yellow-banded Bumble Bee (Colla *et al.* 2013; Szabo *et al.* 2012).

At local scales pesticides could threaten extant populations. In the boreal shield ecozone, pesticides may be used to control invasive species. A laboratory study looking at the toxicity of six forestry pesticides on adults of four bee species found differing levels of impact for the Yellow-banded Bumble Bee (Helson *et al.* 1994). Permethrin, fenitrothion and maxacarbate were found to be particularly harmful (Helson *et al.* 1994). This study did not consider sub-lethal effects which are also a significant threat to eusocial bees (e.g. Desneux *et al.* 2007) or newer pesticides which may also be harmful.

In urban and agricultural landscapes, populations may be threatened by a variety of pesticides including neonicotinoids. Neonicotinoids are a class of systemic pesticides that travel and accumulate throughout the plant, including pollen and nectar. These pesticides are more detrimental to bees (than other pesticide classes) at concentrations in the parts per billion (ppb) (EPA 1994; Marletto *et al.* 2003).

Imidacloprid is non-lethal to bumble bees when used as directed (e.g., Tasei *et al.* 2001). However, studies of its effects on bumble bees only tested managed bees as representative of all North American species (Gels *et al.* 2002; Morandin and Winston 2003). Further study showed neonicotinoids had negative lethal and sub-lethal impacts on a European bumble bee in the same subgenus, including at levels found in crops treated as directed (Feltham *et al.* 2014; Gill and Raine 2014; Tasei *et al.* 2001; Whitehorn *et al.* 2012).

Neonicotinoids are commonly used on golf courses, ornamental plants and agricultural lands (Sur and Stork 2003). Large treated areas, such as golf courses, may expose bumble bees to large quantities of pesticides in otherwise suitable habitat (Tanner and Gange 2004). In dry conditions, contaminated soil can become airborne with tilling and contaminate adjacent areas where bees might be foraging or nesting (Krupke *et al.* 2012).

Many species began exhibiting declines prior to the widespread use of neonicitinoids in North America (Colla *et al.* 2012). The data available on neonicotinoid use may not explain landscape levels of decline in the Yellow-banded Bumble Bee (Colla *et al.* 2013); it may contribute to declines in extant populations at local levels.

Invasive and Other Problematic Species and Genes (Unknown) (Threat 8)

Invasive non-native/alien species (Threat 8.1)

Pathogen spillover has been implicated in the significant declines of many wide-ranging animals (Morton *et al.* 2004; Power and Mitchell 2004) and is considered a major threat to bumble bees in North America. Pathogen spillover due to the increased use of managed bumble bees in greenhouse operations in recent decades has been implicated in the declines of the Yellow-banded Bumble Bee, the Rusty-patched Bumble Bee and the Western Bumble Bee (Thorp and Shepherd 2005; NRC 2007; Evans *et al.* 2008) and could provide an avenue for rapid and catastrophic disease outbreaks in the future.

Pathogen spillover occurs when pathogens spread from a heavily infected ‘reservoir’ host population to a sympatric ‘non-reservoir’ host population (Power and Mitchell 2004). Managed bumble bees have been documented to have much higher than natural levels of pathogens (Graystock *et al.* 2013a; Colla *et al.* 2006). The use of infected commercial bumble bees (e.g., Common Eastern Bumble Bee [*Bombus impatiens*] 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). In Canada, greenhouses using managed bees are present mostly across southern BC, ON and QC and to a lesser extent in southern AB, NT and YT. The area used by vegetable greenhouses grew 37% from 2001 to 2006 in Canada (Statistics Canada 2006).

The parasite species involved (*Crithidia bombi* and *Nosema bombi*) in spillover to wild bumble bee have detrimental effects on colony-founding queens, foraging workers and entire nests (Brown *et al.* 2000, 2003; Otterstatter *et al.* 2005). Commercial bumble bees have been found to have high prevalence of these parasites [approx. 34-80% (Murray *et al.* 2013; Colla *et al.* 2006)]. These parasites are also found naturally in a variety of bumble bee species at lower levels (Macfarlane 1974; Macfarlane *et al.* 1995; Colla *et al.* 2006), but their virulence in wild Yellow-banded Bumble Bees remains unknown. Additional studies have found declining species including the Yellow-banded Bumble Bee to have higher pathogen loads in the wild compared to co-occurring species (Cordes *et al.* 2012; Cameron *et al.* 2011; Richardson, unpubl. data); however, pathogen loads have been found to be highly variable in common bumble bees as well (5-44%) (Koch and Strange 2012; Malfi and Roulston 2014). Szabo *et al.* (2012) found that declines in the Yellow-banded Bumble Bee throughout its US range and in the southern parts of its Canadian range were weakly correlated with the density of vegetable greenhouses indicating pathogen spillover from managed greenhouse bees may be a factor threatening this species.

In agricultural and urban landscapes Yellow-banded Bumble Bee likely competes for nectar and pollen with the introduced and managed European Honey Bee. However, competition is difficult to quantify under natural conditions (Thomson 2006), so the impact in agricultural landscapes is unknown. The European Honey Bee has been in North America for hundreds of years making it difficult to correlate the recent decline of the Yellow-banded Bumble Bee to direct competition. However, there is increasing evidence that the honey bee poses threats to natural mutualisms (reviewed in Aizen *et al.* 2014). Recent studies have shown that honey bee diseases may be transmittable to bumble bees (e.g. Li *et al.* 2011; Peng *et al.* 2011). In Canada it is estimated that there are 600,000 honey bee colonies in use for pollination and honey production (Canadian Honey Council 2014) and this number is expected to grow (AAFC 2012). Given that disease is a rampant problem in managed honey bees, honey bees do pose a threat to native bumble bees. In the UK, honey bees have been documented transmitted *Nosema ceranae* to bumble bees (Graystock *et al.* 2013b). Other diseases, such as viruses, are understudied but may pose a threat (e.g. Manley *et al.* in press).

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

The general threat of invasive species in the boreal ecozone is not well-studied; however, it has been identified as an important research priority in Canada, particularly in NF, QC and ON (Langor *et al.* 2014).

Problematic native species (Threat 8.2)

The use of the highly successful Common Eastern Bumble Bee [(originally from central Canada and the US but now used for pollination of greenhouse crops (e.g. tomato) and field crops (e.g. blueberry throughout Canada)] may further impact Yellow-banded populations. The movement of this species may threaten declining populations as it is now known to be established in the wild outside its native range (BC, Ratti and Colla 2010) and has expanded its native range eastward (NS, Sheffield *et al.* 2003). This successful species may outcompete the Yellow-banded Bumble Bee for nesting habitat or forage resources. The adverse impacts of bumble bees introduced for commercial pollination on native species is unknown in Canada but has been documented elsewhere (Williams and Osborne 2009; Goulson 2003b). Currently the movement of the Common Eastern Bumble Bee outside its native range within Canada is not being monitored at any jurisdictional level.

Biological Resource Use (Unknown) (Threat 5)

Logging and wood harvesting (Threat 5.3)

Logging takes place throughout much of boreal portion of the species' range; however, the range-wide threat of logging to the Yellow-banded Bumble Bee is unknown. Two studies found logging practices negatively impacted the bumble bee and flowering plant communities in adjacent pristine sites by disrupting natural density-dependent processes (Cartar 2005; Pengally and Cartar 2010). While logged sites may provide more open forage, bees may be exposed to higher competition. A recent study in Algonquin Provincial Park found Yellow-banded Bumble Bees at all sites (logged and unlogged) but noted that bumble bees made up a higher proportion of bees collected at unlogged sites (Nardone 2013).

Residential and Commercial Development (Negligible) (Threat 1)

Habitat loss from intensive residential and commercial developments within the urban areas may be contributing to local declines of this species (Szabo *et al.* 2012) but is not a major threat throughout the majority of this species' range. While declines have been noted near urban areas, there have also been recent (within the past five years) records of the Yellow-banded Bumble Bee in Toronto (e.g. Rouge Park, 2012, G. Ross Lord Park, 2013, Montréal, 2013).

An emerging threat is that of bee-friendly plants sold in nurseries contaminated with pesticides. Muratet and Fontaine (2015) found bumble bee diversity and abundance was higher in French gardens that abstained from pesticides than those that used pesticides. This negative effect of pesticides was especially prominent in gardens in urban areas. Thus, the use of insecticides and herbicides for garden, ornamental, and other residential purposes may pose a risk to this species.

Agriculture and Aquaculture (Negligible) (Threat 2)

Annual and perennial non-timber crops (Threat 2.1)

Habitat loss as a result of agricultural intensification is ongoing throughout southern portions of the species' Canadian range, which has some of the most highly urbanized and farmed regions in Canada. 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). In Illinois, intensive agriculture expanded from 1940-1960 and is correlated with declines of bumble bee species richness, including the local extirpation of the Yellow-banded Bumble Bee (Grixti *et al.* 2009). However, since much of this species' range is in the boreal ecozone, habitat loss due to agriculture is unlikely to be a major threat. Indeed, many crops (e.g. cranberry, blueberry) provide forage for bumble bees, including the Yellow-banded Bumble Bee, during the growing season. However, Javorek and Grant (2011) indicate that most of Canada's agricultural regions have low capacities to support wildlife. Increasing production of greenhouse crops, corn and soybean may cause declines in parts of this species' range in the future due to habitat loss.

Livestock farming and ranching (Threat 2.3)

Several studies have suggested negative impacts to bumble bees associated with intensive grazing (e.g. Kimoto *et al.* 2012; Hatfield and LeBuhn 2007). For this species, the threat of grazing would be localized to a small portion of its range. Grazing at some capacity may be beneficial to bumble bees through maintenance of floral diversity (i.e., in cases where grazing duplicates the natural grazing associated with large herbivores). A study in BC found pastureland can support higher abundances of bumble bees in agriculture-intensive areas (Morandin *et al.* 2007).

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

Climate change is another possible threat to bumble bees. Vasseur *et al* (2014) modelled invertebrate responses under climate models, and found climate variability to likely have a greater detrimental effect on invertebrates than warmer temperatures. Temperate invertebrates were found to be most at risk to such fluctuations (Vasseur *et al.* 2014). Given the pattern of greater climate extremes with climate change (Seneviratne *et al* 2012), there is reason to suspect the threat posed by climatic variability may impact the Yellow-banded Bumble Bee. Increased drought and/or flooding could also impact the Yellow-banded Bumble Bee but the extent of this threat is unknown.

At the congeneric level, it has been found that bumble bee species with narrow climatic tolerances are more vulnerable to extrinsic threats (Williams *et al.* 2009). A recent study of two bumble bee species that co-occur with Yellow-banded Bumble Bee in eastern Canada and northeastern US (*B. impatiens* and *B. bimaculatus*) determined bee species are emerging 10 days earlier than a century ago due to climate change (Bartomeus *et al.* 2011). This could lead to mismatch of early spring forage or increase the likelihood of queens emerging before the end of winter storms. Either of these scenarios could lead to the death of founding queens; however, it is not currently known if this is the case for native bees.

Bartomeus *et al.* (2013) found that Yellow-banded Bumble Bee declines are most prominent in the southern portion of its range, consistent with the species being outcompeted at its warm boundary by more southern warm-adapted species. This is also consistent with their broader finding that northern-latitude species tend to be declining more than southern species, consistent with climate change.

Bumble bees require a constant suite of floral resources that supply pollen and nectar throughout the growing season, and several authors have suggested that climate change will lead to phenological mismatches between bees and the plants on which they feed (e.g., Miller-Rushing and Primack 2008; Bartomeus *et al.* 2011).

Limiting Factors

Bumble bees are haplodiploid organisms with complementary sex determination, which makes them extremely susceptible to extinction when effective population sizes are small (Zayed and Packer 2005). This is due to the 'diploid male extinction vortex' (Zayed and Packer 2005). Sex in bees, and most other haplodiploids, is determined by genotype at a single "sex locus": hemizygotes (haploids) are males, heterozygotes are female and homozygotes are 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. Due to the production of sterile males when sex-determining locus heterozygosity is low (i.e. populations are small and inbreeding occurs), bees are more vulnerable to habitat fragmentation than many other animal species (Packer and Owen 2001). This means that as bumble bee populations decrease in size, the frequency of diploid males increases. 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 extinct even under stable environmental conditions unless its number increases within a few generations.

Bumble bees require large inputs of floral resources (i.e., pollen and nectar) over the entire growing season: queens for the next generation are only produced towards the end of the colony cycle.

Recent evidence also suggests that bumble bees with small populations suffer from lowered genetic diversity and increased susceptibility to parasites (e.g. Whitehorn *et al.* 2014).

Number of Locations

It is not possible to calculate the number of locations for this species.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

There are no federal laws that specifically protect Yellow-banded Bumble bees in Canada.

In Quebec, Yellow-banded Bumble Bee is integrated on the Liste des espèces susceptibles d'être désignées menacées ou vulnérables (list of wildlife species likely to be designated threatened or vulnerable) (http://www3.mffp.gouv.qc.ca/faune/especes/menacees /liste.asp#insectes). This list is produced according to the Quebec legislation "Loi sur les espèces menacées ou vulnérables" (RLRQ, c E-12.01) (LEMV) (Act respecting threatened or vulnerable species) (CQLR, c E-12.01). This list also serves as a reference for: official enumeration of at-risk species; selection of species to be designated as threatened or vulnerable and creation of directives during the production of environmental impact studies. The species appearing in the list will be the subject of particular attention in the case of any project subject to assessment by environmental authorities under sections 22 and 31.1 of the *Environment Quality Act*. The directives that are communicated to the promoters of these projects will take listed species into account.

Non-Legal Status and Ranks

Status ranks (Natureserve 2014):

Global status rank: G2G4 (Imperiled to Apparently Secure).

Subnational status ranks:

S5 (Secure) in Ontario (2002); however, considered out-of-date [Oldham pers. comm. 2014]

SX (Extirpated) in Illinois

S1S2 (Critically Imperiled to Imperiled) in Vermont

S1 (Critically Imperiled) in Wisconsin

Unranked in most states, provinces and territories

IUCN Red list (2013): None

Xerces Society for Invertebrate Conservation (2013) Red-list: Imperiled

Habitat Protection and Ownership

Given this expansive range of the Yellow-banded Bumble Bee across Canada, several suitable areas of habitat are within protected areas. The list below is not complete.

BC: Stone Mountain Provincial Park, Tsyl-os Provincial Park.

AB: Banff National Park, Jasper National Park, Rumsey Natural Area.

SK: Athabasca Sand Dunes Provincial Park, Candle Lake Provincial Park, Moose Mountain Provincial Park, Prince Albert National Park.

MB: Dog Lake Wildlife Management Area, Douglas Marsh Protected Area, Hecla/Grindstone Provincial Park, Riding Mountain National Park.

ON: Algonquin Provincial Park, Awenda Provincial Park, Blue Lake Provincial Park, Bruce Peninsula National Park, Cabot Head Provincial Nature Reserve, Esker Lakes Provincial Park, Fathom Five National Park, Georgian Bay Islands National Park, Killarney Provincial Park, Lake of the Woods Waters Conservation Reserve, Lake Superior Provincial Park, Missinaibi Provincial Park, Rouge Park, Sleeping Giant Provincial Park.

QC: Albanel-Témiscamie-Otish, Forillon National Park, Parc National de la Gaspésie, parc de la Gatineau, Lac des Deux Montagnes, Parc National du Mont-Tremblant, Rivière des Caps, Parc Marin du Saguenay-St-Laurent.

NB: Caledonia Gorge Protected Natural Area, Jacquet River Gorge Protected Natural Area, Spednic Lake Protected Natural Area.

NS: Cape Breton Highlands National Park, Kejimkujik National Park, Polletts Cove-Aspy Fault Wilderness Area, Terence Bay Wilderness Area.

PE: Prince Edward Island National Park.

NF: Gros Morne National Park.

NT: Nahanni National Park.

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Authorities contacted

Name of jurisdiction	Name of contact(s) and date(s)[1]
Canadian Wildlife Service	Syd Cannings (Sept 25, 2013) Andrew Boyne (April 23, 2013) Ken Tuininga (April 23, 2013) Dave Duncan (April 25, 2013) Samara Eaton (May 7 2013)
Parks Canada	Dean Nernberg (April 23, 2013) Patrick Nantel (April 25, 2013)
Provincial / territorial representative(s) corresponding to the range of the wildlife species	Rosemary Curley, Prince Edward Island (April 23, 2013) Mary Sabine, New Brunswick (January 23, 2015) Suzanne Carriere, Northwest Territories (April 23, 2013) Shelly Pardy, Newfoundland and Labrador (April 23, 2013) Vanessa Charlwood (April 23, 2013) David Fraser, British Columbia (September 25, 2013) Donald Sutherland (April 23, 2013) Nathalie Desrosiers, Quebec (2014) Isabelle Gauthier, Quebec (2014)
Conservation Data Centre(s) or Natural Heritage Information Centre(s) corresponding to the range of the wildlife species	Isabelle Gauthier (May 13, 2013) John Klymko (April 23, 2013)

[1] In cases where jurisdiction and/or individual(s) have been contacted but a response was not received, indicate as such.

Name of jurisdiction	Name of contact(s) and date(s)[1]
COSEWIC Secretariat: a) sources of Aboriginal Traditional Knowledge b) the preparation of distribution maps and the calculation of extent of occurrence, area of occupancy, and index of area of occupancy	a) Neil Jones (June 3, 2013) b) Alain Filion and Jenny Wu
Other contacts	Cory Sheffield (September 25, 2013) Valerie Fournier (November 1, 2013) David McCorquodale (November 11, 2013) Robin Owen (November 11, 2013) Ralph Cartar (November 15, 2013) Luise Hermanutz (November 20, 2013) Robert Anderson (April 23, 2013) Jim Pojar (April 25, 2013) Jennifer Heron (September 25, 2013)

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BIOGRAPHICAL SUMMARY OF REPORT WRITERS

Sheila R. Colla has studied various aspects of bumble bee ecology and behaviour throughout North America. Previously she worked as a research assistant at the University of Toronto, St. George Campus, looking at pathogen spillover from managed to wild bumble bee populations. She completed her doctorate and was a recipient of the NSERC 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 some of the causes of observed declines. She is currently a Project Leader at Wildlife Preservation Canada.

Leif L. Richardson is a postdoctoral research fellow at the Gund Institute for Ecological Economics and the University of Vermont. He recently completed a PhD at Dartmouth College, Hanover, NH, where he examined 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 others he is co-author of Bumble Bees of North America: an Identification Guide (Williams 2014). More at: www.leifrichardson.org

COLLECTIONS EXAMINED

Academy of Natural Sciences, Philadelphia, PA

Algonquin Provincial Park, Hunstville, ON

American Museum of Natural History, New York, New York

Andre Francoeur Research Collection, Chicoutimi, QC

Atlantic Canada Conservation Data Centre, Sackville, NB

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

BBSL-Utah Logan, Utah

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

Biodiversity Institute of Ontario, Guelph, ON

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

P.H. Williams Research Collection, London, UK
Packer Collection York University, Toronto, ON
Patuxent Wildlife Research Center; Laurel, MD
P. Hallett Personal Collection, Toronto, ON
R. Gegear Research Collection, Toronto, ON
Royal British Columbia Museum, Victoria, BC
Royal Ontario Museum, Toronto, ON.
Royal Saskatchewan Museum, Regina, SK
S. Javorek Research Collection, Kentville, NS
S. Colla Research Collection, Toronto, ON
University of Colorado, Boulder, Colorado
University of Massachusetts, Worchester, MA
University of Minnesota; Minneapolis, MN
University of Michigan; Ann Arbor, MI
University of Alaska, Fairbanks; Alaska
University of Connecticut; Storrs, CT
University of Guelph, Guelph, ON
University of Idaho; Moscow, ID
University of New Hampshire, Durham; New Hampshire
University of Prince Edward Island; Charlottetown, PE
University of Nevada, Reno; NV
V. Fournier Research Collection; Laval, QC
Yale Peabody Museum, New Haven CT

Appendix 1. Summary of recent searches for Yellow-banded Bumble Bee at known historical sites (from Williams *et al.* 2014).

Province	Historical Site (year)	Year of Re-survey	Presence and/or PA	Search effort	Reference/ Collectors
ON	High Park, Toronto (1983)	2012	Absent, 0/33 Total *Bombus*	2 hrs	S. Colla data collected for this status report
ON	Scarborough (2005)	2012 and 2013	Present in 2012, 2 *B. terricola*/ >100 total *Bombus*	Surveys at Rouge Park every 2 weeks from May-Aug	S. Colla data collected for this status report
ON	Algonquin Provincial Park (numerous records 1916-2000)	2008	Present, common	Surveys every two weeks May-Aug along Hwy 60	S. Colla data collected for this status report
ON	Forks of the Credit Provincial Park (1968 and1969)	2013	Absent, 0/20 total *Bombus*	175 mins	S. Colla data collected for this status report
ON	City of Barrie (1988)	2013	Absent, 0/31 total *Bombus*	20 mins	S. Colla data collected for this status report
ON	Guelph (numerous records, 1915-2006	2013	Absent, 0/50 total *Bombus*	10 hrs over 2 days	S. Colla data collected for this status report
AB	Edmonton (1924)	2013	Present, 1 specimen/ 76 total *Bombus*	2.5 hr survey	G. Rowe data collected for this status report
AB	Slave Lake (1924)	2013	Present, 24 *B. terricola*/ 97 total *Bombus*	2.5 hr survey	G. Rowe data collected for this status report
QC	Montréal (1965)	2012	Present, 1 *B. terricola* / 508 Total *Bombus*	16 days (pan traps), 10 days (netting)	
NS	Lockeport	2013	Present, 1 *B. terricola*/ 95 Total *Bombus*	2 hours	J. Klymko data collected for this status report
NS	Greenfield (1999)	2013	Present, 2 *B. terricola*/ 38 total *Bombus*	50 mins	J. Klymko data collected for this status report
NS	Port Medway (2001)	2013	Absent, 0/64 total *Bombus*	64 mins	J. Klymko data collected for this status report
NS	New Germany (1994)	2013	Present, 2 *B. terricola*/ 43 total *Bombus*	38 mins	J. Klymko data collected for this status report
NB	Springfield (1973)	2013	Present, 6 *B. terricola* /119 total *Bombus*	62 mins	J. Klymko data collected for this status report
NB	Norton (1979)	2013	Present, 7 *B. terricola* of 268 total *Bombus*	60 mins	J. Klymko data collected for this status report
NB	Elgin (1996 and1974)	2013	Absent, 0/189 total *Bombus*	120 mins	J. Klymko data collected for this status report
NB	Fredericton (1915)	2013 and 2014	Absent, 0/7 total *Bombus*	72 mins; Numerous specimens in urban areas in 2014	J. Klymko data collected for this status report M. Sabine pers. comm. 2014
PE	Crapaud (1984)	2013	Absent, 0/61 total *Bombus*	160 mins	J. Klymko data collected for this status report
PE	Clyde River (1971)	2013	Absent, 0/31 total *Bombus*	70 mins	J. Klymko data collected for this status report

Province	Historical Site (year)	Year of Re-survey	Presence and/or PA	Search effort	Reference/ Collectors
PE	Charlottetown (2009)	2013	Present, 2 *B. terricola*/ 60 total *Bombus*	90 mins	J. Klymko data collected for this status report
PE	Cardigan (1970)	2013	Absent, 0/43 total *Bombus*	66 mins	J. Klymko data collected for this status report
NL	Numerous localities (from 1897)	2010	Present, 41 *B. terricola*/ 1,172 *Bombus*	9 pan trapping events 6/17/2010-9/6/2010	
BC	Numerous localities (from 1911)	2013	Present, 290 *B. terricola*/ 6,763 *Bombus*	98 survey points (18 historical resurveys), 35-520 minutes each	J. Heron and C. Sheffield pers. data 2013

Appendix 2. IUCN Threats calculation on the Yellow-banded Bumble Bee (*Bombus terricola*).

Species Scientific Name	Yellow-banded Bumble Bee, Bombus terricola			
Date:	April 3, 2014.			
Assessor(s):	Sheila Colla (status report author), Leif Richardson (status report author), Syd Cannings (Canadian Wildlife Service), Robin Owen (Arthropods SSC member), Cory Sheffield (Arthropods SSC member), Ruben Boles (Canadian Wildlife Service), John Richardson (Arthropods SSC member), Mary Sabine (Government of New Brunswick), Shelley Pardy (Government of Newfoundland), Vivian Brownell (Government of Ontario), Isabelle Gauthier (Government of Québec), Christy Morrissey (University of Saskatchewan), Nathalie Desrosiers (Government of Québec), Marie-France Noel (Canadian Wildlife Service), Sherman Boates (Government of Nova Scotia), Dave Fraser (Government of British Columbia), Jennifer Heron (Arthropods SSC co-chair) and Angele Cyr (COSEWIC Secretariat).			
Overall Threat Impact Calculation			**Level 1 Threat Impact Counts**	
	Threat Impact		**high range**	**low range**
	A	Very High	0	0
	B	High	0	0
	C	Medium	0	0
	D	Low	1	1
	Calculated Overall Threat Impact:		Low	Low

Threat		**Impact (calculated)**	**Scope (next 10 Yrs)**	**Severity (10 Yrs or 3 Gen.)**	**Timing**	**Comments**
1	Residential and commercial development	Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	
1.1	Housing and urban areas	Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	Potentially a threat in developed areas, especially in eastern Canada, but most of species' range is not urbanized.
1.2	Commercial and industrial areas	Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	Commercial and industrial areas are a small proportion of the range also but commercial development may be a higher risk to this species. Shopping malls and Industrial parks may be a higher threat. However, Goldenrod and other plants have been growing around shopping malls where Bumble Bees tend to be found. Cape Bretton population is not accounted for since development occurred in the past.

Threat		Impact (calculated)	Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1.3	Tourism and recreation areas	Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	Ski area development alters habitat but may not be a threat. Pesticides (including neonicotinoids) applied to Golf Courses are accounted for under pollution (threat 9).
2	Agriculture and aquaculture	Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	
2.1	Annual and perennial non-timber crops	Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	Stats Canada studies on agricultural changes 2006-2011 shows decrease in area of vegetable production and increase in area of fruit production. Corn crops have increased as a result of increased market value for corn (not beneficial for bees though). Greenhouse development increasing as well. Agricultural land use in Canada is a small percentage of this species range. Pesticide use for agricultural crops is accounted for under pollution (threat 9).
2.2	Wood and pulp plantations					Not applicable
2.3	Livestock farming and ranching	Not a Threat	Negligible (<1%)	Neutral or Potential Benefit	High (Continuing)	Grazing may be both detrimental and beneficial. Flower growth may cause interference. Study on cattle grazing in the Okanagan showed severe soil disturbance.
2.4	Marine and freshwater aquaculture					Not applicable
3	Energy production and mining	Negligible	Negligible (<1%)	Extreme - Serious (31-100%)	High (Continuing)	
3.1	Oil and gas drilling	Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	Could degrade habitat, but could also result in beneficial increase in flowers.
3.2	Mining and quarrying	Negligible	Negligible (<1%)	Extreme - Serious (31-100%)	High (Continuing)	Could degrade habitat, but could also result in beneficial increase in flowers.
3.3	Renewable energy	Negligible	Negligible (<1%)	Unknown	High (Continuing)	Could degrade habitat, but could also result in beneficial increase in flowers.
4	Transportation and service corridors	Negligible	Negligible (<1%)	Unknown	High (Continuing)	

Threat		Impact (calculated)	Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
4.1	Roads and railroads	Negligible	Negligible (<1%)	Unknown	High (Continuing)	Increased mortality due to bee collisions with cars, but potential benefit from increased production of roadside weeds.
4.2	Utility and service lines	Not a Threat	Negligible (<1%)	Neutral or Potential Benefit	High (Continuing)	Potential benefit from maintenance of early successional shrub lands and grasslands. Potential threat from pesticide application (included under threat 9).
4.3	Shipping lanes					Not applicable
4.4	Flight paths					Not applicable
5	Biological resource use	Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	
5.1	Hunting and collecting terrestrial animals	Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	Not applicable. Scientific collecting may be threat but this is likely negligible.
5.2	Gathering terrestrial plants					Not likely a threat.
5.3	Logging and wood harvesting	Negligible	Negligible (<1%)	Unknown	High (Continuing)	Potential benefit given the large opening but also likely a threat given the increased competition and change in foraging patterns post logging.
5.4	Fishing and harvesting aquatic resources					Not applicable.
6	Human intrusions and disturbance					
6.1	Recreational activities					Not likely a threat.
6.2	War, civil unrest and military exercises					Not applicable
6.3	Work and other activities					Not applicable
7	Natural system modifications	Unknown	Small (1-10%)	Unknown	High (Continuing)	
7.1	Fire and fire suppression	Unknown	Small (1-10%)	Unknown	High (Continuing)	The impacts of fire on bee abundance can be beneficial and/or detrimental.
7.2	Dams and water management/use					Not applicable
7.3	Other ecosystem modifications					Not applicable
8	Invasive and other problematic species and genes	Unknown	Unknown	Unknown	High (Continuing)	

Threat		Impact (calculated)	Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
8.1	Invasive non-native/alien species	Unknown	Unknown	Unknown	High (Continuing)	Pathogens are an unquantified threat, including parasite spillover from greenhouses (e.g., Bombus impatiens and other pathogen transfer to native been populations).
8.2	Problematic native species	Unknown	Unknown	Unknown	High (Continuing)	Bombus cryptarum competition is unknown.
8.3	Introduced genetic material					
9	Pollution	Low	Small (1-10%)	Serious (31-70%)	High (Continuing)	
9.1	Household sewage and urban waste water					Not applicable
9.2	Industrial and military effluents					Not applicable
9.3	Agricultural and forestry effluents	D Low	Small (1-10%)	Serious (31-70%)	High (Continuing)	Neonicotinoid pesticides applied to agricultural land and golf courses. Soil tilled and dried. Dust is lethal to bees. Nectar and pollen concentrations. Cumulative properties and persistent. Half life when exposed to sunlight. Found in garden plants as well.
9.4	Garbage and solid waste					Not applicable
9.5	Air-borne pollutants					Neonicotinoid pesticides (accounted for in 9.3)
9.6	Excess energy					Not applicable
10	Geological events					
10.1	Volcanoes					Not applicable
10.2	Earthquakes/tsunamis					Not applicable
10.3	Avalanches/landslides					Not applicable
11	Climate change and severe weather	Unknown	Unknown	Unknown	High (Continuing)	
11.1	Habitat shifting and alteration	Unknown	Unknown	Unknown	High (Continuing)	Potential to reduce species' range size and alter phenology of host plants.
11.2	Droughts	Unknown	Unknown	Unknown	High (Continuing)	Affects flowering plants
11.3	Temperature extremes					Not applicable

Threat		Impact (calculated)	Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
11.4	Storms and flooding	Unknown	Unknown	Unknown	High (Continuing)	Some evidence on flooding in its range (nest flooding) but may have an affect on spring queens and foraging (unknown).